LIGO LABORATORY
California Institute of Technology
1200 E. California Blvd.
Pasadena, CA 91125

Statement of Work
Fabrication of
HAM LARGE TRIPLE SUSPENSION (HLTS)
STRUCTURES

The following documents are incorporated into and made a part of this purchase order. Click on the following LIGO Document Control Center (DCC) links to access these documents or go on line to the LIGO Public DCC at https://dcc.ligo.org/ to access the DCC#.

1.0 Scope:

This SOW is for the fabrication of the structure per the unique drawings included in this package as part of the Advanced LIGO HAM Large Triple Suspension (HLTS) Structure. This fabrication includes:

- Fabrication of stainless steel and aluminum parts
- Welding of stainless steel parts (including tubing)
- Drilling, tapping and gaging of through holes and tapped holes (including tapped holes for Helicoils)
- Temporary assembly of parts using provided fasteners
- Flycutting of parts to achieve required dimensions and tolerances

2.0 Terms:

DCC #	*Description*
C080185-v1	Laser Interferometer Gravitational Wave Observatory (LIGO) Commercial Items or Services Contract General Provisions California Institute of Technology "Institute", LIGO Rev 11/12/08
F0810001-v4	Technical Direction Memorandum

3.0 Quality Control:

DCC #	*Description*
Q0900001-v4	Advanced LIGO Supplier Quality Requirements, dated 2/10/10, describes following contractor/supplier QA/QC actions for this procurement:

☒	3.1 Pre-Award Inspection	☒	3.9 Discrepant Material Storage	☒	4.4 Calibration Program
☒	3.2 Supplier In Process Quality Control	☒	3.10 Quality Records	☐	4.5 Critical Interface
☒	3.3 In Process Inspection	☒	3.11 Drawing and Specification Change Control	☒	4.6 Cleanliness
☒	3.4 Pre-Ship Inspection	☒	3.12 Welding Certification	☒	4.7 Packaging
☒	3.5 Receiving Inspection	☒	3.13 End Item Data Package (including Certifications of Compliance)	☒	4.8 Storage
☒	3.6 Discrepant Material	☐	4.1 Design Verification	☒	4.9 Transport
☐	3.7 Material Review Action	☒	4.2 Raw Material Procurement	☐	4.10 Customs
☒	3.8 Material Review Actions at Contractor	☒	4.3 Traceability of Materials		

For the above list, the Supplier shall: 1) Identify the corresponding sections/paragraphs in their existing QA/QC system 2) meet or exceed the design requirements contained in the attached engineering documents for each area called out.

4.0 Included Documents:

The drawings cited below are fully dimensioned. In addition to the drawings, the contractor will be provided with CAD solid models of the parts (SolidWorks Professional 2010, SP4.0).

DCC #	*Description*
D070537-v2	Structure, HLTS
D070442-v5	Structural Weldment, HLTS
D070575-v2	Base Plate, Structural Weldment, HLTS
D070580-v2	Top Gusset, Structural Weldment, HLTS
D070579-v2	Upper Front Gusset, Structural Weldment, HLTS
D070576-v2	Lower Front Gusset, Structural Weldment, HLTS
D070578-v2	Side Strut, Structural Weldment, HLTS
D070577-v2	Side Gusset, Structural Weldment, HLTS
D070374-v2	Mounting Pad Body, HLTS
E0900048-v8	Welding Specification for Weldments Used Within the Advanced LIGO Vacuum System
E0900364-v6	Metal Components Intended for Use in the Advanced LIGO Vacuum System

5.0 End Item Data Package:

At the time of delivery of the parts, the Supplier shall also provide the following data, as a minimum:

- Any as-built modifications (with approval of the LIGO Contracting Officer) as mark-ups to the drawings
- Material certifications (including inspection reports on stainless steel seamed tubing as described in Section 2 of E0900048 – link given in Section 4.0 above)
- Welding and welding personnel certifications (see requirements in Section 2 of E0900048 – link given in Section 4.0 above)
- Heat treatment certifications
- Dimensional & QC inspection reports—this shall include a report showing that parts have been inspected and fall within specified tolerances
  - **Complete dimensional inspection reports for the first, last, and one (1) additional structure are required**
  - **All tapped holes for Helicoils are to be 100% gaged using appropriate gage tools according to the Emhart Helicoil Systems Catalog HC2000, Rev 4**
  - **Dimensional inspection reports of the overall structure height and flatness and parallelism of fly cut surfaces (see note 5 of D070537-v2) of ALL structures are also required**
- Certificate or statement of compliance with all contract and drawing process restrictions

6.0 Quantity Required:

D070537-v2	Structure, HLTS	Total quantity: 8

All other drawings listed in Section 4.0 are for parts or subassemblies which should be made in sufficient quantities to produce the total quantity of structures given above.

7.0 Delivery Requirements:

The deliveries are FOB at these destinations, i.e. the contractor has responsibility for shipping title and control of goods until they are delivered and the transportation has been completed. The contractor selects the carrier and is responsible for the risk of transportation and for filing claims for loss or damage.

7.1 Shipping Locations:

All structures are to be shipped to these locations in the following quantities: three (3), with serial numbers 001, 002 and 003, to LIGO Livingston Observatory (LLO) and five (5), with serial numbers 004, 005, 006, 007 and 008, to LIGO Hanford Observatory (LHO).

LIGO Livingston Observatory (LLO)
Attn: Derek Bridges and Tom Gentry
19100 LIGO Lane
Livingston, LA 70754

LIGO Hanford Observatory (LHO)
Attn: Betsy Bland and Jodi Fauver
127124 North Route 10
Richland, WA 99354

7.2 Shipping Containers:

The contractor is responsible for providing shipping containers and transportation to protect these parts from damage from the transportation environment (weather, handling, accidents, etc.). Edges of parts should be especially protected from damage during shipping.

7.3 Delivery Schedule:

All deliveries are to be completed **10 weeks ARO**. If this cannot be accomplished, please provide an alternative delivery schedule for consideration with your bid package. Early and/or partial deliveries are welcome.

8.0 Manufacturing:

8.1 Precedence:

The Statement of Work (SOW) sections below regarding processing or fabrication of the parts are meant to convey the scope and nature of the requested work. If there is a conflict between the SOW and the drawing, the drawing has precedence.

3D CAD files are available upon request and are provided as reference only. The structures are to be manufactured to the linked 2D drawings. If there are any discrepancies between the drawings and the CAD files, the drawings take precedence.

8.2 Machining:

Please note that the structure has machining requirements after welding, and post-weld stress relief heat treatment, to mate with other components.

All surfaces of all parts are to be machined, except the inner surfaces and outer radii of the tubing. Abrasive removal techniques are not acceptable. No grinding or lapping with abrasive wheels, cloth or

stones is permitted. No sanding of any type is permitted. No parts shall be cast or molded. Blanchard grinding is acceptable if all ground surfaces are machined afterwards.

All machining fluids must be fully synthetic, fully water soluble and free of sulfur, silicone, and chlorine. Upon award of contract, vendor will be required to supply MSDS sheets for all proposed machining fluids for approval prior to starting work.

Treatment of raw materials and work-in-process materials with respect to cleanliness is covered in the welding specification, E0900048.

All tapped holes for Helicoils are to be machined according to the Emhart Helicoil Systems Catalog HC2000, Rev 4, page 17. These steps include drilling, countersinking, tapping and gaging the holes to the sizes specified on the LIGO drawings. All tapped holes for Helicoils are to be gaged after tapping to ensure that they are prepared properly (see Section 5 for additional information regarding the inspection of tapped holes for Helicoils). The contractor is NOT responsible for procurement, cleaning or insertion of Helicoils.

8.3 Materials:

Material is specified on the drawings. For the square stainless steel tubing called out as having a wall thickness of 0.188", a wall thickness of 7 gauge (0.180") is permissible depending on availability. Vendor should indicate in their quote which wall thickness they plan to use. All materials specified by drawings or SOW have been approved for use in the ultra-high vacuum (UHV) environment in LIGO. No materials may be substituted or added without prior knowledge and testing by LIGO. Cast tooling plate is not permitted.

Note that if seamed tubing is used, the weld seam and any weld flash must meet the requirements listed in E0900048. If the weld flash does not meet the requirements, then it must be removed. Details, including fixtures required to remove this flash and a method for removal should be included in this quote. The flash removal process must be inspected 100% visually and certified by the vendor and approved by LIGO.

8.4 Hardware:

Fasteners required to assemble the parts of structure (washers and silver-plated socket head cap screws) in order to perform flycutting will be provided by LIGO.

8.5 Welding:

All welds are to be per E0900048 referenced in the "Included Documents" section of this SOW. All dimensions apply after heat treatments.

Note that E0900048 calls for the structures to undergo a post-weld stress relief heat treatment and to be pickled and passivated. Please make sure to list sub-contractor information with the bid package.

8.6 Marking:

Each structure must be marked with a part number, revision code and serial number at the location indicated on the drawing. Marking is to be accomplished by mechanically scribing, stamping or engraving (no dyes or inks).

If not indicated in the drawing, mechanically scribe, stamp or engrave as follows:

<drawing number> - <revision code>, <type number if applicable>

<unique 3 digit serial number starting at 001 for the first part and incrementing thereafter>

As an example:
D070442-V5
S/N – 001

The serial number must be a sequential 3-digit number, **starting with 001**, for each part. Also where indicated, mechanically scribe, stamp, or engrave (no dyes or inks) any additional markings called out on drawing sheets.

8.7 Finishing:

Any required surface finish is defined in the drawings.

Localized scratches, digs and blemishes should be minimized.

LIGO Document Control Center

*operated by **Caltech** and **MIT** ::: supported by the **National Science Foundation***

Accessing the DCC

LIGO User (upload and access all documents)

Public User (view public documents only)

Public Document Search

Old DCC Search Google Public Document Search: Go

Using the DCC

The Document Control Center is the central repository for electronic documents related to **LIGO**.

In order to access private documents, you will be prompted for your LIGO account name and password, of the form ***albert.einstein***. If you do not have a LIGO account, you may request one from the **LIGO Directory**. If you have forgotten your password you may **reset it**.

The LIGO DCC is built on top of **DocDB**. For more information on the DCC, please consult the **User's Manual**.

NEWS

All type D documents (Drawings) from the old document system have been **migrated**.

The DCC was updated on October 8, 2009 to add a faster search engine, apply more restrictive author and file content searches by default, and to add a richer group hierarchy for document access starting with an Advanced LIGO Business group. Further details may be found **here**.

The DCC was updated on May 7, 2009 to offer support for Author Groups, granting access to documents based on who is an author, and adding custom access groups apart from the initial set of hierarchical groups. Further details may be found **here**.

The DCC was updated on February 26, 2009 to offer initial support for the public release of documents and QA approval of document metadata by the DCC support team. The full list of bugs and enhancements associated with this release are linked to the **version 2.1.0 support ticket**.

The new DCC was released to the LSC on Jan 26, 2009 as announced **here**.

Contact Us

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY (LIGO)

COMMERCIAL ITEMS OR SERVICES CONTRACT

GENERAL PROVISIONS CALIFORNIA INSTITUTE OF TECHNOLOGY "INSTITUTE"

GENERAL PROVISION TITLE

1. Offer and Contract
2. Time of Delivery
3. Improper Delivery
4. Assignment
5. Authority of Institute Representative and Required Notices
6. Changes
7. Force Majeure
8. Existing Commercial Computer Software – Licensing
9. Export Licenses
10. Disputes and Governing Law
11. Inspection and Acceptance
12. Insurance
13. Indemnification
14. New Material
15. Order of Precedence
16. Payment
17. Use of Name
18. Title and Risk of Loss
19. Government Title to Property Purchased or Fabricated with Contract Funds
20. Taxes
21. Termination
22. Warranty
23. Audit and Records
24. Site Visits
25. Nondiscrimination
26. Equal Employment Opportunity
27. Anti-Kickback
28. Clean Air Act and the Federal Water Pollution Contract Act
29. Debarment and Suspension
30. Byrd Anti-Lobbying Amendment
31. Copeland "Anti-Kickback" Act
32. Davis Bacon Act
33. Surety Bonds
34. Rights to Inventions – 37 CFR part 401
35. Patent Rights - Bayh-Dole Act [35 U.S.C. 200 et seq.]

(See Page 2 for Individual General Provision Applicability)

APPLICABILITY OF INDIVIDUAL GENERAL PROVISIONS

APPLICABLE TO ALL TRANSACTIONS IN THE UNITED STATES

The term *United States* includes the several States of the United States, the District of Columbia, the Commonwealth of Puerto Rico, the Virgin Islands, American Samoa, Guam, Wake Island, the Canal Zone, and all other territories and possessions of the United States, and the term *States* includes any one of the forgoing.

1. Offer and Contract
2. Time of Delivery
3. Improper Delivery
4. Assignment
5. Authority of Institute Representatives and Required Notices
6. Changes
7. Force Majeure
8. Existing Commercial Computer Software – Licensing
10. Disputes and Governing Law
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23. Audit and Records
24. Site Visits
25. Nondiscrimination
26. Equal Employment Opportunity
28. Clean Air Act and the Federal Water Pollution Control Act

TAXES

20. The applicability of State sales tax is addressed on the face of the Purchase Order
[For imports] Value Added Tax (VAT) is addressed on the face of the Purchase Order

APPLICABLE IN SPECIAL CIRCUMSTANCES ACCORDING TO THEIR TERMS

9. [For exports] Compliance with Export Regulations
12. [Suppliers Working on Site] Insurance
27. [For Contracts in excess of $100,000] Anti-Kickback Enforcement Act of 1986
29. [For Contracts in excess of $25,000] Debarment and Suspension
30. [For Contracts of $100,000 or More] Byrd Anti-Lobbying Amendment
31. [For designated Construction/Repair Contracts in excess of $2,000] Copeland "Anti-Kickback" Act
32. [For designated Construction/Repair Contracts in excess of $2,000] Davis-Bacon Act
33. [For designated Construction/Repair Contracts in excess of $500,000] Surety Bonds
34. [For designated Experimental, Development or Research Work] Rights to Inventions- 37 CFR part 401
35. [For designated Experimental, Development or Research Work] Patent Rights - Bayh-Dole Act [35 U.S.C. 200 et seq.]

APPLICABLE TO ALL TRANSACTIONS IN THE UNITED STATES

These provisions **do not apply to foreign suppliers** performing outside the United States.

25. Nondiscrimination
27. Equal Employment Opportunity
32. Clean Air Act and the Federal Water Pollution Control Act

This agreement is a subcontract pursuant to an NSF Cooperative Agreement (CA) between the NSF and the Institute, **PHY-0328418**.

1. **OFFER AND CONTRACT** The following terms, together with such terms, plans, specifications or other documents as attached or incorporated by reference as set forth on the face of this purchase order, constitute the offer of the Institute to Supplier and shall, when accepted, constitute the entire agreement ("Contract") between the Institute and Supplier. Institute hereby gives notice of its objection to any different or additional terms. This Contract is valid only as written. If price, terms, shipping date or other expressed condition of this Contract are not acceptable, the Institute must be notified and any variation must be accepted in writing prior to shipment or delivery. This Contract shall be deemed to have been accepted (a) in the absence of written notification of non-acceptance by the Supplier within a reasonable time, or (b) upon timely delivery of the products identified to the shipping address specified on the face of the order.
2. **TIME OF DELIVERY** Time is of the essence in this Contract. If delivery dates cannot be met, Supplier must notify the Institute immediately. Such notification shall not, however, constitute a change to the terms of this Contract except as the order may be modified in writing by the Institute.
3. **IMPROPER DELIVERY** In addition to other remedies provided by law, the Institute reserves the right to refuse any goods or services and to cancel all or any part of this Contract if Supplier fails to deliver all or any part of the goods or services in accordance with the terms and conditions of this Contract. Acceptance of any part of this order shall not bind the Institute to accept any future shipments nor deprive it of the right to return goods already accepted.
4. **ASSIGNMENT** The Supplier shall have no right to assign this Contract or any benefits from this Contract without prior written consent of the Institute.
5. **AUTHORITY OF INSTITUTE REPRESENTATIVES AND REQUIRED NOTICES; FACSIMILE AND ELECTRONIC SIGNATURES ACCEPTABLE** (a) No order, notice, or direction received by the Supplier and issued pursuant to this Contract shall be binding upon either the Supplier or the Institute, unless issued or ratified in writing by the Institute Purchasing Agent, the Director of Procurement Services, or by representatives designated in writing by either of them. (b) The parties agree that facsimile (fax) or electronic signature copies of contract documents are just as binding as originally-executed documents.
6. **CHANGES** The Institute may at any time, by a written order to the Supplier, make changes within the general scope of this Contract in any one or more of the following: (a) drawings, designs, or specifications; (b) method of shipment or packing; and (c) time or place of delivery. If any such change causes an increase of decrease in the cost of, or the time required for, the performance of any part of the work under this order, an equitable adjustment may be made in the order price or delivery schedule or both, and the order shall be modified in writing accordingly. Any claim by Supplier for adjustment under this Article must be asserted within 30 days from the date of receipt by Supplier of the notification of change; provided, however, that the Institute, if it decides that the facts justify such action, may receive and act upon any such claim asserted at any time prior to final payment under this purchase order. Nothing in this clause shall excuse Supplier from proceeding with this order as changed.
7. **FORCE MAJEURE** Each party shall not be liable for damages arising out of either its failure to deliver or any delay in delivery caused by strikes, lockouts, fires, war, or acts of God. The Supplier shall notify the Institute in writing as soon as it is reasonably possible after the commencement of any event triggering a delayed delivery or inability to deliver.
8. **EXISTING COMMERCIAL COMPUTER SOFTWARE – LICENSING** (This Article is applicable to the acquisition of any existing commercial computer software under this Contract.) a) Where the Supplier proposes its standard commercial software license, only those applicable portions that comply with the provisions of this Contract are incorporated into and made a part of this Contract. (b) If the Supplier does not propose its standard commercial software license until after this Contract has been issued, or at or after the time the computer software is delivered, such license shall nevertheless be deemed incorporated into and made a part of this Contract under the same terms and conditions as in paragraph (a) above. For purposes of receiving updates, correction notices, consultation, and similar activities on the computer software, any authorized user may acknowledge receipt of a registration form or card and return it directly to the Supplier; however, such signing shall not add to or alter any of the terms and conditions of this Contract. (c) If the specified computer software is shipped or delivered to the Institute, it shall be understood that the Supplier has unconditionally accepted the terms and conditions set forth in this Article, and that the terms and conditions of this Contract (including the incorporated license) constitute the entire agreement between the parties concerning rights in the computer software. (d) Supplier understands and agrees that the computer software may be: (1)

Used, or copied for use, in or with any computer owned or leased by, or on behalf of the Institute provided that the software is not used, nor copied for use, in or with more than one computer simultaneously, unless otherwise permitted; (2) Reproduced for safekeeping (archives) or backup purposes; (3) Modified, adapted, or combined with other computer software, provided that the modified, combined, or adapted portions of the derivative software incorporating restricted computer software shall be subject to the same restricted rights; and (4) Disclosed and reproduced for use by Institute designees in accordance with this Article. (e) Supplier agrees that the software may be used by the Institute in support and furtherance of any of its obligations to the US Government or other funding organization. (f) Supplier warrants that it has the right to sell, license, or transfer the license for the software furnished to the Institute under this Contract in accordance with the terms of this Contract.

9. **EXPORT LICENSES** The Supplier shall comply with all U.S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this Contract. In the absence of available license exemptions/exceptions, the Supplier shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of hardware, technical data, and software, or for the provision of technical assistance.
10. **DISPUTES AND GOVERNING LAW** (a) Any dispute or claim arising out of, in connection with, or relating to this Contract shall be submitted for resolution to ascending levels of management of the parties. If the dispute cannot be resolved after such negotiations, either party may pursue any appropriate legal recourse not inconsistent with the provisions of this Contract. (b) Pending any decision, appeal or judgment or the settlement of any dispute, Supplier agrees to proceed diligently with the performance of the requirements of this Contract. (c) This Contract shall be construed and enforced in accordance with the laws of the State of California. Disputes will be adjudicated in Los Angeles, California.
11. **INSPECTION AND ACCEPTANCE** The Institute shall have the right to inspect the work and activities of the Supplier under this Contract in such manner and at all reasonable times as are deemed appropriate. Final inspection shall be at the Institute's premises unless otherwise agreed in writing. The Institute, at its option, may reject any non-conforming items and (i) return such non-confirming items to the Supplier at the Supplier's risk and expense for credit to the Institute at the full invoice price plus all transportation and other related costs, or (ii) hold them for disposition in accordance with the Supplier's instructions at the Supplier's expense, including storage and handling. If the Institute rejects items as nonconforming, the quantities under this Contract will automatically be reduced unless the Institute otherwise notifies the Supplier. The Supplier will not replace quantities so reduced without written instruction by the Institute. Payment for nonconforming goods shall not constitute an acceptance thereof, limit, or impair the Institute's right to assert any legal or equitable remedy, or relieve the Supplier's responsibility for latent defects. The Institute may also opt for a refund of the amount paid under this Contract.
12. **INSURANCE** (This Article is applicable when the Supplier will be entering Institute-controlled premises.) (a) The Supplier shall, at its own expense, provide and maintain during the entire performance period of this Contract at least the following types and minimum amounts of insurance with the Institute named as an additional insured in policies for comprehensive liability insurance with a licensed carrier authorized to do business in the State of California: (1) Workers' Compensation and Employer's Liability Insurance, as required by applicable Federal and State workers' compensation and occupational disease statutes. The Employer's Liability coverage shall be at least $100,000, except in states with exclusive or monopolistic funds that do not permit worker's compensation to be written by private carriers. (2) Comprehensive Liability Insurance, including automobiles (owned, non-owned, or leased), completed operations, products, and contractual liability, for a combined single limit of not less than $1,000,000 for all deaths, injuries, and property damage arising from one accident or occurrence. (b) Insurance Certificates and Endorsements. Before commencing work under this Contract, the Supplier shall furnish (i) certificates of insurance for the coverages specified in paragraph (a) above, and (ii) an additional insured endorsement naming the Institute as an additional insured to the Contract for the coverage specified above. Such certificates and the endorsement shall provide that any cancellation or material change in the insurance policies shall not be effective (i) for such period as the laws of the State in which this Contract is to be performed, or (ii) until 30 days after the insurer or the Supplier gives written notice to the Institute, whichever period is longer. Also, such certificates and the endorsement shall (i) cover contractual liability assumed under this Contract, and (ii) be primary and noncontributing to any insurance procured by the Institute. The Supplier agrees to

permit the Institute to examine its original policies, should the Institute so request. Should the Supplier at any time neglect or refuse to provide the insurance required herein, or should such insurance be canceled, the Institute shall have the right to procure same and the costs thereof shall be deducted from monies then due or thereafter to become due to the Supplier.

13. **INDEMNIFICATION** The Supplier agrees to defend, indemnify and hold harmless the Institute from and against all claims, liability and expenses, including reasonable legal fees, arising from any actual or claimed: (i) injury to any person or property resulting from any act or omission of Supplier, its employees or agents, excepting such liability as may result solely from the negligent acts or omissions of the Institute or its employees; and (ii) infringement of any patent, copyright, or trademark by reason of the sale or use of the goods provided by Supplier hereunder. The Supplier's obligations hereunder shall survive acceptance of the goods and payment thereof by the Institute.
14. **NEW MATERIAL** Unless this Contract specifies otherwise, the Supplier represents that the supplies are new and are not of such age or so deteriorated as to impair their usefulness or safety. If the Supplier believes that furnishing other than new material will be in the Institute's interest, the Supplier shall so notify the Purchasing Agent in writing and request authority to use such material.
15. **ORDER OF PRECEDENCE** To the extent there is inconsistency among any documents relating to this order, the inconsistency will be resolved in the following order of priority: (a) These General Provisions; (b) The details specified on the order, or description of products or services; (c) any other documents the Institute agrees in writing to incorporate by reference.
16. **PAYMENT** (a) Invoices shall be submitted in duplicate to the attention of the Institute's Accounts Payable Department, unless otherwise specified, and shall contain the following information as applicable: (i) Contract number, (ii) item number, (iii) description of supplies or services, (iv) size, (v) quantity, (vi) unit price, (vii) extended totals and (viii) any other information which may be specified on the face of this Contract. Any applicable state sales or use taxes or Federal excise taxes shall be shown separately on the invoice. (b) The Institute shall pay the Supplier, upon the submission of proper invoices, the prices stipulated in this Contract for supplies delivered and accepted or services rendered and accepted, less any deductions provided in this Contract. (c) The Institute shall make its best effort to make payments within the net period, if any, specified in the Contract, measured from the date of receipt of the goods or services at the destination or the date of receipt of the invoice, whichever is later. Discount time periods will be measured from the same date. Payment shall be deemed to have been made on the date the check is mailed or on the date on which an electronic funds transfer was made. In no event will the Institute be liable for or pay a surcharge, interest, or any kind of penalty as a result of the Institute's payment not being made within the net period, if any, specified in the Contract or the date of payment by electronic funds transfer. (d) Payment for goods or services in accordance with this paragraph will not waive or otherwise affect the right of the Institute to inspect such goods or services or to reject, or revoke acceptance of, nonconforming goods.
17. **USE OF NAME** Supplier agrees not to use the name or trademarks of the Institute or any member its staff in sales promotional work or advertising, or in any form of publicity, without the prior written permission of the Institute.
18. **TITLE AND RISK OF LOSS** (a) Unless otherwise provided in Section 19 or elsewhere in this Contract, title to tangible property (property of any kind except intangible property and debt instruments) furnished under this Contract shall pass to the Institute upon formal acceptance by the Institute, regardless of when or where the Institute takes physical possession, unless the Contract specifically provides for earlier passage of title. (b) Risk of loss shall not pass to the Institute until the tangible property called for in this Contract has been actually received and accepted by the Institute at the destination specified. Supplier assumes all responsibility for packing, crating, marking, transportation and liability for loss or damage in transit, notwithstanding any agreement by Institute to pay freight, express or other transportation charges. Supplier agrees to trace lost or delayed shipments at the request of the Institute.
19. **GOVERNMENT TITLE TO PROPERTY PURCHASED OR FABRICATED WITH CONTRACT FUNDS** Title to tangible property shall vest in the Government upon acquisition when the tangible property is intended to be installed at, incorporated into, built, or necessary for the construction or operation of either the Hanford or Livingston Observatories. All Government property acquired in accordance with this Section 19 shall be subject to the requirements set forth below:

    1. Title.

    (a) Tangible Property means property of any kind except intangible property and debt instruments. Title to all tangible property procured with funds provided through this Contract, and subject to this Section 19, shall vest in the Government as follows:

1) If this Contract contains a provision directing the Supplier to purchase material which the Government will reimburse as a direct item of cost under the Institute's primary Award, title to property shall pass to and vest in the Government upon delivery of such property to the Government, to the Institute, to the Supplier, to any subcontractor, or to any agent of the Government, of the Supplier, or of any subcontractor; and

2) Title to all other property shall pass to and vest in the Government upon the earliest to occur of the following:

(i) issuance of the property for use in contract performance pursuant to this Contract;

(ii) commencement of processing of the property or its use in contract performance pursuant to this Contract; or

(iii) reimbursement of the cost of the property by the Institute on behalf of the Government.

2. Legal title to all tangible property furnished by the NSF or acquired from other Government agencies shall remain with the Government, unless otherwise specified in this Contract.

3. Title to Government property shall not be affected by the incorporation or attachment thereof to any property not owned by the Government, nor shall any Government property lose its identity by reason of affixation to any reality.

4. All subcontracts issued or awarded with respect to the performance of this Contract shall include provisions regarding the determination of title to tangible property acquired by the subcontractor in accordance with Sections 18 and 19.

5. Should Supplier purchase tangible property pursuant to this Contract and subject to this Section 19, Supplier shall be a limited agent of the NSF solely for the purpose of transferring and vesting title to such tangible property in the Federal Government. The agent shall be solely responsible for the payment of the purchase price of tangible property acquired, and the agent shall have no authority to bind or obligate the Institute, NSF or the Federal Government for payment of the purchase price to any third party. Such agents shall be and shall remain liable for the risk of loss of, destruction of, or damage to tangible property acquired until such tangible property is transferred to the possession of the Government or acceptance by the Institute.

20. **TAXES** (a) **Except as may be otherwise provided on this order,** the contract price includes all applicable Federal, State, and local taxes and duties. With respect to transactions for which the Institute may be exempt from any tax or duty, the Institute will provide, upon request, evidence to support its claim to such exemption. (b) The Institute will comply with all Federal and State income tax laws with respect to withholding and year-end tax reporting. (c) The Internal Revenue Service (IRS) requires the Institute to have on file a Taxpayer Identification Number (TIN) for every US person or US business that receives a payment, regardless if the payment is tax reportable or not. This information is provided on IRS Form W-9. US Citizens and Resident Aliens are required to complete a Form W-9 before receiving any payments from the Institute. A TIN can be any of the following: a Social Security Number (SSN) an Individual Taxpayer Identification Number (ITIN) or an Employer Identification Number (EIN). Failure to provide a TIN will result in delay of payment and/or backup withholding. (d) Foreign businesses providing services in the US for the Institute are required to provide the appropriate IRS Form W-8 (i.e., Form W-8BEN, W-8ECI, or W-8IMY). (e) Foreign individuals providing services in the US for the Institute are required to provide an IRS Form W-8BEN or IRS Form 8233 depending on the appropriate tax withholding treatment.

21. **TERMINATION** (a) For Cause. The Institute may terminate this Contract, or any part of it, for cause in the event of any default by the Supplier, or if the Supplier fails to comply with any Contract terms and conditions, or fails to provide the Institute, upon request, with adequate assurances of future performance. In the event of termination for cause, the Institute shall not be liable to the Supplier for any amount for supplies or services not accepted, and the Supplier shall be liable to the Institute for any and all rights and remedies provided by law. If it is determined that the Institute improperly terminated this Contract for cause, such termination shall be deemed a termination for convenience. (b) For Convenience. The Institute reserves the right to terminate this Contract, or any part hereof, for its sole convenience. In the event of such termination, the Supplier shall immediately stop all work hereunder and shall immediately cause any and all of its subcontractors to cease work. Subject to the terms of this Contract, the Supplier shall be paid a percentage of the Contract price reflecting the percentage of the work performed prior to the notice of termination, plus reasonable charges the Supplier can demonstrate to the satisfaction of the Institute, using its standard record keeping system, have resulted from the termination. The Supplier shall not be paid for any work performed or costs incurred which reasonably could have been avoided.

22. **WARRANTY** Supplier expressly warrants all goods and services delivered under this Contract to be free from defects in material and workmanship and to be of the quality, size and dimensions ordered. This express warranty shall not be waived by reason of the acceptance of the goods or services or payment by Institute. The Supplier shall provide the Institute with a copy of any standard warranty which is normally offered on a commercial product deliverable under this Contract. The commercial product warranty shall be deemed to be incorporated by reference and the Institute shall be entitled to all rights under such warranty.
23. **AUDIT AND RECORDS** Financial records, supporting documents, statistical records, and other records pertinent to this Contract shall be retained by the Supplier for a period of five years from acceptance by the Institute. Supplier agrees that the Institute, the National Science Foundation, the Comptroller General of the United States, or any of their duly authorized representatives, shall have access to any books, documents, papers and records of the Supplier which are directly pertinent to this Contract, for the purpose of making audits, examinations, excerpts and transcriptions.
24. **SITE VISITS** NSF and the Institute, through authorized representatives, have the right, at all reasonable times, to make site visits to review project accomplishments and management control systems and to provide such technical assistance as may be required. If any site visit is made by NSF or the Institute on the premises of the Supplier or a contractor under a subcontract, the Supplier shall provide and shall require its contractors to provide all reasonable facilities and assistance for the safety and convenience of the Institute or Government representatives in the performance of their duties. All site visits and evaluations shall be performed in such a manner that will not unduly delay the work.
25. **NONDISCRIMINATION** The Contract is subject to the provisions of Title VI of the Civil Rights Act of 1964 [42 U.S.C. § 2000d], Title IX of the Education Amendments of 1972 [20 USC §§ 1681 et seq.], the Rehabilitation Act of 1973 [29 U.S.C. § 794], the Age Discrimination Act of 1975 [42 U.S.C. §§ 6101 et seq], and all regulations and policies issued by NSF pursuant to these statutes. In accordance with these statutes, regulations, and policies, no person on the basis of race, color, national origin, sex, disability, or age shall be excluded from participation in, be denied the benefits of, or otherwise be subjected to discrimination under the Contract.
26. **EQUAL EMPLOYMENT OPPORTUNITY** This Contract is subject to the requirements of Executive Orders 11246 and 11375 and the rules and regulations or the Secretary of Labor (41 CFR Chapter 60) in promoting Equal Employment Opportunities.
27. **ANTI-KICKBACK ENFORCEMENT ACT OF 1986** This Contract is subject to the provisions of the Anti-Kickback Enforcement Act of 1986, Public Law 99-634 (41 U.S.C. 51-58). By accepting this order, Seller certifies that it has not paid kickbacks directly or indirectly to any Institute employee for the purpose of obtaining this or any other Institute purchase order or to obtain favorable treatment in an Institute matter.
28. **CLEAN AIR ACT AND THE FEDERAL WATER POLLUTION CONTROL ACT** – Should this Contract be for an amount in excess of $100,000, Supplier agrees to comply with all applicable standards, orders or regulations issued pursuant to the Clean Air Act (42 U.S.C. 7401 et seq.) and the Federal Water Pollution Control Act as amended (33 U.S.C. 1251 et seq.). Further, Supplier agrees as follows:
    a. To comply with all the requirements of Section 114 of the Clean Air Act [42 U.S.C. §7414] and Section 308 of the Clean Water Act [33 U.S.C. § 1318], respectively, relating to inspection, monitoring, entry, reports and information, as well as other requirements specified in Section 114 and Section 308 of the Clean Air Act and the Clean Water Act, respectively, and all regulations and guidelines issued thereunder before the Contract.
    b. That no portion of the work required by the Contract will be performed in a facility listed on the Environmental Protection Agency List of Violating Facilities on the date that the Contract was awarded unless and until EPA eliminates the name of such facility or facilities from such listing.
    c. To use its best efforts to comply with clean air standards and clean water standards at the facility in which the Contract is being performed.
    d. To insert the substance of the provisions of this article into any nonexempt subcontract.
29. **DEBARMENT AND SUSPENSION** – (a) Supplier shall fully comply with the requirements stipulated in 2 CFR Part 180, as modified by 45 CFR 620.330 and shall ensure that any lower tier covered transaction, as described in 2 CFR 180.220 and modified by 45 CFR 620.200 and 620.220 includes a term or condition requiring compliance with these requirements. The Supplier acknowledges that failing to disclose the information required under 45 CFR § 620.335 may result in the termination of the Contract, or pursuance of other available remedies, including suspension and debarment. Supplier may access the Excluded Parties List System at http://epls.arnet.gov.
    (b) No contract at any tier shall be made to parties listed on the General Services Administration's List

of Parties Excluded from Federal Procurement or Nonprocurement Programs in accordance with E.O.s 12549 and 12689, "Debarment and Suspension." This list contains the names of parties debarred, suspended, or otherwise excluded by agencies, and contractors declared ineligible under statutory or regulatory authority other than E.O. 12549. Supplier, whose Contract exceeds the small purchase threshold, shall provide the required certification regarding its exclusion status and that of its principal employees.

30. **[FOR CONTRACTS OF $100,000 OR MORE] BYRD ANTI-LOBBYING AMENDMENT** - Supplier warrants that Supplier has applied or bid on a Contract of $100,000 or more and has filed the required certification. Each subcontracting tier must certify to the tier above that it will not and has not used Federal appropriated funds to pay any person or organization for influencing or attempting to influence an officer or employee of any agency, a member of Congress, officer or employee of Congress, or an employee of a member of Congress in connection with obtaining any Federal contract, grant or any other award covered by 31 U.S.C. 1352. Each tier shall also disclose any lobbying with non-Federal funds that takes place in connection with obtaining any Federal award. Such disclosures are forwarded from tier to tier up to the recipient.
31. **[FOR CONSTRUCTION/REPAIR CONTRACTS >$2000] Copeland "Anti-Kickback" Act (18 U.S.C. 874 and 40 U.S.C. 276c)** Supplier shall comply with the Copeland "Anti-Kickback" Act (18 U.S.C. 874), as supplemented by Department of Labor regulations (29 CFR part 3, "Contractors and Subcontractors on Public Building or Public Work Financed in Whole or in Part by Loans or Grants from the United States").
32. **[FOR CONSTRUCTION/REPAIR CONTRACTS >$2000] Davis-Bacon Act, as amended (40 U.S.C. 276a to a-7)** Supplier shall comply with the Davis-Bacon Act (40 U.S.C. 276a to a-7) and as supplemented by Department of Labor regulations (29 CFR part 5, "Labor Standards Provisions Applicable to Contracts Governing Federally Financed and Assisted Construction").
33. **[FOR CONSTRUCTION/REPAIR CONTRACTS >$500,000] Surety Bonds** - **If so directed,** the Supplier shall furnish separate bid guarantees, performance and payment bonds to the Institute. Each bond shall set forth a penal sum in an amount not less than the Contract Price. Each bond furnished by the Supplier shall incorporate by reference the terms of this Contract as fully as though they were set forth verbatim in such bonds. In the event the Contract Price is adjusted by Change Order executed by the Contractor, the penal sum of both the performance bond and the payment bond shall be deemed increased by like amount. The performance and payment bonds furnished by the Supplier shall be in form suitable to Institute and shall be executed by a surety, or sureties, reasonably acceptable to the Institute.
34. **[For designated Experimental, Development or Research Work] Rights to Inventions** - For non-profit organizations and small business firms, patent rights shall be governed by 37 CFR part 401, titled “Rights to Inventions Made by Non-Profit Organizations and Small Business Firms under Government Grants, Contracts and Cooperative Agreements”.
35. **[For designated Experimental, Development or Research Work] Patent Rights** – Bayh-Dole Act [35 U.S.C. 200 et seq.]

Embedded Adobe XML Form

The file *https://dcc.ligo.org/public/0000/F0810001/004/Technical_Direction_Memo_template_F0810001-v4.pdf* is an Adobe XML Form document that has been embedded in this document. Double click the pushpin to view.

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-Q0900001-V4-P *Advanced LIGO* February 10th, 2010

Advanced LIGO Supplier Quality Requirements

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1. Quality Program Guideline

1.1. Purpose of this Document

The purpose of this document is to provide guidance, requirements and general procedures for a Quality Assurance and Quality Control program (QA/QC) as it applies to procurements and contracted effort. It provides recommendations on the policies and phrases to be used in all “Request for Proposal” (RFP) or “Request for Quote” (RFQ) solicitations to be sent to prospective suppliers and vendors for Advanced LIGO components, parts, or services. The audience for this document is the LIGO technical and procurement staff, as well as the potential suppliers bidding against and RFQ/RFP. Section 3 and 4 provide detailed descriptions of the applicable sections in the RFQ/RFP that are checked by the LIGO procurements and Engineering teams, providing suppliers definitions to assist in formulating the bids.

Advanced LIGO is a project undertaken by the LIGO Laboratory (or simply ‘LIGO’).

This document is intended for use when the supplier is manufacturing and/or assembling components, or providing services, which require a LIGO review of the supplier QA/QC monitoring. LIGO engineering, projects, procurement and QA teams will make determinations on the applicability of this document on a case by case basis.

1.2. Purpose of a Quality Program

A Quality Program is a framework for ensuring completeness, correctness, reliability and maintainability of a system and its components. The specific goals and deliverables of a Quality program for Advanced LIGO are:

1.2.1. All designs are to be carefully reviewed and finalized through an Advanced LIGO Design Review process.

1.2.2. The supplier has an accurate and complete set of design specifications, drawings, and material and performance characteristics.

1.2.3. The supplier maintains an internal quality program to ensure systems are fabricated, assembled, and tested to specifications provided by LIGO.

1.2.4. The supplier ensures appropriate workmanship, including but not limited to certification, safety, handling, cleanliness and documentation.

1.2.5. The supplier will provide appropriate packaging and shipping methods to protect the component(s) from damage in transit.

1.2.6. The supplier shall provide reliability estimates, maintenance procedures and schedules, if applicable.

1.2.7. Both LIGO and the supplier may, in general (depending upon the particular aspects and criticality of the effort), participate in pre-award audits, in process inspections; post-assembly and post-install inspections and acceptance testing. Enable LIGO and the supplier to establish specific expectations, and mechanisms, up front on remedying issues which arise during fabrication and testing, where the component does not meet design, assembly or performance specifications due to improper manufacturing, faulty sub-components, or improper fit or performance of critical interfaces, or improper packaging and shipping methods. An example is a Material Review Board (MRB)

1.3. Relevant Documents

LIGO-E010613-02, Generic Requirements & Standards for Detector Subsystems [in particular section 9]

LIGO-E030350-A, Drawing Requirements

Other documents specific to the given RFP/RFQ will be provided as part of the package and not referenced here. Also additional documents may be released once the bid process is complete and contract award is taking place.

2. Procurement Process

2.1. Pre-Procurement Activities

RFPs and RFQs shall be written to use contractor/vendor existing QA systems to the fullest extent possible consistent with the provisions outlined in LIGO Quality Assurance Plan M960076-P. Should a contractor lack an existing quality system, the contractor shall develop a quality assurance plan in compliance with the requirements negotiated at contract award.

2.2. LIGO Procurement Documentation

LIGO will provide the supplier with the following documentation in support of the bid process (if and as applicable):

2.2.1. Technical documents, drawings, and specifications, identified by revision.
2.2.2. Preservation, packaging, storage, and shipping requirements.
2.2.3. Requirements for component longevity.
2.2.4. Specific Inspection and Test requirements.
2.2.5. End Item Data Package requirements.
2.2.6. Requirements for source inspection by customer.
2.2.7. Safety Performance requirements.

2.3. Supplier Bid Package Requirements

As part of the bid package, and for consideration in contract award, the supplier shall confirm the intent to comply with the following Quality Program requirements (if and as applicable):

2.3.1. Provide with the deliverables all supplier-generated technical documents, drawings, and specifications, identified by revision, with all red line items updated in electronic format (source files and Adobe Acrobat) for the as-built system or component.
2.3.2. Adhere to all shipping, packaging and cleanliness requirements as required in the Advanced LIGO design documents.
2.3.3. Submit all tests and inspection reports to LIGO immediately following completion, in agreed upon electronic format.
2.3.4. Fulfill requirements for source inspection by customer, which can include a pre-award inspection, in process audits, as well as a pre-ship inspection.
2.3.5. Provide a copy of their existing QA/QC program, with a strategy for implementing in conformance to Advanced LIGO requirements, if necessary.

3. Manufacture, Assembly and Receiving Inspection Requirements

3.1. Pre-Award Inspection

Prior to contract award LIGO staff may perform an audit of the prospective supplier quality programs. The need to perform an audit will be determined by the Contracting Officer's Technical Representative (COTR), the subsystem leader and/or the chief engineer, based on criticality, cost, and use case of components. The audit scope includes but is not limited to:

- Calibration program review.
- Maintenance and reliability programs for manufacturing equipment.
- Critical worker certification levels (i.e., welding, electrical, CNC, etc.).
- Supplier QA/QC program and how it will be implemented for Advanced LIGO contracts.
- Manufacturing methodologies, especially as regards cleanliness and use of approved materials and fluids.
- Cleaning and packaging methodologies compared to RFP/RFQ requirements.

3.2. Supplier in Process Quality Control

Critical processes shall be controlled using manufacturing travelers or procedures established and qualified prior to LIGO equipment production. As an example, these manufacturing procedures shall include:

- Equipment to be used including calibration requirements.

- Identification of operational constraints.
- Workmanship standards.
- Call-outs for inspections, tests, and other verification processes.
- Acceptance criteria.

3.3. In Process Inspection

In-process inspections shall be performed where subsequent assembly stages will prevent/limit inspection access, and to detect defects early in the process. In-process inspections shall be identified in fabrication and assembly by planning Mandatory Control Points (MCPs). Suppliers shall document all deficiencies and discrepancies, and report immediately to LIGO. Electronic format, via email transmission, is the preferred method of report delivery.

3.4. Pre-Shipment Inspection

Supplier shall inspect and validate system integrity prior to shipment of equipment to any LIGO site. LIGO may choose to send a representative to participate in inspections deemed critical. Pre-shipment inspection of equipment to be delivered to the LIGO observatories shall include the following (as appropriate):

- End Item Data Package review.
- Certificate of Compliance, where required.
- Shipping documentation such as the manifest or shipper.
- LIGO property control documentation, when LIGO materials are in possession of a supplier.
- Verification of the adequacy of the shipment packaging and weather protection.
- Evidence of contractor quality assurance acceptance.
- Evidence of safety requirements compliance.
- Verification that transportation environmental controls and monitoring requirements will be satisfied.

3.5. Receiving Inspection

Receiving inspection will be performed to ensure that articles procured by LIGO, or its suppliers, conform to contractual or procurement document requirements prior to release of payment to supplier. This will be a time-critical activity. Receiving inspection includes the following (as applicable):

- Inspection of incoming hardware and documentation for compliance to applicable Drawings, Specifications, and/or other documentation specified by the procurement documentation.
- Evidence of acceptance by contractor/supplier inspection.
- Evidence of source inspection acceptance as applicable.
- Identification of deviations from requirements specified in the procurement documentation.
- Securing dispositions of discrepant materials.
- Verification that equipment complies with shipping, handling and safety constraints.
- Identification of hardware acceptance status with appropriate labels.
- Documentation of receiving inspection, one copy stored at site and a second sent to procurements for potential release of payments, shall be completed by LIGO personnel.

