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OCEAN THERMAL ENERGY CONVERSION, POWER SYSTEM
DEVELOPMENT II

Preliminary Design Report. Appendix 1—Specifications and Drawings

By
R. O. Pearson

August 10, 1979

Work Performed Under Contract No. ET-78-C-01-3408

MASTER

TRW, Inc.
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U.S. Department of Energy

Solar Energy

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PRELIMINARY DESIGN REPORT

Ocean Thermal Energy Conversion (OTEC) POWER SYSTEM DEVELOPMENT (PSD) II

APPENDIX I - SPECIFICATIONS AND DRAWINGS

10 AUGUST 1979

CONTRACT NO. ET-78-C-01-3408

Prepared for
UNITED STATES DEPARTMENT OF ENERGY
WASHINGTON, D.C. 20545

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DEFENSE AND SPACE SYSTEMS GROUP

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1. SPECIFICATION TREE

Figure 1-1. P&ID Specification Tree

2. SYSTEM SPECIFICATION (10 MWe)

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DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

FSCM NO. 11982

TITLE

SYSTEM SPECIFICATION

OCEAN THERMAL ENERGY CONVERSION

10 MWe POWER SYSTEM MODULE PSD-II

DATE 13 April 1979

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27 February 1979

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REVISION RECORD

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SYSTEM SPECIFICATION
OCEAN THERMAL ENERGY CONVERSION
10 MWe POWER SYSTEM MODULE PSD II

1. SCOPE

1.1 This specification establishes the performance, design, development and test requirements for the 10 MWe Power System Module (PSM) used in the Ocean Thermal Energy Conversion (OTEC) 10 MWe Power System Development Project II (PSD-II) utilizing UCC/Linde enhanced plate type heat exchangers.

2. APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

STANDARDS

Occupational Safety and Health Administration (OSHA)

1910.11 Storage and Handling of Anhydrous Ammonia

REGULATIONS

National Bureau of Standards (NBS)

Circular 142 Tables of Thermodynamic Properties of Ammonia
16 April 1923

Coast Guard (CG)

115 Marine Engineering Regulations
1 August 1977

257 Rules and Regulations for Cargo and
1 Sept 1977 Miscellaneous Vessels

REGULATIONS (Cont'd)

2.2 Non-Government Documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between these documents and this specification, the contents of this specification shall be considered a superseding requirement.

STANDARDS

National Electrical Manufacturers Association (NEMA)

MG-1972 Motors and Generators
14 October 1977

National Fire Protection Association (NFPA)

70-1978 National Electrical Code
August 1977

American Society of Mechanical Engineers (ASME)

BPV-VIII Boiler and Pressure Vessel Code Section VIII,
1 July 1977 Divisions 1 and 2

DRAWINGS

Drawings are from "Preliminary Engineering Design of an OTEC Pilot Plantship", Volume D: Engineering Drawings, November 1978, ABAM Engineering and The Johns Hopkins University, Applied Physics Laboratory (APL).

H-01 31 October 1978	General Arrangement
MO-07 21 September 1978	Fire and Washdown System Diagram
MO-10 8 September 1978	Air Conditioning and Ventilation System
M-1 15 September 1978	OTEC Plant Platform Layout
E-1 12 September 1978	4.16KV and OTEC Power Plans
E-3 12 September 1978	OTEC 4.16KV Switch Gear Units

3. REQUIREMENTS

3.1 System Definition

3.1.1 General Description. The PSM is a closed-loop system for generating electricity through ammonia operating in a Rankine cycle. It functions as follows:

- a. Filtered warm sea water is pumped from just below the surface of the ocean into the top of the warm sea water trough. This water flows by gravity through water passages in the shell-less plate type evaporator heat exchanger then exits back into the ocean through the effluent discharge plenum. The warm sea water pumps and their associated filters, ducts and electrical operating equipment are not a part of the PSM.
- b. As the sea water flows through the passages in the evaporator, it heats the ammonia surrounding the passages until the ammonia vaporizes.
- c. As the ammonia vaporizes it passes through a phase separator and then expands across the blades of the turbine to drive the generator.
- d. The turbine-generator produces and supplies electricity to the ship system bus.

- e. The gaseous ammonia then passes into the condenser heat exchanger where it is cooled and re-liquefied by cold sea water in the reverse manner to that by which it was vaporized. (The cold sea water is pumped from 3000 feet below the surface of the ocean and stored in the moon pool). The cold sea water pumps and their associated filters, ducts and electrical operating equipment are not a part of the PSM.
- f. The re-liquefied ammonia drains from the condenser and is fed to the condensate feed pump via an accumulator and pumped into the evaporator. The evaporator is also supplied by liquid ammonia which had not vaporized in the evaporator and has been separated in the separator and drained into the feed pipe. The liquid ammonia from both these sources is fed into the evaporator.
- g. The water supply is chlorinated and a mechanism is provided for cleaning the inside of the heat exchanger tubes to control biofouling.
- h. Nitrogen is used to purge the system of air before the ammonia is introduced and to purge ammonia before the system is opened for maintenance or repair to prevent combustion caused by a hazardous combination of air and ammonia.

The PSM consists of the following major subsystems:

<u>Subsystem No.</u>	<u>Quantity</u>	<u>Subsystem</u>
1	1	Evaporator
2	1	Condenser
3	1	Ammonia Power Loop
4	1	Turbine Generator
5	1	Biofouling Control
6	1	Ammonia Leak Detection
7	1	Electrical Power Distribution and Control
8	1	Instrumentation and Control
9	1	Ammonia Storage, Conditioning and Supply
10	1	Nitrogen Storage, Conditioning and Supply

3.1.2 Mission. The primary mission for which the 10 MWe PSM is being considered is for the ammonia plant ship concept of the Applied Physics Laboratory/John Hopkins University. This system is currently going through conceptualization on the basis of the APL heat exchangers. However, spaces are being provided for other PSM candidates based on other heat exchanger concepts, as shown on drawing M-1. The dimensions are only shown as representative and where required may be exceeded to ensure power plant optimization.

3.1.3 System Diagrams. The Figure 1 top-level functional flow diagram identifies all primary PSM system functions.

3.1.4 Interface Definition. Figure 2 shows the relationships between Ship Systems (by others) and the Power System Module subsystems (this specification).

3.1.4.1 Intersystem

3.1.4.1.1 Physical

3.1.4.1.1.1 Evaporators. Evaporators will be mounted to receive warm sea water from a ship system trough located between transverse frames 50 and 80, and longitudinal frames B and F as shown on drawing H-01.

3.1.4.1.1.2 Condensers. Condensers will be mounted to receive cold sea water from a ship system trough located between transverse frames 130 and 160, and longitudinal frames B and F as shown on drawing H-01.

3.1.4.1.1.3 Power Plant. The evaporators, condensers, turbine-generator, bio-fouling, and ammonia power loop subsystem will be located in the plant ship between transverse frames 50 and 160, and longitudinal frames B and F as shown on drawing H-01.

3.1.4.1.1.4 Electrical Equipment. The electrical equipment and control room may be located in either of the following spaces shown on drawing M-1:

- a. Elevation 77 between transverse frames 50 and 160, and longitudinal frames F and G.
- b. Elevation 77 between transverse frames 50 and 160, and longitudinal frames A and B.

3.1.4.1.1.5 Ammonia and Nitrogen Storage. The ammonia and nitrogen support subsystems' components may utilize any of the following spaces, shown on drawing M-1, as required:

- a. Space between elevation 4 and transverse frame 160, and longitudinal frames F and G.

FIGURE 1 - PSM TOP-LEVEL FUNCTIONAL FLOW DIAGRAM

FIGURE 2. SHIF SYSTEM AND PSM INTERFACE RELATIONSHIPS

- b. Space between elevations 4 and 77, transverse frames 50 and 160, and longitudinal frames A and B.
- c. Unused space available in the power plant space described in 3.1.4.1.1.3.

3.1.4.1.1.6 Effluent Pipe. The PSM plenum gathering warm and cold water effluents will be connected to a centrally located 25+1 foot diameter pipe through hull connection provided by Ship Systems in the PSM pump room floor.

3.1.4.1.2 Functional

3.1.4.1.2.1 Warm Sea Water. The evaporators receive sea water, from Ship Systems, with the following characteristics:

- a. Design Properties. Section 10, Appendix I provides design data on the properties of sea water as a function of temperature.
- b. Supply Characteristics

Static Head	6.3 feet above mean sea level, minimum
Flow	721,800 GPM, minimum
Temperature	Design: 82°F, minimum Off-Design: 82 + 3, -10°F

3.1.4.1.2.2 Cold Sea Water. The condensers receive sea water from Ship Systems, with the following characteristics:

- a. Design Properties. Section 10, Appendix I provides design data on properties of sea water as a function of temperature.
- b. Supply Characteristics

Static Head	6.0 feet above mean sea level, minimum
Flow	679,600 GPM, minimum
Temperature	Design: 40°F, maximum

3.1.4.1.2.3 Electrical. Electrical power will be delivered by the PSM to the Ship Systems 4.16KV bus shown on drawing E-1. The connection or tie feeder provided by the PSM shall be in accordance with Diagram "C" of drawing E-3. The PSM electrical power subsystem functional interface characteristics include:

- a. Electrical power will be delivered to the bus at 4.16KV.

- b. The power delivered will be no less than 13.28 MWe with the PSM operating at a ΔT of 42°F with the sea water design temperatures specified in 3.1.4.1.2.1 and 3.1.4.1.2.2. The delivered power is based on satisfying the following ship system load breakdown:

Net Power	10.00 MWe
Cold Water Pumps	1.96 MWe
Warm Water Pumps	1.21 MWe
Hotel	0.11 MWe
Gross Power to Bus	13.28 MWe

- c. PSM intrasystem electrical power usage shall be at 440V, 3-phase to be functionally compatible with Ship System usage as indicated on drawing E-1.

3.1.4.1.2.4 Ship System Services

- a. Fire and Washdown. PSM compartment sprinkler, deluge and washdown services will be provided by Ship Systems as shown on drawing MO-07.
- b. Air Conditioning and Ventilation. Air conditioning of the PSM control room and compartment ventilation will be provided by Ship Systems as shown on drawing MO-10.

3.1.4.2 Intrasystem. The PSM major components and subsystems interface as shown in Figure 2.

3.1.5 Government Furnished Property List. The Power System Module development has no design requirements to incorporate government furnished property.

3.2 Characteristics

3.2.1 Performance Characteristics

3.2.1.1 Design. The PSM shall be designed to deliver no less than 13.28 MWe of electrical power to the Ship System 4.16KV bus when provided with warm sea water at 82°F, minimum and cold sea water at 40°F, maximum with the sea water supply characteristics specified in 3.1.4.1.2.1 and 3.1.4.1.2.2. The following performance characteristics provide sufficient guidance to form the basis for technical features and development of subsystems to obtain the aforementioned PSM design performance requirement.

3.2.1.1.1 The Evaporator Subsystem shall generate a minimum of 779.6 lb/sec of ammonia vapor at no less than 72.22°F with a minimum quality of 97 percent as a result of extracting heat from 721,800 GPM of seawater, minimum provided at no less than 82°F. Effluent sea water shall be discharged at no more than 77.91°F. The pressure drop of the sea water through the plate type heat exchanger passages including entrance and exit pressure losses, shall not exceed 2.56 psi. The pressure drop of the ammonia through the evaporator subsystem shall not exceed 1.46 psi.

3.2.1.1.2 The Condenser Subsystem shall condense a minimum of 764 lb/sec ammonia vapor entering at no greater than 51.60°F with a maximum quality of 96.4 percent as a result of rejecting heat to 679,600 GPM of sea water, minimum, provided at 40°F, maximum. Effluent sea water shall be discharged at no less than 44.19°F. The pressure drop of the sea water through the plate type heat exchanger passages, including entrance and exit pressure losses, shall not exceed 2.44 psi. The pressure drop of the ammonia through the condenser subsystem shall not exceed 0.39 psi between vapor inlet and liquid discharge.

3.2.1.1.3 The Ammonia Power Loop Subsystem shall deliver no less than 764 lb/sec of liquid ammonia at no greater than 51.27°F from the condenser to the evaporator at a pressure of 135.4 psia, minimum. The feed pump shall be capable of developing a pressure rise of no less than 44.62 psi at a flow of 8,807 GPM, maximum. Separators located upstream of the turbine inlet shall separate no less than 15.6 lb/sec of liquid ammonia to ensure turbine entrance ammonia vapor quality of no less than 99 percent.

3.2.1.1.4 The Turbine-Generator Subsystem shall generate no less than 13.87 MWe, three phase AC electric power at 4.16KV and 60Hz as a result of expanding no less than 764 lb/sec ammonia vapor at 72.02°F with a minimum quality of 99 percent to a turbine exhaust condition of 51.60°F maximum, and a minimum quality of 96 percent.

3.2.1.1.5 The Biofouling Control Subsystem shall be capable of maintaining an average fouling (biological and chemical) thermal resistance of no greater than 0.0005 hr-ft²-°F/BTU on the water side of both the evaporator and condenser passages. The design goal is to achieve 0.0003 hr-ft²-°F/BTU or less.

3.2.1.1.6 The Ammonia Leak Detection Subsystem shall detect heat exchanger ammonia leaks into the operating sea water flow. The detection subsystem shall be capable of detecting PSM effluent ammonia concentrations of at least 0.1 ppm.

3.2.1.1.7 The Electrical Power Distribution and Control Subsystem shall receive no less than 13.87 MWe, three phase AC power at 4.16KV and 60Hz from the Turbine Generator Subsystem, condition it and supply no more than 0.59 MWe to the PSM feed pump and auxiliaries, and deliver the remaining 13.28 MWe to an external load represented by a bus bar (not a part of the PSM). It shall also be capable of distributing and controlling external power for starting of the PSM.

3.2.1.1.8 The Instrumentation and Control Subsystem shall consist of the sensors required to monitor operation of the PSM and to control its functions. Also it shall include an inventory control liquid level sensor that controls ammonia make-up from the Ammonia Storage Conditioning and Supply Subsystem to make-up losses from system leakage. The control system for the PSM shall be designed to optimize the power output for both design and off-design operation.

3.2.1.1.9 The Ammonia Storage, Conditioning and Supply Subsystem shall supply ammonia to the Ammonia Power Loop Subsystem with no greater than 100 ppm of water. The ammonia stored shall provide a cumulative total of the following requirements:

- a. Ammonia vapor to obtain at least five Ammonia Power Loop, Evaporator and Condenser Subsystem volume changes at atmospheric pressure (for displacing nitrogen).
- b. One complete PSM inventory charge, minimum, with transfer charging capability of at least 90 minutes.
- c. Replenishment make-up ammonia to sustain at least 45 days of continuous operations with a make-up rate no greater than 170 lbs/hr.

3.2.1.1.10 The Nitrogen Storage, Conditioning and Supply Subsystem shall provide nitrogen gas for purging the PSM ammonia loop at a pressure of at least 70 psig during startup and shutdown cycles. Nitrogen storage shall be provided to obtain three complete startup and shutdown cycles with the following purge requirements:

- a. A startup cycle shall require no less than three PSM ammonia loop volume changes with nitrogen, to remove air from the system prior to charging the system with ammonia to avoid flammable mixtures of air and ammonia.
- b. A shutdown cycle shall require no less than three PSM ammonia loop volume changes with nitrogen to remove ammonia from the system prior to breaking into the ammonia loop to avoid flammable mixtures of air and ammonia.

3.2.1.2 Off-Design. The PSM, as designed to satisfy the performance requirements of 3.2.1.1, shall be capable of operating with the off-design warm sea water characteristics of 3.1.4.1.2.1 with no degradation of safety or component life or required manual control adjustments. The electrical power delivery requirement of 3.1.4.1.2.3 shall be relaxed with PSM operation at off-design conditions to provide more or less than 13.28 MWe to the Ship Systems bus as available.

3.2.2 Physical Characteristics

3.2.2.1 Weight. The PSM including support systems shall not exceed 1,175 tons.

3.2.2.2 Size. The PSM shall not exceed the envelopes specified in 3.1.4.1.1.

3.2.2.3 Lift Points. The evaporator and condenser module subassemblies shall have lift points to facilitate installation, removal and handling by shipboard crane.

3.2.2.4 Durability. The PSM shall be sufficiently durable to:

- a. Perform in accordance with the off-design conditions of 3.2.1.2.
- b. Operate normally in a surface vessel under Sea State 6 conditions, and shall survive in a secured condition in Sea State 9.

3.2.3 Reliability

3.2.3.1 Redundancy. The PSM design shall include redundancy as required to ensure continuity of key functions, as well as fail-safe operations.

3.2.3.2 System Starting. System starting reliability (successful starts divided by attempted starts) shall be 95 percent at a 60 percent confidence level.

3.2.3.3 Allocations. Major components and subsystems shall meet, or be better than, the mean-time-between-failure (MTBF) allocations listed in Table 1.

3.2.4 Maintainability

3.2.4.1 Allocations. Major components and subsystems shall meet, or be better than, the mean-time-to-repair (MTTR) allocations listed in Table 1. MTTR shall include isolation of the fault to the lowest replaceable unit, replacement with a serviceable unit, and verification of correct operation.

3.2.4.2 Downtime. Provisions shall be made for periodic maintenance during power plant downtimes.

TABLE 1 - MTBF and MTTR ALLOCATIONS

No.	Subsystem/Component	MTBF (hours)	MTTR (hours)
1	Evaporator Subsystem	11,500	55
	a. Heat Exchanger Subassembly	11,500	55
	b. Connections	48,700	52
2	Condenser Subsystem	11,500	55
	a. Heat Exchanger Subassembly	11,500	55
	b. Connections	48,700	52
3	Ammonia Power Loop Subsystem	100,000	18
	a. Piping	104,100	14
	b. Check Valve	331,800	18
	c. Relief Valve	100,000	16
	d. Bypass Valve	87,600	18
	e. Flow Control Valve	87,600	18
	f. Separator	400,000	18
	g. Feed Pump/Motor	8,800	12
	h. Butterfly Valve (Isolation)	333,400	11
4	Turbine Generator Subsystem	17,600	90
	a. Turbine	17,600	90
	b. Turbine Stator Vane Control	17,600	26
	c. Generator	69,500	80
5	Biofouling Control Subsystem	12,500	50
	a. Chlorination	100,000	24
	b. Tube Cleaner	13,000	55
6	Ammonia Leak Detection Subsystem	100,000	24
7	Electrical Power and Control Distribution System	43,800	8
8	Instrumentation and Control Subsystem	10,000	50
9	Ammonia Storage, Conditioning and Supply Subsystem	88,000	24
10	Nitrogen Storage, Conditioning and Supply Subsystem	88,000	24

3.2.5 Operability. Operability (i.e., total power per unit time divided by the plant capacity) shall be at least 90 percent at 60 percent confidence level, over a 30 year life, after an initial checkout period.

3.2.6 Environmental Conditions. The PSM shall be designed to operate in the environmental conditions described in the following paragraphs. Design life goals are:

- a. 30-year life.
- b. 1000 start/stop cycles.
- c. 8000 hours of operation per year.

3.2.6.1 Operational Environment. The PSM shall be able to operate and meet performance requirements in the following ocean-based environment:

- a. 65 to 110°F ambient air temperature.
- b. 40 to 100 percent relative humidity.
- c. Sea water design and off-design temperatures specified in 3.1.4.1.2.
- d. OTEC Pilot Plantship nominal periods, and maximum vertical and horizontal accelerations and angular motions are as follows for Sea State 6:

1)	Period	:	14 sec
2)	Vertical Direction	:	0.3g
3)	Horizontal Direction	:	0.15g
4)	Pitch	:	5°
5)	Roll	:	12°

- e. Annual temperature variations to be used for fixed versus variable speed pump trade offs are as follows:

<u>Month</u>	<u>Temperature Difference</u> °F
Jan	38
Feb	38
Mar	40
Apr	41
May	43
June	45
July	45
Aug	45
Sept	45
Oct	43
Nov	41
Dec	40

3.2.6.2 Non-Operational Environment. During shutdown, the PSM shall be able to withstand the following ocean-based environmental conditions without degradation:

- a. 0 to 125°F ambient air temperature.
- b. 0 to 100 percent relative humidity.
- c. Sea motion of Sea State 9 magnitude. Sea State 9 has a significant wave height of 80 feet, resulting in a vertical acceleration of $\pm 0.5g$ and a horizontal acceleration of $\pm 0.5g$

3.2.7 Transportability. PSM components shall be designed to be transported by common carrier with a minimum of protection. If necessary, special packaging may be required to assure that transportation methods will not impose design penalties. Special equipment required for handling, installation, servicing, or operation shall be identified in subsystem design specifications.

3.3 Design and Construction. The PSM shall be designed and constructed to perform in accordance with the functional and environmental requirements of this specification.

3.3.1 Materials, Processes and Parts. All parts shall comply with the applicable codes of BPV-VIII and CG 115.

3.3.1.1 Working Fluid. The power cycle working fluid shall be ammonia with characteristics as specified in NBS Circular 142.

3.3.1.2 Ammonia-Side Materials. The metallic materials for ammonia handling and distribution shall be limited to aluminum, steel or stainless steel. The use of copper bearing materials is not allowed.

3.3.1.3 Heat Exchangers. Heat exchanger materials shall be chosen to be compatible with sea water and ammonia as well as with other materials in the PSM. The material chosen should also exhibit good joinability, strength and thermal properties.

3.3.1.4 Electrical. Electrical system design considerations include:

- a. The auxiliary starting power and operational auxiliary power shall be quantified. Sequential logic and procedures for phased test equipment and prototype module startup/shutdown must be addressed.
- b. The staged application of torque on pump motors shall be considered in the design.
- c. The use of variable versus fixed water flow through the heat exchangers must be assessed in conjunction with net output maximization during off-design operation.
- d. The following power usage criteria shall be addressed: partial load and turndown, load shedding, and startup load carrying capability, and power conditioning (transformation and rectification).

3.3.2 Nameplates and Product Marking. Nameplates and product marking requirements shall be in accordance with standard industrial practice.

3.3.3 Workmanship. The PSM shall be fabricated, finished, and assembled in accordance with normal standards for high quality workmanship.

3.3.4 Interchangeability. Each item within the PSM shall be directly interchangeable for form, fit, and function with other items of the same part number with a minimum of adjustment or re-calibration.

3.3.5 Safety. The PSM shall be designed and constructed to meet the health and safety criteria specified in OSHA 1910.11 and electrical equipment location Class I, Group D, Division 1 specified in NEMA MG-1972 and NFPA 70-1978.

a. Restrictive Use of Mercury

Ammonia reacts with mercury to form an explosive compound. Therefore, equipment, components, instruments containing mercury shall not be used in applications wherein ammonia and mercury could react.

b. Flammable, Toxic, and Unstable Materials

Flammable, toxic, and unstable materials shall not be used.

c. Finish

The surfaces of each equipment/component of the PSD-II system shall be adequately finished to prevent deterioration from exposure to the specified environments that might jeopardize fulfillment of the specified performance.

d. Relief Valves

Relief valves shall be set to prevent a pressure build-up exceeding the system design pressures in accordance with CG-257, Section 98.25-60.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. Inspections shall be conducted during the design and development of the PSM to provide DOE with assurance of compliance with the requirements of this specification.

4.1.1 Responsibility for Tests. Each supplier of a major component of the PSM shall be responsible for developing and conducting the tests and inspections required to demonstrate that his equipment will perform as specified. The system contractor is responsible for review and approval of test plans and procedures and for monitoring test activities as necessary to verify that the test program meets applicable requirements.

4.2 Quality Conformance Inspections. Qualification shall be performed on PSM components that are representative of the approved production design. Qualification of the PSM to assure compliance with the requirements of section 3 shall be by examinations, demonstrations, tests, or analyses. Table 2 provides a matrix of section 3 requirements versus qualification methods. Definition of examination, demonstration, test or analysis is as follows:

- a. Examination is an element of inspection consisting of investigation, without the use of special laboratory appliances or procedures, or supplies and services to determine conformance to those specified requirements which can be determined by such investigation. Examination is generally nondestructive and includes, but is not limited to, visual, auditory, olfactory, tactile, gustatory, and other investigations; simple physical manipulation; gauging, and measurement.
- b. Test is an element of inspection denoting the determination of the properties or elements of supplies (or components thereof) by technical means, including functional operations and the application of established principles and procedures. The analysis of data derived from test is an integral part of the inspection element, and shall not be confused with 4.2.d.
- c. Demonstration is an element of inspection that, although technically a variation of test, differs from 4.2.b by directness of approach in the verification of a requirement(s), and is accomplished without the use of elaborate instrumentation or special equipment. Thus, operation of a representative configuration item (CI) in, or near its use-environment (e.g., ability of a truck to climb a one-half mile, 5 percent grade, from standstill in the required time) would be defined as a "demonstration" rather than a "test".

TABLE 2 - QUALITY CONFORMANCE METHODS

Section 3 Paragraph	Quality Conformance Method			
	Examination	Demonstration	Test	Analysis
3.2 Characteristics				
3.2.1 Performance Characteristics				
3.2.1.1 Design				
3.2.1.1.1 Evaporator Subsystem			X	
3.2.1.1.2 Condenser Subsystem			X	
3.2.1.1.3 Ammonia Power Loop Subsystem			X	
3.2.1.1.4 Turbine-Generator Subsystem			X	
3.2.1.1.5 Biofouling Control Subsystem			X	
3.2.1.1.6 Ammonia Leak Detection Subsystem			X	
3.2.1.1.7 Electrical Power Distribution and Control Subsystem			X	
3.2.1.1.8 Instrumentation and Control Subsystem			X	
3.2.1.1.9 Ammonia Storage, Conditioning and Supply Subsystem			X	X
3.2.1.1.10 Nitrogen Storage, Conditioning and Supply Subsystem			X	X
3.2.1.2 Off-Design			X	
3.2.2 Physical Characteristics				
3.2.2.1 Weight	X			X
3.2.2.2 Size	X			
3.2.2.3 Lift Points	X			
3.2.2.4 Durability	X			
3.2.3 Reliability				
3.2.3.1 Redundancy				X
3.2.3.2 System Starting				X
3.2.3.3 Allocations				X
3.2.4 Maintainability		X		
3.2.4.1 Allocations				X
3.2.4.2 Downtime				X
3.2.5 Operability				X
3.2.6 Environmental Conditions				
3.2.6.1 Operational Environment			X	X
3.2.6.2 Non-Operational Environment			X	X
3.3 Design and Construction				
3.3.1 Materials, Processes and Parts	X			
3.3.2 Nameplates and Product Marking	X			
3.3.3 Workmanship	X			
3.3.4 Interchangeability	X			
3.3.5 Safety	X			X

- d. Analysis is an element of inspection in the form of study, resulting in data, that is intended to verify a requirement(s) when an examination, test, or demonstration cannot feasibly be employed to verify that requirement(s) at the inspection level demanded by this specification. Such data may be comprised of a compilation or interpretation of existing data or design solutions, or derived from original lower-level inspections, or both. Data may be interpolated or extrapolated, as applicable. This would include data derived from fault-tree analysis, and failure modes and effects analysis.

5. PREPARATION FOR DELIVERY

Not applicable. The PSM is not delivered as a system. Its major components are delivered to the containment vessel as separate items, then the PSM is assembled on board.

6. NOTES

6.1 Intended Use. The PSM is intended to be used as a building block for large OTEC power plants. The first PSM will be used as a test article to evaluate and prove the design, to demonstrate the economic parameters of the concept as installed in the APL/JHU OTEC Pilot Plantship.

6.2 Definitions

6.2.1 Ships Systems are defined as those elements of an OTEC Plantship provided by others to support the PSM specified herein. Ships Systems elements include the hull, crew quarters, ship's auxiliaries, cold water pipe, station-keeping, effluent discharge pipes, and cold and warm sea water pump subsystems.

6.3 Life Cycle Cost Estimates. The life cycle costing of heat exchangers which are not designed to last the design life of the power system shall be based upon present value analysis using dollars at the time of expenditures, and a discount rate equal to the current rate of return on investment. The break-even calculation shall be done for three cases namely: Public utility, private utility, and private corporation. For these cases the incremental rate of return over inflation shall be taken as 1, 3, 7% respectively. The base rate of inflation shall be taken as 7% per year.

10. APPENDIX I - PROPERTIES OF SEA WATER

The data in this appendix shall be used for design calculations.

Symbols:

ρ = Density C_p = Specific Heat at Constant Pressure
 μ = Viscosity k = Thermal Conductivity
 $\nu = \frac{\mu}{\rho}$ $\bar{T}$ = Average Temperature

References

1. Kellogg, M. W. Co, Engineering Data Handbook, "Saline Water Conversion", Office of Saline Water, U.S. Government Printing Office, 2nd Ed, 1971
2. Society of Marine Architects and Naval Engineers, "Tables of Coefficients for A.T.T.C Model -- Ship Correlation and Kinematic Viscosity and Density of Fresh and Salt Water", Technical and Research Bulletin No. 1-25, New York, 1964
3. Neumann and Pearson, Principles of Physical Oceanography, Prentice-Hall Inc, Englewood Cliffs, New Jersey, 1966

Evaporator ($\bar{T} = 80^\circ\text{F}$)

$\rho = 63.77 \frac{\text{lb}}{\text{ft}^3}$
 $C_p = 0.9565 \text{ BTU/lb-}^\circ\text{F}$
 $\mu = 2.24 \text{ lb/ft-hr}$
 $k = 0.352 \text{ BTU/hr-ft-}^\circ\text{F}$

Condenser ($\bar{T} = 42^\circ\text{F}$)

$\rho = 64.01 \frac{\text{lb}}{\text{ft}^3}$
 $C_p = 0.9545 \text{ BTU/lb-}^\circ\text{F}$
 $\mu = 3.815 \text{ lb/ft-hr}$
 $k = 0.332 \text{ BTU/hr-ft-}^\circ\text{F}$

From Reference 1:

$^\circ\text{F}$	C_p ($\frac{\text{BTU}}{\text{lb-}^\circ\text{F}}$)	ρ ($\frac{\text{lb}}{\text{ft}^3}$)	k ($\frac{\text{BTU}}{\text{hr-ft-}^\circ\text{F}}$)	μ ($\frac{\text{lb}}{\text{ft-hr}}$)
35	0.9540	64.05	0.328	
40	0.9543	64.05	0.331	
45	0.9547	64.00	0.334	
50	0.9549	63.98	0.337	
55	0.9551	63.94	0.339	
60	0.9554	63.91	0.342	
65	0.9557	63.88	0.3445	
70	0.9560	63.84	0.347	
75	0.9562	63.80	0.3495	2.37
80	0.9565	63.77	0.352	2.24
85	0.9568	63.71	0.354	2.11

Note: All values at salinity of 34.48 parts per thousand.

From Reference 2:

$^\circ\text{F}$	ν ($\frac{\text{ft}^2}{\text{sec}} \times 10^5$)	μ ($\frac{\text{lb}}{\text{ft-hr}}$)
35	1.86367	4.297
40	1.70906	3.939
45	1.57479	3.628
50	1.45724	3.356
55	1.35355	3.115
60	1.26150	2.902
65	1.17937	2.712
70	1.10568	2.541
75	1.03924	2.387
80	0.97915	2.248
85	0.92450	2.120

Note: All values at salinity of 35 parts per thousand.

$$y = a + bx + cx^2$$

Where: x = Temperature ($^{\circ}\text{F}$)

y = C_p , ρ , k , or μ

Data points for C_p , ρ , and k were taken from Reference 1. Values for μ are from Reference 2.

<u>y</u>	<u>a</u>	<u>b</u>	<u>c</u>
C_p (BTU/lb- $^{\circ}\text{F}$)	9.5213E-01	5.4727E-05	0
ρ (lb/ft ³)	6.4131E+01	-6.8811E-04	-4.9417E-05
k (BTU/hr-ft- $^{\circ}\text{F}$)	3.1043E-01	5.2000E-04	0
μ (lb/ft-hr)	7.2180E+00	-1.0139E-01	4.9030E-04

Figure 3. Thermal Conductivity of Sea Water, Salinity 34.48
Parts per Thousand

Figure 4. Viscosity of Sea Water, Salinity
34.48 Parts per Thousand

Figure 5. Density of Sea Water, Salinity 34.48
Parts per Thousand

Figure 6. Heat Capacity of Sea Water, Salinity 34.48 Parts per Thousand

3. 10 MWe HEAT EXCHANGERS

TRW

DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

FSCM NO. 11982

TITLE

REQUIREMENTS SPECIFICATION

HEAT EXCHANGERS

10 MWe OTEC PSD-II

DATE 26 April 1979

NO. SS14-62

SUPERSEDING: _____

PREPARED BY: _____

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REQUIREMENTS SPECIFICATION

HEAT EXCHANGERS

10 MWe OTEC PSD-II

1. SCOPE

This Specification establishes the performance, design, and test requirements for shell-less plate type heat exchangers (an evaporator and a condenser) used in the Ocean Thermal Energy Conversion (OTEC) 10 MWe PSD-II Power System Development Program.

2. APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents of the exact issue shown (or of the latest date if an exact issue is not listed) form a part of this Specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this Specification, the contents of this Specification shall govern.

- STANDARDS

Occupational Safety and Health Administration (OSHA)

1910.11

Storage and Handling of Anhydrous Ammonia

- REGULATIONS

Coast Guard

CG-115

Marine Engineering Regulations (1 August 1977)

- OTHER PUBLICATIONS

National Bureau of Standards (NBS)

Circular 142

Tables of Thermodynamic Properties of Ammonia
(16 April 1923)

2.2 Non-Government Documents. The following documents of the exact issue shown (or of the latest date if an exact issue is not listed) form a part of this Specification to the extent specified herein. In the event of conflict between those documents and this Specification, the contents of this Specification shall govern.

● SPECIFICATIONS

SS14-62

TRW DSSG

Proposal for OTEC Power Systems Development (PSD) II
Proposal No. 34144.000, July 10, 1978
RFP No. ET-78-R-01-3063

SY14-5 10 MWe PSD-II Power Module System Spec.
SS14-64 0.2 MWe Heat Exchanger Tube Cleaner (for reference only)

● STANDARDS

American Society of Mechanical Engineers (ASME)

BPV-II Boiler and Pressure Vessel Code, Section II
BPV-VIII Boiler and Pressure Vessel Code, Section VIII, Division 1
BPV-IX Boiler and Pressure Vessel Code, Section IX

● DRAWINGS

TRW DSSG

6850.94-19 Heat exchanger tube cleaner, open water box design
6850.94-70 Tube cleaner head, open or closed water box design

3. REQUIREMENTS

3.1 Item Definition. The heat exchangers shall be all-aluminum shell-less plate type configuration as described in Section 2.2.2 of the TRW PSD-II Proposal (No. 34144.000). The heat exchangers shall be of the cross-flow configuration, consisting of 16 identical modular units. The modular units are to be hydraulically arranged in four parallel strings of four modules in series on the seawater side as illustrated in Figure 1. All modules in each heat exchanger shall be arranged hydraulically in parallel on the ammonia side. The seawater passages (tubes) of the heat exchanger shall be circular in cross-section and regularly spaced in an uniform tube field compatible with TRW's tube cleaning approach employing an automated tube cleaning machine. The seawater tubes of the four modules arranged in series shall form a passage compatible with the tube cleaning machine brushes and consistent with the need for minimum seawater pressure losses. The working fluid shall be ammonia. Performance and design requirements shall be as specified herein.

3.1.1 Interface Definition. The functional interfaces of the heat exchangers are illustrated in Figure 2. Other interfaces are defined in the major component specifications referenced herein. TRW Specification SY14-5 provides data on the properties of the seawater. NBS Circular 142 provides data on the thermodynamic properties of the ammonia.

Figure 1. 10 MWe Power Module System

Log 197

SS14-62

Figure 2: Heat Exchanger Functional Interfaces

3.2 Characteristics

3.2.1 Performance. The heat exchangers shall be designed to meet the requirements specified in Table 1 and perform as specified in the following paragraphs.

3.2.1.1 Evaporator. When provided with 369,140,000 lb/hr of seawater at 82°F, the evaporator shall supply a minimum of 2,807,000 lb/hr of ammonia vapor at 72.22 °F with minimum quality of 97 percent.

At least 70% of the entrained liquid particle droplets shall be 10 microns or larger. At least 94% of the entrained liquid droplets shall be 5 microns or larger.

The ammonia side shall be designed for nominal operating pressure of 135 psia and a design pressure of 167 psig*. The ammonia side shall also be designed to withstand an external differential pressure of one atmosphere.

3.2.1.2 Condenser. The condenser shall be capable of condensing a minimum of 2,750,000 lb/hr of ammonia vapor at 51.49 °F with a minimum quality of 99.4 percent, when provided with 348,920,000 lb/hr of seawater at 40°F.

The ammonia side shall be designed for a nominal operating pressure of 92 psia and a design pressure of 167 psig*. The ammonia side shall be designed to withstand an external differential pressure of one atmosphere.

3.2.2 Physical Characteristics. The physical characteristics of the heat exchangers shall comply with the following paragraphs.

3.2.2.1 Design Life. The heat exchangers shall be designed to operate continuously for 15 years life with scheduled maintenance. Occasional repairs and plugging of leaking tubes or tube joints are permitted.

