

SSRP (Stanford Synchrotron Radiation Project) and
SSRP User Specifications for Vacuum Systems and
Components Which Interface with the
SPEAR Vacuum System

Introduction

The SPEAR vacuum system is of all metal construction and operates at pressures in the 10^{-9} Torr range. The primary gas load during operation results from beam-induced desorption from the vacuum chamber walls. These desorption rates are extremely high in the case of hydrocarbons and, therefore, these specifications place a major emphasis on eliminating hydrocarbon contamination sources.

These specifications and procedures have been written to serve two primary purposes:

- (1) To insure the cleanliness and vacuum integrity of SPEAR. No system, component or procedure which might jeopardize SPEAR operating capability will be allowed.
- (2) To assist SSRP personnel and users in choosing components which are compatible with SPEAR and which have been determined through testing and evaluation to measure up to SPEAR quality and reliability standards.

Should the occasion arise whereby the user finds that deviation from these specifications is necessary, the request shall take the form of a written communication to SSRP detailing all modifications and / or alternatives. This request will be forwarded to the designated SLAC representative and a written approval or denial issued.

Any modification or deviation incorporated, but not submitted for approval, is done at the users risk and will constitute cause for rejection.

I. Component Procurement Specifications

A. Flanges

All vacuum flanges shall be of the ultra high vacuum "knife edge" type. The flanges must be capable of withstanding temperature excursions of -127° to 450° C. Nominal flange O.D. dimensions shall be 2-3/4", 4-1/2", 6", 8", 10", 13-1/4". Actual flange dimensions shall conform to those shown on Fig. 1, 1A, 1B.

Flange material shall be 304 cross forged stainless steel with a minimum hardness of Rockwell 80 B. In addition, the material shall meet the following sections of mil. spec. 862 B:* Chemical composition 3.1; material processed per 3.2 and 3.2.1; billet inspection per 3.5; workmanship and uniformity per 3.8.

B. Flange Bolts

Ultra high vacuum flange bolts shall be fabricated from 300 series high tensile non-magnetic stainless steel. Bolt heads shall be of the twelve point type. It is recommended that the bolts be silver plated to eliminate both the problem of galling and the contamination hazard represented by the normally used high temperature thread lubricant, which is readily picked up and transmitted by gloves, tissues, tools, clothing, etc. Bolt diameters, threads, and lengths shall be matched with flange sizes as shown in the table below:

<u>FLANGE O. D.</u>	<u>THREAD</u>	<u>LENGTH</u>	<u>NO. REQ'D.</u>
2-3/4	1/4 - 28	1-1/4"	6
4-1/2	5/16 - 24	2"	8
6	5/16 - 24	2"	16
8	5/16 - 24	2-1/4"	20
10	5/16 - 24	2-1/4"	24

C. Gaskets

All gaskets for UHV knife edge type flanges shall be OFHC copper, half hard, $.080 \pm .003$ " thick. The material must be free of nicks, scratches and blemishes. Imperfections may not exceed $.004$ " in width and $.0005$ " in depth.

*Mil. Spec. 862 attached.

Gasket O.D. and I.D. shall conform to the following tabulation:

<u>FLANGE O. D.</u>	<u>GASKET O. D.</u>	<u>GASKET I. D.</u>
2-3/4	1.895 ± .002	1.451 ± .005
4-1/2	3.243 "	2.506 "
6	4.743 "	4.006 "
8	6.743 "	6.007 "
10	8.743 "	8.007 "
13-1/4	11.587 "	10.810 "

Gaskets shall be recleaned before use according to Section III F. of these specifications.

D. Feedthroughs

1. Electrical

The feedthroughs used for electrical connections into the system shall be of the ceramic-to-metal type. No glass to metal feedthroughs shall be used. The preferred installation method is one in which the feedthroughs are mounted in a flange of the knife edge type as specified in Section IA. This flange would then be bolted to a mate on the chamber or other component. Feedthroughs may also be welded directly to the chamber in those instances where a flange connection cannot be used. Weld joint design must conform to normal UHV practice, and care must be exercised to prevent the weld from putting undue stresses on the ceramic. Voltages and currents carried by the feedthroughs must not exceed the manufacturer's ratings. Cleaning of feedthroughs shall conform to Sec. III A of these specifications.

2. Mechanical

Mechanical feedthroughs, which impart a rotational or linear movement to any component, must adhere to the applicable sections of this specification with regard to materials, cleaning, fabrication, bakeout capability, etc. Feedthroughs shall join to the system by means of a knife edge flange as specified in Section I A.

Detailed drawings showing all parts exposed to vacuum shall be submitted for SPEAR approval. Feedthroughs which have bearings exposed to vacuum will be evaluated regarding their UHV suitability. Feedthroughs which contain

D. Feedthroughs, Mechanical (Continued)

parts that cannot be cleaned to SPEAR specifications will not be approved.

E.1. Bellows - Welded Diaphragm Type

The welded stainless steel bellows, in particular, deserve special attention to detail because of their close fitting convolutions. Hydrocarbon contamination of surfaces or particulate matter trapped in the crevices of these convolutions is for all practical purposes there to stay. Experience at SLAC has proven that post-manufacturing chemical cleaning is of little value in removing such contamination. Once contaminated in this way, bellows assemblies shall not be used. The criteria for obtaining bellows which do meet the cleanliness requirements of the ultra high vacuum system is simply this:

- a. Cut and form the diaphragms and end plates without increasing the contamination level of the stock as supplied by the mill.
- b. Thoroughly chemically clean all component parts as specified.
- c. Following cleaning, assemble and weld the parts following the procedure described in the Handling and Assembly section.

Service Requirements: All bellows made to these standards must be guaranteed to withstand repeated thermal cycles at 200° C. concurrent with the axial and offset stroke specified on the detailed drawings accompanying the order.

Cutting and Forming: Clean, white (electron tube manufacturing type)* nylon gloves must be worn by persons handling the strip stock during cutting and forming the diaphragms. Gloved hands which come in contact with the press shall only do so in such a way as not to transfer contamination to the diaphragms. Those parts of the cutting equipment and hydroform press which come in contact with the diaphragms shall be free of any projection which cause indentations or dimples in the formed part. Likewise the finished diaphragms must be free of scratches and other surface imperfections. At no time during handling or storage shall bare hands touch the diaphragms. All parts shall be kept covered during the time between forming and chemical cleaning.

Chemical Cleaning: Chemical cleaning of bellows diaphragms shall conform to stainless steel chemical cleaning as covered in Section III/^B of these specifications.

*Available from: Peninsula Maintenance Supply Co., 1050 Middlefield Rd.,
Redwood City, Ca.

E. Bellows (Continued)

Handling and Assembly: When unwrapping cleaned diaphragms in preparation for welding, they shall only be handled by new, clean, electron tube mfg. type nylon gloves. Gloved hands which touch clean parts must not be allowed to come into contact with surfaces which have not been cleaned in a like manner. The welder must be alert at all times not to touch his face, clothing, tools, bench, stools, etc. Actuation of switches, adjustment of welding torch, etc. must be performed with gloves removed. Gloves which do come in contact shall be immediately replaced with a new pair. New gloves shall also be used at the beginning of each shift and following period breaks.

All those parts of the welding apparatus which come in contact with (or even close proximity to) the diaphragms being welded, must be thoroughly cleaned and wiped down with approved solvent and lint free tissue. Trichloroethylene, trichloroethane or Freon TF may be used. This will be followed by wiping down with another tissue using electronic grade methanol. The welded convolution shall be re-wrapped in new tissue immediately following welding and inspection. The handling criteria for assembly of the convolutions, inserting the spacer rings, welding the core and associated steps shall be the same as for welding the diaphragms, namely: using new gloves at the same intervals; gloved hands which touch the bellows parts touch only similarly cleaned surfaces; ^{and} machinery which comes in contact with or close to the bellows shall be wiped down with the same solvent procedure as before. The copper spacer rings must be thoroughly cleaned to the same standards as the diaphragms with one exception: the Pickle / Passive step 6 is omitted and a copper cleaning solution such as Enthone "Actane 36" or MacDermid Metex chemical polish - "BCB" substituted in its place. All other cleaning parameters remain the same. All handling, welding, and leak testing shall take place in a Clean Room which follows current vacuum industry practice for ultra high vacuum cleanliness and is acceptable to the SLAC representative. Vendor shall submit a "clean room" proposal which is acceptable to the SLAC representative prior to its use.

Weld Quality and Workmanship: Unless otherwise approved, all welding shall be by tungsten inert gas (GTA) fusion process without the use of filler rod.

It is important to state that leak tightness alone is not the only criterion for the acceptability of weld quality. The appearance and workmanship of the welding is equally important. All weld bead shall be continuous

E. Bellows (Continued)

and uniform in height and width. Discontinuities or interruptions which are $1/3$ larger or smaller than the normal bead width or height shall be cause for rejection. Rewelds or repairs to such welds shall only be made with specific approval. Under no circumstances shall any weld bead touchup with the use of files, rotary burrs, etc., be permitted.

Material Certification: Vendor shall furnish original source certifications, including physical and chemical test reports, of all materials which are a part of the final assembly. In the case where these reports are not available, the vendor shall provide evidence that the materials being used are in fact those specified.

End Fittings: All bellows end attachments such as collars, flanges, weld rings, etc., shall be made from solid stock material, either plate, sheet or forgings. No cast material or fittings made by rolling strip stock into a ring and welding the ends will be acceptable.

Inspection: A representative shall be permitted access to these areas of the plant where processing or fabrication of SSRP units is taking place at the time.

Leak Testing: Following welding, bellows shall be leak tested using a mass spectrometer helium leak detector. To avoid contamination from the rotary mechanical pumps, the leak detector shall be located outside the clean leak check area. The leak detector test port shall be extended into the clean area through an opening which is sealed around the test port extension. Unwrapping, handling, and rewinding of the bellows during leak testing shall also follow the previous glove restrictions: periodic glove changes; no contamination transfer, etc. Use of the leak detector, including periodic maintenance, shall conform to the manufacturer's recommendations. During testing, the helium nozzle must be directed at the gap between the copper spacer wires inserted between each convolution so that the gas will enter the void between the convolutions I D weld and the copper ring. No indication of leakage is permitted when tested by a leak detector with minimum helium sensitivity of $1 \text{ to } 2 \times 10^{-10}$ std cc/sec per division. In the event that the leak detector fails to meet the minimum sensitivity set herein, and the vendor chooses to test the bellows with less sensitivity, the responsibility that the bellows so tested meet the minimum requirements for leak integrity rests with the vendor.