3.6. Discrepant Material

When an article does not conform to applicable engineering design documentation it shall be identified as non-conforming. It shall be segregated from on-going work operations, and held for further action. When a discrepancy has been identified and documented it shall be reported immediately to the responsible LIGO science or engineering personnel and the LIGO Quality Assurance Officer.

Only LIGO personnel responsible for the item submitted to the discrepancy evaluation process, or their designees are authorized to issue dispositions for the discrepant item. Initial discrepant hardware dispositions include the following:

- Rework to drawing or specification.
- Repair: Articles that are modified to a useable state but remain nonconforming to drawing or specification requirements.
- Return to vendor.
- Use-as-is: Articles that are useable in the present state without further processing.
- Suspended Action: Articles of which resolution is determined after drawing or specification change, or after hardware fit check.
- Scrap.

LIGO quality assurance representative concurrence is required for all LIGO science or engineering personnel discrepant material dispositions.

3.7. Material Review Action

The Material Review Action shall determine dispositions of nonconforming articles that cannot be resolved by the initial discrepant hardware disposition. For discrepant articles submitted to Material Review Action the LIGO Project Manager shall, with the concurrence of the LIGO Quality Assurance Officer, determine the final disposition.

3.8. Material Review Actions at Contractor

Material Review Actions conducted at a contractor are the responsibility of that contractor. LIGO personnel will not participate as members of the contractor's Material Review Board. However, Contractor Material Review Actions will be subject to review and concurrence by LIGO engineering and quality assurance personnel. Contractor Material Review Actions shall become a part of the EIDP.

3.9. Discrepant Material Storage

Discrepant Material shall be identified and to the degree possible, separated from acceptable material until the disposition action has been completed.

3.10. Quality Records

The LIGO Quality Assurance Office will maintain quality records which provide evidence of inspections, tests, as built configuration, and Material Review Actions.
The LIGO Project Office will establish a facility and procedures for the long term storage of LIGO project QA documentation and other related records. Satellite record storage facilities may also be established at the observatory sites for equipment or materials located at or peculiar to the site. This data shall be maintained for at least the duration of the 20 year operational life of the observatories.

3.11. Drawing and Specification Change Control

All drawings and specifications will be controlled by the suppliers Quality Assurance Department, including receipt and distribution. Upon receiving the order/contract, all drawings will be verified as to correct number and revision.

All such documents shall be marked to indicate that they have been included in the system. Supplier shall ensure distributed copies of master documents must be marked as controlled or uncontrolled. Controlled documents should be numbered serially (1,2,3...n) and recorded in the contract file.

A controlled document must be kept updated at every document change or engineering change. The contract administrator under the guidance of QA will insure that all controlled documents, whether in house or out, will be updated.

Controlled documents must be returned to QA or the contract administrator at the end of their use. At that time they will be removed from the controlled list.

The supplier shall take appropriate measures to control obsolete and uncontrolled documents from contaminating the contract work. This includes a method of marking, checking out, or destroying.

Upon receipt of drawing and specification changes, the supplier Quality Assurance or other appropriate personnel will remove obsolete drawing specification and issue the latest drawing specification to proper personnel. Obsolete drawings will be marked “obsolete” if needed for record or destroyed.

3.12. Welding Certifications

For any work on Advanced LIGO parts or components that requires welding, Caltech will require any contractor to supply certifications for the welders performing the work. Certifications must show valid dates, as well as certified welding type/class for the work to be done. All welders who will be performing work will be required to be certified for the work, and samples of work may be requested.

3.13. End Item Data Package

The end item data package is the set required documents to be supplied to LIGO upon delivery of ordered parts or services, which may include but is not limited to the following items:

- As Built Modifications (with approval of the LIGO Contracting Officer) as markups to the drawings
- Material Certifications
- Dimensional and QC reports, including all test procedures and results
- Certificate or Statement of Compliance with all contract and process restrictions
- Welding Certifications

Specific items above pertinent to a given contract will be called out in the statement of work, as well as any additional EIDP requirements not listed above.

4. Supplier Quality Assurance Review: Definitions

4.1. Design Verification

At appropriate stages of the design process, design verification shall be performed to ensure that the proposed design meets the requirements (see M0500220). This will normally be accomplished through the Design Review process. However, additional design verifications may be instituted where critical elements are involved, or where a potential for errors may have significant impact to functional performance, cost or schedule. In particular if a supplier/contractor/vendor is tasked with design effort, LIGO must plan to review the delivered design before authorization to fabricate.

4.2. Raw Material Procurement

Suppliers of raw materials shall provide certifications and country of origin indicating that materials being provided are in compliance with requirements specified in the procurement documents. Reports of chemical and physical tests are required for critical usage materials to verify conformance to applicable specifications and drawings.

4.3. Traceability of Materials

Materials considered critical for LIGO observatories' successful operations, or used in the vacuum system, shall require identification and country of origin by lot, batch or production run. Materials process records shall be delivered by the supplier and retained in the LIGO Documentation Control Center. Questions regarding traceability requirements for specific items should be directed to the LIGO Quality Assurance Officer.

4.4. Calibration Program

The supplier shall maintain a calibration program of all instruments and tools requiring calibration. Schedules of calibration shall be in accordance with the instrument or tool manufacturers' recommendations. Labels on the instrumentation and tools or their cases shall be in plain view, and have a calibration record referenced to a report on file with the supplier, as well as a date of performed calibration, due date for next cycle, as well as a signature and disposition of calibration (pass or fail). All instruments that have failed calibration will be required to have on file a document showing repair, repair facility, reason for out of spec, and recalibration report showing unit has passed. Out of calibration is defined as a device that is not only out of spec on measurement accuracy, but also one that may function properly but has not sustained an up to date calibration certification.

4.5. Critical Interfaces

A Critical Interface is defined as that particular junction between systems or components which have a specific design characteristic and/or requirement, which are critical to the proper function of the overall LIGO system If these design requirements or characteristics are not met then there could be an increased likelihood of improper functioning, system failure, and/or damage to itself and/or other attached systems or components. It is the responsibility of the LIGO teams to identify and call out all critical interfaces in the design documents and drawings, and to ensure that appropriate standards of inspection and testing are applied to the systems at these interfaces.

The supplier shall perform levels of inspection as defined by the LIGO teams during the manufacturing and assembly process, including verification to design specifications and (if appropriate) interface tests for fit, function and/or performance. Development and performance of the test plan will be in accordance with the negotiated contract, and the final test plan will be reviewed by the supplier and the LIGO team(s). The supplier shall provide LIGO teams with the results from all tested critical interfaces, and the LIGO team(s) shall work with the supplier to assess the results and review discrepancies and proposed solutions.

4.6. Cleanliness

All components are to meet cleanliness standards as outlined in the technical documents provided to the vendor. Cleanliness and contamination control will be particularly sensitive with systems and components installed in the vacuum chambers. As part of the bid package, all suppliers of in-vacuum components must include detailed plans for achieving and maintaining cleanliness of manufactured items during the manufacturing process, through the final cleaning process, as well as processes to maintain this state during transport and storage.

4.7. Packaging

Guidelines shall be developed for packaging to provide sufficient protection for LIGO equipment from the point of manufacture to the delivery at the LIGO observatory sites. Suppliers must ensure that all packaging will meet requirements as defined in the RFP or RFQ, and any deficiencies are reported immediately to LIGO representatives. This includes packaging to protect against environmental, shock, transport noise and vibration, as well as protection from ESD and contamination as required in the negotiated contract or PO. LIGO staff will inspect all packaging upon arrival at a LIGO facility for damage and deficiencies. Note that components and assemblies which have been cleaned for in-vacuum service have special packaging requirements as defined in E960022.

All packaged items shall have appropriate labels attached to properly identify the following:

- Destination Site
- LIGO Subsystem team
- Boldly identify components as clean or environmentally sensitive to prevent opening and contamination in receiving area.
- List any special handling notifications or warnings
- LIGO Contact person and information
- Part ID, serial number or other identifying data
- Shipping manifest with long text description of enclosed items

4.8. Storage

Supplier shall protect system or components against environmental damage or unauthorized personnel access prior to shipment of finished goods. All items shall be stored with appropriate labeling to ensure removal from storage and transport of item is accurate.

4.9. Transport

Transport of items to LIGO facilities shall be handled via LIGO approved shipper, and will be insured as directed in the LIGO-Supplier's contract. All critical and/or environmentally sensitive items must be shipped in a manner that will minimize damage in transit. Supplier and shipping company shall utilize proper ride mechanism (air ride or other specific suspension types, isolation techniques, etc), container types and handling methods to protect sensitive items, such as optics and electronics, from vibration, shock pulse, impacts and crushing, as defined by LIGO. Shipping containers and the items they contain shall be properly secured for transport to avoid falling and shuffling of goods internally.

4.10. Customs

Customs documentation will be filled out appropriately to ensure proper handling, contamination controls and timely throughput while in possession of customs agents. This includes labeling which clearly defines contents, hazards, valuation and contact information. For all customs requirements please contact Rod Luna at Caltech, email luna_r@ligo.caltech.edu

5. System Integration and Commissioning Inspection Requirements

5.1. System Integration Inspection Process

With few exceptions, system installation, integration and commissioning are LIGO Laboratory responsibilities with no supplier involvement. Final inspection shall consist of the following:

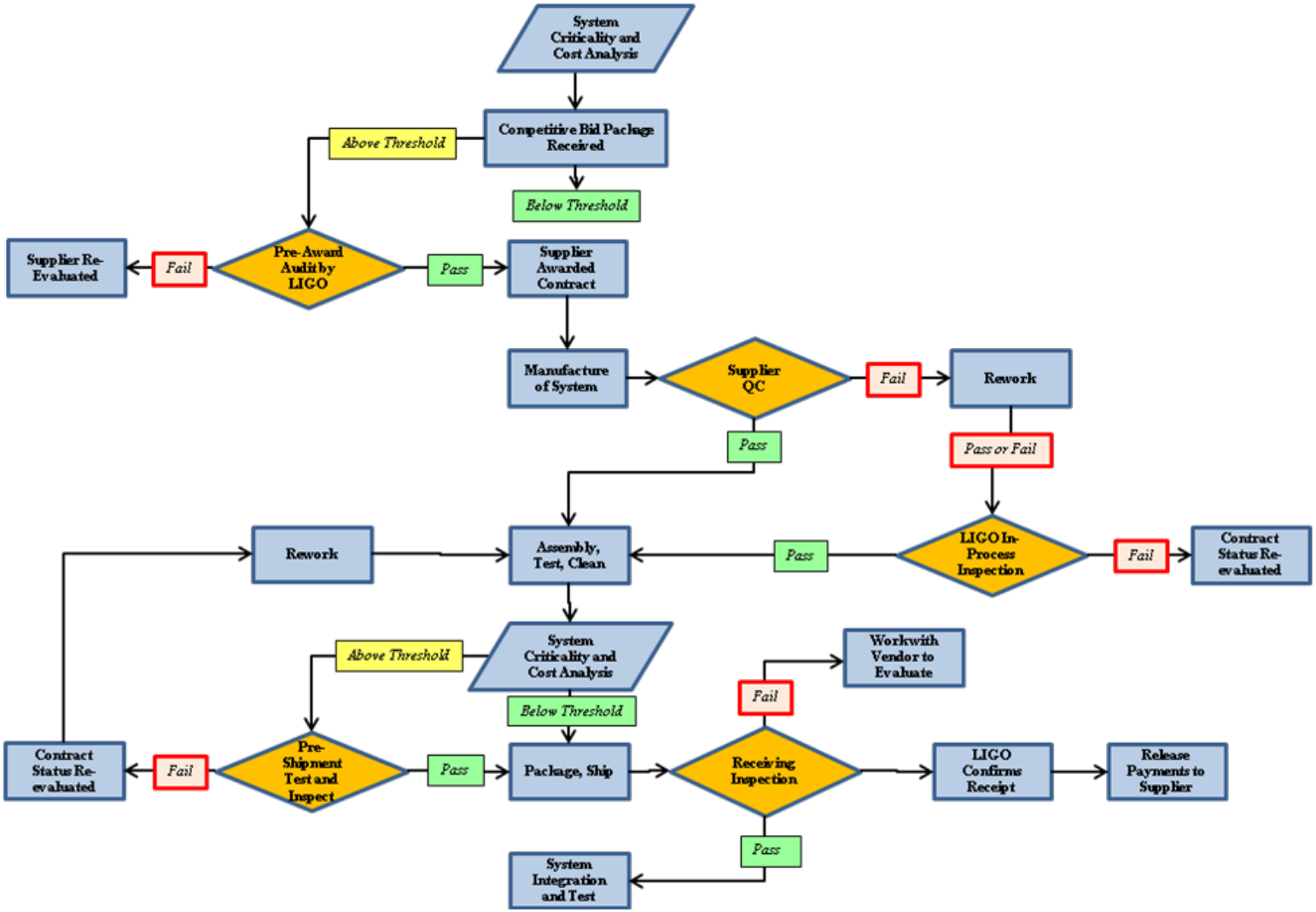
- Verification of the product (subsystem or subassembly) against requirements and test parameters identified as requirements in the subsystem documentation.
- Verification of key physical and interface parameters.
- Verification of Configuration.
- Verification of quality of workmanship.
- Verification of a complete set of as-built documentation

5.2. System Integration Acceptance Test

System integrated acceptance testing is a LIGO Laboratory responsibility. Acceptance testing shall be performed after completion of all required operations. LIGO final acceptance testing requirements are as follows:

- Commissioning acceptance testing plans and reports shall be reviewed and approved (and witnessed if possible) by LIGO QA personnel.
- The test shall be performed in accordance with the current version of the appropriate test procedure.
- Instruments and gages used to determine performance characteristics must be within the range of acceptable calibration parameters, including inspection cycles and tested against known standards.
- Tests shall be conducted in the order specified by the test procedure unless otherwise authorized by responsible LIGO engineering personnel.
- Completed test results shall be documented on authorized summary forms or test data sheets.
- Any deviations from the test procedure or discrepancies noted during the conduct of the test shall be documented.
- If appropriate, and to the extent practical, a post-test inspection shall be conducted of the item under test, for the purpose of identifying and recording any changes that may have occurred as a result of the test.

6. Advanced LIGO QA Inspection Workflow Chart



7. Glossary

Quality Assurance	QA is defined as a procedure or set of procedures intended to ensure that a product or service under development (before work is complete, as opposed to afterwards) meets specified requirements.
Quality Control	Quality control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer.
System Criticality and Cost Analysis	Evaluation taken place to determine whether a system being manufactured meets the minimum threshold for applying additional inspection criteria. Example: An in vacuum component may not meet minimum cost levels to add a supplier pre-award inspection; however since it is in vacuum it is a critical item that requires added inspections. Determination of criticality and cost thresholds is set by the LIGO teams.
Cost Threshold	A LIGO determined value of a component or system which triggers or precludes an audit or inspection point. LIGO sub-teams will determine this value on a case by case basis, and is evaluated in conjunction with criticality thresholds. In some cases criticality thresholds may require a triggered audit or inspection despite the cost being below a threshold. LIGO has sole determination of these values, however at any time LIGO may require an audit or inspection, and will communicate these to the supplier ahead of time.
Criticality Threshold	A LIGO determined level of importance assigned to a system or component. This assignment is based upon factors including but not limited to duty cycle, installation area, redundancy, availability of spares, lead time to manufacture, etc. LIGO sub-teams are solely responsible for assigning criticality levels to components, and will make the determination for inspections and audits based on criticality independent of cost.
Pre Award Audit	Audit/Inspection by LIGO performed to determine to ability of a supplier to meet to the system or component manufacturing requirements including QA/QC. Safety, capacity, cleanliness, skill and stability.
In Process Inspection	Any inspection that takes place during the manufacturing process. This inspection may be performed by supplier as part of its regular quality control processes, or by LIGO as a spot check of workmanship or as a result of a deficiency in the performance of the supplier or the manufactured component.

Receiving Inspection	Inspection at the LIGO site to verify that goods shipped arrive in good condition, without visible damage, contamination, or other problems that may have been caused during the packaging and shipping process. It is also the point at which LIGO team members look for problems related to improper packaging, as well as missing pieces or cartons. During a Receiving Inspection, LIGO team members will provide an inspection report noting any issues. If shipped item passes inspection it will be moved to the proper storage until its intended use. LIGO members will also submit a passed inspection report which authorizes procurements to release payments to supplier as agreed in contract. If the system does not pass receiving inspection, it will be at the discretion of the LIGO Project on how to handle the issues, which may include returning items to vendor, requiring vendor supported testing and rework, or additional testing at LIGO site before receiving inspection is signed off and payments are released to supplier.

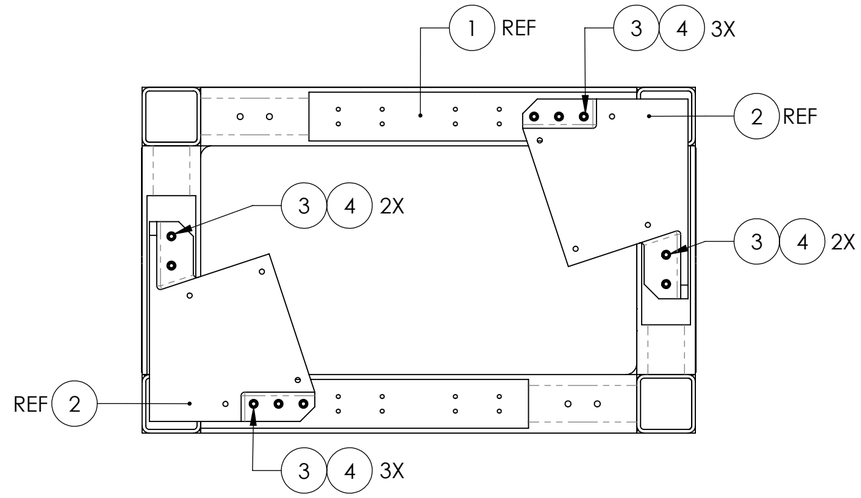
NOTES CONTINUED:

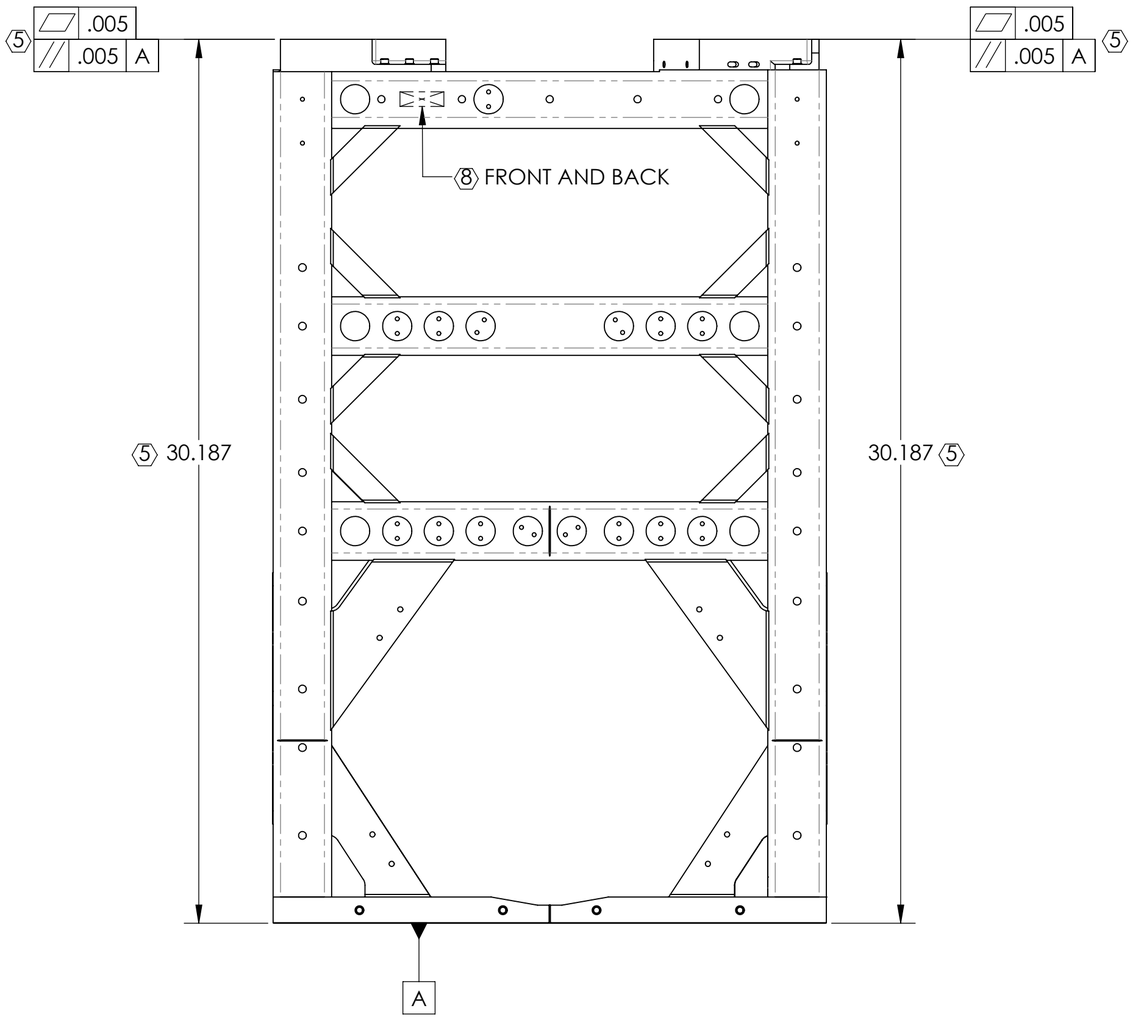
⑤ FLY CUT INDICATED SURFACES TO ACHIEVE DESIRED DIMENSIONS, PARALLELISM AND FLATNESS.

6. MACHINE ALL SURFACES TO REMOVE OXIDES AND MILL FINISH. USE OF ABRASIVE REMOVAL TECHNIQUES IS NOT ALLOWED.
7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

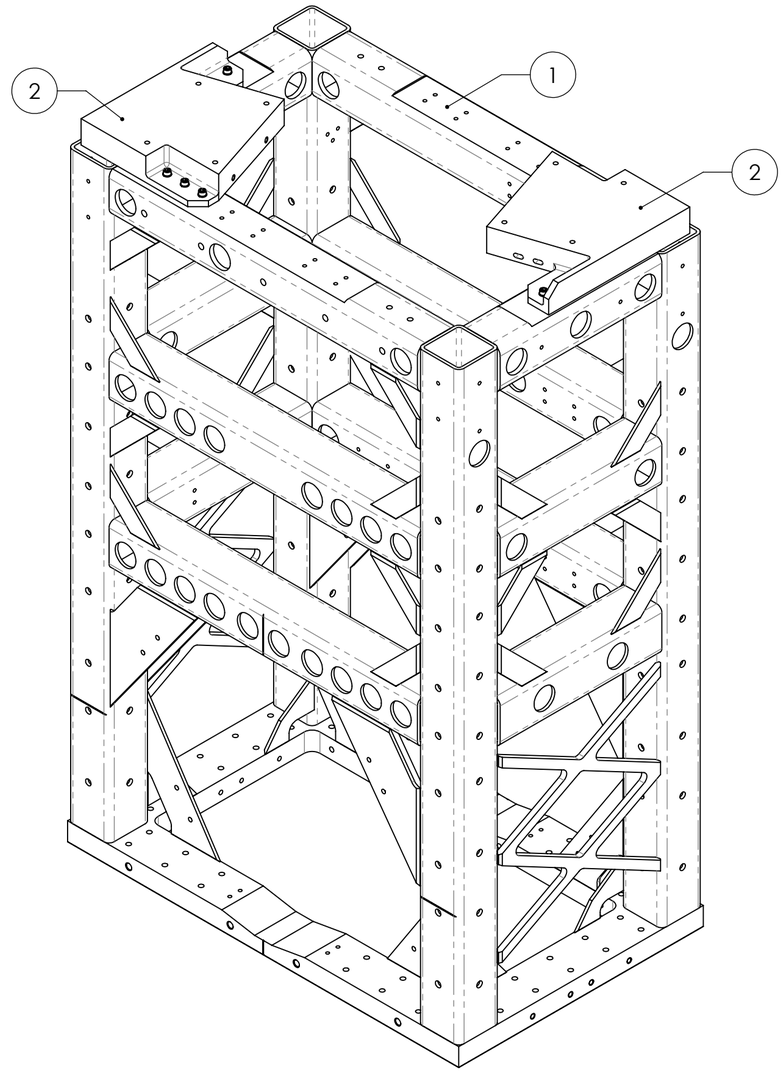
⑧ SCRIBE OR ENGRAVE (NO INKS OR DYES) SERIAL NUMBER OF CORRESPONDING MOUNTING PAD BODY (D070374) ON STRUCTURAL WELDMENT (D070442)AFTER MACHINING.

REV.	DATE	DCN #	DRAWING TREE #
v1	03 MAR 2009	E0900066	E080191
v2	29 AUG 2010	E1000371	E080191
-	-	-	-





FLY CUTTING LAYOUT



ITEM NO.	PART NUMBER	DESCRIPTION	MATERIAL	REQ	SPARE	TOTAL
4	-	WASHER, FLAT, VENTED, #8 (U-C COMPONENTS P/N WFV-08 OR EQUIVALENT)	300 SSTL	10	2	12
3	-	SCREW, SOCKET HEAD CAP, #8-32 UNC-2A X 0.5 LONG	Ag-PLATED 300 SSTL	10	2	12
2	D070374	MOUNTING PAD BODY	6061-T6 Al	2	0	0
1	D070442	STRUCTURAL WELDMENT, HLTS	--	1	0	0

PARTS LIST

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)

DIMENSIONS ARE IN INCHES

TOLERANCES:
.XX ± .01
.XXX ± .005

ANGULAR ± 0.5°

1. INTERPRET DRAWING PER ASME Y14.5-1994.
2. REMOVE ALL SHARP EDGES, R.02 MIN.
3. DO NOT SCALE FROM DRAWING.
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

MATERIAL N/A

FINISH 63 µinch

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM ADVANCED LIGO

SUB-SYSTEM SUS

NEXT ASSY HLTS OVERALL ASSY

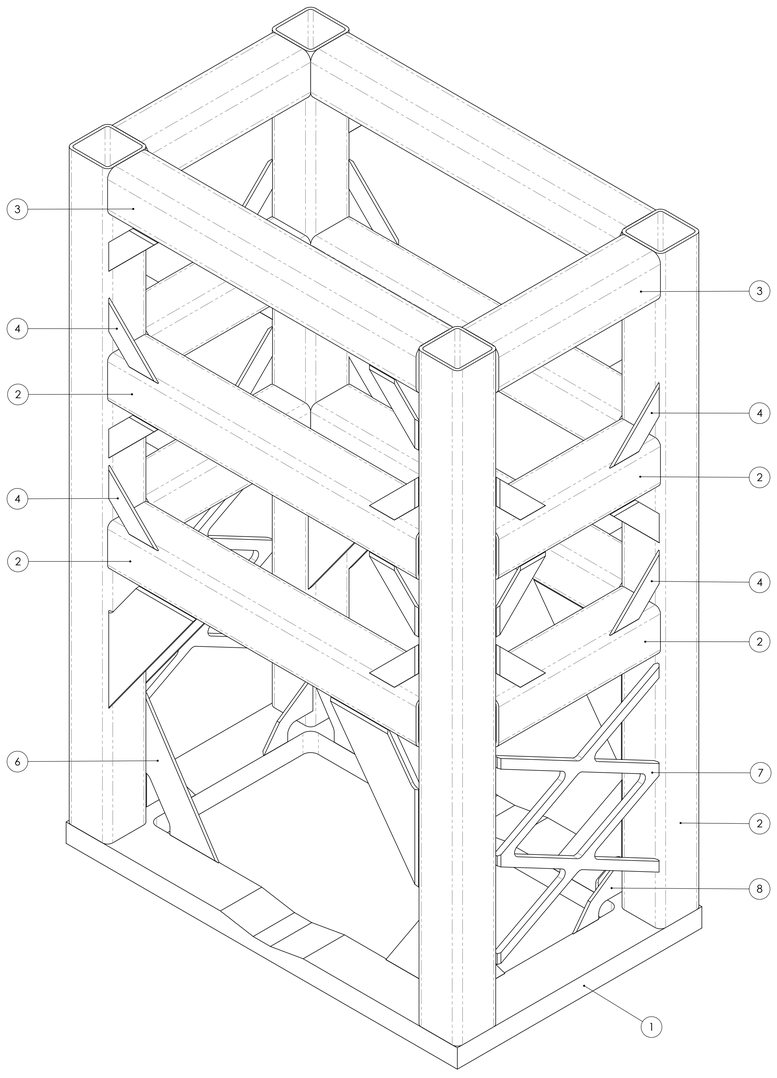
PART NAME STRUCTURE, HLTS

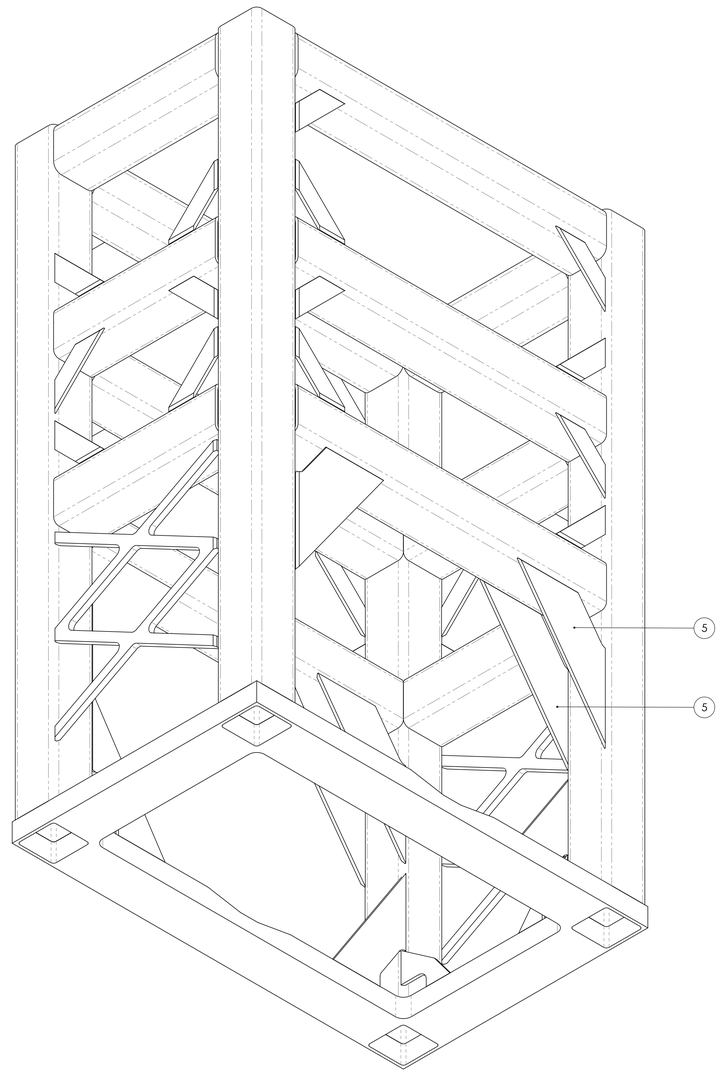
DESIGNER	D. BRIDGES	27 AUG 2010	**SIZE** C	**DWG. NO.** D070537	**REV.** v2
DRAFTER	D. BRIDGES	29 AUG 2010			
CHECKER	M. MEYER	31 AUG 2010			
APPROVAL			**SCALE:** 1:4	**PROJECTION:**	SHEET 1 OF 1

NOTES CONTINUED:

5. SCRIBE, ENGRAVE, OR MECHANICALLY STAMP (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR 'TYPE' IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS. UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. A VIBRATORY TOOL MAY BE USED. EXAMPLE: DXXXXXXX-VY, TYPE-XX, S/N XXX
6. ALL SURFACES OF ALL PARTS ARE TO BE MACHINED (NO AS RECEIVED, AS ROLLED, AS MILLED SURFACES WILL BE ACCEPTED), EXCEPT INNER SURFACES AND OUTER RADIUS OF TUBING. NO GRINDING OR LAPPING WITH ABRASIVE WHEELS, CLOTH OR STONES IS PERMITTED. NO PARTS SHALL BE CAST OR MOLDED (NO TOOLING PLATE IS PERMITTED). BLANCHARD GRINDING IS ACCEPTABLE IF ALL GROUND SURFACES ARE MACHINED AFTERWARDS.
7. ALL WELDING SHALL BE PERFORMED IN ACCORDANCE WITH LIGO SPECIFICATION E0900048.
8. TUBING IS 2.00" SQUARE WITH WALL THICKNESS OF .12" ± .01".
9. TUBING IS 2.00" SQUARE WITH WALL THICKNESS OF .188" ± .01".
10. AFTER WELDING, STRESS RELIEF AND HEAT TREATMENT, FLY-CUT INDICATED SURFACE TO MEET REQUIRED DIMENSION.
11. INDICATED FEATURES ARE TO BE ADDED AFTER ALL WELDING, HEAT TREATMENT AND ALL OTHER MACHINING OPERATIONS, INCLUDING FLY-CUTTING, ARE COMPLETED.
12. SCRIBE LINE WHERE INDICATED. LINE SHOULD BE .04" WIDE X .02" DEEP AND RUN THE LENGTH OF THE FACE AS SHOWN.
13. HOLE THROUGH OUTER WALL OF TUBE ONLY.
14. HOLE THROUGH BOTH WALLS OF TUBE.
15. HOLE THROUGH INNER WALL OF TUBE ONLY.
16. ALL HELICOIL HOLES TO BE PREPARED IN ACCORDANCE WITH EMHART HELICOIL PRODUCT CATALOG, HC2000, REV. 4.
17. ALL HELICOILS TO BE INSTALLED BY LIGO PERSONNEL AFTER DELIVERY. CLEANING AND BAKING OF FINISHED PARTS.

REV.	DATE	DCN #	DRAWING TREE #
v1	03 MAR 2009	E080446	E080191
v2	02 DEC 2009	E0900446	E080191
v3	-	INTERNAL REVISION	-
v4	29 AUG 2010	E1000371	E080191
v5	11 OCT 2010	E1000570	E080191





WELDMENT ISOMETRIC VIEWS

ITEM NO.	PART NUMBER	DESCRIPTION	TOTAL
8	D070577	SIDE GUSSET	4
7	D070578	SIDE STRUT	2
6	D070576	LOWER FRONT GUSSET	4
5	D070579	UPPER FRONT GUSSET	8
4	D070580	TOP GUSSET	28
3	-	2.00" SQUARE TUBE - .188" WALL THICKNESS (9)	-
2	-	2.00" SQUARE TUBE - .12" WALL THICKNESS (8)	-
1	D070575	BASE PLATE	1

PARTS LIST

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)

DIMENSIONS ARE IN INCHES [MM]

TOLERANCES:
.XX ± .01
.XXX ± .005

ANGULAR ± 0.5°

1. INTERPRET DRAWING PER ASME Y14.5-1994.
2. REMOVE ALL SHARP EDGES, R.02 MIN.
3. DO NOT SCALE FROM DRAWING.
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

MATERIAL: 304 OR 304L SSTL
FINISH: N/A µinch

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

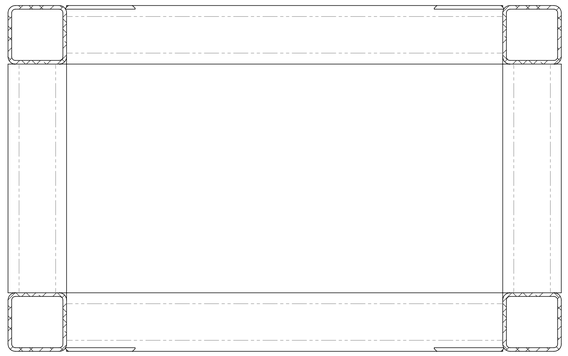
SYSTEM: ADVANCED LIGO
SUB-SYSTEM: SUS
NEXT ASSY: STRUCTURE, HLTS

PART NAME: STRUCTURAL WELDMENT, HLTS

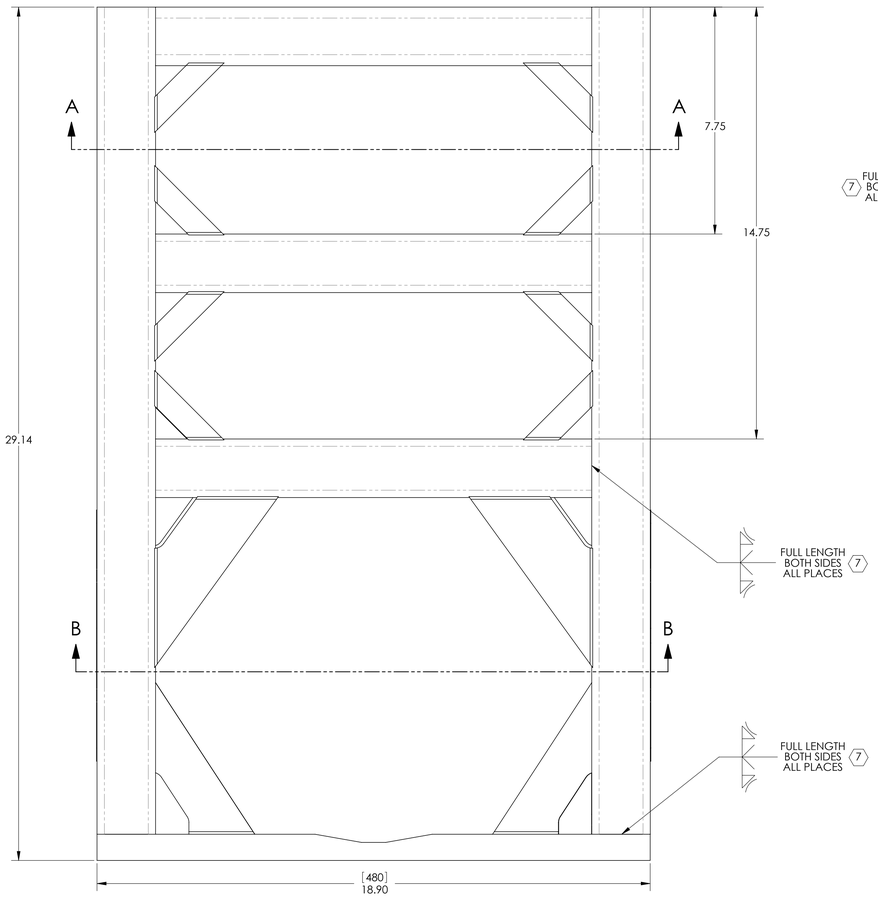
DESIGNER	D. BRIDGES	26 AUG 2010
DRAFTER	D. BRIDGES	08 OCT 2010
CHECKER	J. ROME	11 OCT 2010
APPROVAL		

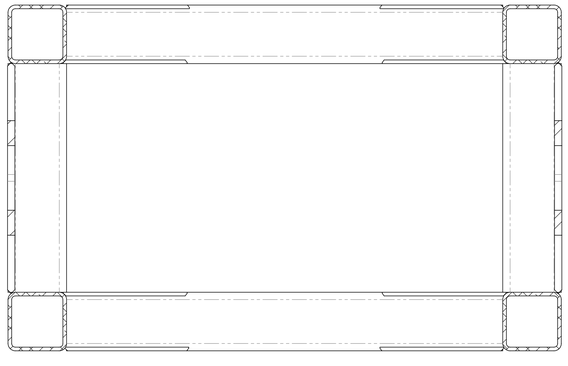
SIZE: E
DWG. NO.: D070442
REV.: v5
SCALE: 1:2
PROJECTION:
SHEET 1 OF 8

D070442_Advanced_LIGO_SUS_HLTS_Structural_Weldment PART FROM REV: 14-000, DRAWING FROM REV: V3

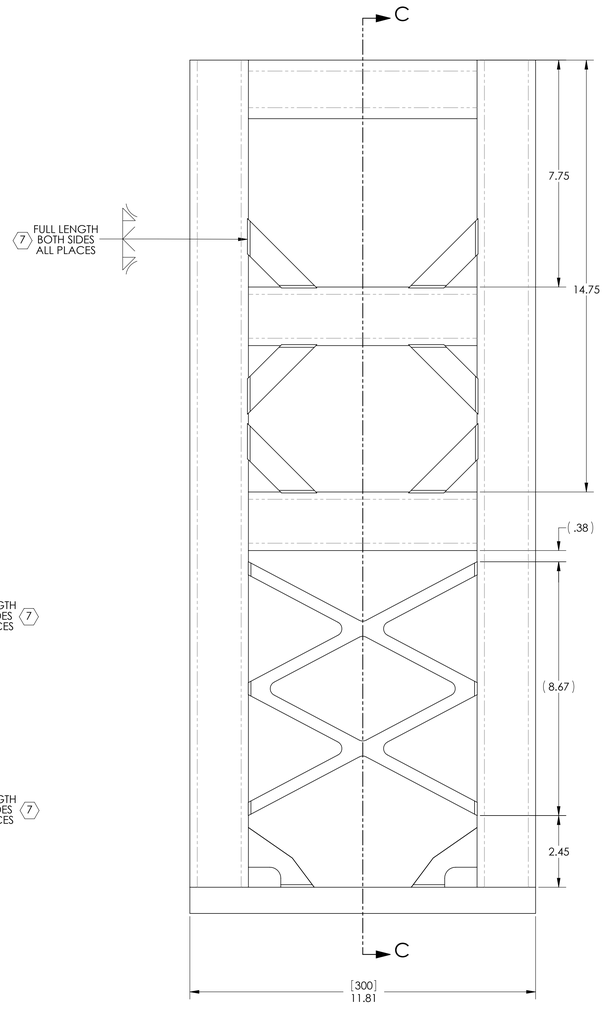


SECTION A-A

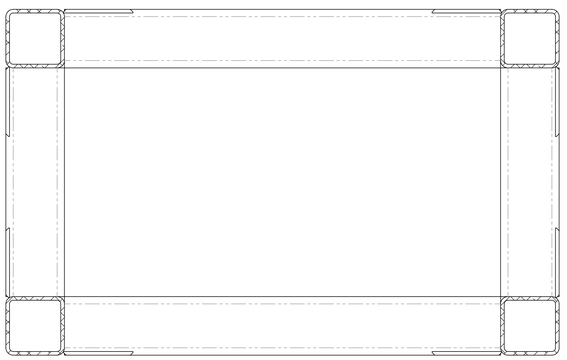




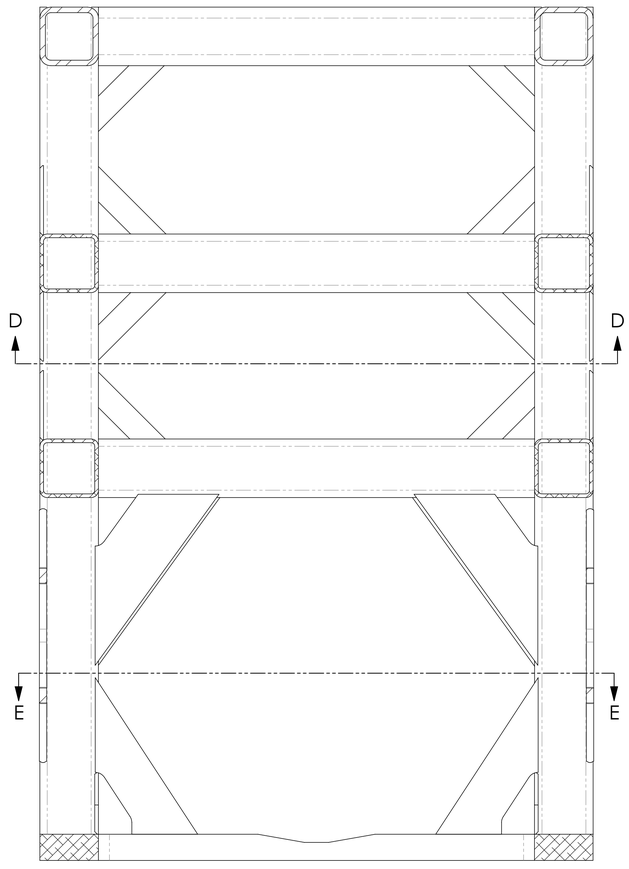
SECTION B-B



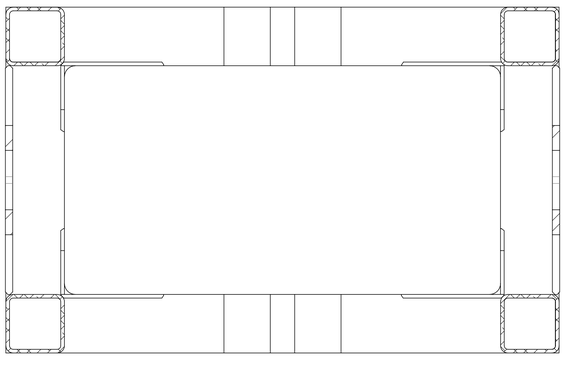
WELDMENT LAYOUT



SECTION D-D

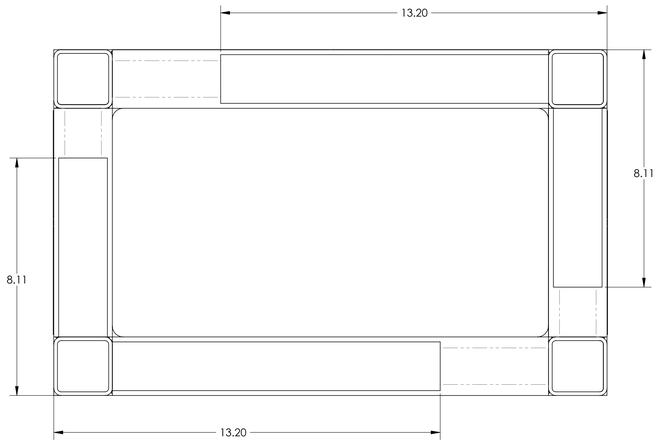


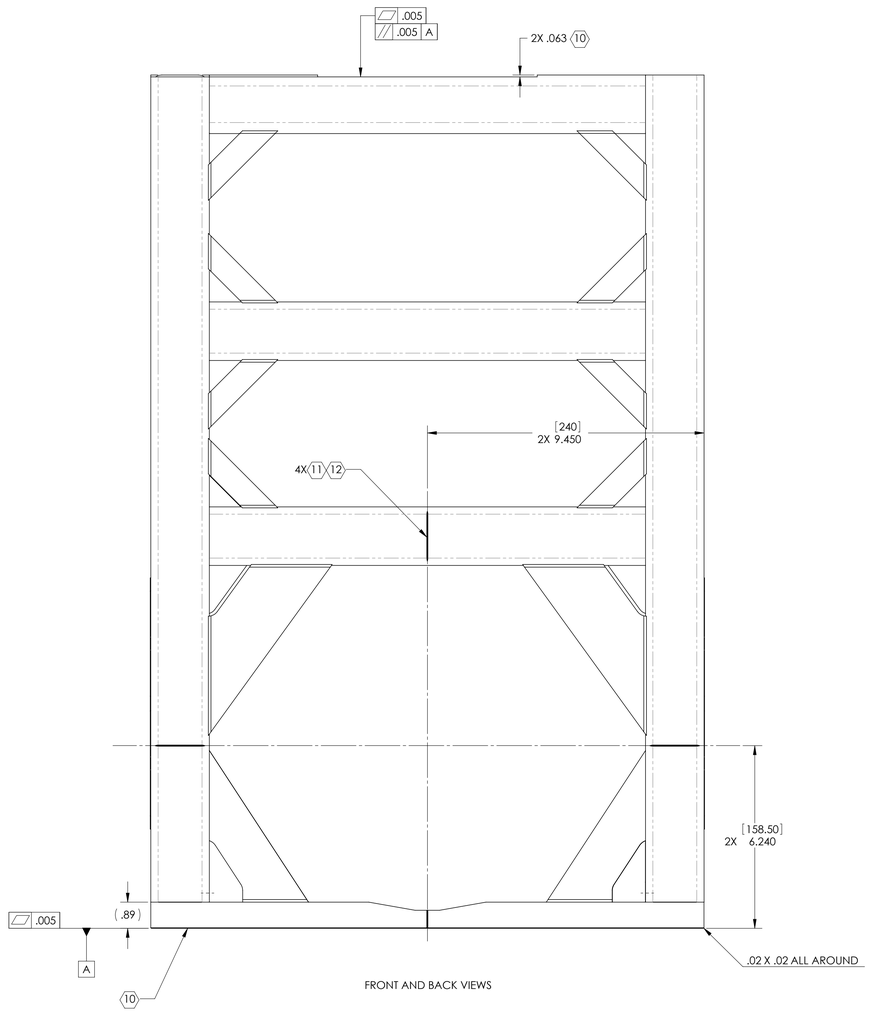
SECTION C-C



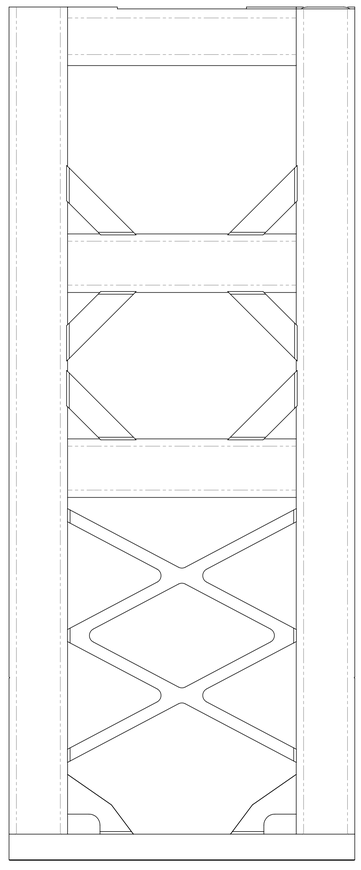
SECTION E-E

LIGO	CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		
SIZE	DWG. NO.		REV.
E	D070442		v5
SCALE: 1:2	PROJECTION:		SHEET 2 OF 8

