INCH-POUND
MIL-P-24540A(SH)
31 August 1989
SUPERSEDING
MIL-P-24540(SH)
23 July 1976
(See 6.10)

MILITARY SPECIFICATION

PLANT, CARBON DIOXIDE REMOVAL, LIQUID ABSORBENT TYPE (MARK IV)

This specification is approved for use by the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers a Mark IV carbon dioxide (CO_2) removal plant, and test kit for the plant, capable of removing CO_2 from the TRIDENT submarine atmosphere and discharging this CO_2 against variable submergence pressures. The CO_2 removal shall be accomplished by continuous absorption and desorption of the CO_2 in an aqueous solution of chelated monoethanolamine (MEA) (see 6.5).

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

FEDERAL

FF-B-171 - Bearings, Ball, Annular (General Purpose).
WW-V-35 - Valve, Ball.
PPP-F-320 - Fiberboard; Corrugated and Solid, Sheet Stock (Container Grade), and Cut Shapes.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 4460

MILITARY

MIL-C-17 - Cables, Radio Frequency, Flexible and Semirigid, General Specification for.
MIL-P-116 - Preservation, Methods of.
MIL-B-121 - Barrier Material, Greaseproofed, Waterproofed, Flexible.
MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-C-915 - Cable and Cord, Electrical, for Shipboard Use, General Specification for.
MIL-E-917 - Electric Power Equipment, Basic Requirements (Naval Shipboard Use).
MIL-F-1183 - Fittings, Pipe, Cast Bronze, Silver-Brazing, General Specification for.
MIL-S-1222 - Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws and Nuts.
MIL-C-2212 - Controllers, Electric Motor A.C. or D.C., and Associated Switching Devices.
MIL-M-7793 - Meter, Time Totalizing.
MIL-T-8606 - Tubing, Steel, Corrosion-Resistant (18-8 Stabilized and Extra Low Carbon).
MIL-B-11722 - Bromophenol Blue Solution; Indicator, 3.0 to 4.6 pH Range.
MIL-V-13811 - Varnish, Waterproofing, Electrical, Ignition.
MIL-P-15024 - Plates, Tags and Bands for Identification of Equipment.
MIL-P-15024/5 - Plates, Identification.
MIL-E-15090 - Enamel, Equipment, Light-Gray (Formula No. 111).
MIL-S-15291 - Switches, Rotary, Snap Action and Detent/Spring Return Action General Specification for.
DOD-P-15328 - Primer (Wash) Pretreatment (Formula No. 117 for Metals). (Metric)
MS16142 - Boss, Gasket Seal Straight Thread Tube Fitting, Standard Dimensions for.
MIL-E-16400 - Electronic, Interior Communication and Navigation Equipment, Naval Ship and Shore: General Specification for.
MIL-W-16878 - Wire, Electrical, Insulated, General Specification for.
MIL-M-17060 - Motors, 60-Hertz, Alternating Current, Integral-Horsepower, Shipboard Use.
MIL-E-17555 - Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts): Packaging of.
MIL-C-17605 - Charcoal, Activated, Unimpregnated.
MIL-P-17639 - Pumps, Centrifugal, Miscellaneous Service, Naval Shipboard Use.
MIL-H-17672 - Hydraulic Fluid, Petroleum, Inhibited.
MIL-B-17931 - Bearings, Ball, Annular, for Quiet Operation.
MIL-V-18436 - Valve, Check: Bronze, Cast-Iron, and Steel Body.
MIL-V-18634 - Valves: Safety, Relief, and Safety-Relief.
MIL-F-18866 - Fittings, Hydraulic Tube, Flared, 37 Degree and Flareless, Steel.

MILITARY (Continued)

MIL-G-18997 - Gauge, Pressure, Dial Indicating.
MIL-L-19140 - Lumber and Plywood, Fire-Retardant Treated.
MIL-F-19207 - Fuseholders, Extractor Post Type, Blown Fuse Indicating and Nonindicating General Specification for.
MIL-F-20042 - Flanges, Pipe and Bulkhead, Bronze (Silver Brazing).
MIL-P-20689 - Plastic Plastisol (for Coating Metallic Objects).
MIL-H-22577 - Heating Elements, Electrical: Cartridge, Strip and Tubular Type.
MIL-M-23573 - Monoethanolamine Chelating Agent Solution.
MIL-I-24092 - Insulating Varnish, Electrical, Impregnating, Solvent Containing.
MIL-T-24107 - Tube, Copper (Seamless) (Copper Alloy Numbers C10100, C10200, C10300, C10800, C12000, C12200 and C14200).
MIL-V-24547 - Valve, Back Pressure Regulating, High Pressure Steam Drain, Quiet-Design, for Submarine Systems.
MIL-V-24586 - Valve, Needle, Size 1/4-Inch and 1/2-Inch, Union Bonnet Construction.
MIL-P-24691 - Pipe and Tube, Carbon, Alloy and Stainless Steel, Seamless and Welded, General Specification for.
MIL-P-24691/3 - Pipe and Tube, Corrosion-Resistant, Stainless Steel, Seamless or Welded.
MIL-P-25732 - Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Limited Service at 275°F (135°C).
MIL-H-46885 - Human Engineering Requirements for Military Systems, Equipment and Facilities.

STANDARDS

MILITARY

MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
MIL-STD-278 - Welding and Casting Standard.
MIL-STD-419 - Cleaning, Protecting, and Testing Piping, Tubing, and Fittings for Hydraulic Power Transmission Equipment.
MIL-STD-471 - Maintainability Verification/Demonstration/Evaluation.
MIL-STD-740-1 - Airborne Sound Measurements and Acceptance Criteria of Shipboard Equipment.
MIL-STD-740-2 - Structureborne Vibratory Acceleration Measurements and Acceptance Criteria of Shipboard Equipment.
MIL-STD-1399, Section 300 - Interface Standard for Shipboard Systems Electric Power, Alternating Current. (Metric)
MIL-STD-1472 - Human Engineering Design Criteria for Military Systems, Equipment and Facilities.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.1.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

DRAWINGS

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

NAVSHIPS 803-0073904	- Bell-Wt., 115 Volts-60 Cycles, Type IC/BIS4, Sym. 2622.
NAVSHIPS 803-1385778	- Mounts, Resilient, EES Type.
NAVSHIPS 803-1385884	- Unions, Fittings and Adapters, Butt and Socket Welding, 6000 PSI WOG and OXY (IPS).
NAVSHIPS 803-4384536	- Valves, Bronze 1/4" - 2" Union End Globe, Angle, and Stop Check.
NAVSHIPS 810-1385888	- Unions, Butt and Socket Welding for O.D. Tubing 6000 P.S.I., WOG.
NAVSHIPS S6202-73907	- Light, Indicator (Switchboard), Lamp, 2 SPF, Types B27A Through B27G.
NAVSHIPS S6202-0073919	- Light, Indicator, Single Dial-WT, Integral Transformer, Base Mtd; 117V., Sym. 2815.1, 450V., Sym. 2815.2, Panel Mtd, 117V., Sym. 2815.3, 450V., Sym 2815.4.
NAVSHIPS SS501-818413	- Carbon Dioxide Removal Systems, Mark II, Special Fittings.
NAVSHIPS SS501-818415	- Lagging and Insulation Schedules.
NAVSHIPS SS501-1524708	- Purifier.
NAVSHIPS SS501-1524716	- Test Kit.

PUBLICATIONS

NAVSEA

NAVSHIPS 0900-LP-001-7000	- Fabrication and Inspection of Brazed Piping System.
NAVSEA 0960-LP-000-5010	- Guide for Design of Shock Resistant Naval Equipment.

(Application for copies should be addressed to the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Non-Government publications. The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE, INC. (ANSI)
B16.5 - Pipe Flanges and Flanged Fittings. (DoD adopted)
B16.11 - Forged Steel Fittings, Socket-Welding and Threaded. (DoD adopted)

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)
AS-604 - Hose Assembly, Tetrafluoroethylene, 400 Degrees F, 3000 PSI Hydraulic, Heavy Braid.

(Application for copies should be addressed to the Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 General. The plant shall consist of absorption, reactivation, cooling, purification, control, indicating and alarm systems and one test kit. Briefly, air shall be drawn from the ship's atmosphere into the top of an absorber to remove CO_2. The air shall then leave the absorber and pass through an air cooler, moisture separator, and air purifier and exit to the ship's atmosphere. The intent of the air purifier is to remove ammonia and MEA vapors. MEA shall be pumped from the bottom of the absorber in such a manner that a large portion of MEA is recycled to the top of the absorber and a small portion goes to a pressurized boiler-stripper where the CO_2 is released. MEA from the boiler-stripper shall be directed to the suction side of the MEA pump. The CO_2 leaving the boiler-stripper shall be cooled, voided of liquid moisture, and compressed to submergence pressure. A means shall also be provided to pump waste (spent) MEA solution to the ship's sanitary tank and to fill the absorber and boiler with MEA and water.

3.2 Operation. After the plant has been filled, started, and control settings have been established, the plant shall operate over a 24-hour period with an average operator attention (excluding maintenance) requirement of 5 minutes maximum per hour. Shipboard operation requires that the operator check the various indicating devices at hourly intervals and test the effluent air for trace MEA at 4-hour intervals, test the MEA normality at 24-hour intervals, and make the necessary adjustment.

3.3 Ambient conditions. The plant shall operate at a ship's ambient temperature range of 40 to 122 degrees Fahrenheit (°F), and a pressure of 30 inches of mercury (Hg) absolute, with variations of plus or minus 6 inches Hg. The plant shall not be damaged when subjected to ship compartment absolute pressures of between 10 and 30 pounds per square inch (lb/in^2).

3.4 Capacity. The plant shall continuously remove CO_2 at minimum rates of 17.0 pounds per hour at 0.5 volume percent concentration in the inlet air, and 25.0 pounds per hour a 1.0 volume percent concentration in the inlet air. These capacities are based on the amount of CO_2 discharged from the compressor, process air conditions of 3.5.1, and the tests of 4.6.3. The plant shall also provide trouble-free operation at an inlet CO_2 concentration of 1.5 volume percent.

3.5 Services. The plant shall operate at rated capacity with the services specified in 3.5.1 through 3.5.5.

3.5.1 Process air. Process air shall be drawn into the plant by a centrifugal blower, through a connection even with the top of the plant. The conditions of the normal inlet process air are 80°F temperature, 70 percent relative humidity and 30 inches Hg absolute pressure.

3.5.2 Chilled water. Chilled water shall be used for indirect cooling. The chilled water shall range between 40 and 50°F and shall have a maximum gauge pressure of 150 lb/in^2. Chilled water flow shall vary from 20 to 26 gallons per minute (gal/min). The maximum allowable heat transferred to the chilled water shall be 120,000 British thermal units per hour (Btu/hr) based on the normal inlet process air conditions of 3.5.1. The maximum allowable pressure drop between the plant inlet and outlet chilled water shall be 10 lb/in^2.

3.5.3 Fresh water. Fresh water (not chilled water) at a maximum gauge pressure of 60 lb/in^2 shall be used for mixing with MEA in the plant.

3.5.4 Operating loads. The plant shall operate with 440-volt alternating current (ac) maximum, 3-phase, 60 hertz (Hz). The plant shall not require more than 40 kilowatts (kW) for normal operating loads nor more than 56 kW for in-rush loads.

3.5.5 Chelated MEA. Chelated MEA in accordance with MIL-M-23573 shall be used as the CO_2 absorbing media. The plant shall operate with MEA available at a maximum gauge pressure of 20 lb/in^2. MEA in the plant shall be a 4.0 maximum normal aqueous solution.

3.6 Moisture. Droplets or slugs of MEA and water shall not enter the purifier resin (see 3.20.7 and 3.20.8) and CO_2 compressor. Discharge air from the plant shall contain no visible droplets of liquid.

3.7 Arrangement. The arrangement shall be based on engineering and human engineering design factors to facilitate systematic operation and maintenance (see 6.3 and appendix C). Equipment shall be arranged to facilitate access for purposes of maintenance and operation. Equipment requiring periodic maintenance shall be easily accessible and removable and replaceable without interference. Access to the plant for maintenance and operation shall be limited to the front and both sides of the plant. The space required for maintenance and operation shall be limited to 24 inches in front and 18 inches on each side of each skid of the plant. The rear of the plant shall not be used for accessibility.

3.7.1 Equipment positioning. The plant shall facilitate the addition of make-up water and MEA while the plant is operating. The control panel shall be mounted on the front of the plant on the right side with the front of the control panel flush with the front of the plant. Adjustable controls on the front of the panel shall be accessible to the operator without having to stoop or bend over. Other equipment requiring positioning or observation during normal plant operation and filling shall be located near the front of the plant in the general vicinity of the middle third of the plant and shall be accessible to the operator without having to stoop, bend over, or in any way have to reach behind other components. The boiler and absorber level gauges shall be located within 6 inches of the front of the plant, may be at any convenient elevation and shall not be obscured for observation from the front of the plant. The blower and compressor oil level indicators shall be located to facilitate oil level observations from the right side of the plant. Compressor oil fill and drain connections shall be at the front of the plant.

3.7.2 Shipboard installation. To facilitate shipboard installation, the space around the upper and lower mounts of each skid (see 3.20.1) shall be void of any material with the exception of the mounts and mount support brackets (see 6.3 and appendix B).

(a) For the lower mounts, the space is that below a horizontal plane passing through the lower edge of the mounts.
(b) For the upper mounts, space is that which is around the mounts and bounded by the following planes:

(1) Vertical planes coincident with the rear and each side of the plant.
(2) A vertical plane parallel to the rear of the plant and 4 inches in front of the centerline of the mount.
(3) Vertical planes parallel to the side of the plant and 4 inches from the centerline of the mounts in directions toward the absorber.
(4) A horizontal plane 6 inches above the mount flanges.
(5) A plane on an angle of 50 degrees with the horizontal sloping downward toward the rear of the plant, and intersecting the vertical centerline of the mounts at a point 10 inches below the mount plates.

3.8 Interchangeability. The TRIDENT maintenance concept requires extensive use of a rotatable pool of replacement end items and components thereof to satisfy a very tight submarine refit turnaround schedule. Under this concept, replacement CO_2 removal plants and their internal components are standardization critical. They shall be identical to the "as built" configuration baseline at points where they interface with foundations or other equipments or components (flange bolt holes). Therefore, the identical plants, their components, and all similar parts, including repair parts, furnished on the same contract or order, or manufactured to the same drawings, shall be interchangeable without further machining, selective assembly, or hand fitting. In addition, these plants and their components which are functionally interchangeable shall also be physically, electrically, and mechanically interchangeable. The decision for any deviation rests with the Naval Sea Systems Command (NAVSEA) whose written permission shall be obtained for any changes affecting the form, fit, function, or training

materials of the plant and its components. The contractor shall perform an appropriate cost-benefit analysis whenever departure from the standardized plant design is contemplated, including the question of whether retrofit should be required in the event design modification appears beneficial.

3.9 Weight, mounting, and overall dimensions. The wet and dry weights, main mount locations and orientation and the width, depth, height, and drainway (see 3.20.2.1) dimensions shall be in accordance with figure 1. The center of gravity of each skid shall be not more than 6 inches and as close as possible to a point in the center of a plane passing through and bounded by the four main mounts. The final location is subject to NAVSEA review.

3.10 Noise and vibration. The plant shall not be damaged by internally excited vibrations, or by environmental vibrations specified in MIL-STD-167-1, type I, for frequencies up to and including 33 Hz. No plant shall exceed the airborne noise limits specified in table I and the structureborne noise limits shown on figure 2 (see 4.6.5 and 4.6.5.1).

TABLE I. Airborne noise limits.

Octave band (Hz)	Sound pressure level (dB)	Octave band (Hz)	Sound pressure level (dB)
37.5 - 75	90	600 - 1200	75
75 - 150	85	1200 - 2400	75
150 - 300	80	2400 - 4800	75
300 - 600	80	4800 - 9600	75

3.11 Shock. The plant shall withstand shock requirements in accordance with grade A, class II, type A of MIL-S-901. For additional information and assistance regarding shock resistance, see NAVSEA 0960-LP-000-5010.