E. Bellows (continued)

The roughing pump used to evacuate the bellows prior to leak testing shall be "trapped" with a clean, re-charged molecular sieve type foreline trap to prevent passage of oil vapors into the bellows. The molecular sieve trap shall have a valve installed on the base plate side of the trap. Periodically the sieve material in the trap shall be processed by closing the valve and plugging in the internal bakeout heater for a period of at least 6 hours. The trap must cool to room temperature before opening the valve.

The internal vacuum plumbing which joins the test plate, the leak detector and roughing pump shall be thoroughly cleaned with approved solvents prior to testing the first bellows.

The rubber gasket used as a seal between the bellows being tested and the base plate should be a low durometer, small cross section, rubber O-ring held in an "H" shaped metal ring. The O-ring shall be new and thoroughly cleaned with soap and water. No grease or other lubricants shall be used on the O-ring. The lower O-ring in the "H" ring (that which contacts the base plate) can be very thinly coated with Apiezon vacuum grease. Wipe off any excess grease with lint-free tissue. The "H" ring should have a step machined on the top side, just outside of the O-ring groove, as an aid to center the bellows in the O-ring. The top of the bellows shall be covered with a flat plate during leak test. Use the same O-ring conditions as the lower O-ring which contacts the bellows. If desirable, clean, new, flat rubber sheet may be used as a vacuum seal in lieu of O-rings.

Marking: All bellows shall be marked to identify the alloy of which the convolutions are made, for example, 304, 347, etc. If the alloy is vacuum melted 347, it shall be marked 347VM. Marking may be by electric vibrator pencil or by the "electric-etch" process. Markings shall be on the end flange only.

Shipment: Each bellows which is accepted shall be completely wrapped with new aluminum foil immediately following leak testing. It will then be placed in a new polyethylene bag and the open end heat sealed. This package will then be placed in its own corrugated paper carton. Shipment of individually boxed bellows may be made in a larger corrugated cardboard carton. Maximum size is not to exceed eight (8) bellows per carton. It is the vendor's responsibility that the cartons selected be able to withstand the abuse received by whatever means he chooses for shipment.

E.2. Bellows - Formed Type

Formed bellows, which are recleanable, are permitted but it should be recognized that they are very limited in axial movement and lateral offset as compared to welded bellows.

Forming must be by hydroforming or mechanical forming. Roll forming is not permitted. Welding must be by fusion butt weld. Lap welds are not permitted.

E. Bellows (continued)

Service requirements, weld quality and workmanship, material certification, end fittings, and inspection shall be as specified in I. E. I. Chemical cleaning shall conform to Section III I. of these specifications.

F. Vacuum Gauges

Vacuum gauges must be capable of measuring the range from .5 Torr to 10^{-11} Torr. This may be done by means of two separate gauges operated from a dual range control unit. Gauges must be of the nude type mounted on flanges of the knife edge variety as specified in Section I A. The gauges must be bakeable to 450° C. In the event of inoperative filaments, the filament should be replaceable.

The gauge for high pressure (.5 Torr to 4×10^{-6} Torr) should have the specific value for emission current supplied with each gauge. The gauge degas must be accomplished by electron bombardment.

The UHV gauge shall contain two independent filaments so that if one filament becomes inoperative, a change of an external connector would permit continuation of pressure measurement without vacuum interruption. Gauge degas must be by electron bombardment. The UHV gauge cable shall be capable of withstanding repeated thermal bakeout cycles.

The control unit for the gauges shall be a single module from which both gauges are operated. The control unit shall be capable of the following functions: gauge selection by means of a single switch; automatic range changing, emission adjustment; two (2) process control function switches and range selectors. The unit shall be rack mountable.

G. Pumps

Pumps used on any apparatus or components which interface with the SPEAR vacuum system shall be of the sputter ion type of either diode or triode configuration.

1. Diode Pump

The active elements in the diode type pump shall consist of an anode and a set of Titanium cathode plates. The anode must be at high positive potential with respect to the cathode plates. The pump body shall be at ground potential.

2. Triode Pump

The triode pump elements shall consist of an anode, a set of Titanium cathodes, and two collectors. The cathode must be at a high negative potential with respect to the anode and collector. The pump body shall be at ground potential.

The pump body must be fabricated of 304 stainless steel. The pump insulators shall be of the "re-entrant" type with sputter shields mounted in a manner which prevents conductive coatings from forming on the insulators. The pump inlet flange shall be of the knife edge type as specified in Section I A. of these specifications.

G. Pumps (Continued)

Prior to shipment the pump shall be baked out under vacuum at 400° C., pinched off and shipped under vacuum.

H. Valves

All valves used on beam lines or systems which interface with the SPEAR vacuum shall be of all metal construction.

1. Pumpout and Appendage Valves

Valves used for pumpout and attachment of various appendages are preferred to be of the 1-1/2" right angle type. The entire valve must be capable of being repeatedly baked to 450° C. in either the open or closed position without damaging the valve seat, drive mechanism or bellows. The valve design must allow the valve to be operated in any orientation. To provide maximum conductance, the main seal disc must be fully retracted when the valve is in the fully open position. Replacement of the metal sealing gasket must be possible without removal of the valve from the system. Valve flanges shall be of the knife edge type as specified in Section I A.

2. Isolation Valves

Pneumatic, remotely operable, beam line isolation valves shall be of the gate type, 6" nominal size with the actual clear opening being not less than 5.88". The main valve seal shall be of gold, which is forced against a stainless steel sealing surface by means of a high pressure gas filled bellows. Sealing pressures must be in the range of 300-600 psig. The closed conductance with atmospheric pressure on one side of the valve shall be less than 10^{-12} liters per second. The nominal closing time from full open shall be 1 second. The nominal sealing time from full closed shall also be 1 second. The valve operation shall be by means of a pneumatic actuator which can be controlled remotely. The valve shall be bakeable in either the open or closed position. In the closed position it shall be capable of withstanding repeated 200° C. bakeouts.

Manually operated beam line isolation valves shall be of the straight through type, bellows sealed, with the sealing mechanism being a confined copper gasket which is pressed against a stainless steel knife edge. Gasket removal and replacement must be possible without removal of the valve from the system. The entire valve must be capable of being repeatedly baked to 450° C. in either the open or closed position without damaging the valve seat, drive mechanism or bellows.

Valve flanges shall be of the knife edge type as specified in Section I A. Valve materials permitted to be exposed to the vacuum system are gold, OFHC copper, 304, 304L, 316, 316L, 321, 347 stainless steel, Inconel 600 and 718.

H. Valves (continued)

3. Fast Acting Valve

Specifications not yet developed.

J. Materials

Materials used in the construction of any component or system which interfaces with SPEAR vacuum shall be metallic or ceramic in nature. No elastomers or organic materials shall be permitted.

The materials used must conform to the following unless otherwise specifically approved: Stainless Steel (304, 304L, 316, 316L, 321, 347); Aluminum (1100, 6061); Gold (vacuum cast, 99.999 %), Copper (OFHC), Inconel (600, 718), and ceramics. (There are a wide variety of ceramics used for feedthrough purposes. No attempt will be made to list them, but the manufacturer and catalog number must appear on any material list or drawing where ceramics are utilized.)

II. Fabrication Technique

A. Material Certifications

The user shall furnish original source certifications, including physical and chemical test reports, of all metal and ceramic materials used. In the case where these reports are not available, the user shall provide evidence to the SPEAR representative that the materials being used do in fact meet SPEAR requirements.

B. Surface Preparation

No operation which might result in contaminants becoming embedded in the material shall be used. Grinding with resin bonded wheels, using rouge, emery cloth, crocus cloth or similar abrasives is prohibited.

C. Machining Lubrication

No lubricant may be used which results in material contamination that cannot be removed by the required cleaning methods. No Sulphur bearing lubricants are permitted. Recommended lubricants are:

Stainless Steel	- Polar Chip Mfg. Lubri-Cool Inc. Glendale, Ca.	Tap Magic Mfg. Steco Corp. Little Rock, Ark.
Aluminum	- Alumicut Mfg. Mystic Metal Mover Princeton, Ill.	Relton A - 9 Mfg. Relton Corp. Arcadia, Ca.
Copper	- Cut Max Mfg. E. S. Houghton So. San Francisco	

- III. Chemical Cleaning

The following chemical cleaning procedures which are presently used at SLAC have been determined to yield the best results on UHV materials. All parts made from the materials listed which interface with the SPEAR vacuum system shall be cleaned according to these specifications. A proposed step by step cleaning process shall be submitted for approval when approved materials other than those listed are to be used.

The SLAC facility is capable of cleaning aluminum and stainless steel parts to these specifications up to a maximum size of 20" x 20" x 12'.

A. Ceramic-to-Metal Feedthroughs

Ceramic-to-Metal feedthroughs present particular cleaning problems in that there are usually cracks and crevices which may trap acid cleaning solutions. Those feedthroughs having potential trapped areas shall not be acid cleaned. Cleaning shall be accomplished as follows:

1. Vapor degrease in Trichlorethylene for 15 minutes. Place feedthroughs on side in a stainless steel basket.
2. Oven dry at 150° F. for approximately 2 hours.

B. Welded Bellows Diaphragms

Welded bellows present cleaning problems similar to feedthroughs in that the convolutions represent areas that trap chemical solutions. Therefore all parts must be chemically cleaned prior to welding and subsequent handling must be done in a manner which does not contaminate the bellows. Any bellows assembly which is contaminated following final welding is considered not recleanable and will not be used.

The cleaning procedure for bellows diaphragms is as follows:

1. Pieces shall be suspended on a stainless steel holding fixture in such a way that diaphragms or parts do not touch each other.
2. Degrease in trichlorethylene vapor for 5 minutes.
3. Cold running tap water rinse for 1 minute. Immersion rinse preferred over spray rinse.
4. Alkaline* soak clean for 5 minutes at a temperature of 190° F.
5. Cold running tap water rinse for 2 minutes. Not in tank 3 above.
6. Immerse in a stainless steel pickle solution consisting of:
 - 1 part 42° Baume Nitric Acid
 - 1 part 48 % Hydrofluoric acid
 - 1 part distilled water

Solution shall be at room temperature. Immersion time is approximately 1 minute. Do not over-etch.

7. Cold running tap water rinse for 2 minutes. Not in tank 3 or 5 above.

*Enthone Brass Cleaner, Mfg.: Enthone Inc., New Haven, Conn.

III. Chemical Cleaning (continued)

8. Immersion rinse in cold de-ionized or distilled water for 2 minutes.
(minimum resistivity of 500,000 ohms)
9. Immersion rinse in hot (150° F.) de-ionized or distilled water for 2 minutes.
(minimum resistivity 500,000 ohms)
10. Electronic grade methanol rinse. (See attached specification)
11. Oven dry at 150° F. or blow with dry nitrogen gas preferably taken from an evaporated liquid source. Dry, high purity (99.99%), water-pumped nitrogen bottled gas may also be used.
12. When dry, remove from rack using clean, white nylon gloves. Wrap individual pieces in lint-free tissue or new aluminum foil.