3.2.2.2 Envelope. Each heat exchanger shall be built up by the assembly of 16 identical modules as noted in Section 3.1. The module, as shown in Figure 3, shall not be larger than 15' high** X 20' wide x 5' deep (parallel to the seawater flow direction). Each heat exchanger subassembly, consisting of four modules in series, shall not exceed 15' high** X 20' wide X 18' deep (parallel to the seawater flow direction).

* based on saturation pressure at 85°F + 10%

** includes top and bottom nozzles

TABLE 1
PSD II, 10 MWe HEAT EXCHANGERS FLUID AND THERMAL DESIGN DATA⁽¹⁾

(TOTAL FOR 16 MODULES, 4 IN SERIES AND 4 IN PARALLEL)

		EVAPORATOR	CONDENSER
● AMMONIA SIDE			
- FLOW	LB/HR	2,807,000	2,750,000
- INLET TEMPERATURE	°F	51.69	51.49
- INLET PRESSURE	PSIA	135.49	91.77
- PRESSURE DROP	PSI	1.46	0.39
- OUTLET TEMPERATURE	°F	72.22	51.27
- VAPOR QUALITY	--	0.970 (out)	0.964 (in)
● SEAWATER SIDE			
- FLOW	LB/HR	369,140,000	348,920,000
- INLET TEMPERATURE	°F	82.0	40.0
- OUTLET TEMPERATURE	°F	77.91	44.19
- PRESSURE DROP	PSI	2.56	2.44
- "TUBE" DIAMETER (I.D.)	IN	0.75	0.75
- VELOCITY IN "TUBE"	FT/SEC	6.42	6.05
- NUMBER OF "TUBES"	--	81,600	81,600
● OVERALL DESIGN			
- NUMBER OF PANELS ⁽²⁾	--	16 X 204	16 X 204
- HEAT TRANSFER AREA ⁽³⁾	FT ²	245,670	245,670
- HEAT TRANSFERRED	MBTU/HR ⁽⁵⁾	1,444	1,395
- OVERALL H.T. COEFF. U ⁽⁴⁾	BTU/HR-FT ² F	819.7	622.6
- AMMONIA H.T. COEFF. h ⁽³⁾	BTU/HR-FT ² F	5,725	2,230
- TUBE WALL H.T. COEFF. h ⁽⁴⁾	BTU/HR-FT ² F	25,567	25,567
- WATER H.T. COEFF. h ⁽⁴⁾	BTU/HR-FT ² F	1,368	1,148
- FOULING FACTOR ⁽⁴⁾	HR-FT ² F/BTU	0.0003	0.0003
- MEAN TEMPERATURE DIFFERENCE	°F	7.17	9.12

NOTES: (1) BASED ON REVISED BASELINE OF 2/7/79

(2) 100 "TUBES" PER PANEL

(3) BASED ON AMMONIA SIDE

(4) BASED ON WATERSIDE

(5) MBTU = 10⁶ BTU 3-10

Figure 3: Typical Heat Exchanger Module

(0.625 MWe of each of 16)

3-11

3.2.2.3 Transportation, Handling and Installation. The design shall incorporate the necessary heat exchanger mountings to provide for secure, safe handling during fabrication, test, transportation, installation, and removal. All heat exchanger mountings such as lifting lugs, etc., intended to carry loadings shall be permanently secured to the heat exchanger. The exchangers shall be capable of being lifted vertically and of being repositioned without applying torque to the module. Every module will have the required protective devices and procedures established to minimize the probability of any damage to the equipment and to prevent contamination with water, dust, rust, etc., during any phase of transportation, handling or operation.

Any and all restrictions that this design might impose during the handling/transportation of this product (s) shall be identified. The modules (with any handling devices) shall be identified with data such as weight, center of gravity, restrictions as to methods of lifting, any restrictions such as "Do not rotate," "This end up only," etc., restrictions relating to acceleration/deceleration rates for lifting, lowering, any restrictions for anti-vibration, g-loading, etc.

The heat exchanger shall be designed to withstand the static and dynamic stresses imposed by support and handling operations. It shall be demonstrated by test that the heat exchanger modules when loaded at the maximum design and with the lifting arrangements provided, has a behavior when lifted which is stable and controllable. This demonstration test shall be made either in the presence of a Coast Guard inspector or by a testing agency acceptable to the Commandant for this purpose.

3.2.2.4 Relief Valves. Relief valves will be in the header manifolds and supplied/selected by TRW.

3.2.2.5 Removal of Non-Condensables. Provisions to remove non-condensables during start-up and operation shall be incorporated in the design. Particular attention shall be given to removal of non-condensables from dead pockets and enclosed areas.

3.2.2.6 Removal of Non-Evaporables. Provisions to remove non-evaporables during start-up and operation shall be incorporated in the design.

3.2.2.7 Biofouling Control. The heat exchangers shall be compatible with the biofouling control subsystem referenced herein.

3.2.2.8 Seawater Passages (Tubes). Heat exchanger seawater passages (tubes) shall be compatible with the TRW tube cleaning approach. To permit indexing and operation of the tube cleaning equipment of the TRW biofouling control subsystem, the tubes shall be spaced at equal intervals or at multiples of equal intervals, on a triangular pitch. The seawater tubes of the modules arranged in series shall be aligned within $\pm 1/8$ inch for each module and within $\pm 1/4$ inch for each subassembly of four modules in series.

3.2.2.9 Instrumentation. Instrumentation will be the responsibility of TRW. Evaporator and condenser temperature sensors will be located in connecting piping supplied by TRW. Ammonia quality at evaporator outlet shall be measured at the inlet to the separators supplied by TRW. Seawater temperature and pressure measurements are external to the heat exchangers and will be supplied by TRW. Attachments for evaporator pressure sensors shall be provided: one sensor at the top of the panels in the upper manifold header and one sensor at the bottom of the panels. Attachments for condenser pressure sensors shall be provided at the upper manifold and also at the condenser sump. These attachments shall be provided by the heat exchanger manufacturer.

3.2.3 Reliability and Maintainability

3.2.3.1 Reliability Allocation. The design shall meet, or be better than, a mean-time-between-failure (MTBF) allocation of 11,500 hours for each heat exchanger.

3.2.3.2 Maintainability Allocation. The design shall meet, or be better than, a mean-time-to-repair (MTTR) allocation of 55 hours for each heat exchanger. MTTR shall include isolation of the fault to the lowest replaceable unit, replacement with a serviceable unit, and verification of correct operation.

3.2.3.4 Downtime. Provisions shall be made for periodic maintenance during power plant downtimes.

3.2.4 Environmental Conditions. The heat exchangers shall be designed to operate in the environmental conditions described in the following paragraphs. Design life goals are:

- a. 15-year life.
- b. 1000 start/stop cycles in 30-year period
- c. 8000 hours of operation per year.

3.2.4.1 Operational Environment. The heat exchangers shall be able to operate and meet performance requirements in the following ocean-based environment:

- a. 65⁰ to 110⁰F ambient air temperature.
- b. 40 to 100 percent relative humidity.
- c. OTEC Pilot Plantship nominal periods, and maximum vertical and horizontal accelerations and angular motions are as follows for Sea State 6:
 - 1) Period: 14 sec
 - 2) Vertical Direction: 0.3 g
 - 3) Horizontal Direction: 0.15 g
 - 4) Pitch: 5⁰
 - 5) Roll: 12⁰

3.2.4.2 Non-Operational Environment. During shutdown, the heat exchangers shall be able to withstand the following ocean-based environmental conditions without degradation:

- a. 0 to 125⁰F ambient air temperature.
- b. 0 to 100 percent relative humidity.
- c. Sea motion of Sea State 9 magnitude. Sea State 9 has a significant wave height of 80 feet, resulting in a vertical acceleration of ± 0.5 g and a horizontal acceleration of ± 0.5 g.

3.2.5 Corrosion Resistance. Surfaces exposed to seawater shall not suffer excessive corrosion or pitting due to the corrosive effects of seawater

organisms. A suitable corrosion/erosion allowance shall be provided on the materials of construction to meet the service life requirement.

Surfaces exposed to ammonia shall be resistant to both dry and hydrated ammonia.

3.2.6 Transportability. The exchanger modules shall be designed to be transported by common carrier. If necessary, special packaging may be required to assure that transportation methods will not impose design penalties. Lifting lugs shall be included in the design.

3.3 Design and Construction. The design will incorporate supporting features between two plates of panel to provide for shipping and to uphold external water pressure during upsets in which ammonia pressure may be lost.

The heat exchanger shall incorporate features to electrically isolate it from surrounding dissimilar metal.

3.3.1 Materials, Processes, and Parts. Materials used in fabrication of the exchangers shall have adequate corrosion resistance for the environmental conditions defined in the Specification in accordance with BPV-II. Welding shall be in accordance with BPV-IX. All construction shall be compatible with the environmental requirements of this Specification and comply with BPV-VIII, Division 1 and CG-115.

3.3.2 Cleanliness. The exchangers shall be thoroughly cleaned during fabrication and assembly to remove all contaminants.

3.3.3 Safety. The heat exchangers shall be designed for welded connections to ammonia ducts. The leakage of ammonia shall be minimized by proper design. Relief valves shall be set to prevent a pressure build-up exceeding the design pressure in accordance with CG-115, Section 54.15.

4. QUALITY ASSURANCE PROVISIONS

Compliance with all requirements of Section 3 shall be demonstrated by the methods listed in Table 2 or by a TRW approved substitute technique. The manufacturer shall have and maintain a quality control system which will establish that all Code requirements will be met per Appendix X, Quality Control System, Section VIII, Division 1, ASME Boiler and Pressure Vessel Code.

The requirements of Section 3 shall be by examinations, demonstrations, tests, or analyses. Table 2 provides a matrix of Section 3 requirements versus qualification methods. Definition of examination, demonstration, test or analysis is as follows:

- a. Examination is an element of inspection consisting of investigation, without the use of special laboratory appliances or procedures, or supplies and services to determine conformance to those specified requirements which can be determined by such investigation. Examination is generally nondestructive and includes, but is not limited to, visual, auditory, olfactory, tactile, gustatory, and other investigations; simple physical manipulation; gauging, and measurement.
- b. Test is an element of inspection denoting the determination of the properties or elements of supplies (or components thereof) by technical means, including functional operations and the application of established principles and procedures. The analysis of data derived from test is an integral part of the inspection element, and shall not be confused with 4.d.
- c. Demonstration is an element of inspection that, although technically a variation of test, differs from 4.b by directness of approach in the verification of a requirement (s), and is accomplished without the use of elaborate instrumentation or special equipment. Thus, operation of a representative configuration item (CI) in, or near its use-environment (e.g., ability of a truck to climb a one-half mile, 5% grade, from standstill in the required time) would be defined as a "demonstration" rather than a "test".
- d. Analysis is an element of inspection in the form of study, resulting in data, that is intended to verify a requirement (s) when an examination, test, or demonstration cannot feasibly be employed to verify that requirement (s) at the inspection level demanded by this specification. Such data may be comprised of a compilation or interpretation of existing data or design solutions, or derived from original lower-level inspections or both. Data may be interpolated or extrapolated, as applicable. This would include data derived from fault-free analysis, and failure modes and effects analysis.

5. PREPARATION FOR DELIVERY

Not Applicable.

6. NOTES

None.

Table 2. Methods for Proving Quality Compliance

Paragraph		A	D	E	T
3.2.1.1	Evaporator Performance	X			
3.2.1.2	Condenser Performance	X			
3.2.2	Physical Characteristics			X	
3.2.2.1	Design Life	X			
3.2.2.2	Envelope			X	
3.2.2.3	Transportation, Handling, and Installation		X		
3.2.2.5	Removal of Non-Condensables	X	X	X	
3.2.2.6	Biofouling Control			X	
3.2.2.7	Seawater Passages (Tubes)			X	
3.2.2.8	Instrumentation			X	
3.2.3	Maintainability	X		X	
3.2.3.1	Availability & Reliability	X			
3.2.4	Environmental Conditions	X	X		
3.2.5	Corrosion Resistance			X	
3.2.6	Transportability	X	X		
3.3.1	Materials, Processes, & Parts	X		X	
3.3.2	Cleanliness			X	
3.3.3	Safety			X	

Abbreviations: A = Analysis D = Demonstration
 E = Examination T = Test

4. NITROGEN STORAGE CONDITIONING AND SUPPLY SUBSYSTEM SPECIFICATION

DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

FSCM NO. 11982

TITLE

REQUIREMENTS SPECIFICATION

NITROGEN STORAGE, CONDITIONING AND SUPPLY SUBSYSTEM

10 MWe POWER SYSTEM MODULE PSD-II

DATE 13 April 1979

NO. SS14-60

SUPERSEDING: _____

PREPARED BY:

R.O. Pearson

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APPROVAL SIGNATURES:

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DATE

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TRW
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REVISION RECORD

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REQUIREMENTS SPECIFICATION
NITROGEN STORAGE, CONDITIONING AND SUPPLY SUBSYSTEM
10 MWe POWER SYSTEM MODULE PSD-II

1. SCOPE

1.1 This specification establishes the performance, design, and test requirements for the Nitrogen Storage, Conditioning and Supply Subsystem used in the Ocean Thermal Energy Conversion (OTEC) 10 MWe Power System Module (PSM), Power System Development Project II (PSD-II)

2. APPLICABLE DOCUMENTS

2.1 Government Documents: The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

STANDARDS

Occupational Safety and Health Administration (OSHA)

1910.11 Storage and Handling of Anhydrous Ammonia

REGULATIONS

National Bureau of Standards (NBS)

Circular 142 Tables of Thermodynamic Properties of Ammonia

16 April 1923

Coast Guard (CG)

115 Marine Engineering Regulations

1 August 1977

123 Rules and Regulations for Tank Vessels

1 August 1977

174 A Manual for the Safe Handling of Flammable and
1 Sept 1977 Combustible Liquids and Other Hazardous Products

259 Electrical Engineering Regulations

1 July 1977

2.2 Non-Government Documents: The following documents of the exact issue (of the latest date if an exact issue is not shown) form a part of this specification to the extent specified herein. In the event of conflict between these documents and this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS

American Society for Testing and Materials (ASTM)

A53	Welded and Seamless Steel Pipe
A105	Forged or Rolled Steel Pipe Flanges, Forged Fittings and Valves, and Parts for High Temperature Service
A106	Seamless Carbon Steel Pipe for High Temperature Service
A181	Forged or Rolled Steel Pipe Fittings, Forged Fittings and Valves, and Parts for General Service
A193	Alloy Steel Bolting Materials for High Temperature Service
A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
A234	Factory-Made Wrought Carbon Steel and Ferritic Alloy Steel Welding Fittings
A333	Seamless and Welded Steel Pipe for Low Temperature Service
A350	Forged or Rolled Carbon and Carbon Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Low Temperature Service
A420	Factory-Made Wrought Carbon Steel and Alloy Steel Welding Fittings and Seamless Welded Construction for Low Temperature Service
B337	Seamless and Welded Titanium Pipe
B363	Seamless and Welded Unalloyed Titanium Welding Fittings

TRW DSSG

SY14-5	System Specification, OTEC 10 MWe Power System Module PSD-II
SS14-61	Ammonia Storage, Conditioning and Supply Subsystem, PSD-II

STANDARDS

American National Standards Institute (ANSI)

B16.5	Steel Pipe Flanges, Flanged Valves and Fittings
B16.9	Factory-Made Wrought Steel Welding Fittings
B16.11	Forged Steel Fittings, Socket Welding and Threaded
B16.25	Butt Welding Ends
B18.2.1	Square and Hexagonal Head Bolts and Screws, Including Askew Head Bolts, Hexagonal Cap Screws, and Lag Screws
B18.2.2	Square and Hexagonal Nuts
B31.3-1976	Chemical Power Plant and Petroleum Refinery Piping

American Society of Mechanical Engineers (ASME)

BPV-VIII 1 July 1977	Boiler and Pressure Vessel Code, Section VIII, Divisions 1 and 2
BPV-IX	Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications

National Electrical Manufacturers Association (NEMA)

MG-1972 14 Oct 1977	Motors and Generators
------------------------	-----------------------

National Fire Protection Association (NFPA)

70-1978 August 1977	National Electrical Code
------------------------	--------------------------

3. REQUIREMENTS

3.1 Subsystem Definition. The Nitrogen Storage, Conditioning and Supply Subsystem is a major subsystem of the 10 MWe PSM (defined in SY14-5).

The major components include a liquid nitrogen transport tank, a liquid nitrogen storage tank and a nitrogen vaporizer.

3.1.1 Subsystem Diagram. A functional type of process flow diagram is presented in Figure 1. As shown liquid nitrogen is pumped from a transport tank to a storage tank. From storage, the liquid nitrogen flows to a vaporizer which converts liquid nitrogen to gas to be used for purging.

3.1.2 Interface Definition. This subsystem will interface with Ships Systems and the following PSM subsystems:

- a. Ammonia Power Loop
- b. Electrical Power Distribution and Control
- c. Instrumentation and Control
- d. Ammonia Storage, Conditioning and Supply

3.1.2.1 Functional. The Figure 2 piping and instrumentation diagram identifies the functional interfaces with Ships Systems and PSM Subsystems.

3.1.2.2 Physical.

3.1.2.2.1 Ships Systems. The subsystem will be located in the Plant Ship in the space between elevations 4 and 65, transverse frames 80 and 160, and longitudinal frames F and G as shown in Figure 3.

Bulkhead conduit interfaces will be as identified in Figures 4 and 5.

3.1.2.2.2 PSM Subsystems. Interface piping sizes are indicated in Figure 2 and header locations are identified in Figures 4 and 5.

3.1.3 Major Component List. The major components of the Nitrogen Storage, Conditioning, and Supply Subsystem consist of the following.

- a. Transport Tank
- b. Storage Tank
- c. Vaporizer

3.2 Characteristics.

3.2.1 Performance. The Nitrogen Storage, Conditioning, and Supply Subsystem shall be sized to support a 10 MWe PSD-II Power System Module. The subsystem shall be designed for continuous operation with capability to cope with anticipated emergencies and routine maintenance.

FIGURE 1 - NITROGEN SUBSYSTEM PROCESS FLOW DIAGRAM

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NOTES

1. REFER TO 46 CFR (CODE OF FEDERAL REGULATIONS) FOR ALL EQUIPMENT ON THIS P&I FLOW DIAGRAM
2. ALL MODULATING DIAPHRAGM CONTROL VALVES HAVE AN INTEGRAL ELECTRO-PNEUMATIC TRANSDUCER
3. ALL LIQUID NITROGEN LINES ARE INSULATED
4. THE INSTRUMENTATION & CONTROL OF THE LIQUID NITROGEN SHIPPING TANK D-107 IS NOT SHOWN. HOWEVER, IT IS IDENTICAL TO THAT SHOWN ON THE NITROGEN STORAGE TANK D-106.

ALHAMBRA C F BRAUN & CO CALIFORNIA		REV	DATE	REVISION	BY	APPD
DESIGNED	By Rel	OTEC POWER SYSTEM DEVELOPMENT - II				
DRAWN	TERRELL	TRW				
CHECKED	J. J. J.	DRAWING NUMBER				
APPROVED		6850.94-09				
PROG OFFICE		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY				
RELEASED BY		ISSUE DATE		5-9-79		

Figure 2 5A

SECTION A
SCALE: 1/8"=1'-0" 13 R.R. 11

1/8" = 1'-0"
SCALE
0 5 10 15 20
FEET

PIPING PLAN
ELEVATION 48'-0" BELOW
SCALE: 1/8"=1'-0"

DESIGNED BY: PEG BROWN	OTEC POWER SYSTEM DEVELOPMENT - II	DATE	REVISION	BY	APPD
DRAWN BY: PEG BROWN					
CHECKED BY: [Signature]					
APPROVED BY: [Signature]					
PROJ. OFFICE: P.J. [Signature]	10 MW. POWER MODULE GENERAL ARRANGEMENT SECTION 4 PLAN	FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			
		6050.94-13			
		5-1-79			

Figure 3 58

NOTES:

- SEAWATER DISCHARGE OPENINGS IN EFFLUENT DISCHARGE PLENUM SHALL BE SIZED IDENTICALLY WITH SEAWATER OPENINGS IN WATER TROUGHS AND LOCATED ON SAME CENTERLINE.
- PIPE MATERIALS SHALL BE ASTM A 106 GR. B OR C, ASTM A 333 GR. 6 OR ASTM A 516 GR. 70
- PIPE MATERIAL WALL THICKNESSES ARE AS FOLLOWS:

PIPE SIZE	WALL THICKNESS
20" AND BELOW	STANDARD WEIGHT
24" - 36"	5/8" (.375)
- ALL PIPE ENDS SHALL TERMINATE 1'-0" FROM WALLS UNLESS OTHERWISE NOTED AND SHALL BE PREPARED FOR WELDING IN ACCORDANCE WITH ANSI PIPING CODE B31.8
- UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND INCHES WITH TOLERANCES AS FOLLOWS:
 LINEAR DIMENSIONS $\pm 1/4"$, ANGULAR DIMENSIONS $\pm 1^\circ$
- POWER/SHIP INTERFACE CONTROL DRAWING SET INCLUDES 6850.94-05 AND 6850.94-06.
- 10 MW_e POWER PLANT EQUIPMENT ROOM LOCATED BETWEEN TRANSVERSE FRAMES 50 AND 160, LONGITUDINAL FRAMES B AND F, AND ELEVATIONS B.L. AND 89'. INSTALLED EQUIPMENT WEIGHT 1,150,000 LBS.
- ELECTRICAL EQUIPMENT AND CONTROL ROOM LOCATED BETWEEN TRANSVERSE FRAMES 50 AND 160, LONGITUDINAL FRAMES A AND B AND ELEVATIONS 77' AND 89'. INSTALLED EQUIPMENT WEIGHT 30,000 LBS.
- NH₃/N₂ SUPPORT SUBSYSTEM EQUIPMENT ROOM LOCATED BETWEEN TRANSVERSE FRAMES 50 AND 160, LONGITUDINAL FRAMES F AND G, AND ELEVATIONS B.L. AND 65'. INSTALLED EQUIPMENT WEIGHT 590,000 LBS. DRY. MAXIMUM OPERATING WEIGHT 1,100,000 LBS. WET.

PLAN
EL. 80' AND BELOW
SCALE 1/8" = 1'-0"

1/8" = 1'-0"
SCALE
5 0 5 10 15 20
FEET

DESIGNED BY P.B. BROWN
 DRAWN BY P.B. BROWN
 CHECKED BY R.O. PETERSON
 APPROVAL
 RELEASED BY J.E. 7/2/79
 PROJ. OFFICE

OTEC POWER SYSTEM DEVELOPMENT - II
 10 MW_e POWER MODULE
 POWER/SHIP SYSTEM INTERFACES
 PLAN

REV	DATE	REVISION	BY	APP
1				
DRAWING NUMBER 6850.94-05				
FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			ISSUE DATE 5-9-79	CHK LTR

Figure 4 5C

1/8" = 1'-0"
SCALE
FEET

DESIGNED BY: P. J. BROWN
DRAWN BY: P. J. BROWN
CHECKED BY: R. J. BROWN
APPROVED BY: P. J. BROWN
PROJECT OFFICE: P. J. BROWN

OTEC POWER SYSTEM DEVELOPMENT - II
10 MW_e POWER MODULE
POWER/SHIP SYSTEM INTERFACES
SECTIONS

DATE	REVISION	BY	APPV
5-7-79	1	P. J. BROWN	

6850.94-06
FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY
ISSUE DATE: 5-7-79
ONE LTR

Figure 5 5D

3.2.1.1 The Nitrogen Storage, Conditioning and Supply Subsystem shall provide nitrogen gas for purging the PSM ammonia loop at a pressure of at least 70 psig during startup and shutdown cycles. Nitrogen storage shall be provided to obtain three complete startup and shutdown cycles with the following purge requirements:

- a. A startup cycle shall require no less than three PSM ammonia loop volume changes with nitrogen, to remove air from the system prior to charging the system with ammonia to avoid flammable mixtures of air and ammonia.
- b. A shutdown cycle shall require no less than three PSM ammonia loop volume changes with nitrogen to remove ammonia from the system prior to breaking into the ammonia loop to avoid flammable mixtures of air and ammonia.

3.2.1.2 Storage. The subsystem shall have the capacity to store 11,000 gallons of liquid nitrogen at 250 psig.

3.2.1.3 Transportation. The nitrogen transport tank shall be sized at 8000 gallons of liquid nitrogen at 26 psig.

3.2.1.4 Unloading. The subsystem shall be capable of unloading liquid nitrogen at 100 gpm into storage at a pressure of 250 psig.

3.2.1.5 Vaporization. The subsystem shall be able to vaporize and heat liquid nitrogen at the rate of 120 pounds per minute. The gaseous nitrogen shall be at 70°F and 175 psig.

3.2.2 Physical Characteristics.

3.2.2.1 Weight. The subsystem weight shall not exceed 55 tons wet (operating).

3.2.2.2 Size. The installed subsystem shall not exceed the envelope indicated in Figure 3.

3.2.2.3 Lift Points. The subsystem components shall have lift points to facilitate installation, removal and handling by shipboard crane.

3.2.2.4 Durability. The subsystem shall be sufficiently durable to operate normally in a surface vessel under Sea State 6 conditions, and shall survive in a secured condition in Sea State 9.

3.2.3 Reliability.

3.2.3.1 Redundancy. The subsystem design shall include redundancy as required to ensure continuity of key functions, as well as fail-safe operations.

3.2.3.2 Subsystem Starting. Subsystem starting reliability (successful starts divided by attempted starts) shall be 95 percent at a 60 percent confidence level.

3.2.3.3 Allocation. The subsystem shall meet, or be better than, a mean-time-between-failure (MTBF) allocation of 88,000 hours.

3.2.4 Maintainability.

3.2.4.1 Allocation. The subsystem shall meet, or be better than, a mean-time-to-repair (MTTR) allocation of 24 hours. MTTR shall include isolation of the fault to the lowest replaceable unit, replacement with a serviceable unit, and verification of correct operation.

3.2.4.2 Downtime. Provisions shall be made for periodic maintenance during power plant downtimes.

3.2.5 Availability. Availability shall be at least 90 percent at 60 percent confidence level; over a 30 year life, after an initial checkout period.

3.2.6 Environmental Conditions. The subsystem shall be designed to operate in the environmental conditions described in the following paragraphs. Design life goals are:

- a. 30-year life
- b. 1000 start/stop cycles
- c. 8000 hours of operation per year

3.2.6.1 Operational Environment. The subsystem shall be able to operate and meet performance requirements in the following ocean-based environment:

- a. 65 to 100°F ambient air temperature
- b. 40 to 100 percent relative humidity
- c. Sea water design and off-design temperatures specified in 3.1.4.1.2 of SY14-5.

- d. OTEC Pilot Plantship nominal periods, and maximum vertical and horizontal accelerations and angular motions are as follows for Sea State 6:

1) Period	:	14 sec
2) Vertical Direction	:	0.3g
3) Horizontal Direction	:	0.15g
4) Pitch	:	5°
5) Roll	:	12°

3.2.6.2 Non-Operational Environment. During shutdown, the Sub System shall be able to withstand the following ocean-based environmental conditions without degradation:

- a. 0 to 125°F ambient air temperature
- b. 0 to 100 percent relative humidity
- c. Sea motion of Sea State 9 magnitude. Sea State 9 has a significant wave height of 80 feet, resulting in a vertical acceleration of $\pm 0.5g$ and a horizontal acceleration of $\pm 0.5g$.

3.2.7 Transportability. Subsystem components shall be designed to be transported by common carrier with a minimum of protection. If necessary, special packaging may be required to assure that transportation methods will not impose design penalties. Special equipment required for handling, installation, servicing, or operation shall be identified in subsystem design specifications.

3.3 Design and Construction. The subsystem shall be designed and constructed to perform in accordance with the functional and environmental requirements of this specification.

3.3.1 Materials, Processes and Parts. All parts shall comply with the applicable codes of BPV-VIII and CG 115.

3.3.1.1 Nitrogen Piping Materials

Pipe, ASTM A53, Grade B, Seamless
 1/2" through 1-1/2" - Schedule 80
 2" through 10" - Schedule 40

Fittings, ASTM A234, Grade WPB, Carbon Steel
 1/2" through 2" - 3000# Socketweld
 3" through 10: - Std Wt, Butt weld

Flanges, ASTM A105, 150 lb, RF, Carbon Steel
 1/2" through 2" - Socketweld
 3" through 10" - Weldneck

Bolting, ASTM A193 Grade B7 W/A194 Grade 2H Nuts

Valves, Carbon Steel, Cast or Forged
 1/2" through 2" - 800# Socketweld
 3" through 10" - 150#, RF, Flanged
 (For tight shutoff, use ball type or sleeve
 type plug valves)

3.3.1 Sea Water Piping Materials.

Pipe, Titanium ASTM B337, Grade 2
 1/2" through 1" - Schedule 40, Seamless
 1-1/2" through 4" - Schedule 10S, Seamless
 6" through 10" - Schedule 10S, Welded

Fittings, Titanium ASTM B363, Grade WPT2, Butt weld
 1/2" through 1" - Schedule 40
 1-1/2" through 10" - Schedule 10S

Flanges, ASTM A105, Carbon Steel, Lap Joint, Galvanized
 all sizes

Bolting, ASTM A307, Grade B, Galvanized Valves
 1/2" through 2" - 150# Flanged, Cast Iron
 Polypropylene Lined Body, EPC
 Diaphragm, Hills-McCanna or equal
 3" through 10" - 150# Butterfly, Ductile Iron Lug
 Type Body, Duna-N Seat, 416 SS Stem,
 Kynar Coated Disc, DEMCO or equal

3.3.2 Nameplates and Product Marking. Nameplates and product marking requirements shall be in accordance with standard industrial practice.

3.3.3 Workmanship. The subsystem shall be fabricated, finished, and assembled in accordance with normal standards for high quality workmanship.

3.3.4 Interchangeability. Each item within the subsystem shall be directly interchangeable for form, fit, and function with other items of the same part number with a minimum of adjustment or re-calibration.

3.3.5 Safety. The subsystem shall be designed and constructed to meet the health and safety criteria specified in OSHA 1910.11 and electrical equipment location Class I, Group D, Division 1 specified in NEMA MG-1972 and NFPA 70-1978.

a. Restrictive Use of Mercury

Ammonia reacts with mercury to form an explosive compound. Therefore, equipment, components, instruments containing mercury shall not be used in applications wherein ammonia and mercury could react.

b. Flammable, Toxic, and Unstable Materials

Flammable, toxic, and unstable materials shall not be used.

c. Finish

The surfaces of each equipment/component of the PSD-II system shall be adequately finished to prevent deterioration from exposure to the specified environments that might jeopardize fulfillment of the specified performance.

d. Relief Valves

Relief valves shall be set to prevent a pressure build-up exceeding the system design pressures in accordance with CG-257, Section 98.25-60.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. Inspections shall be conducted during the design and development of the subsystem to provide DOE with assurance of compliance with the requirements of this specification.

4.1.1 Responsibility for Tests. Each supplier of a major component of the subsystem shall be responsible for developing and conducting the tests and inspections required to demonstrate that this equipment will perform as specified. The system contractor is responsible for review and approval of test plans and procedures and for monitoring test activities as necessary to verify that the test program meets applicable requirements.

4.2 Quality Conformance Inspections. Qualification shall be performed on subsystem components that are representative of the approved production design. Qualification of the subsystem to assure compliance with the requirements of section 3 shall be by examinations, demonstrations, tests, or analyses. Table 1 provides a matrix of section 3 requirements versus qualification methods. Definition of examination, demonstration, test or analysis is as follows:

- a. Examination is an element of inspection consisting of investigation, without the use of special laboratory appliances or procedures, or supplies and services to determine conformance to those specified requirements which can be

TABLE 1 - QUALITY CONFORMANCE METHODS

SECTION 3 PARAGRAPH		METHOD			
		EXAM	DEMO	TEST	ANAL
3.2	Characteristics				
3.2.1	Performance				
3.2.1.1	Nitrogen Storage, Condition & Supply				X
3.2.1.2	Storage	X			
3.2.1.3	Transportation	X			
3.2.1.4	Unloading		X		
3.2.1.5	Vaporization			X	
3.2.2	Physical Characteristics				
3.2.2.1	Weight	X			X
3.2.2.2	Size	X			
3.2.2.3	Lift Points	X			
3.2.2.4	Durability	X			X
3.2.3	Reliability				
3.2.3.1	Redundancy				X
3.2.3.2	Subsystem Starting				X
3.2.3.3	Allocation				X
3.2.4	Maintainability				
3.2.4.1	Allocation				
3.2.4.2	Downtime				X
3.2.5	Availability				X
3.2.6	Environmental Conditions				
3.2.6.1	Operational Environment			X	
3.2.6.2	Non-Operational Environment			X	
3.2.7	Transportability	X			
3.3	Design and Construction	X			
3.3.1	Materials, Processes and Parts	X			
3.3.1.1	Nitrogen Piping Materials	X			
3.3.1.2	Sea Water Piping Materials	X			
3.3.2	Nameplates	X			
3.3.3	Workmanship	X			
3.3.4	Interchangeability	X			
3.3.5	Safety	X			X

determined by such investigation. Examination is generally nondestructive and includes, but is not limited to, visual auditory, olfactory, tactile, gustatory, and other investigations; simple physical manipulation; gauging, and measurement.

- b. Test is an element of inspection denoting the determination of the properties or elements of supplies (or components thereof) by technical means, including functional operations and the application of established principles and procedures. The analysis of data derived from test is an integral part of the inspection element, and shall not be confused with 4.2.d.
- c. Demonstration is an element of inspection that, although technically a variation of test, differs from 4.2.b by directness of approach in the verification of a requirement(s), and is accomplished without the use of elaborate instrumentation or special equipment. Thus, operation of a representative configuration item (CI) in, or near its use-environment (e.g., ability of a truck to climb a one-half mile, 5 percent grade, from standstill in the required time) would be defined as a "demonstration" rather than a "test."
- d. Analysis is an element of inspection in the form of study, resulting in data, that is intended to verify a requirement(s) when an examination, test, or demonstration cannot feasibly be employed to verify that requirement(s) at the inspection level demanded by this specification. Such data may be comprised of a compilation or interpretation of existing data or design solutions, or derived from original lower-level inspections, or both. Data may be interpolated or extrapolated, as applicable. This would include data derived from fault-tree analysis and failure modes and effects analysis.

5. PREPARATION FOR DELIVERY

Not applicable. The subsystem is not delivered as a system. Its major components are delivered to the containment vessel as separate items, then the subsystem is assembled on board.

6. NOTES

6.1 Intended Use. The subsystem is intended to be used to support a 10 MWe PSM. The first PSM will be used as a test article to evaluate and prove the design, to demonstrate the economic parameters of the concept as installed in the APL/JHU OTEC Pilot Plantship.

6.2 Definitions.

6.2.1 Ships Systems are defined as those elements of an OTEC Plantship provided by others to support the Subsystem specified herein. Ships Systems elements include the hull, crew quarters, ship's auxiliaries, cold water pipe, station-keeping, effluent discharge pipes, and cold and warm sea water pump subsystems.

5. AMMONIA STORAGE CONDITIONING AND SUPPLY SUBSYSTEM SPECIFICATION

TRW

DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

FSCM NO. 11982

TITLE

REQUIREMENTS SPECIFICATION

AMMONIA STORAGE, CONDITIONING AND SUPPLY SUBSYSTEM

10 MWe POWER SYSTEM MODULE PSD-II

DATE 13 April 1979

NO. SS14-61

SUPERSEDING: _____

PREPARED BY:

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APPROVAL SIGNATURES:

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REQUIREMENTS SPECIFICATION
AMMONIA STORAGE, CONDITIONING AND SUPPLY SUBSYSTEM
10MWe POWER SYSTEM MODULE PSD-II

1. SCOPE

1.1 This specification establishes the performance, design, and test requirements for the Ammonia Storage, Conditioning and Supply Subsystem used in the Ocean Thermal Energy Conversion (OTEC) 10 MWe Power System Module (PSM), Power System Development Project II (PSD-II)

2. APPLICABLE DOCUMENTS

2.1 Government Documents: The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

STANDARDS

Occupational Safety and Health Administration (OSHA)
1910.11 Storage and Handling of Anhydrous Ammonia

REGULATIONS

National Bureau of Standards (NBS)
Circular 142 Tables of Thermodynamic Properties of Ammonia
16 April 1923

Coast Guard (CG)
115 Marine Engineering Regulations
1 August 1977

123 Rules and Regulations for Tank Vessels
1 August 1977

174 A Manual for the Safe Handling of Flammable and
1 Sept 1977 Combustible Liquids and Other Hazardous Products

259 Electrical Engineering Regulations
1 July 1977

2.2 Non-Government Documents: The following documents of the exact issue (or the latest date if an exact issue is not shown) form a part of this specification to the extent specified herein. In the event of conflict between these documents and this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS

American Society for Testing and Materials (ASTM)

A53	Welded and Seamless Steel Pipe
A105	Forged or Rolled Steel Pipe Flanges, Forged Fittings and Valves, and Parts for High Temperature Service
A106	Seamless Carbon Steel Pipe for High Temperature Service
A101	Forged or Rolled Steel Pipe Fittings, Forged Fittings and Valves, and Parts for General Service
A193	Alloy Steel Bolting Materials for High Temperature Service
A194	Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
A234	Factory-Made Wrought Carbon Steel and Ferritic Alloy Steel Welding Fittings
A333	Seamless and Welded Steel Pipe for Low Temperature Service
A350	Forged or Rolled Carbon and Carbon Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for Low Temperature Service
A420	Factory-Made Wrought Carbon Steel and Alloy Steel Welding Fittings and Seamless Welded Construction for Low Temperature Service
B337	Seamless and Welded Titanium Pipe
B363	Seamless and Welded Unalloyed Titanium Welding Fittings

TRW DSSG
SY14-5

System Specification, OTEC 10 MWe Power System Module PSD-II

SS14-60

Nitrogen Storage, Conditioning and Supply Subsystem, PSD-II

STANDARDS

American National Standards Institute (ANSI)

B16.5	Steel Pipe Flanges, Flanged Valves and Fittings
B16.9	Factory-Made Wrought Steel Welding Fittings
B16.11	Forged Steel Fittings, Socket Welding and Threaded
B16.25	Butt Welding Ends
B18.2.1	Square and Hexagonal Head Bolts and Screws, Including Askew Head Bolts, Hexagonal Cap Screws, and Lag Screws
B18.2.2	Square and Hexagonal Nuts
B31.3-1976	Chemical Power Plant and Petroleum Refinery Piping

American Society of Mechanical Engineers (ASME)

BPV-VIII 1 July 1977	Boiler and Pressure Vessel Code, Section VIII, Divisions 1 and 2
BPV-IX	Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications

National Electrical Manufacturers Association (NEMA)

MG-1972 14 Oct 1977	Motors and Generators
------------------------	-----------------------

National Fire Protection Association (NFPA)

70-1978 August 1977	National Electrical Code
------------------------	--------------------------

3. REQUIREMENTS

3.1 Subsystem Definition. The Ammonia Storage, Conditioning and Supply Subsystem is a major Subsystem of the 10 MWe PSM (defined in SY14-5). The subsystem is a process unit for storage and handling of ammonia and is designed for safe containment and conditioning of ammonia with maximum recovery of ammonia consistent with minimum cost using modern industrial equipment and procedures.