3.12 Pitch and roll. The plant will be installed in the ship with the front of the plant parallel or perpendicular to a vertical plane through the longitudinal axis of the ship. The plant shall perform its principal function of removing CO_2, remain structurally sound, and shall avoid loss of MEA solution, lubricating oil, and cooling water under the following conditions:

(a) When the ship is permanently trimmed down by the bow or stern at any angle between 0 and 30 degrees.
(b) When the ship is permanently listed at any angle between 0 and 15 degrees to either side of a vertical plane through the ship's longitudinal axis.
(c) When the ship is pitching through an angle of 10 degrees up or down from its normal horizontal plane in a full period of 10 seconds.
(d) When the ship is rolling through an angle of 45 degrees to either side of a vertical plane through the ship's longitudinal axis in a full period of 16 seconds.

(e) The conditions of (a) with (c); and (b) with (d) shall not be considered additive.
(f) The conditions of (a) with (b); (b) with (c); (a) with (d); and (c) with (d) shall be considered additive.

The period is the time required for the ship to rotate from one extreme to the other and return.

3.13 Insulation. Insulation materials shall be in accordance with NAVSHIPS Drawing SS501-818415. Adequate insulation shall be provided for heat and cold conservation, personnel safety, and where condensation is likely to form on the external surface of piping. Insulation, as required, for valves, unions, flanges and special fittings, except pipe hangers shall be removable and reusable.

3.14 Electrical system requirements. The electrical system shall include motors, boiler heater, level defection and alarm system, temperature indicator system, and control panel. The electrical system shall conform to MIL-E-917, as applicable, and shall be similar to that shown on figure 3.

3.14.1 Circuitry. Power supply to the plant disconnect switch, motors, controllers, boiler heaters, and primary side of a control transformer shall be 440 volts, 3-phase, 60 Hz, type I power in accordance with MIL-STD-1399, section 300. The control circuits for the motors and heater shall be 440 volts. The secondary side of the control transformer shall be 110 volts and shall govern the voltage input to other electrically operated components.

3.14.2 Discrete contact closure. A discrete contact closure shall be provided by an unpowered contact set and shall be used only for the purpose of providing plant operating status to the ship monitoring subsystem. Switch characteristics shall be not more than 50 ohms contact resistance in the closed state and not less than 6120 ohms in the open state. Voltages supplied across the contacts of up to 160 volts root mean square (rms), 60 or 400 Hz or up to 60 volts direct current (dc) shall not damage the contacts when currents between 10 and 100 milliamperes (mA) provided by the specified source voltages are passed through the closed contacts. Also, these contacts shall exhibit a closed resistance of not less than 50 ohms.

3.14.3 Motors. Single speed motors of the smallest required size shall be furnished. Motors shall be in accordance with MIL-M-17060, except that the structureborne noise level of integral horsepower motors shall not cause the carbon dioxide removal plant to exceed the requirements of the structureborne acceptance criteria curve shown on figure 2. Motors shall start, accelerate, and operate the driven auxiliaries under all maximum load conditions. Motors shall operate on 440-volt, 3-phase 60 Hz power and shall conform to the following requirements and characteristics:

(a) Type: Squirrel-cage induction.
(b) Voltage: 440 volt, 60 Hz, 3-phase.
(c) Enclosure: Dripproof protected 45 degrees.
(d) Horsepower: Five.
(e) Speed: As required.
(f) Bearings: Ball.
(g) Duty: Continuous.

(h) Service: A.
(i) Ambient: 122°F (50 degrees Celsius (°C)).
(j) Insulation: Class, B, F, or H.
(k) Temperatures: At rated load shall not exceed class B rise for 122°F (50°C) ambient.
(l) Motor shall be for submarine service.
(m) Motor balancing rings are required.

(a) Type: Squirrel-cage induction.
(b) Voltage: 440-volt, 60 Hz, 3-phase.
(c) Enclosure: Totally enclosed fan cooled.
(d) Horsepower: Three.
(e) Speed: As required.
(f) Bearings: Ball.
(g) Duty: Continuous.
(h) Service: A.
(i) Ambient: 122°F (50°C).
(j) Insulation: Class, B, F, or H.
(k) Temperature: At rated load shall not exceed class B rises for 122°F (50°C) ambient.
(l) Motor shall be for submarine service.
(m) Motor balancing rings are required.

Individual controllers and control circuits shall be provided for each motor. Each motor shall be grounded.

3.14.4 Boiler heater box and heater assembly. The boiler heater box and heater assembly shall supply a constant (within voltage limitations) rate of heat to reactivate the MEA solution in the boiler and shall consist of heater box and heater assembly, terminal box and associated fasteners. Caution shall be taken to minimize MEA breakdown due to excessive heat. The heater surfaces shall not be exposed to MEA fluid. The heating elements shall conform to type I of MIL-H-22577, with hermetic end seals and threaded terminals. The heating elements shall be provided with type 347 or 316L corrosion-resisting steel or nickel-chromium-iron alloy seamless pipe sheaths. The elements shall minimize stress corrosion and shall be electro-polished if necessary to minimize corrosion pitting. The element terminals shall be enclosed in a dripproof terminal box conforming to MIL-C-2212. The terminal box shall have a terminal access cover. A controller, control circuit, and "heater-on" indicating light (see 3.14.7.3) shall be provided for specific control of the heater. The watt density of the heater elements shall be not greater than 20 watts per square inch.

3.14.5 Level detection and alarm system. A level detection and alarm system shall be installed to monitor the MEA liquid level in the boiler section and CO_2/water separator. The level detection system shall contain sensing probes fitted with air gaps through which an ultrasonic signal is transmitted when filled with liquid. The system shall include liquid level detectors for both high and low levels, necessary electrical and electronic assemblies, and an alarm bell. The bell shall be type 1C/B1S4 in accordance with NAVSHIPS Drawing 803-0073904 and shall sound at both high and low levels. Indicating lights (see 3.14.7.3) shall be provided to indicate both normal and abnormal levels for both high and low levels. Green lights shall indicate normal; red lights with flashers shall indicate abnormal. An electrical interlock device shall be

ound shall be calculated using the following equation: determination. The feet per m

provided to automatically shut off the heaters, compressor, and air blower at the low level condition. An electrical interlock device shall be provided to automatically shut off the heaters and all motors at the high level condition in the boiler or separator. The low level limit shall be above the top of the boiler heater. The boiler high level limit shall be located below the packing and at a level which will permit adequate heating and will avoid nuisance shutdowns (see 3.20.2.2). The separator high level limit shall be located below the separator inlet. A device shall be provided to de-energize the bell when the levels are high or low, and when in this de-energized position, the alarm shall sound when the level once again becomes normal. This same device shall be used to test the alarm bell. A separate device shall be provided to silence the alarm under any condition. A red indicating light shall be provided to silence the alarm under any condition. A red indicating light shall be provided to indicate that the alarm is in the silent position. The level detection system indicating lights shall remain lit as appropriate when the alarm bell is de-energized. In the event of failure of the internal wiring of the electronic assemblies, the alarm shall sound and level indicating lights shall indicate abnormal conditions. Unless previously considered satisfactory for CO_2 plant service, the electronic assemblies associated with level detection shall be subject to NAVSEA review.

3.14.6 Temperature indicating system. A temperature indicating system shall be provided to indicate the temperatures of the CO_2 leaving the CO_2 cooler; processed air leaving the air cooler, and inlets and outlets of the MEA heat exchanger (four places). Except as specified herein, the temperature indicating system shall include resistance elements, protecting covers (thermowells), leads, selector switch, and temperature indicator. The resistance elements shall be readily replaceable and shall include resistors and protective sheaths retained by corrosion-resisting steel protective covers. The selector switch and temperature indicator shall be mounted adjacent to each other on the front of the control panel, and the enclosures of those portions extending outside the control panel shall be dripproof or watertight in accordance with MIL-C-2212. The points on the selector switch shall be plainly marked. An information plate (see 3.31) shall be mounted on or adjacent to the selector switch and shall be marked to identify the point where the temperature is read and the normal operating temperature range. The temperature indicator shall have a scale range of 50 to 350°F. Scales shall have black lettering and graduations on a white background. Unless previously considered satisfactory for CO_2 plant service, the temperature indicating system shall be subject to NAVSEA review.

3.14.7 Control panel. Except as specified herein, the control panel shall conform to MIL-C-2212. The control panel shall have a dripproof enclosure and shall serve as the enclosure for all electrical components mounted therein. Controllers, relays, transformers, amplifiers, and other similar devices shall be mounted in the control panel and shall operate at the conditions prevailing within the control panel when the ship's ambient conditions are as specified in 3.3. The control panel cover shall be hinged and provided with captive screws. The cover shall facilitate complete access when open to electrical components mounted within the enclosure. The control panel cover shall be equipped with a means to lock the cover in the open position. Components such as indicator lights, switches, information and identification plates, fuse receptacles, and similar devices shall be mounted conveniently on the front of the control panel (see 3.14.6 and 3.31). The cable entrance plate shall not be at the top or front of the control panel.

3.14.7.1 Disconnect switch. The disconnect switch shall conform to type 3SR3A2 or 6SR3A2 of MIL-S-15291.

3.14.7.2 Controllers, relays, and control circuits. Controllers and relays, and the motor and heater control circuits shall conform to MIL-C-2212 and shall have the following characteristics:

(a) Operation: Magnetic.
(b) Type: Across-the-line.
(c) Performance: Nonautomatic.
(d) Protection: Low voltage protection.
(e) Function: As applicable.
(f) Master switches: Local pushbuttons.
(g) Enclosure: Open (inside control panel).

3.14.7.3 Indicating lights. Indicating lights shall conform to types B27A and B27B, as applicable, of NAVSHIPS Drawing S6202-73907, or type B41C and B41D, as applicable, of NAVSHIPS Drawing S6202-0073919. Lenses shall be permanently marked to indicate plant condition. Lenses shall be flat, slightly raised above the mounting surface, and translucent except for marking. The lens colors shall be as specified herein. The two abnormal level lights shall have flasher units.

3.14.7.4 Fuseholders. Fuseholders shall conform to type FHL12G of MIL-F-19207.

3.14.8 Other electrical equipment. Other electrical equipment such as toggle switches and cable clamps which are not specified in MIL-C-2212 shall be in accordance with the selection of parts requirements of MIL-E-917.

3.14.9 Wire and cable. Wire and cable shall be installed in a neat and workmanlike manner and shall be arranged to minimize slack. However, sufficient slack shall be provided to preclude breakage and chafing, particularly between hinged parts. Wire and cable shall be bundled, and laced or clamped or both. Lacing shall be accomplished with slow burning fungus resistant cordage. Clamping shall be accomplished with polyamide clamps. Metal clamps may be used but shall not form complete loops around the wire. Nylon cloth shall be placed under cordage or metal clamps to preclude breakage or chafing of the wire or cable. The ends of braided coverings shall be protected to prevent fraying. Where wires or cable, single or in groups, pass through metal, the passage holes shall be provided with grommets or other devices to prevent breakage or chafing. Wire and cable shall be color coded or tagged on each end to facilitate shipboard testing and locating of faults. Color coding, if used, shall be in accordance with the identification of conductors requirements of MIL-E-16400.

3.14.9.1 Wiring. Wiring inside the control panel shall conform to MIL-W-16878.

3.14.9.2 Cable. Interconnecting cable between points outside of the control panel to points inside the control panel shall conform to MIL-C-915 and MIL-C-17.

3.15 Connections. Connections and joints for all mechanical and electrical equipment shall be as specified in 3.16.1.

3.15.1 Service connections. Unless otherwise specified (see 6.2), the service connections and their location shall be in accordance with figure 1.

3.15.2 Threaded connections. Taper pipe threaded connections including "Dryseal" between piping and equipment and within piping systems and equipment are not permitted except for the connection between the inlet piping and the distributor of the boiler-stripper. For size 1-inch outside diameter (od) and below, flareless mechanical bite type fittings in accordance with MIL-F-18866 are acceptable when installed with corrosion-resisting steel tubing, except unions shall be as specified herein. For sizes larger than 1/2 inch od, mechanical bite type fittings with SAE straight threads and O-rings for boss mounting may be used for connection to components. Female threads in threaded connections shall be in accordance with MS16142.

3.16 Pipe. Corrosion-resisting steel pipe for welded fittings shall conform to MIL-P-24691 and MIL-P-24691/3, grade TP 304L or TP 316L. Grade TP 304 and TP 316 steel pipe may be used for nonwelded fittings. When the latter materials are fabricated in any manner which reduces their corrosion resistance, they shall be heat-treated to restore their original condition. Passivating treatment, paint, or other surface coatings shall be used to protect materials subject to corrosion.

3.16.1 Piping. Piping includes pipe, tube, valves, special valves, flanges, fittings and special fittings. Flanges or unions shall be provided to facilitate removal of equipment that may require repair or replacement. Piping shall be kept to a minimum but shall be sufficient to provide for proper flow of chilled water, fresh water, MEA, CO_2, air and condensate. The requirements specified herein for pipe shall also apply to tube and lines. Service connections except those for air and power shall be flanges, unions, or union-ended valves.

3.16.2 Flushing line. A means to prevent spillage shall be provided to fill the absorber, and to flush the MEA drainway (see 3.20.2.1) with fresh water. The flushing line and a portion of the filling line shall be seamless copper tube conforming to MIL-T-24107 with a minimum wall thickness of 0.065 inch. Fresh water from the ship shall be directed through the copper fill line to a funnel (see 3.18.1(g)). The flushing line shall be a branch off the copper fill line. The copper fill line and the funnel shall be arranged to provide an atmospheric break and to enable the operator to see that the water is flowing. The balance of the water fill line from the funnel to the absorber shall be corrosion-resisting steel. Piping subjected to submergence pressure shall be made of grade TP 316L corrosion-resisting steel and constructed for pressures specified by NAVSEA.

3.16.3 Chilled water. Chilled water lines shall be of corrosion-resisting stainless steel. The stainless steel welds on the chilled water lines (two 1-inch lines) shall replace 70-30 copper-nickel alloy by adding stainless steel pipe, fittings and two unions having separate brass and stainless parts.

3.16.4 Other pipe. Other pipe shall be seamless corrosion-resisting steel in accordance with MIL-P-24691 and MIL-P-24691/3 or MIL-T-8606. Welded joints in the CO_2 compressor discharge line shall be socket welds. A means shall be provided to fill the absorber with MEA with a minimum amount of spillage. The

MEA piping shall be so arranged that the boiler-stripper may be filled by pumping (with MEA pump) from the absorber, and waste MEA from the boiler-stripper may be drained by gravity to the absorber sump. The MEA pump shall be used to pump waste MEA from the absorber. Relief valves shall vent to ship's atmosphere in a manner to prevent harm to personnel. Condensate return lines from CO_2 cooler, air cooler, and separators to the absorber or boiler-stripper as applicable, shall be provided to minimize the loss of MEA and water. Lean and rich MEA (see 6.5) sampling lines shall be provided and shall terminate near, and drain into the funnel. The sampling lines and funnel shall be so arranged that a test tube (see 3.20.15) can be used to collect the sample.

3.17 Valves. Valves conforming to NAVSHIPS Drawing 803-4384536 shall be installed as throttle valves in the copper portion of the fresh water filling and flushing lines. Valves shall be made of corrosion-resisting steel. Means shall be incorporated to prevent galling and seizing, utilizing material (except steel) other than that specified herein. Where socket weld ends are used, the valve shall be conditioned as necessary to prevent corrosion after welding. The valves shall be constructed and installed so that all internal valve parts may be adjusted as required, and removed without removing the valve body from the plant. Valve packing and soft seats shall be polytetrafluoroethylene or synthetic rubber or similar materials. Valves shall have soft seats.

3.17.1 Shut-off valves. Shut-off valves shall be provided for fresh water fill (between funnel and absorber), MEA pump suction, lean MEA discharge from the boiler to the absorber, MEA waste discharge, compressor discharge (in-line), compressor suction vent, and as otherwise required. The MEA pump suction valve shall be flanged.

3.17.2 Throttle valves. Throttle valves shall be provided for rich MEA flow control to the boiler-stripper, rich MEA sampling, compressor discharge vent, MEA supply to absorber, and as otherwise required.