C. Vacuum Flanges

Prior SLAC inspections and experience have determined that new vacuum flanges are not sufficiently clean, and an additional cleaning must take place before they can be used in a UHV system. Flange cleaning shall be accomplished by the following steps:

1. Vapor degrease in Trichlorethylene for 5 minutes.
2. Cold running tap water rinse for 1 minute.
3. Soak in Enthone Brass Cleaner at a temperature of 190° F. for 5 minutes.
Brush with nylon bristle brush if necessary.
4. Cold running tap water rinse for 2 minutes.
5. Immerse in the following solutions:
Nitric Acid 42° Baume..... 97% by volume
Hydrofluoric Acid 48%..... 3% by volume
Solution shall be at room temperature. Immersion time 30-60 seconds.
6. Cold running tap water rinse for 2 minutes.
7. Cold distilled water rinse for 2 minutes (minimum resistivity of 500,000 ohms).
8. Hot (150° F.) distilled water rinse for 2 minutes (minimum resistivity of 500,000 ohms).
9. Electronic grade methanol rinse. (See attached specification)
10. Oven dry at 150° or blow with dry nitrogen gas preferably taken from an evaporated liquid source. Dry, high purity (99.99%) water pumped nitrogen bottled gas may also be used.
11. Wrap in lint free tissue or new aluminum foil.

D. 300 Series Stainless Steel (304, 304L, 316, 316L, 321, 347)

The following chemical cleaning procedure shall be used for 300 series stainless steel tubing and parts.

1. Vapor degrease in hot trichlorethylene vapor for 5 minutes.
2. Cold running tap water rinse for 1 minute.
3. Soak in Enthone Brass Cleaner for 5 minutes at a temperature of 190° F.
4. Cold running tap water rinse for 2 minutes.
5. Immerse in a stainless steel pickle consisting of:
1 part 42° Baume Nitric acid
1 part 48% Hydrofluoric acid
1 part distilled water

Solution shall be at room temperature. Immersion time shall be sufficient to clean surface of scale and oxide. Care should be taken to avoid over-etching. Part may be glass bead water-air blasted or brushed with a stainless steel brush to facilitate oxide removal.

6. Cold running tap water rinse for 2 minutes.
7. Repeat steps 3 and 4.
8. Immerse in McDermid No. 629* acid dip for 30 seconds.
9. Cold running tap water rinse for 2 minutes.
10. Cold distilled water rinse for 2 minutes (minimum resistivity of 500,000 ohms).
11. Hot (150° F.) distilled water rinse for 2 minutes (minimum resistivity 500,000 ohms).
12. Electronic grade methanol rinse. (See attached specification)
13. Oven dry at 150° F. or blow with dry nitrogen gas preferably taken from an evaporated liquid source. Dry, high purity (99.99%) water pumped nitrogen bottled gas may also be used.
14. When dry, wrap in lint free tissue or new aluminum foil.

*McDermid No. 629 Acid Dip mfg. by McDermid Co., Waterbury, Conn.

E. Aluminum (Caustic Etch Procedure)

The following shall be used for cleaning of all aluminum tubing and parts:

1. Vapor degrease in Trichlorethylene for 5 minutes.
2. Cold running tap water rinse for 1 minute.
3. Soak in Amchem No. 53 Non-Etch Aluminum Cleaner**for approximately 5 minutes.
4. Cold running tap water rinse for 2 minutes. If water breaks appear, repeat steps 3 and 4.

E. Aluminum (Continued) (Caustic Etch Procedure)

5. Deoxidize in Wyandotte PD-5533-3 Liquid Desmutter and Deoxidizer * at a concentration of 20 percent by volume until all mill scale is removed.
6. Cold running tap water rinse for 2 minutes.
7. Etch in Amchem Etchant #33** from 1-10 minutes depending on depth of etch required.
8. Cold running tap water rinse for 2 minutes.
9. Desmutt until surface is clean. Use same solution as step #5.
10. Cold running tap water rinse for 2 minutes.
11. Cold distilled water rinse for 2 minutes (minimum resistivity of 500,000 ohms).
12. Hot (150° F.) distilled water rinse for 2 minutes (minimum resistivity of 500,000 ohms).
13. Blow with dry nitrogen gas preferably taken from an evaporated liquid source. Dry, high purity (99.99 percent) water pumped nitrogen bottled gas may also be used.
14. When dry wrap in lint free tissue or new aluminum foil.

* Wyandotte PD-5533-3 is a product of Wyandotte Chemical Inc., Wyandotte, Mich. PD-5533-3 is biodegradeable and may be dumped to sanitary sewers. If preferred, PD-5533-3 may be substituted with Deoxidizer #6 from Amchem, Inc. This is a chromate type of solution and may be used for both step #5 and #9. This solution cannot be dumped into the sanitary sewer.

** Amchem #53 and Etchant #33 are products of Amchem, Inc., Ambler, Pa.

E. Aluminum (#1312 Process)

The aluminum caustic etch cleaning procedure requires a number of tanks to accomplish cleaning and thorough rinsing. At SLAC there was a need for a cleaning process for the 32' long curved SPEAR vacuum chambers which could not be accommodated in the standard 12' tanks. This process requires only 3 tanks and may be used following caustic etch where adequate rinsing has not been possible. The process is referred to as 1312 and is recommended only for very large or irregularly shaped parts.

E. Aluminum (#1312 Process) (Continued)

1. Solvent clean with chloroethane.
2. Cold running tap water rinse.
3. Steam clean with detergent* inside and out for 5 minutes.
4. Cold running tap water rinse.
5. Cold running distilled water rinse.
6. Immerse in #1312 solution** until surface is covered or for 1 minute.

Do not exceed 1 minute immersion time or smutting will occur.

7. Tap water spray rinse using a hose and as much pressure and volume as possible.
8. Hot distilled water rinse for 5 minutes.
9. Blow with dry nitrogen gas preferably taken from an evaporated liquid source.
Dry, high purity (99.99 percent) water pumped nitrogen bottled gas may also be used.
10. When dry, cover openings with new aluminum foil.

* Steam detergent available from Bay Chemicals, San Francisco, Ca.

** #1312 solution available from Yosemite Chemical Co., San Francisco, Ca.

F. OFHC Copper

All OFHC copper parts, including UHV flange gaskets shall be cleaned according to the following procedure:

1. Vapor degrease in trichlorethylene for 5 minutes.
2. Cold running tap water rinse for 1 minute.
3. Soak in Enthone Brass Cleaner at a temperature of 190° F.
4. Cold running tap water rinse for 2 minutes.
5. Dip in 50 percent Hydrochloric acid at room temperature for 1 minute.'
6. Cold running tap water rinse for 1 minute.
7. Bright dip in a solution consisting of:
Sulfuric Acid 66° Baume60 percent
Nitric Acid 42° Baume40 percent
Hydrochloric Acid 20° Baume1/5 fluid oz. per gallon
Distilled Water Add 8 fluid oz. per 5 gallons of solution.
Solution at room temperature.
For a slower, more controlled dip use the following solution:
Phosphoric Acid, 75 percent3 parts by volume
Nitric Acid, 42° Baume1 part by volume
Solution at room temperature.
8. Cold running tap water rinse for 2 minutes.

F. OFHC Copper (Continued)

9. Cyanide dip in a solution consisting of:

Potassium cyanide 8 avoirdupois oz.

Potassium hydroxide 2 avoirdupois oz.

Add distilled water to make 1 gallon. Solution shall be at room temperature.

Immersion time: approximately 30 seconds.

10. Cold running tap water rinse for 2 minutes.

11. Cold distilled water rinse for 2 minutes. (minimum resistivity of 500,000 ohms)

12. Hot (150° F.) distilled water rinse for 2 minutes. (minimum resistivity of 500,000 ohms)

13. Electronic grade methanol rinse. (See attached specification)

14. Oven dry at 150° F. or by blowing with dry nitrogen gas, preferably taken from an evaporated liquid source. Dry, high purity (99.99 percent) water pumped nitrogen bottled gas may also be used.

15. When dry, wrap in lint free tissue or new aluminum foil.

G. Explosion Bonded Transitions AL - SS

Explosion bonded transitions are sections of aluminum and stainless steel which have been joined at their interface to a layer ($\approx .030$ ") of Silver by means of a proprietary explosive process. This material, which is sold under the tradename Detaclad, is available from E.I. DePont de Nemours and Co., Explosives Products Sales Division, Wilmington, Delaware.

These transitions must be cleaned according to the following procedure:

1. Vapor degrease in trichlorethylene for 5 minutes.

2. Cold running tap water rinse for 1 minute.

3. Soak in Amchem #53 Non-Etch Aluminum Cleaner for 15 minutes.

4. Cold running tap water rinse for 2 minutes.

5. Deoxidize in Wyandotte PD-5533-3 Aluminum Deoxidizer and Desmutter at a 20 percent concentration for 3 minutes. Air agitate the solution. The solution shall be at room temperature.

6. Cold running tap water rinse for 2 minutes.

7. Lightly etch in Amchem Etchant #33 for 10-15 seconds at a solution temperature of 140° F.

8. Cold running tap water rinse for 2 minutes.

9. Desmutt in Wyandotte PD-5533-3 for 1 minute.

10. Cold running tap water rinse for 2 minutes.

11. Cold distilled water rinse for 1 minute. (Minimum resistivity of 500,000 ohms)

12. Hot (150° F.) distilled water rinse for 1 minute. (Minimum resistivity of 500,000 ohms)

13. Electronic Grade Methanol rinse. (See attached specification.)

G. Explosion Bonded Transitions AL - SS (Continued)

14. Oven dry at 150° F. or blow with dry nitrogen gas preferably taken from an evaporated liquid source. Dry, high purity (99.99 percent) water pumped nitrogen bottled gas may also be used.
15. When dry, wrap in lint free tissue or new aluminum foil.

H. Ceramics

Ceramic parts used in the vacuum system as insulators, spacers, etc. must be chemically cleaned as follows:

1. Vapor degrease in trichlorethylene for 5 minutes.
2. Cold running tap water rinse for 1 minute.
3. Soak in Enthone Brass cleaner at a temperature of 150° F. for 30 minutes.
4. Cold running tap water rinse for 2 minutes.
5. Immerse in 50 percent nitric acid Reagent Grade for 1 to 4 hours at a temperature of 150° F.
6. Cold running tap water rinse for 2 minutes.
7. Cold distilled water rinse for 2 minutes. (minimum resistivity of 500,000 ohms)
8. Boil in distilled water for 1 hour. Boil again in fresh distilled water for 1 hour (minimum resistivity of 500,000 ohms).
9. Drain water from beaker and oven dry at 150° F.