The subsystem is designed to operate in the following operational modes.

- a. Startup from complete standstill
- b. Normal operation
- c. Normal shutdown
- d. Maintenance standby
- e. Restart from maintenance standby
- f. Emergency shutdown

The major components of the subsystem include the following.

- a. Equipment for transferring ammonia from transport barges into storage
- b. Storage facility
- c. Pumps
- d. Ammonia conditioning facility
- e. Ammonia recovery facility

3.1.1 Subsystem Diagram. A functional type of process flow diagram is presented in Figure 1. Ammonia is supplied from transport barges and stored. During operation, ammonia is supplied to the power loop as makeup. Ammonia is also recovered from vents, shaft seals, relief valves, etc., and returned to storage. Commercial ammonia contains water which must be removed before ammonia is sent to the power loop. The ammonia conditioning system does the task of removing the water and other trace impurities from the ammonia.

3.1.2 Interface Definition. This subsystem will interface with Ships Systems and the following PSM subsystems:

- a. Ammonia Power Loop
- b. Electrical Power Distribution and Control
- c. Instrumentation and Control
- d. Nitrogen Storage, Conditioning and Supply

3.1.2.1 Functional. The Figure 2 piping and instrumentation diagram identifies the functional interfaces with Ships Systems and PSM Subsystems.

3.1.2.2 Physical.

3.1.2.2.1 Ships Systems. The subsystem will be located in the Plant Ship in the space between elevations 4 and 65, transverse frames 80 and 160, and longitudinal frames F and G as shown in Figure 3.

Bulkhead conduit interfaces will be as identified in Figures 4 and 5.

3.1.2.2.2 PSM Subsystems. Interface piping sizes are indicated in Figure 2 and header locations are identified in Figures 4 and 5.

3.1.3 Major Component List. The major components of the Ammonia Storage, Conditioning, and Supply Subsystem consist of the following:

FIGURE 1 - AMMONIA SUBSYSTEM PROCESS FLOW DIAGRAM

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Figure 2

SECTION (A) 13 R&P 11
SCALE: 1/8" = 1'-0"

PIPING PLAN
ELEVATION 48'-6" ± BELOW
SCALE: 1/8" = 1'-0"

1/8" = 1'-0"
SCALE
0 5 10 15 20
FEET

DESIGNED BY: BROWN	OTEC POWER SYSTEM DEVELOPMENT - II	DATE: 5-12-79	REVISION: 1
DRAWN BY: BROWN	10 MWe POWER MODULE		
CHECKED BY: BROWN	GENERAL ARRANGEMENT		
APPROVED BY: [Signature]	SECTION & PLAN		
PROJ OFFICE: P.J. [Signature]			
		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY	5-12-79

NOTES:

- SEAWATER DISCHARGE OPENINGS IN EFFLUENT DISCHARGE PLENUM SHALL BE SIZED IDENTICALLY WITH SEAWATER OPENINGS IN WATER TIGHTS AND LOCATED ON SAME CENTERLINE.
- PIPE MATERIALS SHALL BE ASTM A 106 GR. B OR C, ASTM A 333 GR. 6 OR ASTM A 516 GR. 70
- PIPE MATERIAL WALL THICKNESSES ARE AS FOLLOWS:

PIPE SIZE	WALL THICKNESS
20" AND BELOW	STANDARD WEIGHT
24" - 36"	5/8" (.875)
- ALL PIPE ENDS SHALL TERMINATE 1'-0" FROM WALLS UNLESS OTHERWISE NOTED AND SHALL BE PREPARED FOR WELDING IN ACCORDANCE WITH ANSI PIPING CODE B31.3
- UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN FEET AND INCHES WITH TOLERANCES AS FOLLOWS:
 LINEAR DIMENSIONS: ± 1/4", ANGULAR DIMENSIONS: ± 1°
- POWER/SHIP INTERFACE CONTROL DRAWING SET INCLUDES 6850.94-05 AND 6850.94-06.
- 10 MW_e POWER PLANT EQUIPMENT ROOM LOCATED BETWEEN TRANSVERSE FRAMES 50 AND 160, LONGITUDINAL FRAMES B AND F, AND ELEVATIONS 8'-L AND 89'. INSTALLED EQUIPMENT WEIGHT 1,150,000 LBS.
- ELECTRICAL EQUIPMENT AND CONTROL ROOM LOCATED BETWEEN TRANSVERSE FRAMES 50 AND 160, LONGITUDINAL FRAMES A AND B, AND ELEVATIONS 77' AND 89'. INSTALLED EQUIPMENT WEIGHT 30,000 LBS.
- NH₃/N₂ SUPPORT SUBSYSTEM EQUIPMENT ROOM LOCATED BETWEEN TRANSVERSE FRAMES 50 AND 160, LONGITUDINAL FRAMES F AND G, AND ELEVATIONS 8'-L AND 65'. INSTALLED EQUIPMENT WEIGHT 530,000 LBS. DRY. MAXIMUM OPERATING WEIGHT 1,100,000 LBS. WET.

PLAN
 EL. 80' AND BELOW
 SCALE 1/8" = 1'-0"

DESIGNED BY: P. J. BROWN	OTEC POWER SYSTEM DEVELOPMENT - II		DATE	REVISION	BY	APP
DRAWN BY: P. J. BROWN	10 MW _e POWER MODULE		TRW			
CHECKED BY: P. J. BROWN	POWER/SHIP SYSTEM INTERFACES		6850.94-05			
APPROVED BY: [Signature]	PLAN		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			
PROJ. OFFICE: [Signature]			ISSUE DATE: 5-9-79			

Figure 4

Figure 5

a. Vessels for storage, receiving, and surge service.

Ammonia Heel Storage Drum
 Ammonia Wet Storage Drum
 Ammonia Dry Storage Drum
 Ammonia Reflux Accumulator
 Ammonia Blowdown Drum
 Recovered Ammonia Drum

b. Pumps

Blowdown pump
 Ammonia Transfer Pump
 Ammonia Column Feed Pump
 Reflux Pump
 Recovered Ammonia Pump
 Ammonia Blowdown Drum Pump

c. Ammonia Recovery Compressor

d. Exchangers

Ammonia Overhead Condenser
 Recovered Ammonia Condenser
 Ammonia Column Reboiler

e. Ammonia Purification Column

f. Vent Stack

3.2 Characteristics

3.2.1 Performance. The Ammonia Storage, Conditioning, and Supply Subsystem shall be sized to support a 10 MWe PSD-II Power System Module. The subsystem shall be designed for continuous operation with capability to cope with anticipated emergencies and routine maintenance.

3.2.1.1 Ammonia Storage, Conditioning and Supply. The subsystem shall supply ammonia to the Ammonia Power Loop Subsystem with no greater than 100 ppm of water. The ammonia stored shall provide a cumulative total of the following requirements:

- a. Ammonia vapor to obtain at least five Ammonia Power Loop, Evaporator and Condenser Subsystem volume changes at atmospheric pressure (for displacing nitrogen).
- b. One complete PSM inventory charge, minimum, with transfer charging capability of at least 90 minutes.
- c. Replenishment make-up ammonia to sustain at least 45 days of continuous operations with a make-up rate no greater than 170 lbs/hr.

3.2.1.2 Operational Modes.

3.2.1.2.1 Startup from Complete Standstill. The subsystem shall receive commercial ammonia of 99.5 to 99.8 percent purity from transport barges. It is assumed that the transport barges have pumps for transfer. Connection lines and valves shall be a part of this subsystem to place 86.955 gallons of ammonia in three storage drums. Suitable nitrogen purging shall accompany the transfer operation so that flammable mixtures of air and ammonia are never allowed to exist.

For startup, the PSM ammonia space is first purged with nitrogen, then 191,960 lbs of ammonia is pumped into the evaporator. During this initial charging of the power loop, the Heel Storage drum is emptied. Warm sea water evaporates and purifies the ammonia reducing its moisture content to ten ppm.

The heel remaining in the evaporator will contain approximately 2 percent water. The heel is transferred to the heel storage tank for later rectification to recover most of the ammonia. The power loop is now charged with purified ammonia and is ready for startup.

3.2.1.2.2 Normal Operation. The ammonia conditioning facility is operated continuously for four purposes.

- a. Recover dry ammonia from the heel
- b. Recover ammonia from vent
- c. Recover ammonia from the evaporator blowdown
- d. Provide dry ammonia make up to the power loop

Any combination of the first three streams are fed to the Ammonia Purification Column. The overhead product of essentially dry ammonia is condensed with cold sea water, then either pumped into the power loop for make up, or sent to the Dry Ammonia Storage Drum.

Within 30 to 45 days, all of the ammonia remaining in storage has been conditioned and stored in the Dry Ammonia Storage Drum. The subsystem is then ready to receive a fresh supply of commercial grade ammonia, which will be placed in the Heel Storage Drum and the Wet Ammonia Storage Drum.

The vent system will collect ammonia vapor from many places in the PSM, to be collected in a Blowdown Drum. Blowdown from the Ammonia Purification Column will also be sent to the Blowdown Drum. Dry ammonia vapor will be compressed, condensed with cold sea water, and pumped to storage. The liquid bottoms from

the Blowdown Drum will contain oil, water, ammonia, and other constituents. Its moisture content will be about 25 percent. The bottoms will be discarded by either of two methods. If there are no environmental objections, it will be mixed with warm sea water and dumped into the ocean. If there are environmental objections, it will be stored for shipment back to shore.

3.2.1.2.3 Normal Shutdown. Complete shutdown capability is to be provided. Sufficient storage capacity shall be maintained so that all of the ammonia in the power loop can be transferred to storage. Complete shutdown includes transferring all ammonia to storage so that the power loop can be opened for maintenance.

3.2.1.2.4 Maintenance Standby. Provisions shall be made to isolate major equipment items for maintenance while holding the rest of the system or subsystem on standby or reduced rate.

3.2.1.2.5 Restart from Maintenance Standby. The subsystem shall be capable of restarting after a maintenance standby or slowdown.

3.2.1.2.6 Emergency Shutdown. The subsystem shall be capable of executing an emergency shutdown. Some of the emergencies include fire, storm, power failure, ammonia leak. Other emergency situations shall be evaluated during final design.

3.2.2 Physical Characteristics.

3.2.2.1 Weight. The subsystem weight shall not exceed 250 tons dry or 370 tons wet (operating).

3.2.2.2 Size. The installed subsystem shall not exceed the envelope indicated in Figure 3.

3.2.2.3 Storage Facility. Three ammonia storage drums are to be provided. Code requirements limit the filling of the drums to 85 percent of the total volume. The available storage capacity of each drum is to be 28,985 gallons. The drums are to be uninsulated and painted to protect against corrosion. Each drum will have two pressure relief valves piped in parallel and connected to the vent system. A remotely operated valve shall switch the drum to either relief valve.

The design pressure shall be 250 psig.

As a precaution, a sea water spray system shall be provided for each storage drum. A separate controller for each drum will activate the water spray when the pressure in the vessel reaches 225 psig, which corresponds to an ammonia temperature of 108° F. Water for the sprays will be obtained from utility pumps which are not a part of this subsystem.

3.2.2.4 Pumps. Sufficient pumps shall be provided. All pumps will be electric motor operated. A shaft seal shall be provided to minimize ammonia leakage.

- a. Blowdown Pump shall transfer blowdown from the evaporator into storage or to the ammonia purification column. It shall be rated at 3 GPM at 103 psi differential pressure.
- b. Ammonia Transfer Pump shall transport ammonia from storage into the power loop at 500 GPM at 155 psi.
- c. Ammonia Column Feed Pump shall transfer ammonia from storage into the Ammonia Purification Column at 4 GPM at 60 psi.
- d. Reflux Pump shall transport purified ammonia from the Ammonia Reflux Accumulator to reflux, to storage, and to the ammonia evaporator at 4 GPM at 112 psi.
- e. Recovered Ammonia Pump shall transport ammonia from the recovered ammonia drum to storage at 2 GPM at 100 psi.
- f. Ammonia Blowdown Drum Pump shall remove ammonia from the blowdown of the ammonia purification column and transport the fluid to the Heel Storage Drum or into the sea water disposal pipe at 10 GPM at 200 psi.

3.2.2.5 Ammonia Conditioning Facility. The ammonia conditioning facility consists of the following items of equipment.

- a. Ammonia Purification Column is a packed tower or distillation column operating at a design pressure of 250 psig and a design temperature of 250° F and -30° F. It shall be provided with means for minimizing liquid carryover. Two pressure relief valves shall connect to the vent systems.
- b. Ammonia Column Reboiler will have a duty of 600,000 BTU/Hr, have a liquid reservoir, and a tube bundle immersed in the liquid. Warm sea water will circulate through the tubes. The shell design pressure shall be 250 psig, and the tube design pressure shall be 100 psig.

- c. Ammonia Overhead Condenser shall be a shell and tube exchanger operating under partially flooded conditions. Its duty shall be 600,000 BTU/hr with a shell design pressure of 250 psig and a design temperature of 100° F and -30° F.
- d. Ammonia Reflux Accumulator shall be a vessel of approximately 70 gallons capacity with a design pressure of 250 psi and a design temperature of -30° F. Two parallel relief valves shall connect to the vent system.

3.2.2.6 Ammonia Recovery Facility. The ammonia recovery facility consists of the following items.

- a. Vent system is a piping network collecting ammonia from all possible sources of escape. Relief valves, seals, shaft packing glands, etc. will have a connection to the vent system.
- b. Relief valves. All sections of vessels and piping containing ammonia that can be blocked off will be protected by pressure relief valves. Each relief point will have two relief valves in parallel. A 3-way solenoid valve will direct the fluid to one or the other relief valve. The solenoid valve will have a selector switch mounted on one of the control panels.
- c. Ammonia Blowdown Drum will receive all ammonia vapor and liquid which is collected by the vent system. Also liquid blowdown from the Ammonia Column Reboiler will be collected. The drum is to have a design pressure of 250 psig and a design temperature of 100° F and -30° F.
- d. An Ammonia Recovery Compressor shall pressurize the ammonia vapors emanating from the Ammonia Blowdown Drum. It shall be sized for at least 75 ACFM to compress the vapors from slightly below atmospheric to 200 psig.
- e. A Recovered Ammonia Condenser shall be provided to liquefy the compressed recovered ammonia. It shall be a heat exchanger using cold sea water. The shell design pressure shall be 250 psig and the design temperature shall be -30° F.
- f. A Recovered Ammonia Drum shall receive ammonia from the Recovered Ammonia Compressor. The design pressure shall be 250 psig and the design temperature shall be -30° F.
- g. A Recovered Ammonia Pump shall transfer liquid ammonia from the Recovered Ammonia Drum to storage. The pump shall be rated at 4 GPM at 45 psi.
- h. An Ammonia Blowdown Drum Pump shall remove liquid from the Ammonia Blowdown Drum. The pump shall be rated at 10 GPM at 220 psi.

3.2.2.7 Lift Points. The subsystem components shall have lift points to facilitate installation, removal and handling by shipboard crane.

3.2.2.8 Durability. The subsystem shall be sufficiently durable to operate normally in a surface vessel under Sea State 6 conditions, and shall survive in a secured condition in Sea State 9.

3.2.3 Reliability.

3.2.3.1 Redundancy. The subsystem design shall include redundancy as required to ensure continuity of key functions, as well as fail-safe operations.

3.2.3.2 Subsystem Starting. Subsystem starting reliability (successful starts divided by attempted starts) shall be 95 percent at a 60 percent confidence level.

3.2.3.3 Allocation. The subsystem shall meet, or be better than, a mean-time-between-failure (MTBF) allocation of 88,000 hours.

3.2.4 Maintainability.

3.2.4.1 Allocation. The subsystem shall meet, or be better than, a mean-time-to-repair (MTTR) allocation of 24 hours. MTTR shall include isolation of the fault to the lowest replaceable unit, replacement with a serviceable unit, and verification of correct operation.

3.2.4.2 Downtime. Provisions shall be made for periodic maintenance during power plant downtimes.

3.2.5 Availability. Availability shall be at least 90 percent at 60 percent confidence level, over a 30 year life, after an initial checkout period.

3.2.6 Environmental Conditions. The subsystem shall be designed to operate in the environmental conditions described in the following paragraphs. Design life goals are:

- a. 30-year life
- b. 1000 start/stop cycles
- c. 8000 hours of operation per year

3.2.6.1 Operational Environment. The subsystem shall be able to operate and meet performance requirements in the following ocean-based environment:

- a. 65 to 100° F ambient air temperature.
- b. 40 to 100 percent relative humidity.
- c. Sea water design and off-design temperatures specified in 3.1.4.1.2 of SY14-5.
- d. OTEC Pilot Plantship nominal periods, and maximum vertical and horizontal accelerations and angular motions are as follows for Sea State 6:

1)	Period	:	14 sec
2)	Vertical Direction	:	0.3g
3)	Horizontal Direction	:	0.15g
4)	Pitch	:	5°
5)	Roll	:	12°

3.2.6.2 Non-Operational Environment. During shutdown, the subsystem shall be able to withstand the following ocean-based environmental conditions without degradation:

- a. 0 to 125° F ambient air temperature
- b. 0 to 100 percent relative humidity
- c. Sea motion of Sea State 9 magnitude. Sea State 9 has a significant wave height of 80 feet, resulting in a vertical acceleration of $\pm 0.5g$ and a horizontal acceleration of $\pm 0.5g$.

3.2.7 Transportability. Subsystem components shall be designed to be transported by common carrier with a minimum of protection. If necessary, special packaging may be required to assure that transportation methods will not impose design penalties. Special equipment required for handling, installation, servicing, or operation shall be identified in subsystem design specifications.

3.3 Design and Construction. The subsystem shall be designed and constructed to perform in accordance with the functional and environmental requirements of this specification.

3.3.1 Materials, Processes and Parts. All parts shall comply with the applicable codes of BPV-VIII and CG 115.

3.3.1.1 Working Fluid. The working fluid shall be ammonia with characteristics as specified in NBS Circular 142.

3.3.1.2 Ammonia Piping Materials.

Pipe, ASTM A333, Grade 6, Seamless

1/2" through 1-1/2"	- Schedule 80
2" through 10"	- Schedule 40
12" through 24"	- Std Wt (0.375" Wall)

Fittings, ASTM A420, WPL6

- 1/2" through 2" - 3000# Socketweld
- 3" through 24" - Std Wt Butt weld

Flanges, ASTM A350-LF2

- 1/2" through 2" - 300# Socketweld RF
- 3" through 24" - 300# Weldneck RF

Bolting, ASTM A193, GR B7M W/2H Nuts

Valves, ASTM A352-LCB or ASTM-LF2

- 1/2" through 2" - 800# Socketweld
 - 3" through 24" - 300# Flanged
- (No copper or copper alloy in valves)

3.3.1.3 Sea Water Piping Materials.

Pipe, Titanium ASIM B337, Grade 2

- 1/2" through 1" - Schedule 40, Seamless
- 1-1/2" through 4" - Schedule 10S, Seamless
- 6" through 10" - Schedule 10S, Welded

Fittings, Titanium ASTM B363, Grade WPT2, Butt weld

- 1/2" through 1" - Schedule 40
- 1-1/2" through 10" - Schedule 10S

Flanges, ASTM A105, Carbon Steel, Lap Joint, Galvanized all sizes

Bolting, ASTM A307, Grade B, Galvanized Valves

- 1/2" through 2" - 150# Flanged, Cast Iron
Polypropylene Lined Body, EPC
Diaphragm, Hills-McCanna or equal
- 3" through 10" - 150# Butterfly, Ductile Iron Lug
Type Body, Buna-N Seat, 416 SS Stem,
Kynar Coated Disc, DEMCO or equal

3.3.2 Nameplates and Product Marking. Nameplates and product marking requirements shall be in accordance with standard industrial practice.

3.3.3 Workmanship. The subsystem shall be fabricated, finished, and assembled in accordance with normal standards for high quality workmanship.

3.3.4 Interchangeability. Each item within the subsystem shall be directly interchangeable for form, fit, and function with other items of the same part number with a minimum of adjustment or re-calibration.

3.3.5 Safety. The subsystem shall be designed and constructed to meet the health and safety criteria specified in OSHA 1910.11 and electrical equipment location Class I, Group D, Division 1 specified in NEMA MG-1972 and NFPA 70-1978.

a. Restrictive Use of Mercury

Ammonia reacts with mercury to form an explosive compound. Therefore, equipment, components, instruments containing mercury shall not be used in applications wherein ammonia and mercury could react.

b. Flammable, Toxic, and Unstable Materials

Flammable, toxic, and unstable materials shall not be used.

c. Finish

The surfaces of each equipment/component of the PSD-II system shall be adequately finished to prevent deterioration from exposure to the specified environments that might jeopardize fulfillment of the specified performance.

d. Relief Valves

Relief valves shall be set to prevent a pressure build-up exceeding the system design pressures in accordance with CG-257, Section 98.25-60.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. Inspections shall be conducted during the design and development of the subsystem to provide DOE with assurance of compliance with the requirements of this specification.

4.1.1 Responsibility for Tests. Each supplier of a major component of the subsystem shall be responsible for developing and conducting the tests and inspections required to demonstrate that his equipment will perform as specified. The system contractor is responsible for review and approval of test plans and procedures and for monitoring test activities as necessary to verify that the test program meets applicable requirements.

4.2 Quality Conformance Inspections. Qualification shall be performed on subsystem components that are representative of the approved production design. Qualification of the subsystem to assure compliance with the requirements of section 3 shall be by examinations, demonstrations, tests, or analyses. Table 1 provides a matrix of section 3 requirements versus qualification methods. Definition of examination, demonstration, test or analysis is as follows:

TABLE 1 - QUALITY CONFORMANCE METHODS

SECTION 3 PARAGRAPH	METHOD			
	EXAM	DEMO	TEST	ANAL
3.2				
3.2.1				
3.2.1.1				X
3.2.1.2				
3.2.1.2.1		X		X
3.2.1.2.2		X		
3.2.1.2.3		X		
3.2.1.2.4		X		
3.2.1.2.5		X		
3.2.1.2.6		X		
3.2.2				
3.2.2.1	X			X
3.2.2.2	X			
3.2.2.3	X			X
3.2.2.4			X	
3.2.2.5			X	
3.2.2.6			X	
3.2.2.7	X			
3.2.2.8	X			
3.2.3				X
3.2.3.1				X
3.2.3.2				X
3.2.3.3				X
3.2.4				
3.2.4.1				X
3.2.4.2				X
3.2.5				X
3.2.6				
3.2.6.1			X	
3.2.6.2			X	
3.2.7	X			
3.3				
3.3.1				
3.3.1.1				X
3.3.1.2	X			
3.3.1.3	X			
3.3.2	X			
3.3.3	X			
3.3.4	X			
3.3.5	X			X

- a. Examination is an element of inspection consisting of investigation, without the use of special laboratory appliances or procedures, or supplies and services to determine conformance to those specified requirements which can be determined by such investigation. Examination is generally nondestructive and includes, but is not limited to, visual, auditory, olfactory, tactile, gustatory, and other investigations; simple physical manipulation; gauging, and measurement.
- b. Test is an element of inspection denoting the determination of the properties or elements of supplies (or components thereof) by technical means, including functional operations and the application of established principles and procedures. The analysis of data derived from test is an integral part of the inspection element, and shall not be confused with 4.2.d.
- c. Demonstration is an element of inspection that, although technically a variation of test, differs from 4.2.b by directness of approach in the verification of a requirement(s), and is accomplished without the use of elaborate instrumentation or special equipment. Thus, operation of a representative configuration item (CI) in, or near its use-environment (e.g., ability of a truck to climb a one-half mile, 5 percent grade, from standstill in the required time) would be defined as a "demonstration" rather than a "test."
- d. Analysis is an element of inspection in the form of study, resulting in data, that is intended to verify a requirement(s) when an examination, test, or demonstration cannot feasibly be employed to verify that requirement(s) at the inspection level demanded by this specification. Such data may be comprised of a compilation or interpretation of existing data or design solutions, or derived from original lower-level inspections, or both. Data may be interpolated or extrapolated, as applicable. This would include data derived from fault-tree analysis, and failure modes and effects analysis.

5. PREPARATION FOR DELIVERY

Not applicable. The subsystem is not delivered as a system. Its major components are delivered to the containment vessel as separate items, then the subsystem is assembled on board.

6. NOTES

6.1 Intended Use. The subsystem is intended to be used to support a 10 MWe PSM. The first PSM will be used as a test article to evaluate and prove the design, to demonstrate the economic parameters of the concept as installed in the APL/JHU OTEC Pilot Plantship.

6.2 Definitions.

6.2.1 Ships Systems are defined as those elements of an OTEC Plantship provided by others to support the subsystem specified herein. Ships Systems elements include the hull, crew quarters, ship's auxiliaries, cold water pipe, station-keeping, effluent discharge pipes, and cold and warm sea water pump subsystems.

6. ELECTRICAL POWER DISTRIBUTION &
CONTROL SUBSYSTEM SPECIFICATION

TRW

DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

FSCM NO. 11982

TITLE

REQUIREMENTS SPECIFICATION
ELECTRICAL POWER DISTRIBUTION AND CONTROL SUBSYSTEM
10 MWe POWER SYSTEM MODULE PSD-II

DATE 13 APRIL 1979

NO. SS14-66

SUPERSEDING: _____

PREPARED BY:

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R. O. PEARSON

APPROVAL SIGNATURES:

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REVISION RECORD

REV	DATE	AUTHORIZATION	CHANGE DESCRIPTION	PAGES AFFECTED
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REQUIREMENTS SPECIFICATION
ELECTRICAL POWER DISTRIBUTION AND CONTROL SUBSYSTEM
10 MWe POWER SYSTEM MODULE PSD-II

1. SCOPE

1.1 This specification establishes the performance, design, and test requirements for the Electrical Power Distribution and Control Subsystem used in the Ocean Thermal Energy Conversion (OTEC) 10 MWe Power System Module (PSM), Power System Development Project II (PSD-II).

2. APPLICABLE DOCUMENTS

2.1 Government Documents: The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered a superseding requirement.

STANDARDS

<u>Occupational Safety and Health Administration (OSHA)</u>	
1910.11	Storage and Handling of Anhydrous Ammonia

REGULATIONS

<u>Coast Guard (CG)</u>	
259	Electrical Engineering Regulations
1 July 1977	

2.2 Non-Government Documents: The following documents of the exact issue (or the latest date if an exact issue is not shown) form a part of this specification to the extent specified herein. In the event of conflict between these documents and this specification, the contents of this specification shall be considered a superseding requirement.

SPECIFICATIONS

TRW DSSG

SY14-5

System Specification, OTEC 10 MWe Power System
Module PSD-II

STANDARDS

- National Electrical Manufacturers Association (NEMA)

MG-1972

Motors and Generators

14 Oct 1977

National Fire Protection Association (NFPA)

70-1978

National Electrical Code

August 1977

3. REQUIREMENTS

3.1 Subsystem Definition. The Electrical Power Distribution and Control Subsystem is a major subsystem of the 10 MWe Power System Module (defined in SY14-5). The subsystem supports safe generation of 10 MWe base loaded net power after the needs of the auxiliary loads have been satisfied. The subsystem is designed to permit maximum flexibility in the operation and testing of the OTEC facility.

The design of the subsystem permits the following operational modes:

- a) Independent operation and test of auxiliary loads using startup power only
- b) Simultaneous independent operation and test of auxiliary loads and the startup power source and independent operation of the turbine-generator and system loads
- c) Transfer to 480V shipboard power for operation of critical loads when both the OTEC system and the startup power source are down
- d) Normal operation of the OTEC system with the turbine-generator energizing the system, auxiliary, and critical loads.

To satisfy these design requirements, a split bus 4.16 kV primary power system has been used. There are five major elements, each controlled by its own 4.16 kV power circuit breaker as follows:

1. System load
2. Turbine-generator
3. Startup power source
4. Seawater pumps
5. 480V subsystem, including auxiliary and critical loads.

Elements 1 and 2 are supported by Bus A; 3, 4, and 5 by Bus B. These elements can be operated independently for system testing or they can be tied together (by the tie power circuit breaker) for normal operation.

The subsystem includes standard protective relaying for safety and a full compliment of instrumentation and metering. The instrumentation connects with a data acquisition subsystem for performance assessment. The metering is for routine operation.

Autotransformer-type reduced voltage is used to start the seawater pump induction motors. This limits the inrush current to 2.3 times the normal running current. (Without this limitation, inrush current would be approximately six times the normal running current.) The reduced voltage starting permits a proportional reduction ($\times \frac{2.3}{6}$) in the size of the startup power source. Using reduced voltage starting and limiting the startup-caused voltage drop to 10 percent result in an 11 MVA startup power source requirement.

3.1.1 Subsystem Diagrams. A 480V power system single line diagram is presented in Figure 1 and an electrical distribution and control subsystem single line diagram is presented in Figure 2.

3.1.2 Interface Definition. The subsystem shall interface with the following other electrical systems:

- a) Turbine-generator set feeder and instrumentation tie-in to the 5 kV switchgear
- b) Load feeder tie-in to the 5 kV switchgear circuit breaker
- c) Startup power source feeder and instrumentation tie-in to the 5 kV switchgear
- d) Shipboard 480V emergency power source feeder tie-in to the 480V automatic transfer switch.

3.1.2.1 Functional. Figures 1 and 2 identify the functional interfaces with Ship Systems and PSM Subsystems.

3.1.2.2 Physical.

3.1.2.2.1 Ships Systems. The subsystem will be located in the Plant Ship in the space between elevations 77 and 89, transverse frames 50 and 160, and longitudinal frames A and B as shown in Figure 3.

Bulkhead conduit interfaces will be as identified in Figures 4 and 5.

NOTE: BREAKERS TIED TO THE AUTOMATIC TRANSFER SWITCH INTERLOCK SHALL BE FURNISHED WITH 120V 60HZ SHUNT TRIPS.
 4 X 3 #700 MCM THW-34°C.
 FROM AUTOMATIC TRANSFER SWITCH SEE DRAWING 6850.94-17
 TO AUTOMATIC TRANSFER SWITCH INTERLOCK

MOTOR CONTROL CENTER

LOAD TABLE			
	TOTAL CONNECTED	TOTAL CRITICAL	STEADY STATE STARTUP LOADS
CURRENT (AMPERES)	1,303	693	763
LOAD (kVA)	1,082	575	634

MOTOR CONTROL CENTER
 GENERAL ARRANGEMENT
 N.T.S.

NOTE: BREAKER TRIP RATINGS OF COMBINATION LINE STARTERS AND COMBINATION LINE CONTACTORS SHALL BE SPECIFIED BY MOTOR CONTROL CENTER MANUFACTURER.

LEGEND	
SYMBOL	DESCRIPTION
	CIRCUIT BREAKER TRIP CURRENT RATING
	CONTACTOR NEMA SIZE
	THERMAL OVERLOAD RELAY HEATER ELEMENT
	MOTOR
	NOT AVAILABLE
	HEATER

NOTES:
 1 THIS INCLUDES 18 AMPS FROM THE CONTROL POWER DISTRIBUTION PANEL.

DESIGNED: J. Sauer	OTEC POWER SYSTEM DEVELOPMENT - II		LTR	DATE	REVISION	BY	APPRO
DRAWN: J. Sauer	10 MWe POWER MODULE MOTOR CONTROL CENTER		TRM				
CHECKED: J. Sauer	SINGLE LINE DIAGRAM & GENERAL ARRANGEMENT		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY				
APPROVALS: J. Sauer			Drawing number 6850.94-18				
RELEASED BY: J. Sauer			ISSUE DATE				
PROG OFFICE: J. Sauer			CNO LTR

FIGURE 2

FIGURE 3

1/8" = 1'-0"
SCALE FEET

DESIGNED BY: [Signature]	OTEC POWER SYSTEM DEVELOPMENT - II	DATE: 5-9-79	REVISION: 1	BY: [Signature]	APPD: [Signature]
CHECKED BY: [Signature]	10 MW POWER MODULE POWER/SHIP SYSTEM INTERFACES SECTIONS	DRAWING NUMBER: 6850.94-06			
APPROVALS: [Signature]		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			
PROJECT OFFICE: [Signature]		DATE: 5-9-79			

FIGURE 4 6-12 8

FIGURE 5

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3.1.2.2.2 PSM Subsystems. Interface wiring sizes are indicated in Figures 1 and 2.

3.1.3 Major Component List. Table 1 lists the major components of the subsystem and describes their functions.

3.1.4 Government Furnished Property List. The following electrical subsystem support equipment must be furnished by the government:

- a) A 4.6 kV startup power source and feeder
- b) The vessel itself and its electrical (switchgear) room
- c) The 10 MWe electrical base load and its 5 kV tie-in feeder
- d) A 480V emergency power feeder to operate dormant electrical subsystem support equipment (slow roll drive for the turbine-generator set; drives for the turbine-generator lubrication pump, turbine ammonia seal pump and ammonia handling subsystem; and critical control and monitoring circuits.

3.2 Characteristics.

3.2.1 Performance. The subsystem shall be sized to support a 10 MWe PSD-II Power System Module. The subsystem shall be designed for continuous operation with capability to cope with anticipated emergencies and routine maintenance.

3.2.2 Physical Characteristics. The physical characteristics of the major components of the subsystem are listed in Table 1.

3.2.2.1 Weight. The subsystem weight shall not exceed 59,000 pounds.

3.2.2.2 Size. The installed subsystem shall not exceed the envelope indicated in Figure 3.

3.2.2.3 Lift Points. The subsystem components shall have lift points to facilitate installation, removal and handling by shipboard crane.

3.2.2.4 Durability. The subsystem shall be sufficiently durable to operate normally in a surface vessel under Sea State 6 conditions, and shall survive in a secured condition in Sea State 9.

TABLE 1 - MAJOR COMPONENTS

COMPONENT	FUNCTIONS	QTY REQ	APPROX SIZE (INCHES)	APPROX WEIGHT (POUNDS)
5 kV Switchgear	Provides distribution, switching and transfer of 4.16 kV primary power; protection for the primary power system; local metering and signals for remote operational and alarm indicators; and analog signals for remote electrical parametric metering and recording.	1	90 H 194 W 88 D	20,600
480V Power Transformer	Transforms 60 Hz, 4.16 kV primary power to 60 Hz, 480V power for use by the electric drives and other electrical equipment in the 0.5 to 250 kVA range.	1	90 H 64 W 60 D	5,800
4.16 kV Motor Starters	Provides power switching and reduced voltage starting functions for the 4.16 kV seawater pump drives; drive and drive feeder protective relaying; local signals and metering for remote operational and alarm indicators; and analog signals for remote electrical parametric metering and recording.	2	90 H 72 W 30 D	7,000
480V Automatic Transfer Switch	Transfers 480V motor control center feed the 480V power transformer to the ship-board 480V power source.	1	90 H 22 W 50 D	1,100
480V Motor Control Center	Groups and houses all 480V motor starters used for the power switching function for the various 480V motors. Provides 480V motor and feeder protection; signals for remote operational and alarm indicators; and analog signals for remote electrical parametric metering and recording. Includes the relay cabinet used for motor control logic switching and sequencing and the 120/208V, 3 phase control power transformer and control power distribution panel.	1	90 H 140 W 20 D	3,415
Local Control Stations	Provided at each drive to facilitate servicing and safe operation. The local station permits jogging, emergency shutdown, and lockout.	1 Lot	4 H 6 W 2 D	1 each
Wiring Devices	Devices include conduits, cables, condulets, junction boxes, wires, signal leads, miscellaneous hardware, etc.	1 Lot	N/A	10,650

3.2.3 Reliability.

3.2.3.1 Redundancy. The subsystem design shall include redundancy as required to ensure continuity of key functions, as well as fail-safe operations.