3.17.3 Spring loaded soft-seat check valves. Spring loaded soft-seat check valves conforming to MIL-V-18436 shall be provided to prevent backflow of rich MEA from the boiler-stripper, and to prevent backflow of CO_2 discharge from the compressor and as otherwise required.

3.17.4 Automatic, spring loaded, soft-seat relief valves. Automatic, spring loaded, soft seat relief valves conforming to MIL-V-18634 shall be provided to protect the boiler-stripper and CO_2 cooler, compressor, and as otherwise required. The compressor discharge relief valve setting shall be as specified by NAVSEA.

3.17.5 Back pressure regulating valve. A back pressure regulating valve conforming to MIL-V-24547 shall be installed to maintain a pressure on the boiler-stripper and CO_2 cooler. The valve shall be a diaphragm type and shall modulate the flow of CO_2. Materials in contact with CO_2 shall be corrosion-resisting steel, polytetrafluoroethylene or synthetic rubber. The valve shall minimize cycling (intermittent or varying flow).

3.17.6 Ball valves. Plug valves (eight 2-way valves and three 3-way valves) shall be replaced with six 2-way ball valves conforming to WW-V-35, three 3-way ball valves and two needle valves conforming to MIL-V-24586 including respective fittings, supports, brackets and modified gauge board and identification plates.

3.17.7 Valve hand wheels. Valve hand wheels shall be plastisoled in accordance with the submarine system color code requirements specified in MIL-P-20689.

3.18 Fittings. Fittings include items such as tees, elbows, unions, pipe couplings and reducers. Fittings for the chilled water system and copper portions of the fresh water system shall conform to MIL-F-1183 and shall have silver braze socket connections. Fittings for other systems shall be corrosion-resisting steel, shall have socket weld connections, and shall conform to ANSI B16.11 or the equivalent tube fitting standard.

3.18.1 Special fittings. Special fittings include the following and shall be as specified:

(a) Wye type strainers shall be installed in the rich and lean MEA lines and in the CO_2 discharge line between the CO_2 cooler and back pressure regulator. An MEA pump discharge wye strainer shall be installed on the recycle line. The strainer shall be 1-1/4 inch size with a removable 1-inch screen to ensure cleaning, and a drain plug. Strainers 2 inches and larger shall be flanged. Strainers less than 2 inches shall be socket welded. The strainers shall be arranged for screen removal without disconnection of piping. Screen cartridges shall retain foreign matter on the inside of the screen and shall be arranged for adequate clearance between the outside of the screen and inside of the shell. Screen cartridges shall be removable for cleaning but shall be positively located. Materials shall be corrosion-resisting steel. A blow-down shall be installed on the CO_2 strainer including tubing, connectors, 1/2-inch valve and identification plate.

(b) Unions in the chilled water and copper portion of the fresh water systems shall be silver braze socket unions conforming to MIL-F-1183. Unions for other systems shall be socket weld with an O-ring seal conforming to NAVSHIPS Drawing 803-1385884 or 810-1385888 and shall be constructed of corrosion-resisting steel. Where unions are used as adapters between tube and pipe they shall conform to Drawing 803-1385884 as specified above except the socket for the tail piece shall be bored in accordance with Drawing 810-1385888.

(c) O-rings and similar items shall be in accordance with MIL-P-25732. Only ethylene propylene rubber O-rings shall be used in aqueous monoethanolamine systems.

(d) Hose shall be installed for sound, shock, and vibration isolation. The length of hose shall be suitable to meet shock and vibration motions and in no case shall be less than 9 inches exclusive of end fittings. Hose shall be arranged to preclude breakage or cracking. For fluid temperature of 400°F or less, polytetrafluoroethylene or corrosion-resisting steel flexible hose, conforming to SAE AS-604, shall be installed, except that flexible synthetic rubber hose may be used for fluid temperatures of 140°F or less. Hoses with materials subject to age or environmental degradation shall have a minimum burst pressure of at least four times the maximum working pressure of the system

where installed. Metallic type flexible hose shall have a minimum burst strength of at least two times the maximum working pressure of the system where installed. Hose connections shall facilitate hose removal without twisting the hose or equipment. Permanent markings shall be provided to clearly show the date of manufacture and manufacturer's trade mark. Flexible hose shall not be used in any system exposed to submergence pressure. Hose clamps may be used for service under 15 lb/in^2 and shall provide a tight seal and facilitate easy removal without the use of special tools. Special tools are defined as those tools not listed in the Federal Supply Catalog. (Copies of this catalog may be consulted in the office of the Defense Contract Administration Service Management Area (DCASMA). A portable flexible hose shall be provided to facilitate pressurizing the boiler-stripper by connecting the compressor discharge vent valve and a connection such as the CO_2 line wye strainer. This portable hose shall be used during start-up and flushing operations. Means shall be provided to store and secure the portable hose to the plant.

(e) Pipe shall be structurally sound and shall be furnished with means to minimize noise transmission through the hanger from the pipe to other portions of the plant. Pipe hangers shall be installed for every unsupported length of piping in excess of 3 feet and for every unsupported length of piping that forms a cantilever of 1 foot or more. Pipe joints with equipment which is mounted securely to supports, foundations or the base are considered to be supported. Pipe hangers shall be welded or bolted to the absorber base, boiler-stripper, or foundations.

(f) Brass, bronze or copper-nickel, vent fittings shall be installed to vent the chilled water system.

(g) A fresh water filling funnel shall be installed. The funnel shall be constructed of corrosion-resisting steel and shall have a screen to prevent foreign objects from entering the absorber. The funnel shall have a socket weld connection.

(h) Flowmeters shall be installed to indicate the quantity of CO_2 leaving the CO_2 cooler, MEA to the boiler-stripper, and MEA to the MEA filter. The scale ranges shall be selected to facilitate accurate readability. The MEA flowmeter scale shall be graduated in gal/min and fractions thereof and so marked. The CO_2 flowmeter scale shall be graduated in pounds per hour at normal operating temperature and pressure and so marked. The scales shall have black markings on a white background and shall have ranges as close as practical to 1-2/3 times the normal operating flow. Flowmeters shall be configured so that moving parts will not bind or remain in their static location when flow commences. If stops are used, a graduation mark and the appropriate flow rate corresponding to the stop position shall be shown. A means shall be provided to minimize the effect of pump and compressor pulsations on flowmeter readability. This means may be internal or external to the flowmeters.

(i) Pressure gauges shall be installed to indicate the CO_2 pressure at the inlet and discharge of the back pressure regulator, and at the discharge of the MEA pump. The pressure gauges shall conform

to MIL-G-18997, with Bourdon tubes of corrosion-resisting steel. The scale range shall be in accordance with MIL-G-18997 and shall be as close as practical to 1-2/3 times the normal operating procedure. A pressure gauge shall be used to indicate the inlet pressure to the back-pressure regulator, and a compound gauge shall be used to indicate its discharge pressure. Snubbers shall be installed to reduce pressure pulsations in the pressure gauges. Materials in contact with CO_2 shall be of corrosion-resisting steel.

(j) A diffuser to minimize compressor pulsations shall be installed if necessary in the CO_2 compressor discharge line and shall be in accordance with NAVSHIPS Drawing 8S501-818413 except drain plugs shall be furnished. Materials shall be TP 316L.

(k) A sonic tube shall be installed downstream of the pump discharge to perform the function of a limiting orifice and for noise attenuation.

3.19 Flanges. Flanges for the chilled water systems shall be bronze and shall conform to class 150, plain of MIL-F-20042. Flanges for other systems shall conform to ANSI B16.5 with socket weld connections, as applicable, except that the material shall be corrosion-resisting steel.

3.20 Components.

3.20.1 Mounts. Mounts shall conform to NAVSHIPS Drawing 803-1385778. The four main mounts of each skid (see 3.9) shall be type 6E2000. Mounts for double mounting (see 3.20.11) shall be suitable for the intended loading.

3.20.2 Absorber, base, and boiler-stripper. The materials for the absorber, base and boiler-stripper shall be corrosion-resisting steel. Pipe which is an integral part of the absorber or boiler-stripper shall be seamless. The completed absorber, base, and boiler-stripper shall be acid cleaned internally and externally in accordance with the requirements for corrosion-resistant steel pipe as specified in MIL-STD-419. The absorber and boiler-stripper shall be packed column designs. The packing shall be wire mesh made of corrosion-resisting steel. Other packing material or types may be used subject to review by NAVSEA. Packing shall be cleaned to remove dirt and oil prior to filling the absorber. The boiler-stripper shall be installed at an elevation which facilitates complete gravity drain of waste MEA to the absorber.

3.20.2.1 Absorber and base. The absorber and base shall be a welded integral unit constructed so as to aid in attenuating noise and vibration. The top of the base shall consist of a plate and shall prevent parts, tools, and MEA leakage from falling below the plant. A structural angle or similar device shall be welded around the perimeter of the base to form an MEA leakage drainway not more than 2 inches deep by 2 inches wide. The drainway shall be sloped to drain connections provided on the sides of the plant near each of the front corners of the plant. Removable screens shall be installed over each drain to protect the ship's drain system from foreign matter. A portable hose (see 3.18.1(d)) and fresh water shall be used to flush the drainway. Plates or bars shall be welded across the front and rear of the plant and on top of the base to prevent MEA leakage. The absorber shall allow air and MEA to enter near the top to provide concurrent flow. The lower portion of the absorber shall act as an MEA sump.

The bottom of the absorber shall be dished head, or similar construction, to form a curved radius at the lower edge. The bottom of the absorber may extend below the top of the base. A horizontal drain line and valve, facing the front, shall be provided at the lowest extremity of the absorber and shall completely drain the absorber by gravity. A liquid level gauge with shut-off valves shall be provided to indicate the sump MEA level and to facilitate measurement of liquid added to the absorber. The normal operating range shall be approximately 6 gallons from the bottom of the level gauge. This will necessitate a hole in the absorber base allowing the level gauge to penetrate the absorber base. The hole shall be 3-1/2 inches. The level gauge piping shall come from the bottom of the absorber. The level on the gauge shall be marked to read below the normal operating level of 13 to 16 gallons. It shall indicate a level as low as 9 gallons. The liquid gauge shall be furnished with a replaceable clear rigid acrylic tubing, which shall be shockproof, and transparent, shut-off valves, and corrosion-resisting material tube guards and graduated scale (see 3.31.7). The absorber shall be isolated from the air purifier drain located near the bottom of the absorber. A 3/4-inch valve shall be provided on the condensate drain line include tubing, two connectors, 90 degree elbow and brackets and identification plate. The top of the absorber shall be flanged and bolted to the main body of the absorber. Thickness of the dome plates shall be 1/4-inch. The exhaust air duct from the absorber shall be sized so that the effluent air velocity does not exceed 10 feet per second.

3.20.2.2 Boiler-stripper. The boiler-stripper shall be a welded integral unit. The boiler section shall be provided with an automatic liquid level control device and a reflex type gauge (see 3.31.7). The float control valve shall prevent forcible discharge of hot MEA to the surroundings. The level control device shall control the amount of MEA leaving the boiler section. This flow shall be regulated over a flow range that will allow adequate heat transfer in the heat exchanger and MEA cooler (see 3.20.6). A heater (see 3.14.4) shall be installed in the boiler section in a manner to facilitate easy access, removal, and replacement. The boiler section shall also be provided with liquid level detecting devices (see 3.14.5). The top of the boiler-stripper shall be flanged to accommodate a removable top cover for the CO_2 cooler (see 3.20.6). The boiler-stripper shall operate under a normal gauge pressure of 25 lb/in^2, to prevent excessive thermal degradation of the MEA. Gauge pressure to a maximum of 35 lb/in^2 is permissible when operating at CO_2 inlet concentrations of 1 percent or more. The back pressure regulating valve shall be tightly closed when not under gas pressure.

3.20.3 MEA filter. The plant shall include a packed bed of activated carbon, located in a cold MEA stream. Flow through the bed shall be upward and shall be 1.5 to 2 gal/min. Air purification carbon in accordance with MIL-C-17605 shall serve to remove foam-and-color-causing contaminants from the MEA solution. The bed shall contain a volume of not less than 2.0 cubic feet of carbon, and shall be provided with afterfilters, drain and vent valves, and flow controls as necessary to permit convenient and simple replacement of used carbon, and to prevent carbon dust from contaminating the MEA solution.

3.20.4 MEA pump. An MEA pump shall be used to recycle MEA (see 6.5), to pump rich MEA (see 6.5) to the top of the stripper, and to pump waste MEA to the ship's sanitary tank, and shall be in accordance with class C-1 of MIL-P-17639, except as specified herein. Thermometer gauges, and shock tests are not required

specifically for the pump. The pump shall be provided with mechanical shaft seals. Replacement of the seal mating ring shall not require replacement of the impeller. A pressure gauge isolation valve shall be installed between the MEA pump, and a gauge including 1/4-inch valve, connectors, gauge brackets and an identification plate shall be furnished. Motors and controllers shall be as specified in 3.14. Materials in contact with MEA, or with MEA leakage from the pump seals with the exception of nonmetallic materials, shall be corrosion-resisting steel. The pump shall have a discharge gauge pressure compatible with the boiler-stripper and not less than 40 lb/in^2 to facilitate pumping waste MEA to the ship's sanitary tank.

3.20.5 Air blower and CO_2 compressor.

3.20.5.1 General requirements. Both the air blower and CO_2 compressor shall meet the requirements for the conditions imposed in plant service. They shall be reliable, and parts shall be resistant to corrosion and shall be accessible for repair (see 4.6.8).

3.20.5.2 Bearings. Bearings shall be anti-friction type in accordance with either MIL-B-17931 or FF-B-171.

3.20.5.3 Lubrication. The CO_2 compressor shall be furnished with a self-contained lubrication system. Lubricant for the compressor shall be lubricating oil in accordance with MIL-H-17672. Lubrication replenishment devices shall be easily accessible from the front or either side of the plant. The plant shall provide drain facilities as applicable and shall preclude lubricant leakage outside the confines of the CO_2 compressor.

3.20.5.4 Oil indicators. Oil level indicators shall be provided and shall be connected to the oil sump in a manner so as not to be affected by pressure variations between the oil sump and the atmosphere. This type of indicator connection applies whether or not the sump is vented to atmosphere. Oil indicators shall be marked "F-" and "L-" to indicate full and low, respectively. If the indicators are the type that when oil is visible the level is satisfactory, only "F-" to indicate full shall be marked on the indicator.

3.20.5.5 Air blower and CO_2 compressor drive. The air blower shall be direct motor drive and the CO_2 compressor shall be driven by a V-belt. Couplings shall be avoided. Where V-belt drives are used, the number of pulleys shall be kept to a minimum. Pulleys shall be single groove and made of 304 or 316 corrosion-resisting steel. The pulleys shall be aligned to a tolerance of plus or minus 1/32 of an inch. V-belts shall be high strength and shall be rated to transmit power at least 1.25 times the required horsepower for the driven auxiliary. A means to adjust V-belt tension and pulley alignment shall be provided.

3.20.5.6 Air blower. The air blower shall be furnished and shall operate continuously under the conditions specified herein and at the back pressure afforded by the plant and the conditions of 3.5.1. A dial indicator shall be provided to measure the total blower discharge pressure. The rotational speed of the blower impeller shall be not greater than 3600 revolutions per minute (r/min).

3.20.5.7 CO_2 compressor. The CO_2 compressor shall be a three-stage air cooled reciprocating compressor. A compressor interstage pressure gauge shall be installed located at the front of the plant with interstage piping, fittings, brackets, snubber, gaugeboard, 1/4-inch valve, supports, brackets and identification plates. The CO_2 compressor shall operate continuously when used to raise the pressure of CO_2 to gauge pressure which will vary from 25 lb/in^2 to the pressure specified by NAVSEA. The compressor shall also continue to operate with suction pressures and capacities afforded by the plant. Vent valves (3.17) shall be installed in the compressor suction and discharge piping to facilitate starting the compressor in the unloaded condition. Oil filters or screens shall be accessible through a cover or similar means in the crank case.