Use Pyrex glass containers when processing ceramics. Do not use stainless steel.

J. Thin (≈.006") Stainless Steel Chambers or Formed Bellows

The following procedure shall be used for cleaning thin stainless steel chambers, windows or formed bellows in which no chemical traps exist.

1. Vapor degrease in trichlorethylene for 5 minutes.
2. Cold running tap water rinse for 1 minute.
3. Soak in Enthone Brass Cleaner for 10 minutes at 190° F.
4. Cold running tap water rinse to cool part.
5. Repeat step #3 for 2 minutes.
6. Cold running tap water rinse for 1 minute.
7. Immerse in a stainless steel pickle consisting of:
 - 1 part 42° Baume Nitric acid
 - 1 part 48 percent Hydrofluoric acid
 - 1 part distilled waterSolution shall be at room temperature. Immersion time shall be 10 min.
8. Cold running tap water rinse for 1 minute.

J. Formed Bellows (continued)

9. Cold distilled water rinse for 1 minute (minimum resistivity of 500,000 ohm)
10. Hot (150° F.) distilled water rinse for 1 minute (minimum resistivity of 500,000 ohms)
- *11. Electronic grade methanol rinse.
12. Oven dry at 150° F. or blow with dry nitrogen gas preferably taken from an evaporated liquid source. Dry, high purity (99.99 percent) water pumped nitrogen bottled gas may also be used.
13. When dry, wrap in lint free tissue or new aluminum foil.

*Electronic Grade Methanol Specifications

Purity, percent W, min.	99.85
Specific Gravity, 20/20° C. (in air), max.	0.7927
Color (Pt-Co standards), max.	5
Acidity, (as HAc), percent W, max.	0.003
Alkalinity, (as NH ₃), percent W, max.	0.003
Acetone Content, percent W, max.	0.003
Distillation Range	1.0° C. including 64.5° C.
Nonvolatile Matter, g/100 ml, max.	0.001
Permanganate Time, min.	30 minutes
Carbonizable Substances (Pt-Co Standard), max.	50
Odor	Characteristic and free of foreign odors.

IV. Welding and Brazing

A. Tungsten Inert Gas Welding

Unless specifically approved, all welding shall be by the tungsten inert gas fusion process. Welding electrodes shall be 2 percent thoriated tungsten.

Prior to welding, all parts must be cleaned as per Section III of this specification. During welding, new, white nylon gloves must be worn while handling cleaned parts. For operations which require contact with other than the cleaned surfaces, the gloves must be removed. If the gloves come into contact with other than clean surfaces, they must be replaced with new ones. Jigs, fixtures, or chill rings which contact the clean parts must themselves be cleaned according to Section III specifications and handled thereafter in the same manner as a cleaned part.

1. Aluminum

All brushes used for cleaning shall be of the hand type having stainless steel bristles from .002" to .008" in diameter. Power driven brushes, abrasive papers and abrasive wheels shall not be used. Hand scrapers shall be high quality, high strength steel of triangular shape, heat treated to a minimum Rockwell hardness of 65. Brushes and scrapers shall be vapor degreased in trichlorethylene before use.

A. Tungsten Inert Gas Welding - Aluminum (continued)

For welding of thick aluminum 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. For parts of 1/8" thickness or less, use A.C. polarity with Argon cover gas. Welding shall take place not more than 24 hours following chemical cleaning.

2. Stainless Steel

All brushes used for cleaning shall be of the hand type having stainless steel bristles from .002" to .008" in diameter. Power driven brushes, abrasive papers and abrasive wheels shall not be used. Brushes shall be vapor degreased in trichlorethylene before use.

Stainless steel welds shall be back purged in all cases. Gas flow shall be maintained until the metal cools to prevent oxidation. Cover and purge gas shall be Argon or Nitrogen Commercial Grade 99.98 percent or mixture thereof. Welding shall take place within 48 hours following chemical cleaning.

3. Joint Design

Figures 2, 2a, 2b, 2c show examples of joint designs recommended for ultra high vacuum systems. Inside welds should be made in every possible case. This becomes particularly important if the need arises to reclean the assembly at a later date. Assemblies which have internal crevices due to outside welds are considered not recleanable since these crevices act as traps and continue to "weep" cleaning solutions.

B. Filler Rod

Filler metal shall be stored in such a manner that it is protected from oil and other contaminants. 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 protected area within the clean welding area. Prior to welding, the filler rod shall be wiped clean with lint free tissue and Reagent Grade acetone.

Filler rod used with the various alloys shall conform to the following:

Stainless Steel

304
304L
316
316L
321
347

Filler

308, 308L
308L
316, 316L
316L
347
347

Aluminum

6061

4043 (Linde H.Q.)

IV. Welding and Brazing (Continued)

C. Brazing Procedures and Materials

All brazing must take place in vacuum or a dry Hydrogen atmosphere. Prior to brazing, the parts involved must be chemically cleaned per Section III of these specifications. Following cleaning, the parts must only be handled with new clean nylon gloves. Parts must not contact any surface which will result in contamination.

All metal-to-metal and ceramic-to-metal brazes shall have adequate filler metal to provide a smooth uniform fillet throughout. There shall be no gaps, discontinuities or non-wet areas in the fillet. All filler metal shall be in the liquidus temperature range long enough to permit free flow throughout. In all possible cases the filler shall be placed in a manner which results in the joint side nearest the vacuum being uniformly filled. When brazing parts onto a stainless steel vacuum flange, the brazing temperature shall not exceed 900° C. to avoid annealing the flange sealing surface.

To preclude discoloration and "greening" of stainless steel, the Hydrogen gas shall be dry (dewpoint - 80° F.).

There are a wide variety of commercially available brazing alloys which are acceptable. The alloy used will depend to some extent upon the material being brazed, the joint design, stresses on the part, etc. No alloy containing Zinc or Cadmium shall be permitted.

Certification of brazing material used shall be submitted upon request by SLAC.

V. Bakeout

All "permanent" vacuum assemblies shall be designed to withstand bakeout temperatures of 200° C. minimum for as many as 50 thermal cycles. The duration of the bakeout is dependent in part on the size and geometry of the assembly. A typical bakeout will require approximately 7 working days from start to completion. This time period includes the necessary wiring and insulation required, the time to bring the assembly up to temperature, the time at temperature and the subsequent cool down period.

Those components installed for short duration will be evaluated individually regarding their bakeout requirements.

VI. Internal Water Cooling

Any component or device which requires water-cooling and is an internal part of the vacuum system shall be designed in such a manner that no direct water-to-vacuum welds are incorporated.

Fig. 3 illustrates how water cooled assemblies may be designed which avoid water-to-vacuum welds.

VII. Assembly and Test Procedures

A. Control and Certification of Material

All drawings submitted for review must be accompanied by complete materials lists, including part numbers and manufacturer of purchased parts.

Certification of materials used in the fabrication of vacuum components is required as stated in Section II A.

B. Fabrication Control

All vacuum parts fabricated shall conform to the applicable sections of this specification regarding machining, cleaning, welding, handling, assembling, etc. Any fabrication process which deviates from these specifications shall be submitted for review and approval. All fabrication steps are subject to SLAC inspection at any stage of the process.

C. Procurement Control

All materials, parts, and components which are part of or influence the vacuum system shall be procured according to specifications in Section I, A through L. SLAC shall reserve the right to vendor inspection to insure the adherence to these specifications.

D. Assembly

All assembly must be consistent with good ultrahigh vacuum technique. Prior to welding or final assembly, all parts must be cleaned per Section III. Handling of parts must be done using new, clean, white nylon gloves of the electron tube manufacturing type. Gloved hands which touch clean parts must not be allowed to come into contact with surfaces which have not been cleaned in a like manner. Gloves which do come in contact with other than clean parts shall be replaced with a new pair. If hand tools are required during assembly of parts which are exposed to vacuum, the tools must also be cleaned per Section III and handled the same as any cleaned assembly part. Tools with rubber or plastic surfaces shall not be used for assembly of vacuum exposed parts.

D. Assembly (continued)

The area used for assembly should preferably not contain power tools such as drill presses, hand drills, band saws, etc. Should it be necessary to assemble vacuum parts in an area where these tools are present, care shall be taken to insure that the power tools are not operated during the time parts are being assembled or are uncovered.

Cleaned parts or sub-assemblies shall not come in direct contact with any work surface. Lint-free tissue* or new aluminum foil shall be the only acceptable surface on which parts may be placed. Likewise, parts may occasionally be picked up or handled using several layers of lint-free tissue in lieu of gloves. All clean parts not immediately in process shall be kept wrapped and covered in aluminum foil or lint-free tissue. Assembly shall take place in a clean area with controlled air intakes. The floor shall be either tile, linoleum or concrete sealed with a suitable sealant, and shall be cleaned at least once a day by wet mopping.

E. Bakeout

Following assembly and prior to installation, the chamber or sub assembly shall be baked at a temperature of 200° C. while being pumped. Provision must be made for in-place bakeout of "permanent" assemblies. Therefore any assembly or component which will be inaccessible after installation due to shielding, magnets, etc. shall be wrapped for bakeout, insulated and instrumented prior to installation in a manner such that repeated bakeouts can be accomplished simply by connecting a power source and thermocouple leads.

F. Residual Gas Analysis - Specifications not yet developed.

VIII. Mechanical Adjustments

All components and assemblies which have built in movement capability for either alignment or functional purposes, must have adjustments provided for said movement. For adjustments in X or Y a three point triangular system is preferred over a four point adjustment.

In instances where there is bellows movement as a result of adjustment, the bellows manufacturers' tolerances for stroke and axial offset shall not be exceeded. During operation no movement which exceeds the design limits will be permitted.

* Available from C. H. Dexter and Co., Windsor Locks, Conn. Designation: Paper, lint-free, Grade 10, 9" sq. and 19" sq.

IX. Vacuum Loading and Restraints

All components, assemblies, and instruments shall be designed to safely withstand the loading exerted by atmospheric pressure while under vacuum. A minimum safety factor of 2 shall be incorporated in all designs. Those modules utilizing bellows or geometries which result in differential loading while under vacuum shall have restraints provided which prevent lateral and axial movements due to the differential loading.