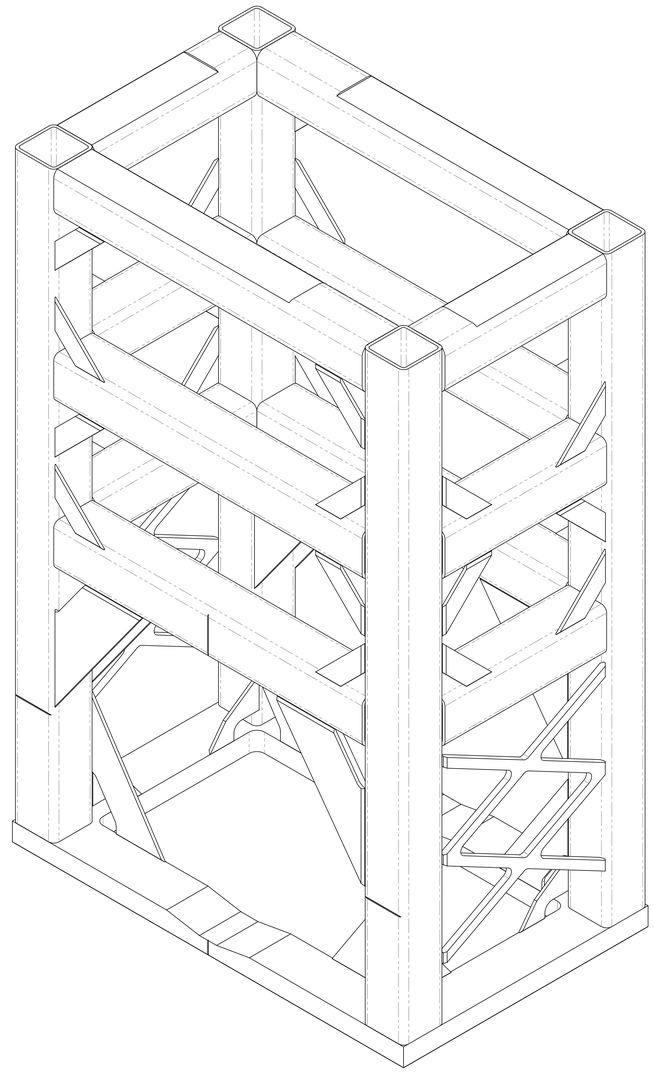




FRONT AND BACK VIEWS

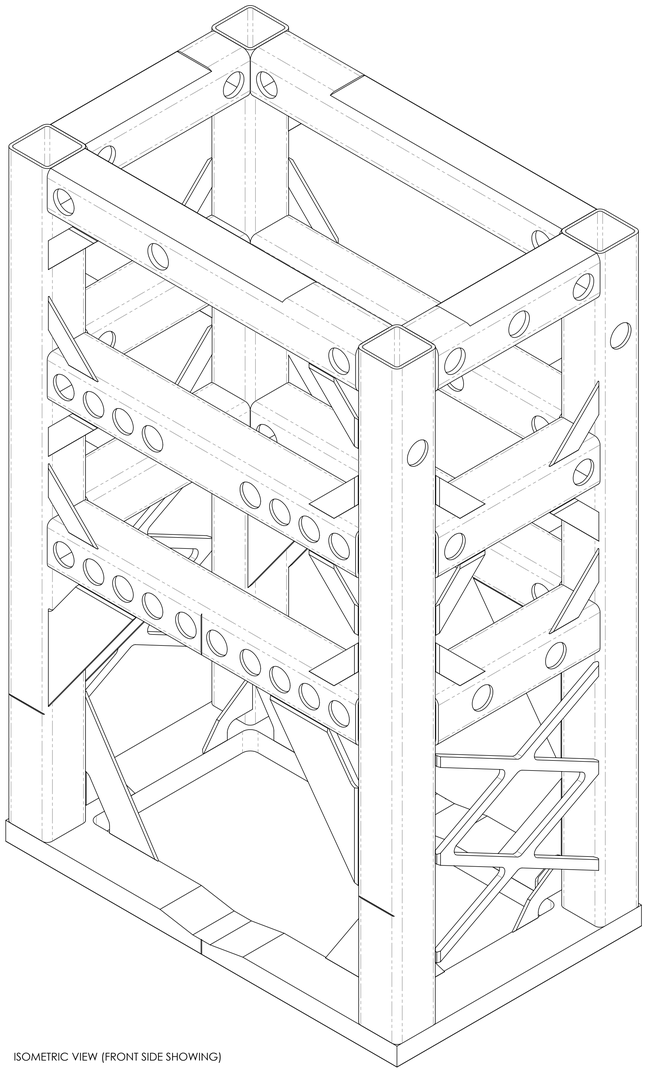


RIGHT AND LEFT VIEWS

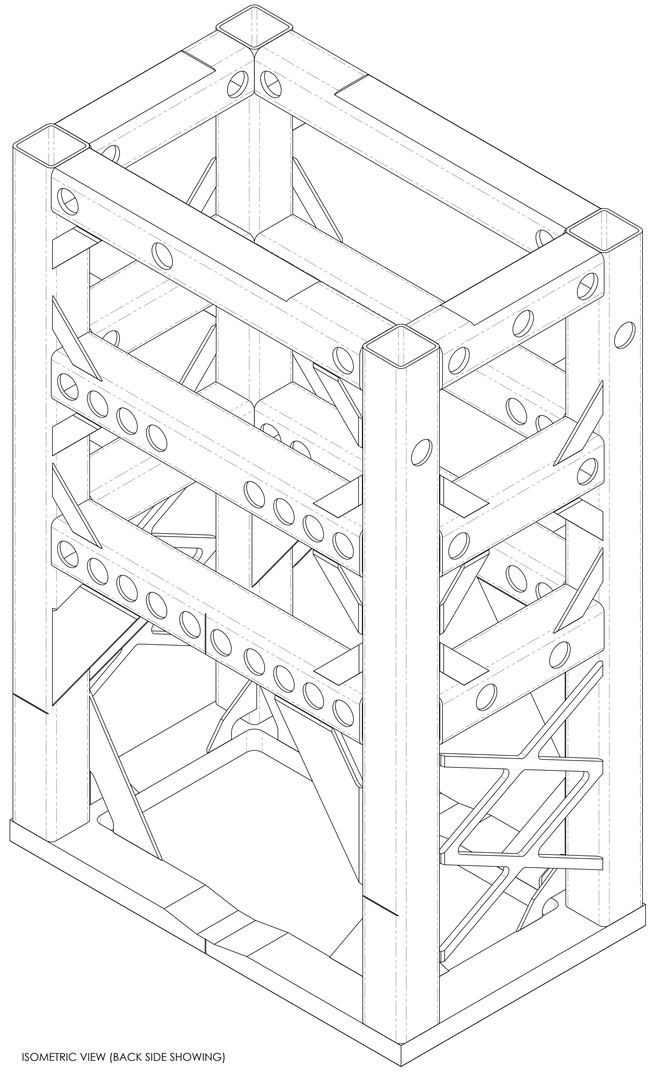


MACHINING LAYOUT

LIGO	CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		
SIZE	DWG. NO.		REV.
E	D070442		v5
SCALE: 1:2	PROJECTION:		SHEET 3 OF 8



ISOMETRIC VIEW (FRONT SIDE SHOWING)



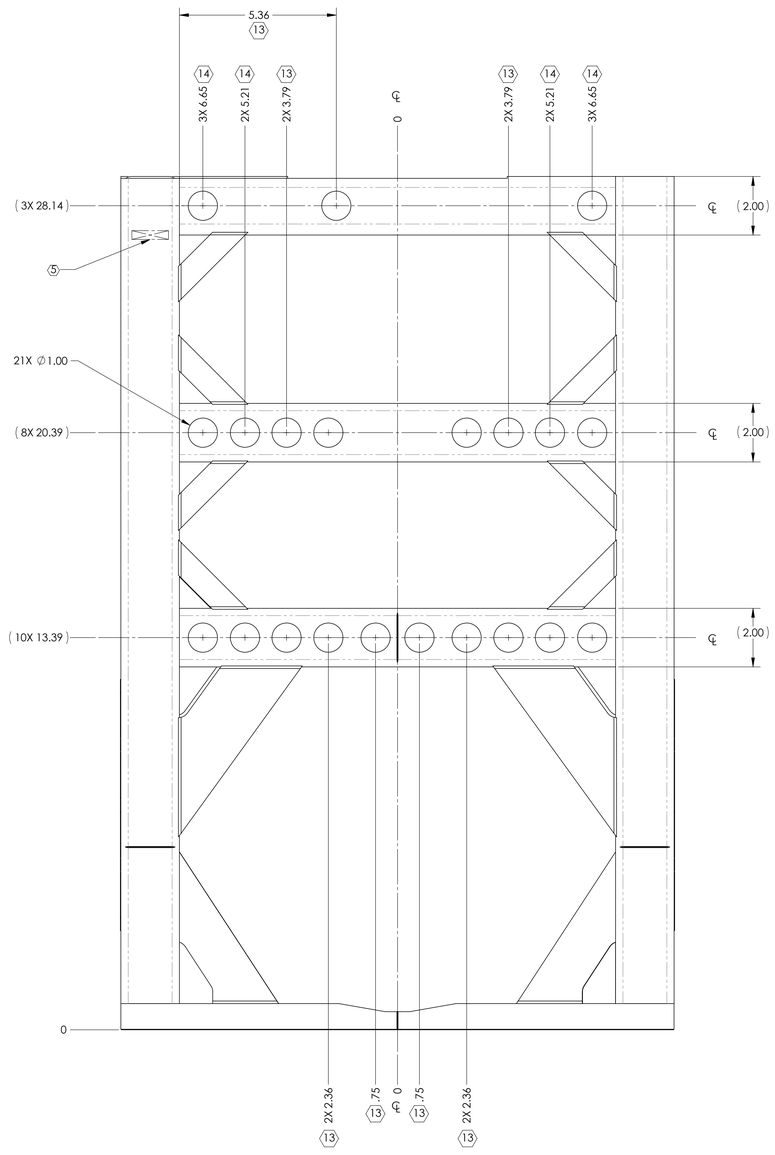
ISOMETRIC VIEW (BACK SIDE SHOWING)

ISOMETRIC VIEWS FOR LARGE HOLE PLACMENT

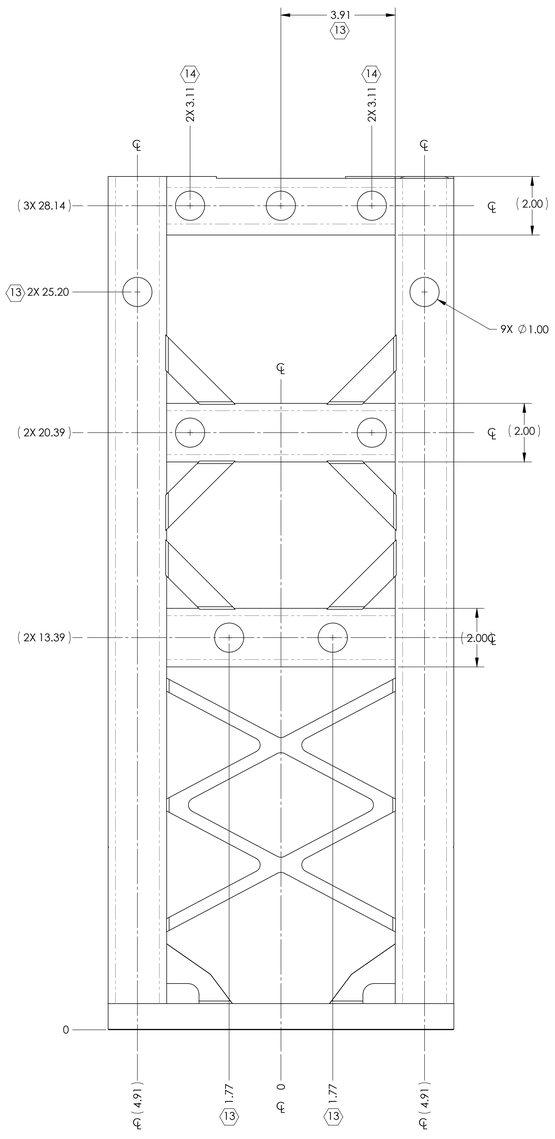
LIGO
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SIZE	DWG. NO.	REV.
E	D070442	v5

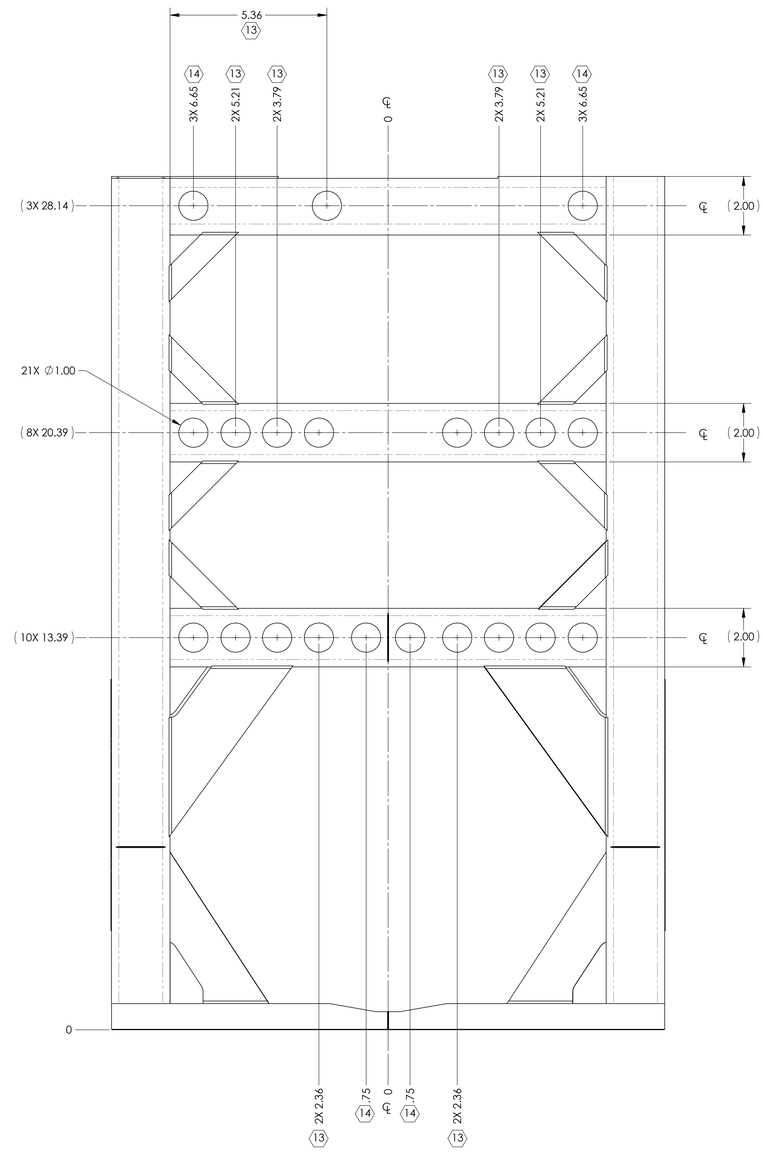
SCALE: 1:2 | PROJECTION: | SHEET 4 OF 8



FRONT VIEW



RIGHT AND LEFT VIEWS



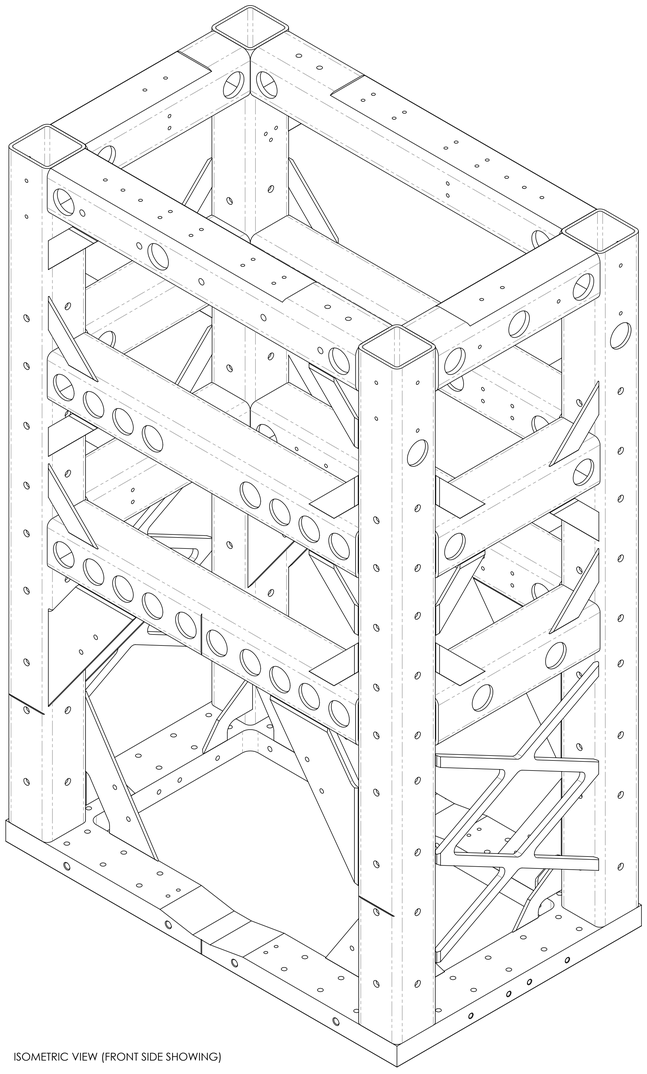
BACK VIEW

LARGE HOLE LAYOUT

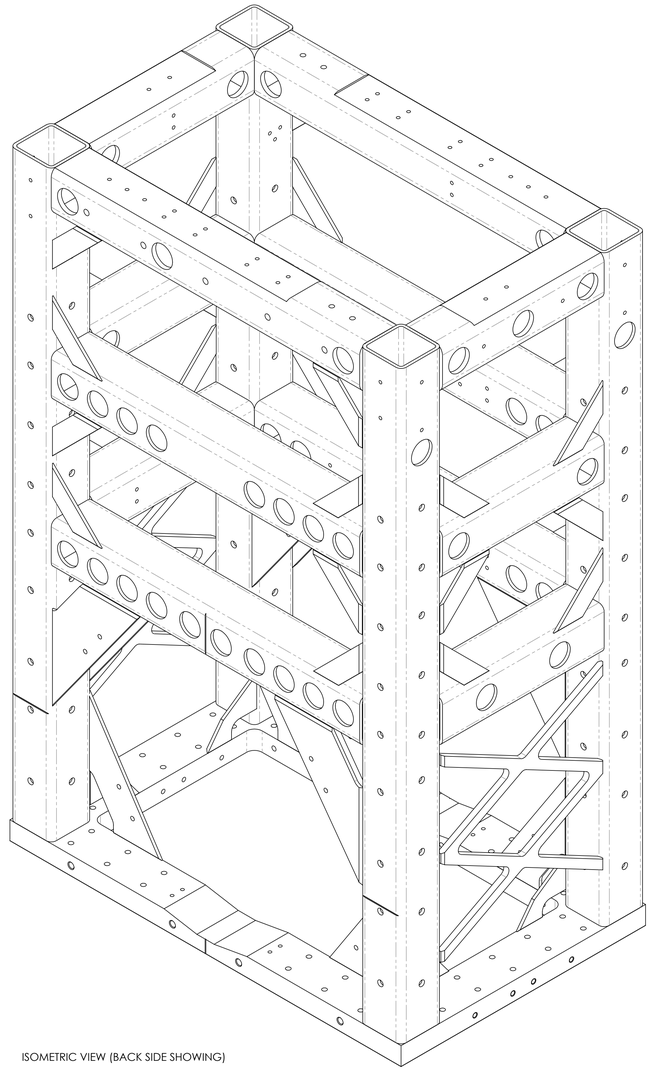
LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SIZE	DWG. NO.	REV.
E	D070442	v5

SCALE: 1:2 | PROJECTION: | SHEET 5 OF 8



ISOMETRIC VIEW (FRONT SIDE SHOWING)



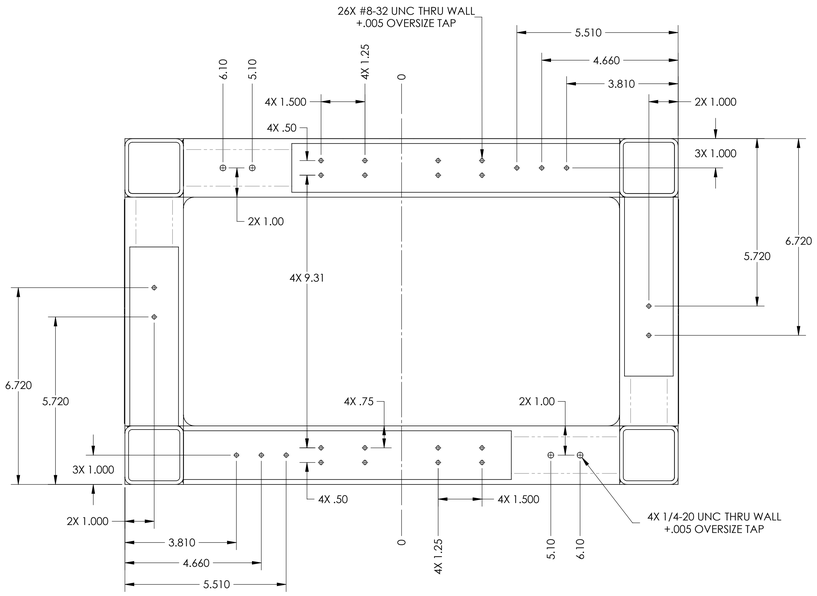
ISOMETRIC VIEW (BACK SIDE SHOWING)

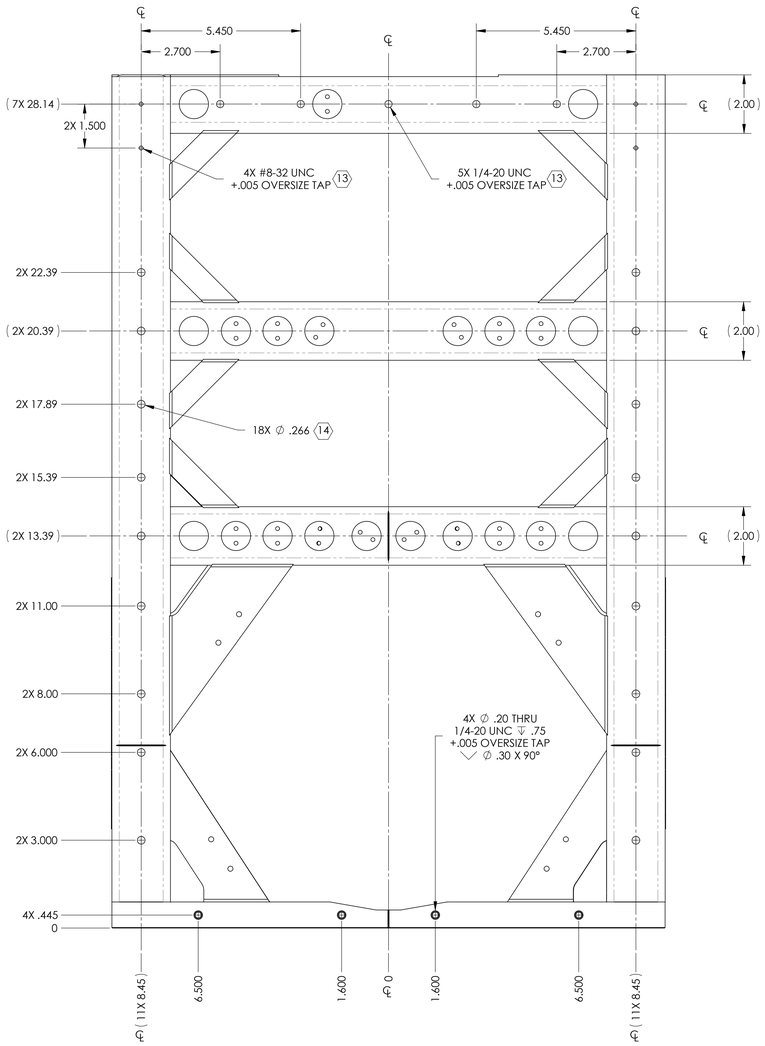
ISOMETRIC VIEWS FOR LARGE HOLE PLACMENT

LIGO
CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

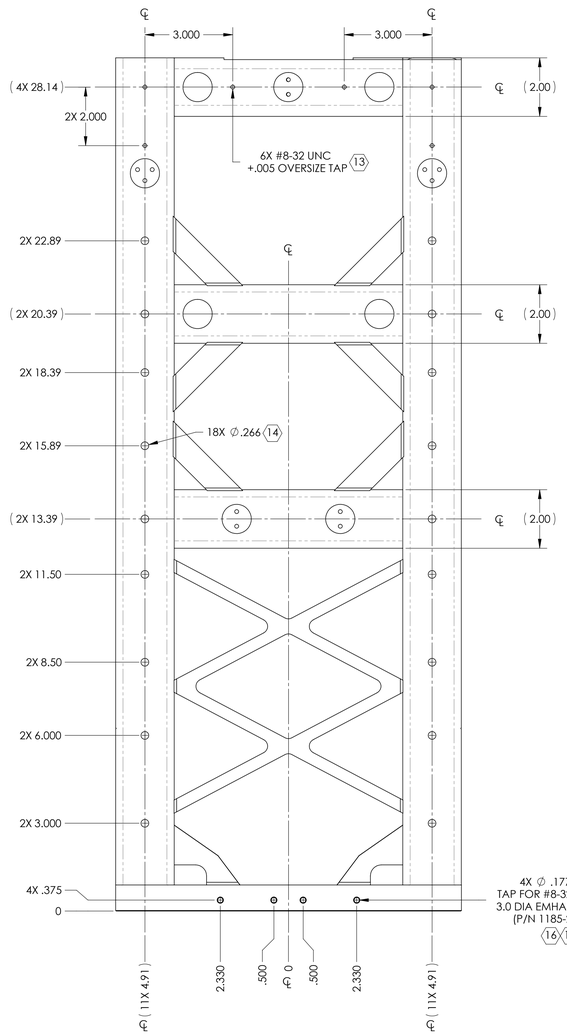
SIZE	DWG. NO.	REV.
E	D070442	v5

SCALE: 1:2 | PROJECTION: | SHEET 6 OF 8

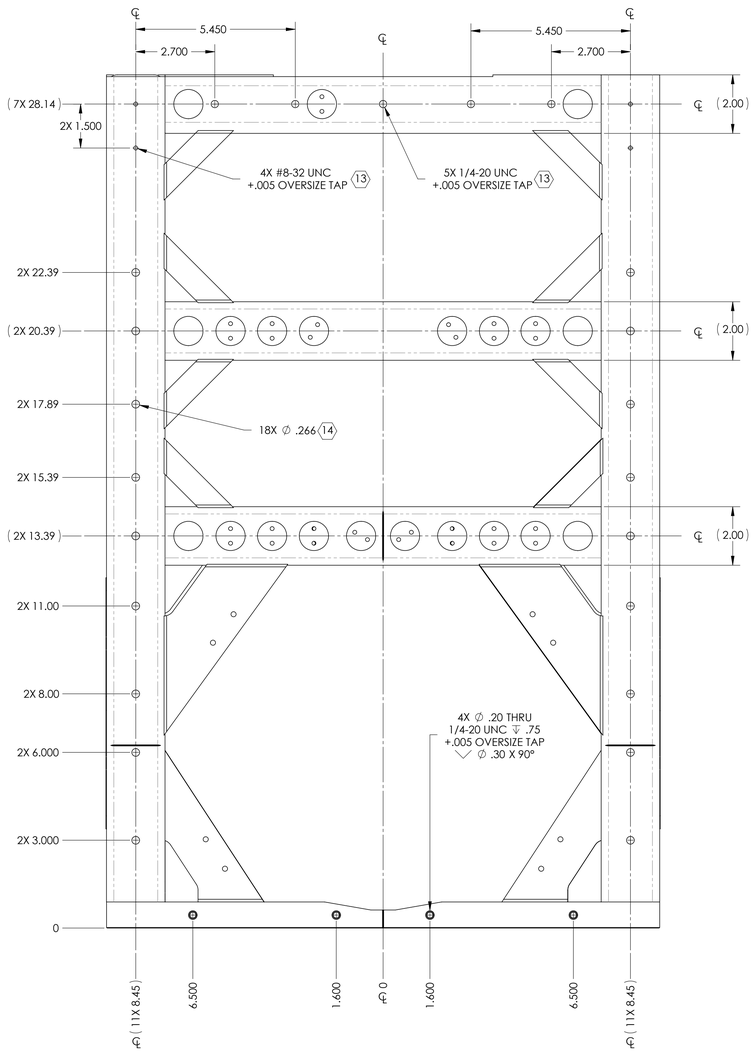




FRONT VIEW



RIGHT AND LEFT VIEWS



BACK VIEW

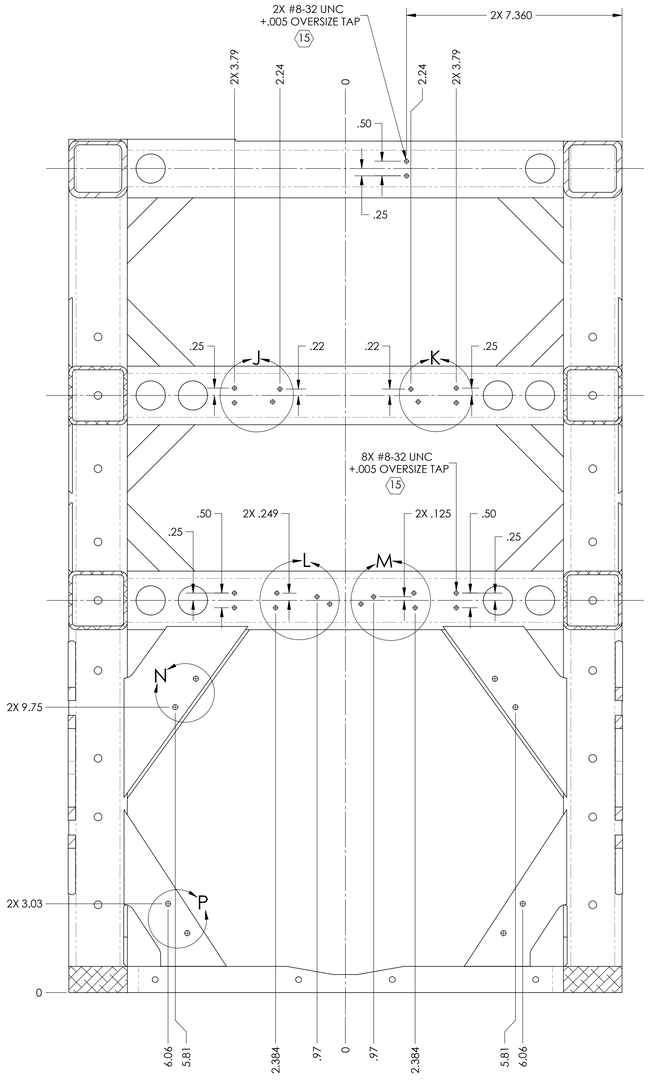
SMALL HOLE LAYOUT

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

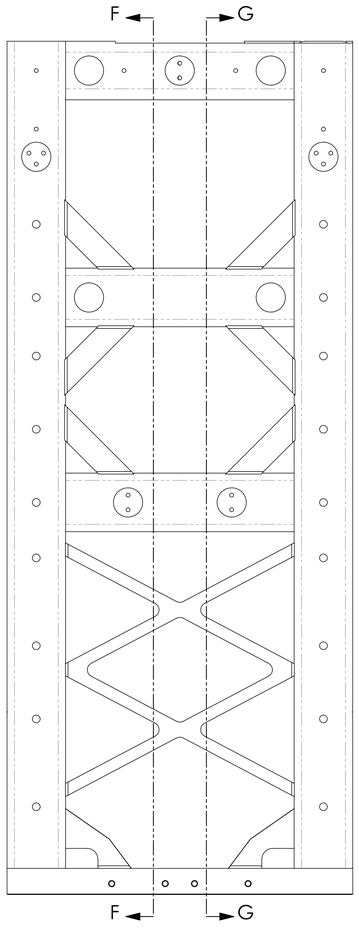
SIZE	DWG. NO.	REV.
E	D070442	v5

SCALE: 1:2 | PROJECTION: | SHEET 7 OF 8

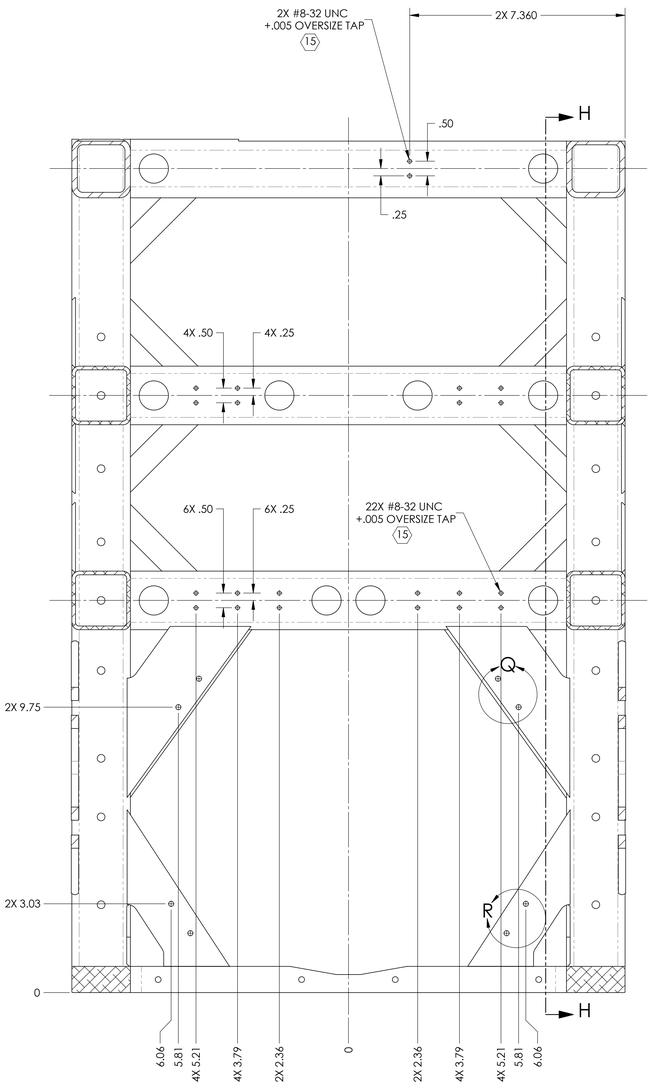
D070442_Advanced_LIGO_SUS_HLTS_Structural_Weldment PART PDM REV: V4 000, DRAWING PDM REV: V3



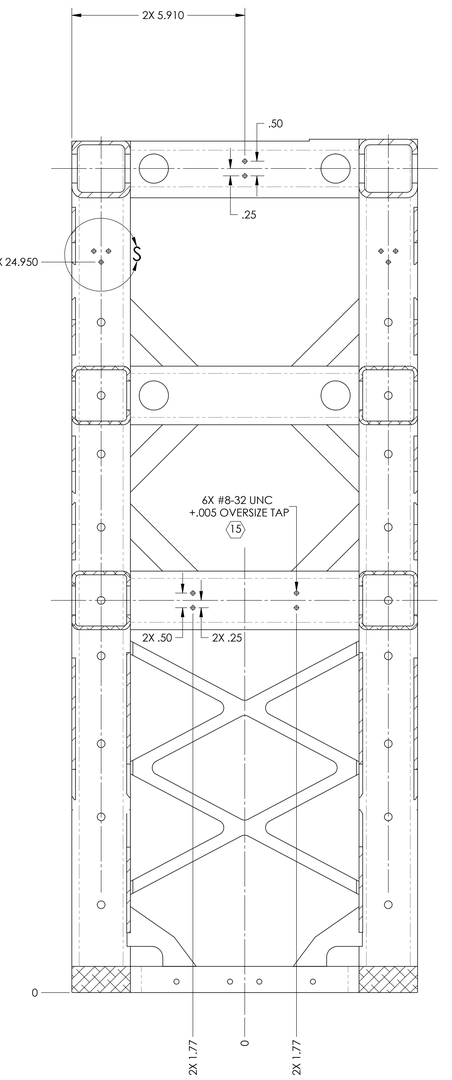
SECTION F-F
FRONT INSIDE VIEW



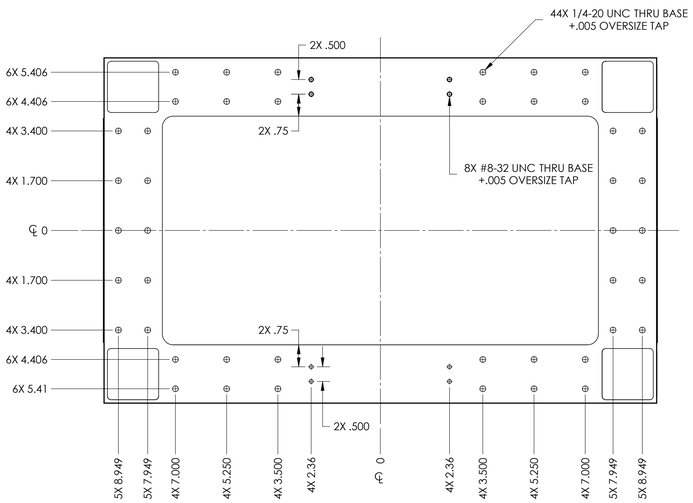
LEFT AND RIGHT VIEWS

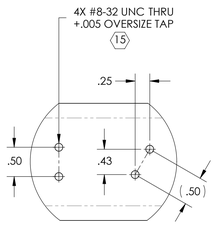


SECTION G-G
BACK INSIDE VIEW

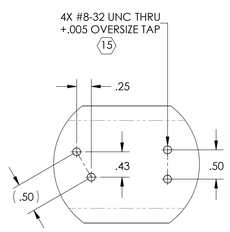


SECTION H-H
LEFT AND RIGHT INSIDE VIEWS

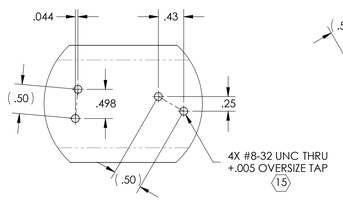




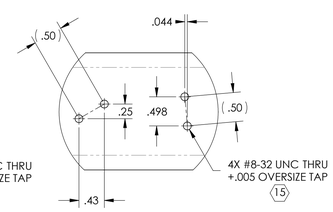
DETAIL J
SCALE 1 : 1



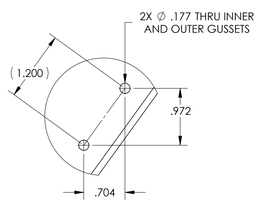
DETAIL K
SCALE 1 : 1



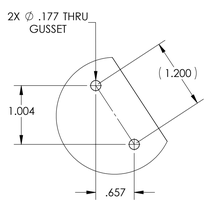
DETAIL L
SCALE 1 : 1



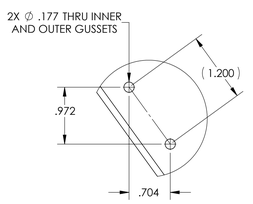
DETAIL M
SCALE 1 : 1



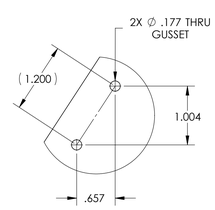
DETAIL N
SCALE 1 : 1
2 PLACES



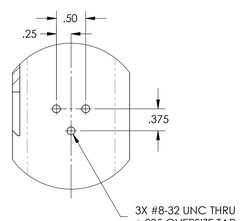
DETAIL P
SCALE 1 : 1
2 PLACES



DETAIL Q
SCALE 1 : 1
2 PLACES



DETAIL R
SCALE 1 : 1
2 PLACES



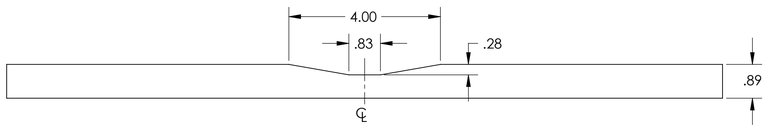
DETAIL S
SCALE 1 : 1

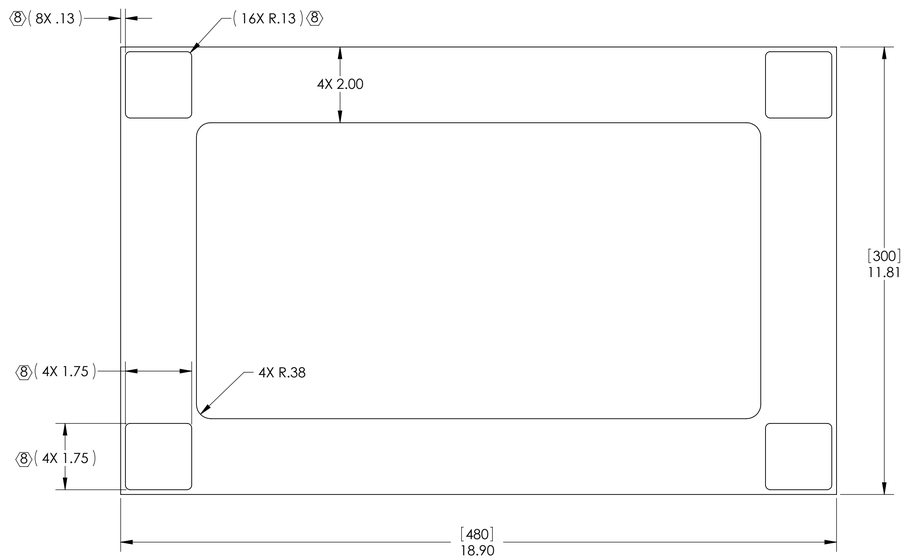
LIGO	CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
SIZE: E	DWG. NO.: D070442	REV.: v5
SCALE: 1:2	PROJECTION:	SHEET 8 OF 8

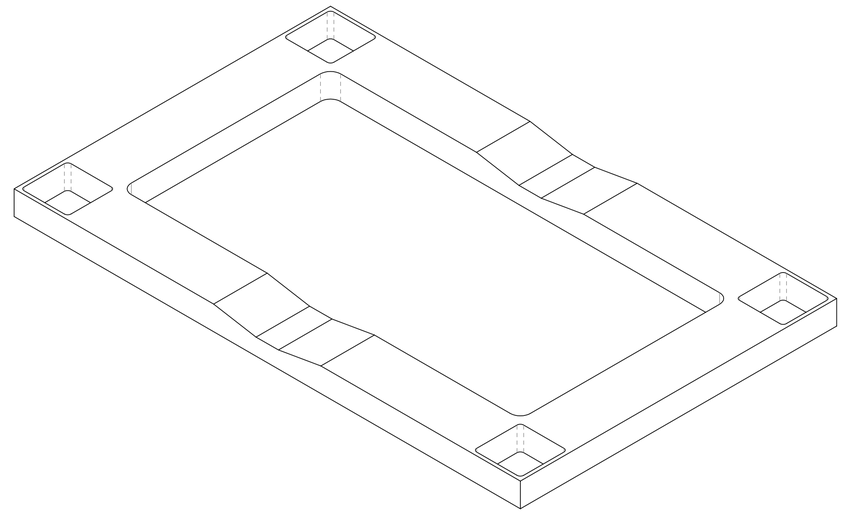
NOTES CONTINUED:

5. THIS PIECE IS ONE PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE. WELD INDUCED SHRINKAGE AND DISTORTION, STRESS ANNEALING, AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE E070442 (STRUCTURAL WELDMENT, HLTS) FOR REQUIRED DIMENSIONS AFTER WELDING.
6. MACHINE ALL SURFACES TO REMOVE OXIDES AND MILL FINISH. USE OF ABRASIVE REMOVAL TECHNIQUES IS NOT ALLOWED.
7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
(8) MACHINE CUTOUT TO MATCH INNER PROFILE OF LEG TUBE. DIMENSIONS PROVIDED ARE FOR REFERENCE ONLY.