3.2.3.2 Subsystem Starting. Subsystem starting reliability (successful starts divided by attempted starts) shall be 95 percent at a 60 percent confidence level.

3.2.3.3 Allocation. The subsystem shall meet, or be better than, a mean-time-between-failure (MTBF) allocation of 43,800 hours.

3.2.4 Maintainability.

3.2.4.1 Allocation. The subsystem shall meet, or be better than, a mean-time-to-repair (MTTR) allocation of eight hours, MTTR shall include isolation of the fault to the lowest replaceable unit, replacement with a serviceable unit, and verification of correct operation.

3.2.4.2 Downtime. Provisions shall be made for periodic maintenance during power plant downtimes.

3.2.5 Availability. Availability shall be at least 90 percent at 60 percent confidence level, over a 30 year life, after an initial checkout period.

3.2.6 Environmental Conditions. The subsystem shall be designed to operate in the environmental conditions described in the following paragraphs. Design life goals are:

- a. 30-year life
- b. 1000 start/stop cycles
- c. 8000 hours of operation per year.

3.2.6.1 Operational Environment. The subsystem shall be able to operate and meet performance requirements in the following ocean-based environment:

- a. 65 to 100°F ambient air temperature
- b. 40 to 100 percent relative humidity
- c. Seawater design and off-design temperatures specified in 3.1.4.1.2 of SY14-5

- d. OTEC Pilot Plantship nominal periods, and maximum vertical and horizontal accelerations and angular motions are as follows for Sea State 6:

1) Period	:	14 sec
2) Vertical Direction	:	0.3g
3) Horizontal Direction	:	0.15g
4) Pitch	:	5°
5) Roll	:	12°

3.2.6.2 Non-Operational Environment. During shutdown, the PSM shall be able to withstand the following ocean-based environmental conditions without degradation:

- a. 0 to 125°F ambient air temperature
- b. 0 to 100 percent relative humidity
- c. Sea motion of Sea State 9 magnitude. Sea State 9 has a significant wave height of 80 feet, resulting in a vertical acceleration of $\pm 0.5g$ and a horizontal acceleration of $\pm 0.5g$.

3.2.7 Transportability. Subsystem components shall be designed to be transported by common carrier with a minimum of protection. If necessary, special packaging may be required to assure that transportation methods will not impose design penalties. Special equipment required for handling, installation, servicing, or operation shall be identified in subsystem design specifications.

3.3 Design and Construction. The subsystem shall be designed and constructed to perform in accordance with the functional and environmental requirements of this specification.

3.3.1 Nameplates and Product Marking. Nameplates and product marking requirements shall be in accordance with standard industrial practice.

3.3.2 Workmanship. The subsystem and its components shall be fabricated, finished, and assembled in accordance with normal standards for high quality workmanship.

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TABLE 2 - QUALITY CONFORMANCE METHODS

		METHOD			
		EXAM	DEMO	TEST	ANAL
3.2	CHARACTERISTICS				
3.2.1	PERFORMANCE				
3.2.2	PHYSICAL CHARACTERISTICS				
3.2.2.1	WEIGHT	X			X
3.2.2.2	SIZE	X			
3.2.2.3	LIFT POINTS	X			
3.2.2.4	DURABILITY	X			
3.2.3	RELIABILITY				X
3.2.3.1	REDUNDANCY				X
3.2.3.2	SUBSYSTEM STARTING				X
3.2.3.3	ALLOCATION				X
3.2.4	MAINTAINABILITY				
3.2.4.1	ALLOCATION				X
3.2.4.2	DOWNTIME				X
3.2.5	AVAILABILITY				X
3.2.6	ENVIRONMENTAL CONDITIONS				
3.2.6.1	OPERATIONAL ENVIRONMENT			X	
3.2.6.2	NON-OPERATIONAL ENVIRONMENT			X	
3.2.7	TRANSPORTABILITY	X			
3.3	DESIGN AND CONSTRUCTION				
3.3.1	NAMEPLATES AND PRODUCT MARKING	X			
3.3.2	WORKMANSHIP	X			
3.3.3	INTERCHANGEABILITY	X			
3.3.4	SAFETY			X	

- c. Demonstration is an element of inspection that, although technically a variation of test, differs from 4.2.b by directness of approach in the verification of a requirement(s), and is accomplished without the use of elaborate instrumentation or special equipment. Thus, operation of a representative configuration item (CI) in, or near its use-environment (e.g., ability of a truck to climb a one-half mile, 5 percent grade, from standstill in the required time) would be defined as a "demonstration" rather than a "test."
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7. EQUIPMENT, VALVES, INSTRUMENTS AND
LINE LISTS AND SPECIFICATIONS

LISTINGS

- LINES (LINE 101 THROUGH 220)
- VALVES (V-1 THROUGH V-71)
- RELIEF VALVES (PSV-1 THROUGH PSV-22)
- CHECK VALVES (CV-1 AND CV-2)
- STRAINERS (S-1 AND S-2)
- ORIFICE PLATE (OP-1)
- MAJOR EQUIPMENT (T-1 THROUGH T-5, C-1 THROUGH C-4,
E-1 THROUGH E-4, T/G-1, P₃ AND P₄,
M₃ AND M₄)
- TEMPERATURE SENSORS (TE-1 THROUGH TE-27)
- PRESSURE SENSORS (PE-1 THROUGH PE-27)
- FLOW METERS (FE-1 THROUGH FE-16)
- POWER SENSORS (JE-1 THROUGH JE-3)
- SPEED SENSORS (SE-1 THROUGH SE-3)
- LIQUID LEVEL SENSORS (LE-1 AND LE-2)
- DIFFERENTIAL PRESSURE SENSORS (PDE-1 AND PDE-2)

TABLE 3
T R W
LINE LIST

LINE NO	LINE SIZE	LINE CLASS	SCH. NO.	FROM	TO	MEDIA	MAX. TEMP. °F	MAX. PRESS. PSIG
101	12	F	20	Condenser C-1	Line 105	LNH ₃	100	167
102	12	F	20	Condenser C-2	Line 106	LNH ₃	100	167
103	12	E	20	Condenser C-3	Line 107	LNH ₃	100	167
104	12	F	20	Condenser C-4	Line 108	LNH ₃	100	167
105	12	E	20	Line 101	Line 125	LNH ₃	100	167
106	12	E	20	Line 102	Line 125	LNH ₃	100	167
107	12	E	20	Line 103	Line 125	LNH ₃	100	167
108	12	E	20	Line 104	Line 125	LNH ₃	100	167
109	2	E	40	Condenser C-1	Line 113	GNH ₃	100	167
110	2	E	40	Condenser C-2	Line 114	GNH ₃	100	167
111	2	E	40	Condenser C-3	Line 115	GNH ₃	100	167
112	2	E	40	Condenser C-4	Line 116	GNH ₃	100	167
113	2	E	40	Line 109	Line 117	GNH ₃	100	167
114	2	E	40	Line 110	Line 117	GNH ₃	100	167
115	2	E	40	Line 111	Line 117	GNH ₃	100	167
116	2	E	40	Line 112	Line 117	GNH ₃	100	167
117	4	E	40	Line 116	NH ₃ Vapor Dump	GNH ₃	100	167
118	4	E	40	Line 124	NH ₃ Vapor Dump	GNH ₃ GN ₂	100	167
119	4	E	40	Line 124	NH ₃ Liquid Storage	LNH ₃	100	167
120	2	E	40	Line 105	Line 124	LNH ₃	100	167
121	2	E	40	Line 106	Line 124	LNH ₃	100	167
122	2	E	40	Line 107	Line 124	LNH ₃	100	167
123	2	E	40	Line 108	Line 124	LNH ₃	100	167
124	4	E	40	Line 123	Line 118	LNH ₃	100	167

TABLE 3, cont'd
T R W

LINE LIST

LINE NO	LINE SIZE	LINE CLASS	SCH. NO.	FROM	TO	MEDIA	MAX. TEMP. °F	MAX. PRESS. PSIG
125	24	E	20	Line 105	Line 108	LNH ₃	100	167
126	6	E	40	NH ₃ Liquid Supply	Line 127	LNH ₃	100	167
127	24	E	20	Line 125	Tank	LNH ₃	100	167
128	6	E	40	Tank	Line 203	LNH ₃	100	167
129	24	E	20	Tank	Line 130	LNH ₃	100	167
130	24	E	20	Line 129	Pump P4	LNH ₃	100	167
131	24	E	20	Line 129	Pump P3	LNH ₃	100	167
132	24	E	20	Pump P3	Line 145	LNH ₃	100	167
133	24	E	20	Pump P4	Line 145	LNH ₃	100	167
134	1	E	40	Line 138	Line 131	GNH ₃ GN ₂	100	167
135	1	E	40	Pump P3	Line 141	LNH ₃	100	167
136	1	E	40	Line 135	Line 137	GNH ₃ GN ₂	100	167
137	1	E	40	Line 136	Line 130	LNH ₃	100	167
138	1	E	40	Line 139	Line 136	GNH ₃ GN ₂	100	167
139	1	E	40	N ₂ Supply	Line 138	GN ₂	100	167
140	1	E	40	NH ₃ Vapor Supply	Line 138	GNH ₃	100	167
141	1	E	40	Line 135	Line 143	LNH ₃	100	167
142	1	E	40	Pump P4	Line 141	LNH ₃	100	167
143	1	E	40	Line 141	NH ₃ Vapor Dump	GNH ₃ GN ₂	100	167
144	1	E	40	Line 141	NH ₃ Liquid Storage	LNH ₃	100	167
145	24	E	20	Line 132	Line 149	LNH ₃	100	167
146	8	E	20	Line 145	NH ₃ Vapor Dump	GNH ₃ GN ₂	100	167
147	8	E	20	NH ₃ Liquid Supply	Line 145	LNH ₃	100	167
148	6	E	40	Line 198	Line 149	LNH ₃	100	167

TABLE 3, cont'd
 T R W

LINE LIST

LINE NO	LINE SIZE	LINE CLASS	SCH. NO.	FROM	TO	MEDIA	MAX. TEMP. °F	MAX. PRESS. PSIG
149	24	E	20	Line 156	Line 162	LNH ₃	100	167
150	2	E	40	Line 157	Line 154	LNH ₃	100	167
151	2	E	40	Line 159	Line 154	LNH ₃	100	167
152	2	E	40	Line 161	Line 154	LNH ₃	100	167
153	2	E	40	Line 163	Line 154	LNH ₃	100	167
154	4	E	40	Line 150	Line 155	LNH ₃	100	167
155	4	E	40	Line 154	NH ₃ Liquid Storage	LNH ₃	100	167
156	4	E	40	Line 154	NH ₃ Vapor Dump	GNH ₃ GN ₂	100	167
157	12	E	20	Line 149	Line 170	LNH ₃	100	167
158	2	E	40	Line 166	Line 165	LNH ₃	100	167
159	12	E	20	Line 149	Line 171	LNH ₃	100	167
160	2	E	40	Line 167	Line 165	LNH ₃	100	167
161	12	E	20	Line 149	Line 172	LNH ₃	100	167
162	2	E	40	Line 168	Line 165	LNH ₃	100	167
163	12	E	20	Line 149	Line 173	LNH ₃	100	167
164	2	E	40	Line 169	Line 165	LNH ₃	100	167
165	4	E	40	Line 158	NH ₃ Purification	LNH ₃	100	167
166	2	E	40	Evaporator E-1	Line 158	LNH ₃	100	167
167	2	E	40	Evaporator E-2	Line 160	LNH ₃	100	167
168	2	E	40	Evaporator E-3	Line 162	LNH ₃	100	167
169	2	E	40	Evaporator E-4	Line 164	LNH ₃	100	167
170	12	F	20	Line 157	Evaporator E-1	LNH ₃	100	167
171	12	F	20	Line 159	Evaporator E-2	LNH ₃	100	167
172	12	F	20	Line 161	Evaporator E-3	LNH ₃	100	167
173	12	F	20	Line 163	7-3 Evaporator E-4	LNH ₃	100	167

TABLE 3, cont'd
T R W
LINE LIST

LINE NO	LINE SIZE	LINE CLASS	SCH. NO.	FROM	TO	MEDIA	MAX. TEMP. °F	MAX. PRESS. PSIG
174	2	E	40	PHASE SEPARATOR T-1	Line 157	LNH ₃	100	167
175	2	E	40	PHASE SEPARATOR T-2	Line 159	LNH ₃	100	167
176	2	E	40	PHASE SEPARATOR T-3	Line 161	LNH ₃	100	167
177	2	E	40	PHASE SEPARATOR T-4	Line 163	LNH ₃	100	167
178	42	F	—	Evaporator E-1	Line 182	GNH ₃	100	167
179	42	F	—	Evaporator E-2	Line 183	GNH ₃	100	167
180	42	F	—	Evaporator E-3	Line 184	GNH ₃	100	167
181	42	F	—	Evaporator E-4	Line 185	GNH ₃	100	167
182	42	E	—	Line 178	PHASE SEPARATOR T-1	GNH ₃	100	167
183	42	E	—	Line 179	PHASE SEPARATOR T-2	GNH ₃	100	167
184	42	E	—	Line 180	PHASE SEPARATOR T-3	GNH ₃	100	167
185	42	E	—	Line 181	PHASE SEPARATOR T-4	GNH ₃	100	167
186	4	E	40	Line 194	Line 190	GNH ₃ GN ₂	100	167
187	4	E	40	Line 194	Line 191	GNH ₃ GN ₂	100	167
188	4	E	40	Line 194	Line 192	GNH ₃ GN ₂	100	167
189	4	E	40	Line 194	Line 193	GNH ₃ GN ₂	100	167
190	42	E	—	PHASE SEPARATOR T-1	Line 197	GNH ₃	100	167
191	42	E	—	PHASE SEPARATOR T-2	Line 197	GNH ₃	100	167
192	42	E	—	PHASE SEPARATOR T-3	Line 197	GNH ₃	100	167
193	42	E	—	PHASE SEPARATOR T-4	Line 197	GNH ₃	100	167
194	8	E	20	Line 195	Line 186	GNH ₃ GN ₂	100	167
195	8	E	20	N ₂ Supply	Line 194	GN ₂	100	167
196	8	E	20	NH ₃ Vapor Supply	Line 194	GNH ₃	100	167
197	88	E	—	Line 193	Line 190	GNH ₃	100	167

TABLE 3, cont'd
T R W
LINE LIST

LINE NO	LINE SIZE	LINE CLASS	SCH. NO.	FROM	TO	MEDIA	MAX. TEMP. °F	MAX. PRESS. PSIG
198	88	E	—	Line 197	Turbine-Inlet	GNH ₃	100	167
199	4	E	40	N ₂ Supply	Line 202	GN ₂	100	167
200	4	E	40	NH ₃ Vapor Supply	Line 202	GNH ₃	100	167
201	30	E	20	Line 198	Line 203	GNH ₃	100	167
202	4	E	40	Line 200	Line 198	GNH ₃ GN ₂	100	167
203	94	E	40	Turbine Outlet	Line 204	GNH ₃	100	167
204	94	E	—	Line 212	Line 209	GNH ₃	100	167
205	4	E	—	Line 204	NH ₃ Vapor Dump	GNH ₃ GN ₂	100	167
206	8	E	20	N ₂ Supply	Line 208	GN ₂	100	167
207	8	E	20	Line 206	Line 216	GNH ₃ GN ₂	100	167
208	8	E	20	Line 206	Line 216	GNH ₃ GN ₂	100	167
209	54	E	—	Line 204	Line 217	GNH ₃	100	167
210	54	E	—	Line 204	Line 218	GNH ₃	100	167
211	54	E	—	Line 204	Line 219	GNH ₃	100	167
212	54	E	—	Line 204	Line 220	GNH ₃	100	167
213	4	E	40	Line 208	Line 209	GNH ₃ GN ₂	100	167
214	4	E	40	Line 208	Line 210	GNH ₃ GN ₂	100	167
215	4	E	40	Line 208	Line 211	GNH ₃ GN ₂	100	167
216	4	E	40	Line 208	Line 212	GNH ₃ GN ₂	100	167
217	54	F	—	Line 209	Condenser C-1	GNH ₃	100	167
218	54	F	—	Line 210	Condenser C-2	GNH ₃	100	167
219	54	F	—	Line 211	Condenser C-3	GNH ₃	100	167
220	54	F	—	Line 212	Condenser C-4	GNH ₃	100	167

EQUIPMENT LIST - VALVES

ITEM NUMBER	ITEM FUNCTION	TYPE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
V-1	SHUT OFF VALVE	BUTTERFLY	LINE 113	2" 150 #RF	1
V-2			LINE 114	2" 150 #RF	1
V-3			LINE 115	2" 150 #RF	1
V-4			LINE 116	2" 150 #RF	1
V-5			LINE 118	4" 150 #RF	1
V-6			LINE 119	4" 150 #RF	1
V-7			LINE 120	2" 150 #RF	1
V-8			LINE 105	12" 150 #RF	1
V-9			LINE 121	2" 150 #RF	1
V-10			LINE 106	12" 150 #RF	1
V-11			LINE 122	2" 150 #RF	1
V-12			LINE 107	12" 150 #RF	1
V-13			LINE 123	2" 150 #RF	1
V-14			LINE 108	12" 150 #RF	1
V-15			LINE 126	6" 150 #RF	1
V-16			LINE 128	6" 150 #RF	1
V-17			LINE 131	24" 150 #RF	1
V-18			LINE 134	1" 150 #RF	1
V-19			LINE 135	1" 150 #RF	1
V-20			LINE 132	24" 150 #RF	1
V-21			LINE 137	1" 150 #RF	1
V-22			LINE 130	24" 150 #RF	1

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EQUIPMENT LIST - VALVES

ITEM NUMBER	ITEM FUNCTION	TYPE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
V-23	SHUT OFF VALVE	BUTTERFLY	LINE 139	1" 150 #RF	1
V-24			LINE 140	1" 150 #RF	1
V-25			LINE 142	1" 150 #RF	1
V-26			LINE 143	1" 150 #RF	1
V-27			LINE 144	1" 150 #RF	1
V-28			LINE 133	24" 150 #RF	1
V-29			LINE 145	24" 150 #RF	1
V-30			LINE 146	8" 150 #RF	1
V-31			LINE 147	8" 150 #RF	1
V-32			LINE 157	12" 150 #RF	1
V-33			LINE 150	2" 150 #RF	1
V-34			LINE 159	12" 150 #RF	1
V-35			LINE 151	2" 150 #RF	1
V-36			LINE 161	12" 150 #RF	1
V-37			LINE 152	2" 150 #RF	1
V-38			LINE 163	12" 150 #RF	1
V-39			LINE 153	2" 150 #RF	1
V-40			LINE 156	4" 150 #RF	1
V-41			LINE 155	4" 150 #RF	1
V-42			LINE 158	2" 150 #RF	1
V-43			LINE 160	2" 150 #RF	1
V-44			LINE 162	2" 150 #RF	1
V-45			LINE 164	2" 150 #RF	1
V-46			LINE 148	6" 150 #RF	1

EQUIPMENT LIST - VALVES

ITEM NUMBER	ITEM FUNCTION	TYPE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
V-47	SHUT OFF VALVE	BUTTERFLY	LINE 190	42 " 150 #RF	1
V-48			LINE 186	4" 150 #RF	1
V-49			LINE 191	42 " 150 #RF	1
V-50			LINE 187	4" 150 #RF	1
V-51			LINE 192	42 " 150 #RF	1
V-52			LINE 188	4" 150 #RF	1
V-53			LINE 193	42 " 150 #RF	1
V-54			LINE 189	4" 150 #RF	1
V-55			LINE 195	8" 150 #RF	1
V-56			LINE 196	8" 150 #RF	1
V-57			LINE 198	88" 150 #RF	1
V-58			LINE 201	30" 150 #RF	1
V-59			LINE 199	4" 150 #RF	1
V-60			LINE 200	4" 150 #RF	1
V-61			LINE 212	54" 150 #RF	1
V-62			LINE 216	4" 150 #RF	1
V-63			LINE 211	54" 150 #RF	1
V-64			LINE 215	4" 150 #RF	1
V-65			LINE 210	54" 150 #RF	1
V-66			LINE 214	4" 150 #RF	1
V-67			LINE 209	54" 150 #RF	1
V-68			LINE 213	4" 150 #RF	1
V-69			LINE 205	4" 150 #RF	1
V-70			LINE 206	8" 150 #RF	1
V-71			LINE 207	8" 150 #RF	1

EQUIPMENT LIST - RELIEF VALVES

ITEM NUMBER	ITEM FUNCTION	TYPE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
PSV-1	RELIEF PRESSURE	RELIEF VALVE	LINE 124	1" 150 #RF	1
PSV-2			TANK T-5	2" 150 #RF	1
PSV-3			TANK T-5	2" 150 #RF	1
PSV-4			LINE 131	1" 150 #RF	1
PSV-5			LINE 141	1" 150 #RF	1
PSV-6			LINE 138	1" 150 #RF	1
PSV-7			LINE 130	1" 150 #RF	1
PSV-8			LINE 145	1" 150 #RF	1
PSV-9			LINE 145	2" 150 #RF	1
PSV-10			LINE 154	1" 150 #RF	1
PSV-11			LINE 182	6" 150 #RF	1
PSV-12			LINE 183	6" 150 #RF	1
PSV-13			LINE 184	6" 150 #RF	1
PSV-14			LINE 185	6" 150 #RF	1
PSV-15			LINE 194	2" 150 #RF	1
PSV-16			LINE 198	4" 150 #RF	1
PSV-17			LINE 212	6" 150 #RF	1
PSV-18			LINE 211	6" 150 #RF	1
PSV-19			LINE 210	6" 150 #RF	1
PSV-20			LINE 209	6" 150 #RF	1
PSV-21			LINE 208	2" 150 #RF	1
PSV-22			LINE 203	6" 150 #RF	1

EQUIPMENT LIST - CHECK VALVES

ITEM NUMBER	ITEM FUNCTION	TYPE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
CV-1	CHECK VALVE	—	LINE 132	24" 150 #RF	1
CV-2	CHECK VALVE	—	LINE 133	24" 150 #RF	1
7-10

EQUIPMENT LIST - STRAINERS

ITEM NUMBER	ITEM FUNCTION	TYPE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
S-1	STRAINER	CONE	LINE 131	24" 150 #RF	1
S-2	STRAINER	CONE	LINE 130	24" 150 #RF	1
7-11					

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EQUIPMENT LIST - ORIFICE PLATE

ITEM NUMBER	ITEM FUNCTION	TYPE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
OP-1	PRESS, DROP	FLAT PLATE	LINE 201	30" 150 #RF	1
7-12

EQUIPMENT LIST - MAJOR EQUIPMENT

ITEM NUMBER	ITEM FUNCTION	TYPE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
T-1	PHASE SEPARATOR	CENTRIFUGAL	LINE 182	42" BW	1
T-2	↓	↓	LINE 183	42" BW	1
T-3	↓	↓	LINE 184	42" BW	1
T-4	↓	↓	LINE 185	42" BW	1
T-5	ACCUM. TANK	CYLINDER	LINE 127	24" BW	1
C-1	CONDENSER	PLATE	LINE 217	54" 150#RF IN	1
C-2	↓	↓	LINE 218	12" 150#RF OUT	1
C-3	↓	↓	LINE 219	↓	1
C-4	↓	↓	LINE 220	↓	1
E-1	EVAPORATOR	PLATE	LINE 179	12" 150#RF IN	1
E-2	↓	↓	LINE 180	42" 150#RF OUT	1
E-3	↓	↓	LINE 181	↓	1
E-4	↓	↓	LINE 182	↓	1
T/G-1	TURBINE	↓	LINE 198	88" 150#RF INLET	1
P-3	FEED PUMP	CENTRIFUGAL	LINE 131	94" 150#RF OUTLET	1
P-4	↓	↓	LINE 137	24" 150#RF	1
				↓	

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INSTRUMENTATION LIST - TEMPERATURE SENSORS

ITEM NUMBER	TYPE	MEASUREMENT RANGE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
TE-1 & TT-1	TEMP. SENSOR	30°F to 100°F	LINE 105	1/2" NPT	1
TE-2 & TT-2	↓	↓	LINE 106	↓	1
TE-3 & TT-3	↓	↓	LINE 107	↓	1
TE-4 & TT-4	↓	↓	LINE 108	↓	1
TE-5 & TT-5	DELETED	DELETED	DELETED	DELETED	DELETED
TE-6 & TT-6	TEMP. SENSOR	30°F to 100°F	LINE 131	1/2" NPT	1
TE-7 & TT-7	↓	↓	LINE 132	↓	1
TE-8 & TT-8	↓	↓	LINE 130	↓	1
TE-9 & TT-9	↓	↓	LINE 133	↓	1
TE-10 & TT-10	↓	↓	LINE 157	↓	1
TE-11 & TT-11	↓	↓	LINE 159	↓	1
TE-12 & TT-12	↓	↓	LINE 161	↓	1
TE-13 & TT-13	↓	↓	LINE 163	↓	1
TE-14 & TT-14	↓	↓	LINE 182	↓	1
TE-15 & TT-15	↓	↓	LINE 183	↓	1
TE-16 & TT-16	↓	↓	LINE 184	↓	1
TE-17 & TT-17	↓	↓	LINE 185	↓	1
TE-18 & TT-18	↓	↓	LINE 190	↓	1
TE-19 & TT-19	↓	↓	LINE 191	↓	1
TE-20 & TT-20	↓	↓	LINE 192	↓	1
TE-21 & TT-21	↓	↓	LINE 193	↓	1
TE-22 & TT-22	↓	↓	LINE 198	↓	1
TE-23 & TT-23	↓	↓	LINE 203	↓	1
TE-24 & TT-24	↓	↓	LINE 212	↓	1
TE-25 & TT-25	↓	↓	LINE 211	↓	1
TE-26 & TT-26	↓	↓	LINE 210	↓	1
TE-27 & TT-27	↓	↓	LINE 209	↓	1

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INSTRUMENTATION LIST - PRESSURE SENSORS

ITEM NUMBER	TYPE	MEASUREMENT RANGE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
PE-1 & PT-1	PRESS. SENSOR	0 PSIG to 170 PSIG	LINE 105	1/2" NPT	1
PE-2 & PT-2	↓	↓	LINE 106	↓	1
PE-3 & PT-3	↓	↓	LINE 107	↓	1
PE-4 & PT-4	↓	↓	LINE 108	↓	1
PE-5 & PT-5	DELETED	DELETED	DELETED	DELETED	DELETED
PE-6 & PT-6	PRESS. SENSOR	0 psig to 170 psig	LINE 131	1/2" NPT	1
PE-7 & PT-7	↓	↓	LINE 132	↓	1
PE-8 & PT-8	↓	↓	LINE 130	↓	1
PE-9 & PT-9	↓	↓	LINE 133	↓	1
PE-10 & PT-10	↓	↓	LINE 157	↓	1
PE-11 & PT-11	↓	↓	LINE 159	↓	1
PE-12 & PT-12	↓	↓	LINE 161	↓	1
PE-13 & PT-13	↓	↓	LINE 163	↓	1
PE-14 & PT-14	↓	↓	LINE 182	↓	1
PE-15 & PT-15	↓	↓	LINE 183	↓	1
PE-16 & PT-16	↓	↓	LINE 184	↓	1
PE-17 & PT-17	↓	↓	LINE 185	↓	1
PE-18 & PT-18	↓	↓	LINE 190	↓	1
PE-19 & PT-19	↓	↓	LINE 191	↓	1
PE-20 & PT-20	↓	↓	LINE 192	↓	1
PE-21 & PT-21	↓	↓	LINE 193	↓	1
PE-22 & PT-22	↓	↓	LINE 198	↓	1
PE-23 & PT-23	↓	↓	LINE 203	↓	1
PE-24 & PT-24	↓	↓	LINE 212	↓	1
PE-25 & PT-25	↓	↓	LINE 211	↓	1
PE-26 & PT-26	↓	↓	LINE 210	↓	1
PE-27 & PT-27	↓	↓	LINE 209	↓	1

INSTRUMENTATION LIST - FLOW METERS

ITEM NUMBER	TYPE	MEASUREMENT RANGE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
FE-1 & FT-1	FLOW METER	1.0 to 4.0 $\frac{FT^3}{Sec}$	LINE 117	4" 150 #RF	1
FE-2 & FT-2		1000 to 3000gpm	LINE 105	12" 150 #RF	1
FE-3 & FT-3		1000 to 3000gpm	LINE 106	12" 150 #RF	1
FE-4 & FT-4		1000 to 3000gpm	LINE 107	12" 150 #RF	1
FE-5 & FT-5		1000 to 3000gpm	LINE 108	12" 150 #RF	1
FE-6 & FT-6		200 to 700 gpm	LINE 126	6" 150 #RF	1
FE-7 & FT-7		700 to 2500gpm	LINE 147	8" 150 #RF	1
FE-8 & FT-8		1000 to 3000gpm	LINE 157	12" 150 #RF	1
FE-9 & FT-9		1000 to 3000gpm	LINE 159	12" 150 #RF	1
FE-10 & FT-10		1000 to 3000gpm	LINE 161	12" 150 #RF	1
FE-11 & FT-11		1000 to 3000gpm	LINE 163	12" 150 #RF	1
FE-12 & FT-12		200 to 700 gpm	LINE 165	4" 150 #RF	1
FE-13 & FT-13		20 to 70 gpm	LINE 174	2" 150 #RF	1
FE-14 & FT-14		20 to 70 gpm	LINE 175	2" 150 #RF	1
FE-15 & FT-15		20 to 70 gpm	LINE 176	2" 150 #RF	1
FE-16 & FT-16		20 to 70 gpm	LINE 177	2" 150 #RF	1

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INSTRUMENTATION LIST - POWER SENSORS

ITEM NUMBER	TYPE	MEASUREMENT RANGE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
JE-1 & JT-1	POWER SENSOR	0 to 400 KW	MOTOR M-3	_____	1
JE-2 & JT-2	POWER SENSOR	0 to 400 KW	MOTOR M-4	_____	1
JE-3 & JT-3	POWER SENSOR	8 to 15 MW	TURBINE	_____	1
7-17					

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INSTRUMENTATION LIST -SPEED SENSORS

ITEM NUMBER	TYPE	MEASUREMENT RANGE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
SE-1 & ST-1	SPEED SENSOR	0 to 2000 RPM	PUMP P-3	_____	1
SE-2 & ST-2	SPEED SENSOR	0 to 2000 RPM	PUMP P-4	_____	1
SE-3 & ST-3	SPEED SENSOR	0 to 4000 RPM	TURBINE	_____	1
7-18					

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INSTRUMENTATION LIST - LIQUID LEVEL SENSORS

ITEM NUMBER	TYPE	MEASUREMENT RANGE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
LE-1 & LT-1	LIQUID LEVEL	0 to 100 IN WC	TANK T-5	1/2" NPT	1
LE-2 & LT-2	LIQUID LEVEL	0 to 100 IN WC	LINE 148	1/2" NPT	1

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INSTRUMENTATION LIST - DIFFERENTIAL PRESSURE SENSORS

ITEM NUMBER	TYPE	MEASUREMENT RANGE	LOCATION	SIZE AND TYPE END CONNECTION	NUMBER REQUIRED
PDE-1 & PDT-1	DIFF. PRESS.	0 to 2 PSID	LINE 131	1/2" NPT	1
PDE-2 & PDT-2	DIFF. PRESS.	0 to 2 PSID	LINE 130	1/2" NPT	1
7-20					

TRW
VALVE SPECIFICATIONS

(V-1 THROUGH V-71)

Item Number V-1

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Gaseous Ammonia Density = 0.304 lbs/ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 0.62 Ft³/Sec.

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
TECHNICAL AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-2

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 0.62 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-3

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Gaseous Ammonia Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 0.62 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
DEFENSE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-4

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 0.63 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
VALVE SPECIFICATION SHEET

Item Number V-5

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 2.50 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.41

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown abc

TRW
SPACE AND NAUTICAL SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-6

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 462 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>	
b. Pneumatic Supply Pressure <u>100 PSIG</u>	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed position</u>	
e. Actuating Solenoid Valve <u>Yes</u>	
f. Position of Valve in Failed Position <u>Closed</u>	
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>	
h. Manual Over-ride <u>Yes</u>	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-7

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop 1.0 PSID

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed Position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-8

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 12" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 2.98 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 6808

Maximum Pressure Drop 1.0 PSID

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras, (As Applicable)

a. Type of Actuator <u>Manual</u>	
b. Pneumatic Supply Pressure _____	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed Position</u>	
e. Actuating Solenoid Valve _____	
f. Position of Valve in Failed Position _____	
g. Explosion Proof _____	
h. Manual Over-ride _____	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-9

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop 1.0 PSID

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed Position</u>
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-10

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 12" 150 #RF

Working Fluid Liquid Ammonia, Density = 1bs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 2198 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 6808

Maximum Pressure Drop 1.0 PSID

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>	
b. Pneumatic Supply Pressure _____	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed Position</u>	
e. Actuating Solenoid Valve _____	
f. Position of Valve in Failed Position _____	
g. Explosion Proof _____	
h. Manual Over-ride _____	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
EXPLOSION AND SHOCK SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-11

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop 1.0 PSID

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed Position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-12

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 12" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 2198 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 6808

Maximum Pressure Drop 1.0 PSID

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed Position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown :

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-13
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 2" 150 #RF
Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³
Service Transporting Liquid Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Manual
Flow Rate 116 GPM
Maximum Operating Pressure 167 PSIG
Flow Coefficient 189.1
Maximum Pressure Drop 1.0 PSID
Temperature Range -28°F to 100°F
Material
a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)

- a. Type of Actuator Manual
- b. Pneumatic Supply Pressure _____
- c. Type of Transducer _____
- d. Limit Switches Yes, Both Open and Closed Position
- e. Actuating Solenoid Valve _____
- f. Position of Valve in Failed Position _____
- g. Explosion Proof _____
- h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-14

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 12" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 2198 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 6808

Maximum Pressure Drop 1.0 PSID

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed Position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-15

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 6" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 460 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 1702

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>	
b. Pneumatic Supply Pressure <u>100 PSIG</u>	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed position</u>	
e. Actuating Solenoid Valve <u>Yes</u>	
f. Position of Valve in Failed Position <u>Closed</u>	
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>	
h. Manual Over-ride <u>Yes</u>	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-16

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 6" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 10 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 1702

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>	
b. Pneumatic Supply Pressure _____	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed position</u>	
e. Actuating Solenoid Valve _____	
f. Position of Valve in Failed Position _____	
g. Explosion Proof _____	
h. Manual Over-ride _____	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
VALVE SPECIFICATION SHEET

Item Number V-17

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 24", 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 8792 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 27231

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>	
b. Pneumatic Supply Pressure <u>100 PSIG</u>	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed position</u>	
e. Actuating Solenoid Valve <u>Yes</u>	
f. Position of Valve in Failed Position <u>Closed</u>	
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>	
h. Manual Over-ride <u>Yes</u>	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-18

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 1" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 0.30 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 47.3

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

VALVE SPECIFICATION SHEET

Item Number V-19Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 1" 150 #RFWorking Fluid Liquid Ammonia, Density = 39 lbs/Ft³Service Transporting Liquid Ammonia in a Sea Air EnvironmentType of Operation Full Open, Full Closed, PneumaticFlow Rate 78 GPMMaximum Operating Pressure 167 PSIGFlow Coefficient 47.3

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SSc. Seat Teflon d. Backup Ring _____e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumaticb. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed positione. Actuating Solenoid Valve Yesf. Position of Valve in Failed Position Closedg. Explosion Proof NEMA 7, NEC Class I, Division 2, Group Dh. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
TECHNOLOGY RESEARCH AND DEVELOPMENT
VALVE SPECIFICATION SHEET

Item Number V-20

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 24" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 8792 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 27231

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown ---ve

TRW
RESEARCH AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-21

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 1" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 0.30 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 47.3

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND FORCE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-22

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 24" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 8792 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 2731

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
DEFENSE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-23

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 1" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 0.30 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 47.3

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
TELEPHONE RECORDING AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-24

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 1" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 0.25 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 1/47.3

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-25

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 1" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 778 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 47.3

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown

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TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-26
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 1" 150 #RF
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³
Service Transporting Gaseous Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Pneumatic
Flow Rate 0.30 Ft³/Sec
Maximum Operating Pressure 167 PSIG
Flow Coefficient 47.3
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F
Material
a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing _____
Extras (As Applicable)
a. Type of Actuator Pneumatic
b. Pneumatic Supply Pressure 100 PSIG
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed position
e. Actuating Solenoid Valve Yes
f. Position of Valve in Failed Position Closed
g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D
h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS..
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
VALVE SPECIFICATION SHEET

Item Number V-27

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 1" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 78 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 47.3

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-28

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 24" 150 #RF

Working Fluid Liquid Ammonia • Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 8792 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 27231

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number W-29

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 24" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 8792 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 27231

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
RESEARCH AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-30
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 8" 150 #RF
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³
Service Transporting Gaseous Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Pneumatic
Flow Rate 21 Ft³/Sec
Maximum Operating Pressure 167 PSIG
Flow Coefficient 3026
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic
b. Pneumatic Supply Pressure 100 PSIG
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed position
e. Actuating Solenoid Valve Yes
f. Position of Valve in Failed Position Closed
g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D
h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
TELEPHONE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-31