3.20.6 Coolers and heat exchangers.

3.20.6.1 Pressures. An air cooler, CO_2 cooler, MEA heat exchanger and, if needed, and MEA cooler shall be installed in the plant. The coolers and heat exchangers shall be the indirect type and shall be stress relieved where required. The chilled water side of the coolers shall be constructed for the following:

(a) 150 lb/in^2 operating gauge pressure.
(b) 225 lb/in^2 design gauge pressure.
(c) 338 lb/in^2 test gauge pressure.

3.20.6.2 Air cooler. The air cooler shall be furnished with a means to facilitate drainage of condensate to the absorber. The air cooler shall meet the heat transfer requirements encountered in plant service. The air cooler shall be a fin-tube design. The air side shall use fins and the water side shall use tubes. Water side fins shall not be used. The temperature of the air leaving the cooler shall be not greater than 70°F. Cooler surfaces shall be corrosion-resisting steel.

3.20.6.3 Characteristics. Coolers and heat exchangers shall be constructed of corrosion-resisting steel and shall meet the heat transfer requirements encountered in plant service. The CO_2 cooler shall be furnished with a condensate drain connection. The temperature of the fluid leaving the CO_2 cooler shall be not greater than 70°F. The MEA heat exchanger shall minimize the heat input requirement for the boiler-stripper. These coolers and exchangers may be made of grade TP 304 or grade TP 316 corrosion-resistant steel provided the corrosion-resisting properties are not impaired. Grade TP 304L or 316L shall be used for welded parts.

3.20.7 Separators. Moisture and MEA mechanical separators shall be installed in air and CO_2 lines. Separators shall be constructed of materials suitable for the intended use, shall be furnished with condensate drain connections, and may be combined as integral parts of applicable coolers or purifier, or both. The condensate drain lines shall be equipped with sight gauges or other means to ensure adequate drainage. Moisture removal methods requiring reactivation or replaceable cartridges are not acceptable. If demisters or similar devices are used, retainers and supports to prevent deflection, dislocation, and disconfiguration of the demisters or devices shall

be provided, and the superficial gas velocity through them shall be not greater than 8 feet per second. The CO_2 moisture separator shall contain demisting section at least 4 inches deep and shall hold not less than 1 gallon of carry-over liquid from the CO_2 cooler without flooding the CO_2 compressor.

3.20.8 Purifier. A purifier shall be installed to remove MEA vapor from the effluent air. The purifier shall incorporate a minimum of eight resin filled bags. The resin and resin filled bags shall conform to piece numbers 24 and 25 of NAVSHIPS Drawing 88501-1524708, except that the weight of the nylon cloth shall be 1-1/2 ounces per square yard. A means shall be provided to prevent shifting of the resin in the bag. The resin filled bags shall be arranged within the purifier to a minimum depth of 2-1/2 inches. The linear velocity of process air through the resin bag assembly shall be not greater than 150 feet per minute and shall be in a downward direction. The resin filled bags shall be housed in an enclosure with retainers and supports to prevent deflection, dislocation, and disconfiguration of the resin filled bags. A means with positive holding devices shall be provided to facilitate removal and replacement of the resin filled bags. The purifier shall be constructed of corrosion-resisting steel, and may be combined as an integral part of the air cooler or applicable separator or both.

3.20.9 Guards. Guards shall be provided to prevent accidental contact with moving parts. Guards for V-belt drives shall consist of an expanded metal steel mesh with an enclosing steel band. Access openings or doors, as required for plant operation and examination, shall be furnished on all guards.

3.20.10 Panel board. A panel board may be installed for mounting plates and pressure gauges. The panel board shall not interfere with the operation and maintenance of the CO_2 removal plant (see 3.7). The panel board shall not obscure the observation of items such as gauges, meters, plates, and indicators nor require removal for maintenance of the plant. No threaded components, including valves, shall be located behind the panel board. The panel board shall not be used to support piping (excluding pressure gauges) except by means of bolted pipe hangers. Where piping passes through the panel board, hole dimensions shall be large enough to permit removal of the piping and associated fittings.

3.20.11 Machinery beds and foundations. The MEA pump, air blower, CO_2 compressor, and drivers shall be bolted to machinery beds which shall be mounted to the base frame or a foundation with mounts (see 3.20.1). Machinery beds shall be sufficiently rigid and shall be installed in a horizontal plane and may be made of types 304 or 316 corrosion-resisting steel. Snubbers shall be provided to minimize movement of the machinery beds in a horizontal plant. The snubbers shall not affect the shock and noise attenuating characteristics of the mounts. Each machinery bed shall be electrically grounded. Foundations and supports to support equipment shall be welded or bolted to the absorber, base, or boiler-stripper. Vibration isolated pads may be used in lieu of snubbers and mounts.

3.20.12 Fasteners. Except as specified herein, bolts, nuts, studs, pins, screws, and other fasteners shall be made of corrosion-resisting steel. The bolt requirements specified herein shall also apply to studs and screws. Bolts shall be installed with a locking device to prevent loosening and backing off as a result of vibration and shock (see 3.10 and 3.11). Nicking of threads or welding of nuts is prohibited except as specified herein. Mounting bolts for equipment

in excess of 10 pounds and bolts for flanges shall be fastened with nylon insert type, self-locking nuts. Nuts shall be easily accessible for removal. Where bolts pass through metal in a manner that makes the bolt head inaccessible, tack welding or other means shall be provided to retain the bolt in position when the nut is removed. Such bolts shall be hardened to minimize stripping of threads and their material shall be selected to minimize galling. MIL-S-1222 shall be used as a design guide for bolts. The allowable shear stress for bolts shall be 0.6 times the allowable yield strength of the material. Bolts designed to be stressed in shear shall be installed in holes with a maximum diameter of the nominal bolt diameter plus 1/32 inch maximum for bolts 3/4 inch and smaller, and plus 1/16 inch maximum for bolts larger than 3/4 inch.

3.20.13 Time totalizing meter. The plant shall contain a time totalizing meter in accordance with MIL-M-7793. It may be incorporated in the electrical control panel if sufficient operational and cost effectiveness can be established.

3.20.14 Plant and test kit. The plant and test kit shall conform to the requirements specified herein and shall be manufactured in accordance with the approved drawings. The plant shall include all necessary materials and equipment arranged as a package unit mounted on a common base.

3.20.15 Test kit. The test kit shall conform to NAVSHIPS Drawing 88501-1524716; except that the methyl purple indicator shall be replaced with bromophenol blue indicator conforming to MIL-B-11722, and 0.5 normal nitric acid shall be used in lieu of 0.5 normal sulfuric acid. Test kits shall not be installed in the plant. One test kit shall be furnished with each plant.

3.21 Painting. Surfaces to be painted shall be completely free of rust, mill scale, weld scale, weld flux, oil, grease, deteriorated paint, and other surface contaminants. Metal surfaces requiring paint for corrosion-resistance shall receive pretreatment and paint as soon as practical after cleaning. Pretreatment shall consist of one complete coverage coat of a pretreatment coating conforming to DOD-P-15328. Paint shall consist of two complete coverage coats of light-grey enamel conforming to MIL-E-15090. Insulation shall be painted with two complete coverage coats of fire-retardant paint. Second coats shall not be applied until the preceding coat has become dry and hard. Before the application of any paint coating, all bare spots on the preceding coating shall be touched-up. The preparation, pretreatment, and paint requirements as specified in the component specifications specified herein shall preclude the above similar requirements.

3.22 Reactive materials. Materials shall be corrosion-resistant and suitable for the intended service. Materials that are in contact with each other in a marine environment shall be galvanically compatible. Reactive materials such as magnesium, or brittle materials such as gray cast iron, are unacceptable. MEA solution shall not be permitted to come in contact with copper or copper alloys, carbon steel, natural rubber, or other materials subject to corrosive attack.

3.23 Harmful materials. Materials which produce dangerous gases or other harmful effects under conditions (including fire) encountered in Naval shipboard service shall not be used with the exception of MEA.

3.24 Mercury. During the manufacturing process, tests, or inspections, the material offered shall not have come in direct contact with mercury or any of its compounds nor with any mercury containing devices employing only a single boundary of containment (see 6.3). (A single boundary of containment is one which is not backed by a second seal or barrier to prevent contamination in event of rupture of the primary seal or barrier.)

3.25 Recovered materials. Unless otherwise specified herein, all equipment, material, and articles incorporated in the products covered by this specification shall be new and may be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.26 Routine overhaul. Items requiring routine overhaul, such as pumps, motors, and heat exchangers shall be configured to pass through a 25-inch diameter hatch and a 20-inch wide door.

3.27 Human engineering. The plant shall incorporate the human engineering design requirements of MIL-H-46855 and MIL-STD-1472.

3.28 Safety design review. Safety shall be an integral part of all design reviews held for all equipment, subsystems, and components. The contractor shall conduct system safety program reviews (see 6.3). Where possible, the system safety program reviews shall be conducted as part of the overall program review to assess the status of compliance with the overall safety objectives. This review shall identify any deficiencies of the system with respect to safety and provide guidance for further analysis or design effort which may be required. Qualified contractor system safety personnel shall attend these design reviews. NAVSEA shall be notified prior to each system safety program review, to permit participation by Navy personnel (see 6.3).

3.28.1 Safety analyses. Safety analyses shall be performed to identify hazardous conditions for the purpose of their elimination or control. Analyses shall be made to examine the equipment, subsystems, components and their interrelationship to include logistic support, training, maintenance, and operational environments.

3.29 Reliability and maintainability requirements.

3.29.1 Reliability. The specified mean-time-between-failures (MTBF) of the plant shall be not less than 350 hours (see 6.3 and appendix A). A failure is defined as when either of the following conditions occur:

(a) A condition resulting in an unavoidable, forced shutdown of the plant, that cannot be restored without some degree of disassembly to repair or replace an internal element. This includes any requirement for maintenance during test not specifically identified as scheduled (preventive) maintenance prior to initiation of the test.

(b) When either the plant ceases to function or its performance degrades below the requirements of this specification.

3.29.2 Maintainability. The mean-time-to-repair (MTTR) of the plant shall be not greater than 2.5 hours when determined in accordance with MIL-STD-471 (see 6.3). The time to replace the most inaccessible component shall be not greater than 5 hours.

3.29.3 Maintenance engineering analysis. The contractor shall perform a maintenance engineering analysis in accordance with MIL-M-24365 (see 6.3).

3.30 Performance monitoring. Performance monitoring shall be provided to permit the continuous sensing of performance degradation or approaching failure through the incorporation of sending devices and related displays for the critical performance parameters quantitatively specified herein. The devices shall be centrally located and shall not reduce the effectiveness of the system. The monitoring feature shall provide both a visual and audible indication of equipment or component failure and a visual identification of the specified failed assembly or module.

3.31 Plates. Identification and information plates are required and shall conform to types A, B, and C of MIL-P-15024 and MIL-P-15024/5 except plastic is not acceptable. Serial numbers may be punched and do no require an enamel fill. Etched, engraved and stamped letters, numerals and other characters shall be filled with black enamel, except for warning and caution plates which shall be filled with red enamel. Plates shall be mounted on or near its associated equipment and shall be as specified herein. Plates shall be readable from the front or sides of the plant.

3.31.1 Identification plate. The plant shall have an identification plate located on the front of the plant. The plate shall be not less than 3 by 5 inches and shall contain the following:

(a) Title of equipment.
(b) U.S. Navy serial numbers (to be furnished by NAVSEA) (see 6.6).
(c) Manufacturer's name, model, and serial numbers.
(d) Contract or order number.
(e) Section for Government representative stamp.

3.31.2 Instruction plate. Plants shall contain an instruction plate or paper instruction sheet laminated in plastic. Where multiple sheets are used, they may be installed in book form provided a metal hinge and fastening device are firmly affixed to the plant and all sheets are readily visible. The plate or sheet shall contain the following data:

(a) CO_2 plant flow diagram color coded with valve and special valve identifying numbers, and the descriptive names of other equipment shown on the diagram, and shall be sufficiently complete to illustrate all of the flow processes.
(b) List of valves and special valves with descriptive names and identifying numbers (see appendix C). This information may be included on the flow diagram.
(c) Prestart instructions.

(d) Start-up instructions.
(e) Shut-down instructions.
(f) Cautions and warnings (red enamel filler for plates; red print for paper sheets).

3.31.3 Plates for pressure gauges, MEA pump and motors. Plates for the pressure gauges, MEA pump, and motors shall conform to the applicable equipment specifications.

3.31.4 Plates for control and indicator. Information and identification plates shall be provided to indicate the function of each control and indicator, and shall be as specified in MIL-C-2212. Plates shall be mounted adjacent to the applicable control or indicator and shall show information such as, heater-on, heater-off, no. 2 motor start, no. 2 motor stop, high boiler level, heater fuse, and similar information (see 3.31).

3.31.5 Plate information. Plates for the blower, compressor, coolers, and heat exchanger shall show the following information:

(a) Manufacturer's name.
(b) Manufacturer's identification numbers, such as model number, part number, and size.
(c) Manufacturer's serial number.
(d) Design characteristics, such as capacity, pressures, except where classified, heat transfer characteristics, speeds, calibration data, horsepower, and test pressure.
(e) Contract number.
(f) National stock number when known (consult NAVSEA).

Additional plates for special valves shall contain information conforming to 3.31.6. Additional plates for flowmeters and pressure gauges shall show the normal flow and pressure ranges.

3.31.6 Plates for valves. Plates for valves (including special valves) shall contain the following:

(a) Valve identifying number (see appendix C).
(b) Brief description of function of the valve and valve position, as applicable.

3.31.7 Liquid level scale plate. The liquid level scale plate for the absorber shall be graduated in gallons. The liquid level scale plate for the boiler-stripper shall indicate the alarming level of the liquid level detection devices (see 3.20.2.2) and the level of the highest portion of the heaters and shall be so marked.

3.31.8 Plates for control panel. Plates for the control panel shall be in accordance with 3.14.6 and 3.31.4.

3.31.9 Warning plates. Warning plates shall be installed at critical locations, such as the heater terminal box cover, to warn against danger or hazards. Warning plates shall contain the following information:

"Warning - 440 volts".

3.32 Workmanship.

3.32.1 Cleaning. Parts, especially machine surfaces and passages, tubing and piping for the MEA solution, cooling water, air, CO_2 and lubricating oil shall be kept clean and protected during storage, fabrication, and assembly. Burrs, chips, shavings, refuse, pipe dope, dirt, scale, and water shall be removed.

3.32.2 Alignment. Piping and tubing shall be so aligned that the halves of flanges or unions, when disconnected, shall not move more than 1/4 inch from the centerline and mating surface of the mating half of the mating flange or union.

3.32.3 Deficiencies. The following typical deficiencies are listed for guidance in determining workmanship defects. These and similar workmanship defects shall be avoided during the manufacturing and packaging of the plant.

(a) Miscellaneous damage during shipment. Damage is caused by loose mounting bolts, capillary tubes, and cable and unprotected gauges and meters.
(b) Leaks in vessels, piping, shaft seals, heater element gaskets.
(c) Cracked gauge glass and misaligned level gauge.
(d) Noisy blower.
(e) Regulator malfunction.
(f) Compressor does not rotate.
(g) Chafing of flexible hose, flexible hoses not bonded at compression fitting, flexible hose bends too sharp.
(h) Lock washers or similar locking devices missing, causing loose or missing bolts. Threads not fully engaged (two to three threads should extend beyond nut).
(i) V-belts and sheaves rubbing on components and belt-guard.
(j) Inadequate welding and misaligned piping.
(k) Inadequate valve handwheel clearance.
(l) Carbon steel bolts used.
(m) Float valve binds.
(n) Construction does not permit examination. For example, a nipple may be so small that the weld completely covers the nipple. Government representative has no visual means to certify that the nipple has been installed. If design requires such a joint, the joint will be certified and tagged by the Government representative.
(o) Foreign matter in items such as absorber, boiler, piping, and control panel.
(p) Broken coaxial connectors.
(q) Cable and wire loose or not bundled properly, locking devices missing, cable and wire markers missing, unacceptable code markers used.
(r) Electrical connection diagram missing from controller.
(s) Cable and wire markers missing, E-Z code markers used.
(t) Markers missing from inside control panel, metal markers in the control panel come loose which can cause shorts or operator hazard.

ound shall be calculated using the following equation: determination. The feet per m

(u) Heater insulation resistance meggers low.
(v) Panel door binds.
(w) No protection where cable passes through metal openings.
(x) Damage to heat exchanger tubing and gaskets due to freezing of residual water in the system.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program (see 6.3). The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of the manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.2 Examination. Each plant shall be examined to determine conformance to the requirements of this specification for materials, general design, mechanical design, electrical requirements, electrical design, test kit, reliability and maintainability, and workmanship.