REV.	DATE	DCN #	DRAWING TREE #
v1	03 MAR 2009	E080446	E080191
v2	29 AUG 2010	E1000371	E080191
-	-	-	-







ISOMETRIC VIEW

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)

DIMENSIONS ARE IN INCHES [MM]

TOLERANCES:
.XX ± .01
.XXX ± .005

ANGULAR ± 0.5°

1. INTERPRET DRAWING PER ASME Y14.5-1994.
2. REMOVE ALL SHARP EDGES, R.02 MIN.
3. DO NOT SCALE FROM DRAWING.
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

MATERIAL: 304 OR 304L SSTL
FINISH: 63 µinch

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO
SUB-SYSTEM: SUS
NEXT ASSY: STRUCTURAL WELDMENT, HLTS

PART NAME: BASE PLATE

DESIGNER	D. BRIDGES	29 AUG 2010	
DRAFTER	D. BRIDGES	29 AUG 2010	
CHECKER	M. MEYER	30 AUG 2010	
APPROVAL			

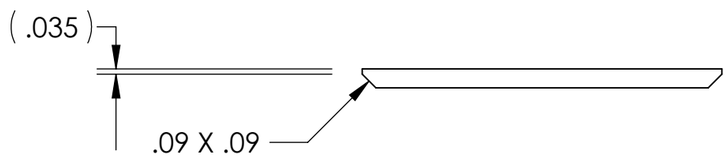
SIZE: D | DWG. NO.: D070575 | REV.: v2
SCALE: 1:2 | PROJECTION: | SHEET 1 OF 1

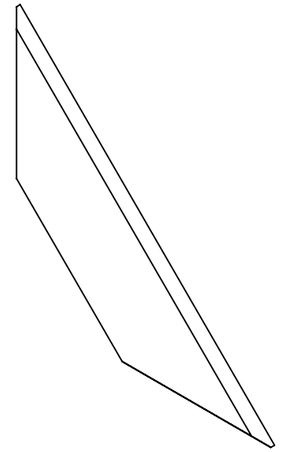
D070575_Advanced_LIGO_SUS_HLTS_Structure_Base_Plate, PART PDM REV: V1-002, DRAWING PDM REV: V1-002

NOTES CONTINUED:

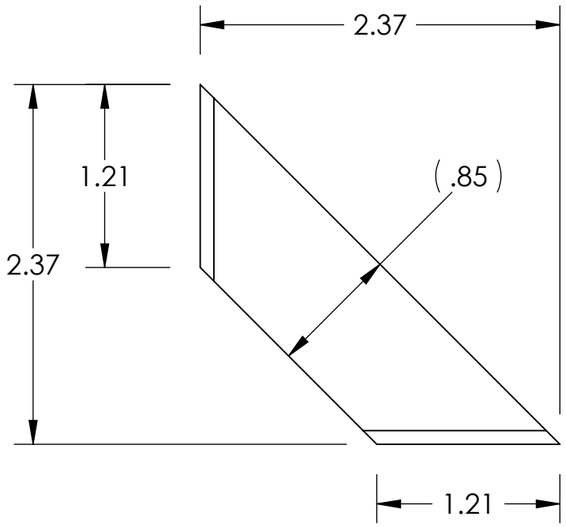
5. THIS PIECE IS ONE PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST-WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D070442 (STRUCTURAL WELDMENT, HLTS) FOR REQUIRED DIMENSIONS AFTER WELDING.
6. MACHINE ALL SURFACES TO REMOVE OXIDES AND MILL FINISH. USE OF ABRASIVE REMOVAL TECHNIQUES IS NOT ALLOWED.
7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

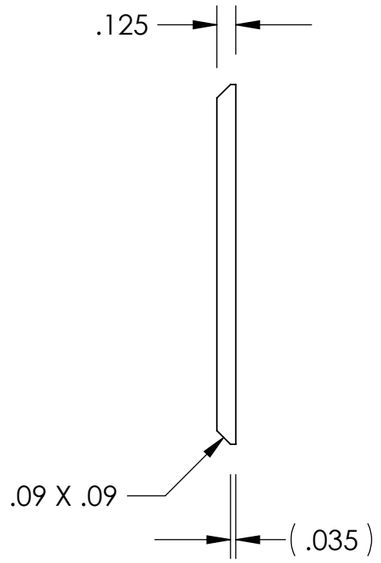
REV.	DATE	DCN #	DRAWING TREE #
v1	03 MAR 2009	E080446	E080191
v2	29 AUG 2010	E1000371	E080191
-	-	-	-





ISOMETRIC VIEW





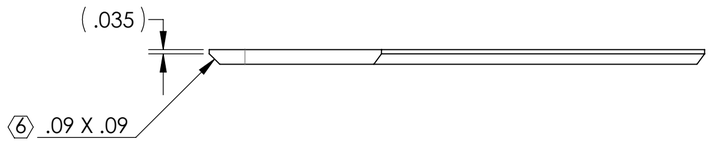
NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)										
DIMENSIONS ARE IN INCHES TOLERANCES: .XX ± .01 .XXX ± .005 ANGULAR ± 0.5°	1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, R.02 MIN. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME: TOP GUSSET					
	MATERIAL: 304 OR 304L SSTL	FINISH: 63 µinch	SYSTEM: ADVANCED LIGO	SUB-SYSTEM: SUS	DESIGNER	D. BRIDGES	29 AUG 2010	SIZE: B	DWG. NO.: D070580	REV.: v2
			NEXT ASSY: STRUCTURAL WELDMENT, HLTS		DRAFTER	D. BRIDGES	29 AUG 2010			
					CHECKER	M. MEYER	30 AUG 2010			
					APPROVAL			SCALE: 1:1	PROJECTION:	SHEET 1 OF 1

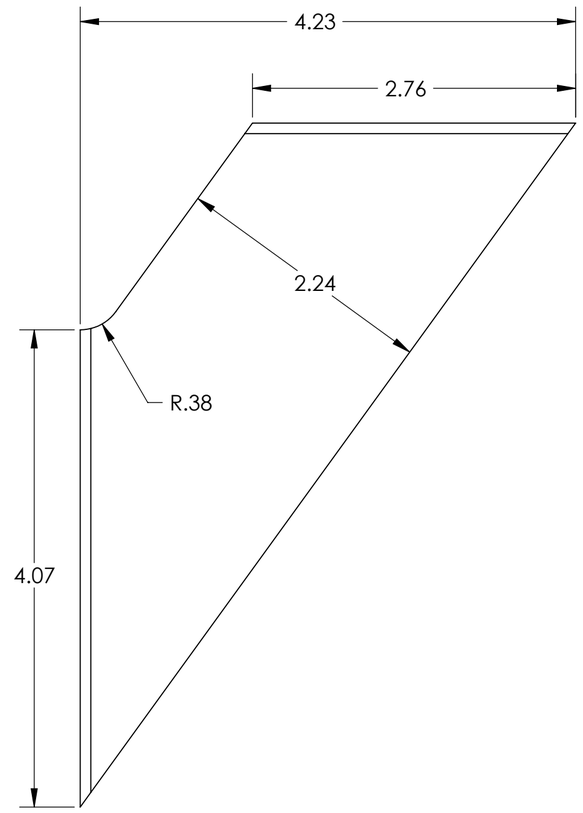
D070580_Advanced_LIGO_SUS_HLTS_Structure_Top_Gusset, PART PDM REV: V1-003, DRAWING PDM REV: V1-001

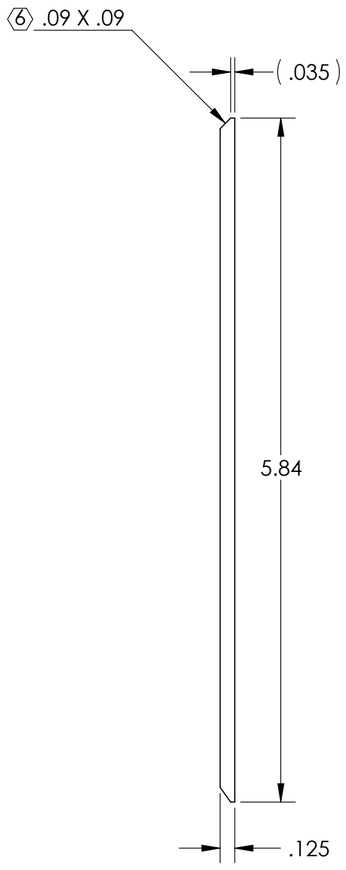
NOTES CONTINUED:

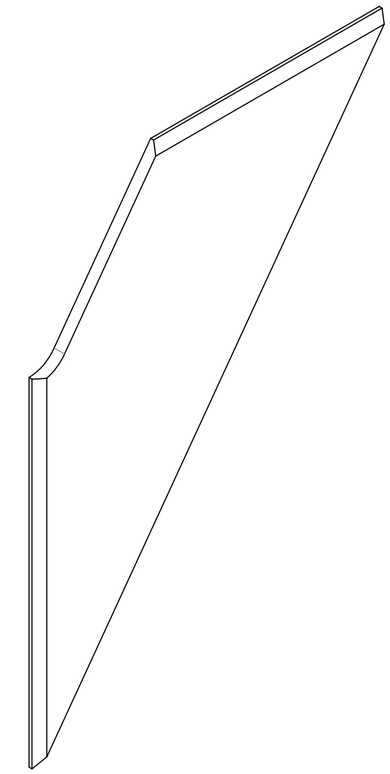
5. THIS PIECE IS ONE PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST-WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D070442 (STRUCTURAL WELDMENT, HLTS) FOR REQUIRED DIMENSIONS AFTER WELDING.
6. ⟨6⟩ HALF OF ALL UPPER FRONT GUSSETS TO HAVE CHAMFER ON OPPOSITE FACE (MIRROR IMAGE OF PART SHOWN).
7. MACHINE ALL SURFACES TO REMOVE OXIDES AND MILL FINISH. USE OF ABRASIVE REMOVAL TECHNIQUES IS NOT ALLOWED.
8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

REV.	DATE	DCN #	DRAWING TREE #
v1	03 MAR 2009	E080446	E080191
v2	29 AUG 2010	E1000371	E080191
-	-	-	-









ISOMETRIC VIEW

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)

DIMENSIONS ARE IN INCHES

TOLERANCES:
.XX ± .01
.XXX ± .005

ANGULAR ± 0.5°

1. INTERPRET DRAWING PER ASME Y14.5-1994.
2. REMOVE ALL SHARP EDGES, R.02 MIN.
3. DO NOT SCALE FROM DRAWING.
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

MATERIAL: 304 OR 304L SSTL

FINISH: 63 µinch

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO

SUB-SYSTEM: SUS

NEXT ASSY: STRUCTURAL WELDMENT, HLTS

PART NAME: UPPER FRONT GUSSET

DESIGNER	D. BRIDGES	29 AUG 2010	
DRAFTER	D. BRIDGES	29 AUG 2010	
CHECKER	M. MEYER	30 AUG 2010	
APPROVAL			

SIZE: C

DWG. NO.: D070579

REV.: v2

SCALE: 1:1

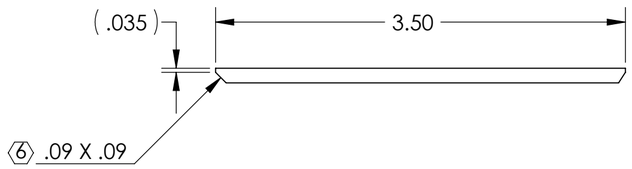
PROJECTION:

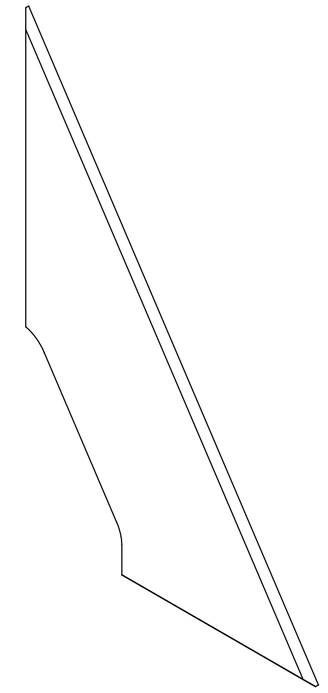
SHEET 1 OF 1

NOTES CONTINUED:

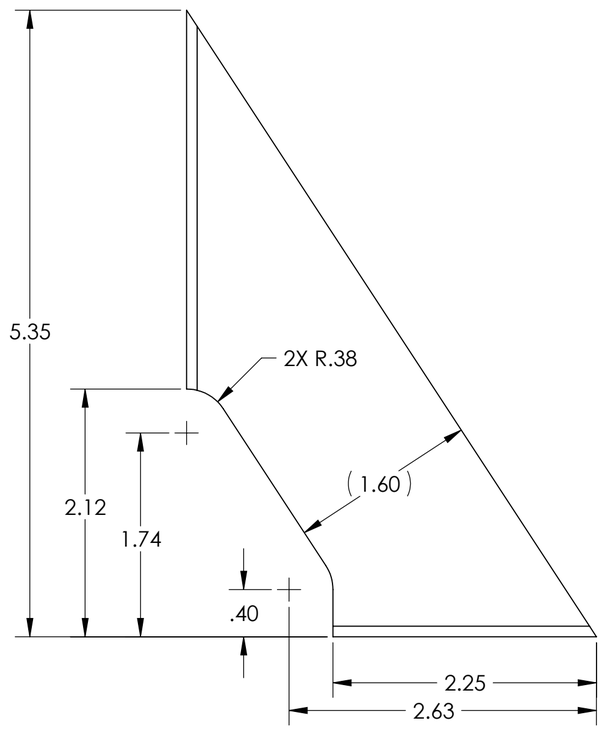
5. THIS PIECE IS ONE PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST-WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D070442 (STRUCTURAL WELDMENT, HLTS) FOR REQUIRED DIMENSIONS AFTER WELDING.
6. ⟨6⟩ HALF OF ALL LOWER FRONT GUSSETS TO HAVE CHAMFER ON OPPOSITE FACE (MIRROR IMAGE OF PART SHOWN).
7. MACHINE ALL SURFACES TO REMOVE OXIDES AND MILL FINISH. USE OF ABRASIVE REMOVAL TECHNIQUES IS NOT ALLOWED.
8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

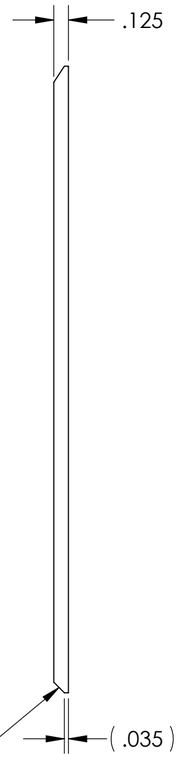
REV.	DATE	DCN #	DRAWING TREE #
v1	03 MAR 2009	E080446	E080191
v2	29 AUG 2010	E1000371	E080191
-	-	-	-





ISOMETRIC VIEW





NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)

DIMENSIONS ARE IN INCHES

TOLERANCES:
.XX ± .01
.XXX ± .005

ANGULAR ± 0.5°

1. INTERPRET DRAWING PER ASME Y14.5-1994.
2. REMOVE ALL SHARP EDGES, R.02 MIN.
3. DO NOT SCALE FROM DRAWING.
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

MATERIAL 304 OR 304L SSTL

FINISH 63 µinch

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM ADVANCED LIGO

SUB-SYSTEM SUS

NEXT ASSY STRUCTURAL WELDMENT, HLTS

PART NAME LOWER FRONT GUSSET

DESIGNER	D. BRIDGES	29 AUG 2010	
DRAFTER	D. BRIDGES	29 AUG 2010	
CHECKER	M. MEYER	30 AUG 2010	
APPROVAL			

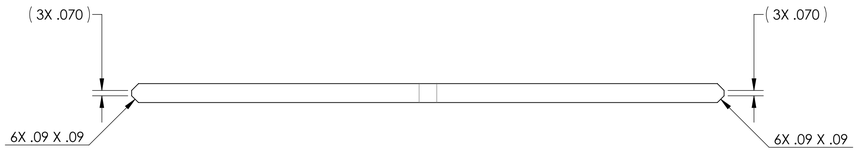
SIZE C **DWG. NO.** D070576 **REV.** v2

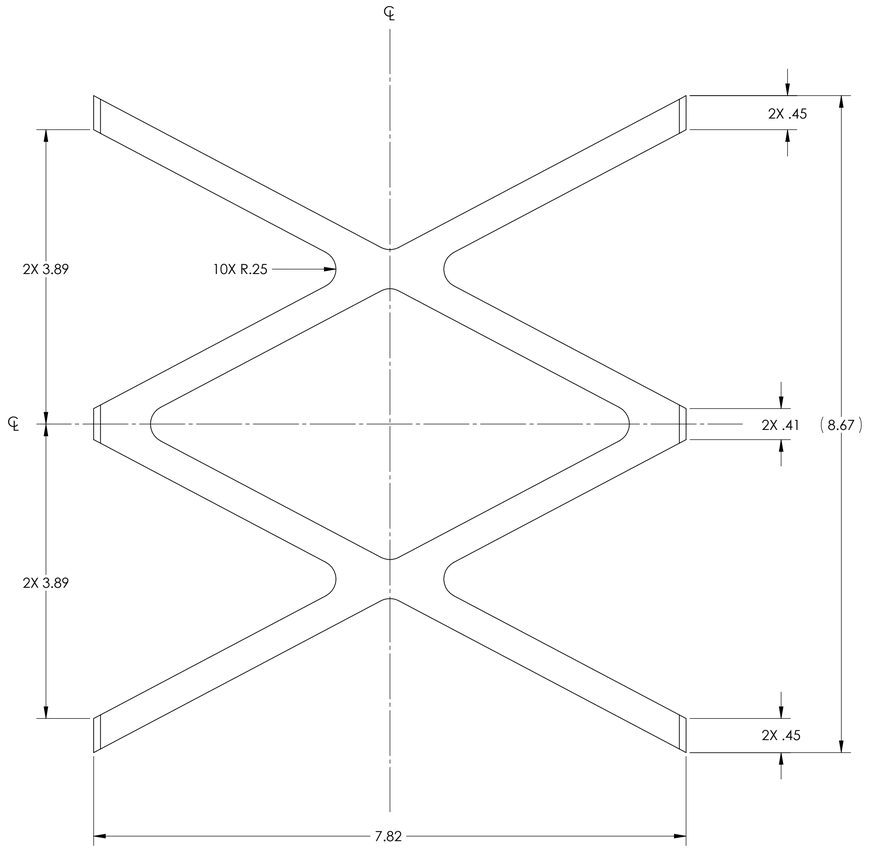
SCALE: 1:1 **PROJECTION:** SHEET 1 OF 1

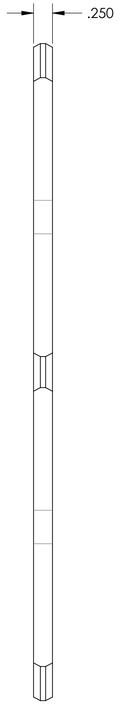
NOTES CONTINUED:

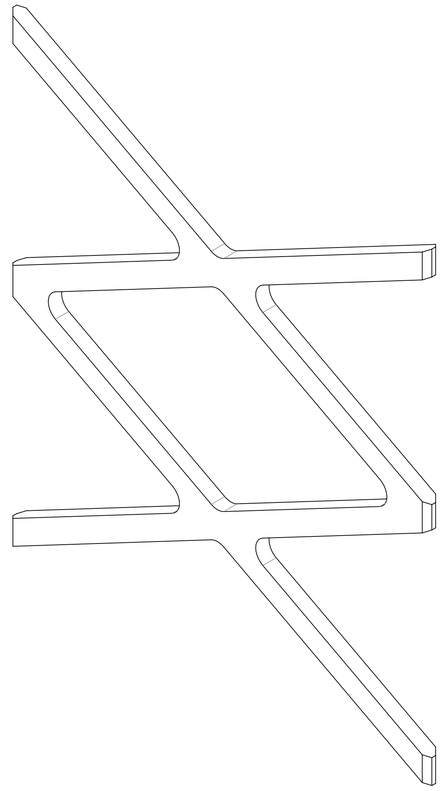
5. THIS PIECE IS ONE PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE; WELD INDUCED SHRINKAGE OR FILL, AND POST-WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D070442 (STRUCTURAL WELDMENT, HLTS) FOR REQUIRED DIMENSIONS AFTER WELDING.
6. MACHINE ALL SURFACES TO REMOVE OXIDES AND MILL FINISH. USE OF ABRASIVE REMOVAL TECHNIQUES IS NOT ALLOWED.
7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

REV.	DATE	DCN #	DRAWING TREE #
v1	03 MAR 2009	E080446	E080191
v2	29 AUG 2010	E1000371	E080191
-	-	-	-









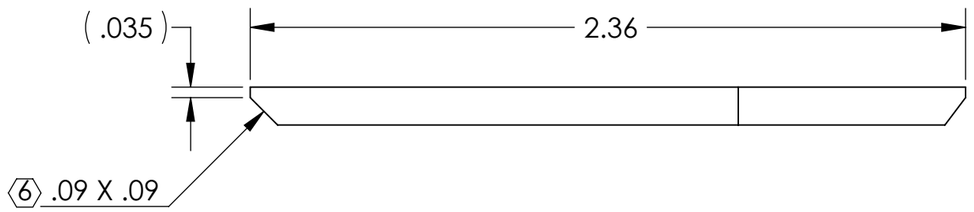
ISOMETRIC VIEW

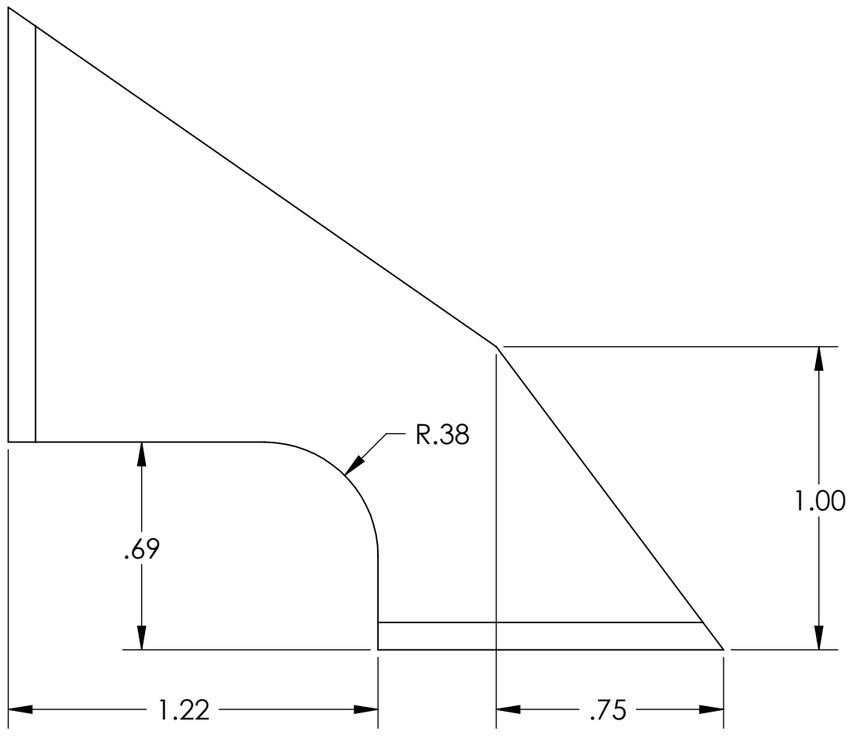
NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)									
DIMENSIONS ARE IN INCHES TOLERANCES: .XX ± .01 .XXX ± .005 ANGULAR ± 0.5°	1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, R.02 MIN. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.	LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME: SIDE STRUT					
		SYSTEM: ADVANCED LIGO	SUB-SYSTEM: SUS	DESIGNER	D. BRIDGES	29 AUG 2010	SIZE	DWG. NO.	REV.
				DRAFTER	D. BRIDGES	29 AUG 2010	D	D070578	v2
	MATERIAL: 304 OR 304L SSTL	FINISH: 63 µinch	NEXT ASSY: STRUCTURAL WELDMENT, HLTS	CHECKER	M. MEYER	30 AUG 2010			
				APPROVAL			SCALE: 1:1	PROJECTION:	SHEET 1 OF 1

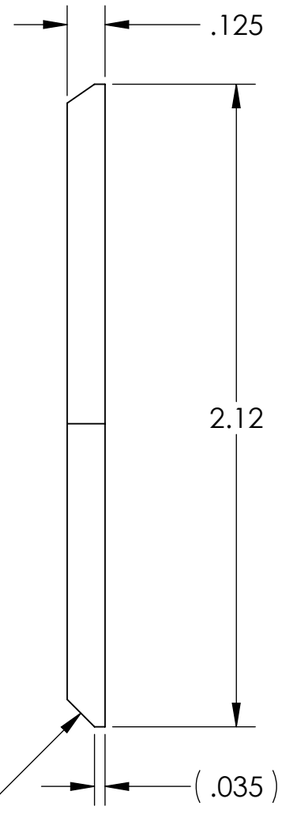
NOTES CONTINUED:

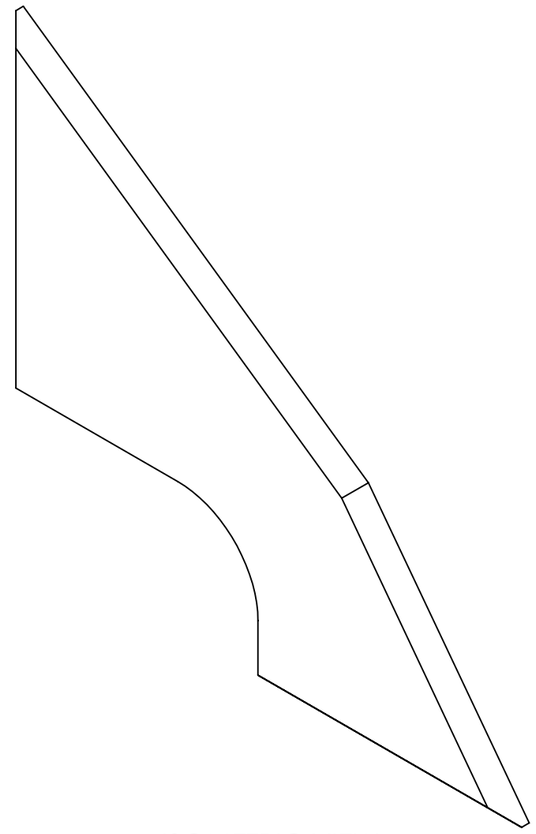
5. THIS PIECE IS ONE PART OF A WELDMENT. DIMENSIONS SHOWN ARE APPROXIMATE. WELD INDUCED SHRINKAGE OR FILL, AND POST-WELD ANNEALING AND MACHINING CONSIDERATIONS ARE NOT INCLUDED. SEE D070442 (STRUCTURAL WELDMENT, HLTS) FOR REQUIRED DIMENSIONS AFTER WELDING.
6. ⟨6⟩ HALF OF ALL SIDE GUSSETS TO HAVE CHAMFER ON OPPOSITE FACE (MIRROR IMAGE OF PART SHOWN).
7. MACHINE ALL SURFACES TO REMOVE OXIDES AND MILL FINISH. USE OF ABRASIVE REMOVAL TECHNIQUES IS NOT ALLOWED.
8. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.

REV.	DATE	DCN #	DRAWING TREE #
v1	03 MAR 2009	E080446	E080191
v2	29 AUG 2010	E1000371	E080191
-	-	-	-









ISOMETRIC VIEW

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)									
DIMENSIONS ARE IN INCHES TOLERANCES: .XX ± .01 .XXX ± .005 ANGULAR ± 0.5°	1. INTERPRET DRAWING PER ASME Y14.5-1994. 2. REMOVE ALL SHARP EDGES, R.02 MIN. 3. DO NOT SCALE FROM DRAWING. 4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.		LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY		PART NAME: SIDE GUSSET				
	MATERIAL: 304 OR 304L SSTL	FINISH: 63 µinch	SYSTEM: ADVANCED LIGO	SUB-SYSTEM: SUS	DESIGNER: D. BRIDGES 29 AUG 2010	SIZE: B	DWG. NO.: D070577	REV.: v2	
			NEXT ASSY: STRUCTURAL WELDMENT, HLTS		DRAFTER: D. BRIDGES 29 AUG 2010				
					CHECKER: M. MEYER 30 AUG 2010				
					APPROVAL:	SCALE: 2:1	PROJECTION:	SHEET 1 OF 1	

D070577_Advanced_LIGO_SUS_HLTS_Structure_Side_Gusset, PART PDM REV: V1-004, DRAWING PDM REV: V1-000

NOTES CONTINUED:

Ⓢ SCRIBE, ENGRAVE, OR MECHANICALLY STAMP (NO INKS OR DYES) DRAWING PART NUMBER, REVISION (AND VARIANT OR "TYPE" IF APPLICABLE) ON NOTED SURFACE OF PART FOLLOWED ON THE NEXT LINE WITH A THREE DIGIT SERIAL NUMBER. SERIAL NUMBERS START AT 001 FOR THE FIRST ARTICLE AND PROCEED CONSECUTIVELY. USE MINIMUM 0.12" HIGH CHARACTERS, UNLESS THE SIZE OF THE PART DICTATES SMALLER CHARACTERS. A VIBRATORY TOOL MAY BE USED. EXAMPLE: DXXXXXXX-VY, TYPE-XX, S/N XXX

6. MACHINE ALL SURFACES TO REMOVE OXIDES AND MILL FINISH. USE OF ABRASIVE REMOVAL TECHNIQUES IS NOT ALLOWED.
7. ALL PARTS SHALL BE MANUFACTURED IN ACCORDANCE WITH LIGO SPECIFICATION E0900364.
8. ALL HELICOIL HOLES TO BE PREPARED IN ACCORDANCE WITH EMHART HELICOIL PRODUCT CATALOG, HC2000, REV. 4.
9. ALL HELICOILS TO BE INSTALLED BY LIGO PERSONNEL AFTER DELIVERY, CLEANING AND BAKING OF FINISHED PARTS.

REV.	DATE	DCN #	DRAWING TREE #
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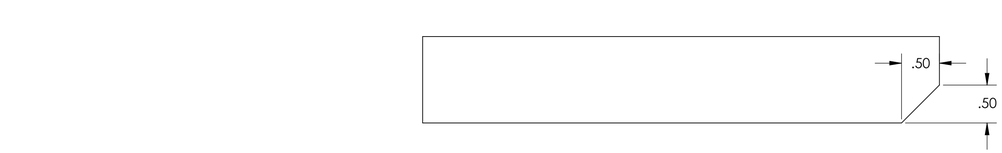
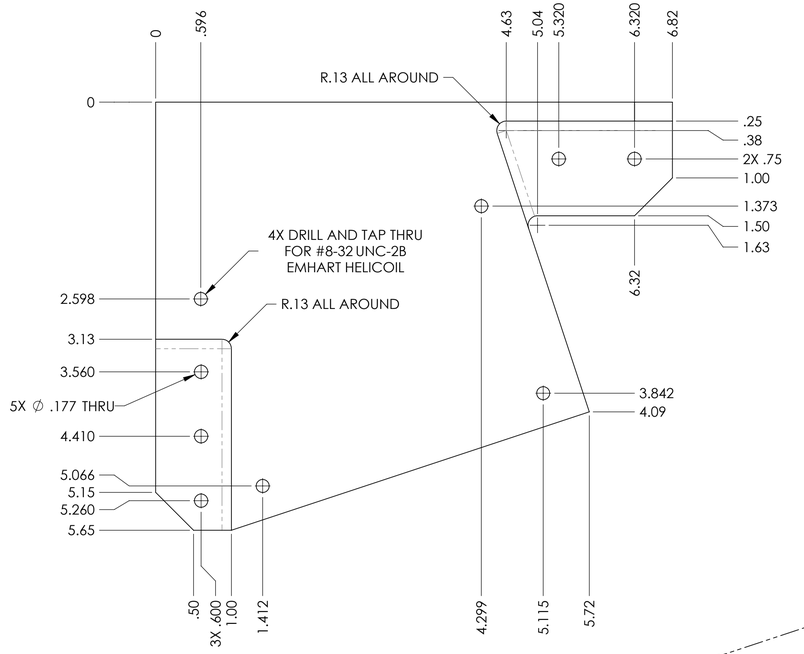
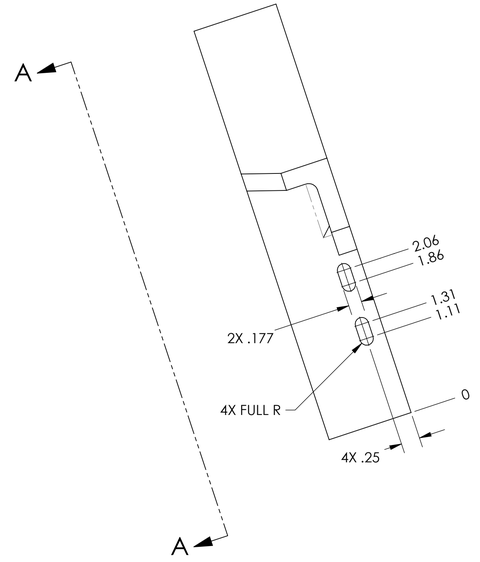
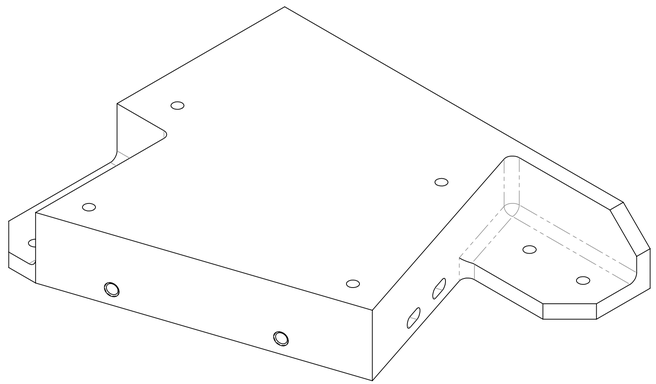
v2	29 AUG 2010	E1000371	E080191
-	-	-	-

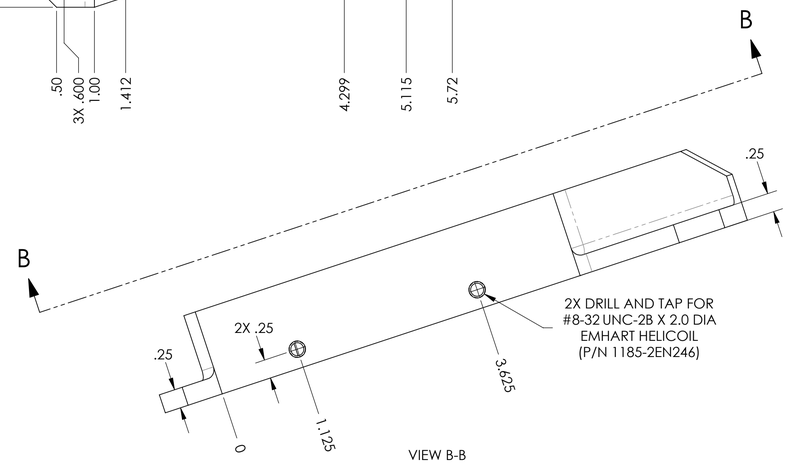






VIEW A-A





VIEW B-B

NOTES AND TOLERANCES: (UNLESS OTHERWISE SPECIFIED)

DIMENSIONS ARE IN INCHES

TOLERANCES:
.XX ± .01
.XXX ± .005

ANGULAR ± 0.5°

1. INTERPRET DRAWING PER ASME Y14.5-1994.
2. REMOVE ALL SHARP EDGES, R.02 MIN.
3. DO NOT SCALE FROM DRAWING.
4. ALL MACHINING FLUIDS MUST BE FULLY SYNTHETIC, FULLY WATER SOLUBLE AND FREE OF SULFUR, SILICONE, AND CHLORINE.

MATERIAL: 6061-T6 Al

FINISH: 32 µinch

LIGO CALIFORNIA INSTITUTE OF TECHNOLOGY
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SYSTEM: ADVANCED LIGO

SUB-SYSTEM: SUS

NEXT ASSY: MOUNTING PAD ASSY

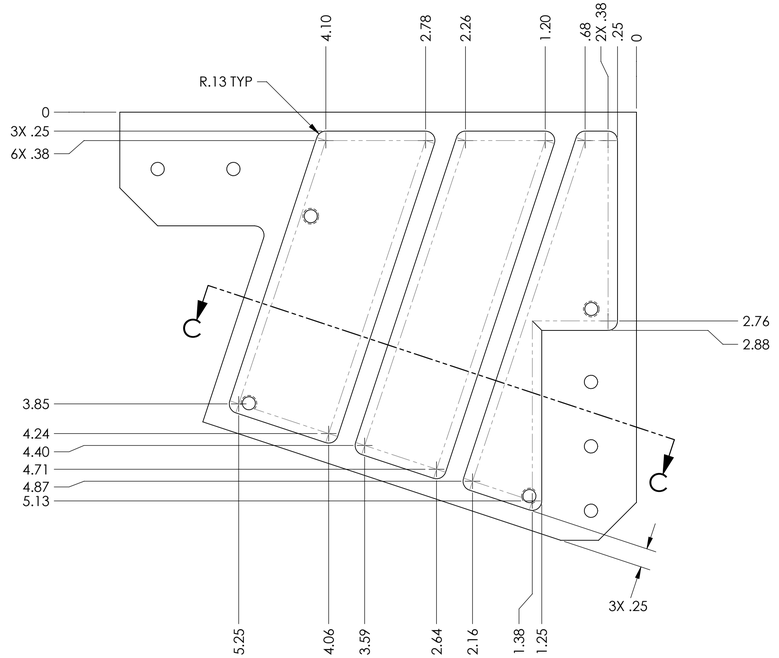
PART NAME: MOUNTING PAD BODY

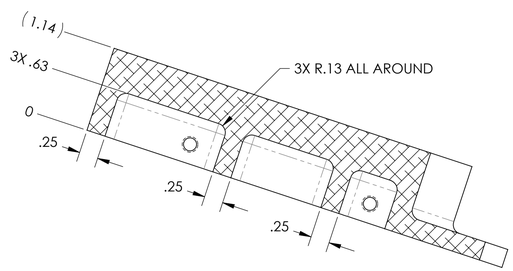
DESIGNER	D. BRIDGES	27 AUG 2010
DRAFTER	D. BRIDGES	27 AUG 2010
CHECKER	M. MEYER	30 AUG 2010
APPROVAL		

SIZE: D **DWG. NO.:** D070374 **REV.:** v2

SCALE: 1:1 **PROJECTION:** **SHEET** 1 OF 2

D070374_Advanced_LIGO_SUS_HLTS_Mounting_Pad_Body, PART PDM REV: V1-001, DRAWING PDM REV: V1-001





SECTION C-C

LIGO	CALIFORNIA INSTITUTE OF TECHNOLOGY MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
SIZE D	DWG. NO. D070374	REV. v2
SCALE: 1:1	PROJECTION:	SHEET 2 OF 2

Welding Specification for Weldments used within the Advanced LIGO Vacuum System

APPROVALS	DATE	Document Change Notice
AUTHOR(S): Calum Torrie, Dennis Coyner	06-Oct-2010	see DCC record Status: APPROVED

1 Scope

This specification controls the process of welding aluminum and stainless steel for parts (weldments) intended for service inside the Ultra-High Vacuum (UHV) for the Advanced LIGO project. Unless otherwise directed all weldments should be fabricated in compliance with this specification.

This specification does not cover welding elements of the vacuum envelope itself, but rather parts which are placed within the vacuum envelope.

2 Certification and End Item Data Package

The fabricator must provide the following certification or documentation:

1. To approve seamed tubing, if applicable, (see section 3.2) submit an inspection report confirmation on qualification of as received stainless steel seamed tubing, prior to starting production. As noted in section 3.2 this should include 100% inspection of flash removal if required (see section 3.2)
2. To approve welder and weld samples submit a Procedure Qualification Record (PQR) on welder and weld samples (see section 8), prior to starting production.
3. To approve method used for production weldments (see section 7) submit a Certified Welding Procedure Specification (WPS) on production weldments, this can be submitted with the PQR, prior to starting production.
4. To approve production weldments (see section 10) submit prior to final machining:
    a. An inspection report confirming the qualification of the production weldments to Class C, as per section 7.1 and 7.2 should be submitted.
    b. Certification that the requirements of the specification (WPS) have been met
    c. Material certifications for all materials (filler rod and base material) which comprise the weldment.
5. To approve final machining (see section 12) submit dimensional inspection report on final machining, at the time of delivery.

Welding Specification for Weldments used within the Advanced LIGO Vacuum System

3 Acceptable Materials

3.1 Base Material

Only the material alloys defined in the associated drawings are acceptable. No substitutions shall be made without prior written consent from the LIGO Contracting Officer. All material should be selected and transported according to our requirements, for example for stainless steel tubing follow section 3.2.5 and 3.2.6 below. A similar specification should be followed and agreed with the LIGO Contractual officer for Aluminum or other materials.

No parts, including seamed tubing, shall be ground or cut off with grinding tools.

3.2 Stainless steel tubing

Stainless steel seamed tubing, although an option, should not be the first choice if seamless tubing is available.

If seamed tubing is utilized, the weld seam and any weld flash must meet the requirements listed below. If the weld flash does not meet the requirements, then it must be removed. Details, including fixtures required to remove this flash and a method for removal should be included in this quote. The flash removal process must be inspected 100% visually and certified by the vendor and approved by LIGO.