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 8" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 1530 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 3026

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>	
b. Pneumatic Supply Pressure <u>100 PSIG</u>	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed position</u>	
e. Actuating Solenoid Valve <u>Yes</u>	
f. Position of Valve in Failed Position <u>Closed</u>	
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>	
h. Manual Over-ride <u>Yes</u>	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-32

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 12" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 2200 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 6808

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>	
b. Pneumatic Supply Pressure _____	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed Position</u>	
e. Actuating Solenoid Valve _____	
f. Position of Valve in Failed Position _____	
g. Explosion Proof _____	
h. Manual Over-ride _____	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
VALVE SPECIFICATION SHEET

Item Number V-33
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 2" 150 #RF
Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³
Service Transporting Liquid Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Manual
Flow Rate 116 GPM
Maximum Operating Pressure 167 PSIG
Flow Coefficient 189.1
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F

Material
a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)
a. Type of Actuator Manual
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed Position
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
VALVE SPECIFICATION SHEET

Item Number V-34

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 12" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 2200 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 6808

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed Position</u>
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-35

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed Position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-36

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 12" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 2200 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 6808

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>	
b. Pneumatic Supply Pressure _____	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed Position</u>	
e. Actuating Solenoid Valve _____	
f. Position of Valve in Failed Position _____	
g. Explosion Proof _____	
h. Manual Over-ride _____	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
VALVE SPECIFICATION SHEET

Item Number V-37

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 1.116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed Position</u>
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
VALVE SPECIFICATION SHEET

Item Number V-38

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 12" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 2200 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 6808

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>	
b. Pneumatic Supply Pressure _____	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed Position</u>	
e. Actuating Solenoid Valve _____	
f. Position of Valve in Failed Position _____	
g. Explosion Proof _____	
h. Manual Over-ride _____	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
DEFENSE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-39

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed Position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
REPORT AND SPECIFICATION GROUP
VALVE SPECIFICATION SHEET

Item Number V-40

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Gaseous Ammonia, Density = .447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 2.5 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing _____

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-41

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 460 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TPW
TRIM, PACKING AND SEAT SPECIFICATION SHEET
VALVE SPECIFICATION SHEET

Item Number V-42

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>	
b. Pneumatic Supply Pressure <u>100 PSIG</u>	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed position</u>	
e. Actuating Solenoid Valve <u>Yes</u>	
f. Position of Valve in Failed Position <u>Closed</u>	
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>	
h. Manual Over-ride <u>Yes</u>	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
VALVE SPECIFICATION SHEET

Item Number V-43

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/FT³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1 /

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND NAUTICS SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-44

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	b. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>	
b. Pneumatic Supply Pressure <u>100 PSIG</u>	
c. Type of Transducer _____	
d. Limit Switches <u>Yes, Both Open and Closed position</u>	
e. Actuating Solenoid Valve <u>Yes</u>	
f. Position of Valve in Failed Position <u>Closed</u>	
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>	
h. Manual Over-ride <u>Yes</u>	

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-45

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 2" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 116 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 189.1

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-46
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 6" 150 #RF
Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³
Service Transporting Liquid Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Manual
Flow Rate 58 GPM
Maximum Operating Pressure 167 PSIG
Flow Coefficient 1702
Maximum Pressure Drop 1.0 PSID
Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed Position
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TPW
TEST PROCEDURE WORKSHEET
VALVE SPECIFICATION SHEET

Item Number V-47

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4 1/2" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 427.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 83395

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
TRW SYSTEMS AND SERVICES GROUP
VALVE SPECIFICATION SHEET

Item Number V-48

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Gaseous Ammonia, Density = .447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 5.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

TRW
DEFENSE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-49

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4 1/2" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 427.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 83395 ⁷⁵²⁹⁵

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
VALVE SPECIFICATION SHEET

Item Number V-50
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 4" 150 #RF
Working Fluid Gaseous Ammonia Density = 0.447 lbs/Ft³
Service Transporting Gaseous Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Pneumatic
Flow Rate 5.3 Ft³/sec
Maximum Operating Pressure 167 PSIG
Flow Coefficient 756.4
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic
b. Pneumatic Supply Pressure 100 PSIG
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed position
e. Actuating Solenoid Valve Yes
f. Position of Valve in Failed Position Closed
g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D
h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-51

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4.2" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 427.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 83395

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown abc

TRW
ROCKET AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-52
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 4" 150 #RF
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³
Service Transporting Gaseous Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Pneumatic
Flow Rate 5.3 Ft³/Sec
Maximum Operating Pressure 167 PSIG
Flow Coefficient 756.4
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F
Material
a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos
Extras (As Applicable)
a. Type of Actuator Pneumatic
b. Pneumatic Supply Pressure 100 PSIG
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed position
e. Actuating Solenoid Valve Yes
f. Position of Valve in Failed Position Closed
g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D
h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-53

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 42" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 427.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 83395

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual

b. Pneumatic Supply Pressure _____

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve _____

f. Position of Valve in Failed Position _____

g. Explosion Proof _____

h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

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TRW
TECHNICAL RESEARCH CORPORATION
VALVE SPECIFICATION SHEET

Item Number V-54
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 4" 150 #RF
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³
Service Transporting Gaseous Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Pneumatic
Flow Rate 5.3 Ft³/Sec
Maximum Operating Pressure 167 PSIG
Flow Coefficient 756.4
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F
Material
a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)
a. Type of Actuator Pneumatic
b. Pneumatic Supply Pressure 100 PSIG
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed position
e. Actuating Solenoid Valve Yes
f. Position of Valve in Failed Position Closed
g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D
h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges must be concentrically machined.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-55

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 8" 150 #RF

Working Fluid Gaseous Ammonia • Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 21 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 3026

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-56

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 8" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 21 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 3026

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
TELETYPE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-57

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 88" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 1709 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 366106

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
TELEPHONE RECORDING AND OTHER SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-58

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 30" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Proportional Control and shut off

Flow Rate 1709 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 42548

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer Electro-pneumatic with 4-20 MA Input signal

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown. ...ov

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-59

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Gaseous Ammonia Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 53 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Pack <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
VALVE SPECIFICATION SHEET

Item Number V-60

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Gaseous Ammonia Density = 0.447

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 5.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

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TRW
SPACE AND NAUTICS SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-61
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 54" 150 #RF
Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³
Service Transporting Gaseous Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Manual
Flow Rate 628.3 Ft³/Sec
Maximum Operating Pressure 167 PSIG
Flow Coefficient 137857
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Manual
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed position
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-62
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 4" 150 #RF
Working Fluid Gaseous Ammonia, Density = 0.307 lbs/Ft³
Service Transporting Gaseous Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Pneumatic
Flow Rate 5.3 Ft³/Sec
Maximum Operating Pressure 167 PSIG
Flow Coefficient 756.4
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F
Material
a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)
a. Type of Actuator Pneumatic
b. Pneumatic Supply Pressure 100 PSIG
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed position
e. Actuating Solenoid Valve Yes
f. Position of Valve in Failed Position Closed
g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D
h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

TRW
RESEARCH AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-63

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 54" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 628.3 Ft³/ Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 137857

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-64

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 5.3 Ft³/Sec

Maximum Operating Pressure _____

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

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TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-65

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 54" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 628.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 137857

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-66

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.307 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 5.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-67

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 54" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Manual

Flow Rate 628.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 137857

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Manual</u>
b. Pneumatic Supply Pressure _____
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve _____
f. Position of Valve in Failed Position _____
g. Explosion Proof _____
h. Manual Over-ride _____

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
SPACE AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-68

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 4" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 5.3 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 756.4

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

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TRW
TRW VALVE AND SEAT SYSTEMS CORP.
VALVE SPECIFICATION SHEET

Item Number V-69
Type of Valve Butterfly
Manufacturer _____
Part and/or Model Number _____
Size and type End Connection 4" 150 #RF
Working Fluid Gaseous Ammonia, Density = 0.304 lbs/Ft³
Service Transporting Gaseous Ammonia in a Sea Air Environment
Type of Operation Full Open, Full Closed, Pneumatic
Flow Rate 5.3 Ft³/Sec
Maximum Operating Pressure 167 PSIG
Flow Coefficient 756.4
Maximum Pressure Drop _____
Temperature Range -28°F to 100°F
Material
a. Body CS b. Trim 316 SS
c. Seat Teflon d. Backup Ring _____
e. Packing Asbestos

Extras (As Applicable)
a. Type of Actuator Pneumatic
b. Pneumatic Supply Pressure 100 PSIG
c. Type of Transducer _____
d. Limit Switches Yes, Both Open and Closed position
e. Actuating Solenoid Valve Yes
f. Position of Valve in Failed Position Closed
g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D
h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRW
VALVE AND ACTUATOR SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-70

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 8" 150 #RF

Working Fluid Gaseous Ammonia; Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 21 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 3026

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body <u>CS</u>	b. Trim <u>316 SS</u>
c. Seat <u>Teflon</u>	d. Backup Ring _____
e. Packing <u>Asbestos</u>	

Extras (As Applicable)

a. Type of Actuator <u>Pneumatic</u>
b. Pneumatic Supply Pressure <u>100 PSIG</u>
c. Type of Transducer _____
d. Limit Switches <u>Yes, Both Open and Closed position</u>
e. Actuating Solenoid Valve <u>Yes</u>
f. Position of Valve in Failed Position <u>Closed</u>
g. Explosion Proof <u>NEMA 7, NEC Class I, Division 2, Group D</u>
h. Manual Over-ride <u>Yes</u>

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown

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TRW
TELEPHONE RECORDING AND SPACE SYSTEMS GROUP
VALVE SPECIFICATION SHEET

Item Number V-71

Type of Valve Butterfly

Manufacturer _____

Part and/or Model Number _____

Size and type End Connection 8" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³

Service Transporting Gaseous Ammonia in a Sea Air Environment

Type of Operation Full Open, Full Closed, Pneumatic

Flow Rate 21 Ft³/Sec

Maximum Operating Pressure 167 PSIG

Flow Coefficient 3026

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material

a. Body CS b. Trim 316 SS

c. Seat Teflon d. Backup Ring _____

e. Packing Asbestos

Extras (As Applicable)

a. Type of Actuator Pneumatic

b. Pneumatic Supply Pressure 100 PSIG

c. Type of Transducer _____

d. Limit Switches Yes, Both Open and Closed position

e. Actuating Solenoid Valve Yes

f. Position of Valve in Failed Position Closed

g. Explosion Proof NEMA 7, NEC Class I, Division 2, Group D

h. Manual Over-ride Yes

MISCELLANEOUS DATA

- All construction material used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- No valve shall be used that traps fluid in the open or closed position.
- There shall be no detectable leak through the valve when pressurized to the operating pressure with the working fluid.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above

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TRK
RELIEF VALVE SPECIFICATIONS

(PSV-1 THROUGH PSV-22)

Item Number PSV-1

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 1" 150 #RF

Outlet Size and type end connection 1" 150 #RF

Working Fluid Liquid Ammonia

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Pressure Relief for Liquid Ammonia

Minimum Orifice Size 0.44"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28°F to 100°F

Material

a. Body	<u>CS</u>
b. Trim	<u>316 SS</u>
c. Seat	<u>Teflon</u>

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-2
Manufacturer _____
Part and/or Model Number _____
Inlet Size and type end connection 2" 150 #RF
Outlet Size and type end connection 2" 150 #RF
Working Fluid Liquid Ammonia
Service Transporting Liquid Ammonia in a Sea Air Environment
Type of Operation Pressure Relief for Liquid Ammonia
Minimum Orifice Size 1.56"
Maximum Operating Pressure 152 PSIG
Relief Pressure 167 PSIG
Temperature Range -28°F to 100°F
Material
a. Body CS
b. Trim 316 SS
c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-3

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 2" 150 #RF

Outlet Size and type end connection 2" 150 #RF

Working Fluid Liquid Ammonia

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Pressure Relief for Liquid Ammonia

Minimum Orifice Size 1.56"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28°F to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-4

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 1" 150 #RF

Outlet Size and type end connection 1" 150 #RF

Working Fluid Liquid Ammonia

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Pressure Relief for Liquid Ammonia

Minimum Orifice Size 0.76"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28°F to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-5
Manufacturer _____
Part and/or Model Number _____
Inlet Size and type end connection 1" 150 #RF
Outlet Size and type end connection 1" 150 #RF
Working Fluid Liquid Ammonia
Service Transporting Liquid Ammonia in a Sea Air Environment
Type of Operation Pressure Relief for Liquid Ammonia
Minimum Orifice Size 0.23"
Maximum Operating Pressure 152 PSIG
Relief Pressure 167 PSIG
Temperature Range -28°F to 100°F
Material
a. Body CS
b. Trim 316 SS
c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief Valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-6

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 1" 150 #RF

Outlet Size and type end connection 1" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 0.17"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body	<u>CS</u>
b. Trim	<u>316 SS</u>
c. Seat	<u>Teflon</u>

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-7

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 1" 150 #RF

Outlet Size and type end connection 1" 150 #RF

Working Fluid Liquid Ammonia

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Pressure Relief for Liquid Ammonia

Minimum Orifice Size 0.76"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28°F to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSY-8

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 1" 150 #RF

Outlet Size and type end connection 1" 150 #RF

Working Fluid Liquid Ammonia

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Pressure Relief for Liquid Ammonia

Minimum Orifice Size 0.90"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28°F to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-9

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 2" 150 #RF

Outlet Size and type end connection 2" 150 #RF

Working Fluid Liquid Ammonia

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Pressure Relief for Liquid Ammonia

Minimum Orifice Size 1.44"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28°F to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-10

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 1" 150 #RF/

Outlet Size and type end connection 1" 150 #RF

Working Fluid Liquid Ammonia

Service Transporting Liquid Ammonia in a Sea Air Environment

Type of Operation Pressure Relief for Liquid Ammonia

Minimum Orifice Size 0.44"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28°F to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-1T

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 6" 150 #RF

Outlet Size and type end connection 6" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1.74"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-12
Manufacturer _____
Part and/or Model Number _____
Inlet Size and type end connection 6" 150 #RF
Outlet Size and type end connection 6" 150 #RF
Working Fluid Gaseous Ammonia
Service Transporting Gaseous Ammonia In a Sea Air Environment
Type of Operation Pressure Relief for Gaseous Ammonia
Minimum Orifice Size 1.74"
Maximum Operating Pressure 152 PSIG
Relief Pressure 167 PSIG
Temperature Range -28 to 100°F
Material
a. Body CS
b. Trim 316 SS
c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-13

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 6" 150 #RF

Outlet Size and type end connection 6" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1.74"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-14

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 6" 150 #RF

Outlet Size and type end connection 6" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1.74"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-15

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 2" 150 #RF

Outlet Size and type end connection 2" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 0.45"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-16

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 4" 150 #RF

Outlet Size and type end connection 4" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1.26"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-17

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 6" 150 #RF

Outlet Size and type end connection 6" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1.74"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-18

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 6" 150 #RF

Outlet Size and type end connection 6" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1/74"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-19

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 6" 150 #RF

Outlet Size and type end connection 6" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1.74"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body	<u>CS</u>
b. Trim	<u>316 SS</u>
c. Seat	<u>Teflon</u>

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-20

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 6" 150 #RF

Outlet Size and type end connection 6" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1.74"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-21

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 2" 150 #RF

Outlet Size and type end connection 2" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 0.45"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body	<u>CS</u>
b. Trim	<u>316 SS</u>
c. Seat	<u>Teflon</u>

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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PRESSURE RELIEF VALVE SPECIFICATION SHEET

Item Number PSV-22

Manufacturer _____

Part and/or Model Number _____

Inlet Size and type end connection 6" 150 #RF

Outlet Size and type end connection 6" 150 #RF

Working Fluid Gaseous Ammonia

Service Transporting Gaseous Ammonia In a Sea Air Environment

Type of Operation Pressure Relief for Gaseous Ammonia

Minimum Orifice Size 1.42"

Maximum Operating Pressure 152 PSIG

Relief Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction materials used in the valve shall be compatible with the working fluid.
- All construction materials used in the valve shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the valve at 90% of maximum operating pressure.
- Design shall meet the requirements of Section VIII, Division 1, ASME Pressure Vessel Code.
- Relief valve shall have a closed bonnet.
- Identify item with manufacturer part number and dash number and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
CHECK VALVE SPECIFICATIONS

(CV-1 AND CV-2)

Item Number CV-1

Type of Check Valve _____

Manufacturer _____

Part and/or Model Number _____

Size and Type End Connection 24" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Check Valve for Liquid Ammonia Feed Pump Outlet

Type of Operation Continuous

Flow Rate 8792 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 25000

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material:

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction material used in the check valve shall be compatible with the working fluid.
- All construction materials used in the check valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- There shall be no detectable leak through the check valve when back pressurized to the operating pressure with the working fluid.
- Identify item with manufacturer part number and dash number and item number as shown above.

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CHECK VALVE SPECIFICATION SHEET

Item Number CV-2

Type of Check Valve _____

Manufacturer _____

Part and/or Model Number _____

Size and Type End Connection 24" 150 #RF

Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³

Service Check Valve for Liquid Ammonia Feed Pump Outlet

Type of Operation Continuous

Flow Rate 8792 GPM

Maximum Operating Pressure 167 PSIG

Flow Coefficient 25000

Maximum Pressure Drop _____

Temperature Range -28°F to 100°F

Material:

a. Body CS

b. Trim 316 SS

c. Seat Teflon

MISCELLANEOUS DATA

- All construction material used in the check valve shall be compatible with the working fluid.
- All construction materials used in the check valve shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ inches RMS.
- There shall be no detectable leak through the check valve when back pressurized to the operating pressure with the working fluid.
- Identify item with manufacturer part number and dash number and item number as shown above.

TRW

DEFENSE AND SPACE DIVISION GROUP

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STRAINER SPECIFICATIONS

(S-1 AND S-2)

Item Number S-1

Manufacturer _____

Part and/or Model Number _____

Size and Type End Connection 24" 150 #RF

Working Fluid Liquid Ammonia

Type of Strainer Cone

Maximum Flow Rate 807.6 Lbs/Sec of Ammonia at 52°F

Maximum Pressure Drop, Clean 0.25 PSID

Micron Rating of Element 500 Microns Absolute

Maximum Operating Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat _____

d. Element _____

MISCELLANEOUS DATA

- All construction material used in the Filter shall be compatible with the working fluid.
- All construction materials used in the Filter shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

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STRAINER SPECIFICATION SHEET

Item Number S-2

Manufacturer _____

Part and/or Model Number _____

Size and Type End Connection 24" 150 #RF

Working Fluid Liquid Ammonia

Type of Strainer Cone

Maximum Flow Rate 807.6 Lbs/Sec of Ammonia at 52°F

Maximum Pressure Drop, Clean 0.25 PSID

Micron Rating of Element 500 Microns Absolute

Maximum Operating Pressure 167 PSIG

Temperature Range -28 to 100°F

Material

a. Body CS

b. Trim 316 SS

c. Seat _____

d. Element _____

MISCELLANEOUS DATA

- All construction material used in the Filter shall be compatible with the working fluid.
- All construction materials used in the Filter shall be compatible with a sea air environment or have an approved protection coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

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TRW
TELEPHONE AND SPACE SYSTEMS GROUP
ORIFICE PLATE SPECIFICATION SHEET

Item Number OP-1

Manufacturer _____

Part and/or Model Number _____

Size and Type End Connection 30" 150 #RF

Working Fluid Gaseous Ammonia, Density = 0.447 lbs/Ft³, Temp. 72°F

Flow Rate 764.03 lbs/Sec

Service Provide a pressure drop of 45 PSID

Orifice Size _____

Maximum Operating Pressure 167 PSIG

Pressure Drop 45 PSID

Temperature Range -28°F to 100°F

Material

a. Body CS

b. Plate 316 SS

MISCELLANEOUS DATA

- All construction materials used in the Orifice Plate shall be compatible with the working fluid.
- All construction materials used in the Orifice Plate shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ Inches RMS.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

MAJOR EQUIPMENT SPECIFICATIONS

- PHASE SEPARATORS (T-1 THROUGH T-4)
 - ACCUMULATOR TANK (T-5)
 - CONDENSERS* (C-1 THROUGH C-4)
 - EVAPORATORS* (E-1 THROUGH E-4)
 - TURBINE/GENERATOR (T/G-1)
 - AMMONIA FEED PUMPS (P-3 AND P-4)
AND DRIVE MOTORS (M-3 AND M-4)
- } SEE
APPENDIX I
SECTION 3

* TRW SPECIFICATION NO. SS14-62

TRW
DEFENSE AND SPACE SYSTEMS GROUP
PHASE SEPARATOR SPECIFICATION

Item Number T-1
Type Centrifugal
Manufacturer _____
Part And/Or Model Number _____
Size And Type End Connection For Inlet 42" BW
Size And Type End Connection For Outlet 42" BW
Size And Type End Connection For Liquid Return 2" BW
Outside Diameter 80" Maximum
Overall Length 200" Maximum
Outside Corrosion Allowance 1/8"
Working Fluid Wet Ammonia Vapor, T = 72.2°F, P = 133.9 at Inlet
Service _____
Flow Rate And Quality In 194.90 Lbs/sec, X = 97%, Density = 0.461 Lbs/Ft³
Flow Rate And Quality Out 191.0 Lbs/sec, X = 99%, Density = 0.452 Lbs/Ft³
Maximum Operating Pressure 167 PSIG
Maximum Pressure Drop 0.20 PSID
Temperature Range -28°F to 100 °F
Type Of Supports _____
Shock And Vibration 0.50g, X, Y, & Z
Applicable Codes Sec. VIII, ASME BPV Codes, CG-115
Operating Position Vertical
Material
a. Heads SA-516 GR 60 b. Shell SA-516 GR 60 c. Nozzles SA-106 GR B
d. Flanges SA-105 e. Internals CS or 304LSS

MISCELLANEOUS DATA

- All construction material used that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ inches RMS.
- Identify item with manufacturers part number and dash number and item number as shown above.

GEOMETRIC CONFIGURATION

TRW
TECHNICAL RESEARCH CORPORATION
PHASE SEPARATOR SPECIFICATION

Item Number T-2
Type Centrifugal
Manufacturer _____
Part And/Or Model Number _____
Size And Type End Connection For Inlet 42" BW
Size And Type End Connection For Outlet 42" BW
Size And Type End Connection For Liquid Return 2" BW
Outside Diameter 80" Maximum
Overall Length 200" Maximum
Outside Corrosion Allowance 1/8"
Working Fluid Wet Ammonia Vapor, T = 72.2°F, P = 133.9 at Inlet
Service _____
Flow Rate And Quality In 194.90 Lbs/sec, X = 97%, Density = 0.461 Lbs/Ft³
Flow Rate And Quality Out 191.0 Lbs/sec, X = 99%, Density = 0.452 Lbs/Ft³
Maximum Operating Pressure 167 PSIG
Maximum Pressure Drop 0.20 PSID
Temperature Range -28°F to 100 °F
Type Of Supports _____
Shock And Vibration 0.50g, X, Y, & Z
Applicable Codes Sec. VIII, ASME BPV Codes, CG-115
Operating Position Vertical
Material
a. Heads SA-516 GR 60 b. Shell SA-516 GR 60 c. Nozzles SA-106 GR B
d. Flanges SA-105 e. Internals CS or 304LSS

MISCELLANEOUS DATA

- All construction material used that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ inches RMS.
- Identify item with manufacturers part number and dash number and item number as shown above.

GEOMETRIC CONFIGURATION

TRW
DEFENSE AND SPACE SYSTEMS GROUP
PHASE SEPARATOR SPECIFICATION

Item Number T-3
Type Centrifugal
Manufacturer _____
Part And/Or Model Number _____
Size And Type End Connection For Inlet 42" BW
Size And Type End Connection For Outlet 42" BW
Size And Type End Connection For Liquid Return 2" BW
Outside Diameter 80" Maximum
Overall Length 200" Maximum
Outside Corrosion Allowance 1/8"
Working Fluid Wet Ammonia Vapor, T = 72.2°F, P = 133.9 at Inlet
Service _____
Flow Rate And Quality In 194.90 Lbs/sec, X = 97%, Density = 0.461 Lbs/Ft³
Flow Rate And Quality Out 191.0 Lbs/sec, X = 99%, Density = 0.452 Lbs/Ft³
Maximum Operating Pressure 167 PSIG
Maximum Pressure Drop 0.20 PSID
Temperature Range -28°F to 100 °F
Type Of Supports _____
Shock And Vibration 0.50g, X, Y, & Z
Applicable Codes Sec. VIII, ASME BPV Codes, CG-115
Operating Position Vertical
Material
a. Heads SA-516 GR 60 b. Shell SA-516 GR 60 c. Nozzles SA-106 GR B
d. Flanges SA-105 c. Internals CS or 304LSS

MISCELLANEOUS DATA

- All construction material used that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ inches RMS.
- Identify item with manufacturers part number and dash number and item number as shown above.

GEOMETRIC CONFIGURATION

TRW
SPACE AND SPACE SYSTEMS GROUP
PHASE SEPARATOR SPECIFICATION

Item Number T-4
Type Centrifugal
Manufacturer _____
Part And/Or Model Number _____
Size And Type End Connection For Inlet 42" BW
Size And Type End Connection For Outlet 42" BW
Size And Type End Connection For Liquid Return 2" BW
Outside Diameter 80" Maximum
Overall Length 200" Maximum
Outside Corrosion Allowance 1/8"
Working Fluid Wet Ammonia Vapor, T = 72.2°F, P = 133.9 at Inlet
Service _____
Flow Rate And Quality In 194.90 Lbs/sec, X = 97%, Density = 0.461 Lbs/Ft³
Flow Rate And Quality Out 191.0 Lbs/sec, X = 99%, Density = 0.452 Lbs/Ft³
Maximum Operating Pressure 167 PSIG
Maximum Pressure Drop 0.20 PSID
Temperature Range -28°F to 100 °F
Type Of Supports _____
Shock And Vibration 0.50g, X, Y, & Z
Applicable Codes Sec. VIII, ASME BPV Codes, CG-115
Operating Position Vertical
Material
a. Heads SA-516 GR 60 b. Shell SA-516 GR 60 c. Nozzles SA-106 GR B
d. Flanges SA-105 c. Internals CS or 304LSS

MISCELLANEOUS DATA

- All construction material used that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- Flanges, if specified, must have a finish between 150 and 250 μ inches RMS.
- Identify item with manufacturers part number and dash number and item number as shown above.

GEOMETRIC CONFIGURATION

TANK
SPECIFICATION SHEETEquipment List
Item No.: T-5

TANK NAME:

DESIGN CONDITIONS:

1. Service: Ammonia Storage (Anhydrous)

2. Inside Diameter (in.): 60" ID

3. Applicable Code: ASME VIII, CG-115

4. Internal Design Pressure (psig): 167 psig

5. At Design Temperature (°F): -28°F to 100°F

6. External Design Pressure (PSIA) 1/2 Atmos.

7. At Design Temperature (°F):

8. Corrosion Allowance (in.) 1/8"

9. Joint Efficiency

Heads: 0.85

Shell: 1.0

10. Wind Pressure:

11. Shock and Vibration (g) ±0.5g X, Y, & Z

12. Post Weld Heat Treat:

13. Radiographic Inspection: Spot

14. Insulation: None

Material:

Thickness (in.):

15. Type of Support:

16. Insulation/Fireproofing Support:

17. Manhole Cover:

Hinged: Yes

With Davit: Yes

18. Clips for Ladders and Platforms: Internal & External

19. Lifting Lugs: Required

20. Surface Preparation:

21. Painting:

OPERATING CONDITIONS:

22. Operating Pressure (psig): 77 psig

23. Operating Temperature (°F): 52°F

24. Specific Gravity of Liquid: 0.625

TANK MATERIALS

25. Heads: SA-516 GR 60

26. Shell: SA-516 GR 60

27. Support: SA-516 GR 60

28. Nozzle Necks: SA-106 GRB

29. Flanges:

30. Couplings:

31. Gaskets: Flexitallic Type CGI

32. Removable Internals: No

NOZZLES

	Mark	Number	Size (inches)	Rating of Facing	Service		Mark	Number	Size (inches)	Rating of Facing	Service
33.	N1	1	6"	BW	Vaporout	43.					
34.	N2	1	24"	BW	Inlet	44.					
35.	N3	1	24"	BW	Outlet	45.					
36.	N4	1	2"	150#RF	Relief	46.					
37.	N5	1	2"	150#RF	Relief	47.					
38.	N6	4	6"x6"x11	10,000#	Support	48.					
39.						49.					
40.						50.					
41.						51.					
42.						52.					

STEELS USED MUST BE APPROVED
AND ARE LIMITED TO A MAXI-
MUM YIELD STRESS OF 50,000
PSI.

FLANGES, IF SPECIFIED, MUST HAVE A FINISH
BETWEEN 150 AND 250 μ INCHES RMS.

SIZE	FSCM NO.	REV.
A	11982	
SCALE	ACCUMULATOR TANK	SHEET

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TRW
OFFICE AND SPACE SYSTEMS GROUP
PUMP SPECIFICATION SHEET

Item Number P-3
Manufacturer _____
Model Number _____
Type of Pump Centrifugal
Type of Driver Variable Speed, See Pump Drives Specification
Working Fluid Liquid Ammonia at 50°F, specific gravity = 0.625
Type of Operation Pumping Liquid Ammonia at a Variable flow rate
Temperature Range -28 to 100°F
Maximum Pump Outlet Pressure 167 PSIG
Maximum NPSH Required at Rated Flow Conditions: 10 Ft. Maximum
Maximum Flow Rate 10,088 GPM Total Developed Head 177 FT
Minimum Flow Rate 5044 GPM Total Developed Head 166 FT
Pump Suction Connection 24" 150 #RF
Pump Discharge Connection 24" 150 #RF
Speed Sensor Yes, see specification
Power Sensor Yes, see specification

MISCELLANEOUS DATA

- All construction material used in the pump shall be compatible with the working fluid.
- All construction materials used in the pump shall be compatible with a sea air environment or have an approved protection coating.
- Flange finish shall be between 150 and 250 μ Inches RMS.
- The shaft seal shall be a tandum mechanical seal with pumping ring.
- Inner seal flush piping type API Plan 11; outer seal flush piping type API Plan 52 with pressure switch.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

PUMP DRIVER SPECIFICATION SHEET

ITEM NUMBER: M-3

DESCRIPTION:

The adjustable pump drive system shall consist of an adjustable frequency inverter, adjustable speed motor and motor controls. Control input is 4 to 20 MA from a liquid level sensor.

MANUFACTURER:

PART AND/OR MODEL NUMBER:

TYPE: Adjustable frequency drive

SERVICE: Centrifugal pump drive

MOTOR:

Type: Horizontal AC squirrel cage induction motor, explosion proof and compatible with adjustable frequency drive.
Horsepower:
Frequency: 60 HZ
National Electrical Code Rating: Class 1 Div 1 Group D
Maximum RPM:
Minimum RPM:
Service Factor: 1.0

POWER SUPPLY:

Type: Adjustable frequency
Manufacturer:
Part And/Or Model Number:
Rating: horsepower; 3 phase, 60 Hz
Speed Regulation: $\pm 2\%$ no load to full load
Controlled Speed Range:

The inverter shall be a voltage source design which converts incoming 3 phase 460 V (+ 10% - 5%) 60 Hz ± 2 Hz to an adjustable voltage DC and then to adjustable frequency AC by use of a 3 phase inverter. The converter and inverter shall be of modular construction.

MISCELLANEOUS DATA

- Construction materials must be compatible with a sea air environment or have an approved protective coating.
- Identify Item with Manufacturer part number and dash number and Item number as shown above.

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TRW
OFFICE AND SPACE SYSTEMS GROUP
PUMP SPECIFICATION SHEET

Item Number P-4

Manufacturer _____

Model Number _____

Type of Pump Centrifugal

Type of Driver Variable Speed, See Pump Drives Specification

Working Fluid Liquid Ammonia at 50°F, specific gravity = 0.625

Type of Operation Pumping Liquid Ammonia at a Variable flow rate

Temperature Range -28 to 100°F

Maximum Pump Outlet Pressure 167 PSIG

Maximum NPSH Required at Rated Flow Conditions: 10 Ft. Maximum

Maximum Flow Rate 10.088 GPM Total Developed Head 177 FT

Minimum Flow Rate 5.044 GPM Total Developed Head 166 FT

Pump Suction Connection 24" 150 #RF

Pump Discharge Connection 24" 150 #RF

Speed Sensor Yes, see specification

Power Sensor Yes, see specification

MISCELLANEOUS DATA

- All construction material used in the pump shall be compatible with the working fluid.
- All construction materials used in the pump shall be compatible with a sea air environment or have an approved protection coating.
- Flange finish shall be between 150 and 250 μ Inches RMS.
- The shaft seal shall be a tandem mechanical seal, with pumping ring.
- Inner seal flush piping type API Plan 11; outer seal flush piping type API Plan 52 with pressure switch.
- Identify Item with Manufacturer Part Number and Dash Number and Item Number as shown above.

PUMP DRIVER SPECIFICATION SHEET

ITEM NUMBER: M-4

DESCRIPTION:

The adjustable pump drive system shall consist of an adjustable frequency inverter, adjustable speed motor and motor controls. Control input is 4 to 20 MA from a liquid level sensor.

MANUFACTURER:

PART AND/OR MODEL NUMBER:

TYPE: Adjustable frequency drive

SERVICE: Centrifugal pump drive

MOTOR:

Type: Horizontal AC squirrel cage induction motor, explosion proof and compatible with adjustable frequency drive.
Horsepower:
Frequency: 60 HZ
National Electrical Code Rating: Class 1 Div 1 Group D
Maximum RPM:
Minimum RPM:
Service Factor: 1.0

POWER SUPPLY:

Type: Adjustable frequency
Manufacturer:
Part And/Or Model Number:
Rating: horsepower, 3 phase, 60 Hz
Speed Regulation: $\pm 2\%$ no load to full load
Controlled Speed Range:

The inverter shall be a voltage source design which converts incoming 3 phase 460 V (+ 10% - 5%) 60 Hz ± 2 Hz to an adjustable voltage DC and then to adjustable frequency AC by use of a 3 phase inverter. The converter and inverter shall be of modular construction.

MISCELLANEOUS DATA

- Construction materials must be compatible with a sea air environment or have an approved protective coating.
- Identify Item with Manufacturer part number and dash number and Item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATIONS

Temperature Sensor Element: (TE-1 THROUGH TE-27)

Item Number TE-1
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 lbs/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-1
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-2
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-2
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-3
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS ~~Wet~~ 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-3
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm 0.15^{\circ}\text{F}$ Repeatability $\pm 0.070^{\circ}\text{F}$ Linearity $\pm 0.070^{\circ}\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-4
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-4
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-6

Type of Sensor RTD

Manufacturer _____

Part Number and/or Model Number _____

Size and Type of End Connection 1/2" NPT

Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³

Service Continuous Measurement of Liquid Ammonia Temperature

Maximum Operating Pressure of Working Fluid 167 PSIG

Temperature Range of Working Fluid -28°F to 100°F

Sensing Element Length 4"

Input Power _____

Output Signal _____

Measurement Range 30°F to 100°F

Material: Body 304SS Well 304SS Element Platinum Lead Wire _____

Lead Wire Size _____

TRANSMITTER:

Item Number TT-6

Type of Transmitter _____

Manufacturer _____

Part Number and/or Model Number _____

Input Power 24 V dc

Output Signal 4-20 MA dc

Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐

Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-7
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-7
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-8
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-8
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$

Identify items with manufacturer part number, dash number, and item number as shown above.

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DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-9
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-9
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-10
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-10
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-11
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-11
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-12
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-12
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm 0.15^{\circ}\text{F}$ Repeatability $\pm 0.070^{\circ}$ Linearity $\pm 0.070^{\circ}\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-13
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Liquid Ammonia, Density = 39 LBS/Ft³
Service Continuous Measurement of Liquid Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 4"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element / Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT -13
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-14
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-14
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-15
 Type of Sensor RTD
 Manufacturer _____
 Part Number and/or Model Number _____
 Size and Type of End Connection 1/2" NPT
 Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
 Service Continuous Measurement of Gaseous Ammonia Temperature
 Maximum Operating Pressure of Working Fluid 167 PSIG
 Temperature Range of Working Fluid -28°F to 100°F
 Sensing Element Length 6"
 Input Power _____
 Output Signal _____
 Measurement Range 30°F to 100°F
 Material: Body 304SS Well 304SS Element / Platinum Lead Wire _____
 Lead Wire Size _____

TRANSMITTER:

Item Number TI-15
 Type of Transmitter _____
 Manufacturer _____
 Part Number and/or Model Number _____
 Input Power 24 V dc
 Output Signal 4-20 MA dc
 Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
 Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-16
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element / Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-16
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^{\circ}\text{F}$ Repeatability $\pm 0.070^{\circ}$ Linearity $\pm 0.070^{\circ}\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-17
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

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Item Number TT-17
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-18
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-18
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$

Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-19
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-19
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^{\circ}\text{F}$ Repeatability $\pm 0.070^{\circ}$ Linearity $\pm 0.070^{\circ}\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-20
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-20
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$

Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-21
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-21
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-22
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.447 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element / Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-22
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-23
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.304 LBS/Ft²
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-23
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^{\circ}\text{F}$ Repeatability $\pm 0.070^{\circ}$ Linearity $\pm 0.070^{\circ}\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-24
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.304 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-24
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^{\circ}\text{F}$ Repeatability $\pm 0.070^{\circ}$ Linearity $\pm 0.070^{\circ}\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-25
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.304 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-25
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^\circ\text{F}$ Repeatability $\pm 0.070^\circ$ Linearity $\pm 0.070^\circ\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-26
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.304 LBS/Ft³
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-26
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^{\circ}\text{F}$ Repeatability $\pm 0.070^{\circ}$ Linearity $\pm 0.070^{\circ}\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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DEFENSE AND SPACE SYSTEMS GROUP
TEMPERATURE SENSOR SPECIFICATION

Temperature Sensor Element:

Item Number TE-27
Type of Sensor RTD
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT
Working Fluid Gaseous Ammonia, Density = 0.304 LBS/Ft
Service Continuous Measurement of Gaseous Ammonia Temperature
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length 6"
Input Power _____
Output Signal _____
Measurement Range 30°F to 100°F
Material: Body 304SS Well 304SS Element Platinum Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number TT-27
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm 0.15^{\circ}\text{F}$ Repeatability $\pm 0.070^{\circ}$ Linearity $\pm 0.070^{\circ}\text{F}$
- Identify items with manufacturer part number, dash number, and item number as shown above.