X. Venting and Pumpdown Procedure

When venting a system from vacuum to atmospheric pressure, dry nitrogen shall be employed as the venting gas. The nitrogen may be gas taken from an evaporated liquid source or bottled, dry, high purity (99.99 %) water pumped nitrogen gas may also be used. Venting shall be done through clean, dry copper or stainless steel tubing which is connected to the system by means of a knife edge flange as specified in Sec. I A. Upon completion of venting, but prior to breaking flange connections, the area to be disconnected shall be cleaned with Micro Duster*. Once the flanged connections are broken, the openings shall be immediately covered with new aluminum foil.

Pumpdown from atmospheric pressure shall take place using cryosorption pumps or a liquid nitrogen trapped mechanical pump, trapped in such a manner as to prevent heavy hydrocarbon contamination. When using a mechanical pump, the trap must be filled with liquid nitrogen prior to opening the system pumpout valve. The mechanical pump may be used down to pressures of approximately 10 Torr, at which time it must be valved off to protect against oil vapor backstreaming. Pumpdown from this pressure must proceed using cryosorption pumps.

* Micro Duster available from the Texwipe Co., Hillsdale, New Jersey.

XI COOLING CRITERIA

All synchrotron absorbing surfaces on SPEAR are water cooled. This was necessary because the intense heat fluxes represented a potential catastrophic hazard to the operation of the storage ring. In general, conservative design criteria were used. While the heat fluxes will be lower for most SSRP surfaces, the same general criteria should be applied wherever synchrotron radiation impinges on a surface. These criteria are derived in SPEAR Notes 41 and 156.

Specifically, the following items should be used in SSRP design:

1. No welds between water cooled passages and vacuum spaces.
2. The linear power flux is given by: $P' = \frac{P_t \sin \alpha}{2\pi d}$

where: p' = power density in watts per cm.

p_t = beam power = 150 KW.

d = tangential distance between the surface and the beam orbit in cm.

α = angle between the surface and the light ray.

3. The height of the heated area is given by: $h = 2d$.

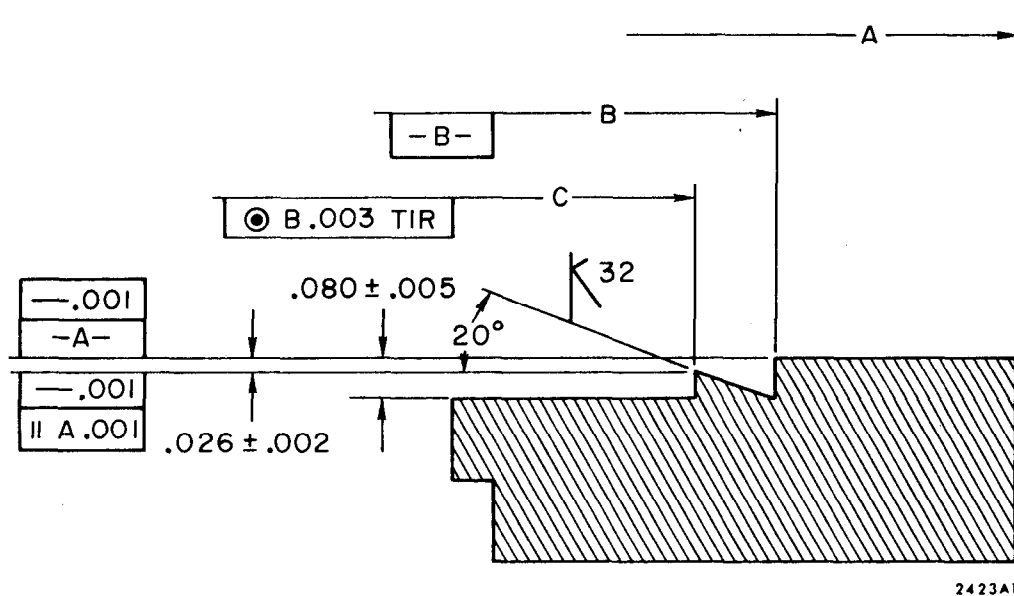
where: $\gamma = \frac{0.51}{E}$

E = Beam energy in GeV = 4.8 GeV

4. The coefficient of heat transfer to water is 0.8 watts/sq. cm deg C.
The coefficient of heat transfer to air is 1.0 milliwatt/sq. cm deg C.
5. The cooling water temperature is 40 deg C. The ambient air temperature is 20 deg C.
6. The maximum metal temperature is 150 deg C.
7. The maximum heat flux on the vacuum side is 1.0 KW/sq.cm.

ACKNOWLEDGEMENTS

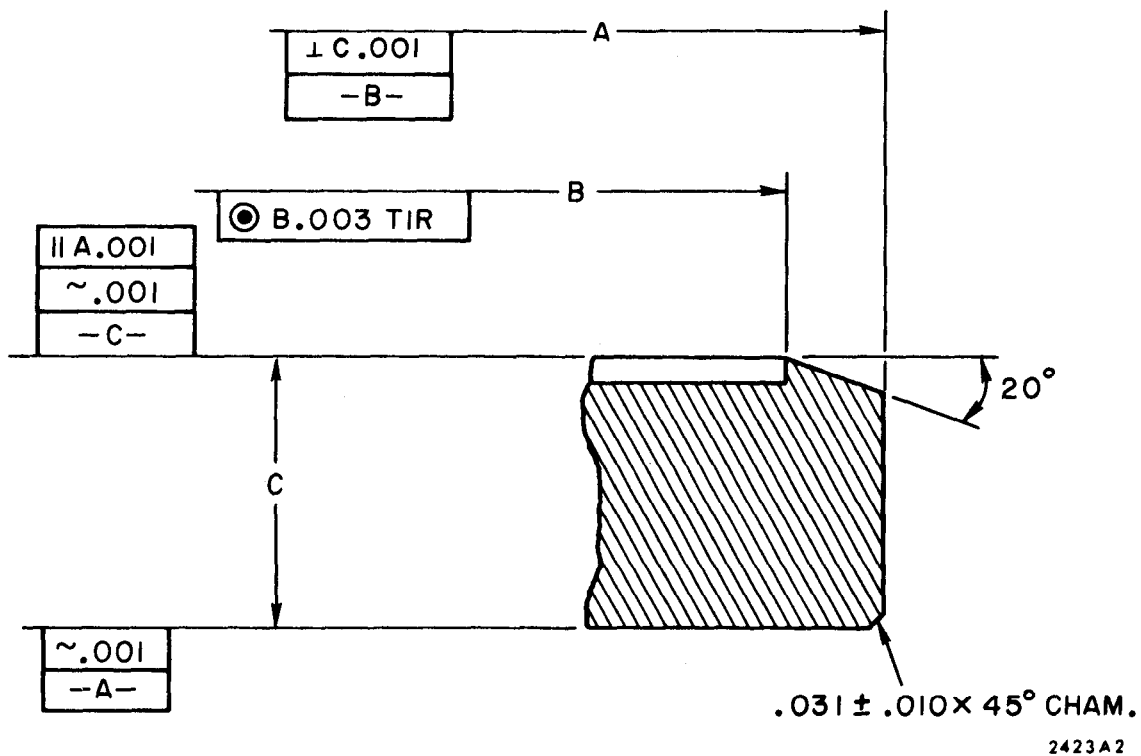
We wish to acknowledge the willing assistance of D. Bostic, U. Cummings, N. Dean, J. Jurow, and P. Keiser in the compilation and editing of these specifications.



NONROTATABLE FLANGE

Flange	A	B	C	Max. Tube O.D.
2 3/4	2.73 ± .015	1.902 ± .002	1.650 ± .002	1 1/2
4 1/2	4.47	3.250	3.040	2 1/2
6	5.97	4.750	4.540	4
8	7.97	6.750	6.540	6
10	9.97	8.750	8.540	8
13 1/4	13.25	11.595 ⁺ .005 - .000	11.350 ⁺ .005 - .000	10 1/2

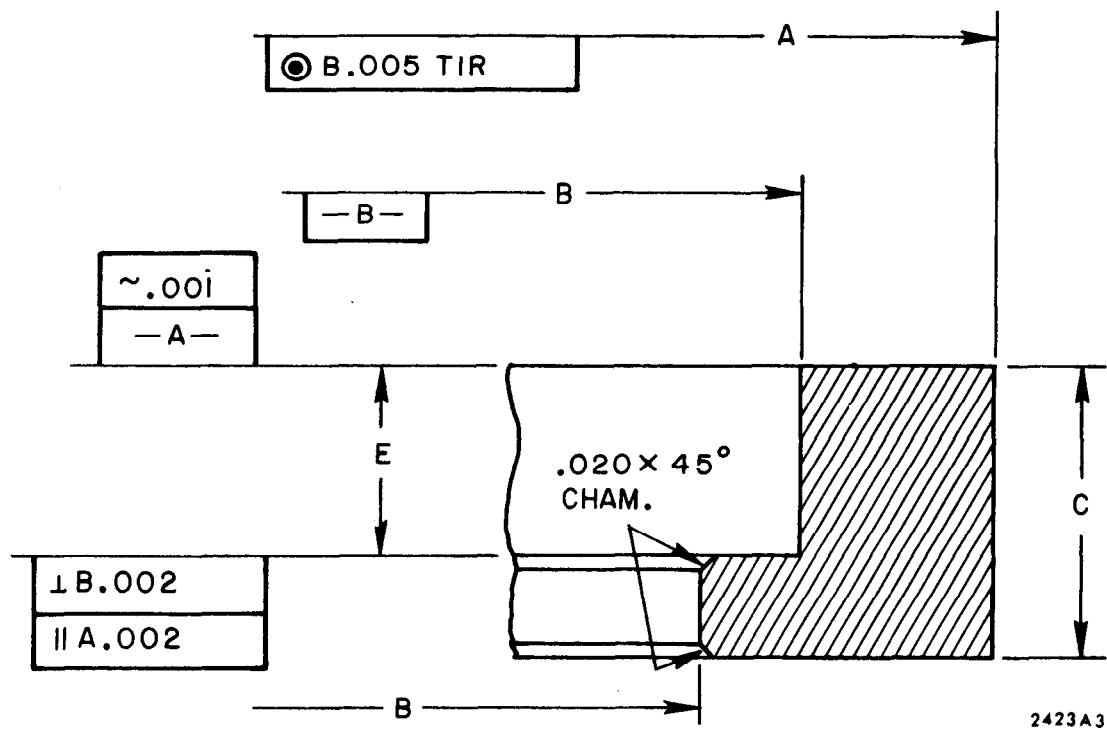
FIG. 1



ROTATABLE FLANGE INSERT

Flange	A	B	C	Max. Tube O.D.
2 3/4	1.893 ± .002	1.650 ± .002	.275 ± .002	1 1/2
4 1/2	3.241	3.040	.474	2 1/2
6	4.741	4.540	.537	4
8	6.741	6.540	.598	6
10	8.741	8.540	.649	8
13 1/4	11.590 ⁺ .000 - .005	11.350 ⁺ .005 - .000	.654	10 1/2