4.3 Fabrication and inspection. Fabrication and inspection of welded joints and inspection and repair of castings shall be in accordance with MIL-STD-278. Silver brazing shall not be performed on corrosion-resisting steel. Fabrication and inspection of silver brazed joints shall be in accordance with NAVSHIPS 0900-LP-001-7000.

4.4 Support and test equipment. The contractor shall establish and document the requirement for support and test equipment at the operational, intermediate, and depot level for repair, overhaul performance monitoring, alignment, calibration, and preventive maintenance.

4.5 Fault isolation. Where failure of the lowest replaceable module or part is not automatically identified by built-in test equipment, portable test equipment shall be provided for fault isolation, along with support equipment for removal or replacement, adjustment, calibration, and alignment, if required. Emphasis shall be placed upon the adaptation and selection of standard items already in Government inventory.

4.6 Tests. Tests shall be conducted in accordance with 4.6.1 through 4.6.12 (see 6.3).

4.6.1 Pressure tests. The pressure test shall be conducted on each plant. If any portion of the plant is tested at a pressure higher than the minimum and fails to meet the requirements specified herein, the plant shall be considered as having failed at the minimum pressure. For purposes of this specification pneumatic tests shall be conducted with air or noncorrosive gas as the pressurizing media. The complete plant shall be pneumatically and hydrostatically tested, except that the compressor test and 5 lb/in^2 tests shall be pneumatic tests only. The CO_2 compressor discharge connection shall be leak-tested externally (with a leak-test fluid) while the compressor is discharging gas (air or CO_2) at their discharge pressure setting. The pressures shall be held for 1 hour after which the plant shall be examined and tested for leaks, deformation, and failure, any of which shall be cause for rejection. The minimum pressure applied to each portion shall be not less than 1.5 times the maximum pressure which a given portion will encounter in service, but shall be not less than 5 lb/in^2. In addition, relief valves shall be tested to relieve at their respective pressure settings.

4.6.2 Electric circuit test. Independent electrical circuits on each plant shall be checked at room temperature to determine the leakage of current from the circuit to ground and from the circuit being tested to other circuits. The test shall be conducted in such a way so as to reveal any defects in materials and workmanship. The circuits shall be tested using a 500 volt dc constant voltage type instrument with a 0 to 100 megohm scale.

4.6.3 Capacity and operation tests-factory acceptance. Each plant shall be tested in accordance with 4.6.3.1 and 4.6.3.2 and shall be operated with 440-volt maximum 3-phase, 60 Hz power with 49°F minimum cooling water for not less than 16 hours. Also, the first CO_2 plant on each contract or order shall be operated for not less than 30 days continually (if not already accomplished on a previously supplied identical unit) to demonstrate the ability to meet the requirements specified herein. The MEA normality shall be not greater than 4.0. The MEA shall not be changed during the entire 30-day test. A synthetic atmosphere consisting of CO_2 and air shall be used for the test process air. Where percentages of CO_2 are specified herein, they shall be by volume, measured directly at the time of sampling by either infrared analysis or gas chromatography, to an accuracy of plus or minus 0.04 percent CO_2. Except as specified herein, the CO_2 compressor discharge pressure shall be two-thirds of the maximum working pressure. Air to be used for all tests shall conform to the conditions of 3.5.1. The differential pressure of the cooling water shall not exceed 10 lb/in^2 during testing (see 6.3).

4.6.3.1 Satisfactory operation. The liquid level in the boiler-stripper and the separator shall be raised and lowered to demonstrate satisfactory operation of the liquid level detection and alarm system including the indicating lights and automatic plant shutdown and by-pass at low level. The plant shall be operated to demonstrate satisfactory operation of indicating lights, temperature and pressure indicators, and switches. The compressor shall be subjected to discharge pressures of 0 to maximum in 18 to 22 minutes not less than three times.

4.6.3.2 Operation tests. Each plant shall be tested for two separate, 6-consecutive-hour tests at 0.5 and 1.0 percent CO_2 inlet concentrations respectively. The tests shall not begin until equilibrium flow conditions for 0.5 and 1.0 percent CO_2 as applicable, have been established. The plants shall be operated at optimum stripper feed rates. During each of these tests the CO_2 compressor discharge gauge pressure may be maintained at 100 lb/in^2 for not more than 4 hours to facilitate noise testing. After establishment of steady flow conditions the following items shall be measured at the frequency indicated for each 6-hour test:

Item	Frequency
Date and time of measurement	As applicable
Input power for each motor (kW)	Every 4 hours
Input power for heater (kW)	Every 4 hours
Speed of each rotating component	Every 4 hours
Ambient temperature (°F)	Hourly
Relative humidity (percent)	Hourly
Barometric pressure (Hg)	Hourly
Temperatures, pressures and flows from all gauges and indicators installed in the plant	Hourly
Gauge pressure of CO_2 from compressor unless classified (lb/in^2)	Hourly
Cooling water flow (gal/min)	Hourly
Plant inlet and discharge cooling water temperature (°F) and gauge pressure (lb/in^2)	Hourly
Absorber liquid level (gallons) - This level shall also be measured before start-up and 5 minutes after pump shut-down	Hourly
MEA normality	Every 4 hours
Stripper feed rate (gal/min)	Hourly
Air rate (cubic feet per minute (ft^3/min)), actual	Hourly
Corrected air rate (at 70°F - standard ft^3/min - calculated)	Hourly
Percent CO_2 in entering and processed air	Hourly
Cumulative pounds of CO_2	At time zero and hourly
Amount of water and MEA make-up (gallons)	As applicable

The amount of CO_2 leaving the compressor shall be measured with a totalizing positive displacement type meter with corrections for moisture, temperature, and pressure. The capacity of each CO_2 plant shall be determined in pounds of CO_2 (dry basis) per hour by dividing the cumulative 6-hour total of CO_2 discharged from the compressor by six. This capacity shall be recorded.

4.6.3.3 Continuous operation. Following the tests of 4.6.3.1 and 4.6.3.2 the first plant of a new contractor's contract or order for this equipment shall be operated continuously for a total of 30 days. The inlet CO_2 concentration

shall be maintained at 0.5 percent for the first 15 days, at 1.0 percent for the next 10 days, and at 1.5 percent for the remaining 5 days. Interruptions not exceeding a total of 5 hours shall be allowed during the 30-day period. If more than two interruptions occur or if any single interruption exceeds 5 hours, the test run shall start over from the beginning. Repeated failure of the same component, or similar components performing the same function, shall be cause to discontinue the test to correct the deficiency. If the test is discontinued, action shall be taken to determine the cause of failure and to correct the deficiency. Verification of the corrective action shall be accomplished by a continuation of test, wherein the test item shall accumulate at least 360 hours of test without recurrence of the failure. Any design changes resulting from the test shall be approved by NAVSEA. Conformance with 3.5 and 3.4 and the proper operation of all safety devices shall be demonstrated during the test period. Shut-downs due to power failure or to planned maintenance, such as charging of lubricant and testing of controls, shall not be considered interruptions. (Planned maintenance is defined as any organizational maintenance procedure described in the technical manual and prepared on maintenance requirements cards (MRC) (OPNAV 3700/1).) If the plant is shutdown for replacement of a failed or malfunctioning component, the period of interruption shall be considered to start with those operations necessary to the removal of that component. A shut-down due to the failure of one component shall be utilized to repair a second component which is in danger of failing. Items to be measured include, in addition to the items in 4.6.3.2, the pressure drops through each equipment in the air system, and each cooler and heat exchanger, at hourly intervals, and ammonia and monoethanolamine in effluent air before and after the air purifier every 8 hours.

4.6.4 Center of gravity. The dry center of gravity and weight of each skid of the first plant on each contract or order shall be measured.

4.6.5 Noise tests. Noise tests shall be conducted for each plant to determine conformance to the requirements specified in 3.10. Instrumentation and methods for noise measurement shall conform to MIL-STD-740-1 and MIL-STD-740-2 except as specified herein. A structural steel test stand may be used for noise tests provided the plant noise levels are less than the limits specified without corrections for the test stand. Structureborne noise measurements shall be taken above and below the resilient mounts of the equipment (see 6.3).

4.6.5.1 Testing. Testing shall be accomplished with the plant suspended from the main mounts jointly and operating under normal rated conditions and after the plant has been in operation for at least 1 hour. The compressor discharge gauge pressure shall be 100 lb/in^2 during the tests.

4.6.6 Vibration tests. A vibration test shall be performed on the plant to determine conformance to the requirements specified in 3.10 if not previously performed by the contractor. The testing shall be accomplished with the plant attached without mounts and operating under normal rated conditions. The compressor discharge gauge pressure shall be 100 lb/in^2 during the tests. The plant shall demonstrate continuous proper functioning during and subsequent to the specified tests (see 6.3).

4.6.7 Shock test. One plant shall be shock tested to determine conformance to the requirements specified in 3.11, if not previously performed by the contractor. The contractor shall be responsible for the modification of each plant under the contract or order for any deficiencies noted as a result of this test. The inclined shock tests shall be conducted on equipment inclined 30 degrees from the vertical in both the front-to-back and side-to-side directions. A minimum of nine blows is required. The equipment shall be tested while operating, using water in lieu of MEA and pressurizing the boiler with compressed air. The compressor discharge gauge pressure shall be 100 lb/in^2 during the test (see 6.3).

4.6.7.1 Failing to pass. Equipment shall be considered to have failed to pass the shock test in the event of any of the following:

(a) Breakage of parts, including mounting bolts.
(b) Appreciable distortion or dislocation of any part.
(c) Significant effect on performance (more than 10 percent reduction in CO_2 capacity).
(d) Leakage of pressurized gas or liquid.

4.6.7.2 Successfully pass. Equipment which has successfully passed the high-impact shock test shall be reconditioned by the contractor as follows:

(a) Bearings shall be replaced.
(b) Minor deformations shall be corrected.
(c) Each part shall be carefully examined, and all substandard parts replaced.
(d) The plant shall be cleaned and tested in accordance with the requirements specified herein.

4.6.8 Life test. The compressor and blower shall each be given a 500-hour life test. The compressor and blower shall be operated intermittently or continuously for a total of 500 hours. At the conclusion of this time, the compressor and blower shall be dismantled and visually examined for wear and appearance. Breakage, distortion, or detectable wear shall be cause for rejection. Tests shall be conducted under the conditions which will be encountered in plant application. NAVSEA may consider waiver of life tests if identical blowers or compressors or both have been previously tested.

4.6.9 Safety testing. Safety testing shall be as approved by the contracting activity.

4.6.10 Reliability demonstration test. The equipment shall be subjected to a 910 hour endurance test (see 6.3) with no failure, if not previously performed by the contractor. The following test provisions shall apply:

(a) Definition of failure: The test failure shall not be considered to have occurred if the event is the result of a cause such as variation of input voltage beyond specified limits, input power interruption, operator error, ambient temperature over specified limit, or other extraneous causes, determination of which shall be subject to acceptance by the contracting activity.

4.6.11 Maintainability demonstration test. The contractor shall conduct a maintainability demonstration test (see 6.3) to verify the requirements specified in 3.29.2, if not previously performed by the contractor.

4.6.11.1 Maintenance task selection. Proposed maintenance tasks shall be selected by the contractor in accordance with the procedure outlined in appendix A of MIL-STD-471. Actual task selection will be made by the contracting activity at the time of test.

4.6.12 Failure of reliability and maintainability tests. In the event of inability to reach an "accept" decision, the contractor shall perform an analysis to determine the cause, perform corrective action, and propose appropriate modifications to the design. Verification of success of any modifications made shall be accomplished by a period of retest to be determined by the contracting activity.

4.7 Rejection. Breakage, deformation, or failure to meet the requirements of this specification when examined and tested in accordance with 4.2 and 4.6 shall be cause for rejection.

4.7.1 Mercury contamination. Mercury contamination or reasonable cause to suspect material of being contaminated by mercury, will be cause for rejection (see 3.24).

4.8 Inspection of packaging. Sample packs, and the inspection of the preservation, packing, and marking for shipment, stowage, and storage shall be in accordance with the requirements of section 5 and the documents specified within.

5. PACKAGING

(The packaging requirements specified herein apply only for a direct Government acquisition. For the extent of applicability of the packaging requirements of referenced documents listed in section 2, see 6.8.)

5.1 General.

(a) Navy shipboard stowage fire-retardant requirements.

(1) Treated lumber and plywood. Unless otherwise specified (see 6.2), all lumber and plywood including laminated veneer material used in shipping containers and pallet construction, members, blocking, bracing, and reinforcing shall be fire-retardant treated material conforming to MIL-L-19140 as follows:

Levels A and B - Type II - Weather resistant.
Category 1 - general use.
Level C - Type I - non-weather resistant.
Category 1 - general use.

(2) Fiberboard. Unless otherwise specified (see 6.2), fiberboard used in the construction of class-domestic, non-weather resistant fiberboard, cleated fiberboard boxes including interior packaging forms shall meet the flame spread index and the specific optic density requirements of PPP-F-320 and amendments thereto.

5.2 Preservation, packing, and marking. Carbon dioxide removal plants and accessories, shall be preserved level A, C, or commercial, packed level A, B, C, or commercial and marked in accordance with MIL-E-17555, as specified (see 6.2) and as follows (see 6.3):

(a) CO_2 removal plants shall be preserved by method IIA.
(b) Painted surfaces on which the paint is damaged or defective shall be cleaned and repainted with the original specified paint of the same quality and color.
(c) Rotating joints, bearings, and similar moving parts shall be thoroughly lubricated with the lubricant specified in the equipment specification. Excess lubricants shall be removed prior to packaging operations.
(d) Drive belts shall be removed or released from tension. When level A preservation is specified, pulley faces, grooves, and sheave grooves shall be coated with a light coat of clear, air drying insulating compound conforming to MIL-I-24092 or MIL-V-13811. When drive belts are not removed for shipment, strips of grease-proof barrier material conforming to grade A of MIL-B-121 shall be placed between belts and pulleys after the insulation compound has dried. The pulleys and belts shall not be rotated thereafter. When drive belts are removed for shipment, they shall be wrapped either individually or in sets and packaged in unit containers as specified in MIL-E-17555.
(e) Each test kit and its carrying case shall be preserved method III in accordance with MIL-P-116 and shall be secured within the main container.
(f) Desiccant shall not be placed in any interior spaces of the plant. Desiccant shall be distributed within the barrier and shall be secured by taping or tying or otherwise secured to prevent movement, rupture of the desiccant bags, or damage to the barrier. Openings into the plant shall not be capped, sealed, or plugged to ensure effective action of the desiccant.
(g) The plant shall be packed and shipped (with the four main mounts installed) in a structural steel shipping frame which may also be used for testing in the shipyard. Plants shall be mounted on the shipping frame to prevent damage which would affect the performance or noise characteristics of the plants. Securing hardware in mounts, suspension brackets, and similar items of the shipping frame shall be secured by means of positive locking devices such as double nuts or nicked threads to prevent loosening during shipment. Tack welding and other means are not permitted. Shipping frames may be used for shipyard testing and storage. Frames are the contractor's property. The contractor shall advise the contracting activity whether the shipping frames shall be scrapped or returned.

(h) Method of mounting of the unit within the shipping container shall ensure the integrity for the requirements of MIL-STD-740-1 and MIL-STD-740-2. Where shipboard mounts are used, the barrier shall be placed between the shipping frame and the mounts.

5.2.1 Special marking. Each container shall have a placard attached conspicuously and secured to the exterior shipping container in addition to a placard attached to the unit as soon as the tests have been completed. The placards shall remain on the plant and shipping containers after delivery. The placards shall read as follows:

"This unit has been completely noise tested and components have been precision balanced. Handle with extreme care to prevent mechanical shock and exposure to atmospheric conditions."

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The mark IV carbon dioxide (CO_2) removal plant is intended for removal of CO_2 from the atmosphere of the TRIDENT submarine. The CO_2 removed is discharged against variable submergence pressures.