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DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATIONS

Pressure Sensor Element: (PE-1 THROUGH PE-27)

Item Number PE-1
Type of Sensor Strain Gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-1
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-2
Type of Sensor Stain Gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-2
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .2\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-3
Type of Sensor Stain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-3
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-4
Type of Sensor Stain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-4
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-6
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-6
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-7
Type of Sensor Strain Gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-7
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-8
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-8
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-9
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-9
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-10
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-10
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-11
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-11
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-12
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-12
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-13
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density = 39 lbs/ft³
Service Continuous Measurement of Liquid Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-13
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-14
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-14
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-15
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-15
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-16
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-16
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-17
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-17
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Sp
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-18
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-18
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-19
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-19
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-20
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-20
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-21
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-21
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Sp
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-22
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.447 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-22
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-23
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.304 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-23
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-24
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.304 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-24
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-25
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.304 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-25
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-26
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.304 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-26
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
PRESSURE SENSOR SPECIFICATION

Pressure Sensor Element:

Item Number PE-27
Type of Sensor Strain gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Gaseous Ammonia, Density = 0.304 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Pressure
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSIG to 170 PSIG
Material: Body CS Trim 304SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PT-24
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Sp.
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
FLOW METER SPECIFICATIONS
(FE-1 THROUGH FE-16)

FLOW METER ELEMENT:

Item Number FE-1
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 4" 150 #RF
Working Fluid Gaseous Ammonia, Density = 0.304 lbs/ft³
Service Continuous Measurement of Gaseous Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSIG
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1.0 FT³/Sec to 4.0 FT³/Sec
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-1
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the flow meter at maximum operating pressure. Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number 1 FE-2
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 12" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1000 to 3000 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-2
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-3
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 12" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1000 to 3000 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-3
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure. Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-4
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 12" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1000 to 3000 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-4
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-5
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 12" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1000 to 3000 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-5
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure. Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-6
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 6" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 200 to 700 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-6
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-7
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 8" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 700 to 2500 GPM
Material: Body CS Trim 304SS Lead Wire _____
ad Wire Size _____

TRANSMITTER:

Item Number FT-7
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure. Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-8
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 12" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1000 to 3000 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-8
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-9
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 12" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1000 to 3000 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-9
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure. Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-10
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 12" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1000 to 3000 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-10
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-11
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 12" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 1000 to 3000 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-11
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure. Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-12
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 4" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 200 to 700 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-12
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-13
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 2" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 20 to 70 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-13
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure. Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-14
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 2" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 20 to 70 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-14
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-15
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 2" 150 #RF
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 20 to 70 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-15
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure. Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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FLOW METER SPECIFICATION

FLOW METER ELEMENT:

Item Number FE-16
Type of Flow Meter Element Turbine Meter
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 2" 150 #RF
Working Fluid Liquid Ammonia, Density = 37.9 #/FT³
Service Continuous Measurement of Liquid Ammonia Flow Rate
Maximum Pressure Drop 1.0 PSID
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Input Power _____
Output Signal Magnetic
Measurement Range 20 to 70 GPM
Material: Body CS Trim 304SS Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number FT-16
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the flow meter at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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TRW
DEFENSE AND SPACE SYSTEMS GROUP
POWER SENSOR SPECIFICATIONS
(JE-1 THROUGH JE-3)

POWER SENSOR ELEMENT:

Item Number JE-1
Type of Sensor _____
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection _____
Service Continuous Measurement of Feed Pump Power
Ambient Temperature Range 40°F to 100°F
Input Power _____
Output Signal _____
Measurement Range 0 KW to 400 KW
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number JT-1
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 Vdc
Output Signal 4 to 20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA:

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
Identify items with manufacturer part number, dash number, and item number as shown above.

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POWER SENSOR SPECIFICATION

POWER SENSOR ELEMENT:

Item Number JE-2-2
Type of Sensor _____
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection _____
Service Continuous Measurement of Feed Pump Power
Ambient Temperature Range 40°F to 100°F
Input Power _____
Output Signal _____
Measurement Range 0 KW to 400 KW
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number JT-2
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 Vdc
Output Signal 4 to 20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA:

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Identify items with manufacturer part number, dash number, and item number as shown above.

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POWER SENSOR SPECIFICATION

POWER SENSOR ELEMENT:

Item Number JE-3
Type of Sensor _____
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection _____
Service Continuous Measurement of Generator Output Power
Ambient Temperature Range 40°F to 100°F
Input Power _____
Output Signal _____
Measurement Range 8 MW to 15 MW
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number JT-3
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 Vdc
Output Signal 4 to 20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA:

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Identify items with manufacturer part number, dash number, and item number as shown above.

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SPEED SENSOR SPECIFICATIONS

(SE-1 THROUGH SE-3)

SPEED SENSOR ELEMENT:

Item Number SE-1
Type of Sensor _____
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection _____
Service Continuous Measurement of Feed Pump Speed
Ambient Temperature Range 40°F to 100°F
Input Power _____
Output Signal _____
Measurement Range 0 RPM to 2000 RPM
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number ST-1
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 Vdc
Output Signal 4 to 20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA:

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Identify items with manufacturer part number, dash number, and item number as shown above.

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SPEED SENSOR SPECIFICATION

SPEED SENSOR ELEMENT:

Item Number SE-2
Type of Sensor _____
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection _____
Service Continuous Measurement of Feed Pump Speed
Ambient Temperature Range 40°F to 100°F
Input Power _____
Output Signal _____
Measurement Range 0 RPM to 2000 RPM
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number ST-2
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 Vdc
Output Signal 4 to 20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA:

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Identify items with manufacturer part number, dash number, and item number as shown above.

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SPEED SENSOR SPECIFICATION

SPEED SENSOR ELEMENT:

Item Number SE-3
Type of Sensor _____
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection _____
Service Continuous Measurement of Turbine Speed
Ambient Temperature Range 40°F to 100°F
Input Power _____
Output Signal _____
Measurement Range 0 RPM to 4000 RPM
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number ST-3
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V&C
Output Signal 4 to 20 Ma dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA:

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Accuracy $\pm .25\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .25\%$ of Span
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.

Identify items with manufacturer part number, dash number, and item number as shown above.

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LIQUID LEVEL SENSOR SPECIFICATION

Liquid Level Sensor Element:

Item Number LE-1
Type of Sensor Differential Pressure With Temperature Compensation
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid ammonia, temperature varies from 40°F to 85°F
Service Continuous measurement of liquid ammonia level
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 in. to 100 in. of water column
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number LT-1
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4 to 20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
 - All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
 - There shall be no detectable leakage through the sensor at maximum operating pressure.
 - Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
 - Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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LIQUID LEVEL SENSOR SPECIFICATION

Liquid Level Sensor Element:

Item Number LE-2
Type of Sensor Differential Pressure With Temperature Compensation
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid ammonia, temperature varies from 40°F to 85°F
Service Continuous measurement of liquid ammonia level
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 in. to 100 in. of water column
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number LT 2
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4 to 20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

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DIFFERENTIAL PRESSURE SENSOR SPECIFICATION

Differential Pressure Sensor Element:

Item Number PDE-1
Type of Sensor Strain Gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Pressure Drop Across a Strainer
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSID to 2 PSID
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PDT-1
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

79.6852.2.9-77
ATTACHMENT 1
22 FEB 1979
PAGE 233

DIFFERENTIAL PRESSURE SENSOR SPECIFICATION

Differential Pressure Sensor Element:

Item Number PDE-2
Type of Sensor Strain Gauge
Manufacturer _____
Part Number and/or Model Number _____
Size and Type of End Connection 1/2" NPT with shut off valves
Working Fluid Liquid Ammonia, Density =
Service Continuous Measurement of Liquid Ammonia Pressure Drop Across a Strainer
Maximum Operating Pressure of Working Fluid 167 PSIG
Temperature Range of Working Fluid -28°F to 100°F
Sensing Element Length _____
Input Power _____
Output Signal _____
Measurement Range 0 PSID to 2 PSID
Material: Body CS Trim 304 SS Element _____ Lead Wire _____
Lead Wire Size _____

TRANSMITTER:

Item Number PDT-2
Type of Transmitter _____
Manufacturer _____
Part Number and/or Model Number _____
Input Power 24 V dc
Output Signal 4-20 MA dc
Location of Transmitter With Respect To Sensing Element: LOCAL ☒ REMOTE ☐
Lead Wire Size 22 AWG

MISCELLANEOUS DATA

- All construction material that is in contact with the working fluid shall be compatible with the working fluid.
- All construction material that is used shall be compatible with a sea air environment or have an approved protective coating.
- There shall be no detectable leakage through the sensor at maximum operating pressure.
- Explosion proofing shall be NEMA 7, NEC Class I, Division 2, Group D.
- Accuracy $\pm .20\%$ of Span Repeatability $\pm .10\%$ of Span Linearity $\pm .10\%$ of Span
- Identify items with manufacturer part number, dash number, and item number as shown above.

8. DRAWING TREE

<u>TITLE</u>	<u>DWG. NO.</u>
• <u>10 MWe POWER MODULE:</u>	
COVER SHEET/DWG INDEX	6850.94-00
DRAWING TREE	6850.94-01
LEGEND & SYMBOLS	6850.94-02
SYMBOLS & ABBREVIATIONS	6850.94-03
PROCESS FLOW DIAGRAM - NOMINAL FLOW CONDITION	6850.94-04
POWER/SHIP SYSTEM INTERFACES - PLAN	6850.94-05
POWER/SHIP SYSTEM INTERFACES - SECTIONS	6850.94-06
PIPING & INSTRUMENTATION DIAGRAM	6850.94-07
AMMONIA SUPPORT SYSTEM - PIPING & INSTRUMENTATION DIAGRAM	6850.94-08
NITROGEN SUPPORT SYSTEM - PIPING & INSTRUMENTATION DIAGRAM	6850.94-09
GENERAL ARRANGEMENT - PLAN	6850.94-10
GENERAL ARRANGEMENT - ELEVATION	6850.94-11
GENERAL ARRANGEMENT - SECTION	6850.94-12
GENERAL ARRANGEMENT - SECTION & PLAN	6850.94-13
HEAT EXCHANGER SUPPORT DETAILS	6850.94-14
EVAPORATOR & CONDENSER SUPPORTS - PLAN & DETAIL	6850.94-15
TURBINE DECK SUPPORT - PLAN, ELEVATION & SECTION	6850.94-16
PRIMARY DISTRIBUTION ELECTRICAL - SINGLE LINE DIAGRAM	6850.94-17
MOTOR CONTROL CENTER - SINGLE LINE DIAGRAM & GENERAL ARRANGEMENT	6850.94-18
HEAT EXCHANGER - TUBE CLEANER - OPEN WATER BOX DESIGN	6850.94-19
STAINLESS STEEL OPTION - PROCESS FLOW DIAGRAM-NOMINAL FLOW CONDITION	6850.94-20
• <u>0.2 MWe TEST ARTICLE:</u>	
CONCEPTUAL TEST LOOP - PIPING & INSTRUMENTATION DIAGRAM	6850.94-50
HEAT EXCHANGER - TUBE PATTERN & CLEANING SEQUENCE	6850.94-51
TUBE CLEANER - OPEN WATER BOX DESIGN	6850.94-52
TUBE CLEANER - CLOSED WATER BOX DESIGN	6850.94-53
CONCEPTUAL TEST LOOP - OTEC-1 SHIPBOARD ARRANGEMENT	6850.94-54
TUBE CLEANER - CLOSED WATER BOX DESIGN - MANUAL OPERATION	6850.94-55
CONCEPTUAL TEST LOOP - PROCESS FLOW DIAGRAM	6850.94-56
TUBE CLEANER HEAD - CLOSED WATER BOX - MANUAL OPERATION	6850.94-57
HEAT EXCHANGER - CLOSED WATER BOX ASSEMBLY	6850.94-58
• <u>10 MWe & 0.2 MWe TEST ARTICLE:</u>	
TUBE CLEANER HEAD - OPEN OR CLOSED WATER BOX DESIGN	6850.94-70
• <u>10 MWe POWER MODULE:</u>	
<u>CONCEPTUAL</u>	
STACKED HEAT EXCHANGERS - PLAN	6850.94-90
STACKED HEAT EXCHANGERS - ELEVATION	6850.94-91

OTEC PSD-II DRAWING TREE

LEGEND:

DESIGNED By *E. J. Edd*
 DRAWN By *E. J. Edd*
 CHECKED By *R. O. Brown*
 APPROVALS
 RELEASED BY *R. O. Brown*
 PRDGO OFFICE *P. J. H. H. H.*

OTEC POWER SYSTEM DEVELOPMENT - II
 DRAWING TREE

LTR	DATE	REVISION	BY	APPRO
TRW FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY				
DRAWING NUMBER				
6850.94-01				
ISSUE DATE				
5-16-79				
CHG LTR				

9. DRAWING PACKAGE

DEPARTMENT OF ENERGY

OCEAN THERMAL ENERGY CONVERSION

POWER SYSTEM DEVELOPMENT - II

PRELIMINARY DESIGN

TITLE

DRAWING NO.

10 MW_e POWER MODULE:

COVER SHEET/DWG INDEX	6850.94-00
DRAWING TREE	6850.94-01
LEGEND & SYMBOLS	6850.94-02
SYMBOLS & ABBREVIATIONS	6850.94-03
PROCESS FLOW DIAGRAM - NOMINAL FLOW CONDITION	6850.94-04
POWER/SHIP SYSTEM INTERFACES - PLAN	6850.94-05
POWER/SHIP SYSTEM INTERFACES - SECTIONS	6850.94-06
PIPING & INSTRUMENTATION DIAGRAM	6850.94-07
AMMONIA SUPPORT SYSTEM - PIPING & INSTRUMENTATION DIAGRAM	6850.94-08
NITROGEN SUPPORT SYSTEM - PIPING & INSTRUMENTATION DIAGRAM	6850.94-09
GENERAL ARRANGEMENT - PLAN	6850.94-10
GENERAL ARRANGEMENT - ELEVATION	6850.94-11
GENERAL ARRANGEMENT - SECTION	6850.94-12
GENERAL ARRANGEMENT - SECTION & PLAN	6850.94-13
HEAT EXCHANGER SUPPORT DETAILS	6850.94-14
EVAPORATOR & CONDENSER SUPPORTS - PLAN & DETAIL	6850.94-15
TURBINE DECK SUPPORT - PLAN, ELEVATION & SECTION	6850.94-16
PRIMARY DISTRIBUTION ELECTRICAL - SINGLE LINE DIAGRAM	6850.94-17
MOTOR CONTROL CENTER - SINGLE LINE DIAGRAM & GENERAL ARRANGEMENT	6850.94-18
HEAT EXCHANGER - TUBE CLEANER - OPEN WATER BOX DESIGN	6850.94-19
STAINLESS STEEL OPTION - PROCESS FLOW DIAGRAM-NOMINAL FLOW CONDITION	6850.94-20

0.2 MW_e TEST ARTICLE:

CONCEPTUAL TEST LOOP - PIPING & INSTRUMENTATION DIAGRAM	6850.94-50
HEAT EXCHANGER - TUBE PATTERN & CLEANING SEQUENCE	6850.94-51
TUBE CLEANER - OPEN WATER BOX DESIGN	6850.94-52
TUBE CLEANER - CLOSED WATER BOX DESIGN	6850.94-53
CONCEPTUAL TEST LOOP - OTEC-1 SHIPBOARD ARRANGEMENT	6850.94-54
TUBE CLEANER - CLOSED WATER BOX DESIGN - MANUAL OPERATION	6850.94-55
CONCEPTUAL TEST LOOP - PROCESS FLOW DIAGRAM	6850.94-56
TUBE CLEANER HEAD - CLOSED WATER BOX - MANUAL OPERATION	6850.94-57
HEAT EXCHANGER - CLOSED WATER BOX ASSEMBLY	6850.94-58

10 MW_e & 0.2 MW_e TEST ARTICLE:

TUBE CLEANER HEAD - OPEN OR CLOSED WATER BOX DESIGN	6850.94-70
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10 MW_e POWER MODULE:

CONCEPTUAL

STACKED HEAT EXCHANGERS - PLAN	6850.94-90
STACKED HEAT EXCHANGERS - ELEVATION	6850.94-91

DESIGNED <i>E. J. ...</i>	OTEC POWER SYSTEM DEVELOPMENT - II	DATE	REVISION	BY	APPD
DRAWN <i>E. J. ...</i>	COVER SHEET/DWG INDEX	TRW FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY DRAWING NUMBER 6850.94-00 ISSUE DATE CNG LTR			
CHECKED <i>...</i>					
APPROVALS <i>...</i>					
RELEASED BY <i>R/S</i>	FROM OFFICE <i>...</i>				

OTEC PSD-II DRAWING TREE

LEGEND:

DESIGNED <i>Egon Finkel</i>	OTEC POWER SYSTEM DEVELOPMENT - II		TRW	
DRAWN <i>Egon Finkel</i>	DRAWING TREE		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY	
CHECKED <i>RO Brown</i>	APPROVALS		DRAWING NUMBER 6850.94-01	
PROJ OFFICE <i>PJB</i>	RELEASED BY <i>181</i>		ISSUE DATE 5-10-79	
				CHG LTR

VALVES	
	GATE
	EXCESS FLOW VALVE
	GLOBE
	CHECK
	BUTTERFLY
	MODULATING CONTROL BUTTERFLY
	THREE-WAY
	MODULATING CONTROL
	CYLINDER OPERATED
	SOLENOID OPERATED
	RELIEF
	AUTO-OPERATED HAND OVERRIDE
	SELF CONTAINED PRESSURE CONTROL
	THREE-WAY AUTO-OPERATED HAND OVERRIDE
	THREE-WAY AUTO-OPERATED
	BALL
	NEEDLE

EQUIPMENT	
	PUMP
	VACUUM PUMP
	FILTER
	TURBINE FLOW METER
	SONIC FLOW METER
	RUPTURE DISC
	VENTURI
	HEAT EXCHANGER
	SPRAY NOZZLE
	ORIFICE PLATE
	EXPANSION JOINT
	Y - TYPE STRAINER
	FLANGE
	REDUCER
	FLEXIBLE
	INSULATED LINE
	STRAINER (B=BASKET, C=CONE, P=PLATE)
	DESUPERHEATER

LINE DESIGNATIONS	
	INSULATION LINE SIZE (INCHES) LINE CLASS LINE NUMBER
	PROCESS LINE - PRIMARY
	PROCESS LINE - SECONDARY
	SEAWATER
INSTRUMENT LINES	
	PNEUMATIC
	ELECTRICAL

MISCELLANEOUS	
	LINE CONTINUATION ON DIFFERENT SHEET
	INTERFACE WITH SHIP SYSTEM
	STATE POINT
	REVISED AREA OF DRAWING

DESIGNED <i>EE</i>	OTEC POWER SYSTEM DEVELOPMENT - II	LTR	DATE	REVISION	BY	APPD
DRAWN <i>R. COREY</i>	LEGEND & SYMBOLS	FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY DRAWING NUMBER 6850.94-02 ISSUE DATE 5-14-79 CHK LTR				
CHECKED <i>R.D.</i>						
APPROVALS <i>N. K. H. H. H.</i>						
PROG OFFICE <i>J. J. H. H.</i>						

ABBREVIATIONS

ACFM — ACTUAL CUBIC FEET PER MINUTE
 ACFS — ACTUAL CUBIC FEET PER SECOND
 AL — ALUMINUM
 BL — BASE LINE
 B — NITROGEN VAPORIZER
 BHP — BRAKE HORSEPOWER
 BTU — BRITISH THERMAL UNIT
 CFS — CUBIC FEET PER SECOND
 C — CONDENSER
 CFR — CODE OF FEDERAL REGULATIONS
 CKT — CIRCUIT
 CS — CARBON STEEL
 CV — CHECK VALVE
 CW — COLD WATER
 CFM — CUBIC FEET PER MINUTE
 U — U-SUPERHEATER
 DISCH — DISCHARGE
 D_o — OUTSIDE DIA OF TUBE
 DP — DIFFERENTIAL PRESSURE
 DT — DESIGN TEMPERATURE
 DWG — DRAWING
 EA — EACH
 E — EVAPORATOR
 FC — FAIL CLOSED
 F — FILTER
 FT — FEET
 FO — FAIL OPEN
 GAL — GALLONS
 GN₂ — GASEOUS NITROGEN
 GPM — GALLONS PER MINUTE
 GFE — GOVERNMENT FURNISHED EQUIPMENT
 H — HEAT EXCHANGER
 HP — HORSEPOWER
 HR — HOUR
 HZ — HERTZ (CYCLES PER SEC)
 ID — INSIDE DIAMETER
 IN — INCHES
 KV — KILOVOLT
 KVA — KILOVOLT AMPERES
 KW — KILOWATT
 KWe — KILOWATT ELECTRICAL

LB — POUND
 L_{eff} — EFFECTIVE LENGTH OF TUBE-FT
 L_{tot} — TOTAL LENGTH OF TUBE-FT

MBTU — MILLION BRITISH THERMAL UNITS
 MCM — THOUSAND CUBIC METERS
 MM — ONE MILLION
 MW — MEGAWATT
 MW — MAN WAY
 MWe — MEGAWATT ELECTRICAL
 MWt — MEGAWATT THERMAL

CONC — CONCENTRIC

DO — DITTO

EB — ELECTRON BEAM

RED — REDUCER

NTS — NOT TO SCALE
 N — NUMBER OF TUBES
 N₂ — NITROGEN GAS
 NC — NORMALLY CLOSED
 NH₃ — AMMONIA
 NIC — NOT IN CONTRACT
 NOM — NOMINAL
 OD — OUTSIDE DIAMETER
 OPNG — OPENING
 PL — PLACE
 PL — PLATE
 P — PUMPS, COMPRESSORS
 P — ABSOLUTE PRESSURE-PSIA
 PC — PURIFICATION COLUMN
 P&I — PIPING & INSTRUMENTATION
 PH — PHASE
 POS — POSITIVE
 PPM — PARTS PER MILLION
 PRESS — PRESSURE
 PSIA — POUNDS PER SQUARE INCH ABSOLUTE
 PSIG — POUNDS PER SQUARE INCH GAUGE
 PSI — POUNDS PER SQUARE INCH
 Q — ACTUAL CUBIC FEET PER SECOND FLOW
 q — HEAT RATE-TOTAL HEAT TRANSFERRED BTU/HR
 REF — REFERENCE
 R — REBOILER
 RPM — REVOLUTIONS PER MINUTE
 REQD — REQUIRED
 SC — SAMPLE CONNECTION
 SCFM — STANDARD CUBIC FEET/MINUTE
 SEC — SECOND
 SUCT — SUCTION
 S — STRAINER
 T — TANK
 T — TEMPERATURE
 TBD — TO BE DETERMINED
 TDH — TOTAL DYNAMIC HEAD
 THW — MOISTURE/HEAT RESISTANT THERMAL PLASTIC
 Ti — TITANIUM
 T/T — TANGENT TO TANGENT
 TT — TEMPERATURE TRANSMITTER
 TYP — TYPICAL
 TOS — TOP OF STEEL
 U — OVERALL HEAT TRANSFER COEFFICIENT BTU/(HR-FT²-°F)

V — VALVE
 W — POUNDS PER SECOND OF FLOW
 W — POUNDS PER HOUR OF FLOW
 WM — WARM WATER

X — QUALITY-POUNDS OF VAPOR/(TOTAL POUNDS-VAPOR PLUS LIQUID)

Y — FUNCTIONAL ELEMENT

ΔP — PRESSURE DROP
 ΔP_{NH₃} — PRESSURE DROP OF AMMONIA (SHELL SIDE) - PSI
 ΔP_W — PRESSURE DROP OF WATER (TUBE SIDE)-PSI

η_G — GENERATOR EFFICIENCY

η_P — PUMP EFFICIENCY

η_T — TURBINE EFFICIENCY

η — EFFICIENCY

°F — DEGREE FAHRENHEIT

°C — DEGREE CELSIUS

Z — ELEVATION, FEET

INSTRUMENTS

AE — AMMONIA QUALITY ELEMENT
 CIE — CORROSION CURRENT ELEMENT
 CE — CHLORINE SENSE ELEMENT
 CIT — CORROSION CURRENT TRANSMITTER
 DPA — DIFFERENTIAL PRESSURE ALARM
 ER — POWER RECORD
 FE — FLOW ELEMENT
 FI — FLOW INDICATOR
 FIC — FLOW INDICATING CONTROLLER
 FO — FLOW ORIFICE
 FR — FLOW RECORDER
 FRA — FLOW RECORDING ALARM
 FRC — FLOW RECORDING CONTROLLER
 FT — FLOW TRANSMITTER
 I/P — CURRENT TO PNEUMATIC CONVERTER
 HCV — HAND CONTROL VALVE
 HS — HAND SWITCH CONTROL
 LAH — HIGH LEVEL ALARM
 LAL — LOW LEVEL ALARM
 LE — LEVEL ELEMENT
 LG — LEVEL GAUGE
 LI — LEVEL INDICATOR
 LIC — LEVEL INDICATING CONTROLLER
 LR — LEVEL RECORDER
 LRA — LEVEL RECORDING ALARM
 LS — LEVEL SWITCH
 LSH — HIGH LEVEL SWITCH
 LSL — LOW LEVEL SWITCH
 LT — LEVEL TRANSMITTER
 MO — MANUAL OVERRIDE
 NE — AMMONIA ELEMENT
 NEA — AMMONIA ALARM
 JE — POWER ELEMENT
 JT — POWER TRANSMITTER

OP — ORIFICE PLATE
 PAH — HIGH PRESSURE ALARM
 PCV — PRESSURE CONTROL VALVE
 PDE — PRESSURE DIFFERENTIAL ELEMENT
 POS — PRESSURE DIFFERENTIAL SWITCH
 PE — PRESSURE ELEMENT
 PEA — PRESSURE ELEMENT ALARM
 PI — PRESSURE INDICATOR
 PIC — PRESSURE INDICATING CONTROLLER
 PR — PRESSURE RECORDER
 PRA — OIL PRESSURE RECORDING ALARM
 PRC — PRESSURE RECORDING CONTROLLER
 PSE — RUPTURE DISC
 PSV — PRESSURE RELIEF VALVE
 PT — PRESSURE TRANSMITTER
 PDT — PRESSURE DIFFERENTIAL TRANSMITTER
 QE — QUALITY ELEMENT
 SE — SPEED ELEMENT
 SC — SPEED CONTROL
 SOV — SOLENOID OPERATED VALVE
 SRA — SPEED RECORDING ALARM
 ST — SPEED TRANSMITTER
 TAL — LOW TEMPERATURE ALARM
 TE — TEMPERATURE ELEMENT
 TI — TEMPERATURE INDICATOR
 TIC — TEMPERATURE INDICATING CONTROLLER
 TRA — TEMPERATURE RECORDER ALARM
 TRC — TEMPERATURE RECORDING CONTROLLER
 TS — TEMPERATURE SENSOR
 TT — TEMPERATURE TRANSMITTER
 TW — THERMOWELL
 XA — ANALYZER
 XR — ANALYZER RECORDER

INSTRUMENT SYMBOLS

⊖ — BOARD MOUNTED INSTRUMENT
 ○ — LOCALLY MOUNTED INSTRUMENT
 ⊙ — QUALITY TRANSMITTER

RELEASED BY

DESIGNED E. J. KELLY	OTEC POWER SYSTEM DEVELOPMENT - II	DATE	REVISION	BY	APPD
DRAWN R. COREY					
CHECKED J. J. KELLY					
APPROVALS J. J. KELLY					
SYMBOLS & ABBREVIATIONS		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY		DRAWING NUMBER 6850.94-03	
				ISSUE DATE 5-14-79

1/8" = 1'-0"
SCALE
5 0 5 10 15 20
FEET

DESIGNED BY: P. BROWN
DRAWN BY: P. BROWN
CHECKED BY: R. P. BROWN
APPROVED BY: R. P. BROWN
PROJ. OFFICE: P. BROWN

OTEC POWER SYSTEM DEVELOPMENT - II
10 MW POWER MODULE
POWER/SHIP SYSTEM INTERFACES
PLAN

DATE	REVISION	BY	APPV
5-9-79	1		
DRAWING NUMBER 6850.94-05			
FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			
ISSUE DATE 5-9-79			
CHG. LTR.

1/8" = 1'-0"
SCALE FEET

DESIGNED BY: B. B. B.	OTEC POWER SYSTEM DEVELOPMENT - II		DATE: 5-9-79	REVISION: 06	BY: J. J. J.	APP: J. J. J.
CHECKED BY: B. B. B.	10 MW _e POWER MODULE		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			
APPROVED BY: J. J. J.	POWER/SHIP SYSTEM INTERFACES		6850.94-06			
PROJ. OFFICE: J. J. J.	SECTIONS		5-9-79

DESIGNED <i>R.A. WISE</i>	OTEC POWER SYSTEM DEVELOPMENT-II		DATE	REVISION	BY	APPD
DRAWN <i>E. ERICH</i>	10 MWe POWER MODULE					
CHECKED <i>R.D. PIERSON</i>	PIPING & INSTRUMENTATION DIAGRAM					
APPROVALS	FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY					
<i>M. Khanmohar</i>	DRAWING NUMBER					
PROD OFFICE <i>P.J. Soltis</i>	6850.94-07					
	ISSUE DATE					
	5-11-79					
	CHG LTR

NOTES

1. REFER TO 46CFR (CODE OF FEDERAL REGULATIONS) FOR REQUIREMENTS ON ALL EQUIPMENT ON THIS P&ID FLOW DIAGRAM.
2. SIZING BASIS FOR AVAILABLE VOLUME IN DRUMS D-100, D-101 & D-102 IS PURGE LOSS + PURIFICATION LOSS + POWER LOOP INVENTORY + 45 DAYS OF NH₃ LOSS AT 170 LBS/HR. THE AVAILABLE CAPACITY IN D-100 HAS BEEN SIZED FOR 7 DAYS BLOWDOWN @ 3 GPM.
3. ALL INSTRUMENTATION, DRAIN AND VENT VALVES ARE TO VENT TO THE AMMONIA VENT SYSTEM.
4. OVERHEAD CONTROL SYSTEM OF T-101 OPERATES WITH PARTIALLY FLOODED, BAFFLED CONDENSER E-100 AND IS SUBJECT TO FURTHER DETAILED EVALUATION OF CONDENSER PERFORMANCE.
5. AMMONIA VENT HEADER AND STACK SIZING IS SUBJECT TO CHANGE PENDING RELIEF SYSTEM SIZING.
6. NH₃ STORAGE AND RECOVERY SUBSYSTEM AREA TO BE PROVIDED WITH 50,000 CFM AIR VENT CHANGE CAPACITY.
7. ALL MODULATING CONTROL VALVES HAVE AN INTEGRAL ELECTRIC-PNEUMATIC TRANSDUCER.
8. PROVIDED BY VENDOR.
9. THERMAL RELIEFS ON NH₃ LINES WILL BE ADDED WHEN PIPING LAYOUT HAS BEEN MADE.

ALHAMBRA C F BRAUN & CO CALIFORNIA		REV	DATE	REVISION	BY	APPD
DESIGNED BY: <i>DeRiel</i>		OTEC POWER SYSTEM DEVELOPMENT - II				
DRAWN BY: <i>TEERELL</i>		10 MWe POWER MODULE AMMONIA SUPPORT SYSTEM PIPING & INSTRUMENTATION DIAGRAM				
CHECKED BY: <i>APPROVALS</i>		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY				
PROG OFFICE: <i>APPROVALS</i>		DRAWING NUMBER 6850.94-08				
RELEASED BY:		ISSUE DATE 5-9-79				

D-107
LIQUID NITROGEN SHIPPING TANK
 96" OD x 33' TT
 6000 GALLON AVAILABLE CAPACITY
 DP 25 PSIG DT -320°F
 (INCLUDES TRANSFER PUMP P-106)

D-106
NITROGEN STORAGE TANK
 122" OD x 31'-7" T/T
 11,000 GAL AVAILABLE CAPACITY
 DP 250 PSIG DT -320°F

E-103
NITROGEN HEATER
 DUTY 1.07 MM BTU/HR AREA 94 SQ. FT.
 TUBE DP 250 PSIG DT -320°F T1
 TROUGH CS

- NOTES**
1. REFER TO 46 CFR (CODE OF FEDERAL REGULATIONS) FOR ALL EQUIPMENT ON THIS P&I FLOW DIAGRAM
 2. ALL MODULATING DIAPHRAGM CONTROL VALVES HAVE AN INTEGRAL ELECTRO-PNEUMATIC TRANSDUCER
 3. ALL LIQUID NITROGEN LINES ARE INSULATED
 4. THE INSTRUMENTATION & CONTROL OF THE LIQUID NITROGEN SHIPPING TANK D-107 IS NOT SHOWN. HOWEVER, IT IS IDENTICAL TO THAT SHOWN ON THE NITROGEN STORAGE TANK D-106.

ALHAMBRA C F BRAUN & CO CALIFORNIA				REV	DATE	REVISION	BY	APPD
DESIGNED	BvRel	OTEC POWER SYSTEM DEVELOPMENT - II			TRM			
DRAWN	TERRELL	10 MWe POWER MODULE			DRAWING NUMBER			
CHECKED	TERRELL	NITROGEN SUPPORT SYSTEM			6850.94-09			
APPROVALS		PIPING & INSTRUMENTATION DIAGRAM			FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			
RELEASED BY		PROG OFFICE			ISSUE DATE		CHG REV	
					5-9-79

SECTION A
SCALE: 1/8" = 1'-0" 12 25R 11

1/8" = 1'-0"
SCALE
5 0 5 10 15 20
FEET

RELEASED BY: [Signature]

DESIGNED BY: KRONIN
DRAWN BY: KRONIN
CHECKED BY: [Signature]
APPROVED BY: [Signature]
PROJ. OFFICE: [Signature]

OTEC POWER SYSTEM DEVELOPMENT - II
10 MW POWER MODULE
GENERAL ARRANGEMENT
SECTION

LYN	DATE	REVISION	BY	APPD

6850.94-12
FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY
ISSUE DATE: 5-9-79
SHEET: 12

SECTION A
SCALE: 1/8" = 1'-0" REF. 11

1/8" = 1'-0"
SCALE 0 5 10 15 20
FEET

PIPING PLAN
ELEVATION 48'-0" BELOW
SCALE: 1/8" = 1'-0"

DESIGNED BY	DATE	REVISION	BY	APPD
DESIGNED BY: REG. BROWN				
DRAWN BY: REG. BROWN				
CHECKED BY: RO. BROWN				
APPROVALS				
RELEASED BY: J. J. J.				
PROJ. OFFICE: P. J. J.				
OTEC POWER SYSTEM DEVELOPMENT - II				
10 MW _e POWER MODULE GENERAL ARRANGEMENT SECTION & PLAN				
FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY				
DRAWING NUMBER: 6850.94-13				
ISSUE DATE: 5-9-79

HEAT EXCHANGER SUPPORT PLAN - ELEVATION 46'-0
SCALE: 1/8" = 1'-0"

- NOTES:
1. ALL STRUCTURAL STEEL SHALL BE STANDARD ROLLED SHAPES AND PLATE, AND SHALL BE CONSTRUCTED USING ASTM A572, GRADE 55 AS THE BASIC METAL.
 2. ALL CONCRETE SHALL HAVE A 28 DAY COMPRESSIVE STRENGTH OF 8,000 PSI.

DESIGNED: D.S.L.	OTEC POWER SYSTEM DEVELOPMENT-II	DATE: 5-9-77	REVISION: 1	BY: J.E.	APPD: J.E.
DRAWN: RCG	10 MW POWER MODULE	DRAWING NUMBER: 6850.94-15			
CHECKED: LDM	EVAPORATOR & CONDENSER SUPPORTS	FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			
APPROVAL: M.P. Handwritten	PLAN & DETAILS	DATE: 5-9-77			
RELEASED BY: J.E. Handwritten	PROG OFFICE: J.E. Handwritten	ONE LTR

DESIGNED <u>D.S.L.</u> DRAWN <u>RC6</u> CHECKED <u>LRM</u> APPROVALS <u>Mellor</u> SPECIAL OFFICE <u>DTIC-1</u>		OTEC POWER SYSTEM DEVELOPMENT - II 10 MWe POWER MODULE TURBINE DECK SUPPORT PLAN, ELEVATION & SECTION		LTR DATE REVISION TRK DRAWING NUMBER 6850.94-16 ISSUE DATE 5-9-79 CHG LTR	
--	--	--	--	---	--

NOTE: BREAKERS TIED TO THE AUTOMATIC TRANSFER SWITCH INTERLOCK SHALL BE FURNISHED WITH 120V 60HZ SHUNT TRIPS.