With prior approval from a LIGO Contract Officer stainless steel seamed tubing can be used under the following conditions: -

1. Take a cross-sectional sample of the tube weld for every ~20 ft. of every continuous weld run (batch) and verify that the weld is Class B in Table V of Mil-Std-2219. The verification requires
   (a) visual inspection for weld discontinuities, porosity and inclusions,
   (b) x-ray for complete penetration and fusion and
   (c) microstructural examination of weld samples cross-sections (refer to section 8.3 for further details)
2. Supply inspection report for approval to the LIGO contract officer confirming that the as-received seamed welds conform to class B prior to continuing.
3. Prior to welding all seamed tubing (inside and out) should be electropolished to ASTM B-912. (Scotch-Brite(TM) or similar products are prohibited.)
4. As per section 11 of ASTM A554-10 the finished tubes shall be free of injurious defects and have a workmanlike finish. Surface imperfections such as handling marks, shallow pits and scratches shall not be considered as serious defects provided they are within 10% of the specified wall or 0.002 inch (0.05mm), whichever is greater.
5. Each tube should be individually wrapped and protected from scratches, pitting and digs during transport and handling. Each tube should be inspected and handled appropriately.

If stainless steel seamless tubing is available items 3.2.4 and 3.2.5 still apply.

Welding Specification for Weldments used within the Advanced LIGO Vacuum System

3.3 Filler Rod

The following Table shows the filler rod that should be used with various alloys:

Table 1: Welding Filler Rod

Material	Alloy	Filler
Stainless Steel	304	308, 308L
	304L	308L
	316	316, 316L
	316L	316L
	321	347
	347	347
Aluminum	6061	4043 (Linde H.Q.)

4 Cleaning and Preparation

1. Pre weld machining must be carefully controlled. All machines & fixtures are to be cleaned to avoid cross contamination before any machining takes place.
2. Weld preps must be machined and under no circumstances should weld preps be ground (due to risk of cross contamination). If machining is impractical use new carbide burrs.
3. Welds are not to be ground (due to risk of cross contamination); If welds need to be cleaned up, they must be cut.
4. Water soluble (not just water miscible) cutting fluid (lubrication) is to be used for all machining operations, such as weld prep, weld clean up or weld repair. The use of cutting fluids or lubricants, which contain sulfur, chlorine or silicone compounds is prohibited.
5. The contractor must define suitable methods for initial cleaning (oxide cleaning, degreasing, and dirt/soil removal), interpass cleaning and post-weld cleaning. An etchant (acid or basic) should be used, similar to the solutions defined in Annex G, "Solutions for Macroetching Aluminum Weldments" of AWS D1.2/D1.2M:2003 Structural Welding Code -- Aluminum. The contractor must define degreasing, deoxidizing, interpass and post-weld cleaning methods in the Weld Process Specification (WPS) and Process Qualification Record (PQR) which must be approved by LIGO before welding.
6. Prior to welding, clean the filler rod using lint- free tissue and analytical Reagent Grade isopropyl alcohol.

5 Handling and Storage

1. Latex gloves are to be worn for handling room temperature cleaned parts – parts to be welded or tools and fixtures.
2. If hot parts must be manipulated, clean tools are preferred rather than gloved hands. If hot parts or tools/fixtures need to be handled, then clean welding gloves should be used. A new pair of gloves should be dedicated to the LIGO work.

3. Tools and fixtures, which may contain cleaned parts in assembly or transport, are to be kept clean from oxides, oils, fingerprints, etc.
4. Parts are to be stored in a clean dry area until welding commences. Parts should not be stored for a long periods after cleaning, welding should commence as soon as possible and definitely within one work shift after parts are chemically cleaned.
5. Store filler metal in bonded storage and in a manner such that it is protected from oil and other contaminates. The package seal must not be broken until just prior to welding. Rod from an opened package must be kept in a cabinet or other area within the clean welding area.
6. Weldments and cleaned parts, tools and fixtures are to be covered between welding operations. The material used for covering can be UHV quality aluminum foil or clean stainless steel covers/boxes. If the parts are at room temperature, then cleanroom grade sheeting materials (low lint, low shedding), such as DuPont™ Tyvek®.
7. Welding should be performed in a clean, particulate and humidity (50% maximum relative) controlled environment.
8. Completed weldments are to be double wrapped and stored in a clean, controlled area prior to shipment. The inner wrap must be UHV quality aluminum foil. The outer wrapping, or bag, should be Ameristat® or similar class 100 cleanroom grade packaging material. No tape (adhesive) should be used to attach or close the inner wrapping. Heat sealing can not be performed with the part in the wrapping/bag.

6 Welding

6.1 General Requirements

1. All welding must take place in a clean, particulate and humidity (50% maximum relative) controlled environment. Welders must adhere to the contamination control practices described in these specifications.
2. Thin (less than 0.010 inch thick) stainless steel or beryllium-copper parts (e.g.: RF shields) may be spot welded using a resistance welding process. All other welding shall be by the tungsten inert gas (TIG) fusion process, unless specifically approved. Welding electrodes shall be 2 percent thoriated tungsten.
3. Prior to welding, all parts must be cleaned according to these specifications. Jigs, fixtures, chill rings (if used), and welding bench which contact the clean parts must also be cleaned according to these specifications.
4. The filler rod and must be kept clean at all times.
5. Leather welders gloves are of course used by the welder during welding. However, Latex gloves must be worn when clean “cold” parts are handled. If the gloves come in contact with anything other than clean surfaces, they must be replaced with new ones.

6. Appropriate brushes and high quality hand scrapers can be used for cleaning oxides off welds. Brushes and scrapers shall be degreased before use and kept free from oxides. Brass brushes and Scotch-Brite pads are prohibited.
7. Preheating is discouraged. If preheating the parts is necessary we would prefer that neither Propane nor Oxy-Acetylene be used as this will cause contamination in the weld. If Oxy-Acetylene is required please get prior written approval from the LIGO contracting officer.
8. All welds must be full penetration and full fusion welds. No trapped volumes are permitted. Weldments with crevices are considered non-cleanable since these crevices act as traps for cleaning solutions. Inspect the root weld before further passes, if remedial action is required only use clean Carbide burrs. Grinding (with abrasive wheels, cloth, or stones), or use of abrasive cloth or paper, is not permitted.
9. It can be difficult to achieve full penetration with a single-sided weld. Double-sided welds are permissible, as long as sectioning of weld samples indicate weld overlap and no voids (refer to section 7).
10. The welder shall protect material adjacent to the welds to prevent damage. In general final machining and machined details (tapped holes, etc.) are added after welding, but not in all cases. Care should be taken not to blemish or damage the part while welding.

6.2 Stainless Steel

1. Careful control of the parts shall be imposed so that carbon steel contamination is prohibited. In the event of carbon steel contamination, skim with a carbide tool to remove any residual contaminant
2. Back purge stainless steel welds in all cases. Maintain gas flow until the metal cools to prevent oxidation. Use Argon or Nitrogen Commercial Grade 99.98 percent or mixture of these for cover and purge gas.
3. Stainless steel parts should be welded within 24 hours after they are chemically cleaned.

6.3 Aluminum

1. For welding thick parts, the suggested procedure is to use D.C. straight polarity with Atomic Grade Helium as the cover gas. This method does not require pre-heating of the parts.
2. For parts of 1/8 inch thickness or less, use A.C. polarity with Argon cover gas.
3. Aluminum parts should be welded within 24 hours after they are chemically cleaned.

7 Weld Quality Requirements and Inspection

1. All welds on production weldments must meet requirements for Class C in table V of Mil-Std-2219 verified by visual inspection. Note that dye penetrant may only be used on a practice weld configuration and never on a final weldment.
2. All Class C welds shall be 100% visually inspected for cracks and weld discontinuities, porosity and inclusions. This should be aided by a magnifying lens of [5X] or [10X] power

wherever required to discern indications or defects otherwise not clear. Measure size and contour of welds with suitable gages. Clean welds per section 6.1.6 for inspection.

3. Submit a copy of certified Welding Procedure Specification (WPS) for approval, describing how the welding will be carried out on the production weldments. This should be submitted for approval with the LIGO Contracting Officer's Technical Representative along with the Procedure Qualification Record (PQR) referenced below in section 8. Once all of this is approved work can start on the production weldments.

8 Weld & Welder Qualification

1. All welders should be certified to American Welding Society (AWS).
2. Qualify the weld preparation, cleaning process, welders and welds by creating sample welds representative of each type of weld in the final weldment. It is important to design the samples to mimic the weld access and heat path that will be present in the weldment.
3. The sample weldments must meet requirements for Class B in Table V of Mil-Std-2219 as verified by: -

   (a) visual inspection for weld discontinuities, porosity and inclusions,

   (b) x-ray for complete penetration and fusion and

   (c) Cross-sections of weld samples, for microstructural examination, should be prepared by cutting in an orientation perpendicular to the direction of the weld bead so that the size and shape of the weld and the heat-affected zone (HAZ) can be observed. Each weld sample should be sectioned and polished by standard metallographic procedures (for example, mounted in an epoxy, polished with a 5 micron diamond paste and then be etched with Keller's reagent). The section samples should be examined and photo-micrographed at approximately 15x. Any weld discontinuities should be further examined and photographed at 50x to 200x magnification.
4. Submit a Procedure Qualification Record (PQR) and the sample welds to LIGO. The PQR should include all evidence of compliance with the Class B qualification including photographic evidence of samples and documentation on the weld preparation, parts cleaning process, welding process, and preparation and qualification of the welder(s). All welds, and associated photographs and micrographs, must be labeled and presented in the form of a test or inspection report.
5. Prior to a new welder producing a LIGO weldment. They must be qualified for the welding process(es) and weld joints used on the LIGO weldment. Copies of the welder's certification for the LIGO weldment, in the form of a Performance Qualification Record on the weld samples outlined above, must be kept on file and available for LIGO inspection.

6. Vendors should qualify the welding procedures, welders and welder operators in accordance with Section 3 of AWS D1.2/D1.2M:2003 and Section 4 of AWS D1.1/D1.1M:2008.

9 Weld Repair

1. If a weld has surface blemishes, high porosity, hairline cracks or incomplete penetration then the weld should be re-flowed and then re-inspected.

10 Weld approval

Once the production weldments have been satisfactorily completed and prior to completing the remaining steps in this specification the contractor must have the welds accepted and approved by the LIGO Contracting Officer's Technical Representative. The approval step should include a visit by the LIGO Contracting Officer's Technical Representative. At the time of the visit the following items should be delivered to the LIGO Contracting Officer's Technical Representative: -

1. An inspection report confirming the qualification of the production weldments to Class C, as per section 7 (points one and two) should be submitted.
2. Certification that the requirements of the specification (WPS) have been met
3. Material certifications for all materials (filler rod and base material) which comprise the weldment.

The approval step can also be done without a visit and via e-mail, if approved by the LIGO Contracting Officer's Technical Representative and only if photographs of all of the welds are added to the report.

Once approval is obtained the contractor should continue with the following steps.

11 Post-Weld Stress Relief

After welding and approval all weldments must go through a stress relief heat treatment prior to any final machining.

12 Final Machining

Any features on the weldment which are dimensionally critical are machined after welding and post-welding stress relief. These features will be called out in the associated drawing package. Any dimensional inspection required will be called out in the associated RFQ / RFP / SOW.

13 Post-weld Cleaning

The weldment must be cleaned as per the following specification. (Scotch-Brite(TM) or similar products are prohibited.)

13.1 Aluminum

1. First the parts or assemblies are de-burred, and cleaned, removing all possible machining and weld process residue. Use only clean Carbide burrs. Grinding (with abrasive wheels, cloth, or stones), or use of abrasive cloth or paper, is not permitted.
2. The part(s) are then washed with Alkaline Soak Cleaner and inspected for cleanliness using the water break test.
3. The weldment is then submerged in a tank of Bright Dip chemicals at elevated temperature (typically 140 to 200 degrees F) for several minutes (typically 2 to 10 mins). The bright dip acid formulation, time and temperature should be chosen to achieve slight chemical etching (<0.0005 inch).
4. The weldment is then thoroughly rinsed with clean water. After rinsing, a full visual inspection is performed, to assure a satisfactory Bright Dip surface finish has been achieved uniformly, over the entire weldment
5. The parts are then dried, re-inspected and un-racked.
6. In order to remove any weld stain, left behind after the Bright Dip process, use acetone and fine Stainless Steel wire brushing, the brush bristles should be .004”/.006” in diameter.
7. No LIGO weldments intended for use within the vacuum system shall be anodized.

13.2 Stainless Steel

1. First the parts or assemblies are de-burred, and cleaned, removing all possible machining and weld process residue. Use only clean Carbide burrs. Grinding (with abrasive wheels, cloth, or stones), or use of abrasive cloth or paper, is not permitted.
2. The part(s) are then cleaned and inspected for cleanliness using the water break test. The water-break test is performed by withdrawing the surface to be tested, in a vertical position, from a container overflowing with water, refer to ASTM A380-06 and in particular ASTM F22 for further information on this step.
3. Stainless steel parts are to be pickled and passivated at room temperature, with special attention paid to sufficiently agitate the solution or flush the inside of the box section used in the particular design. The pickling and passivation process formulation, time and temperature should be chosen to achieve slight chemical etching (<0.0005 inch).
4. The weldment is then thoroughly rinsed with clean water. After rinsing, a full visual inspection is performed, to assure a satisfactory surface finish has been achieved uniformly, over the entire weldment
5. The parts are then dried, re-inspected and if appropriotte un-racked.

14 Delivery and receipt

After post-weld cleaning (section 13) re-inspect all welds. Refer to RFQ / RFP / SOW for information on acceptance and deliver criteria.

15 Subsequent Processing Steps

Any subsequent processing steps are not performed by the manufacturing/welding contractor, but listed here for completeness.

15.1 Ultra-High Vacuum (UHV) Cleaning & Baking

LIGO will inspect, clean and bake in preparation for Ultra-High Vacuum (UHV) service in accordance with E960022.

16 References

1. Mil-Std-2219 — Fusion Welding for Aerospace Applications
2. AWS D1.2/D1.2M:2003 — Structural Welding Code - Aluminum
3. AWS D1.1/D1.1M:2008 — Structural Welding Code - Steel
4. ASTM E-165 — Standard Test Method for Liquid Penetrant Examination
5. ASTM B-912 — Standard Specification for Passivation of Stainless Steels Using Electropolishing
6. LIGO-E960022-v2 — LIGO Vacuum Compatibility, Cleaning Methods and Qualification Procedures
7. ASTM A380 - 06 — Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
8. ASTM F22 — Test Method for Hydrophobic Surface Films by the Water-Break Test

Welding Specification for Weldments used within the Advanced LIGO Vacuum System

17 Supply Sources

Item	Description	Supplier
Ameristat®	Clean room sheeting Class 100 stratogrey, single wound, rollstock	Bay Stat 3575 Haven Avenue Menlo Park, CA 94025-1009 (650)364-3205 Voice (650)363-8079 Fax
UHV Aluminum Foil	Part # ASTM B 479 0.015” x 24” x 500’ and 0.015” x 48” x 500’ UHV Certified Aluminum Foil	All Foil 4597 Van Epps Road Brooklyn Heights, Ohio 44131 (216)661-0211 Voice (216)398-4161 Fax

Metal components intended for use in the Adv LIGO Vacuum System

APPROVALS	DATE	Document Change Notice
AUTHOR(S): Calum Torrie, Dennis Coyne, Ken Mailand	19-Oct-2010	see DCC record Status:

1 Introduction

All metal components intended for vacuum service shall have quality finishes on all surfaces, suitable for service in an Ultra-High Vacuum (UHV) system. These requirements define the restrictions and practices which must be followed for parts to be used in the LIGO UHV system.

Exceptions, additions or clarifications should be obtained from the LIGO Contractual officer or the Contracting Officer's Technical Representative.

2 Scope

These requirements only apply to metal components intended for in-vacuum service; If the parts are not intended for in vacuum, then these requirements do not apply.

In addition these requirements do not apply to cantilever blade springs, all weldments and porcelain steel. For these applications, see the following references:

LIGO-E0900023, Process for Manufacturing Cantilever Spring Blades

LIGO-E0900048, Welding Specification for Weldments used within the Advanced LIGO Vacuum System

LIGO-E1000083, Specification for Enameled Steel Sheet to be used in the LIGO Ultra-High Vacuum System

3 Purchase Order Specific Requirements

In addition to the requirements defined in this specification, additional requirements, specific to a particular procurement or part, may be defined in the Statement Of Work (SOW) or Request for Quotation (RFQ).

4 General Requirements for Metal parts in vacuum

4.1 Materials

Only materials (specific alloys) approved for use in the LIGO UHV system may be used. All materials should be specified on the drawing. No substitutions may be made without prior approval by the Contracting Officer or the Contracting Officer's Technical Representative.

Tooling plate material is not permitted.

All material is to be virgin material (i.e. no weld repairs or plugs unless approved in advance in writing by LIGO (see also section 4.8)

4.2 Castings, Moldings

No cast or molded parts are permitted.

4.3 Machining

All final surfaces of all parts are to be machined; No as received, as rolled, as milled surfaces will be accepted, unless otherwise noted on the drawing.

All machining, and tapping, fluids must be fully synthetic, water soluble (not simply water miscible) and free of sulfur, chlorine, and silicone. If this is difficult or expensive please talk to LIGO staff about an exemption.

4.4 Abrasive Removal Techniques

4.4.1 Grinding

No grinding or lapping with abrasive wheels, cloth or stones is permitted for the final surface, unless otherwise noted on the drawing. Grinding (e.g. Blanchard grinding) is acceptable if all ground surfaces are machined afterwards.

4.4.2 Sanding

No parts are to be sanded with abrasive techniques e.g. sanding, grinding. Scotch-Brite ™ or similar products are not permitted. Stainless steel wool can be used if sanding is required.

4.4.3 Scotch-Brite™

The use of Scotch-Brite™ or similar products is not permitted at any time.

4.5 Finishing (Surface roughness)

The required surface roughness (finish) is defined in the drawing block entitled “finish. If no call-out is included in this block, then the surface finish should default to: -

- 63 micro-inch (Ra) for stainless all surfaces
- 63 micro-inch (Ra) for aluminum all surfaces

Please note if finish is called out on the drawing it is in Ra.

Localized scratches, digs and blemishes should be minimized and addressed though visual inspection and QA. If such blemishes compromise the function or performance of the part (e.g. a stray light control baffle), then limits on acceptable scratches and digs should be defined in the drawing or associated process specification.

In general no coatings or finishes shall be applied to any metal parts, with the exception of silver or other approved coatings for tribology or thermal control reasons. If any coatings or finishes are required they

will be defined in the drawing or associated process specification. In particular no aluminum parts are to be anodized.

4.6 Cleaning requirements

Thoroughly clean part to remove all ink, oil, grease, dirt, and chips with soap and water. Solvents may be used.

4.7 De-burring

All sharp edges and corners shall be rounded. You can de-burr with de-burring tools, filing and / or stainless steel wire brushes. Tumbling or use of steel wool is not acceptable for de-burring. All deburring tools, files and stainless wire brushes must be clean and free of contaminants.

4.8 Repairs

No repairs shall be made unless approved in advance, and in writing, by LIGO Laboratory. In general weld repairs and press fit insert repairs are never acceptable; The material should be virgin material. Special circumstances can be reviewed if/when brought to the attention of LIGO Contracting Officer's Technical Representative (COTR), through a Material Review Board (MRB) process.

4.9 Exceptions

When it is not practical to machine all surfaces, e.g.

1) if extruded tubular sections (or angles or other stock shapes) are to be used, then machining the interior surfaces is not practical and machining the outer radius on the corners is prohibitive. In this case either

a) all surfaces of all parts are to be machined, except those not practical to machine. In this case the inner surface and outer radius will be accepted "as extruded" or "as rolled", or

b) the part is electropolished to remove all surface oxides and potentially embedded contaminants

2) large thin sheet should be either acid etch or bright dip to remove the oxide layer

3) large thin sheet (alternative) could have a surface finish higher than the standard 32 Ra micro inch delivered from the supplier. If this option is selected the surface finish should be discussed with LIGO Contractual officer prior to acceptance.

Further questions related to machining all surfaces can be discussed with the LIGO Contractual officer or the Contracting Officer's Technical Representative.

5 Further Cleaning (only if specified)

These cleaning steps only apply if called out in the individual SOW/RFQ and/or drawing. Additional questions related to this section on further cleaning can be discussed with the LIGO Contractual officer or the Contracting Officer's Technical Representative.

5.1 Aluminum

1. First the parts or assemblies are de-burred, and cleaned, removing all possible machining residue..
2. The part(s) are then washed with Alkaline Soak Cleaner and inspected for cleanliness using the water break test.
3. The part(s) are then submerged in a tank of Bright Dip chemicals at elevated temperature (typically 140 to 200 degrees F) for several minutes (typically 2 to 10 mins). The bright dip acid formulation, time and temperature should be chosen to achieve slight chemical etching (<0.0005 inch).
4. The part(s) are then thoroughly rinsed with clean water. After rinsing, a full visual inspection is performed, to assure a satisfactory Bright Dip surface finish has been achieved uniformly, over the entire part(s).
5. The parts are then dried, re-inspected and packaged for shipment.

5.2 Stainless Steel

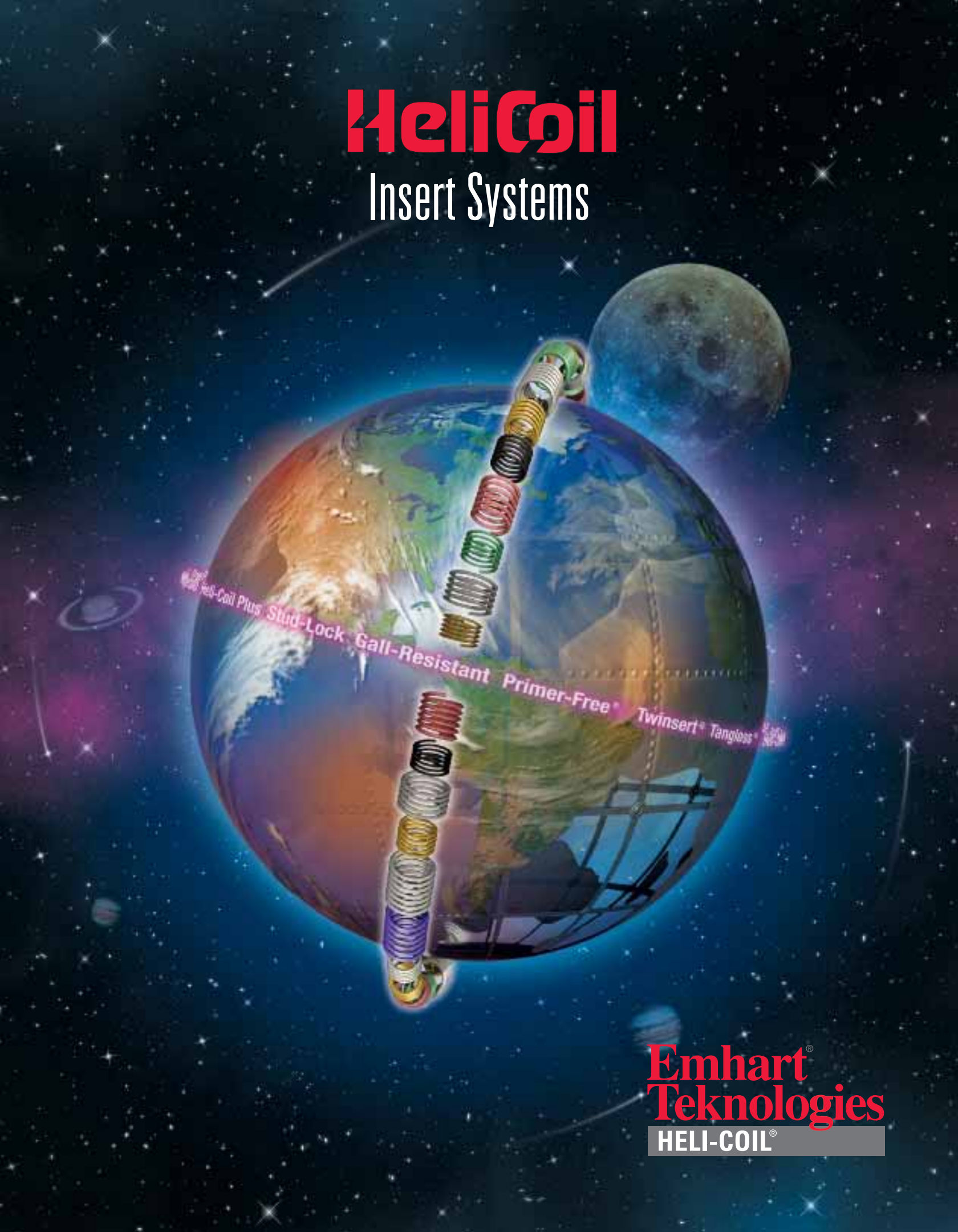
5.2.1 Pickling & Passivation

1. First the parts or assemblies are de-burred, and cleaned, removing all possible machining residue and inspected for cleanliness using the water break test..
2. Stainless steel parts are to be pickled and passivated at room temperature, with special attention paid to sufficiently agitate the solution or flush the inside of the box section used in the particular design. The pickling and passivation process formulation, time and temperature should be chosen to achieve slight chemical etching (<0.0005 inch).
3. The part(s) are then thoroughly rinsed with clean water. After rinsing, a full visual inspection is performed, to assure a satisfactory surface finish has been achieved uniformly, over the entire part(s).
4. The parts are then dried, re-inspected and packaged for shipment.

5.2.2 Electropolish

Electropolishing stainless steel parts is also allowed. If using electropolishing on a part follow similar steps to those outlined in section 5.2.1 Pickling. The use of Scotch-Brite ™ or similar products is not permitted.

HeliCoil
Insert Systems



Emhart® Teknologies
HELI-COIL®

Creating the Future Worldwide.

At Emhart Teknologies, creating the future is about growth, about change and about taking risks. It is who we are and what we do. Our focus is to reduce the overall product assembly costs of our customers by anticipating needs and meeting those needs with technology and market-driven solutions.

Emhart is a global leader in the design and creation of unique assembly technologies, delivering depth and breadth of service and product through a flexible, cross-functional global organization.

Owning The Customer's Total Experience

We provide every customer with the capability to satisfy every aspect of fastening and assembly technology. From concept through installation, around the corner and around the globe, Emhart develops and delivers solutions for challenging assembly applications.

Technology Optimization

Emhart has the ability to objectively match customer priorities, applications and manufacturing environment with the most appropriate assembly technology and fastening systems. We provide this capability through Application Engineers, and Mobile, Stationary and Virtual Innovation Centers located around the world. Each is capable of sharing application data and new design concepts with each other as well as with our customers.

System Integration

Emhart provides technological solutions in over 100 different countries. For each of these countries and for every application, we deliver innovative, integrated systems solutions from concept and design through system integration, worldwide.

Product Consultancy

Emhart employs Application Analysis and Value Engineering to demonstrate how our technology can enhance the assembly process, and Value Analysis to detail the cost/benefit relationship of applying our technologies.

Innovative Services

Emhart is infused with the spirit and culture of innovation. From our Stationary Innovation Centers to our unique Mobile Innovation Centers, Emhart has built a worldwide service and technology infrastructure to support our customers, 24 hours a day, seven days a week.

DODGE GRIPCO HELI-COIL NPR PARKER-KALON POP TUCKER WARREN

HeliCoil® Wire Inserts

Heli-Coil® precision formed wire inserts are readily recognized and highly regarded products in the industry. Since its inception in 1938, Heli-Coil has been identified as an industry leader offering products with superior performance, reliability and integrity.

Our strict quality programs ensure that we meet the latest industry standards of AS9100 Rev. B, ISO 9001: 2000 and ISO/TS 16949: 2002. A comprehensive Business Management System elevates our quality levels well above our competitors.

Heli-Coil wire inserts are manufactured with over 70 years of experience. We are dedicated to exceeding our customers' expectations by providing innovative value-added design and engineering services, on-time deliveries and excellent customer service support. Heli-Coil is committed to developing superior products manufactured to only the highest quality standards. We are more than just a supplier, we are a business partner.

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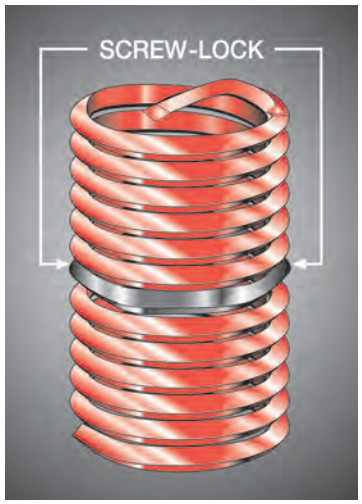
Types of Inserts

There are two styles of Heli-Coil inserts. The **STANDARD** or Free Running Insert – available in both Tanged and Tangless – which provides a smooth free-running thread; and **SCREW-LOCK** – available in both Tanged and Tangless – which provides self-locking torque on the male member by a series of "chords" on one or more of the insert coils. They are available in inch series, coarse and fine and metric series, coarse and fine. Inch series Screw-Lock inserts are dyed red for identification.

Standard Heli-Coil Insert



Screw-Lock Heli-Coil Insert

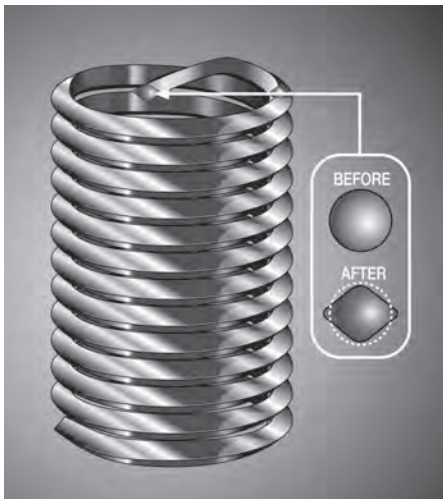
Heli-Coil inserts are precision formed coils of extremely hard, diamond shaped 304 stainless steel. When installed into an STI tapped hole, they provide permanent conventional 60° internal screw threads. This assembled insert accommodates any standard bolt or screw as per MIL-S-7742 and AS8879 (UNJ controlled root radius). See page 9 for material availability.

Heli-Coil inserts are larger in diameter before installation than the tapped hole. During installation the inserting tool applies torque to the tang reducing the diameter of the leading coil permitting it to enter the tapped thread. After installation, each high tensile coil of the insert expands outward with a spring-like action permanently anchoring the insert.

Tanged Size Range:

- UNC #1 through 1-1/2
- UNF #2 through 1-1/2
- Metric Coarse M2 through M39
- Metric Fine M8 through M39

Inserts are also available in UNEF, UNS, 8UN, 12UN, 16UN, Spark Plug and Pipe Thread.



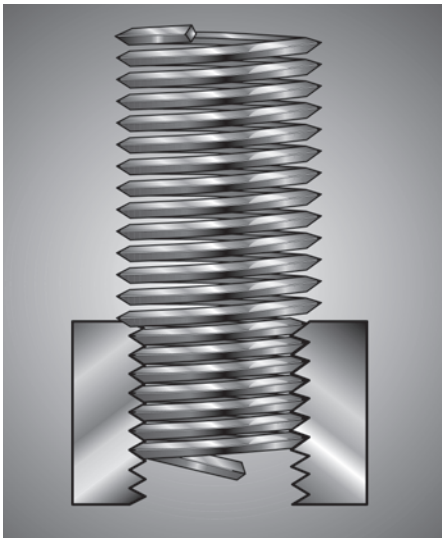


Illustration of the Retention Principle

Tangless Heli-Coil Insert

Tangless Size Range:

- UNC #2 through 1/4
- UNF #10 and 1/4

FEATURES & BENEFITS...

Heli-Coil inserts provide a positive means for protecting and strengthening tapped threads in any material. The unique design features of the insert offer many benefits.

- **Stronger Assemblies.** Tapped threads are strengthened because the inherent flexibility of the insert provides a more balanced distribution of dynamic and static loads throughout the length of thread engagement. This flexibility also compensates for variation in lead and angle error allowing each coil to carry its share of the load.
- **No Thread Wear.** Thread life is dramatically increased even after repeated assembly and disassembly because the insert hardness and surface finish practically eliminate erosion of the thread form due to friction.
- **Corrosion Resistance.** Under normal environmental conditions, Heli-Coil inserts minimize galvanic action within the threaded assembly because of their superior corrosion resistance.
- **Design Flexibility.** Bolt tensile strength can be balanced against parent material shear strength, assuring bolt failure rather than parent material damage. Five insert lengths are available in each thread size.
- **Eliminate Stress.** Virtually no stress is introduced into the parent material because there is no staking, locking, swaging or keying in place – the outward spring-like action of the insert holds it in place.
- **Minimize Space & Weight.** Heli-Coil inserts allow use of smaller bosses, flanges and fasteners than any other insert. Heli-Coil inserts can generally be incorporated in existing designs, where no provision has been made for an insert, without increasing boss size.
- **Minimize Total Cost.** Cost savings abound. Lower insert cost, lower installation cost and Heli-Coil inserts provide design flexibility by allowing a wide choice of parent materials while maintaining maximum threaded assembly strength.
- **True Clamping Torque.** Maximum clamping action and bolt tension are assured with minimum wrench torque because of the mirror-smooth surface finish of Heli-Coil inserts.
- **Wide Temperature Range.** Heli-Coil stainless steel inserts can be used in temperatures ranging from –320°F to +800°F.
- **Quality & Reliability.** Stringent Quality Assurance and Engineering Standards are rigidly enforced in all phases of the manufacturing process. This assures integrity of your product design.

High Production

Heli-Coil inserts are available mounted on plastic strips and wound onto reels (500 or 1000 inserts per reel). With power installation tooling, use of strip feed inserts will substantially increase installation rates by minimizing handling.

Universal Acceptance

Heli-Coil Standard and Screw-lock Inserts are the original – and have an extensive background of tension, torque, shear, vibration and fatigue tests conducted by American industry's leading companies as well as the U.S. Military. Successful applications in the fields of aviation, electronics, industrial, automotive and military equipment provide a wealth of experience and confidence in the performance and reliability of Heli-Coil inserts.

Total Design Service

In addition to the benefits listed above, Heli-Coil provides a wide range of support to solve fastening problems. This manual is one of them – the following pages are presented in a manner to make it easy to "design-in" Heli-Coil inserts to take advantage of the extraordinary benefits they provide.

Additionally, our Sales Engineers, Applications Engineers and Design Engineers are available for consultation for specific designs. When the product gets to the manufacturing phase, our extensive experience in production tooling and installation techniques ensures that you can indeed make your product better with Heli-Coil inserts.

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Canada (514) 351-0330 • Mexico +52-55-5326-7100

Heli-Coil® screw locking thread inserts

Heli-Coil offers three types of Locking Inserts for multiple applications…

Screw-Lock Inserts:

- Positive self-locking torque, complying with NASM8846 and MA1565.
- A resilient locking mechanism (applies to Heli-Coil screw-lock inserts) that grips the bolt and prevents it from loosening under vibration or impact.
- Repeated assembly and disassembly without appreciable loss of self-locking torque.
- Savings in space, weight and money, through the elimination of lock wiring, lock nuts, lock washers, chemical compounds, plastic pellets/patches and other locking mechanisms.

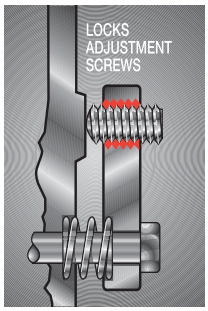
Hi-Torque Inserts:

- Similar to Screw-Lock except higher prevailing torque compensates for reduced friction in highly lubricated applications.
- Ideal for higher vibration applications.
- Approximate 40% increase in prevailing torque levels.
- Available in #10 through 3/8" UNF only.
- Meets **AS1394, AS3094, 3095, 3096, 3097.**

Stud-Lock Inserts:

- Highest prevailing torque insert available.
- Enables use of threaded rod for space-saving stud applications.
- Allows for any class fit of threaded rod.
- Eliminates inconsistencies caused by interference-fit studs.
- Available for both straight and step studs, #10 through 1/2" UNC and UNF.
- Meets **AS1229, AS3080, 3081, 3082, 3083**

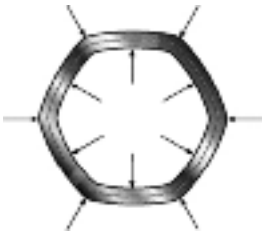
LOCKING FEATURES & BENEFITS…



Locks Adjusment Screws. This simple design allows permanent, positive adjustment of screws in any position, secure against vibration or impact.

Inaccessible or Miniaturized Assemblies. Heli-Coil Screw-Lock inserts permit the installation of the lock from the front or top. No blind fumbling for assembly of lock washers or lock nuts behind or underneath.

Lock Set Screws. Positively locks assembly against loosening at desired adjustment – protects threads against stripping under high torque – permits use of light housing materials.



The locking action is achieved by one or more of the insert coils having a series of straight segments or **"chords"**. When the bolt enters the **"grip"** coil, these chordal segments flex outward, creating pressure on the bolt. The pressure is exerted between the flanks of the bolt thread to establish an extensive positive and consistent self-locking torque over more cycles than any other prevailing torque mechanism.

Heli-Coil® industry standards

Industry Standards

Heli-Coil inserts and tooling comply with the following Standards and Specifications:

- **NASM122076 thru NASM122275.** Insert, corrosion resistant Helical Coil Coarse Thread (Inch Series)
- **NASM124651 thru NASM124850.** Insert, corrosion resistant Helical Coil Fine Thread (Inch Series)
- **NASM21209.** Insert, Screw Thread – Self Locking (Inch Series)
- **NASM33537.** Insert, – Standard Dimensions, Assembly
- **NASM8846.** Insert, Screw Thread, Helical Coil
- **MA1565.** Insert, Screw Thread, Helical Coil (Metric Series)
- **MA1567.** Insert, Screw Thread, Helical Coil (Metric Series), Standard Dimensions, Assembly
- **MA3279, 3280, 3281.** Insert, Screw Thread, Helical Coil, Free Running (Metric Series)
- **MA3329, 3330, 3331.** Insert, Screw thread, Helical Coil, Screw Locking (Metric Series)
- **AS59158.** Tools for inserting and extracting Helical Coil Inserts
- **NAS1130.** Inserts, Screw Thread, Helical Coil, Free Running and Screw Locking (Inch Series)

Heli-Coil® industry standards

- **FED-STD-H28**. Screw Thread Standards for Federal/Services
- **AS1394 thru 3097**
- **AS1229 thru 3083** Special Locking Torque Inserts
- **ASME B18.29.1** Insert, Screw Thread, Helical Coil (Inch Series)
- **ASME B18.29.2M-2005** Helical Coil Screw Thread Inserts, Free Running and Screw Locking (Metric Series)
- **AGS3600-3699** Insert, Screw Thread, Screw Locking, Helical Coil, Cadmium Plated (Inch Series)
- **AGS4677 Series** Insert, Screw Thread, Screw Locking, Helical Coil, Cadmium Plated (Metric Series)
- **AS6733** Inserts, Wire Thread, (UNF) - Unplated
- **AS6734** Inserts, Wire Thread, (UNC) - Unplated
- **AS8455** Inserts, Wire Thread, (UNF) - Cadmium Plated
- **AS8456** Inserts, Wire Thread, (UNC) - Cadmium Plated

Heli-Coil® insert coatings & plating

Coatings/ Plating	Benefits
Dry Film Lubricant	Provides additional lubrication in high friction applications High temperature resistance (400°F) Highly recommended with Heli-Coil Screw-Lock inserts Mildly corrosion resistant
	Material Spec: AS5272 Color: Grey
Cadmium Plating	Provides high corrosion resistance Provides lubrication to prevent galling (Not recommended for new design due to its toxic nature)
	Material Spec: QQ-P-416 Type II Color: Iridescent yellow - Free-Running Color: Olive drab - Screw-Lock
Primer-Free® II	Contains no chromates Eliminates need for zinc primers and epoxies Prevents galvanic corrosion between insert and parent material Eliminates locking torque issues associated with primers Improves installation productivity Provides additional lubrication facilitating insert installation
	Material Spec: None Color: Matte black
Silver Plating	Recommended to reduce galling of threads at high temperatures For use up to 1200ºF
	Material Spec: QQ-S-365 Color: Silver white
Color Coding	Facilitates verification of insert installation Allows for quick identification of similar size inserts Available in blue, green, red, and black*

** All Heli-Coil Inch Screw-Lock inserts are supplied with a red coloring in accordance with NASM21209.*

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Heli-Coil® insert materials

Heli-Coil inserts are available in a wide choice of materials to suit specific application needs.
Contact Heli-Coil Applications Engineering to determine the correct material for your specific application.

304 Stainless Steel

- Standard, general purpose material
- Stocked in most sizes
- Ideal for original equipment applications, repair, and overhaul

Material Spec: AS7245
Temperature range: up to 800ºF
Tensile: 200,000 – 250,000 PSI
Hardness: RHc 43-50
Corrosion resistance: Moderate
Magnetic Permeability: 2-10 G/o (depending on wire size)

Inconel X750

- Used in areas exposed to high temperatures
- Typical uses: gas turbine engines, nuclear applications, well drilling
- Non-magnetic

Material Spec: AS7246
Temperature range: up to 1,000ºF
Tensile: 200,000 PSI
Hardness: RHc 43-50
Corrosion resistance: High
Magnetic Permeability: <1 G/o

Phosphor Bronze

- Ideal for salt water applications
- Non-magnetic
- Excellent electrical conductivity

Temperature range: up to 250ºF
Tensile: 140,000 PSI
Hardness: HRB 95
Corrosion resistance: High
Magnetic Permeability: <1 G/o

Nitronic 60™

- Superb gall resistance
- Compatible with stainless steel screws
- Ideal for use in vacuum environments
- Requires no additional coatings or plating
- Particle free
- Non-magnetic

Material Spec: UNS S21800
Temperature range: up to 500ºF
Tensile: 200,000 PSI
Hardness: RHc 43-50
Corrosion resistance: Moderate
Magnetic Permeability: <1 G/o

Titanium

- Superior strength-to-weight ratio
- Corrosion resistant
- Excellent low temperature stability

Material Spec: AMS 4957 & AMS 4958A
Temperature range: up to 600ºF
Tensile: 150,000 to 220,000 PSI
Hardness: RHc 35-43
Corrosion resistance: High
Magnetic Permeability: non-magnetic

Note: Nitronic 60™ is a trademark of AK Steel

Heli-Coil® screw lock torque data

Heli-Coil Screw-Lock inserts meet the locking torque value of Tables I and II shown below. The values shown conform to NASM8846 (inch series) or MA1565 (metric series) requirement.

IMPORTANT NOTE: When using heat-treated steel screws or stainless steel screws with a Screw-Lock insert, an anti-seize compound MUST be applied to the screw or insert to minimize galling and maximize cycle life. To improve the wear life of the screws in Screw-Lock insert applications, specify Nitronic 60 material, Primer Free II coating, Dry Film Lubricant (Molybdenum Disulfide) or Cadmium plating be applied to the insert.

TABLE I. Heli-Coil Insert Locking Torque – Inch

Thread Size	Max. Locking Torque	Min. Locking Torque 15th Cycle
INCH COARSE THREAD (UNC)		
1 (.073)-64	15 oz-in	2 oz-in
2 (.086)-56	20 oz-in	3 oz-in
3 (.099)-48	32 oz-in	7 oz-in
4 (.112)-40	48 oz-in	10 oz-in
5 (.125)-40	75 oz-in	13 oz-in
6 (.138)-32	6 lb-in	1.0 lb-in
8 (.164)-32	9 lb-in	1.5 lb-in
10 (.190)-24	13 lb-in	2.0 lb-in
12 (.216)-24*	24 lb-in	3.0 lb-in
1/4 (.2500)-20	30 lb-in	4.5 lb-in
5/16 (.3125)-18	60 lb-in	7.5 lb-in
3/8 (.3750)-16	80 lb-in	12.0 lb-in
7/16 (.4375)-14	100 lb-in	16.5 lb-in
1/2 (.5000)-13	150 lb-in	24.0 lb-in
9/16 (.5625)-12	200 lb-in	30.0 lb-in
5/8 (.6250)-11	300 lb-in	40.0 lb-in
3/4 (.7500)-10	400 lb-in	60.0 lb-in
7/8 (.8750)-9	600 lb-in	82.0 lb-in
1 (1.000)-8	800 lb-in	110.0 lb-in
1-1/8 (1.1250)-7	900 lb-in	137.0 lb-in
1-1/4 (1.2500)-7	1000 lb-in	165.0 lb-in
1-3/8 (1.3750)-6	1150 lb-in	185.0 lb-in
1-1/2 (1.5000)-6	1350 lb-in	210.0 lb-in
INCH FINE THREAD (UNF)		
2 (.086)-64	20 oz-in	3 oz-in
3 (.099)-56	32 oz-in	7 oz-in
4 (.112)-48	48 oz-in	10 oz-in
6 (.138)-40	6 lb-in	1.0 lb-in
8 (.164)-36	9 lb-in	1.5 lb-in
10 (.190)-32	13 lb-in	2.0 lb-in
1/4 (.2500)-28	30 lb-in	3.5 lb-in
5/16 (.3125)-24	60 lb-in	6.5 lb-in
3/8 (.3750)-24	80 lb-in	9.5 lb-in
7/16 (.4375)-20	100 lb-in	14.0 lb-in
1/2 (.5000)-20	150 lb-in	18.0 lb-in
9/16 (.5625)-18	200 lb-in	24.0 lb-in
5/8 (.6250)-18	300 lb-in	32.0 lb-in
3/4 (.7500)-16	400 lb-in	50.0 lb-in
7/8 (.8750)-14	600 lb-in	70.0 lb-in
1 (1.000)-14*	800 lb-in	92.0 lb-in
1 (1.000)-12	800 lb-in	90.0 lb-in
1-1/8 (1.1250)-12	900 lb-in	117.0 lb-in
1-1/4 (1.2500)-12	1000 lb-in	143.0 lb-in
1-3/8 (1.3750)-12	1150 lb-in	165.0 lb-in
1-1/2 (1.5000)-12	1350 lb-in	190.0 lb-in

TABLE II. Heli-Coil Insert Locking Torque – Metric

Thread Size	Max. Locking Torque N.m	Min. Locking Torque 15th Cycle N.m
METRIC COARSE		
M2x0.4	0.12	0.003
M2.2x0.45	0.14	0.02
M2.5x0.45	0.22	0.06
M3x0.5	0.44	0.1
M3.5x0.6	0.68	0.12
M4x0.7	0.9	0.16
M5x0.8	1.6	0.3
M6x1	3	0.4
M7x1	4.4	0.6
M8x1.25	6	0.8
M10x1.5	10	1.4
M12x1.75	15	2.2
M14x2	23	3
M16x2	32	4.2
M18x2.5	42	5.5
M20x2.5	54	7
M22x2.5	70	9
M24x3	80	11.0
M27x3	95	12
M30x3.5	110	14
M33x3.5	125	16.0
M36x4	140	18.0
M39x4	150	20.0
METRIC FINE		
M8x1	6	0.8
M10x1	10	1.4
M10x1.25	10	1.4
M12x1.25	15	2.2
M12x1.5	15	2.2
M14x1.5	23	3
M16x1.5	32	4.2
M18x1.5	42	5.5
M20x1.5	54	7
M22x1.5	70	9
M18x2	42	5.5
M20x2	54	7
M22x2	70	9
M24x2	80	11.0
M27x2	95	12
M30x2	110	14
M33x2	125	16.0
M36x2	140	18.0
M39x2	150	20.0
M36x3	140	18.0
M39x3	150	20.0

** These sizes are not included in NASM8846. Torque values shown are interpolated from sizes that are included. All torque data derived for stainless inserts only.*

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Assembly Strength

Heli-Coil offers maximum design flexibility while adhering to conservative engineering practice allowing use of Heli-Coil inserts in virtually any application or material. Five lengths of inserts are available. In this design manual, the lengths are listed as multiples of the nominal thread diameter of the screw; 1, 1-1/2, 2, 2-1/2, and 3.