6.2 Acquisition requirements. Acquisition documents must specify the following:

(a) Title, number, and date of this specification.
(b) Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1.1 and 2.2).
(c) Quantity of CO_2 plants required.
(d) Location of service connections, if other than as specified (see 3.15.1).
(e) Fire-retardant material requirements (see 5.1).
(f) Preservation, packing, and marking requirements (see 5.2).

6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DIDs) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/ provided and that the DIDs are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DoD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Paragraph	DID Number	DID Title	Suggested Tailoring
3.7 and appendix C	DI-DRPR-80651	Engineering drawings	---
3.7.2 and appendix B	DI-MISC-80678	Certification data/report	---
3.24	DI-E-2121	Certificate of compliance	---
3.28	DI-A-7088	Conference agenda	---
3.28	DI-A-7089	Conference minutes	---
3.28	DI-SAFT-80100	System safety program plan	---
3.28	DI-SAFT-80101	System safety hazard analysis	---
3.29.1, 3.29.2 and appendix A	DI-MISC-80652	Technical information reports	---
4.1.1	DI-R-4803	Inspection system program plan	---
4.6	DI-T-23732	Procedures, test	---
4.6	DI-T-2072	Reports, test	---
4.6.3	DI-T-23937	Procedures, acceptance test	---
4.6.5	DI-HFAC-80272	Equipment airborne sound measurements test report	---
4.6.5	DI-HFAC-80274	Equipment structureborne vibration acceleration measurements test report	---
4.6.6	UDI-T-23762	Report, vibration testing	---
4.6.7	UDI-T-23753	Reports, equipment shock test	---
4.6.10	DI-RELI-80250	Reliability test plan	---
4.6.10	UDI-T-23742	Report, failure/malfunction	---
4.6.11	DI-R-7112	Maintainability demonstration test plan	---
4.6.11	DI-R-7113	Report, maintainability demonstration	---
5.2	DI-PACK-80120	Preservation and packing data	---
5.2	DI-PACK-80121	Special packaging instructions	---

The above DIDs were those cleared as of the date of this specification. The current issue of DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DIDs are cited on the DD Form 1423.

6.4 Technical manuals. The requirement for technical manuals should be considered when this specification is applied on a contract. If technical manuals are required, military specifications and standards that have been cleared and listed in DoD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL) must be listed on a separate Contract Data Requirements List (DD Form 1423), which is included as an exhibit to the contract. The technical manuals must be acquired under separate contract line item in the contract.

6.5 Definitions. The following definitions apply to terms used in this specification:

(a) MEA: Water solution of monoethanolamine, chelated, in accordance with MIL-M-23573.
(b) Rich MEA: MEA from absorber sump.
(c) Lean MEA: MEA leaving stripper.
(d) Recycled MEA: MEA pumped from the absorber sump to the absorber top without a change in CO_2 concentration.

6.6 U.S. Navy serial numbers. The U.S. serial numbers will be furnished to the contractor by NAVSEA, upon request.

6.7 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified in the contract.

6.7.1 When ordering spare parts or repair parts for the equipment covered by this specification, the contract should state that such spare parts and repair parts should meet the same requirements and quality assurance provisions as the parts used in the manufacture of the equipment. Packaging for such parts should also be specified.

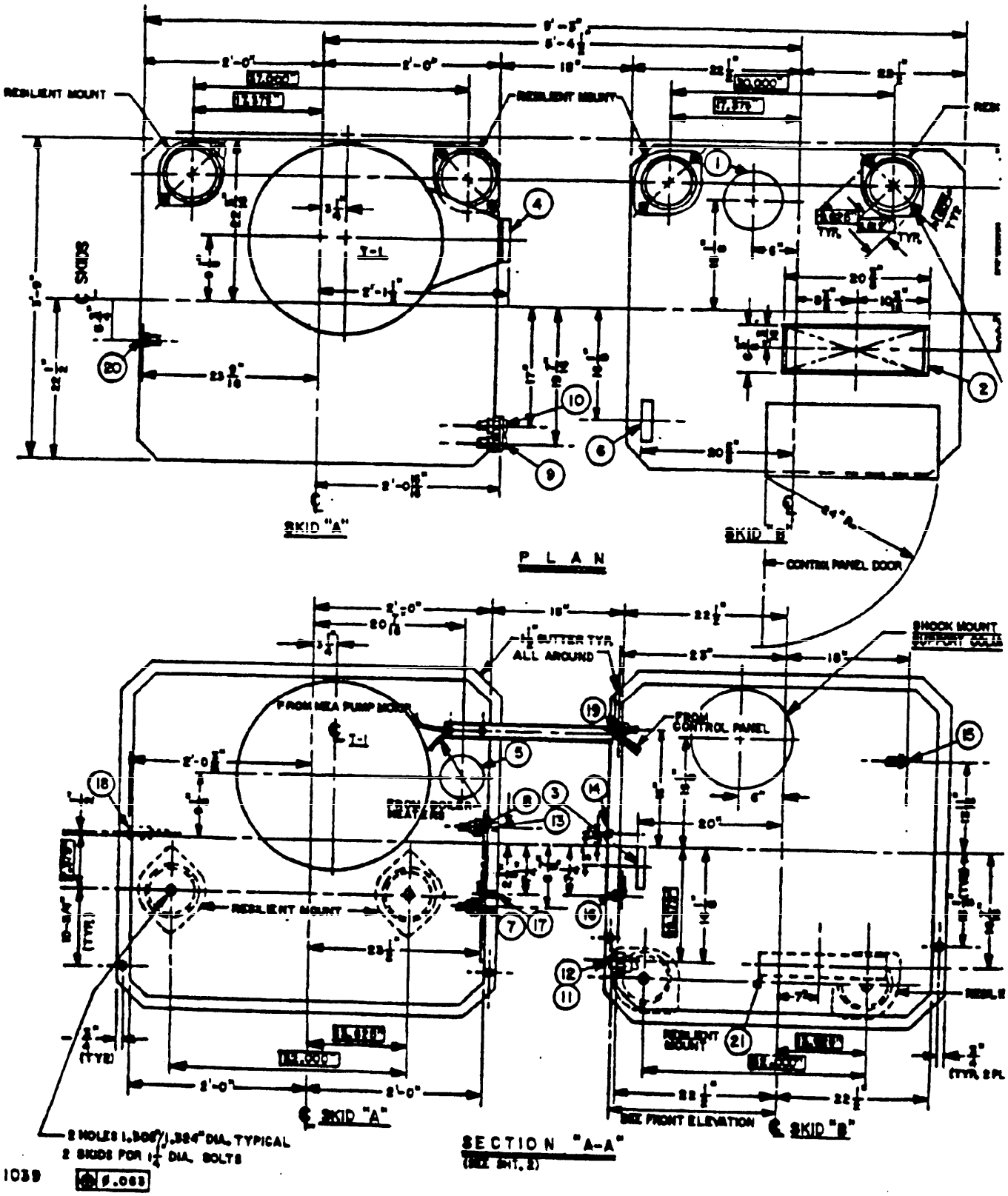
6.8 Sub-contracted material and parts. The packaging requirements of referenced documents listed in section 2 do not apply when material and parts are acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

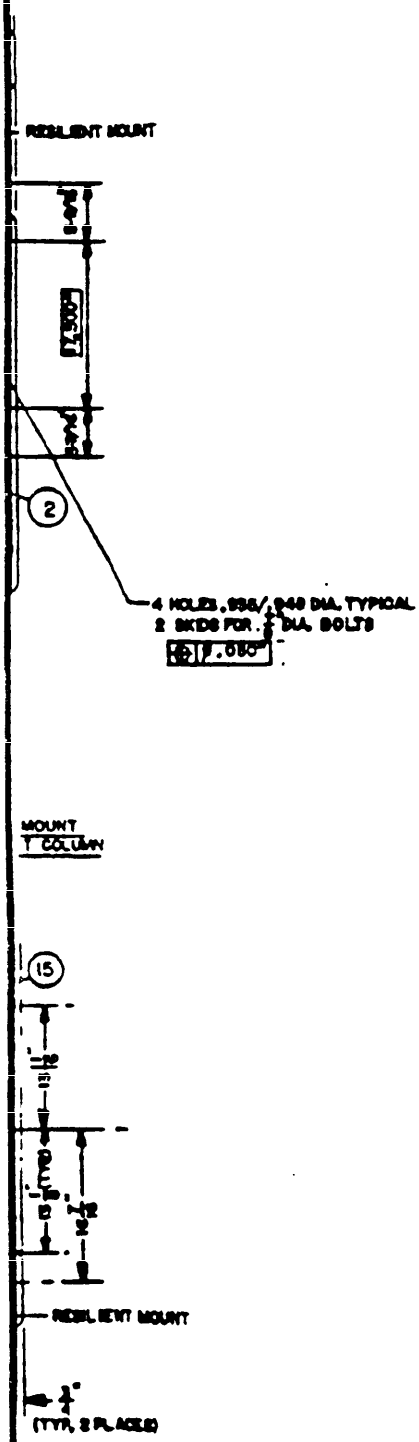
6.9 Subject term (key word) listing.

Air purification
Boiler-stripper
Chelated monoethanolamine (MEA)
Continuous absorption
Continuous desorption

6.10 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 4460-N024)