4 X 3 #700 MCM THW-34°C.
FROM AUTOMATIC TRANSFER SWITCH
SEE DRAWING 6850.94-17

MOTOR CONTROL CENTER

LOAD TABLE			
	TOTAL CONNECTED	TOTAL CRITICAL	STEADY STATE STARTUP LOADS
CURRENT (AMPERES)	1,303	693	763
LOAD (KVA)	1,082	575	634

LOAD IN HP OR AS STATED RPM

AMMONIA HANDLING SYSTEM

NITROGEN HANDLING SYSTEM

FULL LOAD CURRENT AMPERES

65 65 15 15 4 77 11 124 5 27 5 27 96 96 27 65 21 120 29 420 36

STANDBY DRIVE NOT INCLUDED IN TOTAL CONNECTED LOAD AND TOTAL CRITICAL CONNECTED LOAD

CRITICAL LOADS

STEADY STATE STARTUP LOADS

NOTE: BREAKER TRIP RATINGS OF COMBINATION LINE STARTERS AND COMBINATION LINE CONTACTORS SHALL BE SPECIFIED BY MOTOR CONTROL CENTER MANUFACTURER.

NOTES:

THIS INCLUDES 18 AMPS FROM THE CONTROL POWER DISTRIBUTION PANEL.

MOTOR CONTROL CENTER
GENERAL ARRANGEMENT
N.T.S.

LEGEND	
SYMBOL	DESCRIPTION
	CIRCUIT BREAKER TRIP CURRENT RATING
	CONTACTOR NEMA SIZE
	THERMAL OVERLOAD RELAY HEATER ELEMENT
	MOTOR
	HEATER
	NOT AVAILABLE

DESIGNED J. Sauer	OTEC POWER SYSTEM DEVELOPMENT - II			
DRAWN J. Sauer	10 MWe POWER MODULE			
CHECKED J. Sauer	MOTOR CONTROL CENTER			
APPROVALS	SINGLE LINE DIAGRAM & GENERAL ARRANGEMENT			
RELEASED BY J. Sauer	FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			
PROG OFFICE J. Sauer	DRAWING NUMBER 6850.94-18			
	ISSUE DATE CHG LTR

SECTION A
SCALE: 1/4" = 1'-0"

DETAIL 1 REF II
SCALE: 1/4" = 1'-0"

1/4" = 1'-0"
SCALE
2 0 2 4 6 8 10
FEET

RELEASED BY *[Signature]*

DESIGNED *R. WELTNER*
DRAWN *R. WELTNER*
CHECKED *W. J. Hingle*
APPROVALS
Mechanical
TRUSS OFFICE *J. T. Baker*

OTEC POWER SYSTEM DEVELOPMENT - II
10 MW POWER MODULE
HEAT EXCHANGER
TUBE CLEANER

DATE	REVISION	BY	APPRO

TRW
DRAWING NUMBER
6850.94-19
ISSUE DATE
5-10-79
CHG LTR

NOMINAL FLOW CONDITION

9-22

TUBE PATTERN

DETAIL (1) 51
SCALE: HALF SIZE

TUBE CLEANING SEQUENCE

ELEVATION (C) 51 REF 53
NTS

1 0 1 2 3 4 5
SCALE INCHES

RELEASED BY: [Signature]

DESIGNED: HUNTINGTON	OTEC POWER SYSTEM DEVELOPMENT - II	TRW	
DRAWN: SAKAMOTO	0.2 MWe TEST ARTICLE	DRAWING NUMBER	
CHECKED: [Signature]	HEAT EXCHANGER	6850.94-51	
APPROVALS:	TUBE PATTERN & CLEANING SEQUENCE	ISSUE DATE	
PROG OFFICE: [Signature]		5-10-79	
		CHG LTR

ELEVATION
SCALE: 1/4" = 1'-0"

SECTION A
SCALE: 1/4" = 1'-0"

DESIGNED <i>E. WELTHER</i>		OTEC POWER SYSTEM DEVELOPMENT - II		LTR		DATE	REVISION		BY	APPD	
DRAWN <i>E. WELTHER</i>		O.2 MWe TEST ARTICLE TUBE CLEANER OPEN WATER BOX DESIGN		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY		DRAWING NUMBER 6850.94-52		ISSUE DATE 5-10-79		CHG LTR	
CHECKED <i>W. J. Hinkle</i>											
APPROVALS <i>M. K. Hinkle</i>											
RELEASED BY <i>[Signature]</i>		PROG OFFICE <i>P. J. [Signature]</i>

PLAN

ELEVATION A
53

ELEVATION B
53

RELEASED BY *[Signature]*

DESIGNED BY *H. HUNTINGTON*
 CHECKED BY *H. HUNTINGTON*
 ENGINEER *[Signature]*
 APPROVALS
M. Khanjoo
 PROJECT OFFICE *[Signature]*

OTEC POWER SYSTEM DEVELOPMENT - II
 0.2 MW_e TEST ARTICLE
 TUBE CLEANER
 CLOSED WATER BOX DESIGN

REV	DATE	REVISION	BY	APPD
1	5-10-79	TRM		
DRAWING NUMBER 6850.94-53				
FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY			ISSUE DATE 5-10-79	DWG LTR

1/8" = 1'-0"

SCALE

FEET

DESIGNED LRV	OTEC POWER SYSTEM DEVELOPMENT - II	LTR	DATE	REVISION	BY	APPD
DRAWN L. VILLALBA						
CHECKED R. O. P.						
APPROVALS						
RELEASED BY						
PROG OFFICE						
	0.2 MWe TEST ARTICLE CONCEPTUAL TEST LOOP OTEC-1 SHIPBOARD ARRANGEMENT	FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY	DRAWING NUMBER 6850.94-54	ISSUE DATE 5-10-79	CHG LTR

DESIGNED	DATE	REVISION	BY	APPD
DESIGNED <i>R.A. WISE</i>				
DRAWN <i>R. COREY</i>				
CHECKED <i>R. W. BROWN</i>				
APPROVALS				
MECHANICAL				
PROG OFFICE <i>P.J. BOWEN</i>				

OTEC POWER SYSTEM DEVELOPMENT - II		DRAWING NUMBER	
0.2 MWe TEST ARTICLE CONCEPTUAL TEST LOOP PROCESS FLOW DIAGRAM		6850.94-56	
FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY		ISSUE DATE	CHG LTR
		5-11-79

NOT TO SCALE

DESIGNED R. WELTHER
 DRAWN R. WELTHER
 CHECKED W. D. Gable
 APPROVALS
 MECHANICAL
 PROG OFFICE P. J. GOWEN

OTEC POWER SYSTEM DEVELOPMENT - II
 0.2 MWe TEST ARTICLE
 TUBE CLEANER HEAD
 CLOSED WATER BOX
 MANUAL OPERATION

LTG	DATE	REVISION	BY	APPRO
TAM				
FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY				
DRAWING NUMBER			6850.94-57	
ISSUE DATE			5-10-79	CHG LTR

MODULE PENETRATIONS SCHEDULE
(NOT TO SCALE)

0.2 MW_e HEAT EXCHANGER PENETRATION SCHEDULE
EVAPORATOR (E) AND CONDENSER (C)

MARK	NUMBER	SIZE	SERVICE
N1	1	4"	AMMONIA LIQUID IN (E), OUT (C)
N2	1	14"	AMMONIA VAPOR OUT (E), IN (C)
N3	1	1 1/2"	NONEVAPORABLE (E) NONCONDENSABLE (C)
N4	4	1 1/2" NPT	TEMPERATURE CONNECTION
N5	4	1 1/2" NPT	PRESSURE CONNECTION
N6	1	1 1/2" NPT	DRAIN
N7	1	1 1/2" NPT	VENT
O1	2	6"	OBSERVATION PORT (SIGHT GLASS)
O2	2	6"	OBSERVATION PORT (SIGHT GLASS)
O3	1	6"	HAND HOLE

ELEVATION A
SCALE: 1/2" = 1'-0"

ELEVATION B
SCALE: 1/2" = 1'-0"

1/2" = 1'-0"
SCALE FEET

DESIGNED: <i>ROD BROWN</i>	OTEC POWER SYSTEM DEVELOPMENT - II	TRW
DRAWN: <i>PEG BROWN</i>		
CHECKED: <i>JOHN F. BROWN</i>		
APPROVALS:		
PROD OFFICE: <i>P.T. BROWN</i>		
0.2 MW _e TEST ARTICLE HEAT EXCHANGER CLOSED WATER BOX ASSEMBLY		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY
DRAWING NUMBER 6850.94-58		ISSUE DATE 5-14-79

DETAIL (1) REF 53
70

1 0 1 2 3 4
SCALE INCHES

RELEASED BY *P. H. H.*

DESIGNED *R. WELTHER*
DRAWN *R. WELTHER*
CHECKED *[Signature]*
APPROVAL
[Signature]
PROD OFFICE *[Signature]*

OTEC POWER SYSTEM DEVELOPMENT - II
10 MWe & 0.2 MWe TEST ARTICLE
TUBE CLEANER HEAD
OPEN OR CLOSED WATER BOX DESIGN

LTR	DATE	REVISION	BY	APPD
<p>TRW</p> <p>FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY</p> <p>6850.94-70</p> <p>5-10-79</p>

PLAN
NTS

NOTES:
GILGILATOR, TURBINE GENERATOR CONTR. PANEL
AND LUBE OIL COOLING UNIT WILL REQUIRE SPACE
OTHER THAN STACKED ENVELOPE ALLOCATION.

DESIGNED PEG BROWN	OTEC POWER SYSTEM DEVELOPMENT - II	TRW	
DRAWN PEG BROWN	10 MW _e POWER MODULE CONCEPTUAL STACKED HEAT EXCHANGERS PLAN	FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY	DRAWING NUMBER 6850.94-90
CHECKED RO BROWN	APPROVALS	ISSUE DATE 5-11-79	CHG LTR
RELEASED BY [Signature]	PROD OFFICE P.J. HANLEY

ELEVATION A REF
NTS 91 90

DESIGNED	OTEC POWER SYSTEM DEVELOPMENT - II	LTR	DATE	REVISION	BY	APPO
DRAWN						
CHECKED						
APPROVALS						
PROG OFFICE						
10 MW _e POWER MODULE CONCEPTUAL STACKED HEAT EXCHANGERS ELEVATION		FACILITIES, MECHANICAL AND POWER INTEGRATION LABORATORY		DRAWING NUMBER 6850.94-91		
				ISSUE DATE	CHG	LTR
				5-11-79		

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10.1 0.2 MWe TEST HEAT EXCHANGERS

TRK

DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

FSCM NO. 11982

TITLE

PROCUREMENT SPECIFICATION

PSD II

0.2 MWe TEST HEAT EXCHANGERS

DATE 18 April 1979

NO. SS14-63

SUPERSEDING: _____

PREPARED BY: _____

G. S. Gibson

APPROVAL SIGNATURES:

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PROCUREMENT SPECIFICATION

OTEC PSD-II

0.2 MWe HEAT EXCHANGERS

1. SCOPE

This document is intended to specify the design goals and requirements for the 0.2 MWe test heat exchangers for the Power System Development II Project (PSD II) which is part of the Ocean Thermal Energy Conversion (OTEC) Program sponsored by the U.S. Department of Energy (DOE).

The contents establish requirements and goals for the design, performance, fabrication, test, quality assurance, and delivery of the 0.2 MWe evaporator and condenser.

2. APPLICABLE DOCUMENTS

The following documents are referenced and thus form a part of this specification. If no revision or date is specified, the latest issue of the applicable document shall apply. In the event of conflict between the referenced documents and this specification, this specification shall take precedence.

Government Documents

U. S. Coast Guard (USCG)

- USCG 115, Marine Engineering Regulations (1 August 1977)

National Bureau of Standards (NBS)

- Circular 142, Tables of Thermodynamic Properties of Ammonia (16 April 1923)

Non-Government Documents

● SPECIFICATIONS

TRW DSSG

SS14-62	10 MWe Heat Exchanger
SS14-64	0.2 MWe Heat Exchanger Tube Cleaner
SY14-5	10 MWe PSD-II Power Module

● STANDARDS

American Society of Mechanical Engineers (ASME)

BPV-II	Boiler and Pressure Vessel Code, Section II
BPV-VIII	Boiler and Pressure Vessel Code, Section VIII, Division 1
BPV-IX	Boiler and Pressure Vessel Code, Section IX

3. REQUIREMENTS

3.1 Item Definition

The 0.2 MWe PSD II test heat exchangers consist of

- One Evaporator
- One Condenser

The heat exchangers are to be installed in a Government Furnished Equipment (GFE) shipboard OTEC-1 test loop. The test loop will process the liquid ammonia through a GFE cleaning and drying system and then feed the liquid ammonia to the evaporator.

Ammonia vapor flow out of the evaporator will be piped through a phase separator (TRW delivered), a GFE throttle valve, a GFE desuperheater and thence to the condenser inlet nozzle. Condensate from the condenser will be piped through GFE equipment (pump, piping, etc.) to the evaporator inlet. Figure 1 shows functionally how the test heat exchangers interface with the test loop.

Internal to the evaporator, the excess ammonia will mix with the make up liquid ammonia which is recirculated by natural circulation (thermosiphon).

Both exchangers are to be all-aluminum, plate-type heat exchangers of Union Carbide Corporation, Linde Division (UCC/Linde) design. The design of the plates shall be such that the waterside passages are functionally similar to tubes with seawater on the tubeside. The working fluid and seawater are in cross flow.

The evaporator shall be designed to operate with nominally 82°F seawater as the heating medium. Liquid ammonia recirculating through internal downcomers shall evaporate by nucleate boiling from plates fully covered with UCC/Linde "High Flux" proprietary surface coating.

The condenser shall be designed to operate with nominally 40°F seawater as the cooling medium. Condensation shall take place in one pass between plates with UCC/Linde proprietary condensing surface enhancement on the ammonia side.

FIGURE 1

3.1.1 Interface Definitions

3.1.1.1 Physical Interfaces

3.1.1.1.1 Water Connections

Water connections are shown in Figure 2.

3.1.1.1.2 Ammonia Connections

Ammonia connections are shown in Table I and Figure 3.

3.1.1.1.3 Instrumentation Taps

Instrumentation taps are shown in Table I and Figure 3.

3.1.1.1.4 Mountings

Heat exchanger mountings are shown in Figure 2. The Skid is a GFE on OTEC-1 test loop.

3.1.1.2 Functional Interfaces

3.1.1.2.1 Evaporator

The evaporator shall evaporate a minimum of 16.4 lb/sec. of ammonia at 97% or higher quality at 72.3°F outlet temperature, when provided with 49,500 GPM of warm seawater at 82°F. This is the first module performance requirements outlined in Table II (See Section 6 for discussion).

3.1.1.2.2 Condenser

The condenser shall condense a minimum of 16.7 lb/sec. of ammonia at 52.3°F inlet temperature when provided with 46,600 GPM of cold seawater at 40°F. This is the first module performance requirements outlined in Table III.

3.1.1.2.3 Fluid Properties

TRW Specification SY14-5 provides data on the properties of the seawater. NBS Circular 142 provides data on the thermodynamic properties of the ammonia.

Figure 2. Relationship of Test Article To Full Scale Module

TABLE I
PENETRATIONS: EVAPORATOR (E) AND CONDENSER (C)

Mark	No	Size	Pressure Rating	Service
N1	1	4"	* 4" RF	Ammonia Liquid in (E), out (C)
N2	1	14"	* 14" RF	Ammonia Vapor out (E), in (C)
N3	1	1"	* 1" RF	Nonevaporables (E), Noncondensables (C)
N4	4	1/2" NPT	** 167 psig	Temperature Connections
N5	4	1/2" NPT	** 167 psig	Pressure Connections
N6	1	1"	* 1" RF	Drain
N7	1	1"	* 1" RF	Vent
O1	2	6"	** 167 psig	Observation Ports (Sight Glasses)
O2	2	6"	** 167 psig	Observation Ports (Sight Glasses)
O3	1	6"	** 167 psig	Handhole

* Flange rating will be for 167 psig maximum operating pressure

** Rated for 167 psig maximum operating pressure

FIGURE 3

0.2 MWe TEST HEAT EXCHANGER PENETRATION MAP

* See Table I (Page 6) for designations.

TABLE II

EVAPORATOR PERFORMANCE REQUIREMENTS AND GOALS (56 Panel Design)

Parameter	First Module	Average(2) Module	Last Module
<u>Requirements (Nominal Condition)</u>			
Warm Seawater Temperature, Inlet °F	82.0	80.2	78.7
Warm Seawater Flow Rate ⁽¹⁾ GPM	49,500	49,500	49,500
Seawater Side Δp , psid	0.78	0.78	0.78
Seawater Velocity in Passages, ft/sec	6.42	6.42	6.42
Ammonia Exit Temperature, °F	72.3	72.3	72.3
Ammonia Exit Pressure, psig	119	119	119
Ammonia Side Δp , psid	1.46	1.46	1.46
Ammonia Recycle Ratio, (1-X)/X	0.5	1.00	1.5
<u>Goals (at Design Fouling Factor 0.0003)</u>			
Ammonia Flow Rate @ 97% Exit Quality, lb/sec	16.4	13.4	10.6
Thermal Duty, MBtu/hr	30.3	24.7	19.6
Mean Temperature Difference, MTD, °F	8.78	7.17	5.70
Overall U, Btu/hr ft ² °F	819	818	817

Notes

1. Performance sensitivities to seawater flow variations of ± 20 percent shall be analytically predicted for verification by test.
2. Average of units 2 and 3 in heat exchanger subassembly.

TABLE III

CONDENSER PERFORMANCE REQUIREMENTS AND GOALS

Parameter	First Module	Average (2) Module	Last Module
<u>Requirements (Nominal Conditions)</u>			
Cold Seawater Temperature, Inlet °F	40.0	41.8	43.3
Cold Seawater Flow Rate, (1) GPM	46,600	46,600	46,600
Seawater Side Δp , psid	0.74	0.74	0.74
Seawater Velocity in Passages, ft/sec	6.05	6.05	6.05
Ammonia Inlet Temperature, °F	52.3	51.7	51.2
Ammonia Inlet Pressure, psig	79	78	77
Ammonia Side Δp , psid (two-phase)	0.37	0.28	0.21
<u>Goals (At Design Fouling Factor 0.0003)</u>			
Ammonia Flow Rate @ 97% Inlet Quality, lb/sec	16.7	13.6	10.8
Thermal Duty, MBtu/hr	30.3	24.7	19.6
Mean Temperature Difference (MTD), °F	11.70	9.45	7.42
Overall U, Btu/hr ft ² °F	614.	620.	626.

Notes

1. Performance sensitivities to seawater flow variations of ± 20 percent shall be analytically predicted for verification by test.
2. Average of units 2 and 3 in heat exchange subassembly.

3.2 Characteristics

3.2.1 Performance

The test heat exchangers shall provide data to verify the performance of the full scale 10 MWe heat exchangers defined by TRW Specification No. SS14-62 when compared on a per panel bases, and operated under equivalent thermal/fluid conditions as described in Paragraphs 3.2.1.1 and 3.2.1.2.

3.2.1.1 Evaporator

The evaporator shall be a cross flow, plate-type heat exchanger employing UCC/Linde "High Flux" surface on the ammonia side. The ammonia flows upwards as a two-phase fluid with evaporation taking place from the "High Flux" surface. Water is to flow horizontally in circular passages.

Installed in the test loop shown schematically in Figure 1, with a variable throttle valve, the evaporator will be operated under conditions simulating the first module, the last module or any module in between in the subassembly of the full scale 10 MWe heat exchanger assembly. The ammonia is recirculating internally by natural circulation and the recirculation rate shall be controlled and maintained by external control of downcomer liquid level. This liquid level shall nominally be 5.5 feet relative to the bottom of the panels. The nominal recycle rate will be 1 (i.e., evaporation rate equal to recycle rate). The quality at the exit from the plates will therefore be nominally 0.50. Quality variations from the nominal, when operated at state conditions simulating the first to last module in series, has been estimated to be 0.50 ± 0.20 .

The vapor space over the panels shall be designed to provide moisture separation. The exit quality from the evaporator shall equal or exceed 0.97, whether operated as the first, last, or an in between module.

For an external moisture separator to provide final separation to quality of 99+ percent, as a design goal the droplet size distribution at evaporator outlet shall be such that 70 percent of the moisture by weight are droplets of 10 μ or larger and 94 percent 5 μ or larger.

The nominal operating pressure on the ammonia side is 119 psig and the maximum design pressure (based on 850F saturation conditions plus

ten percent) is 167 psig. The exchanger shall be designed to withstand a full vacuum on ammonia side with no water pressure present.

Performance requirements and goals are summarized in Table II. This table shows operating conditions and performance goals when the test evaporator is operated as the first, last and average module in a sub-assembly of the full scale 10 MWe evaporator (see Section 6).

3.2.1.2 Condenser

The condenser is functionally the opposite of the evaporator. The ammonia vapor shall condense in vertical downflow between plates provided with UCC/Linde proprietary condensing surface enhancement. The water is to flow horizontally in circular passages. The discussion in Paragraph 3.2.1.1 of operating modes in the test loop applies.

There shall be no recirculation in the condenser. The liquid level in the sump under the panels will be maintained by external control. The nominal operating pressure on the ammonia side is 79 psig and the maximum design pressure is 167 psig. The exchanger shall also be designed to withstand a full vacuum on the ammonia side with no water pressure present.

Performance requirements and goals are summarized in Table III, to which the comments on Table II apply.

3.2.1.3 Design Life Goal

The test articles (evaporator and condenser) shall be designed to operate on an ocean test platform for 5 years without repair. Periodic downtime will be scheduled for maintenance.

3.2.1.4 Operating Dynamics

The test articles shall be designed to operate in a dynamic environment characterized by 0.5 G in all directions. Angular motions are TBD.

The pitch and roll axes relative to the test articles are defined in Figure 4.

3.2.2 Physical Characteristics

The physical characteristics of the test articles shall be such that thermal/fluid and design features duplicate the full scale heat exchangers (see TRW Specification No. SS14-62). The scaling shall be accomplished by reducing the number of active panels relative to a full scale module as schematically indicated in Figure 2. The panel geometry and panel to down-comer geometry are to be maintained identical to the full scale design. Figure 3 shows a perspective of the test articles. Note that, except for penetration details, the evaporator and the condenser are to have identical exterior form and size.

3.2.2.1 Weight and Envelope

The maximum allocated weight and envelope of the test articles are summarized in Table IV below.

TABLE IV
MAXIMUM ALLOCATED WEIGHT AND ENVELOPE OF THE TEST ARTICLES
(See Figure 4 for Definitions)

Parameter	Evaporator	Condenser
Overall Width (ft)	8	8
Overall Height (ft)	14	14
Overall Depth (ft)	5	5
Dry Weight (lbs)	12,900	12,900
Operating Weight Including Ammonia (lbs)	15,000	13,500
Operating Weight Including ammonia and Seawater (lbs)	19,800	18,300

10-17
13

Figure 4. Test Heat Exchanger

3.2.2.2 Water Side Passages Layout

The basic panel geometry shall be as shown in Figure 5. The panels shall be bonded by an adhesive capable of eliminating cracks leading to crevice corrosion over the life of the exchanger. There shall be 100 tube like passages per panel.

Three downcomers shall be incorporated in the design, arranged as shown in Figure 6. Dimensions are nominal, tolerances are (TBD). Each downcomer shall butt up to two half panels (passive panels). Half-size water passages shall be plugged with a filler capable of eliminating the potential for corrosion. The total number of active (heat transfer) panels shall be 56, distributed as shown in Figure 6 (11-17-17-11), to maintain the same panel to downcomer ratio as for the full scale 10 MWe exchangers.

This paragraph applies to both evaporator and condenser.

3.2.2.3 Penetrations

Penetrations of the ammonia side pressure boundary shall be provided as shown in Table I for the evaporator and the condenser. The main ammonia nozzles are sized, based on velocity at typical operating conditions:

Ammonia vapor, approximately 40 fps

Ammonia liquid, approximately 6 fps

Typical locations of penetrations are shown in Figure 3. Charging and draining during operations shall be via the main ammonia nozzles.

In addition to the penetrations shown in Figure 3, any other penetrations required by the referenced USCG and ASME codes shall be incorporated.

3.2.2.4 Provisions for Transportation, Handling and Installation

The exchangers shall be capable of being shipped by truck and installed with an overhead crane. During transportation, nitrogen bottles and regulators shall be provided and connected to maintain a blanket during transit with a pressure

10-19
15

TYPICAL WALL
THICKNESS 0.050"

Figure 5. Basic Panel Concept

Figure 6. Preliminary Basic Panel For 0.2 MWe Heat Exchanger

of 10 psig. Pressure gauges shall be installed to verify the integrity of the nitrogen blanket. A safety valve or other suitable control shall be provided to prevent overpressurization of the shell. The evaporator and condenser shall be clearly marked to warn that the vessels are sealed with nitrogen under pressure.

Openings shall be sealed with metal caps or covers to maintain the nitrogen blanket and protect the opening. The main seawater inlet and outlets shall be protected by rigid covers to prevent contamination during transportation and handling.

The weight and lifting points shall be clearly stencilled in black block letters, minimum three inches tall. A lifting plan, with the appropriate lifting attachments, shall be provided to prevent damage during transportation and installation. Individual lifting/handling arrangements shall be sized for the maximum empty weight of the evaporator and condenser.

3.2.2.5 Special Provisions

3.2.2.5.1 Removal of Non-Condensables

A perforated, 1-1/2-inch, Schedule 40, pipe shall be installed on the ammonia side of the condenser directly under the panels. It shall run the full width of the sump as shown in Figure 3. Details of perforations are (TBD).

3.2.2.5.2 Removal of Non-Evaporables

A perforated, 1-1/2-inch, Schedule 40, pipe shall be installed on the ammonia side of the evaporator directly under the panels. It shall run the full width of the sump as shown in Figure 3. Details of perforations are (TBD).

3.2.2.5.3 Biofouling Control

The design of the inlet and outlet of the circular seawater passages shall be physically compatible with mechanical brush cleaning system defined by TRW Specification SS14-64.

3.2.2.6 Protective Coating

Protective coating shall be applied on the seawater side at locations which are potential sites for fouling and corrosion and which cannot be

cleaned by the mechanical brushes. The coating material shall have a life and performances consistent with the requirements of a full size design.

3.2.3 Maintainability

The exchangers shall be field repairable with standard shipboard equipment and supplied materials.

3.2.4 Environmental Conditions

3.2.4.1 Vibration

The test articles shall be designed to withstand a constant (zero-frequency) acceleration of 0.5 g ($1\text{ g} = 32.2\text{ ft/sec}^2$) in all directions with a full load of ammonia and seawater.

3.2.4.2 Ambient Temperature

Storage	15°F - 120°F
Operating	35°F - 90°F

The test articles shall not be damaged by internal temperatures to -28°F.

3.2.4.3 Humidity

The test articles shall be designed to operate in humidity up to 100 percent in a salt spray environment.

3.2.5 Transportability

The test articles shall include provisions for transportation and fastening to transportation equipment without structural damage. Lifting lugs shall be included to meet the requirements of Paragraph 3.2.2.4.

3.2.6 Installation

The test articles shall be installed on skids (GFE) by others on a shipboard platform specified by DOE. Internal surfaces may require cleaning in the field prior to operation. The evaporator and condenser shall be designed to accomplish such cleaning. Inlet nozzles and drains for cleaning shall be provided as detailed in Paragraph 3.2.2.3.

3.3 Design and Construction

The requirements of this section apply to both evaporator and condenser, except as noted.

3.3.1 Design Standards

The evaporator and condenser shall be designed as required by ASME, Section VIII, Division 1, as applicable. The requirements of USCG-115 shall also be met.

3.3.1.1 Panels

The panels shall be Aluminum 3004-0 Alclad plates. Cladding material shall be Aluminum 7072 alloy. The cladding thickness shall be nominally 0.005 inches on both sides for a total plate thickness before forming of 0.050 inches (which includes corrosion allowance). The ammonia side of the evaporator panels shall be covered with UCC/Linde's "High Flux" surface. The ammonia side of the condenser shall be covered with UCC/Linde's proprietary condensing surface.

3.3.1.2 Structure

Strongbacks, upper and lower manifolds, rails, nozzles and other structural members shall be Aluminum 5083.

3.3.2 Materials

Materials used in fabrication of the exchangers shall have adequate corrosion resistance for the environmental conditions defined in the Specification in accordance with BPV-II. Welding shall be in accordance with BPV-IX. All construction shall be compatible with the environmental requirements of this Specification and comply with BPV-VIII, Division 1 and CG-115.

3.3.3 Nameplate and Product Markings

Marking and stamping shall be as required by ASME, Section VIII, Division 1.

3.3.4 Workmanship

Workmanship shall meet the requirements of ASME, Section VIII, Division 1 (U-2 and UW).

3.3.5 Safety

All components shall be designed, where applicable, to the requirements of ASME, Section VIII, Division 1. Procedure to qualify the design is TBD.

3.3.6 Documentation

Documentation shall be in accordance with Article UG-120 of ASME, Section VIII, Division 1.

4. QUALITY ASSURANCE PROVISIONS

Compliance with all requirements of Section 3 shall be demonstrated by the methods listed in Table V or by a TRW approved substitute technique. The manufacturer shall have and maintain a quality control system which will establish that all Code requirements will be met per Appendix X, Quality Control System, Section VIII, Division 1, ASME Boiler and Pressure Vessel Code.

The requirements of Section 3 shall be by examinations, demonstrations, tests, or analyses. Table 2 provides a matrix of Section 3 requirements versus qualification methods. Definition of examination, demonstration, test or analysis is as follows:

- a. Examination is an element of inspection consisting of investigation, without the use of special laboratory appliances or procedures, or supplies and services to determine conformance to those specified requirements which can be determined by such investigation. Examination is generally nondestructive and includes, but is not limited to, visual, auditory, olfactory, tactile, gustatory, and other investigations; simple physical manipulation; gauging, and measurement.
- b. Test is an element of inspection denoting the determination of the properties or elements of supplies (or components thereof) by technical means, including functional operations and the application of established principles and procedures. The analysis of data derived from test is an integral part of the inspection element, and shall not be confused with 4.d.
- c. Demonstration is an element of inspection that, although technically a variation of test, differs from 4.b by directness of approach in the verification of a requirement (s), and is accomplished without the use of elaborate instrumentation or special equipment. Thus, operation of a representative configuration item (CI) in, or near its use-environment (e.g., ability of a truck to climb a one-half mile, 5% grade, from standstill in the required time) would be defined as a "demonstration" rather than a "test".
- d. Analysis is an element of inspection in the form of study, resulting in data, that is intended to verify a requirement (s) when an examination, test, or demonstration cannot feasibly be employed to verify that requirement (s) at the inspection level demanded by this specification. Such data may be comprised of a compilation or interpretation of existing data or design solutions, or derived from original lower-level inspections or both. Data may be interpolated or extrapolated, as applicable. This would include data derived from fault-free analysis, and failure modes and effects analysis.

Table V Methods For Proving Quality Compliance

PARAGRAPH	A	D	E	T
3.1.1 Interface Definition				
3.1.1.1 Physical				
3.1.1.1.1 Water Connections				
3.1.1.1.2 Ammonia Connections				
3.1.1.1.3 Instrument Taps				
3.1.1.1.4 Mountings				
3.1.1.2 Functional Interface				
3.1.1.2.1 Evaporator				
3.1.1.2.2 Condenser				
3.2 Characteristics				
3.2.1.1 Evaporator	X	*		
3.2.1.2 Condenser	X	*		
3.2.1.3 Design Life Goal	X	*		
3.2.1.4 Operating Dynamics	X	*		
3.2.2 Physical Characteristics			X	
3.2.2.1 Weight and Envelope	X		X	X
3.2.2.2 Water Side Passages Layout	X	*	X	
3.2.2.3 Penetrations	X		X	
3.2.2.4 Provisions for Transportation Handling and Installation	X	X	X	
3.2.2.5 Special Provisions			X	
3.2.2.5.1 Removal of Non-Condensable			X	
3.2.2.5.2 Removal of Non-Evaporables			X	
3.2.2.5.3 Biofouling Control			X	
3.2.2.6 Protective Coating	X	*	X	
3.2.3 Maintainability	X		X	
3.2.4 Environmental Conditions	X	X		
3.2.4.1 Ambient Temperature	X			
3.2.4.2 Humidity	X	*		
3.2.5 Transportability	X	X	X	
3.2.6 Installation		X	X	
3.3 Design and Construction				
3.3.1 Design Standards	X		X	X
3.3.1.1 Panels				
3.3.1.2 Structure				
3.3.2 Materials	X		X	
3.3.3 Nameplate and Product Markings			X	
3.3.4 Workmanship			X	
3.3.5 Safety			X	X
3.3.6 Documentation			X	

Abbreviations: A - Analysis D - Demonstration
 E - Examination T - Test

* Items so marked will be further evaluated during DOE test program.

5. PREPARATION FOR DELIVERY

This section is TBS

6. NOTES

Reference is made to TRW Specification No. SS14-62 (10 Mwe Heat Exchangers) for a discussion of performance of the first, second, third and fourth heat exchanger module in a subassembly. The test articles, evaporator and condenser, will be tested under operating conditions evaluating the full scale system. Tables II and III therefore give performance goals corresponding to operation as first, average (of second and third), and last (fourth) module in a subassembly.

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ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

CODE IDENT 11982

TITLE

PROCUREMENT SPECIFICATION

PSD-II

0.2 MW_e HEAT EXCHANGER

TUBE CLEANER (MANUAL)

DATE 18 April 1979

NO. SS14-64

SUPERSEDING: _____

10.2 0.2 MWe TUBE CLEANER (MANUAL)

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10-29

TRW
DEFENSE AND SPACE SYSTEMS GROUPONE SPACE FOR REVISION RECORD PER REVISION**REVISION RECORD**

REV	DATE	AUTHORIZATION	CHANGE DESCRIPTION	PAGES AFFECTED
0	18 April '79	See Title Page	Original Issue	A11
10-30				

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PROCUREMENT SPECIFICATION

PSD-II

0.2 MW_e HEAT EXCHANGER

TUBE CLEANER (MANUAL)

1. SCOPE

This specification establishes the performance, design, development and test requirements for the PSD-II 0.2 MW_e heat exchanger (HX) tube cleaner (TC) subsystem hereafter referred to as HX/TC.

2. APPLICABLE DOCUMENTS

2.1 Government Documents. The following documents of the issue shown form part of this specification to the extent specified herein. In the event of conflict between the referenced documents and this specification, the contents of this specification shall take precedence.

U.S. DEPARTMENT OF TRANSPORTATION, COAST GUARD

- a) CG-115 Marine Engineering Regulations,
1 August 1977
- b) CG-257 Rules and Regulations for Cargo
and Miscellaneous Vessels,
1 September 1977
- c) CG-259 Electrical Engineering Regulations,
1 July 1977

OFFICE OF SAFETY AND HEALTH ADMINISTRATION

- a) OSHA STD 1910.23 Guarding Floor Openings
and Holes, 1971
- b) OSHA STD 1910.27 Ladders, 1971
- c) OSHA STD 1910.30 Other Working Surfaces
- d) OSHA STD 1910.35 Means of Egress, 1971

2.2

Non-Government Documents

TRW Drawings and Reports

- a) 6850.94-55 Tube Cleaner - Closed Water Box Design - Manually Operated (Figure 1 sheet 1 of this specification)
- b) 6850.94-57 Tube Cleaner Head - Closed Water Box Design - Manually Operated (Figure 1 sheet 2 of this specification)
- c) (TBS) Tube Cleaner Report

3.

REQUIREMENTS

3.1 Item Definition. The HX/TC is a subsystem comprised of components which support, position and stroke cleaning devices(also part of this subsystem) thru the HX tubes to remove surface depositions which degrade heat exchanger performance. The subsystem consists of a cleaning head with cleaning devices (brushes), a positioner to place the cleaning head in preselected positions for executing the tube cleaning function and a manual control and monitoring console to command the head and positioner. The HX/TC also includes the support frame, X and Y drives, cleaning head carriage, machined guide rails, and sensors/controls necessary to perform and monitor the cleaning function. The HX/TC design will be the same for the evaporator and for the condenser.

3.1.1 Item Diagrams. Figure 1 illustrates the basic type of tube cleaner envisioned to perform this function. Figure 2 schematic identifies the major components as delineated in paragraph 3.1.3. Figure 3 shows the HX/TC functional flow and Table 1 establishes a nominal sequence of operation.