This choice of insert length balances the bolt tensile strength against the shear strength of the parent material. This allows for the design of assemblies where the bolt will fail before the parent material. Tables III and IV below show the length of insert to be used with different combinations of bolts and parent materials.

Table III – Inch Bolt & Heli-Coil Insert Selection Guide
Bolt Material Minimum Ultimate Tensile Strength (PSI)

Shear strength of parent material (PSI) (Alum., Mag., Steel)	54,000	75,000	96,000	108,000	125,000	132,000	160,000	180,000	220,000
10.000	2	2-1/2	3	3	–	–	–	–	–
15,000	1-1/2	1-1/2	2	2-1/2	2-1/2	3	3	–	
20,000	1	1-1/2	1-1/2	2	2	2	2-1/2	3	3
25,000	1	1	1-1/2	1-1/2	1-1/2	2	2	2-1/2	2-1/2
30,000	1	1	1	1-1/2	1-1/2	1-1/2	2	2	2-1/2
40,000	1	1	1	1	1	1-1/2	1-1/2	1-1/2	2
50,000	1	1	1	1	1	1	1	1-1/2	1-1/2

Table IV – Metric Bolt & Heli-Coil Insert Selection Guide
Bolt Material Minimum Ultimate Tensile Strength MPa (megapascals)

Shear strength of parent material MPa (megapascals) (Alum., Mag., Steel)	300	400	500	600	800	1000	1200	1400
70	1.5	2	2.5	2.5	–	–	–	–
100	1	1.5	1.5	2	2.5	3	–	–
150	1	1	1.5	1.5	2	2	2.5	3
200	1	1	1	1	1.5	1.5	1.5	2.5
250	1	1	1	1	1	1.5	1.5	2
300	1	1	1	1	1	1.5	1.5	1.5
350	1	1	1	1	1	1	1.5	1.5

Type of Conditions & Protective Methods

Parent Material	Parent Material Treatment			Insert Treatment		
	Normal	Severe	Extremely Severe	Normal	Severe	Extremely Severe
Aluminum	None	1	1	None	2 or 3	2 or 3
Magnesium	1	1	1	None	2 or 3	2 or 3

Corrosion Protection Methods

Method 1 – Parent Material Protection

ALUMINUM: For oxide coating use Alodine, Anodize, Iridite, Hard Coat or equivalent. Iridite 14 or 14-2 (MIL-C-5541) is recommended for critical parts rather than anodizing (MIL-S-5002).

MAGNESIUM: For oxide coating use Iridite 15 or dichromate surface treatments. For HAE finishes, always plug tapped holes first.

Method 2 – Coat the insert with one of the following:
Cadmium per QQ-P-416, Type II, .0001" thick; or Dry Film Lubricant per AS 5272 (MIL-L 46010) (no graphite).

Method 3 – Utilize Heli-Coil Primer-Free II coated inserts or separate the parent material from the insert by using liquid zinc chromate primer, Federal Specification TT-P-1757. Apply the primer to the hole sparingly and install the insert while the primer is still wet.

In addition to the above methods, further corrosion protection can be achieved by:

1. Using blind holes wherever possible.
2. Using a sealing, insulating or step-down (5052 Alum.) washer under the head of the bolt.
3. Using bolts that extend completely through the length of the insert.
4. In critical applications, using a non-hardening sealer or compound on the threaded assembly.

Guidelines for use of table:

1. When the parent material shear strength falls between two listed values, use the lower of the two values.
2. Parent material shear strengths are for room temperature. For applications at elevated tempera tures, the shear strength of the material at that temperature must be determined for proper selection of bolt and insert length.
3. Be sure that the engaged thread length of the bolt is at least as long as the full tapped thread depth for the size selected (Dimension "H", Tables VII & VIII, pages 20 & 21).

Assembly strength is a function of shear area and the shear strength of both the bolt and parent material. For detailed charts on specific load values, Heli-Coil Technical Bulletin 68-2 (inch) or Engineering Standard PP15 (metric) covers the complete range of sizes, parent materials and bolt strengths.

Corrosion Protection

The effect of corrosion on threaded assemblies is dependent on many factors — environment, types of metals used, sealing mechanisms and length of service. The following recommendations apply for minimizing the effects of corrosion on Heli-Coil stainless steel insert assemblies at operating temperatures less than 800°F, using carbon steel or alloy steel bolts.

The following definitions apply…

Normal Service – Natural atmosphere environment with the screw always assembled in the insert.

Severe Service – Mildly contaminated atmospheric conditions involving moisture, occasional exposure to salty air or sea spray and the screw may be left out of the insert for extended periods of time.

Extremely Severe Service – Assembly is exposed to salt water, corrosive atmosphere and/or the screw is out of the assembly frequently allowing a blind hole to trap water.

Heli-Coil® insert specifications – inch

Nominal Thread Size	Type		Size Design-ation	"Q" Nominal Length					Outside Diameter		Number of Coils Nominal Length				
	Standard Insert No.	Screw-Lock Insert No.		1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.	Min.	Max.	1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.
UNIFIED COARSE THREAD (UNC)															
1 (.073)-64	1185	3585	01CN	0.073	0.110	0.146	0.182	0.219	.095	.103	2-3/4	4-7/8	6-7/8	8-7/8	10-7/8
2 (.086)-56	1185	3585	02CN	0.086	0.129	0.172	0.215	0.258	.110	.119	3	5-1/4	7-3/8	9-5/8	11-7/8
3 (.099)-48	1185	3585	03CN	0.099	0.148	0.198	0.248	0.297	.128	.139	2-7/8	5	7-1/4	9-3/8	11-1/2
4 (.112)-40	1185	3585	04CN	0.112	0.168	0.224	0.280	0.336	.144	.159	2-3/4	4-3/4	6-3/4	8-7/8	10-7/8
5 (.125)-40	1185	3585	05CN	0.125	0.188	0.250	0.312	0.375	.158	.173	3-1/4	5-1/2	7-3/4	10	12-1/4
6 (.138)-32	1185	3585	06CN	0.138	0.207	0.276	0.345	0.414	.178	.193	2-3/4	4-3/4	6-7/8	8-7/8	10-7/8
8 (.164)-32	1185	3585	2CN	0.164	0.246	0.328	0.410	0.492	.205	.220	3-1/2	6	8-3/8	10-3/4	13-1/4
10 (.190)-24	1185	3585	3CN	0.190	0.285	0.380	0.475	0.570	.244	.259	2-7/8	5	7-1/8	9-1/4	11-3/8
12 (.216)-24	1185	3585	1CN	0.216	0.324	0.432	0.540	0.648	.270	.285	3-1/2	6	8-3/8	10-5/8	13-1/8
1/4 (.2500)-20	1185	3585	4CN	0.250	0.375	0.500	0.625	0.750	.310	.330	3-3/8	5-3/4	8	10-3/8	12-3/4
5/16 (.3125)-18	1185	3585	5CN	0.312	0.469	0.625	0.781	0.938	.380	.400	4	6-5/8	9-1/4	11-7/8	14-5/8
3/8 (.3750)-16	1185	3585	6CN	0.375	0.562	0.750	0.938	1.125	.452	.472	4-3/8	7-1/4	10	12-7/8	15-3/4
7/16 (.4375)-14	1185	3585	7CN	0.438	0.656	0.875	1.094	1.312	.526	.551	4-1/2	7-3/8	10-1/4	13-1/8	16-1/8
1/2 (.5000)-13	1185	3585	8CN	0.500	0.750	1.000	1.250	1.500	.597	.622	4-7/8	7-7/8	11	14-1/8	17-1/8
9/16 (.5625)-12	1185	3585	9CN	0.562	0.844	1.125	1.406	1.688	.669	.694	5-1/8	8-1/4	11-1/2	14-3/4	17-7/8
5/8 (.6250)-11	1185	3585	10CN	0.625	0.938	1.250	1.562	1.875	.742	.767	5-1/4	8-1/2	11-3/4	15	18-3/8
3/4 (.7500)-10	1185	3585	12CN	0.750	1.125	1.500	1.875	2.250	.881	.906	5-7/8	9-3/8	13	16-1/2	20-1/8
7/8 (.8750)-9	1185	3585	14CN	0.875	1.312	1.750	2.188	2.625	1.022	1.052	6-1/4	10	13-3/4	17-1/2	21-1/4
1 (1.000)-8	1185	3585	16CN	1.000	1.500	2.000	2.500	3.000	1.166	1.196	6-3/8	10-1/8	14	17-3/4	21-5/8
1-1/8 (1.1250)-7	1185	3585	18CN	1.125	1.688	2.250	2.812	3.375	1.315	1.355	6-1/8	9-7/8	13-5/8	17-1/2	21-1/4
1-1/4 (1.2500)-7	1185	3585	20CN	1.250	1.875	2.500	3.125	3.750	1.443	1.483	7	11-1/4	15-3/8	19-1/2	23-3/4
1-3/8 (1.3750)-6	1185	3585	22CN	1.375	2.062	2.750	3.438	4.125	1.598	1.643	6-1/2	10-1/2	14-3/8	18-3/8	22-1/4
1-1/2 (1.5000)-6	1185	3585	24CN	1.500	2.250	3.000	3.750	4.500	1.727	1.772	7-1/4	11-1/2	15-7/8	20-1/8	24-1/2
UNIFIED FINE THREAD (UNF)															
2 (.086)-64	1191	3591	02CN	0.086	0.129	0.172	0.215	0.258	.110	.119	3-1/2	5-7/8	8-3/8	10-3/4	13-1/8
3 (.099)-56	1191	3591	03CN	0.099	0.148	0.198	0.248	0.297	.131	.146	3-3/8	5-5/8	8	10-3/8	12-5/8
4 (.112)-48	1191	3591	04CN	0.112	0.168	0.224	0.280	0.336	.147	.162	3-3/8	5-5/8	7-7/8	10-1/4	12-1/2
6 (.138)-40	1191	3591	06CN	0.138	0.207	0.276	0.345	0.414	.173	.193	3-1/2	6	8-3/8	10-3/4	13-1/4
8 (.164)-36	1191	3591	2CN	0.164	0.246	0.328	0.410	0.492	.204	.224	3-7/8	6-1/2	9-1/8	11-5/8	14-1/4
10 (.190)-32	1191	3591	3CN	0.190	0.285	0.380	0.475	0.570	.236	.256	4-1/8	6-7/8	9-1/2	12-1/4	14-7/8
1/4 (.2500)-28	1191	3591	4CN	0.250	0.375	0.500	0.625	0.750	.306	.326	5	8-1/4	11-3/8	14-1/2	17-5/8
5/16 (.3125)-24	1191	3591	5CN	0.312	0.469	0.625	0.781	0.938	.380	.400	5-1/2	8-7/8	12-1/4	15-5/8	19
3/8 (.3750)-24	1191	3591	6CN	0.375	0.562	0.750	0.938	1.125	.448	.468	6-7/8	11	15	19-1/8	23-1/8
7/16 (.4375)-20	1191	3591	7CN	0.438	0.656	0.875	1.094	1.312	.524	.549	6-5/8	10-5/8	14-5/8	18-1/2	22-1/2
1/2 (.5000)-20	1191	3591	8CN	0.500	0.750	1.000	1.250	1.500	.592	.617	7-7/8	12-3/8	16-7/8	21-3/8	25-7/8
9/16 (.5625)-18	1191	3591	9CN	0.562	0.844	1.125	1.406	1.688	.666	.691	8	12-1/2	17-1/8	21-3/4	26-1/4
5/8 (.6250)-18	1191	3591	10CN	0.625	0.938	1.250	1.562	1.875	.733	.758	9	14-1/8	19-1/4	24-1/4	29-3/8
3/4 (.7500)-16	1191	3591	12CN	0.750	1.125	1.500	1.875	2.250	.876	.901	9-3/4	15-1/8	20-5/8	26	31-1/2
7/8 (.8750)-14	1191	3591	14CN	0.875	1.312	1.750	2.188	2.625	1.021	1.051	9-7/8	15-1/2	21-1/8	26-5/8	32-1/4
1 (1.000)-14*	1191	3591	16CN	1.000	1.500	2.000	2.500	3.000	1.156	1.186	11-1/2	17-7/8	24-1/4	30-5/8	37
1 (1.000)-12	1191	3591	161CN	1.000	1.500	2.000	2.500	3.000	1.169	1.199	9-5/8	15	20-1/2	26	31-1/2
1-1/8 (1.1250)-12	1191	3591	18CN	1.125	1.688	2.250	2.812	3.375	1.304	1.334	11-1/8	17-1/4	23-3/8	29-1/2	35-3/4
1-1/4 (1.2500)-12	1191	3591	20CN	1.250	1.875	2.500	3.125	3.750	1.439	1.469	12-1/2	19-3/8	26-1/4	33	39-7/8
1-3/8 (1.3750)-12	1191	3591	22CN	1.375	2.062	2.750	3.438	4.125	1.575	1.610	13-3/4	21-3/8	28-7/8	36-1/2	44
1-1/2 (1.5000)-12	1191	3591	24CN	1.500	2.250	3.000	3.750	4.500	1.710	1.745	15-1/4	23-1/2	31-5/8	39-7/8	48-1/8

*Inactive for new design per NASM.

1185-4CNY375S

Complete Part No. Example: Free Running Insert; 1/4-20; Stainless Steel; Cadmium; 1-1/2 dia.; On Strip

Type	Size	Material	Finish	Length	Packaging
1185 Free Running, Coarse	See Chart	**CN** – Stainless Steel	**Blank** – None	See Chart	**Blank** – Bulk
1191 Free Running, Fine		**BN** – Phosphor Bronze	**Y** – Cadmium		**S** – Strip Feed
3585 Screw-Lock, Coarse		**TN** – Inconel X	**V** - Silver		
3591 Screw-Lock, Fine		**EN** – Nitronic 60	**W** – Dry Film Lubricant		
		GN – Titanium	**PF** – Primer Free II		

Notes on Insert Specifications:

1. Nominal Length is a computed value and cannot be measured. It is the actual assembled length + 1/2 pitch.
2. The number of coils are counted 90º from the tang.
3. Grip Coil(s) Location for 1, 1-1/2 and 2 diameter long inserts, Grip Coil Location = 1/2 the number of free coils. For 2-1/2 and 3 diameter long inserts, Grip Coil Location (distance from the tang) is the same as 2 diameter long inserts.

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Heli-Coil® insert specifications – metric

Nominal Thread Size	Type		Size Design-ation	"Q" Nominal Length					Outside Diameter		Number of Coils Nominal Length				
	Standard Insert No.	Screw-Lock Insert No.		1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.	Min.	Max.	1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.
METRIC COARSE															
M2x0.4	1084	4184*	2CN	2.0	3.0	4.0	5.0	6.0	2.50	2.70	3-1/2	5-1/2	7-3/4	10-1/8	12-3/8
M2.2x0.45	1084	4184	2.2CN	2.2	3.3	4.4	5.5	6.6	2.80	3.00	3-1/8	5-3/8	7-5/8	9-7/8	12-1/8
M2.5x0.45	1084	4184	2.5CN	2.5	3.8	5.0	6.3	7.5	3.20	3.70	3-3/8	5-3/4	8-1/8	10-1/2	12-3/4
M3x0.5	1084	4184	3CN	3.0	4.5	6.0	7.5	9.0	3.80	4.35	3-3/4	6-3/8	8-7/8	11-3/8	13-7/8
M3.5x0.6	1084	4184	3.5CN	3.5	5.3	7.0	8.8	10.5	4.40	4.95	3-3/4	6-3/8	8-3/4	11-3/8	13-3/4
M4x0.7	1084	4184	4CN	4.0	6.0	8.0	10.0	12.0	5.05	5.60	3-5/8	6-1/8	8-5/8	11-1/8	13-5/8
M5x0.8	1084	4184	5CN	5.0	7.5	10.0	12.5	15.0	6.25	6.80	4-1/8	6-7/8	9-5/8	12-3/8	15-1/8
M6x1	1084	4184	6CN	6.0	9.0	12.0	15.0	18.0	7.40	7.95	4	6-3/4	9-1/2	12-1/8	14-7/8
M7x1	1084	4184	7CN	7.0	10.5	14.0	17.5	21.0	8.65	9.20	4-7/8	8	11-1/8	14-1/8	17-1/4
M8x1.25	1084	4184	8CN	8.0	12.0	16.0	20.0	24.0	9.80	10.35	4-1/2	7-3/8	10-1/4	13-1/4	16-1/8
M10x1.5	1084	4184	10CN	10.0	15.0	20.0	25.0	30.0	11.95	12.50	4-7/8	8	11-1/8	14-1/4	17-3/8
M12x1.75	1084	4184	12CN	12.0	18.0	24.0	30.0	36.0	14.30	15.00	5	8-1/4	11-1/2	14-5/8	17-7/8
M14x2	1084	4184	14CN	14.0	21.0	28.0	35.0	42.0	16.65	17.35	5-1/8	8-1/2	11-3/4	15	18-3/8
M16x2	1084	4184	16CN	16.0	24.0	32.0	40.0	48.0	18.90	19.60	6-1/8	9-3/4	13-1/2	17-1/4	21
M18x2.5	1084	4184	18CN	18.0	27.0	36.0	45.0	54.0	21.30	22.0	5-3/8	8-7/8	12-1/4	15-5/8	19
M20x2.5	1084	4184	20CN	20.0	30.0	40.0	50.0	60.0	23.55	24.40	6-1/8	9-7/8	13-5/8	17-3/8	21-1/8
M22x2.5	1084	4184	22CN	22.0	33.0	44.0	55.0	66.0	25.90	26.90	6-3/4	10-7/8	14-7/8	19	23-1/8
M24x3	1084	4184	24CN	24.0	36.0	48.0	60.0	72.0	28.00	29.00	6-1/8	10	13-3/4	17-1/2	21-3/8
M27x3	1084	4184	27CN	27.0	40.5	54.0	67.5	81.0	31.40	32.40	7	11-1/4	15-1/2	19-3/4	24
M30x3.5	1084	4184	30CN	30.0	45.0	60.0	75.0	90.0	34.80	36.00	6-3/4	10-3/4	14-7/8	18-7/8	23
M33x3.5	1084	4184	33CN	33.0	49.5	66.0	82.5	99.0	37.80	39.20	7-1/2	12	16-1/2	21	25-3/8
M36x4	1084	4184	36CN	36.0	54.0	72.0	90.0	108.0	41.50	42.90	7-1/8	11-3/8	15-5/8	19-7/8	24-1/4
M39x4	1084	4184	39CN	39.0	58.5	78.0	97.5	117.0	44.60	46.00	7-7/8	12-1/2	17-1/8	21-3/4	26-3/8
METRIC FINE															
M8x1	4255	5255	8CN	8.0	12.0	16.0	20.0	24.0	9.70	10.25	5-7/8	9-3/8	13	16-1/2	20-1/8
M10x1	4255	5255	10CN	10.0	15.0	20.0	25.0	30.0	11.95	12.50	7-5/8	12	16-1/2	21	25-1/2
M10x1.25	4649	5649	10CN	10.0	15.0	20.0	25.0	30.0	12.10	12.65	5-7/8	9-1/2	13-1/8	16-3/4	20-3/8
M12x1.25	4649	5649	12CN	12.0	18.0	24.0	30.0	36.0	14.30	15.00	7-1/4	11-5/8	15-7/8	20-1/4	24-1/2
M12x1.5	3745	5145	12CN	12.0	18.0	24.0	30.0	36.0	14.25	14.95	6	9-5/8	13-3/8	17	20-3/4
M14x1.5	3745	5145	14CN	14.0	21.0	28.0	35.0	42.0	16.55	17.25	7-1/8	11-3/8	15-5/8	20	24-1/4
M16x1.5	3745	5145	16CN	16.0	24.0	32.0	40.0	48.0	18.90	19.60	8-1/4	13-1/8	18	22-3/4	27-5/8
M18x1.5	3745	5145	18CN	18.0	27.0	36.0	45.0	54.0	21.05	21.75	9-1/2	15	20-3/8	25-7/8	31-3/8
M20x1.5	3745	5145	20CN	20.0	30.0	40.0	50.0	60.0	23.15	24.00	10-3/4	16-7/8	22-7/8	28-7/8	35
M22x1.5	3745	5145	22CN	22.0	33.0	44.0	55.0	66.0	25.55	26.45	11-7/8	18-1/2	25-1/8	31-5/8	38-1/4
M18x2	4266	5266	18CN	18.0	27.0	36.0	45.0	54.0	21.15	21.85	7	11-1/8	15-3/8	19-1/2	23-5/8
M20x2	4266	5266	20CN	20.0	30.0	40.0	50.0	60.0	23.20	24.05	7-7/8	12-1/2	17-1/4	21-7/8	26-1/2
M22x2	4266	5266	22CN	22.0	33.0	44.0	55.0	66.0	25.60	26.50	8-3/4	13-3/4	18-7/8	23-7/8	29
M24x2	4266	5266	24CN	24.0	36.0	48.0	60.0	72.0	28.10	29.10	9-1/2	15	20-3/8	25-7/8	31-1/4
M27x2	4266	5266	27CN	27.0	40.5	54.0	67.5	81.0	31.30	32.30	10-7/8	17	23-1/4	29-3/8	35-1/2
M30x2	4266	5266	30CN	30.0	45.0	60.0	75.0	90.0	34.50	35.70	12-1/4	19-1/8	25-7/8	32-3/4	39-1/2
M33x2	4266	5266	33CN	33.0	49.5	66.0	82.5	99.0	37.80	39.20	13-5/8	21-1/8	28-5/8	36	43-1/2
M36x2	4266	5266	36CN	36.0	54.0	72.0	90.0	108.0	41.00	42.40	15	23-1/4	31-3/8	39-1/2	47-3/4
M39x2	4266	5266	39CN	39.0	58.5	78.0	97.5	117.0	44.30	45.70	16-3/8	25-1/4	34-1/8	43	51-7/8
M36x3	4277	5277	36CN	36.0	54.0	72.0	90.0	108.0	41.30	42.70	9-3/4	15-1/4	20-7/8	26-1/2	32
M39x3	4277	5277	39CN	39.0	58.5	78.0	97.5	117.0	44.40	45.80	10-3/4	16-3/4	22-3/4	28-7/8	34-7/8

*M2 not available in Screen-Lock 1 diameter length

1084-4CNY060S

Complete Part No. Example: Free Running Insert; M4 x 0.7 Stainless Steel; Cadmium; 1 dia.; On Strip

Type	Size	Material	Finish	Length	Packaging
1084 Free Running, Coarse	See Chart	**CN** – Stainless Steel	**Blank** – None	See Chart	**Blank** – Bulk
4255, 4649, 3745, 4266 &		**BN** – Phosphor Bronze	**Y** – Cadmium		**S** – Strip Feed
4277 Free Running,Fine		**TN** – Inconel X	**V** - Silver		
4184 Screw-Lock, Coarse		**EN** – Nitronic 60	**W** – Dry Film Lubricant		
5255, 5649, 5145, 5266 &		**GN** – Titanium	**PF** – Primer Free II		
5277 Screw-Lock, Fine					

Notes on Insert Specifications:

1. Nominal length is a computed value and cannot be measured. It is the actual assembled length + 1/2 pitch.
2. The number of coils are counted from the notch.
3. Phosphor Bronze Inserts – **Not available** in sizes M2, M2.2, M2.5, M3, M3.5 and M4.
4. Inconel X Inserts – 1 diameter long Screw-Lock inserts **not available** in sizes M2, M2.2, M2.5 and M3.

Heli-Coil® Tangless® Inserts

Heli-Coil Tangless® Inserts eliminate tang break-off and retrieval and are easily adjusted or removed after installation.

- **STRONGER ASSEMBLIES** Tapped threads are strengthened because the inherent flexibility of the insert provides a more balanced distribution of static and dynamic loads throughout the engagement length.
- **BI-DIRECTIONAL DESIGN** Installs quickly and easily from either end.
- **ELIMINATE STRESS.** Virtually no stress is induced into the parent material as no staking, swaging or keying in place is required.
- **POSITIVE SELF-LOCKING TORQUE.** Heli-Coil Tangless® screw-lock inserts provide a positive, self-locking torque complying with the requirements of NASM8846.
- **MINIMIZE SPACE AND WEIGHT.** Requires smaller boss than solid inserts; minimize total in-place cost.
- **CONFORM TO NAS1130**

Selecting a Heli-Coil Tangless® Insert

Heli-Coil Tangless® inserts are made from 304 Stainless Steel per AS7245 (see chart below for thread size designation), and are available in three lengths:
1, 1-1/2 and 2 diameters.

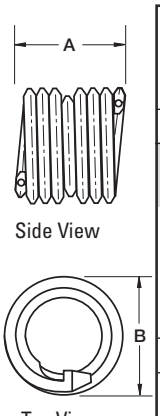
Tangless® inserts can be ordered with a Cadmium Plate finish (Y), Dry Film Lube finish (W), Primer Free II finish (PF) or no finish (Blank).

Below is an example of how to order Heli-Coil Tangles inserts.

T3585–04CW112S

Complete Part No. Example: Screw-locking Insert; #4-40; Stainless Steel; Dry Film Lube, 1 dia.,On Strip

Type	Size	Material	Finish	Length	Packaging
T1185 Free Running, UNC **T1191** Free Running, UNF **T3585** Screw-Lock, UNC **T3591** Screw-Lock, UNF	See Chart	**C** - Stainless Steel	**Y** - Cadmium **W** - Dry Film Lube **PF** - Primer Free **Blank** - No Finish	See Chart	**Blank** - Bulk **S** - Strip Feed



Nominal Thread Size	Type: Free Running	Type: Screw-Lock	Size Designation	"A" Normal Length: 1 Dia.	"A" Normal Length: 1 1/2 Dia.	"A" Normal Length: 2 Dia.	"B" Free Outer Dia.: Min.	"B" Free Outer Dia.: Max.	Number of Coils Nominal Length: 1 Dia.	Number of Coils Nominal Length: 1 1/2 Dia.	Number of Coils Nominal Length: 2 Dia.
Unified Coarse Thread (UNC)											
2 (.086)-56	T1185	T3585	02C	.086	.129	.172	.110	.119	3	5-1/4	7-3/8
4 (.112)-40	T1185	T3585	04C	.112	.168	.224	.144	.159	2-3/4	4-3/4	6-3/4
6 (.138)-32	T1185	T3585	06C	.138	.207	.276	.178	.193	2-3/4	4-3/4	6-7/8
8 (.164)-32	T1185	T3585	2C	.164	.246	.328	.205	.220	3-1/2	6	8-3/8
10 (.190)-24	T1185	T3585	3C	.190	.285	.380	.244	.259	2-7/8	5	7-1/8
1/4(.250)-20	T1185	T3585	4C	.250	.375	.500	.310	.330	3-3/8	5-3/4	8
Unified Fine Thread (UNF)											
10(.190)-32	T1191	T3591	3C	.190	.285	.380	.236	.256	4-1/8	6-7/8	9-1/2
1/4(.250)-28	T1191	T3591	4C	.250	.375	.500	.326	.306	5	8-1/4	11-3/8

Note: Contact your local distributor for specific product availability.

Emhart Teknologies, Shelton, CT • Tel. (877) EMHART-1 • Fax (800) 225-5614
Canada (514) 351-0330 • Mexico +52-55-5326-7100

Thread repair kits & master sets

Heli-Coil inserts are available in thread repair kits and sets for repairing tapped holes which have been stripped or damaged due to wear, corrosion and over-torque. They are available in inch, metric, spark plug and pipe thread series.

All kits have a quantity of inserts, the proper size drill, high speed steel Heli-Coil tap and an installation tool. The Professional Kits* (shown in **bold** type) also includes a tang removal tool and quantities of three lengths of inserts.

Thread Size	Kit P/N	Inserts per Kit
Inch Coarse Thread (UNC)		
4-40	**5401-04**	36*
5-40	**5401-05**	36*
6-32	**5401-06**	36*
8-32	**5401-2**	36*
10-24	**5401-3**	36*
12-24	**5401-1**	36*
1/4-20	**5401-4**	36*
5/16-18	**5401-5**	36*
3/8-16	**5401-6**	18*
7/16-14	**5401-7**	18*
1/2-13	**5401-8**	18*
9/16-12	5401-9	6
5/8-11	5401-10	6
3/4-10	5401-12	4
7/8-9	5521-14	6
1-8	5521-16	6
1–1/8-7	5521-18	5
1–1/4-7	5521-20	4
1–3/8-6	5521-22	4
1–1/2-6	5521-24	4
Inch Fine Thread (UNF)		
6-40	**5402-06**	36*
8-36	**5402-2**	36*
10-32	**5402-3**	36*
1/4-28	**5402-4**	36*
5/16-24	**5402-5**	36*
3/8-24	**5402-6**	18*
7/17-20	**5402-7**	18*
1/2-20	**5402-8**	18*
9/16-18	5402-9	6
5/8-18	5402-10	6
3/4-16	5402-12	4
7/8-14	5528-14	6
1-14	5528-16	6
1-12	5528-161	6
1–1/8-12	5528-18	5
1–1/4-12	5528-20	4
1–3/8-12	5528-22	4
1–1/2-12	5528-24	4

** The total quantity of inserts in the Professional Kits represents 3 lengths.*

Thread Size	Kit P/N	Inserts per Kit
Metric Coarse		
M3x0.5	**5403-3**	36*
M3.5x0.6	**5403-3.5**	36*
M4x0.7	**5403-4**	18*
M5x0.8	**5403-5**	18*
M6x1	**5403-6**	18*
M7x1	**5403-7**	18*
M8x1.25	**5403-8**	18*
M9x1.25	5403-9	12
M10x1.5	**5403-10**	18*
M11x1.5	5403-11	6
M12x1.75	**5403-12**	18*
M14x2	5403-14	12
M16x2	5403-16	6
M18x2.5	5403-18	6
M20x2.5	5403-20	4
Metric Fine		
M8x1	**5404-8**	18*
M10x1	**5404-10**	18*
M10x1.25	**5405-10**	18*
M12x1.25	**5405-12**	18*
M12x1.5	**5406-12**	18*
M14x1.5	5406-14	6
M16x1.5	5406-16	6
M18x1.5	5406-18	6

** The total quantity of inserts in the Professional Kits represents 3 lengths.*

SPARK PLUG SERIES

Thread Size	Part No.	Reach	Inserts Per Kit
10-1.0mm	5523-10	1/2	24
12-1.25mm	5523-12	1/2	12
		3/4	12
14-1.25mm	5523-14	3/8	6
		7/16	6
		1/2	6
		3/4	6
		.472	6
18-1.50mm	5523-18	1/2	24
7/8-18	550	1/2-5/8	10
M14x1.25*	5408-14	Short	6
		Normal	6
		Long	6

(*)Sav-A-Thread®

PIPE THREAD SERIES

Thread Size	Part No.	Inserts Per Kit
1/8-27	5407-2	12
1/4-18	5407-4	12
3/8-18	5407-6	10
1/2-14	5407-8	10
3/4-14	5407-12	10
1-11-1/2	5407-16	6

MASTER THREAD REPAIR SETS

Type	Part No.	Insert sizes included in set
Inch Coarse	4934	1/4-20, 5/16-18, 3/8-16, 7/16-14, 1/2-13, 5/8-11
Inch Fine	4936	10-32, 1/4-28, 5/16-24, 3/8-24, 7/16-20, 1/2-20
Metric	4937-125	M5x0.8, M6x1, M8x1.25, M10x1.25
Metric	4937-150	M5x0.8, M6x1, M8x1.25, M10x1.5

All sets contain a drill, tap, tool and inserts for each size listed above.

Heli-Coil® assembly design

Boss Dimensions

Standard boss configurations may be used with Heli-Coil inserts.

A boss diameter of twice the nominal bolt size is adequate for most load conditions. For critical applications, the boss diameter should be twice the Heli-Coil tap major diameter (Tables VII & VIII, Pages 20 & 21). Boss thickness is a function of the size and length of the insert chosen and the particular requirements of the component being designed. The use of Heli-Coil inserts generally minimizes the size of the boss because their high strength characteristics allow for smaller or fewer fasteners.

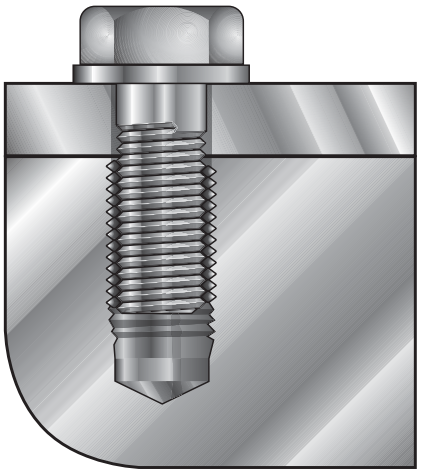
Class of Fit

Since Heli-Coil inserts are flexible, the class of fit of the final assembly is a function of the tapped hole. Heli-Coil STI (Screw Thread Insert) taps are available in inch series for both Class 2B and 3B. Metric Classes include 5H and 4H5H. Class 2B or 5H tapped holes provide widest production tolerances while Class 3B or 4H5H holes provide slightly tighter tolerances.

Class 3B or 4H5H holes are recommended for Screw-Lock applications.

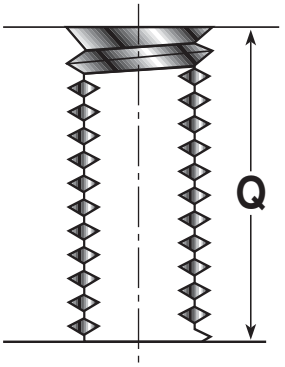
Bolt Projection

The bolt must engage the entire insert to insure maximum strength of a Heli-Coil insert assembly. It is strongly recommended that the tang always be removed and bolt projection be equal to the full tapped thread depth (Dimension H, Tables VII & VIII, Pages 20 & 21). If design limitations prohibit this, contact us to obtain minimum bolt projection data.



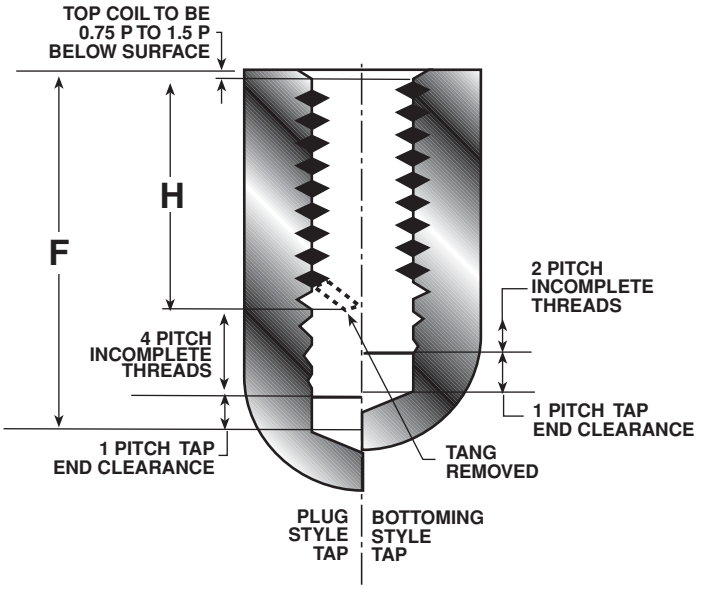
Material Thickness

The **minimum** material thickness for through hole assemblies is equal to the Insert Nominal Length (Dimension Q, Pages 12 &13), without a countersink and the insert installed 1/4-1/2 pitch below the surface. For production, the hole should be counter-sunk, and the insert installed 3/4–1-1/2 pitch below the surface. In this case the minimum material thickness is "Q" + 1 pitch.



Drawing Call Out

Below is a sectional view of an installed insert for a Heli-Coil Insert Assembly. The example used is a 3/8-24 x .562 long Screw-Lock insert in a blind hole, Class 3B fit, tapped with a plug tap.



HOLE PREPARATION

Emhart Teknologies, Shelton, CT • Tel. (877) EMHART-1 • Fax (800) 225-5614
Canada (514) 351-0330 • Mexico +52-55-5326-7100

Engineering Data

Conventional machining methods are used for Heli-Coil assemblies. The process is simple…

1. **Drill**
2. **Countersink**
3. **Tap**
4. **Gage**

1. Drilling

The suggested drill sizes listed for aluminum in Tables V & VI, pages 18 & 19, are within the minor diameter limits specified in NASM33537 or MA1567. Drill sizes listed for steel, magnesium and plastic are larger (in most cases) allowing for parent material "close-in" in soft materials and increased tap wear life in hard materials.

The drill depths listed in this table allow for tap end clearance, maximum insert "set-down", countersink, and the chamfer on the tap. These drill depths are minimum and should be increased where possible, especially when using Spiral Pointed Taps, to allow for chip clearance. The formula for the drill depth is given on Pages 18 & 19.

2. Countersinking

Countersinking the drilled hole is recommended to prevent a feather edge at the top of the tapped hole and to help guide the insert into the tapped threads. A 120° included angle countersink is necessary to insure that the angle of the tapped thread and the countersink are the same (120° ÷ 2 = 60° tapped thread).

3. Tapping

The dimensions for the depth of the full tapped thread (Dimension H, Tables VII & VIII, Pages 20 & 21) are MINIMUM for blind holes with countersinks. For through holes without a countersink the minimum full tapped thread depth must be equal to the insert nominal length (Dimension Q, Pages 12 & 13).

Heli-Coil taps for free machining materials are listed in Tables IX & XII, Pages 20 & 23 Class 2B (inch), 5H metric and 3B (inch) or 4H5H (metric) tapped holes. (Class of fit recommendations are given on Page 14). There are four types of taps listed:

- **Straight, Flute, Plug & Bottoming** style which are used for hand and short run production
- **Spiral Point Plug** taps (chips are pushed forward) are used for through holes and blind hole with ample chip clearance at the bottom.
- **High Spiral Flute Bottoming** taps (chips are pulled out of the hole) are used for deep or blind holes in soft stringy materials and holes with minimal chip clearance
- **Roughing** taps (7/16-1") are available for materials difficult to tap to reduce the load and wear on the finishing tap.

If it is necessary to decrease the **Minimum Depth** of the drilled and tapped hole, one or more of the following steps may be helpful:

Action	Amount of Reduction
Remove the male center on plug taps 5/16, M8 & under	one half of the bolt diameter
Use a bottoming tap	2 pitches
Eliminate the countersink	1/2 pitch
Reduce insert "set-down" to 1/4-1/2 pitch	up to 1/2 pitch

4. Gaging

Heli-Coil thread plug gages should be used to check, according to sampling plan, the tapped holes before insert installation. See Pages 24 & 25 for gage part numbers and further gaging data.

Preparing Process Sheets

A sample process sheet for preparing a tapped hole for Heli-Coil inserts is shown below. Highlighted are references to the various dimensional data and part number specifications listed in the tables on pages listed. Insert installation and tang break off are covered in subsequent pages.

Hole preparation for 3/8-24, Screw-Lock Heli-Coil Insert, .562 long, Part No. 3591-6CN562
Blind Hole, Class 3B, tapped with a plug tap in aluminum

Oper. No.	Operation Description	Tool or Gage
10	Drill hole .3840/.3910 diameter to minimum depth (Dimension F, Tables V & VI, Pages 18 & 19)	25/64 drill (.3906), Tables V & VI, Pages 18 & 19
20	Countersink 120º±5º to .42/.45 diameter (Dimension M, Tables VII & VIII, Pages 20 & 21)	120º countersink
30	Tap 3/8 (.3750)-24 UNF-3B STI Thread Depth .600 (Dimension H, Tables VII & VIII, Pages 20 & 21)	Heli-Coil tap 6FPB, Tables IX & XI, Pages 22 & 24
40	Remove chips	Air Nozzle
50	Gage according to your sampling plan	Heli-Coil gage 3694-6, Pages 26 & 27
60	Install 3591-6CN562 Heli-Coil insert 3/4 to 1-1/2 pitch below surface	Installation Tool 7552-6, Page 29
70	Break off tang	Heli-Coil tang break-off tool 3692-6, Page 33

Heli-Coil® drilling data – inch

The **minimum** drilling depths shown below allow for the following recommended practices:

1. Countersinking the drilled hole to prevent a feather edge at the start of the tapped hole.
2. 3/4 – 1-1/2 pitch of insert **"set-down"** to allow for maximum production tolerance. Dimensions are shown for both plug and bottoming taps.