FIG. 1a



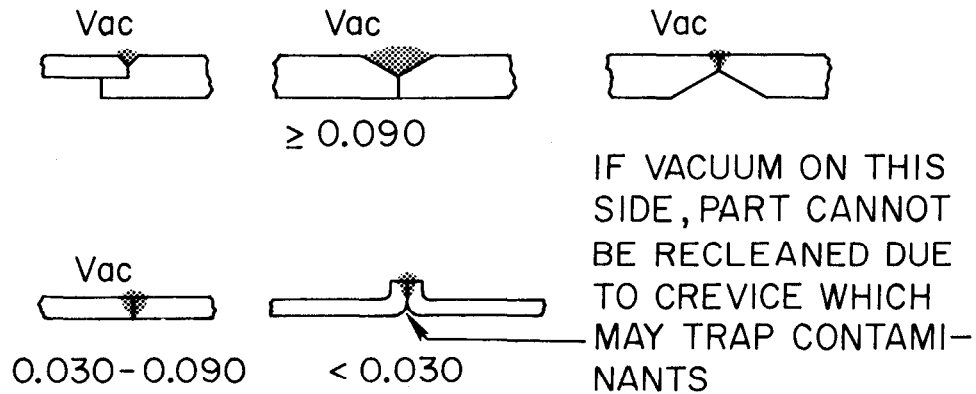
ROTATABLE FLANGE

Flange	A	B	C	D	E
2 3/4	2.73 ± .015	1.52 ± .015	.50 ± .015	1.902 ± .002	.301 ± .002
4 1/2	4.47	2.62	.75	3.250	.500
6	5.97	4.12	.84	4.750	.563
8	7.97	6.12	.94	6.750	.624
10	9.97	8.12	.97	8.750	.675
13 1/4	13.25	11.10	1.18	11.595 $\begin{smallmatrix} + .005 \\ - .000 \end{smallmatrix}$	.680

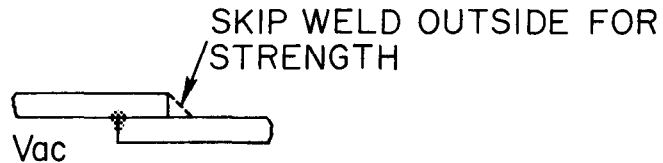
FIG. 1b

PREFERRED JOINT DESIGN FOR WELDING VACUUM COMPONENTS

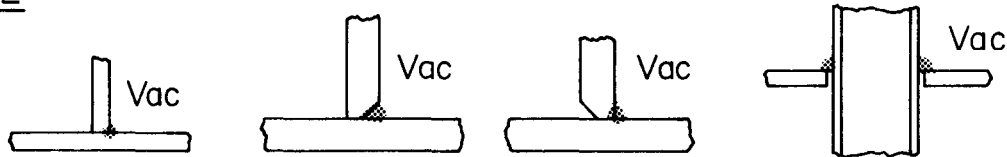
BUTT



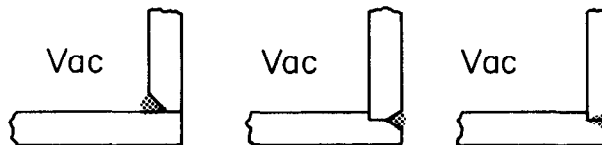
LAP



TEE

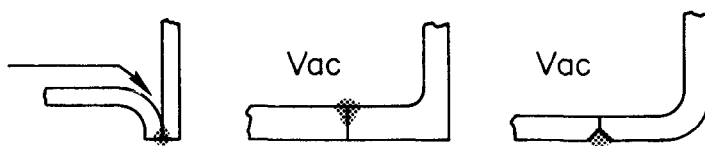


CORNER



EDGE

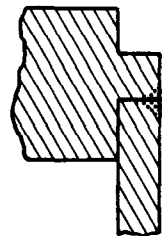
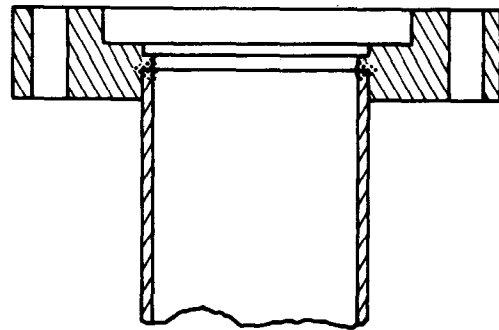
IF VACUUM ON THIS SIDE, PART CANNOT BE RECLEANED DUE TO CREVICE WHICH MAY TRAP CONTAMINANTS



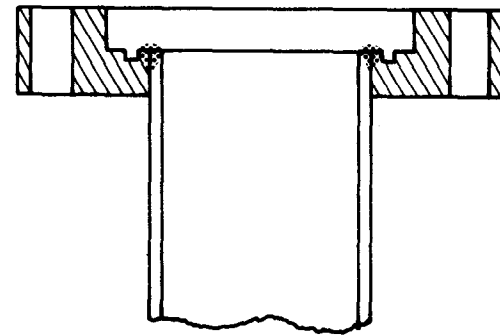
242384

FIG. 2

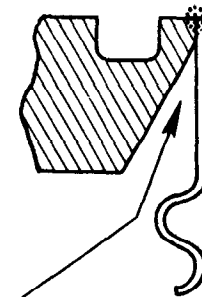
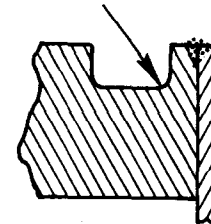
PREFERED JOINT DESIGN FOR WELDING
VACUUM FLANGES



PREFERRED FOR STANDARD
TUBING & FLANGES



RADIUS



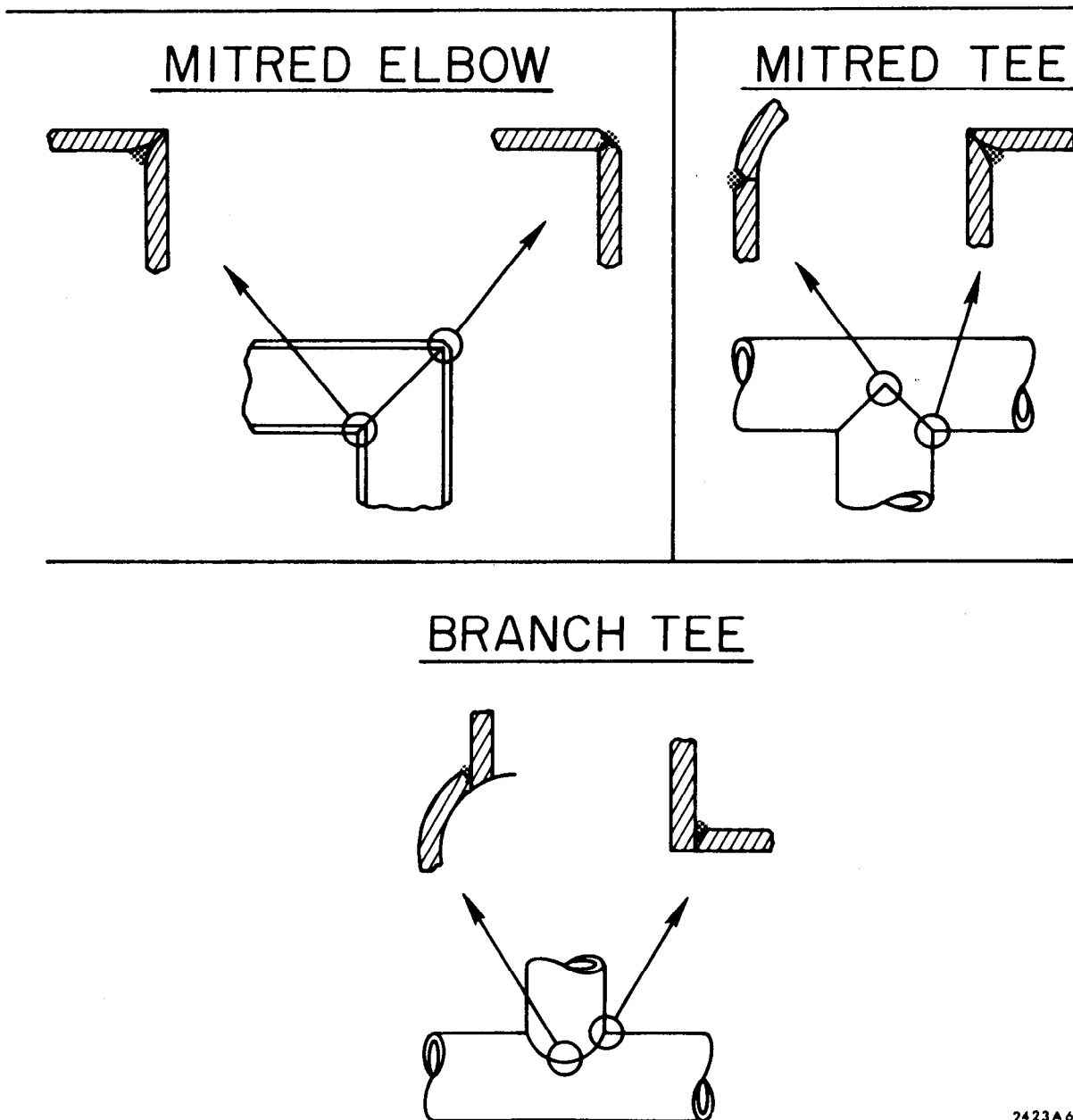
CHAMFER FLANGE
TO AVOID CREVICE
WHICH MAY TRAP
CHEMICAL CLEANING
SOLUTIONS

FOR VERY THIN
SECTIONS
(BELLOWS ETC.)