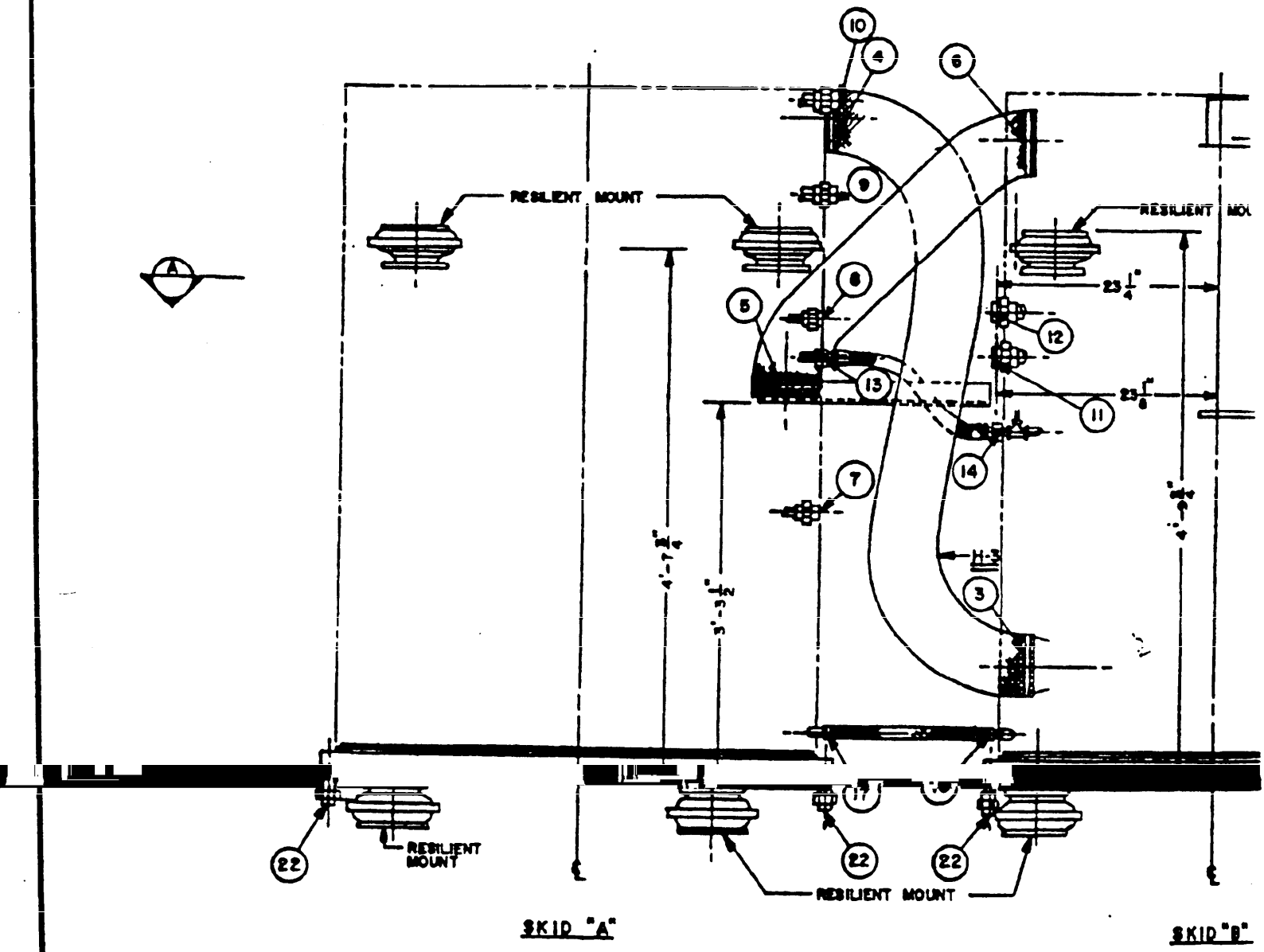




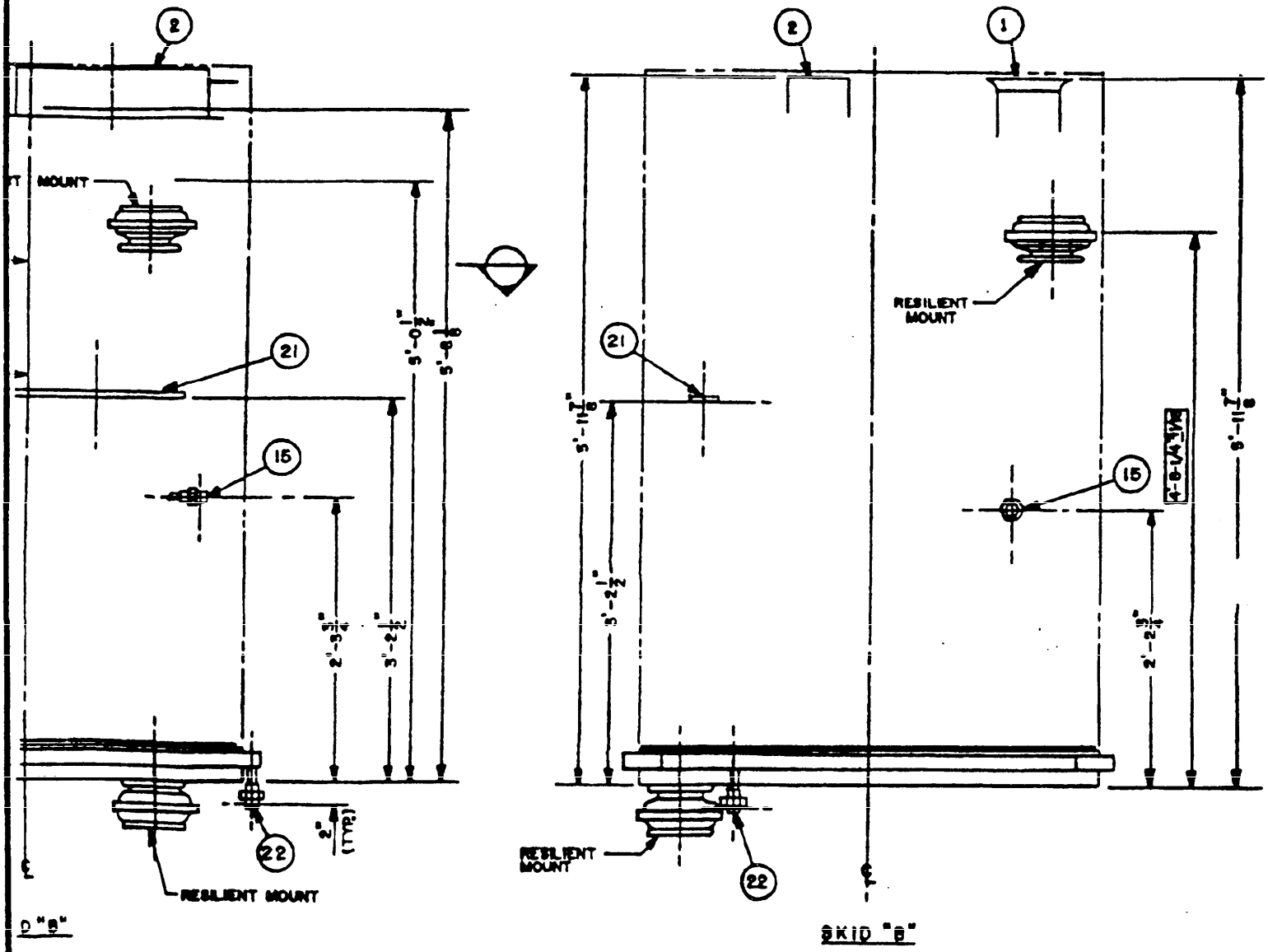
LEGEND

MARK	SERVICE	DESCRIPTION
1	AIR INLET	6" O.D.
2	AIR DISCHARGE	6" X 90° OUTSIDE DIMENSIONS
3	AIR FROM BLOWER TO ABSORBER	6" O.D.
4	ABSORBER AIR INLET FROM BLOWER	6" O.D.
5	ABSORBER AIR OUTLET TO AIR PURIFIER	6" O.D.
6	AIR INLET TO AIR PURIFIER	6" O.D.
7	MEA FILL	SOCKET WELD UNION FOR 1" IPS 304L S.S.
8	FRESH WATER SUPPLY	SOCKET BRAZE UNION FOR 1/2" IPS BRONZE
9	CHILLED WATER SUPPLY TO COOLER	SOCKET BRAZE UNION FOR 1" IPS BRONZE
10	CHILLED WATER RETURN FROM CO2 COOLER	SOCKET BRAZE UNION FOR 1" IPS BRONZE
11	CHILLED WATER SUPPLY TO AIR COOLER	SOCKET BRAZE UNION FOR 1" IPS BRONZE
12	CHILLED WATER RETURN FROM AIR COOLER	SOCKET BRAZE UNION FOR 1" IPS BRONZE
13	CO_2 FROM SKID "A" TO SKID "B"	3/4" ODT, TP 304L S.S. PLAIN END
14	CO_2 TO COMPRESSOR FROM SKID "A"	3/4" ODT, TP 304L S.S. PLAIN END
15	CO_2 DISCHARGE	SOCKET WELD UNION FOR 1/4" IPS 316L S.S.
16	MEA DRAIN FROM AIR PURIFIER TO ABSORBER	3/4" ODT, TP 304L S.S. PLAIN END
17	MEA DRAIN TO ABSORBER FROM	3/4" ODT, TP 304L S.S. PLAIN END
18	ABSORBER SUMP DRAIN	FOR 3/4" 150-1814G, TP 304 S.S.
19	MEA WASTE DISCHARGE FROM AIR PURIFIER	SOCKET WELD UNION FOR 3/4" ODT, TP 304L S.S.
20	MEA WASTE FROM SKID "A"	SOCKET WELD UNION FOR 1/2" ODT, TP 304L S.S.
21	ELECTRICAL CONTROL PANEL CABLE ENTRANCE	18.5" X 2.19" CUT OUT
22	MEA DRAINWAY DRAIN	SOCKET WELD UNION FOR 1/2" IPS, TP 304L S.S.

FIGURE 1. Weight, overall dimensions, mount location and service connection location (sheet 1).



FRONT ELEVATION

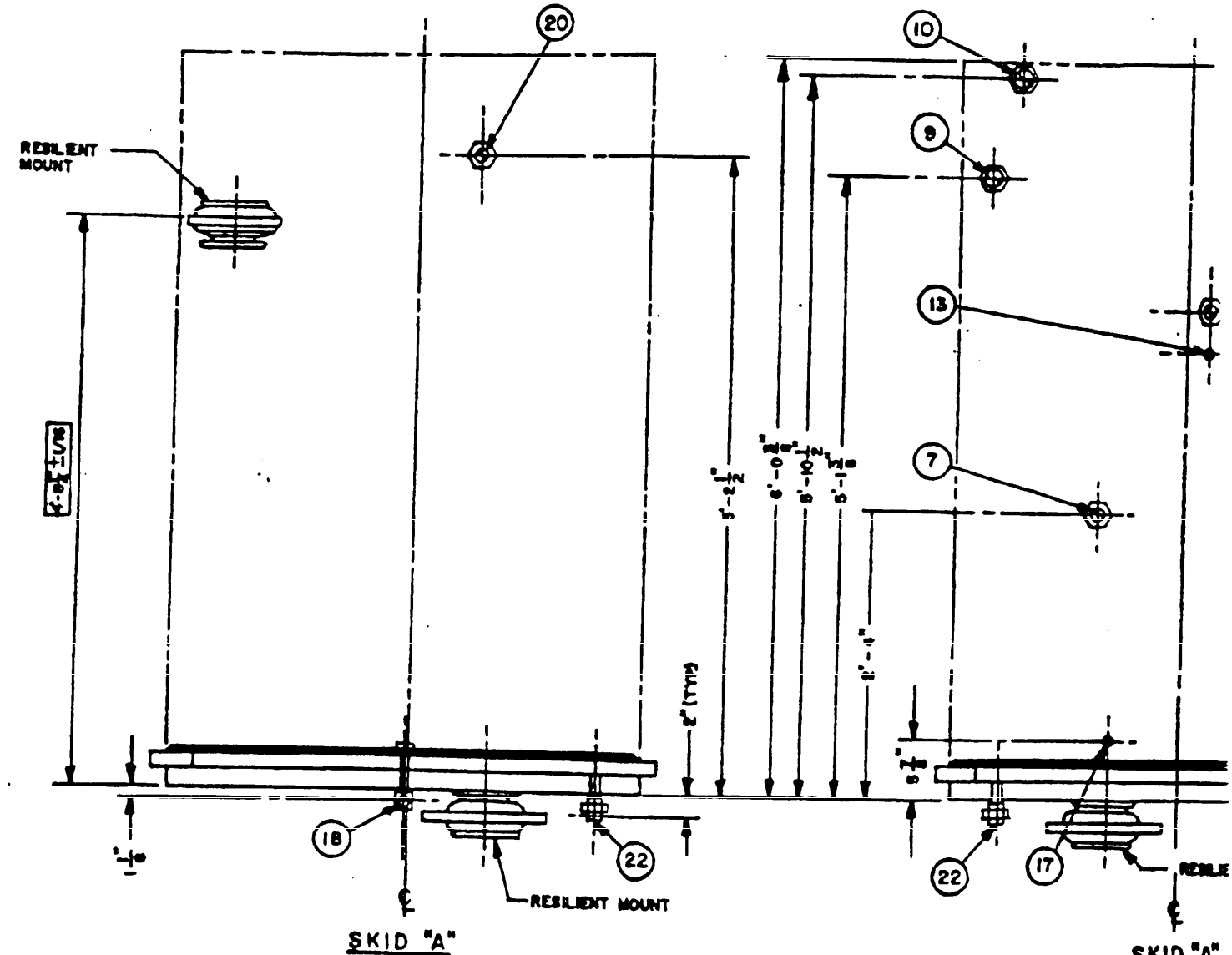


SKID "B"

SKID "B"

RIGHT SIDE ELEVATION

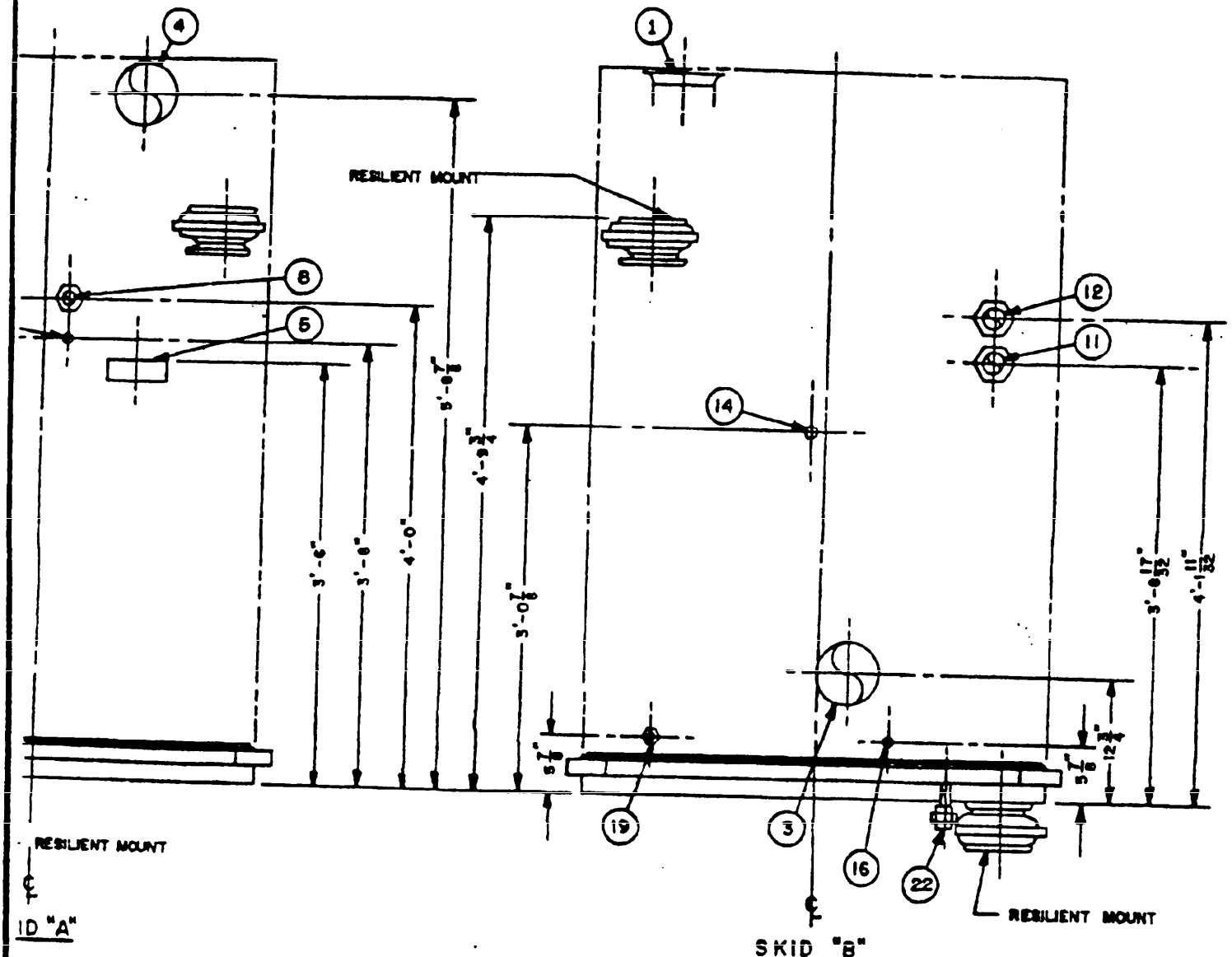
FIGURE 1. Weight, overall dimensions, mount location and service connection location (sheet 2). - Continued



SH 11039

LEFT SIDE ELEVATION

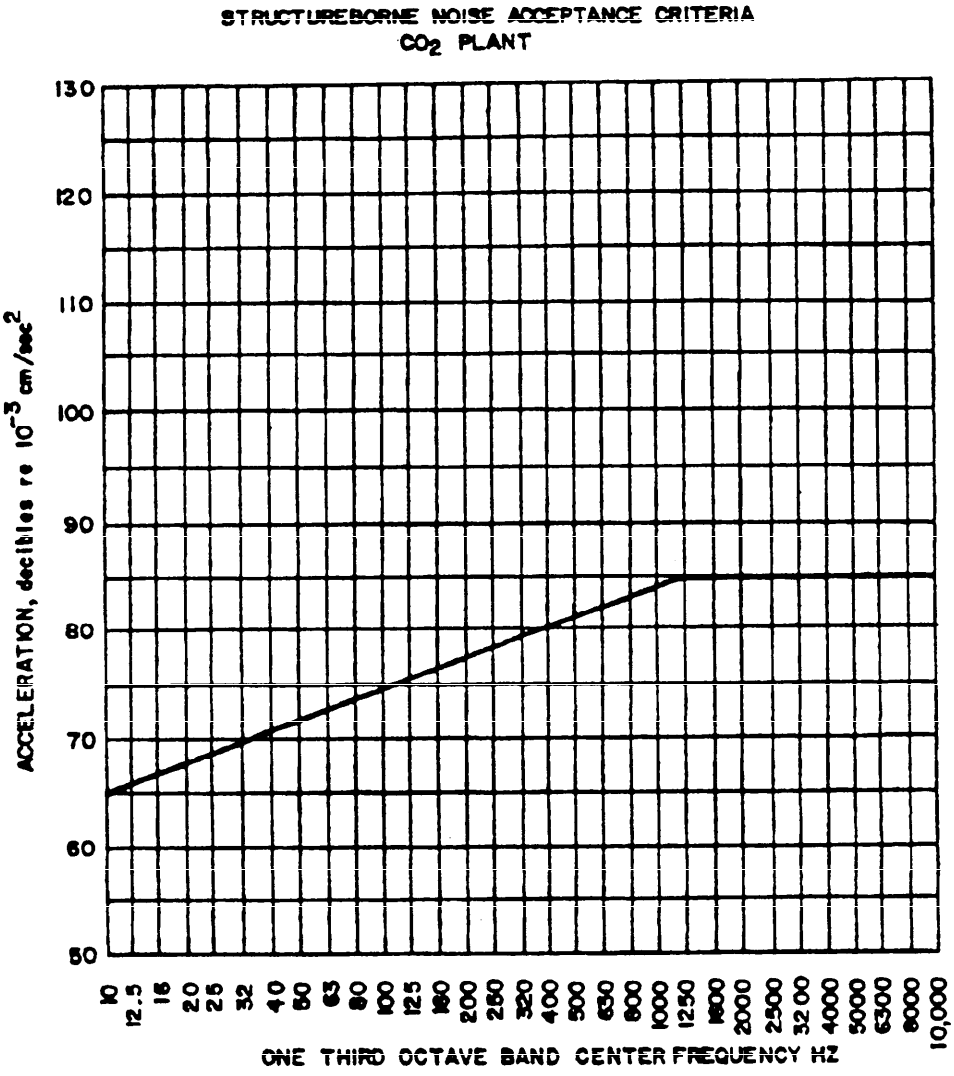
RIGHT SIDE



SIDE ELEVATION

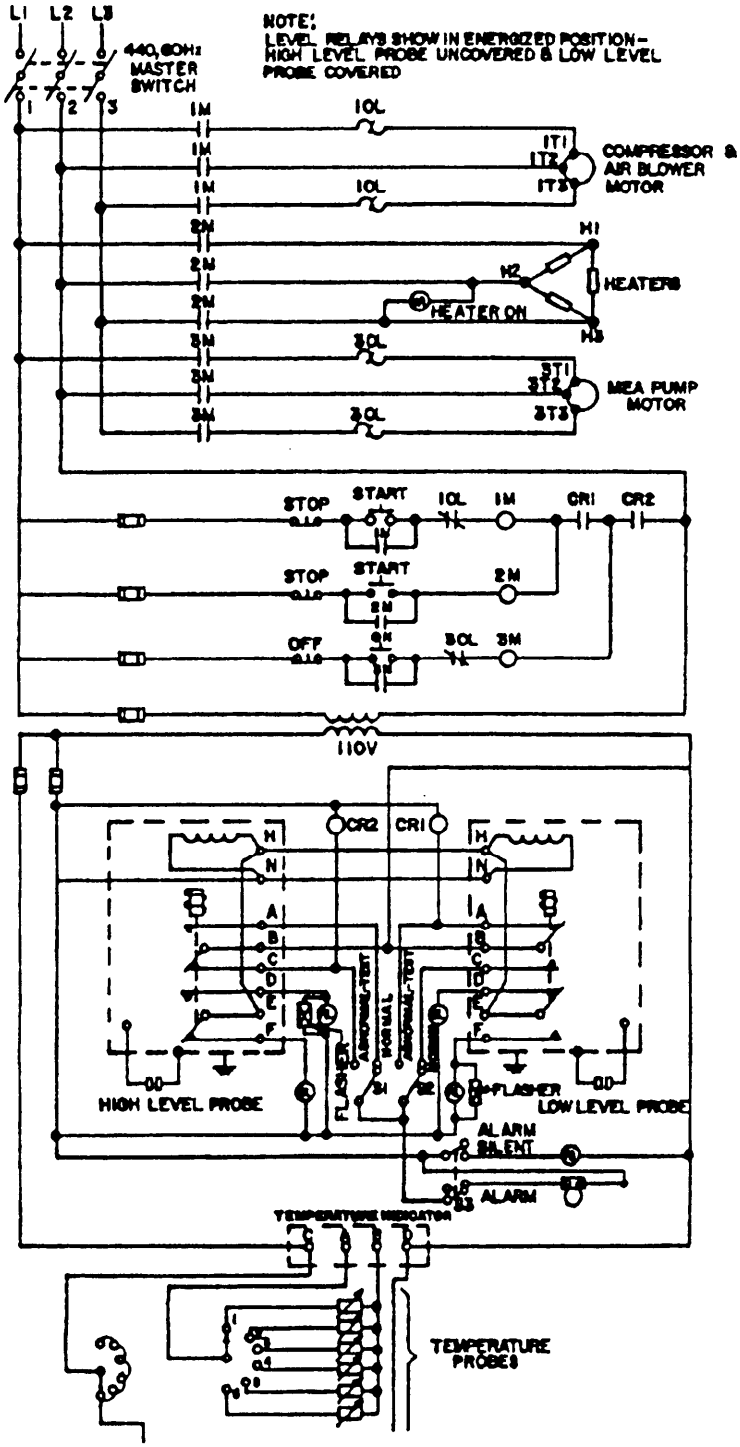
LEFT SIDE ELEVATION

FIGURE 1. Weight, overall dimensions, mount location and service connection location (sheet 3). - Continued



SH 11040

FIGURE 2. Structureborne noise acceptance criteria.