Note: Plug taps 5/16" or M8 and smaller have a male center and the drilled hole depth dimensions allow for this length (one half of the diameter of the bolt). Calculation of dimension "F" is as follows:

TABLE V – INCH DRILLED HOLE DIMENSIONS

Nominal Thread Size	Suggested Drill Size		"F" MINIMUM DRILLING DEPTH FOR EACH INSERT LENGTH									
			Plug Taps					Bottoming Taps				
	Aluminum	Steel, Magnesium, Plastic	1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.	1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.
UNIFIED COARSE THREAD (UNC)												
1 (.073)-64	#47 (.0785)	#46 (.0810)	.203	.240	.276	.313	.349	.136	.172	.209	.245	.282
2 (.086)-56	3/32 (.0938)	#41 (.0960)	.236	.279	.322	.365	.408	.157	.200	.243	.286	.329
3 (.099)-48	#36 (.1065)	7/64 (.1094)	.273	.323	.372	.422	.471	.182	.232	.281	.331	.380
4 (.112)-40	#31 (.1200)	#31 (.1200)	.318	.374	.430	.486	.542	.212	.268	.324	.380	.436
5 (.125)-40	3.4mm (.1339)	#29 (.1360)	.338	.400	.462	.525	.588	.225	.288	.350	.412	.475
6 (.138)-32	#26 (.1470)	#25 (.1495)	.394	.464	.532	.602	.670	.263	.332	.401	.470	.539
8 (.164)-32	#17 (.1730)	#16 (.1770)	.434	.516	.598	.680	.762	.289	.371	.453	.535	.617
10 (.190)-24	13/64 (.2031)	#5 (.2055)	.535	.630	.725	.820	.915	.357	.452	.547	.642	.737
12 (.216)-24*	#1 (.2280)	#1 (.2280)	.574	.682	.790	.898	1.006	.383	.491	.599	.707	.815
1/4 (.2500)-20	H (.2660)	H (.2660)	.675	.800	.925	1.050	1.175	.450	.575	.700	.825	.950
5/16 (.3125)-18	Q (.3320)	Q (.3320)	.801	.957	1.113	1.269	1.425	.534	.690	.846	1.002	1.158
3/8 (.3750)-16	X (.3970)	X (.3970)	.750	.938	1.125	1.312	1.500	.625	.812	1.000	1.188	1.375
7/16 (.4375)-14	29/64 (.4531)	29/64 (.4531)	.867	1.086	1.305	1.524	1.743	.724	.943	1.162	1.381	1.600
1/2 (.5000)-13*	33/64 (.5156)	17/32 (.5312)	.962	1.212	1.462	1.712	1.962	.808	1.058	1.308	1.558	1.808
9/16 (.5625)-12*	37/64 (.5781)	19/32 (.5938)	1.062	1.343	1.624	1.905	2.186	.895	1.176	1.457	1.738	2.019
5/8 (.6250)-11	21/32 (.6562)	21/32 (.6562)	1.170	1.483	1.795	2.108	2.420	.989	1.301	1.614	1.926	2.239
3/4 (.7500)-10	25/32 (.7812)	25/32 (.7812)	1.350	1.725	2.100	2.475	2.850	1.150	1.525	1.900	2.275	2.650
7/8 (.8750)-9	29/32 (.9062)	29/32 (.9062)	1.542	1.979	2.417	2.854	3.292	1.319	1.757	2.194	2.632	3.069
1 (1.000)-8	1-1/32 (1.0312)	1-1/32 (1.0312)	1.750	2.250	2.750	3.250	3.750	1.500	2.000	2.500	3.000	3.500
1-1/8 (1.1250)-7	1-11/64 (1.1719)	1-11/64 (1.1719)	1.982	2.545	3.107	3.670	4.232	1.696	2.259	2.821	3.384	3.946
1-1/4 (1.2500)-7	1-19/64 (1.2969)	1-19/64 (1.2969)	2.107	2.732	3.357	3.982	4.607	1.821	2.446	3.071	3.696	4.321
1-3/8 (1.3750)-6	1-27/64 (1.4219)	1-27/64 (1.4219)	2.375	3.062	3.750	4.437	5.125	2.042	2.729	3.417	4.104	4.792
1-1/2 (1.5000)-6	1-35/64 (1.5469)	1-35/64 (1.5469)	2.500	3.250	4.000	4.750	5.500	2.167	2.917	3.667	4.417	5.167
UNIFIED FINE THREAD (UNF)												
2 (.086)-64	2.35mm (.0925)	2.35mm (.0925)	.223	.266	.309	.352	.395	.149	.192	.235	.278	.321
3 (.099)-56	#37 (.1040)	#36 (.1065)	.256	.305	.355	.404	.454	.170	.220	.269	.319	.368
4 (.112)-48	3mm (.1181)	#31 (.1200)	.293	.349	.405	.461	.517	.195	.251	.307	.363	.419
6 (.138)-40	#26 (.1470)	#25 (.1495)	.357	.426	.495	.564	.633	.238	.307	.376	.445	.514
8 (.164)-36	#17 (.1730)	#16 (.1770)	.413	.495	.577	.659	.741	.275	.357	.439	.521	.603
10 (.190)-32	#7 (.2010)	13/64 (.2031)	.472	.568	.662	.758	.852	.315	.410	.505	.600	.695
1/4 (.2500)-28	G (.2610)	6.7mm (.2638)	.589	.714	.839	.964	1.089	.393	.518	.643	.768	.893
5/16 (.3125)-24	21/64 (.3281)	21/64 (.3281)	.718	.874	1.030	1.186	1.342	.479	.635	.791	.947	1.103
3/8 (.3750)-24	25/64 (.3906)	25/64 (.3906)	.625	.812	1.000	1.187	1.375	.542	.729	.917	1.104	1.292
7/16 (.4375)-20	29/64 (.4531)	29/64 (.4531)	.738	.957	1.176	1.395	1.614	.638	.857	1.076	1.295	1.514
1/2 (.5000)-20	33/64 (.5156)	33/64 (.5156)	.800	1.050	1.300	1.550	1.800	.700	.950	1.200	1.450	1.700
9/16 (.5625)-18	37/64 (.5781)	37/64 (.5781)	.895	1.176	1.457	1.738	2.019	.784	1.065	1.346	1.627	1.908
5/8 (.6250)-18	41/64 (.6406)	41/64 (.6406)	.958	1.271	1.583	1.896	2.208	.847	1.160	1.472	1.785	2.097
3/4 (.7500)-16	49/64 (.7656)	49/64 (.7656)	1.125	1.500	1.875	2.250	2.625	1.000	1.375	1.750	2.125	2.500
7/8 (.8750)-14	57/64 (.8906)	57/64 (.8906)	1.304	1.741	2.179	2.616	3.054	1.161	1.598	2.036	2.473	2.911
1 (1.000)-14	1-1/64 (1.0156)	1-1/32 (1.0312)	1.429	1.929	2.429	2.929	3.429	1.286	1.786	2.286	2.786	3.286
1 (1.000)-12*	1-1/64 (1.0156)	1-1/32 (1.0312)	1.500	2.000	2.500	3.000	3.500	1.333	1.833	2.333	2.833	3.333
1-1/8 (1.1250)-12*	1-9/64 (1.1406)	1-5/32 (1.1562)	1.625	2.187	2.750	3.312	3.875	1.458	2.021	2.583	3.146	3.708
1-1/4 (1.2500)-12*	1-17/64 (1.2656)	1-9/32 (1.2812)	1.750	2.375	3.000	3.625	4.250	1.583	2.208	2.833	3.458	4.083
1-3/8 (1.3750)-12*	1-25/64 (1.3906)	1-13/32 (1.4062)	1.875	2.562	3.250	3.937	4.625	1.708	2.396	3.083	3.771	4.458
1-1/2 (1.5000)-12*	1-33/64 (1.5156)	1-17/32 (1.5312)	2.000	2.750	3.500	4.250	5.000	1.833	2.583	3.333	4.083	4.833

**Standard size drills are suggested even though in these sizes they vary slightly from minor diameter specifications in NASM33537.*

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For Plug Taps 5/16" or M8 and smaller. F is equal to the insert nominal length (Q) + ½ the nominal bolt diameter + 5 Pitch (allowing for tap chamfer, countersink and maximum "set-down").

For Plug Taps 3/8" or M10 and larger. F is equal to the insert nominal length (Q) + 5 Pitch (allowing for tap chamfer, counter sink and maximum "set-down").

For Bottoming Taps. F is equal to the insert nominal length (Q) + 3 Pitch (allowing for tap chamfer, countersink and maximum "set-down").

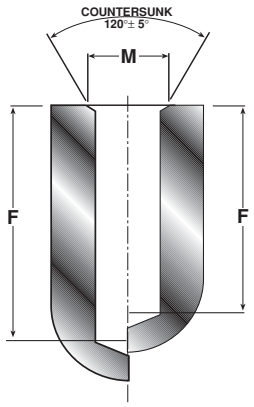

TABLE VI – METRIC DRILLED HOLE DIMENSIONS

Nominal Thread Size	Minor Diameter		Suggested Drill Size		"F" MINIMUM DRILLING DEPTH FOR EACH INSERT LENGTH									
					Plug Taps					Bottoming Taps				
	Min.	Max,	Aluminum	Steel, Magnesium, Plastic	1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.	1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.
METRIC COARSE														
M2X0.4	2.087	2.199	2.1	2.1	5.40	6.40	7.40	8.40	9.40	3.60	4.60	5.60	6.60	7.60
M2.2x0.45	2.297	2.422	2.3	2.35	6.00	7.10	8.20	9.30	10.40	4.00	5.10	6.20	7.30	8.40
M2.5x0.45	2.597	2.722	2.55	2.65	6.45	7.70	8.95	10.20	11.45	4.30	5.55	6.80	8.05	9.30
M3x0.5	3.108	2.248	3.15	3.2	7.50	9.00	10.50	12.00	13.50	5.00	6.50	8.00	9.50	11.00
M3.5x0.6	3.630	3.790	3.7	3.7	8.85	10.60	12.35	14.10	15.85	5.90	7.65	9.40	11.15	12.90
M4x0.7	4.152	4.332	4.2	4.25	10.20	12.20	14.20	16.20	18.20	6.80	8.80	10.80	12.80	14.80
M5x0.8	5.174	5.374	5.2	5.3	12.30	14.80	17.30	19.80	22.30	8.20	10.70	13.20	15.70	18.20
M6x1	6.217	6.407	6.25	6.3	15.00	18.00	21.00	24.00	27.00	10.00	13.00	16.00	19.00	22.00
M7x1	7.217	7.407	7.25	7.3	16.50	20.00	23.50	27.00	30.50	11.00	14.50	18.00	21.50	25.00
M8x1.25	8.271	8.483	8.3	8.4	19.50	23.50	27.50	31.50	35.50	13.00	17.00	21.00	25.00	29.00
M10x1.5	10.324	10.560	10.5	10.5	19.00	24.00	29.00	34.00	39.00	16.00	21.00	26.00	31.00	36.00
M12x1.75	12.379	12.644	12.5	12.5	22.50	28.50	34.50	40.50	46.50	19.00	25.00	31.00	37.00	43.00
M14x2	14.433	14.733	14.5	14.5	26.00	33.00	40.00	47.00	54.00	22.00	29.00	36.00	43.00	50.00
M16x2	16.433	16.733	16.5	16.5	28.00	36.00	44.00	52.00	60.00	24.00	32.00	40.00	48.00	56.00
M18x2.5	18.541	18.896	18.75	18.75	33.00	42.00	51.00	60.00	69.00	28.00	37.00	46.00	55.00	64.00
M20x2.5	20.541	20.896	20.75	20.75	35.00	45.00	55.00	65.00	75.00	30.00	40.00	50.00	60.00	70.00
M22x2.5	22.541	22.896	22.75	22.75	37.00	48.00	59.00	70.00	81.00	32.00	43.00	54.00	65.00	76.00
M24x3	24.649	25.049	24.75	24.75	42.00	54.00	66.00	78.00	90.00	36.00	48.00	60.00	72.00	84.00
M27x3	27.649	28.049	27.75	27.75	45.00	58.50	72.00	85.50	99.00	39.00	52.50	66.00	79.50	93.00
M30x3.5	30.757	31.207	31	31	51.00	66.00	81.00	96.00	111.00	44.00	59.00	74.00	89.00	104.00
M33x3.5	33.757	34.207	34	34	54.00	70.50	87.00	103.50	120.00	47.00	63.50	80.00	96.50	113.00
M36x4	36.866	37.341	37	37	60.00	78.00	96.00	114.00	132.00	52.00	70.00	88.00	106.00	124.00
M39x4	39.866	40.341	40	40	63.00	82.50	102.00	121.50	141.00	55.00	74.50	94.00	113.50	133.00
METRIC FINE														
M8x1	8.217	8.407	8.25	8.3	18.00	22.00	26.00	30.00	34.00	12.00	16.00	20.00	24.00	28.00
M10x1	10.217	10.407	10.25	10.25	16.00	21.00	26.00	31.00	36.00	14.00	19.00	24.00	29.00	34.00
M10x1.25*	10.271	10.483	10.25	10.25	17.50	22.50	27.50	32.50	37.50	15.00	20.00	25.00	30.00	35.00
M12x1.25*	12.271	12.483	12.25	12.25	19.50	25.50	31.50	37.50	43.50	17.00	23.00	29.00	35.00	41.00
M12x1.5*	12.324	12.560	12.25	12.5	21.00	27.00	33.00	39.00	45.00	18.00	24.00	30.00	36.00	42.00
M14x1.5*	14.324	14.560	14.25	14.5	23.00	30.00	37.00	44.00	51.00	20.00	27.00	34.00	41.00	48.00
M16x1.5*	16.324	16.560	16.25	16.5	25.00	33.00	41.00	49.00	57.00	22.00	30.00	38.00	46.00	54.00
M18x1.5*	18.324	18.560	18.25	18.5	27.00	36.00	45.00	54.00	63.00	24.00	33.00	42.00	51.00	60.00
M20x1.5*	20.324	20.560	20.25	20.5	29.00	39.00	49.00	59.00	69.00	26.00	36.00	46.00	56.00	66.00
M22x1.5*	22.324	22.560	22.25	22.5	31.00	42.00	53.00	64.00	75.00	28.00	39.00	50.00	61.00	72.00
M18x2	18.433	18.733	18.5	18.5	30.00	39.00	48.00	57.00	66.00	26.00	35.00	44.00	53.00	62.00
M20x2	20.433	20.733	20.5	20.5	32.00	42.00	52.00	62.00	72.00	28.00	38.00	48.00	58.00	68.00
M22x2	22.433	22.733	22.5	22.5	34.00	45.00	56.00	67.00	78.00	30.00	41.00	52.00	63.00	74.00
M24x2	24.433	24.733	24.5	24.5	36.00	48.00	60.00	72.00	84.00	32.00	44.00	56.00	68.00	80.00
M27x2	27.433	27.733	27.5	27.5	39.00	52.50	66.00	79.50	93.00	35.00	48.50	62.00	75.50	89.00
M30x2	30.433	30.733	30.5	30.5	42.00	57.00	72.00	87.00	102.00	38.00	53.00	68.00	83.00	98.00
M33x2	33.433	33.733	33.5	33.5	45.00	61.50	78.00	94.50	111.00	41.00	57.50	74.00	90.50	107.00
M36x2	36.433	36.733	36.5	36.5	48.00	66.00	84.00	102.00	120.00	44.00	62.00	80.00	98.00	116.00
M39x2	39.433	39.733	39.5	39.5	51.00	70.50	90.00	109.00	129.00	47.00	66.50	86.00	105.50	125.00
M36x3	36.649	37.049	37	37	54.00	72.00	90.00	108.00	126.00	48.00	66.00	84.00	102.00	120.00
M39x3	39.649	40.049	40	40	57.00	76.50	96.00	115.50	135.00	51.00	70.50	90.00	109.50	129.00

** Standard size drills are suggested even though in these sizes they vary slightly from minor diameter limits.*

Heli-Coil® tapping data – inch

The *minimum* tapping depths shown below (Dimension H) are the **MINIMUM** for countersunk holes and an insert set-down of 1 – 1/2 pitch maximum. The calculation for Dimension "H" is:

H is equal to insert nominal length + 1 Pitch.

The tapped hole must be held within the stated pitch diameter limits for the required class of fit for the installed Heli-Coil insert.

When anodize, Iridite or other finishes are used, all tapped hole dimensions must be met after the finishes are applied.

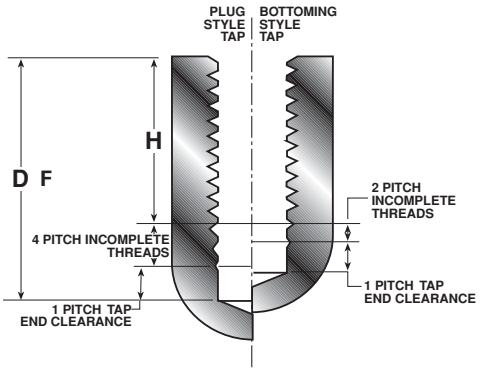

TABLE VII – INCH TAPPED HOLE DIMENSIONS

Nominal Thread Size	Countersink "M" Diameter (120° ±5° included angle)		Pitch Diameter			"H" MINIMUM TAPPING DEPTH					Minor Diameter (after tapping)		Tap Major Dia. Max.	Thread Pitch "P"
						INSERT LENGTH								
	Min.	Max.	Min.	3B Max.	2B Max.	1D	1-1/2D	2 D	1-1/2D	3D	Min.	Max.		
UNIFIED COARSE THREAD (UNC)														
1 (.073)-64	.085	.10	.0832	.0843	.0850	.090	.125	.160	.200	.235	.0764	.0823	.0958	.01563
2 (.086)-56	.09	.11	.0976	.0989	.0996	.100	.150	.190	.230	.280	.0899	.0961	.1117	.01786
3 (.099)-48	.11	.14	.1126	.1140	.1148	.120	.170	.220	.270	.320	.1036	.1104	.1289	.02083
4 (.112)-40	.14	.17	.1283	.1299	.1308	.140	.190	.250	.310	.360	.1175	.1252	.1473	.02500
5 (.125)-40	.16	.19	.1413	.1430	.1438	.150	.210	.280	.340	.400	.1305	.1373	.1603	.02500
6 (.138)-32	.18	.21	.1583	.1601	.1611	.170	.240	.310	.380	.450	.1448	.1527	.1817	.03125
8 (.164)-32	.20	.23	.1843	.1862	.1872	.200	.280	.360	.440	.520	.1708	.1781	.2077	.03125
10 (.190)-24	.24	.27	.2170	.2192	.2203	.230	.330	.420	.520	.610	.1990	.2080	.2475	.04167
12 (.216)-24	.26	.29	.2430	.2453	.2464	.260	.370	.470	.580	.690	.2250	.2340	.2735	.04167
1/4 (.2500)-20	.31	.34	.2825	.2851	.2864	.300	.430	.550	.680	.800	.2608	.2704	.3187	.05000
5/16 (.3125)-18	.38	.41	.3486	.3515	.3529	.370	.530	.680	.840	.990	.3245	.3342	.3884	.05556
3/8 (.3750)-16	.45	.48	.4156	.4189	.4203	.440	.630	.810	1.000	1.190	.3885	.3987	.4602	.06250
7/16 (.4375)-14	.52	.55	.4839	.4875	.4890	.510	.730	.950	1.170	1.380	.4530	.4639	.5343	.07143
1/2 (.5000)-13	.59	.62	.5499	.5537	.5554	.580	.830	1.080	1.330	1.580	.5166	.5273	.6042	.07692
9/16 (.5625)-12	.66	.69	.6167	.6208	.6225	.650	.930	1.210	1.490	1.770	.5806	.5918	.6751	.08333
5/8 (.65250)-11	.73	.76	.6841	.6885	.6903	.720	1.030	1.340	1.650	1.970	.6447	.6564	.7477	.09091
3/4 (.7500)-10	.87	.90	.8149	.8196	.8216	.850	1.230	1.600	1.980	2.350	.7716	.7838	.8850	.10000
7/8 (.8750)-9	1.00	1.03	.9471	.9522	.9543	.990	1.420	1.860	2.300	2.740	.8990	.9119	1.0247	.11111
1 (1.000)-8	1.14	1.17	1.0812	1.0868	1.0890	1.130	1.630	2.130	2.630	3.130	1.0271	1.0421	1.1681	.12500
1-1/8 (1.1250)-7	1.29	1.32	1.2178	1.2239	1.2262	1.270	1.830	2.390	2.960	3.520	1.1559	1.1730	1.3171	.14286
1-1/4 (1.2500)-7	1.41	1.44	1.3428	1.3490	1.3514	1.390	2.020	2.640	3.270	3.890	1.2809	1.2980	1.4421	.14286
1-3/8 (1.3750)-6	1.56	1.59	1.4832	1.4900	1.4926	1.540	2.230	2.920	3.600	4.290	1.4110	1.4310	1.5982	.16667
1-1/2 (1.5000)-6	1.69	1.72	1.6082	1.6151	1.6177	1.670	2.420	3.170	3.920	4.670	1.5360	1.5560	1.7232	.16667
UNIFIED FINE THREAD (UNF)														
2 (.086)-64	.09	.11	.0962	.0974	.0981	.100	.145	.190	.230	.275	.0894	.0947	.1088	.01563
3 (.099)-56	.11	.14	.1106	.1119	.1126	.120	.170	.220	.270	.310	.1029	.1086	.1247	.01786
4 (.112)-48	.14	.17	.1256	.1271	.1279	.130	.190	.240	.300	.360	.1166	.1229	.1419	.02083
6 (.138)-40	.17	.20	.1543	.1560	.1569	.160	.230	.300	.370	.440	.1435	.1503	.1733	.02500
8 (.164)-36	.20	.23	.1821	.1840	.1849	.190	.270	.360	.440	.520	.1701	.1771	.2032	.02778
10 (.190)-32	.23	.26	.2103	.2123	.2133	.220	.320	.410	.510	.600	.1968	.2041	.2337	.03125
1/4 (.2500)-28	.29	.32	.2732	.2754	.2765	.290	.410	.540	.660	.790	.2577	.2646	.2995	.03571
5/16 (.3125)-24	.36	.39	.3395	.3421	.3433	.350	.510	.670	.820	.980	.3215	.3288	.3700	.04167
3/8 (.3750)-24	.42	.45	.4020	.4047	.4059	.420	.600	.790	.980	1.170	.3840	.3910	.4325	.04167
7/16 (.4375)-20	.50	.53	.4700	.4731	.4744	.490	.710	.930	1.140	1.360	.4483	.4561	.5062	.05000
1/2 (.5000)-20	.56	.59	.5325	.5357	.5371	.550	.800	1.050	1.300	1.550	.5108	.5186	.5687	.05000
9/16 (.5625)-18	.63	.66	.5986	.6020	.6035	.620	.900	1.180	1.460	1.740	.5745	.5826	.6384	.05556
5/8 (.6250)-18	.69	.72	.6611	.6646	.6661	.680	.990	1.310	1.620	1.930	.6370	.6451	.7009	.05556
3/4 (.7500)-16	.82	.85	.7906	.7945	.7961	.810	1.190	1.560	.1940	2.310	.7635	.7720	.8352	.06250
7/8 (.8750)-14	.96	.99	.9214	.9257	.9274	.950	1.380	1.820	2.260	2.700	.8905	.8994	.9718	.07143
1 (1.000)-14	1.08	1.11	1.0464	1.0508	1.0527	1.070	1.570	2.070	2.570	3.070	1.0155	1.0243	1.0968	.07143
1 (1.000)-12	1.10	1.13	1.0542	1.0589	1.0608	1.080	1.580	2.080	2.580	3.080	1.0181	1.0281	1.1126	.08333
1-1/8 (1.1250)-12	1.22	1.25	1.1792	1.1841	1.1860	1.210	1.770	2.330	2.900	3.460	1.1431	1.1531	1.2376	.08333
1-1/4 (1.2500)-12	1.35	1.38	1.3042	1.3092	1.3112	1.330	1.960	2.580	3.210	3.830	1.2681	1.2781	1.3626	.08333
1-3/8 (1.3750)-12	1.47	1.50	1.4292	1.4343	1.4364	1.460	2.150	2.830	3.520	4.210	1.3931	1.4031	1.4876	.08333
1-1/2 (1.5000)-12	1.60	1.63	1.5542	1.5595	1.5615	1.580	2.330	3.080	3.830	4.580	1.5181	1.5281	1.6126	.08333

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Heli-Coil taps in various types and styles produce holes for Tolerance Classes 4H5H or 3B and 5H or 2B for use in the general range of aluminums, magnesiums, mild steels, free machining stainless steels and other free machining materials. Conventional shop practice and production procedures, speeds, feeds and lubricants should be used in combination with proper fixturing and good tapping machines or tapping heads. The tapped hole must be held within the stated pitch diameter limits for the required Tolerance Class of fit for the installed Heli-Coil insert. For Standard (free running inserts), a tolerance class 5H or 2B is recommended. For Screw-Lock inserts, a tolerance class 4H5H or 3B is recommended in order to develop higher locking torques.

TABLE VIII – METRIC TAPPED HOLE DIMENSIONS

Nominal Thread Size	"M" Countersink Diameter		Pitch Diameter			"H" MINIMUM TAPPING DEPTH					Tap Major Dia. Max.
	Max.	Min.	Min.	4 H Max.	5H Max.	1 Dia.	1-1/2 Dia.	2 Dia.	2-1/2 Dia.	3 Dia.	
METRIC COARSE											
M2X0.4	2.30	2.70	2.260	2.295	2.310	2.4	3.4	4.4	5.4	6.4	2.581
M2.2x0.45	2.90	2.40	2.492	2.532	2.547	2.7	3.8	4.9	6.0	7.1	2.845
M2.5x0.45	3.40	2.90	2.792	2.832	2.847	3.0	4.2	5.5	6.7	8.0	3.145
M3x0.5	4.00	3.40	3.325	3.367	3.384	3.5	5.0	6.5	8.0	9.5	3.716
M3.5x0.6	4.70	4.10	3.890	3.940	3.959	4.1	5.9	7.6	9.4	11.1	4.354
M4x0.7	5.30	4.70	4.455	4.509	4.529	4.7	6.7	8.7	10.7	12.7	5.007
M5x0.8	6.40	5.80	5.520	5.577	5.597	5.8	8.3	10.8	13.3	15.8	6.145
M6x1	7.70	7.10	6.650	6.719	6.742	7.0	10.0	13.0	16.0	19.0	7.422
M7x1	8.70	8.10	7.650	7.719	7.742	8.0	11.5	15.0	18.5	22.0	8.422
M8x1.25	10.10	9.50	8..812	8.886	8.911	9.3	13.3	17.3	21.3	25.3	9.787
M10x1.5	12.40	11.80	10.974	11.061	11.089	11.5	16.5	21.5	26.5	31.5	12.131
M12x1.75	14.80	14.20	13.137	13.236	13.271	13.8	19.8	25.8	31.8	37.8	14.478
M14x2	17.10	16.50	15.299	15.406	15.444	16.0	23.0	30.0	37.0	44.0	16.822
M16x2	19.10	18.50	17.299	17.406	17.444	18.0	26.0	34.0	42.0	50.0	18.822
M18x2.5	21.80	21.20	19.624	19.738	19.778	20.5	29.5	38.5	47.5	56.5	21.513
M20x2.5	23.80	23.20	21.624	21.738	21.778	22.5	32.5	42.5	52.5	62.5	23.513
M22x2.5	25.50	25.20	23.624	23.738	23.778	24.5	35.5	46.5	57.5	68.5	25.513
M24x3	28.50	27.90	25.948	26.093	26.135	27.0	39.0	51.0	63.0	75.0	28.238
M27x3	31.50	30.90	28.948	29.093	29.135	30.0	43.5	57.0	70.5	84.0	31.238
M30x3.5	35.20	34.60	32.273	32.428	32.472	33.5	48.5	63.5	78.5	93.5	34.925
M33x3.5	38.20	37.60	35.273	35.428	35.472	36.5	53.0	69.5	86.0	102.5	37.925
M36x4	41.90	41.30	38.598	38.763	38.809	40.0	58.0	76.0	94.0	112.0	41.615
M39x4	44.90	44.30	41.598	41.763	41.809	43.0	62.5	82.0	101.5	121.0	44.615
METRIC FINE											
M8x1	9.70	9.10	8.650	8.719	8.742	9.0	13.0	17.0	21.0	25.0	9.422
M10x1	11.70	11.10	10.650	10.719	10.742	11.0	16.0	21.0	26.0	31.0	11.422
M10x1.25	12.10	11.50	10.812	10.886	10.911	11.3	16.3	21.3	26.3	31.3	11.787
M12x1.25	14.10	13.50	12.812	12.898	12.926	13.3	19.3	25.3	31.3	37.3	13.787
M12x1.5	14.40	13.80	12.974	13.067	13.099	13.5	19.5	25.5	31.5	37.5	14.131
M14x1.5	16.40	15.80	14.974	15.067	15.099	15.5	22.5	29.5	36.5	43.5	16.131
M16x1.5	18.40	17.80	16.974	17.067	17.099	17.5	25.5	33.5	41.5	49.5	18.131
M18x1.5	20.40	19.80	18.974	19.067	19.099	19.5	28.5	37.5	46.5	55.5	20.131
M20x1.5	22.40	21.80	20.974	21.067	21.099	21.5	31.5	41.5	51.5	61.5	22.131
M22x1.5	24.40	23.80	22.974	23.067	23.099	23.5	34.5	45.5	56.5	67.5	24.131
M18x2	21.10	20.50	19.299	19.406	19.444	20.0	29.0	38.0	47.0	56.0	20.822
M20x2	23.10	22.50	21.299	21.406	21.444	22.0	32.0	42.0	52.0	62.0	22.822
M22x2	25.10	24.50	23.299	23.406	23.444	24.0	35.0	46.0	57.0	68.0	24.822
M24x2	27.10	26.50	25.299	25.414	25.454	26.0	38.0	50.0	62.0	74.0	26.822
M27x2	30.10	29.50	28.299	28.414	28.454	29.0	42.5	56.0	69.5	83.0	29.822
M30x2	33.10	32.50	31.299	31.414	31.454	32.0	47.0	62.0	77.0	92.0	32.822
M33x2	36.10	35.50	34.299	34.414	34.454	35.0	51.5	68.0	84.5	101.0	35.822
M36x2	39.10	38.50	37.299	37.414	37.454	38.0	56.0	74.0	92.0	110.0	38.822
M39x2	42.10	41.50	40.299	40.414	40.454	41.0	60.5	80.0	99.5	119.0	41.822
M36x3	40.50	39.90	37.948	38.093	38.135	39.0	57.0	75.0	93.0	111.0	40.238
M39x3	43.50	42.90	40.948	41.093	41.135	42.0	61.5	81.0	100.5	120.0	43.238

Heli-Coil® STI tap part numbers – inch

STRAIGHT FLUTE TAPS. Widely used for general hand and machine tapping operations. Available in sizes up to 1-1/2".

- **Plug Style – (4 Thread Chamfer).** Used in thru holes and blind holes that allow for ample chip clearance. Easier to start and require less tapping torque than bottoming taps.
- **Bottoming Style – (2 Thread Chamfer).** Used in blind holes drilled to a minimum depth that requires threads be close to the bottom of the hole.

SPIRAL POINTED – PLUG & SPIRAL FLUTE. Used for efficient chip disposal in production tapping operations. Available in sizes up to 1/2".

- **Spiral Pointed - Plug (4 Thread Chamfer).** Incorporates an angular grind at the point end of the tap which shears chips and drives them forward of the tap. Used widely in long thru holes and blind holes with ample chip clearance. They are free cutting and provide increased tap strength. Not recommended for abrasive materials.

TABLE IX – HELI-COIL STI TAP PART NUMBERS

Nominal Thread Size	Straight Flute				Spiral Point		High Spiral Flute		Roughing Tap
	Plug		Bottoming		Plug		Bottoming		
	3B	2B	3B	2B	3B	2B	3B	2B	
UNIFIED COARSE THREAD (UNC)									
1 (.073)-64	01CPB	01CPA	01CBB	01CBA	01CSB	01CSA	5905-01	6905-01	
2 (.086)-56	02CPB	02CPA	02CBB	02CBA	02CSB	02CSA	5905-02	6905-02	
3 (.099)-48	03CPB	03CPA	03CBB	03CBA	03CSB	03CSA	5905-03	6905-03	
4 (.112)-40	04CPB	04CPA	04CBB	04CBA	04CSB	04CSA	5905-04	6905-04	
5 (.125)-40	05CPB	05CPA	05CBB	05CBA	05CSB	05CSA	5905-05	6905-05	
6 (.138)-32	06CPB	06CPA	06CBB	06CBA	06CSB	06CSA	5905-06	6905-06	
8 (.164)-32	2CPB	2CPA	2CBB	2CBA	2CSB	2CSA	5905-2	6905-2	
10 (.190)-24	3CPB	3CPA	3CBB	3CBA	3CSB	3CSA	5905-3	6905-3	
12 (.216)-24	1CPB	1CPA	1CBB	1CBA	1CSB	1CSA	5905-1	6905-1	
1/4 (.2500)-20	4CPB	4CPA	4CBB	4CBA	4CSB	4CSA	5905-4	6905-4	
5/16 (.3125)-18	5CPB	5CPA	5CBB	5CBA	5CSB	5CSA	5905-5	6905-5	
3/8 (.3750)-16	6CPB	6CPA	6CBB	6CBA	6CSB	6CSA	5905-6	6905-6	
7/16 (.4375)-14	7CPB	7CPA	7CBB	7CBA	7CSB	7CSA	5905-7	6905-7	7CRU
1/2 (.5000)-13	8CPB	8CPA	8CBB	8CBA	8CSB	8CSA	5905-8	6905-8	8CRU
9/16 (.5625)-12	187-9	38187-9	4187-9	43187-9					9CRU
5/8 (.6250)-11	8187-10	18187-10	10187-10	20187-10					10CRU
3/4 (.7500)-10	8187-12	18187-12	10187-12	20187-12					12CRU
7/8 (.8750)-9	8187-14	18187-14	10187-14	20187-14					14CRU
1 (1.0000)-8	8187-16	18187-16	10187-16	20187-16					16CRU
1-1/8 (1.1250)-7	8187-18	18187-18	10187-18	20187-18					
1-1/4 (1.2500)-7	8187-20	18187-20	10187-20	20187-20					
1-3/8 (1.3750)-6	8187-22	18187-22	10187-22	20187-22					
1-1/2 (1.5000)-6	8187-24	18187-24	10187-24	20187-24					
UNIFIED FINE THREAD (UNF)									
2 (.086)-64	02FPB	02FPA	02FBB	02FBA	02FSB	02FSA	5906-02	6906-02	
3 (.099)-56	03FPB	03FPA	03FBB	03FBA	03FSB	03FSA	5906-03	6906-03	
4 (.112)-48	04FPB	04FPA	04FBB	04FBA	04FSB	04FSA	5906-04	6906-04	
6 (.138)-40	06FPB	06FPA	06FBB	06FBA	06FSB	06FSA	5906-06	6906-06	
8 (.164)-36	2FPB	2FPA	2FBB	2FBA	2FSB	2FSA	5906-2	6906-2	
10 (.190)-32	3FPB	3FPA	3FBB	3FBA	3FSB	3FSA	5906-3	6906-3	
1/4 (.2500)-28	4FPB	4FPA	4FBB	4FBA	4FSB	4FSA	5906-4	6906-4	
5/16 (.3125)-24	5FPB	5FPA	5FBB	5FBA	5FSB	5FSA	5906-5	6906-5	
3/8 (.3750)-24	6FPB	6FPA	6FBB	6FBA	6FSB	6FSA	5906-6	6906-6	
7/16 (.4375)-20	7FPB	7FPA	7FBB	7FBA	7FSB	7FSA	5906-7	6906-7	7FRU
1/2 (.5000)-20	8FPB	8FPA	8FBB	8FBA	8FSB	8FSA	5906-8	6906-8	8FRU
9/16 (.5625)-18	38193-9	18193-9	43193-9	20193-9					9FRU
5/8 (.6250)-18	8193-10	18193-10	10193-10	20193-10					10FRU
3/4 (.7500)-16	8193-12	18193-12	10193-12	20193-12					12FRU
7/8 (.8750)-14	8193-14	18193-14	10193-14	20193-14					14FRU
1 (1.0000)-14	8193-16	18193-16	10193-16	20193-16					16FRU
1 (1.0000)-12	8193-161	18193-161	10193-161	20193-161					161FRU
1-1/8 (1.1250)-12	8193-18	18193-18	10193-18	20193-18					
1-1/4 (1.2500)-12	8193-20	18193-20	10193-20	20193-20					
1-3/8 (1.3750)-12	8193-22	18193-22	10193-22	20193-22					
1-1/2 (1.5000)-12	8193-24	18193-24	10193-24	20193-24					

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- **High Spiral Flute – Bottoming (2 Thread Chamfer)**. Have spiral flute for efficiently pulling stringy chips out of deep or blind holes in soft materials.

ROUGHING TAPS. Are available for difficult tapping operations where it is desirable to reduce the load on the finishing tap. Available in sizes 7/16 – 1".

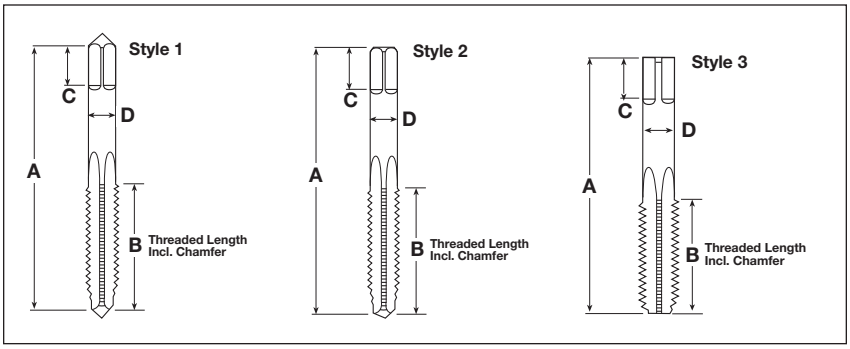

TABLE X – HELI-COIL STI TAP DIMENSIONS

Nominal Thread Size	Tap Dimensions					Number of Flutes			Tap Style*	H Limits	
	Length Overall A	Length Of Thread B	Length Of Square C	Max Dia Of Shank D	Max Size Of Square	Straight Flute	Spiral Point Plug	Spiral Flute Bott.		3B	2B
UNIFIED COARSE THREAD (UNC)											
1 (.073)-64	1-13/16	1/2	3/16	.141	.110	3	2	2	1	H1	H2
2 (.086)-56	1-7/8	9/16	3/16	.141	.110	3	2	2	1	H1	H2
3 (.099)-48	1-15/16	5/8	3/16	.141	.110	3	2	2	1	H1	H2
4 (.112)-40	2	11/16	3/16	.141	.110	3	2	2	1	H1	H2
5 (.125)-40	2-1/8	3/4	1/4	.168	.131	3	2	3	1	H1	H2
6 (.138)-32	2-3/8	7/8	1/4	.194	.152	3	2	3	1	H2	H3
8 (.164)-32	2-3/8	15/16	9/32	.220	.165	3	2	3	1	H2	H3
10 (.190)-24	2-1/2	1	5/16	.255	.191	3	2	3	2	H2	H3
12 (.216)-24	2-23/32	1-1/8	3/8	.318	.238	3	2	3	2	H2	H3
1/4 (.2500)-20	2-23/32	1-1/8	3/8	.318	.238	3	2	3	2	H2	H3
5/16 (.3125)-18	2-15/16	1-1/4	7/16	.381	.286	4	3	3	2	H3	H4
3/8 (.3750)-16	3-3/8	1-21/32	7/16	.367	.275	4	3	3	3	H3	H4
7/16 (.4375)-14	3-19/32	1-21/32	1/2	.429	.322	4	3	4	3	H3	H4
1/2 (.5000)-13	3-13/16	1-13/16	9/16	.480	.360	4	3	4	3	H3	H4
9/16 (.5625)-12	4-1/32	1-13/16	5/8	.542	.406	4	–	–	3	H3	H4
5/8 (.6250)-11	4-1/4	2	11/16	.590	.442	4	–	–	3	H3	H4
3/4 (.7500)-10	4-11/16	2-7/32	3/4	.697	.523	4	–	–	3	H3	H5
7/8 (.8750)-9	5-1/18	2-1/2	13/16	.800	.600	4	–	–	3	H3	H5
1 (1.000)-8	5-3/4	2-9/16	1	1.021	.766	4	–	–	3	H4	H6
1-1/8 (1.1250)-7	6-1/16	3	1-1/16	1.108	.831	4	–	–	3	H4	H6
1-1/4 (1.2500)-7	6-3/8	3	1-1/8	1.233	.925	4	–	–	3	H4	H6
1-3/8 (1.3750)-6	6-11/16	3-3/16	1-1/8	1.305	.979	6	–	–	3	H6	H8
1-1/2 (1.5000)-6	7	3-3/16	1-1/4	1.430	1.072	6	–	–	3	H6	H8
UNIFIED FINE THREAD (UNF)											
2 (.086)-64	1-7/8	9/16	3/16	.141	.110	3	2	2	1	H1	H2
3 (.099)-56	1-15/16	5/8	3/16	.141	.110	3	2	2	1	H1	H2
4 (.112)-48	2	11/16	3/16	.141	.110	3	2	2	1	H1	H2
6 (.138)-40	2-1/8	3/4	1/4	.168	.131	3	2	3	1	H1	H2
8 (.164)-36	2-3/8	15/16	9/32	.220	.165	3	2	3	1	H1	H2
10 (.190)-32	2-1/2	1	5/16	.255	.191	3	2	3	2	H2	H3
1/4 (.2500)-28	2-23/32	1-1/8	3/8	.318	.238	3	2	3	2	H2	H3
5/16 (.3125)-24	2-15/16	1-1/4	7/16	.381	.286	4	3	3	2	H2	H3
3/8 (.3750)-24	3-5/32	1-7/16	13/32	.323	.242	4	3	3	3	H2	H3
7/16 (.4375)-20	3-3/8	1-21/32	7/16	.367	.275	4	3	3	3	H3	H4
1/2 (.5000)-20	3-19/32	1-21/32	1/2	.429	.322	4	3	4	3	H3	H4
9/16 (.5625)-18	3-13/16	1-13/16	9/16	.480	.360	4	–	–	3	H3	H4
5/8 (.6250)-18	4-1/32	1-13/16	5/8	.542	.406	4	–	–	3	H3	H4
3/4 (.7500)-16	4-15/32	2	11/16	.652	.489	4	–	–	3	H3	H4
7/8 (.8750)-14	5-1/8	2-1/2	13/16	.800	.600	4	–	–	3	H3	H4
1 (1.0000)-14	5-7/16	2-9/16	7/8	.896	.672	4	–	–	3	H4	H6
1 (1.0000)-12	5-7/16	2-9/16	7/8	.896	.672	4	–	–	3	H4	H6
1-1/8 (1.1250)-12	5-3/4	2-9/16	1	1.021	.766	6	–	–	3	H4	H6
1-1/4 (1.2500)-12	6-1/16	3	1-1/16	1.108	.831	6	–	–	3	H4	H6
1-3/8 (1.3750)-12	6-3/8	3	1-1/8	1.233	.925	6	–	–	3	H4	H6
1-1/2 (1.5000)-12	6-11/16	3-3/16	1-1/8	1.305	.979	6	–	–	3	H4	H6

** NOTE: All bottoming taps have male center on thread end removed.*

Heli-Coil® STI tap part numbers – metric

STRAIGHT FLUTE TAPS. Widely used for general hand and machine tapping operations. Available in sizes up to 39mm.

- **Plug Style – (4 Thread Chamfer).** Used in thru holes and in blind holes that allow for ample chip clearance. Easier to start and require less tapping torque than bottoming taps.
- **Bottoming Style – (2 Thread Chamfer).** Used in blind holes drilled to a minimum depth that requires threads be close to the bottom of the hole.

SPIRAL POINTED – PLUG & SPIRAL FLUTE. Used for efficient chip disposal in production tapping operations. Available in sizes up to 12mm.

- **Spiral Pointed – Plug (4 Thread Chamfer).** Incorporates an angular grind at the point end of the tap which shears chips and drives them forward of the tap. Used widely in long thru holes and blind holes with ample chip clearance. They are free cutting and provide increased tap strength. Not recommended for abrasive materials.

TABLE XI – HELI-COIL STI TAP PART NUMBERS

Nominal Thread Size	Straight Flute				Sprial Point		High Spiral Flute		Roughing Tap
	Plug		Bottoming		Plug		Bottoming		
	4H5H	5H	4H5H	5H	4H5H	5H	4H5H	5H	
METRIC COARSE									
M2X0.4	4687-2	2087-2	4693-2	2093-2	4863-2	4763-2	5081-2	4681-2	
M2.2x0.45	4687-2.2	2087-2.2	4693-2.2	2093-2.2	4863-2.2	4763-2.2	5081-2.2	4681-2.2	
M2.5x0.45	4687-2.5	2087-2.5	4693-2.5	2093-2.5	4863-2.5	4763-2.5	5081-2.5	4681-2.5	
M3x0.5	4687-3	2087-3	4693-3	2093-3	4863-3	4763-3	5081-3	4681-3	
M3.5x0.6	4687-3.5	2087-3.5	4693-3.5	2093-3.5	4863-3.5	4763-3.5	5081-3.5	4681-3.5	
M4x0.7	4687-4	2087-4	4693-4	2093-4	4863-4	4763-4	5081-4	4681-4	
M5x0.8	4687-5	2087-5	4693-5	2093-5	4863-5	4763-5	5081-5	4681-5	
M6x1	4687-6	2087-6	4693-6	2093-6	4863-6	4763-6	5081-6	4681-6	
M7x1	4687-7	2087-7	4693-7	2093-7	4863-7	4763-7	5081-7	4681-7	
M8x1.25	4687-8	2087-8	4693-8	2093-8	4863-8	4763-8	5081-8	4681-8	
M10x1.5	4687-10	2087-10	4693-10	2093-10	4863-10	4763-10	5081-10	4681-10	
M12x1.75	4687-12	2087-12	4693-12	2093-12	4863-12	4763-12	5081-12	4681-12	3765-12
M14x2	4687-14	2087-14	4693-14	2093-14					3765-14
M16x2	4687-16	2087-16	4693-16	2093-16					3765-16
M18x2.5	4687-18	2087-18	4693-18	2093-18					3765-18
M20x2.5	4687-20	2087-20	4693-20	2093-20					3765-20
M22x2.5	4687-22	2087-22	4693-22	2093-22					3765-22
M24x3	4687-24	2087-24	4693-24	2093-24					3765-24
M27x3	4687-27	2087-27	4693-27	2093-27					
M30x3.5	4687-30	2087-30	4693-30	2093-30					
M33x3.5	4687-33	2087-33	4693-33	2093-33					
M36x4	4687-36	2087-36	4693-36	2093-36					
M39x4	4687-39	2087-39	4693-39	2093-39					
METRIC FINE									
M8x1	5484-8	4984-8	5486-8	4986-8	4864-8	4764-8	5066-8	4666-8	
M10x1	5484-10	4984-10	5486-10	4986-10	4864-10	4764-10	5066-10	4666-10	
M10x1.25	5444-10	4944-10	5445-10	4945-10	4865-10	4765-10	5067-10	4667-10	
M12x1.25	5444-12	4944-12	5445-12	4945-12	4865-12	4765-12	5067-12	4667-12	3767-12
M12x1.5	5476-12	4976-12	5477-12	4977-12	4866-12	4766-12	5068-12	4668-12	3768-12
M14x1.5	5476-14	4976-14	5477-14	4977-14					3768-14
M16x1.5	5476-16	4976-16	5477-16	4977-16					3768-16
M18x1.5	5476-18	4976-18	5477-18	4977-18					3768-18
M20x1.5	5476-20	4976-20	5477-20	4977-20					3768-20
M22x1.5	5476-22	4976-22	5477-22	4977-22					3768-22
M18x2	5490-18	4990-18	5492-18	4992-18					3769-18
M20x2	5490-20	4990-20	5492-20	4992-20					3769-20
M22x2	5490-22	4990-22	5492-22	4992-22					3769-22
M24x2	5490-24	4990-24	5492-24	4992-24					3769-24
M27x2	5490-27	4990-27	5492-27	4992-27					
M30x2	5490-30	4990-30	5492-30	4992-30					
M33x2	5490-33	4990-33	5492-33	4992-33					
M36x2	5490-36	4990-36	5492-36	4992-36					
M39x2	5490-39	4990-39	5492-39	4992-39					
M36x3	5496-36	4996-36	5497-36	4997-36					
M39x3	5496-39	4996-39	5497-39	4997-39					

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- **High Spiral Flute – Bottoming (2 Thread Chamfer).** Have spiral flute for efficiently pulling stringy chips out of deep or blind holes in soft materials.