2423A5

FIG. 2a

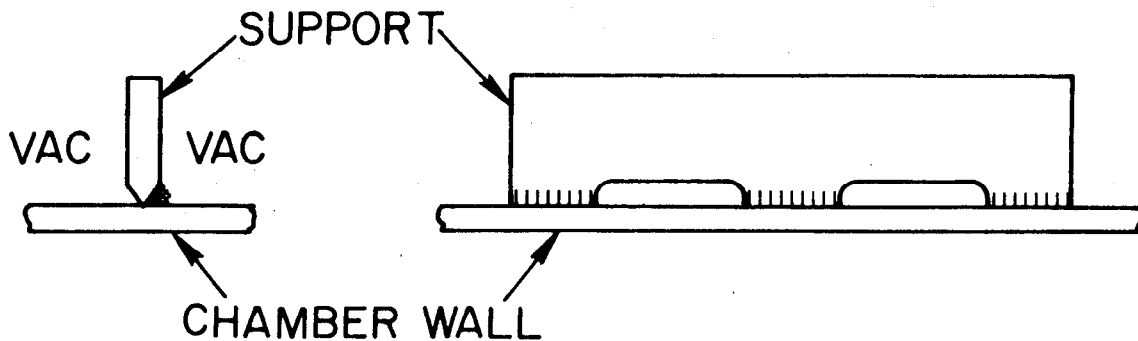
PREFERRED JOINT DESIGN FOR FULL PENETRATION OUTSIDE WELDS ON TEES AND ELBOWS



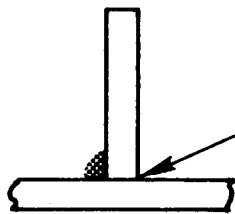
2423A6

FIG. 2b

PREFERRED JOINT DESIGN FOR WELDING INTERNAL SUPPORTS



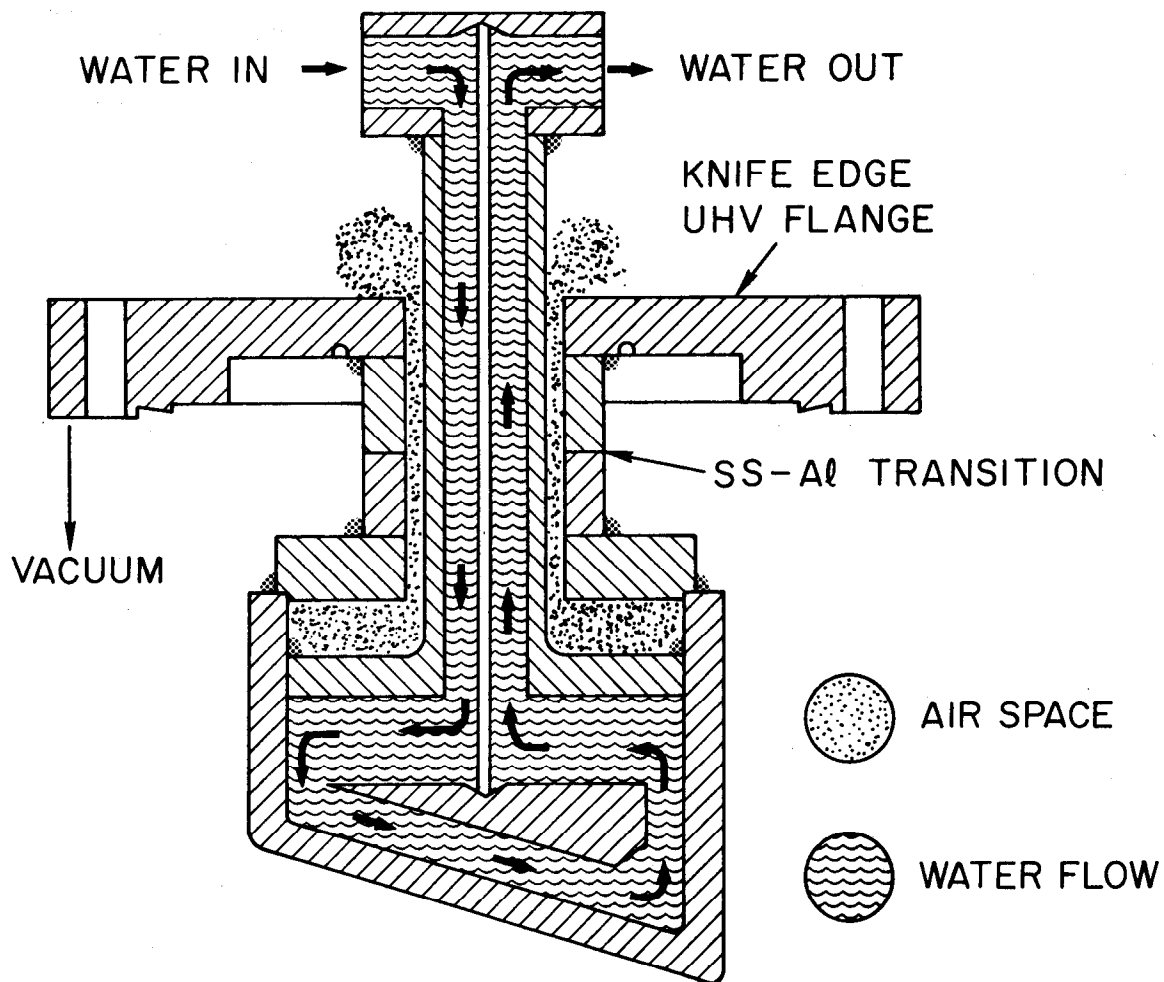
SUPPORT SHOULD BE CHAMFERED ON BOTH SIDES WHERE IT CONTACTS CHAMBER WALL TO AVOID CREVICES.



AVOID JOINTS SUCH AS THIS WHICH ARE TRAPS FOR CLEANING SOLUTIONS. COMPONENTS HAVING SIMILAR TYPE JOINTS AS PART OF THE INTERNAL (VACUUM) STRUCTURE WILL BE CONSIDERED NOT RECLEANABLE FOLLOWING FINAL ASSEMBLY.

2423A7

FIG. 2c



EXAMPLE OF WATER COOLED MODULE
DESIGNED USING NO WATER TO VACUUM
WELDS.

2423A8

FIG. 3

MIL-S-862B

23 MARCH 1959

SUPERSEDING**MIL-S-862A**

6 APRIL 1951

MILITARY SPECIFICATION**STEEL BARS, CORROSION RESISTING, AND STEEL
BILLETS, CORROSION RESISTING; REFORGING
APPLICATION**

This specification has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force.

1. SCOPE

1.1 Scope. This specification covers corrosion-resisting steel forging stock.

1.2 Classification. Corrosion-resisting steel shall be furnished in the classes and conditions shown in table I, as specified (see 6.2) :

TABLE I. Classes and conditions

Class	Condition
302	Hot worked
303	Hot worked
303 Se	Hot worked
304	Hot worked
304 L	Hot worked
309	Hot worked
310	Annealed
316	Hot worked
316 L	Hot worked
317	Hot worked
321	Hot worked
322	Hot worked
324	Hot worked
347	Hot worked
403	Annealed
405	Annealed
410	Annealed
414	Annealed
416	Annealed
416 Se	Annealed
420	Annealed
430	Annealed

TABLE I. Classes and conditions—(Cont'g)

Class	Condition
430 F	Annealed
430 F Se	Annealed
431	Annealed
440 A	Annealed
440 B	Annealed
440 C	Annealed
440 F	Annealed
440F Se	Annealed
416	Annealed

¹ Nonstandard classes.

2. APPLICABLE DOCUMENTS

2.1 The following standards, of the issue in effect on date of invitation for bids, form a part of this specification:

STANDARDS**MILITARY**

MIL-STD-163 — Preparation of Steel Products for Domestic Shipment (Storage) and Overseas Shipment.

FSC 9510, 9640

MIL-S-862B

MIL-STD-183 — Continuous Identification Marking of Iron and Steel Products.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this specification. Unless otherwise indicated, the issue in effect on date of invitation for bids shall apply.

OFFICIAL CLASSIFICATION COMMITTEE

Uniform Freight Classification Rules.

(Application for copies should be addressed to the Official Classification Committee, 1 Park Avenue at 33rd St., New York 16, N. Y.)

3. REQUIREMENTS

3.1 Chemical composition. The material shall conform to the chemical composition show in table II and shall be within the check analysis tolerances shown in table III.

TABLE II. Chemical composition.

Class	Carbon ¹	Manganese ¹	Phosphorus ¹	Sulfur ¹	Silicon ¹	Chromium
	Percent	Percent	Percent	Percent	Percent	Percent
302	0.15	2.00	0.045	0.030	1.00	17.00 — 19.00
303	.15	2.00	.20	.15	1.00	17.00 — 19.00
303Se	.15	2.00	.20	.06	1.00	17.00 — 19.00
304	.08	2.00	.045	.030	1.00	18.00 — 20.00
304L	.03	2.00	.045	.030	1.00	18.00 — 20.00
309	.20	2.00	.045	.030	1.00	22.00 — 24.00
310	.25	2.00	.045	.030	1.50	24.00 — 26.00
316	.08	2.00	.045	.030	1.00	16.00 — 18.00
316L	.03	2.00	.045	.030	1.00	16.00 — 18.00
317	.08	2.00	.045	.030	1.00	18.00 — 20.00
321	.08	2.00	.045	.030	1.00	17.00 — 19.00
* 322	.10	1.00	.045	.030	1.50	16.00 — 18.00
* 324	.07	1.00	.045	.030	1.00	15.50 — 17.50
347	.08	2.00	.045	.030	1.00	17.00 — 19.00
403	.15	1.00	.040	.030	.50	11.50 — 13.00
405	.08	1.00	.040	.030	1.00	11.50 — 14.50
410	.15	1.00	.040	.030	1.00	11.50 — 13.50
414	.15	1.00	.040	.030	1.00	11.50 — 13.50
416	.15	1.25	.06	.15	1.00	12.00 — 14.00
416Se	.15	1.25	.06	.06	1.00	12.00 — 14.00
420	Over .15	1.00	.040	.030	1.00	12.00 — 14.00
430	.12	1.00	.040	.030	1.00	14.00 — 18.00
430F	.12	1.25	.06	.15	1.00	14.00 — 18.00
430F Se	.12	1.25	.06	.06	1.00	14.00 — 18.00
431	.20	1.00	.040	.030	1.00	15.00 — 17.00
440A	0.60 — 0.75	1.00	.040	.030	1.00	16.00 — 18.00
440B	.75 — .95	1.00	.040	.030	1.00	16.00 — 18.00
440C	.95 — 1.20	1.00	.040	.030	1.00	16.00 — 18.00
* 440F	.95 — 1.20	1.25	.060	.050	1.00	16.00 — 18.00
* 440F Se	.95 — 1.20	1.25	.060	.050	1.00	16.00 — 18.00
446	.20	1.50	.040	.030	1.00	23.00 — 27.00

¹ Maximum, unless otherwise indicated.

² Minimum.

³ Manufacturer's option; reported only when intentionally added.

⁴ Nonstandard classes.

Note: Above chemical compositions are the same as specified in Standard FED-STD-46 except classes 322, 324, 440 F, and 440 F Se.