SH 11042

FIGURE 3. Elementary wiring diagram.

APPENDIX A

TECHNICAL INFORMATION REPORT TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers information that should be included in the report when specified in the contract or order. This appendix is mandatory only when data item description DI-MISC-80652 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

20.1 Government documents.

20.1.1 Standards. The following standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

STANDARDS

MILITARY

MIL-STD-470 - Maintainability Program Requirements (For Systems and Equipments).
MIL-STD-785 - Reliability Program for Systems and Equipment Development and Production.
MIL-STD-1629 - Procedures for Performing a Failure Mode, Effects and Criticality Analysis.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

30. SUGGESTED REPORT CONTENTS

30.1 Report content. When required by the contract or order, reports shall contain the following information.

30.1.1 Failure mode and effects analysis. The analysis shall be conducted in accordance with MIL-STD-1629 to the functional subassembly level, except for those failure modes with a level of severity of 4. For these failure modes, the analysis shall be extended to the individually replaceable item level. The FMEA shall identify the design provisions that have been incorporated to inhibit or limit the frequency of occurrence of failure modes with a level of severity of 3 or 4.

30.1.2 Reliability program plan. The reliability program plan shall conform to MIL-STD-785 and shall provide for the formal application of the reliability design requirements therein as specified herein. The program shall include:

(a) Reliability management procedures:

(1) Reliability organization.
(2) Management and control.
(3) Subcontractor and contractor reliability program.
(4) Program review.
(5) Status reports.

(b) Reliability design procedures:

(1) Design techniques.
(2) Reliability analysis.
(3) Parts reliability.
(4) Failure mode and effects analysis.
(5) Reliability critical items.
(6) Effects of storage, shelf-life, transportation, handling and maintenance.
(7) Design reviews.

30.1.3 Maintainability program plan. The maintainability program plan shall conform to MIL-STD-470 and shall provide for the formal application of the maintainability requirements therein as specified herein. The program plan shall include the following elements of the detailed requirements of MIL-STD-470.

(a) Perform maintainability analysis.
(b) Prepare inputs to the detailed maintenance plan.
(c) Perform design trade-offs.
(d) Predict maintainability values.
(e) Incorporate and enforce maintainability requirements.
(f) Integrate other items.
(g) Participate in design reviews.
(h) Establish data collection, analysis, and corrective action system.
(i) Perform maintainability demonstration.
(j) Prepare maintainability status reports.

APPENDIX B

CERTIFICATION DATA/REPORT TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers technical content requirements that should be included in the shipboard installation data which will serve as the certification date for the complete plant. This appendix is mandatory only when data item description DI-MISC-80678 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. CERTIFICATION CONTENTS

30.1 Certification data. Certification data shall be shown in columnar or tabular form. Certification data shall include the information necessary to specifically verify or supplement drawings. Typical information required for certification data is the actual manufacturer's serial numbers, speed, design rating, conditions, design capacity, horsepower, type of drive, design fluid quantities, heat rejection capacity, power requirements, and design, operating, and test pressures.

30.2 Shipboard installation data. The shipboard installation data shall serve as the certification data for the complete plant and shall show all information needed for installation by the installing activity. Data shall include the following:

(a) Plant serial numbers (U.S. and contractor's).
(b) Ship hull numbers.
(c) Contract or order number.
(d) Simplified outline of the plant.
(e) Overall dimensions.
(f) The loaded and unloaded vertical dimensions of the four main mounts relative to their respective mounting supports and the base.
(g) The location (three directions each) of the four main mounts relative to the centerline of the plant.
(h) The type of main mounts.
(i) The location (three directions) of the center of gravity and the radii of gyration about the three principal axes.
(j) The wet and dry weights.
(k) The location (three directions each), size, type, materials, and orientation of the electric, CO_2 discharge, MEA supply, MEA waste drain, drainway drains, MEA drain from absorber, fresh water supply, chilled water supply and return, air inlet and air discharge service connections. Service connections shall be located relative to the centerline of the plant and where applicable to the depth of sockets.
(l) A skeleton outline of the maintenance space requirements.

(m) The arc through which the control panel door swings.
(n) Latent and sensible heat dissipation.
(o) MEA pump performance curve (gal/min versus discharge pressure at speed used on plant).
(p) Power requirements which include volts, number of phases, frequency, normal amperage, inrush amperage and power factor.
(q) Direction of rotation of motors.
(r) Types of lubricant required for specific equipment.
(s) Special handling procedures, as required.
(t) Other necessary installation instructions and precautions.

APPENDIX C

ENGINEERING DRAWING TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers the technical content requirements that should be included in the lists and drawings when specified in the contract or order. This appendix is mandatory only when data item description DI-DRPR-80651 is cited on the DD Form 1423.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. SUGGESTED CONTENTS

30.1 List content.

30.1.1 Mechanical and electrical equipment lists. Mechanical and electrical equipment lists shall be separate lists and shall be in a columnar form. Lists shall include all equipment except piping, insulation, individual foundations, and individual plates. Together these lists shall also serve as a complete list of the drawings specified in 30.2.1. Lists shall show an identifying number, descriptive name, quantity required per plant, actual manufacturer's name, and part number and drawing number with revision symbol, weight if in excess of 10 pounds, remarks, and shall reference certification data where applicable. Where the contractor is the actual manufacturer, a dash shall be placed in the actual manufacturer column.

30.1.2 Piping and insulation material list. The piping and insulation material list shall be in a columnar or tabular form. The list shall include all piping and insulation except gaskets. The portion pertaining to piping shall show the identifying number, descriptive name, service, size, quantity per plant, type of connection, schedule or pressure rating, material, specification or standard (military or commercial such as ASTM or ANSI), actual manufacturer, actual manufacturer's part and drawing number with revision symbol, the weight of components over 5 pounds, and remarks. Information pertaining to the actual manufacturer need not be shown for pipe, tube, flanges, fittings, unions, tailpieces, and pipe hangers. The list shall not show quantities of fittings when submitted for review. Insulation information shall be the same as listed for piping above or shown as a drawing note. The equipment insulated, the materials, and the thickness of each material shall be identified.

30.2 Drawing content.

30.2.1 Requirements. Drawings shall indicate any exceptions to the requirements of this specification. A complete set of drawings shall consist of the following:

(a) Diagram and certification data.
(b) Machinery arrangement.

(c) Piping arrangement.
(d) Assembly drawings.

Drawings shall provide an orderly and systematic presentation and shall be reviewed by NAVSEA. The number of sheets shall be kept to a minimum insofar as is practical and shall be consistent with the requirements specified herein. Drawings shall be reproduced for inclusion in the manual (appendix D).

30.2.2 Skeleton outlines. Skeleton outlines shall consist of a series of dashes to illustrate an outline. Identifying numbers and descriptive names for equipment shall be consistent on all drawings except assembly drawings. Identifying numbers shall be V-1, V-2, and so on for valves and special valves; P-1, P-2, and so on for pipe; F-1, F-2, and so on for fittings and special fittings; and 1, 2, and so on for other equipment.

30.2.3 Diagrams and certification data drawings. Diagrams and certification data drawings shall include the following:

(a) Shipboard installation data (see appendix B).
(b) Piping schematic diagram.
(c) Electrical elementary diagram (see figure 3).
(d) Electrical connection diagram.
(e) Mechanical equipment list (see 30.1.1).
(f) Electrical equipment list (see 30.1.1).
(g) Piping and insulation material list (see 30.1.2).
(h) Certification data (see appendix B).

30.2.4 Diagram. The diagram shall show by symbolic representation all equipment except mounts, belt guards, machinery beds, foundations, plates, fittings (including special fittings), gaskets, pipe hangers, gauge board, insulation, test kit, fuseholders, and components such as cable clamps. The piping diagram shall include a table showing the design quantities, pressure and temperature ranges of fluids entering and leaving the plant absorber, boiler-stripper coolers, heat exchangers, and back pressure regulator. The wiring diagrams shall be in accordance with MIL-C-2212. Figure 3 is a typical elementary wiring diagram. Equipment as represented in the piping diagram shall have an identifying number. The diagram shall include all information necessary to evaluate the process flows.

30.2.5 Machinery arrangement drawing. The machinery arrangement drawing shall delineate outline details of all equipment, except foundation, supports, plates (except as specified herein), test kit and those portions of equipment within the closed control panel need not be shown. The drawing shall be drawn to an accurate scale to illustrate the physical arrangement of equipment and does not require dimensions. Outlines of the instruction plate and plant identification plate shall be shown. Insulation shall be shown as skeleton outlines. This drawing shall include identifying numbers, descriptive name and shall reference the diagram and certification data drawing for complete descriptions of equipment. The machinery arrangement drawing shall show all necessary views and cross sections to evaluate the arrangement.

results and disposition of first articles. Invitations for bids should provide

30.2.6 Piping arrangement drawing. The piping arrangement drawing shall include the details of all piping except gaskets. Where piping is shown as part of an assembly on an assembly drawing, it shall be shown as a skeleton outline on the drawing. The drawing shall be drawn to an accurate scale to illustrate the piping arrangement and does not require dimensions. Descriptive information such as air in, MEA waste, and similar information shall be shown for service connections. Insulation shall be shown with skeleton outlines. This drawing shall include identifying numbers, descriptive names and service, and shall reference the diagram and certification data drawing for complete description of components. A symbolic means shall be used to distinguish the various piping systems. The piping arrangement drawing shall include all necessary views, cross-sections, and skeleton outlines of equipment to evaluate the arrangement design.

30.2.7 Assembly drawings. Assembly drawings shall include the following as applicable to the plant.

(a) Absorber and base.
(b) Boiler-stripper.
(c) Air blower.
(d) CO_2 compressor.
(e) Machinery beds and foundations.
(f) Coolers and heat exchangers.
(g) Separators.
(h) Purifier.
(i) Plates.
(j) Panel board.
(k) Boiler heaters.
(l) MEA pump.
(m) Motors.
(n) Control panel arrangement.
(o) Valves.
(p) Special valves.
(q) Special fittings excluding gaskets, O-rings; hose, and pipe hangers.
(r) Liquid level detection system assemblies such as the sensing element, associated fasteners, and electronic and electrical components assemblies.
(s) Temperature indicating system assemblies such as the resistance elements, protective covers, selector switch, and temperature indicator.

30.2.7.1 Minimize sheets. Assembly drawings shall be combined, where practical, to minimize the number of drawing sheets.

30.2.7.2 Machinery bed and foundation drawing. The machinery bed and foundation drawing shall include bed plates, guards, V-belt systems, foundations and supports. It shall also include necessary skeleton outlines of components to illustrate their physical relationship to machinery beds and foundations.

30.2.7.3 Requirements. Each assembly drawing shall show outline mounting and connection dimensions including methods, sizes, and types of fastenings and dimensions and clearances required for installation and servicing plus supplementary data as necessary to permit installation without the contractor's assistance. The assembly drawings shall include the necessary cross-sections, dimensions, and identity and nomenclature of parts required for maintenance and to evaluate the design and construction. Assembly drawings shall also include general performance data or curves. Assembly drawings shall also list any special tools and their functions that may be required for shipboard maintenance. Assembly drawings for the absorber and base, and boiler-stripper shall identify the fluid and mounting connections such as recycled MEA to absorber, MEA pump suction, and similar connections. O-rings, gaskets, and similar devices shall be completely described on applicable assembly drawings. Assembly drawings shall be sufficiently complete to reflect compliance with specification requirements. As applicable (see 3.20.5.2), notes shall indicate the type of replacement bearings. Where assemblies are commercial equipment or commercial equipment with minor modifications, and drawings are not readily available, catalog sheets or other documents may be furnished. However, the catalog sheets, documents, or supplemented catalog sheets or documents shall contain all the information required for assembly drawings, shall provide for satisfactory reproductions for the manual (see appendix D), and a complete description of the modification shall be included as certification data on the diagram and certification data drawing. Where equipment is furnished in exact accordance with a NAVSEA drawing, the drawing shall be cited, where applicable, on the diagram and certification data drawing along with the manufacturer's drawing. Review of the manufacturer's drawing in this case is not required. It is the contractor's responsibility to assure that the equipment furnished conforms to the NAVSEA drawing.

APPENDIX D

MANUAL TECHNICAL CONTENT REQUIREMENTS

10. SCOPE

10.1 Scope. This appendix covers information that should be included in the manual when required by the contract or order. This appendix is not a mandatory part of the specification. The information contained herein is intended for guidance only.

20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

30. MANUALS

30.1 Manuals. When required by the contract or order, manuals shall contain the following information:

30.1.1 Requirements. The manuals shall not include classified information. The "approval and procurement record page" shall have an EQUIPMENT U.S. SERIAL NUMBERS" column in lieu of a "QUANTITY OF EQUIPMENT" column. The illustrations shall include reproductions of the drawings specified in appendix C, photographs and other illustrations required. Exploded views of the air blower and CO_2 compressor shall also be included. In addition, the parts list shall indicate the actual part manufacturer's name and identifying number. The parts list shall designate parts as either repairable or throwaway and indicate the recommended level for such action. The on board allowance quantity and National Stock Number need not be shown. Separate manuals shall be furnished to describe detailed maintenance procedures for the compressor. If the installed blower and compressor are identical to blowers and compressors installed in previous CO_2 plants, these separate manuals are not required. Separate manuals for individual equipment such as motor, pump, and similar equipment, shall not be furnished. The information shall be incorporated in the plant manual.

30.1.2 Troubleshooting procedures. Troubleshooting procedure shall be prepared and documented by level of maintenance: organizational, intermediate, and depot. They shall include a listing of the support and test equipment required to accomplish each set of procedures along with the estimated man-hours for accomplishment.

30.1.3 Section I and II procedures. Section I on "Adjustments and Alignment" and section II on "Repair" procedures shall be prepared and documented by level of repair: organizational, intermediate, and depot. They shall also include a listing of the support and test equipment required to accomplish each operation, the personnel requirements, and the estimated man-hours for accomplishment.

30.1.4 Scheduled maintenance procedures. The detailed "Scheduled Maintenance" procedures for the organization level of maintenance shall be recorded on maintenance requirement cards and additional information on

maintenance index pages. Scheduled maintenance procedures for the intermediate and depot level of maintenance shall be delineated in the manual in corresponding detail, and the same format.

30.1.5 Technical manual changes. Technical manual changes to incorporate any changes made to original equipment design shall be provided. Change pages shall be provided as camera ready copies.

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