ROUGHING TAPS. Are available for difficult tapping operations where it is desirable to reduce the load on the finishing tap. Available in sizes 12mm thru 24mm.

CUSTOM STI TAPS (Inch and Metric Series)

Taps made to alternate limits, configurations, or to cut difficult materials, or for very high production are available upon request. The following data should be provided at the time of ordering:

- Thread size
- Finished hole class of fit. **Example: 4H5H, 3B, custom pre-plate requirements.**
- Material to be cut, and its hardness.
- Hole configuration. **Example: Thru or Blind including length of drilled and tapped hole.**
- Type tap. **Example: Plug or Bottoming Straight Flute, Spiral Point, Spiral Flute.**
- Special features. **Example: Length, Shank Diameter, Chamfer Length, Tap Material.**
- Special coating of tap.

TABLE XII– HELI-COIL STI TAP DIMENSIONS

** Tap dimensions in millimeters.*

Nominal Thread Size	OVERALL LENGTH		THREAD LENGTH		SHANK DIAMETER		SIZE OF SQUARE		SQUARE LENGTH	
	mm	Tolerance ±	mm	Tolerance ±	Max.	Tolerance - only	mm	Tolerance - only	mm	Tolerance ±
METRIC COARSE										
M2x0.4	46.04	0.79	12.70	1.19	3.58	0.04	2.80	0.10	4.77	0.79
M2.2X0.45	47.62	0.79	14.29	1.19	3.58	0.04	2.79	0.10	4.76	0.79
M2.5x0.45	49.21	0.79	15.88	1.19	3.58	0.04	2.79	0.10	4.76	0.79
M3x0.5	50.80	0.79	17.46	1.19	3.58	0.04	2.79	0.10	4.76	0.79
M3.5x0.6	53.98	0.79	19.05	1.19	4.27	0.04	3.33	0.10	6.35	0.79
M4x0.7	60.32	0.79	22.22	1.19	4.93	0.04	3.86	0.10	6.35	0.79
M5x0.8	63.50	0.79	25.40	1.59	6.48	0.04	4.85	0.10	7.94	0.79
M6x1	69.06	0.79	28.58	1.59	8.08	0.04	6.04	0.10	9.52	0.79
M7x1	74.61	0.79	31.75	1.59	9.68	0.04	7.26	0.10	11.11	0.79
M8x1.25	74.61	0.79	31.75	1.59	9.68	0.04	7.26	0.10	11.11	0.79
M10x1.5	85.72	0.79	42.07	1.59	9.32	0.04	6.98	0.10	11.11	0.79
M12x1.75	91.28	0.79	42.07	2.38	10.90	0.04	8.18	0.15	12.70	0.79
M14x2	102.39	0.79	46.04	2.38	13.77	0.05	10.31	0.15	15.88	0.79
M16x2	107.95	0.79	50.80	2.38	14.99	0.05	11.23	0.15	17.46	0.79
M18x2.5	119.06	0.79	56.36	2.38	17.70	0.05	13.28	0.15	19.05	0.79
M20x2.5	124.62	0.79	56.36	2.38	19.30	0.05	14.48	0.15	19.05	0.79
M22X2.5	130.18	0.79	63.50	2.38	20.32	0.05	15.24	0.15	20.64	0.79
M24X3	138.11	1.59	65.09	2.38	22.76	0.05	17.07	0.20	22.22	1.59
M27X3	146.05	1.59	65.09	2.38	25.98	0.05	19.46	0.20	25.40	1.59
M30X3.5	153.99	1.59	76.20	2.38	28.14	0.05	21.11	0.20	26.99	1.59
M33X3.5	161.92	1.59	76.20	2.38	31.32	0.05	23.50	0.20	28.58	1.59
M36X4	177.80	1.59	80.96	3.18	36.32	0.08	27.23	0.20	31.75	1.59
M39X4	177.80	1.59	80.96	3.18	36.32	0.08	27.23	0.20	31.75	1.59
METRIC FINE										
M8X1	74.61	0.79	31.75	1.59	9.68	0.04	7.26	0.10	11.11	0.79
M10X1	80.71	0.79	36.51	1.59	8.20	0.04	6.15	0.10	10.32	0.79
M10X1.25	85.72	0.79	42.07	1.59	9.32	0.04	6.98	0.10	11.11	0.79
M12X1.25	91.28	0.79	42.07	2.38	10.90	0.04	8.18	0.15	12.70	0.79
M12X1.5	91.28	0.79	42.07	2.38	10.90	0.04	8.18	0.15	12.70	0.79
M14X1.5	96.84	0.79	46.04	2.38	12.19	0.04	9.14	0.15	14.29	0.79
M16X1.5	107.95	0.79	50.80	2.38	14.99	0.05	11.23	0.15	17.46	0.79
M18X1.5	113.51	0.79	50.80	2.38	16.56	0.05	12.42	0.15	17.46	0.79
M20X1.5	119.06	0.79	56.36	2.38	17.70	0.05	13.28	0.15	19.05	0.79
M22X1.5	130.18	0.79	63.50	2.38	20.32	0.05	15.24	0.15	20.64	0.79
M18X2	113.51	0.79	50.80	2.38	16.56	0.05	12.42	0.15	17.46	0.79
M20X2	124.62	0.79	56.36	2.38	19.30	0.05	14.48	0.15	19.05	0.79
M22X2	130.18	0.79	63.50	2.38	20.32	0.05	15.24	0.15	20.64	0.79
M24X2	130.18	1.59	63.50	2.38	22.76	0.05	17.07	0.20	22.22	1.59
M27X2	138.11	1.59	65.09	2.38	25.93	0.05	19.46	0.20	25.40	1.59
M30X2	146.05	1.59	65.09	2.38	28.14	0.05	21.11	0.20	26.99	1.59
M33X2	153.99	1.59	76.20	2.38	31.32	0.05	23.50	0.20	28.58	1.59
M36X2	169.86	1.59	80.96	3.18	33.15	0.08	24.87	0.20	28.58	1.59
M39X2	177.80	1.59	80.96	3.18	36.32	0.08	27.23	0.20	31.75	1.59
M36X3	169.86	1.59	80.96	3.18	33.15	0.08	24.87	0.20	28.58	1.59
M39X3	177.80	1.59	80.96	3.18	36.32	0.08	27.23	0.20	31.75	1.59

Heli-Coil® gages – inch

Accuracy of the finished thread when the insert is installed is dependent upon the accuracy of the tapped hole. If the finished tapped hole gages satisfactorily, the installed insert will be within the thread tolerance. **It is not necessary to gage the installed insert.** After the insert is installed, the **GO** thread plug gage may not enter freely; however, the insert will always seat itself when the bolt or screw is installed and tightened. (Reference NASM33537).

Gage handles and all gage nibs are marked with the extreme product limits for the particular size and class of fit. (See Pages 20 & 21, Tables VII & VIII, Pitch Diameter Limits).

When gaging tapped holes which have been thoroughly cleaned or which have a protective finish applied, the gage should always be lubricated with light oil.

HI nib may enter provided a definite drag results on or before 3rd turn from entry – Ref. FED-STD-H28, Screw thread Standards for Federal Services.

Heli-Coil STI Thread Plug Gages for checking the tapped hole are listed in the table at right.

HELI-COIL STI GAGE WITH GO & HI MEMBERS

Working gages provide a guaranteed minimum wear allowance on the pitch diameter of the **GO** members of two ten thousandths of an inch (.0002). These gages are recommended for production in sizes 1/2 inch and smaller.

Reference gages have pitch diameters on or close to minimum (basic size). They are essentially laboratory or master gages and should be used in case of conflict between two working gages. Conflict can occur when one of the gages has experienced more use and wear.

Nominal Thread Size	WORKING GAGES Suggested for Longer Wear Life		REFERENCE GAGES Suggested as Master Gages	
	3B	2B	3B	2B
UNIFIED COARSE THREAD (UNC)				
1 (.073)-64	3688-01	1442-01	1688-01	1440-01
2 (.086)-56	3688-02	1442-02	1688-02	1440-02
3 (.099)-48	3688-03	1442-03	1688-03	1440-03
4 (.112)-40	3688-04	1442-04	1688-04	1440-04
5 (.125)-40	3688-05	1442-05	1688-05	1440-05
6 (.138)-32	3688-06	1442-06	1688-06	1440-06
8 (.164)-32	3688-2	1442-2	1688-2	1440-2
10 (.190)-24	3688-3	1442-3	1688-3	1440-3
12 (.216)-24	3688-1	1442-1	1688-1	1440-1
1/4 (.2500)-20	3688-4	1442-4	1688-4	1440-4
5/16 (.3125)-18	3688-5	1442-5	1688-5	1440-5
3/8 (.3750)-16	3688-6	1442-6	1688-6	1440-6
7/16 (.4375)-14	3688-7	1442-7	1688-7	1440-7
1/2 (.5000)-13	3688-8	1442-8	1688-8	1440-8
9/16 (.5625)-12			1688-9	1440-9
5/8 (.6250)-11			1688-10	1440-10
3/4 (.7500)-10			1688-12	1440-12
7/8 (.8750)-9			1688-14	1440-14
1 (1.000)-8			1688-16	1440-16
1-1/8 (1.1250)-7			1688-18	1440-18
1-1/4 (1.2500)-7			1688-20	1440-20
1-3/8 (1.3750)-6			1688-22	1440-22
1-1/2 (1.5000)-6			1688-24	1440-24
UNIFIED FINE THREAD (UNF)				
2 (.086)-64	3694-02	1443-02	1694-02	1441-02
3 (.099)-56	3694-03	1443-03	1694-03	1441-03
4 (.112)-48	3694-04	1443-04	1694-04	1441-04
6 (.138)-40	3694-06	1443-06	1694-06	1441-06
8 (.164)-36	3694-2	1443-2	1694-2	1441-2
10 (.190)-32	3694-3	1443-3	1694-3	1441-3
1/4 (.2500)-28	3694-4	1443-4	1694-4	1441-4
5/16 (.3125)-24	3694-5	1443-5	1694-5	1441-5
3/8 (.3750)-24	3694-6	1443-6	1694-6	1441-6
7/16 (.4375)-20	3694-7	1443-7	1694-7	1441-7
1/2 (.5000)-20	3694-8	1443-8	1694-8	1441-8
9/16 (.5625)-18			1694-9	1441-9
5/8 (.6250)-18			1694-10	1441-10
3/4 (.7500)-16			1694-12	1441-12
7/8 (.8750)-14			1694-14	1441-14
1 (1.0000)-14			1694-16	1441-16
1 (1.0000)-12			1694-161	1441-161
1-1/8 (1.1250)-12			1694-18	1441-18
1-1/4 (1.2500)-12			1694-20	1441-20
1-3/8 (1.3750)-12			1694-22	1441-22
1-1/2 (1.5000)-12			1694-24	1441-24

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Heli-Coil STI Thread Plug Gages (metric) for checking the tapped hole are listed below.

The complete gage consists of the **GO** thread plug gage, the **HI** thread plug gage and the appropriately marked gage handle.

Accuracy of the finished thread, when the insert is installed, is dependent upon the accuracy of the tapped hole. If the finished tapped hole gages satisfactorily, the installed insert will be within the thread tolerance. It is, therefore, **not necessary to gage the installed insert.**

After the insert is installed, the **GO** thread plug gage may not enter freely; however, the insert will always seat itself when the bolt or screw is installed and tightened. *(Reference MA1567)*

When gaging tapped holes which have been thoroughly cleaned or which have a protective finish applied, the gage should always be lubricated with light oil.

The **HI** thread plug gage may enter provided that a definite drag results on or before the second turn of entry. *(Reference ANSI B1.16)*

Nominal Thread Size	Complete Gage	
	4H5H	5H
METRIC COARSE		
M2x0.4	4624-2	1324-2
M2.2X0.45	4624-2.2	1324-2.2
M2.5x0.45	4624-2.5	1324-2.5
M3x0.5	4624-3	1324-3
M3.5x0.6	4624-3.5	1324-3.5
M4x0.7	4624-4	1324-4
M5x0.8	4624-5	1324-5
M6x1	4624-6	1324-6
M7x1	4624-7	1324-7
M8x1.25	4624-8	1324-8
M10x1.5	4624-10	1324-10
M12x1.75	4624-12	1324-12
M14x2	4624-14	1324-14
M16x2	4624-16	1324-16
M18x2.5	4624-18	1324-18
M20x2.5	4624-20	1324-20
M22X2.5	4624-22	1324-22
M24X3	4624-24	1324-24
M27X3	4624-27	1324-27
M30X3.5	4624-30	1324-30
M33X3.5	4624-33	1324-33
M36X4	4624-36	1324-36
M39X4	4624-39	1324-39
METRIC FINE		
M8X1	5416-8	4916-8
M10X1	5416-10	4916-10
M10X1.25	5424-10	4924-10
M12X1.25	5424-12	4924-12
M12X1.5	5480-12	4980-12
M14X1.5	5480-14	4980-14
M16X1.5	5480-16	4980-16
M18X1.5	5480-18	4980-18
M20X1.5	5480-20	4980-20
M22X1.5	5480-22	4980-22
M18X2	5418-18	4918-18
M20X2	5418-20	4918-20
M22X2	5418-22	4918-22
M24X2	5418-24	4918-24
M27X2	5418-27	4918-27
M30X2	5418-30	4918-30
M33X2	5418-33	4918-33
M36X2	5421-36	4921-36
M39X3	5421-39	4921-39

Heli-Coil® tooling

Types of Tools

The various tools to install Heli-Coil inserts are presented on the following pages.

For production runs, prototype work, salvage, and repair, hand inserting tools are available. For high volume production, power inserting tools are also available. Both types of tools are dimensioned (pages 29 and 31) to aid determination of accessibility to the tapped hole.

Both hand and power inserting tools feature a threaded mandrel which engages the insert and provides a positive lead to guide the insert into the tapped hole easily and quickly.

Power inserting tools consist of an air motor, adapter and front end assembly. The front end assembly consists of a prewinder, mandrel and 3 spacers (1 for each length of insert to be installed). The versatility and adaptability of Heli-Coil power inserting tools is shown on page 32. The tool can be hand held, vertically or horizontally mounted, and adapted to both semi-automatic and fully automatic installation stations. Heli-Coil power inserting tools can be adapted to assembly stations, rotary tables and transfer lines.

Tool Service

All Heli-Coil tooling is backed by our extensive expertise and experience in virtually any application. Of course, all tools are fully warranteed. In addition, our Application Engineering Department is always available to assist in installation techniques, special tooling (longer or shorter length tools, etc.) and tool service. For very high production, Heli-Coil will provide for the successful development of automated installation systems.

Hand Inserting Tools

TYPE I Threaded Mandrel

TYPE II Prewinder

TYPE III Threaded Mandrel

TYPE IV Non-Captive Prewinder

Pictured above are the various designs of Heli-Coil hand inserting tools. Generally, finer pitch inserts are proportionately larger in the free state than coarse pitch inserts and thus have to be "pre-wound" to a smaller diameter for installation. Large coarse pitch inserts (and #2-56, #3-48 and M2.2 inserts) need only a threaded mandrel tool for installation.

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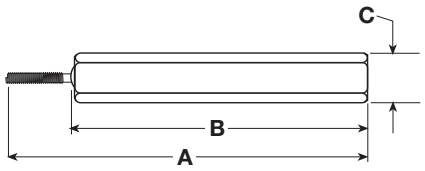
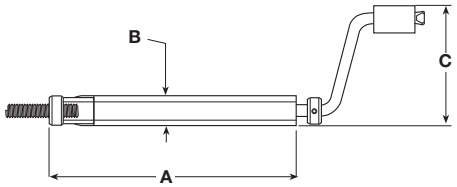
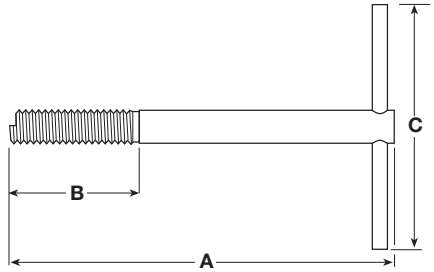
Nominal Thread Size	Hand Inserting Tools 3 Dia. Lengths thru 7/8 2 Dia. Lengths 1" & Up	Tool Type
UNIFIED COARSE (UNC)		
1 (.073)-64	7551-01	IV
2 (.086)-56	551-02	I
3 (.099)-48	551-03	I
4 (.112)-40*	7551-04	II
5 (.125)-40	7551-05	II
6 (.138)-32	7551-06	II
8 (.164)-32*	7551-2	II
10 (.190)-24*	7551-3 (M)	II
12 (.216)-24	7551-1 (M)	II
1/4 (.2500)-20	7551-4 (M)	II
5/16 (.3125)-18	7551-5 (M)	II
3/8 (.3750)-16	7551-6 (M)	II
7/16 (.4375)-14	7551-7 (M)	II
1/2 (.5000)-13	7551-8 (M)	II
9/16 (.5625)-12	3724-9	III
5/8 (.6250)-11	3724-10	III
3/4 (.7500)-10	3724-12	III
7/8 (.8750)-9	3724-14	III
1 (1.0000)-8	3724-16	III
1-1/8 (1.1250)-7	3724-18	III
1-1/4 (1.2500)-7	3724-20	III
1-3/8 (1.3750)-6	3724-22	III
1-1/2 (1.5000)-6	3724-24	III
UNIFIED FINE (UNF)		
2 (.086)-64	7552-02	IV
3 (.099)-56	7552-03	II
4 (.112)-48	7552-04	II
6 (.138)-40	7552-06	II
8 (.164)-36	7552-2	II
10 (.190)-32	7552-3 (M)	II
1/4 (.2500)-28	7552-4 (M)	II
5/16 (.3125)-24	7552-5 (M)	II
3/8 (.3750)-24	7552-6 (M)	II
7/16 (.4375)-20	7552-7 (M)	II
1/2 (.5000)-20	7552-8 (M)	II
9/16 (.5625)-18	535-9	IV
5/8 (.6250)-18	535-10	IV
3/4 (.7500)-16	535-12	IV
7/8 (.8750)-14	535-14	IV
1 (1.0000)-14	535-16	IV
1 (1.0000)-12	535-161	IV
1-1/8 (1.1250)-12	535-18	IV
1-1/4 (1.2500)-12	535-20	IV
1-3/8 (1.3750)-12	535-22	IV
1-1/2 (1.5000)-12	535-24	IV



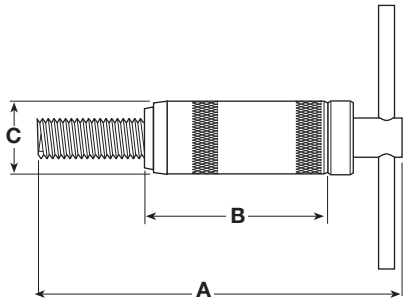
TYPE I Threaded Mandrel



TYPE II Prewinder*



TYPE III Threaded Mandrel



TYPE IV Non-Captive Prewinder

Nominal Thread Size	Hand Inserting Tools 3 Dia. Lengths thru M22 2 Dia. Lengths M24 & Up	Tool Type
METRIC COARSE		
M2X0.4	7751-2	IV
M2.2x0.45	7751-2.2	I
M2.5x0.45*	7751-2.5	II
M3x0.5*	7751-3	II
M3.5x0.6	7751-3.5	II
M4x0.7	7751-4	II
M5x0.8*	7751-5 (M)	II
M6x1	7751-6 (M)	II
M7x1	7751-7 (M)	II
M8x1.25	7751-8 (M)	II
M10x1.5	7751-10 (M)	II
M12x1.75	7751-12 (M)	II
M14x2	7751-14	IV
M16x2	7751-16	IV
M18x2.5	7751-18	III
M20x2.5	7751-20	IV
M22X2.5	7751-22	III
M24X3	7751-24	IV
M27X3	7751-27	III
M30X3.5	7751-30	III
M33X3.5	7751-33	III
M36X4	7751-36	III
M39X4	7751-39	III
METRIC FINE		
M8X1	7755-8	II
M10X1	7755-10	II
M10X1.25	7756-10	II
M12X1.25	7756-12	II
M12X1.5	7753-12	II
M14X1.5	7753-14	IV
M16X1.5	7753-16	IV
M18X1.5	7753-18	IV
M20X1.5	7753-20	IV
M22X1.5	7753-22	IV
M18X2	7754-18	IV
M20X2	7754-20	IV
M22X2	7754-22	IV
M24X2	7754-24	IV
M27X2	7754-27	IV
M30X2	7754-30	IV
M33X2	7754-33	IV
M36X2	7754-36	IV
M39X2	7754-39	IV
M36x3	7752-36	IV
M39x3	7752-39	IV

** Special tools required to install Phosphor Bronze and Inconel X-750 inserts in these sizes. To order add "-9" to the part number shown.*
Note: Inserts marked with an "(M)" are available with a steel prewinder.
For this option, specify when ordering (e.g., 7551-3M).

Hand Inserting Tool Dimensions

INCH	METRIC	A	B	C
TYPE I - Coarse & Fine				
2-56	M2.2	2-7/16	2	5/16
3-56	–	6	3	5/8
TYPE II - Coarse & Fine				
4	M2.5	4-5/8	3/8	2-9/32
5	M3	4-5/8	3/8	2-9/32
6	M3.5	4-5/8	3/8	2-9/32
8	M4	4-5/8	3/8	2-9/32
10	M5	4-5/8	15/32	2-9/32
12	–	4-5/8	33/64	2-17/32
1/4"	M6	4-5/8	33/64	2-17/32
5/16"	–	4-5/8	5/8	3-23/32
3/8"	M7 & 8	5	45/64	3-23/32

INCH	METRIC	A	B	C
TYPE II - Coarse & Fine (continued)				
7/16"	M10 & 11	5-1/4	25/32	3-23/32
1/2"	M12	5-1/2	7/8	3-23/32
TYPE III - Coarse				
9/16"	–	4-7/8	1-13/16	4
5/8"	_	4-7/8	2	4
3/4"	M18	4-7/8	2-3/8	4
7/8"	M20	4-7/8	2-3/4	4-1/2
1"	M24	4-7/8	2-1/8	4-1/2
1-1/8"	M30	6-3/4	2-1/2	6
1-1/4"	M33	6-3/4	2-3/4	6
1-3/8"	M36	6-3/4	3	6
1-1/2"	M39	6-3/4	3-1/.4	6

INCH	METRIC	A	B	C
TYPE IV - Coarse & Fine*				
9/16"	M14*	5-3/8	2-7/8	1-1/8
5/8"	M16*	5-3/8	2-7/8	1-1/8
3/4"	M18	6	2-7/8	1-1/2
7/8"	M20	6-3/8	2-7/8	1-1/2
1-14"	M22	5-7/8	2-7/8	1-5/8
1-12"	M24	5-7/8	2-7/8	1-5/8
1-1/8"	M30	6-5/16	3-1/16	2
1-1/4"	M33	6-13/16	3-5/16	2
1-3/8"	M36	7-5/16	3-9/16	2-1/4
1-1/2"	M39	7-13/16	3-13/16	2-1/4
1-64	M2	2-5/8	3/4	7/16

** M14 & M16 Coarse are Type IV Tools. For metric sizes not shown, see next largest size.*

Heli-Coil® inch power inserting tools

Heli-Coil power tools are available in UNC and UNF sizes #2 thru 1/2"* for rapid installation of Heli-Coil inserts. Power tools consist of a Front End Assembly, an Adapter and a reversible Air Motor. All three components are ordered separately. A Front End Assembly consists of a prewinder, mandrel and spacers. Select the adapter that corresponds with the insert size being used. Power tools for strip feed inserts are available in sizes #2 through 5/16".

	Nominal Thread Size	FRONT END ASSEMBLY P/N for Bulk Inserts (2 dia. max.)	FRONT END ASSEMBLY P/N for Strip Feed Inserts	PREWINDERS P/N for Bulk Inserts	PREWINDERS P/N for Strip Feed Inserts	MANDRELS	SPACERS 1 Dia.	SPACERS 1-1/2 Dia.	SPACERS 2 Dia.
	INCH COARSE THREAD (UNC)								
Small Adapter	2 (.086)-56	–	8551-02-15	–	8557-02-15	8553-02	8559-02	8560-02	8561-02
Small Adapter	4 (.112)-40	8551-04	8551-04-15	8557-04	8557-04-15	8553-04	8559-04	8560-04	8561
Small Adapter	5 (.125)-40	8551-05	–	8557-05	–	8553-05	8559-05	8560-05	8561
Small Adapter	6 (.138)-32	8551-06	8551-06-15	8557-06	8557-06-15	8553-06	8559-06	8560-06	8561
Small Adapter	8 (.164)-32	8551-2	8551-2-15	8557-2	8557-2-15	8553-2	8559-2	8560-2	8561
Small Adapter	10 (.190)-24	8551-3	8551-3-15	8557-3	8557-3-15	8553-3	8559-3	8560-3	8561
Small Adapter	1/4 (.2500)-20	8551-4	8551-4-15	8557-4	8557-4-15	8553-4	8559-4	8560-4	8561
Large Adapter	5/16 (.3125)-18	8251-5	8251-5-15	8257-5	8257-5-15	8253-5	8259-5-10	8259-5-15	
Large Adapter	3/8 (.3750)-16	8251-6	–	8257-6	–	8253-6	8259-6-10	8259-6-15	NONE
Large Adapter	7/16 (.4375)-14	8251-7	–	8257-7	–	8253-7	8259-7-10	8259-7-15	REQ'D
Large Adapter	1/2(.5000)-13	8251-8	–	8257-8	–	8253-8	8259-8-10	8259-8-15	
	INCH FINE THREAD (UNF)								
Small Adapter	6 (.138)-40	8552-06	–	8558-06	–	8554-06	8559-06	8560-06	8561
Small Adapter	10 (.190)-32	8552-3	8552-3-15	8558-3	8558-3-15	8554-3	8559-3	8560-3	8561
Small Adapter	1/4 (.2500)-28	8552-4	8552-4-15	8558-4	8558-4-15	8554-4	8559-4	8560-4	8561
Large Adapter	5/16 (.3125)-24	8252-5	8252-5-15	8258-5	8258-5-15	8254-5	8259-5-10	8259-5-15	
Large Adapter	3/8 (.3750)-24	8252-6	–	8358-6	–	8254-6	8259-6-10	8259-6-15	NONE
Large Adapter	7/16 (.4375)-20	8252-7	–	8258-7	–	8254-7	8259-7-10	8259-7-15	REQ'D
Large Adapter	1/2 (.5000)-20	8252-8	–	8258-8	–	8254-8	8259-8-10	8259-8-15	

**Tools for larger sizes or special applications are available upon request.*

Complete Power Tool Assembly

Small Adapter 8550R (Sizes ≤ 1/4" or M6)

Large Adapter 8550-1R (Sizes > 1/4" or M6)

Air Motor 8510-1

Front End Assembly

Prewinder

Spacers

Mandrel

Power Tool Holder, **Part No. 23537**, can be used with or without Strip Feed inserts.

Note: Recommended for use with **2-56, M2.2x0.45 & M2.5x0.45** power tool.

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Heli-Coil metric power inserting tools are available in coarse and fine sizes up to 12mm* for rapid installation of standard and screw-lock inserts, reducing assembly costs substantially. Strip feed power tools are available in sizes up to 7mm.

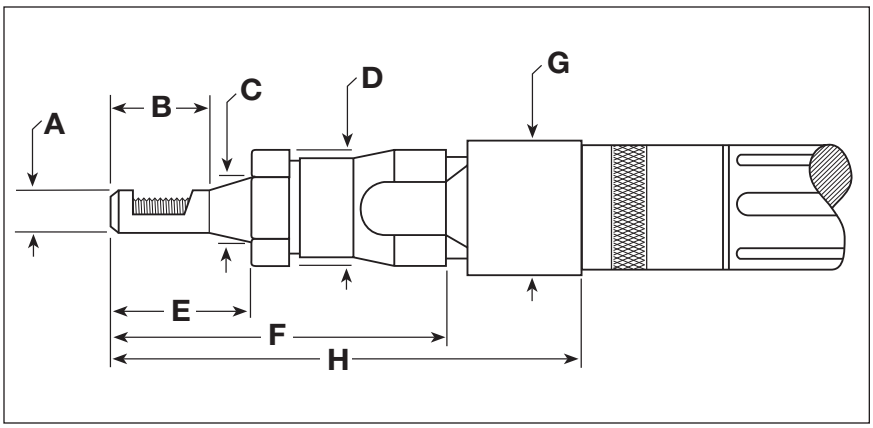
They speed up assembly, eliminate waste and permit an accurate count.

Power tools consist of a **Front End Assembly,** an **Adapter** and a reversible **Air Motor.** All three components are ordered individually. A front end assembly consists of a prewinder, mandrel and spacers. Select an Adapter that is compatible with the Air Motor to be used, and for the size range up thru 6mm or the size range 7mm thru 12mm.

	Nominal Thread Size	FRONT END ASSEMBLY P/N for Bulk Inserts (2 dia. max.)	FRONT END ASSEMBLY P/N for Strip Feed Inserts	PREWINDERS P/N for Bulk Inserts	PREWINDERS P/N for Strip Feed Inserts	MANDRELS	SPACERS 1 Dia.	SPACERS 1-1/2 Dia.	SPACERS 2 Dia.
	METRIC COARSE								
Small Adapter	M2.2x0.45	–	8751-2.2-15	–	8769-2.2-15	8757-2.2	8775-2.2	8776-2.2	8777-2.2
Small Adapter	M2.5x0.45	8751-2.5	8751-2.5-15	8769-2.5	8769-2.5-15	8757-2.5	8775-2.5	8776-2.5	8777
Small Adapter	M3x0.5	8751-3	8751-3-15	8769-3	8769-3-15	8757-3	8775-3	8776-3	8777
Small Adapter	M3.5x0.6	8751-3.5	8751-3.5-15	8769-3.5	8769-3.5-15	8757-3.5	8775-3.5	8776-3.5	8777
Small Adapter	M4x0.7	8751-4	8751-4-15	8769-4	8769-4-15	8757-4	8775-4	8776-4	8777
Small Adapter	M5x0.8	8751-5	8751-5-15	8769-5	8769-5-15	8757-5	8775-5	8776-5	8777
Small Adapter	M6x1	8751-6	8751-6-15	8769-6	8769-6-15	8757-6	8775-6	8776-6	8777
Large Adapter	M7x1	8751-7	8751-7-15	8769-7	8769-7-15	8757-7	8777-7-10	8777-7-15	
Large Adapter	M8x1.25	8751-8	–	8769-8	–	8757-8	8777-8-10	8777-8-15	NONE
Large Adapter	M10x1.5	8751-10	–	8769-10	–	8757-10	8777-10-10	8777-10-15	REQ'D
Large Adapter	M12x1.75	8751-12	–	8769-12	–	8757-12	8777-12-10	8777-12-15	
	METRIC FINE								
Large Adapter	M8x1	8755-8	–	8770-8	–	8764-8	8777-8-10	8777-8-15	
Large Adapter	M10x1	8755-10	–	8770-10	–	8764-10	8777-10-10	8777-10-15	NONE
Large Adapter	M10x1.25	8756-10	–	8758-10	–	8759-10	8777-10-10	8777-10-15	REQ'D
Large Adapter	M12x1.25	8756-12	–	8758-12	–	8759-12	8777-12-10	8777-12-15	
Large Adapter	M12x1.5	8753-12	–	8773-12	–	8774-12	8777-12-10	8777-12-15	

**Tools for larger sizes or special applications are available upon request.*

For evaluating space required for installing Heli-Coil inserts with standard manual, pneumatic and electronic inserting tools and tang break-off tools, the diagrams on pages 29 & 31 give dimensions of standard Heli-Coil tooling. For special variations or adaptations, contact the Applications Engineering Department at (203) 830-3274.



Power Inserting Tool Dimensions

SIZE		A	B	A	B	C	D	E	F	G	H
INCH	METRIC	FOR BULK INSERTS		FOR STRIP FEED INSERTS							
2	M2.2	–	–	5/16	7/16	23/32	1-1/8	1-3/8	3-3/16	1-1/4	4-7/16
4	M2.5	1/4	9/16	3/8	15/16	23/32	1-1/8	1-3/8	3-3/16	1-1/4	4-7/16
5	M3	9/32	9/16	3/8	15/16	2332	1-1/8	1-3/8	3-3/16	1-1/4	4-7/16
6	M3.5	5/16	9/16	1/2	15/16	23/32	1-1/8	1-3/8	3-3/16	1-1/4	4-7/16
8	M4	11/32	9/16	1/2	15/16	23/32	1-1/8	1-3/8	3-3/16	1-1/4	4-7/16
10	M5	3/8	29/32	1/2	15/16	23/32	1-1/8	1-3/8	3-3/16	1-1/4	4-7/16
1/4"	M6	27/64	29/32	5/8	1-3/8	23/32	1-1/8	1-3/8	3-3/16	1-1/4	4-7/16
5/16"	M7 & M8	9/16	1-1/8	11/16	1-1/8	1"	1-9/16	1-3/8	4-7/16	1-1/4	5-3/4
3/8"	–	11/16	1-11/32	–	–	1"	1-9/16	1-7/8	4-3/4	1-1/4	6-1/32
7/16"	M10	3/4	1-17/32	–	–	1"	1-9/16	2-1/4	5-1/8	1-1/4	6-13/32
1/2"	M12	13/16	1-25/32	–	–	1"	1-9/16	1-1/2	5-13/32	1-1/4	6-11/16

Heli-Coil® power inserting tools

Electronic Power Inserting Tool

Heli-Coil offers an electronic power tool where electric power is preferred over air. The slender configuration of the mandrels allows them to reach into constricted areas. Electric power meets the requirements of clean room operations. Operators prefer electric power because it is quieter. The electronic tool is lighter to minimize operator fatigue. Mandrel assemblies are available to install the sizes of Heli-Coil bulk loaded inserts listed below.

Application Note: Variations in Mandrel Assembly dimensions and threads are available on special order to meet individual applications. For Mandrel Assemblies to meet your special conditions, please contact Heli-Coil Applications Engineering Department at (203) 830-3274.

Electronic Tool Mandrel Assembly	
Insert Thread Size (UNC)	**Mandrel Assembly (for bulk inserts)**
2(.086)-56	8051-02
4(.112)-40	8051-04
6(.138)-32	8051-06
8(.164)-32	8051-2
10(.190)-24	8051-3
10(.190)-32	10089-3

Pneumatic Power Tool Installation Kit

This Heli-Coil power tool installation kit (8522) contains an Air Motor (8510-1), adapter, tools, a filter-regulator-lubricator, oil, two quick disconnect fittings, and wrenches. All are packed in a portable molded box with easy-to-follow operating instructions. Front End Assemblies may be ordered separately to fit the sizes of Heli-Coil inserts to be installed.

Power Tools Kit Types	Kit Part#	Small Adapter	Large Adapter
Small Adapter Set	8522	✓	
Large Adapter Set	8521		✓
CombinationSet	8520	✓	✓

Cordless Electric Tool

The Heli-Coil Cordless Tool is a complete kit (7200) that includes a driver, 2 batteries (7200-20), 15 minute charger and mandrel chuck all in a durable metal box. The cordless tool is portable, lightweight, has adjustable torque and uses standard Heli-Coil electronic tool installation mandrels for quick setup.

Power Tool Holder

The Power Tool Holder 23537 is mounted on a bench and the appropriate air motor is attached to a spring loaded air tube at the end of a movable arm. A mounting arm is also provided for attaching reels of strip-feed inserts.

This power tool holder configuration ensures accurate vertical (square to work surface) installations of Heli-Coil inserts in relatively large parts. The tool holder is capable of installing inserts within a radius of 23.5 inches as well as on planes differing by 3.5 inches. Example: Box shape configurations.

NOTE: This tool holder is recommended for use with the **2-56, M2.2x0.45** and **M2.5x0.45** air tools. The tool holder also may be used with the Heli-Coil Electronic Inserting Tool.

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Heli-Coil Tang Break-Off Tools

The driving tangs of Heli-Coil inserts must be removed to eliminate their interference with the end of the assembled bolt. Heli-Coil tang break-off tools are available for use with inserts through 1/2 inch and 12mm metric nominal diameter. Their operation is automatic, having a spring loaded, easily triggered punch that strikes a sharp, uniform blow against the tang of the installed insert. The tool can be operated with one hand.

Nominal Thread Size	Tool Part No.	Replacement Punch Part No.
UNIFIED COARSE THREAD (UNC)		
1 (.073)-64	3695-01	3697-01
2 (.086)-56	3695-02	3697-02
3 (.099)-48	3695-02	3697-02
4 (.112)-40	3695-04	3697-04
5 (.125)-40	3695-04	3697-04
6 (.138)-32	3695-06	3697-06
8 (.164)-32	3695-2	3697-2
10 (.190)-24	3695-3	3697-3
12 (.216)-24	3695-3	3697-3
1/4 (.2500)-20	3695-4	3697-4
5/16 (.3125)-18	3695-5	3643-5
3/8 (.3750)-16	3695-6	3643-6
7/16 (.4375)-14	3695-7	3643-7
1/2 (.5000)-13	3695-8	3643-8
UNIFIED FINE THREAD (UNF)		
2 (.086)-64	3695-02	3697-02
3 (.099)-56	3695-02	3697-02
4 (.112)-48	3695-04	3697-04
6 (.138)-40	3695-06	3697-06
8 (.164)-36	3695-2	3697-2
10 (.190)-32	3695-3	3697-3
1/4 (.2500)-28	3695-4	3697-4
5/16 (.3125)-24	3692-5	3645-5
3/8 (.3750)-24	3692-6	3645-6
7/16 (.4375)-20	3692-7	3645-7
1/2 (.5000)-20	3692-8	3645-8

Nominal Thread Size	Tool Part No.	Replacement Punch Part No.
METRIC COARSE		
M2x0.4	4238-2	3697-01
M2.2x0 45	4238-2.2	3697-02
M2.5x0.45	4238-2.2	3697-02
M3x0.5	4238-3	3697-04
M3.5x0.6	4238-3	3697-04
M4x0.7	4238-4	3697-2
M5x0.8	4238-5	3697-3
M6x1	4238-6	3697-4
M7x1	4238-7	4436-7
M8x1.25	4238-8	3643-5
M10x1.25	4238-10	4436-10
M12x1.75	4238-12	4436-12
METRIC FINE		
M8x1	4238-8	3643-5
M10x1	4238-10	4436-10
M10x1.25	4238-10	4436-10
M12x1.25	4238-12	4436-12
M12x1.5	4238-12	4436-12

Note: Tang break-off tools will break-off tangs thru 2 diameter lengths.

For 2 1/2 - 3 diameter lengths, add "-30" to the standard part number (eg, 3695-01-30).

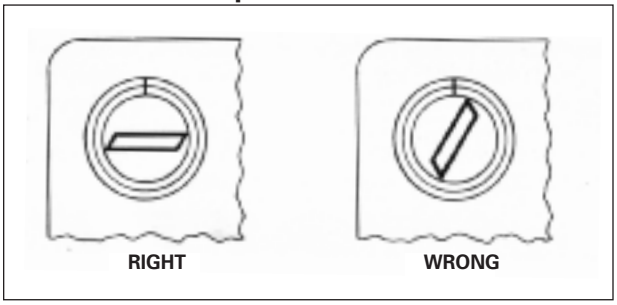
For sizes larger than 1/2" or 12mm, use long nose pliers. Bend tang up and down to snap off at notch.

Heli-Coil Extracting Tools

Occasionally Heli-Coil inserts must be removed. Inserts may be removed manually with little effort. This is done by inserting the blade of the extracting tool into the Heli-Coil insert so that the V section of the blade is toward the top end of the insert. Strike the head of the tool with a light blow. Maintaining a steady pressure of blade against insert, turn the extracting tool counterclockwise until the insert is removed.

Nominal Thread Size		Extracting Tool
Inch	Metric	Part No.
1	M2	1227-01
2	M2.2	1227-02
3 thru 8	M2.5 thru M4	1227-06
10 thru 3/8"	M5 thru M10	1227-6
7/16" thru 1"	M11 thru M24	1227-16
1-1/8" thru 1-1/2"	M27 thru M39	1227-24

Top View Shown



Right & wrong blade positions of insert extracting tool.

Installation and Removal Tools

Tangless® inserts may be installed by hand or electronic power tooling with the same mandrel assembly.

Front end assemblies are also available for pneumatic power tooling.

- Tooling utilizes a "blade" that applies torque to a notch in the end of the coil for installation.
- Installation depth can be adjusted easily for virtually any application.
- Driving blades are replaceable and increase the overall life of the tool.

8050-400C

8050-50

Electronic tool & power supply

Strip-feed reels, available in all sizes

Hand installation tool

Heli-Coil Tangless® Hand Installation Tooling

Nominal Thread Size	Hand Installation Tool		Replacement Installation Blade Kit**		Removal Tool (with handles)	Electronic Driver*
	Crank Style	Gauge Style	Crank Style	Gauge Style		
2-56	17551-02	7571-02	17551-02-5	7571-02-5	7570-02	8050-400C
4-40	17551-04	7571-04	17551-04-5	7571-04-5	7570-04	8050-400C
6-32	17551-06	7571-06	17551-06-5	7571-06-5	7570-06	8050-400C
8-32	17551-2	7571-2	17551-2-5	7571-2-5	7570-2	8050-400C
10-24	17551-3	7571-3	17551-3-5	7571-3-5	7570-3	8050-650C
1/4-20	17551-4	7571-4	17551-4-5	7571-4-5	7570-4	8050-650C
10-32	17552-3	7572-3	17552-3-5	7572-3-5	7570-3	8050-650C
1/4-28	17552-4	N/A	17552-4-5	7572-4-5	7570-4	8050-650C

** An electronic driver requires a power supply, part number 8050-50.*

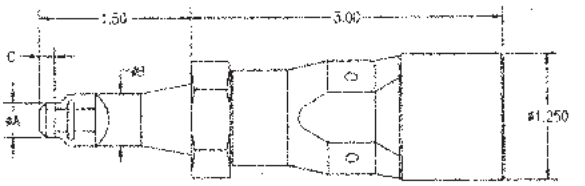
*** Includes blade, spring and pin.*

Heli-Coil Tangless® Power Tooling***

Nominal Thread Size	Front End Assembly	Replacement Mandrel Assembly	Replacement Blade
2-56	18551-02-15	18551-02-30	18551-02-2
4-40	18551-04-15	18551-04-30	18551-04-2
6-32	18551-06-15	18551-06-30	18551-06-2
8-32	18551-2-15	18551-2-30	18551-2-2
10-24	18551-3-15	18551-3-30	18551-3-2
1/4-20	18551-4-15	18551-4-30	18551-4-2
10-32	18552-3-15	18552-3-30	18552-3-2
1/4-28	18552-4-15	18552-4-30	18552-4-2

**** For use with Heli-Coil® Pneumatic Installation Tools & Adapters.*

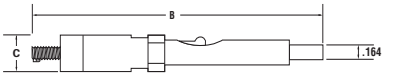
Front End Assembly



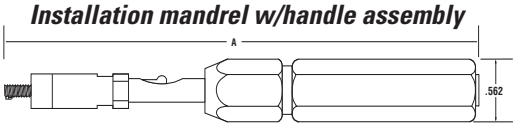
Front End Assembly Dimensions

Nominal	A Nose Diameter	B Body Diameter	C Prewinder Tip Length
2-56	.32	.32	.09
4-40	.25	.40	.13
6-32	.32	.50	.14
8-32	.35	.51	.15
10-24	.38	.51	.19
10-32	.38	.51	.15
1/4-20	.42	.63	.22
1/4-28	.42	.63	.22

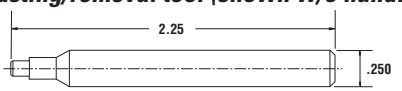
Installation mandrel only



Installation mandrel w/handle assembly



Adjusting/removal tool (shown w/o handle)



Note: Installation mandrel and adjusting/removal tool designed for use with both handle and electronic tool.

Installation Tool Dimensions

Nominal Thread Size	"A" Overall Length (reference)	"B" Mandrel Length	"C" Spinner Diameter
2-56	5.33	2.80	.240
4-40	5.43	2.90	.240
6-32	5.53	3.00	.360
8-32	5.68	3.15	.360
10-24	5.53	3.00	.370
10-32	5.53	3.00	.370
1/4-20	5.53	3.00	.370
1/4-28	5.53	3.00	.370

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- Extensive Product Range
- Installation Equipment Coordination

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- Value-added design and engineering services
- ISO 9100 Rev. B, ISO 9001: 2000 and ISO/TS16949: 2002 Certified
- Thread rolling, thread forming and self-drilling screws
- Assembled screws
- Weld screws and weld pins

POP Blind Riveting Systems offer an extensive range of blind rivets, hand-powered and automated-setting systems for every blind rivet application. POP's extensive experience and commitment to product breakthroughs provide both on- and off-the-shelf products and systems.

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- Production Line Integration

POP NUT Blind Rivet Nuts are designed to provide high quality load bearing threads in thin wall applications including sheet metal, tubing, extrusions, plastics and other materials. Installation tooling uses Spin-pull technology and requires access to only one side of the workpiece.

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