TABLE II. Chemical composition—(Cont'd)

Class	Nickel	Molybdenum ¹	Columbium plus tantalum	Titanium	Others
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	
302	8.00 — 10.00	—	—	—	—
303	8.00 — 10.00	¹ 0.60	—	—	¹ 0.60 maximum, zirconium
303Se	8.00 — 10.00	—	—	—	.15 minimum, selenium
304	8.00 — 12.00	—	—	—	—
304L	8.00 — 12.00	—	—	—	—
309	12.00 — 15.00	—	—	—	—
310	10.00 — 22.00	—	—	—	—
316	10.00 — 14.00	2.00 — 3.00	—	—	—
316L	10.00 — 14.00	2.00 — 3.00	—	—	—
317	11.00 — 15.00	3.00 — 4.00	—	—	—
321	9.00 — 12.00	—	—	5 x carbon ²	—
322	6.00 — 8.00	—	—	¹ 1.50	.50 maximum aluminum
324	3.00 — 5.00	—	0.15 — 0.40	—	3.00/5.00 copper
347	9.00 — 13.00	—	10 x carbon ²	—	—
403	—	—	—	—	—
405	—	—	—	—	.10/.30 aluminum
410	—	—	—	—	—
414	1.25 — 2.50	—	—	—	—
416	—	¹ .60	—	—	¹ .60 maximum, zirconium
416Se	—	—	—	—	.15 minimum, selenium
420	—	—	—	—	—
430	—	—	—	—	—
430F	—	¹ .60	—	—	¹ .60 maximum, zirconium
430F Se	—	—	—	—	.15 minimum, selenium
431	1.25 — 2.50	—	—	—	—
440A	—	.75	—	—	—
440B	—	.75	—	—	—
440C	—	.75	—	—	—
440F	—	.75	—	—	—
440F Se	—	.75	—	—	.15 minimum, selenium
446	—	—	—	—	.25 maximum, nitrogen

3.2 Processing. Unless otherwise specified in the contract or order, corrosion-resisting steel shall be made by the electric-furnace process and shall be cast in metal molds.

3.2.1 The bars or billets may be processed from ingots by rolling, hammering, or pressing.

3.3 Dimensions. Bars and billets shall conform to the form and dimensions as specified (see 6.2).

3.4 Weight tolerance. The tolerance for the specified or theoretical weight of bars and billets shall be 5 percent, plus or minus,

for individual pieces or for quantities of less than a carload. For carload quantities, the tolerance shall be 2½ percent, plus or minus, of the total weight of all pieces of the same nominal cross-sectional dimensions and specified piece weight. (The theoretical weight of steel is calculated on the basis of 0.287 pound per cubic inch for the 300 series, and 0.279 pound per cubic inch for the 400 series. Semi-finished steel is not furnished to tolerance limitations for cross-sectional dimensions.)

*** 3.5 Macroscopic etch.** Material shall, by the macroscopic etch test specified in 4.3.2, be demonstrated to be dense and sound and

TABLE III. *Check analysis tolerances.*

Elements	Limit of maximum of specified element, percent	Tolerance, over the maximum limit or under the minimum limit
Carbon	To 0.20 incl.	0.01
	Over 0.20 to 0.60 incl.	.02
	Over 0.60	.03
Manganese	To 1.00 incl.	.03
	Over 1.00 to 2.00 incl.	.04
Silicon	To 1.00 incl.	.05
	Over 1.00 to 3.00 incl.	.10
Nickel	To 1.00 incl.	.03
	Over 1.00 to 5.00 incl.	.07
	Over 5.00 to 10.00 incl.	.10
	Over 10.00 to 20.00 incl.	.15
	Over 20.00	.20
Chromium	Over 4.00 to 10.00 incl.	.10
	Over 10.00 to 15.00 incl.	.15
	Over 15.00 to 20.00 incl.	.20
	Over 20.00	.25
Molybdenum	Over 0.20 to 0.60 incl.	.03
	Over 0.60 to 1.75 incl.	.05
	Over 1.75	.10
Phosphorus	To 0.040 incl.	.005
	Over 0.040 to 0.20 incl.	.010
Sulphur	To 0.040 incl.	.005
	Over 0.040 to 0.20 incl.	.010
Selenium	All ranges	.03
Titanium	All ranges	.05
Columbium	All ranges	.05
Zirconium	All ranges	.05
Aluminum	To 0.50 incl.	.05
Nitrogen	All ranges	.01

to be free from pipe, fissures, gas cavities, sponginess, abnormal inclusions or segregation, or unusually numerous pinholes.

3.6 Repair of defects. Billets may be chipped or ground to remove surface defects. In the case of billets of a width greater than twice the thickness, the depth of chipping or grinding on the surface having the greatest area shall not exceed $\frac{3}{32}$ inch for each

inch of thickness up to 8 inches. In the case of billets of a width less than twice the thickness, the depth of chipping or grinding shall not exceed $\frac{1}{16}$ inch for each inch of thickness up to 8 inches. For all billets larger than 8 inches in the smaller cross-sectional dimension, the depth of chipping or grinding shall not exceed $\frac{3}{4}$ inch. For rectangular billets, the maximum depth of chipping or grinding on the edges shall be

the same as for billets having a width less than twice the thickness.

3.7 Identification marking. Identification marking shall be in accordance with Standard MIL-STD-183. Continuous marking shall be in ink.

3.7.1 Billets. Each billet shall be marked at least once near one end with the class, legibly die stamped, and the name or trademark of the manufacturer, the specification number, the heat number, and a condition designator selected from Standard MIL-STD-183.

3.8 Workmanship. Material shall be uniform in quality and condition, free from pipe, seams, welds, laps, cracks, slag, hard spots, porosity, slivers, scabs, rolled-in scale excessive nonmetallic inclusions, segregation, or any other defects which due to the nature, degree, or extent detrimentally affect its suitability for the service intended. Bars shall be commercially straight and free from twist.

4. QUALITY ASSURANCE PROVISIONS

4.1 Sampling.

4.1.1 For purposes of sampling, a lot shall consist of all bars or billets made from the same heat. For purposes of chemical analysis, if the heat cannot be identified, a lot shall be limited to 2000 pounds of bars or billets of the same size and shape.

4.1.2 One sample for chemical analysis shall be selected by the inspector from each heat. The sample shall be taken from material representing the topmost usable portion of the ingot, at a point midway between center and surface. If unable to identify the heat or ingot position, two samples shall be taken from the lot and analyzed separately. Samples shall be fine, clean, free from oil, dirt, grit, or other foreign matter, and shall consist of not less than 2 ounces.

4.1.2.1 Macroscopic etch test. Slices representing the entire cross section shall be cut from the top of the top billet and bottom of the bottom billet of 3 representative ingots of the heat. In the case of mill purchases, the results of the manufacturer's tests on material of the heat from which the bars or billets were rolled may be substituted, provided the identity of the material can be established to the satisfaction of the inspector and also that an approximately equal number of tests were taken from essentially equivalent positions in the heat. In the case of bars in which the heat and original position in the ingot has not been identified, a slice shall be taken from one end of sample bars or billets selected as specified in table IV.

TABLE IV. Sampling for macroscopic etch test.

Number of pieces in inspection lot	Number of pieces in sample	Acceptance number (defective)	Rejection number (defective)
25 and under	7	0	1
26 to 65	10	0	1
66 to 110	15	0	1
111 to 300	25	1	2
301 and over	35	1	2

4.2 Weight and visual examination.

4.2.1 The material shall be subject to weight, surface, and visual examination and to inspection for preparation for shipment by the inspector, who shall satisfy himself whether the material conforms to the requirements of this specification. Lots containing defective material shall be subject to rejection.

4.2.2 Reinspection. Lots rejected on account of weight or visual surface defects may be resubmitted for examination in accordance with 4.2.1, provided the manufacturer has reworked and reinspected the lots to remove all nonconforming material.

4.3 Test procedures.

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4.3.1 Chemical analysis. Samples selected in accordance with 4.1.2 shall be forwarded to a Government laboratory designated by the bureau or agency concerned and analyzed to determine conformance with tables II and III. If any sample fails to conform to tables II and III the entire lot shall be rejected.

4.3.2 Macroscopic etch test. The specimens for test shall be cut from the ends of the selected sample and shall represent the full cross-section of the bar or billet. The surfaces of the specimens to be examined shall be suitably prepared for etch testing. The prepared specimens shall first be cleaned and heated in water to the same temperature as the acid etching solution. They shall be immersed in a solution consisting of equal parts, by volume, of concentrated hydrochloric acid and water at approximately 160°F. for a period of time sufficient to develop fully the macroetch structure. Fresh acid shall be used for each lot of specimens. After etching, the specimens shall be washed in running water or steam and any deposit removed by scrubbing. The specimen shall then be dipped in cold concentrated nitric acid, washed in cold water, and dried. Should this test reveal piping or other injurious defects as specified in 3.5, the lot shall be rejected or further discard shall be made until the inspector is satisfied as to the soundness of the material; samples from the same cut from all other ingots in the heat shall be tested.

5. PREPARATION FOR DELIVERY

5.1 Level A and level B. Corrosion-resisting steel bars and billets shall be prepared for delivery in accordance with the applicable requirements of Standard MIL-STD-163. The bars and billets shall be shipped loose, in secured lifts, or in wooden boxes or metal containers as specified therein.

5.2 Level C. The material shall be prepared for shipment in accordance with com-

mercial practice and in a manner to insure carrier acceptance and safe delivery to destination at the lowest applicable rate. Containers shall comply with the Uniform Freight Classification Rules or other carrier regulations applicable to the mode of transportation.

5.3 Marking for shipment. In addition to any special markings required in the contract or order, shipment markings shall be in accordance with Standard MIL-STD-163.

6. NOTES

6.1 Intended use.

6.1.1 Corrosion-resisting steel bars and billets are intended for reforging purposes only. Material for reforging should not be stocked and should not be ordered unless it is certain that the material will be used for reforging purposes.

6.1.2 Corrosion-resisting steel for items to be welded, affecting safety or Military effectiveness, should be class 304, or 321, or 347.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Class of steel required (see 1.2).
- (c) Form and dimensions of bars and billets required (see 3.3).

6.3 The classes of Specification MIL-S-862A listed below are essentially equivalent to and interchangeable with classes of this specification as shown below:

MIL-S-862A	MIL-S-862B
Class	Class
1	304
2	302

MIL-S-862B**MIL-S-862A****Class**

3

4

5

6

7

8

9

10

11

12

MIL-S-862B**Class**

410

430

...

416 or 416 Se

303

321 or 347

316

431

310

...

Notice. When Government drawings, specifications, or other data are used for any purpose other than

in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodians:

Army—Ordnance Corps

Navy — Bureau of Ships

Air Force—WADC.

Preparing activity:

Navy — Bureau of Ships

(Project 508-1)