3.1.2 Interface Definition. The tube cleaner interfaces shall be as follows:

3.1.2.1 External. The external interfaces which constrain the HX/TC are:

3.1.2.1.1 Functional. The HX/TC shall be capable of performing the essential functions described in paragraph 3.2.1 with the exchangers operating. The heat exchangers and the tube cleaner will operate horizontally in an under water (seawater) environment as specified in paragraph 3.2.5. Power for the HX/TC will be provided from the plant in the form of 110/220 volts single phase, 60 cycle AC current to operate the positioner and dry plant compressed air at a pressure (10 to 40 psig) sufficient to drive the brushes through the tubes. The tubes being cleaned are assumed out of service while being cleaned. The positioner shall be manually controlled to progressively place the cleaning head in selected positions and permit coverage of the entire tube field.

3.1.2.1.2 Physical. The HX/TC shall operate in guide rails for alignment with the condenser and evaporator tubes. The tubes to be cleaned are 3/4" I.D. and of alclad aluminum material as shown in Figure 4. The tubes are arranged on an 1.019 inch by 0.976 inch triangular pitch and are 4 feet long as shown in Figure 5. The HX/TC exclusive of the console will physically interface with the HX water box at the HX/TC guide rails which shall be bolted to the water box floor as illustrated on the interface control drawing (TBS). Their relative relationship is illustrated in Figure 1. Alignment of the HX/TC with tubes will be accomplished at installation by shims at this interface. The console shall be mounted in a nearby ships bay. The exchangers are of a closed water box type. Provision shall be made for storing the HX/TC in the space shown in Figure 1 in the water box when not in use. The Subcontractor shall advise the minimum clearance needed for his design between the outer periphery of the tube field and the inside of the water box. The exchanger inlet is rectangular shaped, 9 feet high and 4 foot 6 1/2 inches wide overall.

The HX/TC will be optically aligned with the heat exchanger tubes being cleaned by using a closed circuit television camera equipped with a magnification lens system. Other methods of accomplishing HX/TC alignment may be considered.

3.1.2.2 Internal. The internal interfaces that constrain the HX/TC are:

3.1.2.2.1 Functional. A manually operated control and monitor console shall be used to command the positioner to move the cleaning head to preselected positions as established by video line of sight alignment with targets and to command the cleaning head to stroke the cleaning brushes thru the HX tubes. The control loop internal interfaces are identified in Figure 6.

3.1.2.2.2 Physical. The cleaning brushes interface with the cleaning head which provides the motive power to drive the cleaning brushes through the tubes. The full stroke monitoring sensors also interface with the cleaning head. The cleaning head is supported and positioned (X and Y) by the positioner whose position is established and controlled by the manual control console. The electrical interfaces between the major components of the tube cleaning machine shall be provided by the Subcontractor. Sensor signal levels shall be of sufficient strength to provide the control console with appropriate inputs. All electrical circuits shall meet the requirements of CG-259.

3.1.3 Major Component List

1. Horizontal drive and alignment
2. Manual control console with closed circuit TV monitor
3. Positioner frame assembly
4. Cleaning head assembly

3.2

CHARACTERISTICS

3.2.1 Performance. The HX/TC shall respond to manual commands to position the cleaning head vertically and horizontally in line with preselected groups of 24 HX tubes and force the brushes thru the tubes and return them to their retracted positions to permit repositioning the cleaning head to the next group of 24 tubes to be cleaned. These functions are illustrated in Figure 2 and the sequence of events shown in Figure 3. The cleaning head shall not damage the heat exchanger in any way and the cleaning brushes shall not scratch or mar the tube surfaces or progressively degrade the tube or exchangers or unduly restrict the flow of seawater thru tubes not being cleaned. The HX/TC shall be capable of performing the functions specified herein while under manual control. It shall lock in the X-Y position and signal for corrective action in the event the cleaning functions within a tube are interrupted or are not completed.

The HX/TC shall be designed for continuous operation as the fouling conditions may dictate. Under normal conditions, the HX/TC shall be capable of cleaning the 5600 HX tubes in a 24 hour period. Actual HX/TC duty cycle will be determined from the assessment of plant operating performance characteristics. The brushes shall clean the inner surfaces of the Alclad aluminium tubes to a level of cleanliness to be determined during initial operation. To accommodate this, the contractor shall provide a series of brush configurations (approx 6) as specified in Table 2 (TBS)*. The baseline brush shall be a brush that presents a drag force of 5 ± 1 lbs. The HX/TC shall be designed to provide a brush driving force of 20 lbs max to accommodate the higher drag force brushes specified in Table 2. The brushes shall be designed to be easily replaceable and mounted in a floating socket to permit compliance at entry.

* To be supplied (TBS) by TRW.

The X and Y carriage drives shall be capable of moving the cleaning head to selected positions while under the environment specified in paragraph 3.2.5 with a margin of 2-1/2 times loads. Two travel speeds shall be provided. The fast travel rate shall be from 20 to 30 inches per minute and the slow or vernier rate from 3 to 4 inches per minute. The drives shall be capable of stopping the travel in 120 milliseconds. The positioner drives shall be capable of placing the head to within 1/8 inch of its true position in any group of HX tubes to be cleaned and maintain this position under the environments specified in paragraph 3.2.5

3.2.2 Physical Characteristics. The physical characteristics of the HX/TC are delineated in the referenced TRW document specified in paragraph 2.2 (c). The positioner shall be operated daily over its full range of horizontal and vertical movement to minimize fouling buildup including microfouling, macrofouling, and biofouling.

3.2.3 Reliability/Availability. The HX/TC shall be designed to achieve a minimum mean-time-between-failure (MTBF) of 1000 hours. This level of failure is defined as requiring the HX/TC to be removed from the water box for major repairs. The unit availability shall be 90% to permit maximum use if fouling dictates. The HX/TC design life shall be 5 years minimum for all major components.

3.2.4 Maintainability. The HX/TC positioner and cleaning head shall be designed to be maintained in a drained water box in its stowed position for minor repairs and servicing or removed from the water box for major repairs. The level of repairability of the HX/TC shall be such that the vessel maintenance crew can execute maintenance and repairs using multipurpose tools and test equipment. Module vs parts replacement will be clearly specified by the Subcontractor as well as projected maintenance and repairs cycles.

The console and monitor shall also be designed to be maintained by the vessel maintenance electricians and mechanics. The Subcontractor shall insure interchangeability of all spare parts and shall provide a recommended spare parts list for TRW approval.

3.2.5 Environmental Conditions. The HX/TC with the exception of the control console must be capable of storage and operation in the flooded heat exchanger water box. The control console will be mounted in a nearby ships bay. The entire HX/TC unit may be periodically exposed to a negligible (~ 1 PPM) concentration of ammonia or chlorine or both (continuously) in solution in the seawater. The control console must be capable of exposure to ammonia vapor of negligible (~ 10 PPM) concentration during operation without damage.

3.2.5.1 Operational Environment. The HX/TC shall be capable of operation in the following environmental conditions:

- a) 65 to 100°F ambient air temperature.
- b) 0 to 100% relative humidity, including rain fog, and sea spray.
- c) Accelerations:
 - $1 \pm 0.5g$ Vertical (including gravity)
 - $\pm 0.5 g$ Horizontal (any direction)
- d) 40°F to 84°F sea water temperature.
- e) Seawater velocity in the water box at the tubes: 3 ± 3 fps (non-reversible)
- f) Submersion depth: 20 ft max
- g) Head: 10 to 20 feet above atmospheric (approx.)

3.2.5.2 Non Operational Environment. The HX/TC shall be designed to withstand the following environmental conditions:

- a) 0 to 125 °F ambient air temperture.
- b) 0 to 100% relative humidity.
- c) Rain and salt water spray.

d) Accelerations:

TBS	Vertical
TBS	Horizontal

e) Seawater velocity in the water box of 3 ± 3 fps (non reversible)

f) Submersion depth: 20 feet max

g) Head (TBS)

3.2.6 Transportability. Two modes of transportability shall be satisfied.

The unit shall be disassembled and packaged for initial transportation to the site by conventional carrier. The unit in its operating condition shall be transportable on board the vessel using on-board jib cranes or lift trucks. To accommodate on board handling after assembly, the unit will be equipped with lift points for handling and installation.

3.3 Design and Construction. Since the HX/TC will be used on board an ocean going vessel or platform, it shall be designed to conform to the requirements of the Coast Guard regulations CG-115 and CG-257. All electrical components shall meet the requirements of CG-259. OSHA 1910.23,27,30 and 35 shall apply to personnel access items of construction.

3.3.1 Materials, Processes and Parts. The HX/TC shall be constructed of materials suitable for use in an underwater seawater operating environment. Since the unit may be inadvertently exposed to a seawater/ammonia solution, the use of copper or copper-bearing materials shall be avoided. Protective coatings may be used provided they achieve the protection needed to meet the component design life requirements. Protective coatings over copper or copper bearing metals are not acceptable.

3.3.2 Electromagnetic Radiation. The HX/TC shall not emit radiation which would negate sensor (TBD)* operation or levels which might initiate an explosion in an ammonia rich atmosphere.

3.3.3 Nameplates and Product Markings. The HX/TC shall contain nameplates and part numbers in sufficient detail to permit ready identification of components for replacement part ordering consistent with standard commercial practices. Warning labels must clearly identify hazardous elements and operational procedures. The center of gravity and lift points shall be clearly identified to ensure safe handling.

3.3.4 Workmanship. The HX/TC components and parts shall be manufactured, using best commercial methods, to meet or exceed the requirements of this specification.

3.3.5 Safety. The HX/TC shall be designed and fabricated to OSHA Standards and U.S. Department of Transportation Coast Guard Regulations given in paragraph 2.1. Fail safe and emergency operating restriction shall be incorporated as well as interlocks and emergency/standby circuits to prevent injury or to provide recovery in the event of a failure.

3.3.6 Human Engineering. The HX/TC shall be designed to be operated manually by a full time attendant. The attendant station shall be at the control console, in an adjacent ships bay. Critical operations include such functions as moving the positioner/cleaner to each cleaning position using the closed circuit TV monitor and ascertaining that all brushes have withdrawn from the heat exchanger tubes before moving to the next cleaning position.

3.3.7 Documentation. The HX/TC documentation requirements are:

- a) Drawings of assembly, subassembly, components and installation.

* To be determined (TBD) by the HX/TC Subcontractor.

- b) Engineering Design Analyses
- c) Component Specifications.
- d) Test Plans and Reports
- e) Installation Instructions.
- f) Maintenance and Operating Manuals.
- g) Spare Parts Lists.

3.4 Major Component Characteristics. The characteristics of the major components of the HX/TC are defined in the TRW tube cleaner report (TBS), paragraph 3.1.3. The conceptual design (Figure 1 of this specification) illustrates the basic type of cleaner envisioned to perform the HX cleaning function. Formulation of design details and development of design analyses to insure that the device meets the requirements of this specification, shall be the responsibility of the tube cleaner contractor.

3.5 Precedence. The order of precedence of requirements for the HX/TC are:

- 1) Remove fouling on the tubes by brushing.
- 2) Sequentially index and position the cleaning head for cleaning.
- 3) Insure each tube in an HX unit has been stroked by a brush.
- 4) Identify tubes which are not completely brushed.
- 5) Accessibility for maintenance and repair.

In the event of a conflict between this specification and the referenced documents (paragraph 2) and to avoid inadvertent errors in design the conflict shall be referred to the Buyer for clarification. If the nature of the clarification is such that the Subcontractor must stop design/fabrication it shall be the Subcontractor's responsibility to notify the Buyer immediately for resolution.

4. QUALITY ASSURANCE PROVISIONS

4.1 Performance Verification. The performance of the HX/TC subsystem to meet the requirements of section 3.0 of this specification shall be verified as noted in Table 3. The reliability of components used in the HX/TC shall be based on documented historical data from similar applications. During the design phase, the Subcontractor shall advise TRW of components considered life critical to permit resolution of a means to establish confidence in the design life prior to fabrication.

4.1.1 Responsibility for Tests and Inspections. All tests shall be performed in accordance with test plans/procedures developed by the Subcontractor and approved by the Buyer. All tests will be witnessed by the Buyer. The Subcontractor shall be responsible for all tests. All test plans/procedures/results reports are subject to Buyer's approval. The Subcontractor shall submit test results reports. All tests and demonstrations shall be performed in the Subcontractor's facility.

4.1.2 Special Tests and Examinations. The Subcontractor shall perform post installation tests and checkout of the system in its operating environment to verify major component operation in accordance with the requirements of section 3.0 of this specification.

5. PREPARATION FOR DELIVERY

The HX/TC shall be disassembled to the major component level (TBD) and packaged with sufficient protection to prevent possible damage due to shipment by common carrier or induced by the sea environment on-board the vessel prior to setup and installation.

TABLE 1
HX/TC SEQUENCE OF EVENTS
(ALL MANUAL CONTROL)

APPROX. 5 MIN.	<p>A - Startup operations</p> <ol style="list-style-type: none"> 1 - Release positioner from stowed position 2 - Position to start point (variable traverse speeds)
APPROX. 60 SEC.	<p>B - Alignment sequence</p> <ol style="list-style-type: none"> 1 - Traverse cleaning head to first cleaning position (variable traverse speed) 2 - Visual align using TV monitor (both X & Y axis)
APPROX. 90 SEC.	<p>C - Forward stroke cleaning sequence</p> <ol style="list-style-type: none"> 1 - Initiate brush-forward cycle 2 - Sense first brush forward completion (status panel) 3 - Scan all forward stroke sensors (status panel) 4 - Record any incomplete forward cycles (log book)
APPROX. 90 SEC.	<p>D - Return stroke cleaning sequence</p> <ol style="list-style-type: none"> 1 - Initiate brush-return cycle 2 - Sense first brush-return completion (status panel) 3 - Scan all return stroke sensors (status panel)
APPROX. 60 SEC.	<p>E - Repositioning Sequence</p> <ol style="list-style-type: none"> 1 - Unlock cleaning head and positioner 2 - Move to next cleaning location
APPROX. 5 MIN.	<p>F - Repeat sequence - B thru E</p>

TABLE 2
PSD-II HX/TC
BRUSH/BRISTLE MATRIX

CONFIG NO	BRUSH CHARACTERISTICS				BRISTLE CHARACTERISTICS			
	INTER- FERENCE %	LENGTH IN	SHAPE (RD/ OVAL ETC)	DENSITY (BRISTLES PER IN)	CORE (SINGLE/ DOUBLE TWIST, ETC)	MAT'L	DIA	FORM (STRAIGHT/ CRIMPED. ETC)
1				TBS				
THRU 6								

TABLE 3
PSD-II HX/TC ACCEPTANCE TEST MATRIX

Requirements	Paragraph	Analysis	Demonstration	Inspection	Test
Deliver 20 lbs max force to the brushes	3.2.1	X			X
Spot cleaning head to within 1/8 inch	3.2.1		X		
No tube damage from brushes	3.2.1		X		
Verify interface bolt pattern accuracy	3.1.2.1.2		X		
Verify adequate sensor signal level	3.1.2.2.2		X		
Electric circuits per CG-259	3.1.2.2.2			X	
Fast and slow X&Y travel rates	3.2.1	X	X		
Tube cleaning rate of 5600 tubes in 1 day	3.2.1	X	X		
Lock positioner and signal stuck brushes	3.2.1		X		
Structural integrity under loads	3.1.2.1.1	X	X		
Stiffness to maintain alignment	3.2.1	X			
Move in X&Y @ 2-1/2 time nominal loads	3.2.1		X		
Stop carriages in 120 milliseconds	3.2.1		X		
Handling stability of lift points	3.2.6 & 3.3.3	X	X		
TV camera and monitor resolution	3.1.2.1.2		X		
MTBF & 5 year life	3.2.3	X			
Conformance to CG-115	3.3	X		X	
Conformance to CG-257	3.3	X		X	
Conformance to CG-259	3.3	X		X	
Conformance to OSHA 1910.23, 27, 30 and 35	3.3	X		X	
Materials & Coating Compatibility	3.3.1	X		X	
Electromagnetic Radiation	3.3.2		X		
Nameplates and Product Markings	3.3.3			X	
Workmanship	3.3.4			X	
Safety	3.3.5			X	
Human Engineering	3.3.6			X

FIGURE 1 - Sheet 1 of 2

Approved: <u>R. W. LITHEN</u> Special Agent in Charge Date: <u>12/11/74</u> By: <u>W. J. LITHEN</u> Special Agent in Charge	DTIC POWER SYSTEM DEVELOPMENT - II 02MMX TEST ARTICLE TUBE CLEANER HEAD-CLOSED WATER BOX DESIGN-MANUALLY OPERATED	DTIC 6850.94-57 QUALITIES, MECHANICAL AND CHEMICAL PHYSICAL LABORATORY
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FIGURE 1 - Sheet 2 of 2

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KEY
RS REMOTE SWITCH

HX/TC SCHEMATIC
FIGURE 2

TUBE CLEANER FUNCTIONAL FLOW

FIGURE 3

TUBE ARRANGEMENT

FIGURE 4

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FIGURE 5 - Sheet 1 of 2

TITLE: <u>P5D-11</u>		DRAWING NO.	
<u>HEAT EXCHANGER INDOOR</u>		DATE	
<u>02 INCH INDOOR</u>		BY	
UNION CARBIDE CORPORATION		CHECKED	
PIPE DIVISION		APPROVED	
DRAWING NO. 02 INCH		PDS0038-1

FIGURE 6 - PSD-II HX/TC
INTERNAL FUNCTIONAL
INTERFACE IDENTIFICATION

See FIGURE 6 (cont'd) for
Interface Definitions

FIGURE 6 (Cont'd)
PSD-II HX/TC
INTERNAL INTERFACE DEFINITION

- 1 - The operator observes the cleaning head positioning operation on the video display to properly align the cleaning devices to the groups of tubes to be cleaned.
- 2 - The operator commands the controller to move the positioner and cleaning head in the X and Y directions to align the vidicon to selected targets.
- 3 - The controller commands power to the positioner drive motor to execute movement in the X direction.
- 4 - The controller commands power to the cleaning head drive motor to execute movement in the Y direction.
- 5& 6 - The position of the X and Y carriages is observed by the TV camera.
- 7 - The controller commands the cleaning head to drive the cleaning devices thru the tubes and return them.
- 8 - The cleaning device actuators drive the devices to the stroke sensors.
- 9 - Completion of travel of the cleaning devices, (in and out) is sensed by the cleaning head.
- 10 - Completion of cleaning device travel is signalled to the controller from the cleaning head.
- 11 - The TV camera on the cleaning head senses alignment on the video display.
- 12 - The controller displays completion of cleaning device travel to the operator.

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DEFENSE AND SPACE SYSTEMS GROUP

ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

FSCM NO. 11982

TITLE

PROCUREMENT SPECIFICATION

PSD-II

0.2 MW_e PHASE SEPARATOR ASSEMBLY

DATE 18 April 1979

NO. SS14-65

SUPERSEDING: _____

10.3 0.2 MWe PHASE SEPARATOR ASSEMBLY

PREPARED BY: _____

J. Hoppe/M. J. Nee

APPROVAL SIGNATURES:

W. G. Hample 4/18/79
DATE

W. G. Hample

P. J. Bakstad 4/18/79
DATE

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10-57

ONE SPACE PARK • REDONDO BEACH • CALIFORNIA. 90278

REVISION RECORD

REV	DATE	AUTHORIZATION	CHANGE DESCRIPTION	PAGES AFFECTED
0	18 April '79	See Title Page	Initial Issue	A11

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PROCUREMENT SPECIFICATION

PSD-II

0.2 MW_e Phase Separator Assembly

1. SCOPE

This specification establishes the performance, materials, design, fabrication, inspection, testing and shipping requirements for the 0.2 MW_e ammonia phase separator assembly. The separator shall be furnished complete including a moisture (ammonia condensate) trap and all necessary flanges, bolts, nuts, gaskets, couplings, and attachments.

2. APPLICABLE DOCUMENTS

2.1 GOVERNMENT DOCUMENTS

The following documents of the exact issue shown (or of the latest issue if no specific issue is listed) form a part of this specification to the extent specified herein.

REGULATIONS

Coast Guard

CG-115 Marine Engineering Regulations (1 Aug 1977)

CG-257 Rules and Regulations for Cargo and Miscellaneous Vessels

2.2 NON GOVERNMENT DOCUMENTS

The following documents of the exact issue shown (or of the latest date if an exact issue is not listed) form a part of this specification to the extent specified herein.

SPECIFICATIONS

American National Standards Institute (ANSI)

ANSI B16.5 Steel Pipe Flanges and Flange Fittings

American Society of Mechanical Engineers (ASME)

ASME BPV-II Boiler and Pressure Vessel Code, Section II

ASME BPV-VIII Boiler and Pressure Vessel Code, Section VIII, Division 1.

ASME BPV-IX Boiler and Pressure Vessel Code, Section IX

Structural Steel Painting Council (SSPC)

SSPC PA-1 Paint Application

SSPC SP6 Commercial Blast Cleaning

National Bureau of Standards (NBS)

NBS Circular 142 Table of Thermodynamic Properties of Ammonia
(16 April 1923)

DRAWINGS

TRW

TBD, Interface Dimensional Control Drawing,
PSD-II Phase Separator

3. REQUIREMENTS

3.1 DESIGN

The separator shall be designed for horizontal installation in accordance with Figure 1 and shall be designed for continuous operation.

3.1.1 Operational Environment

The separator shall meet the performance requirements while in the following environmental conditions:

- a) 65 to 100°F ambient air temperature.
- b) 0 to 100% relative humidity, including rain, fog, and sea spray.
- c) Accelerations:
 - 1 ± 0.5g vertical (including gravity)
 - ± 0.5g horizontal (any direction)

3.1.2 Non-Operational Environment

The separator shall be designed to withstand the following environmental conditions:

- a) 0 to 125°F ambient air temperature.
- b) 0 to 100% relative humidity.
- c) Rain and salt water spray.
- d) Accelerations:
 - TBS vertical
 - TBS horizontal

Specification: _____

PHASE SEPARATOR SPECIFICATION SHEET

Equipment List
Item No.: _____

TANK NAME: PHASE SEPARATOR

HORIZONTAL

DESIGN CONDITIONS: Ammonia Phase Separator
(Anhydrous)

1. Service: _____
2. Inside Diameter (in.): 24" O.D. *
3. Applicable Code: ASME BPV VIII; CG-115
4. Internal Design Pressure (psig): 167
5. At Design Temperature (°F): -28 to +100
6. External Design Pressure (psi): 1/2 Atmosphere
7. At Design Temperature (°F): _____
8. Corrosion Allowance (in.) 1/8"
9. Joint Efficiency
Heads: 1.0 Shell: 1.0
10. Wind Pressure: _____
11. Shock and Vibration (g): See Spec.
12. Post Weld Heat Treat: _____
13. Radiographic Inspection: Per Code
14. Insulation: None
Material: _____
Thickness (in.): _____
15. Type of Support: SADDLES
16. Insulation/Fireproofing Support: None

17. Manhole Cover:
Hinged: No With Davit: _____
18. Clips for Ladders and Platforms: No
19. Lifting Lugs: Yes
20. Surface Preparation: SSPC SP6
21. Painting: SSPC PA1
- OPERATING CONDITIONS: 119 Normal
22. Operating Pressure (psig): _____
23. Operating Temperature (°F): 72°F
24. Specific Gravity of Liquid: 0.609 at 70°F

TANK MATERIALS

25. Heads SA 516 GR. 60
26. Shell: SA 516 GR. 60
27. Support: SA 516 GR. 60
28. Nozzle Necks: SA-106 GR. B
29. Flanges: SA-105
30. Couplings: 6000 LBS.
31. Gaskets: _____
32. Removable Internals: No

NOZZLES

	Mark	Number	Size (Inches)	Rating of Facing	Service		Mark	Number	Size (Inches)	Rating of Facing	Service
33.	N1	1	14"	Weld End	Inlet	43.					
34.	N2	1	14"	Weld End	Outlet	44.					
35.	N3	1	1"	6000#	Vent	45.					
36.	N4	1	1"	6000#	Drain	46.					
37.						47.					
38.						48.					
39.						49.					
40.						50.					
41.						51.					
42.						42.					

Steels used shall be approved by Buyer and are limited to a max. yield stress of 50,000 PSI

The phase separator includes an automatic moisture trap and its inter-connecting piping

* DIMENSIONS ARE APPROXIMATE

SIZE	FSCM NO.	FIGURE 1	REV.
A	11982	PHASE SEPARATOR	
SCALE	10-62	SHEET	

3.2 CODE REQUIREMENTS

The separator shall meet the requirements of the ASME Boiler and Pressure Vessel Code Section VIII Division 1 as amended by CG-115.

The separator shall be built in accordance with the edition of the Code in force at the time of bid. Code stamping and certification are required.

In the event of a conflict between the Code and these specifications, the Subcontractor shall notify Buyer. The conflict shall be resolved in writing and approved by Buyer before proceeding with work.

3.3 ITEM DEFINITION

The separator is a contained chamber installed at the evaporator outlet in the PSD-II ammonia loop. It has no moving parts other than those needed to automatically drain collected ammonia condensate and reseal. Outlet ports (N3, N4) are required for venting in order to prevent vapor lock and for draining ammonia condensate. The separator shall be self-cleaning and requires no access port for cleaning or inspection. It will be installed on or below the deck of a :

3.4 PERFORMANCE

The separator shall increase the quality of entering ammonia from 97 to 99 percent minimum by extracting entrained ammonia moisture. At inlet the particle size distribution is estimated to be:

- a) 6 percent by weight 5 microns or smaller
- b) 30 percent by weight 10 microns or smaller
- c) Balance greater than 10 microns

At outlet the particle size shall be less than 10 microns. Collected ammonia condensate shall be automatically drained through a mechanical, moisture trapping device.

The unit shall be sized to flow $48,200 \pm 12,000$ lb/hr of ammonia entering the inlet port at a steady state 134 ± 5 psia and $72 \pm 2^\circ\text{F}$ with a pressure drop not to exceed 0.35 psi at the highest flow rate. Ammonia data given in NBS circular 142 apply.

3.5 DRAWINGS

All Subcontractor fabrication drawings shall be submitted to Buyer for approval. Fabrication drawings shall be complete with all necessary details

and dimensions, including weld sizes, and all seam layouts both longitudinal and circumferential.

The drawings shall have the same designation for nozzles and ports as those shown in these specifications.

In general, dimensioning shall be from a reference work line. Additive dimensions shall not be used.

In the event of a conflict between this specification and the referenced documents (paragraph 2) and to avoid inadvertent errors the conflict shall be referred to the Buyer for clarification. If the nature of the clarification is such that the Seller must stop design/fabrication it shall be the Seller's responsibility to notify the Buyer.

The review and approval of Subcontractor drawings shall in no way relieve him from the responsibility of producing vessels conforming in all respects to the Code requirements, Buyer's drawings and applicable specifications.

3.6 MATERIALS

The materials of the separator shall be as shown in Figure 1. Joints shall be complete penetration welded with weld surfaces properly prepared. All attachments (legs, clips, brackets, insulation supports, etc.) shall be of the same materials as the shell or head to which they are welded. Substitute materials may be allowed provided prior written approval has been obtained from Buyer. No copper or copper bearing parts are allowed in contact with ammonia. Materials shall be per ASME BPV-II.

3.7 SEAMS

Seams shall be positioned so that they do not intersect with external or internal connections or are not positioned behind obstructions that prevent inspection of these welds. Nozzles, couplings and manholes shall not be located in any seam without prior approval of Buyer. If seams are located under necks, or reinforcing pads, they shall be ground and radiographically inspected. This shall be indicated on Subcontractor's drawings.

3.8 CORROSION ALLOWANCE AND PROTECTION

A minimum corrosion allowance of 1/8 inch shall be furnished for the separator.

All exterior surfaces shall be prepared and painted for protection in accordance with the following:

- a) Surface Preparation: SSPC SP-6
- b) Prime and Finish Coating: SSPC PA-1

The separator shall be protected with an inorganic zinc coating similar to Ameron's Dimetecote 6, Marine Coating, or a Marine epoxy coating Amercoat 83/84, or equivalent.

3.9 NOZZLES, MANHOLES AND INSPECTION OPENINGS

Nozzles and manholes shall conform to one of the following unless specified otherwise.

- a) Nozzles shall be furnished with stub ends prepared for welding.
- b) Nozzles may be fabricated construction using steel pipe or rolled plate. Rolled plate used for necks shall be double butt welded.
- c) Coverplates for hand holes, manholes and nozzles shall be forged or plate blind flanges faced and drilled per ANSI B16.5 and of the same material and flange design pressure as the flange to which they are attached.
- d) The minimum nozzle neck shall be equal to extra heavy pipe.
- e) Drain and vent nozzles shall be flush welded and ground to the inside surface of the vessel. Other nozzles may project into the vessels if they do not interfere with vessel internals or flow.
- f) Nozzle reinforcing pads, or each segment thereof, shall have a 1/4 inch NPT drilled and tapped tell-tale hole to permit testing attaching welds with air and soap suds prior to final hydrostatic test.
- g) Nozzles shall be of sufficient length to allow ease of welding to piping.

3.10 COUPLINGS

Couplings 2 inch and smaller shall be 6000 pound socket welded connections welded to the vessel. Half couplings are acceptable. Tapping the vessel wall is not acceptable.

3.11 FABRICATION

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3.11.1 Welding

Welding procedures and qualification are to be submitted and approved by Buyer before any welding is performed.

As a minimum all welds shall be made in accordance with ASME BPV-IX. Any changes made to an essential variable of the welding procedure shall be brought to Buyer's attention and resolved.

Welds not made in accordance with approved, qualified procedures are subject to rejection.

All major weld repairs shall be submitted to Buyer for written approval of the repair with regard to location, size, type of defect, etc. The Subcontractor shall propose a qualified weld procedure for making the repair.

Fabrication involving welding shall not be performed by Subcontractor without the written approval of Buyer.

Vessels shall be welded construction using either shielded metal arc, gas tungsten arc, gas metal arc or automatic submerged arc processes. Oxy-fuel gas welding is prohibited.

Automatic or manual welding electrodes shall deposit a composition corresponding to the material being welded.

Joints shall be full penetration welds, preferably double butt, where size and accessibility permit. Other means, if shown on the Seller's drawings and approved by Buyer, are acceptable.

The weld and heat-affected zones shall not exceed 225 Brinell or equivalent. Submerged arc fluxes for carbon and low alloy steel welds shall be neutral.

Longitudinal seams of individual shell courses shall be welded separately before assembly with other shell courses or heads and shall be re-rolled if weld seam is peaked or inset.

Full run-off pads shall be properly installed at both ends of seam if submerged arc welding is used.

Backing strips may be used only with the written approval of Buyer. If used, they must be in an accessible location and removed after welding.

Cold formed heads shall be stress relieved prior to welding to the shell.

3.11.2 Metal Thickness

Vessel components shall be fabricated from metal which is thick enough to satisfy Code plus corrosion allowance. Additional metal must be added to heads and shells for thinning due to forming and to any machined part for machining.

3.12 SUPPORTS

The separator shall be supported on saddles.

3.13 CLEANING

All internal surfaces shall be free of all lubricants, mill scale, weld spatter, chips, sand, grit and other foreign material. All fabricating scars and rough edges shall be repaired by welding or grinding. Welds shall be wire brushed and ground as necessary. Mill scale shall be removed by sand blasting. The phase separator shall be degreased, hydrostatically tested using clean potable water, drained, and air dried. The external surfaces which require painting must be dry before painting begins.

The separator shall be sealed with dry nitrogen at 2 psig min. following a cleanliness inspection. The cleaning procedure shall be submitted to the Buyer for approval.

3.14 NAMEPLATES

Nameplates shall be of stainless steel and shall be fixed to an accessible part of the vessel. The method of attaching the nameplate to the pressure vessel shall not involve drilling into a pressure part. Nameplate location must be approved by Buyer. Nameplate data shall include:

- a) Order number
- b) Item No.
- c) Manufacturer's name, serial number, type, and size.
- d) Design code.
- e) Design, maximum and minimum working pressures and temperatures.
- f) Pressure vessel weight dry and flooded with water.

4. QUALITY ASSURANCE

4.1 PERFORMANCE VERIFICATION

The performance of the phase separator to meet the requirements of section 3. of this specification shall be verified as noted in Table I. A phase separator not meeting the requirements of this specification is subject to rejection.

4.1.1 Responsibility for Tests

A hydrotest and other tests as necessary shall be performed in accordance with test plans/procedures developed by the Subcontractor and approved by the Buyer. All tests will be witnessed by the Buyer. The subcontractor shall be responsible for all tests. All test plans/procedures/results reports are subject to Buyer's approval. The Subcontractor shall submit test results reports. All tests and demonstrations shall be performed in the Subcontractor's facility.

4.2 INSPECTION

Inspection shall be performed in accordance with ASME BPV-VIII. Materials to be inspected shall be cleaned and prepared as necessary to prevent irregularities from masking or confusing unacceptable defects with false indications.

In addition to the Code inspection, Buyer will inspect all materials and fabrication details and review all tests. All defects shall be repaired in accordance with the requirements of the ASME Code. 100 percent radiographic inspection of weld repairs to base metals and repair welding shall be performed. The hardness of weld metals shall conform to paragraph 3.11.1.

4.3 TESTING

A hydrotest shall be performed per the Code, ASME BPV-VIII. Prior to testing, vessels shall be cleaned in accordance with paragraph 3.13. Unless otherwise advised, Buyer will witness all hydrostatic tests and the checking or radiographs. The Subcontractor shall furnish bolting, a test gasket and a new service gasket for all body flanges and for other openings requiring a blind flange or cover. Test gaskets shall be shipped in place and service gaskets loose. The test temperature should not be less than 60°F.

4.4 DATA REPORTS

Three copies of Code Data Reports shall be submitted to Buyer or to Buyer's Inspector at the time shipment is made. The Data Reports shall include:

TABLE I
VERIFICATION MATRIX

Requirements	Paragraph	Analysis	Certification*	Inspection	Test.
Operational Environment	3.1.1		C		
Non-Operational Environment	3.1.2		C		
Code Requirements	3.2		A	X	X
Performance	3.4	X	B		
Drawings	3.5		D	X	
Materials	3.6		A	X	
Seams	3.7		D	X	
Corrosion Allowance & Protection	3.8	X	A		
Nozzles, Manholes & Inspection Openings	3.9		D	X	
Couplings	3.10		D	X	
Welding	3.11.1		A	X	
Metal Thickness	3.11.2		A	X	
Supports	3.12			X	
Cleaning	3.13		E		
Nameplates	3.14			X	

* Certification means submittal of evidence indicating compliance with the specifications. The following meets this requirement:

- A) Documents satisfying requirements of ASME BPV-VIII, Division 1.
- B) Data indicating performance of phase separator will be met.
- C) Guarantee that equipment will perform in environment specified.
- D) Submittal of drawings for review, concurrence and acceptance.
- E) Submittal of cleaning procedure for review and acceptance.

- a) Manufacturer's data report and test record as specified by the ASME BPV-VIII.
- b) Certified material record identifying all materials.
- c) Dimensions of the finished vessel.
- d) Complete photostatic copies of temperature charts for heating, soaking and air cooling obtained during stress relief.

5. PREPARATION FOR DELIVERY

All flange faces, machined surfaces, and vessel openings shall be protected during shipment. The vessel shall be purged with dry nitrogen gas and shipped sealed.

The sealed gas shall be dry nitrogen at a 2 psig min. All threaded connections shall be plugged with steel plugs. Test holes in reinforcing pads shall be plugged with grease. A loading diagram for the separator shall be submitted for review and comment. This diagram shall be approved by the carrier.

The Subcontractor shall be responsible for loading and anchoring the separator to prevent damage during shipment.

6. NOTES

None.

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Specification: _____

TANK SPECIFICATION SHEET

Equipment List
Item No.: T-5

TANK NAME: ACCUMULATOR

DESIGN CONDITIONS:

1. Service: Liquid Ammonia (Anhydrous)
2. Inside Diameter (in.): 8" ID
3. Applicable Code: ASME VIII (Div.1), CG-115
4. Internal Design Pressure (psig): 167 psig
5. At Design Temperature (°F): -28°F to 100°F
6. External Design Pressure (PSIA) 1/2 Atmos.
7. At Design Temperature (°F):
8. Corrosion Allowance (in.) 1/8"
9. Joint Efficiency
Heads: 1.0 Shell: 1.0
10. Wind Pressure:
11. Shock and Vibration (g): 0.5g X, Y, & Z
12. Post Weld Heat Treat:
13. Radiographic Inspection: Full
14. Insulation: None
Material:
Thickness (in.)
15. Type of Support:
16. Insulation/Fireproofing Support:

17. Manhole Cover:

Hinged: With Devit:

18. Clips for Ladders and Platforms: Internal & External
19. Lifting Lugs: Required
20. Surface Preparation:
21. Painting:

OPERATING CONDITIONS:

22. Operating Pressure (psig): 78 psig
23. Operating Temperature (°F): 52°F
24. Specific Gravity of Liquid: 0.625

TANK MATERIALS

25. Heads: SA-516 GR 60
26. Shell: SA-516 GR 60
27. Support: SA-516 GR 60
28. Nozzle Necks: SA-106 GR. B
29. Flanges:
30. Couplings:
31. Gaskets: Flexitallic Type CGI
32. Removable Internals: No

NOZZLES

Mark	Number	Size (Inches)	Rating of Facing	Service	Mark	Number	Size (Inches)	Rating of Facing	Service
33.	N1	1	4"	BW	Vaporout	43.			
34.	N2	1	4"	BW	Inlet	44.			
35.	N3	1	4"	BW	Outlet	45.			
36.	N4	1	1"	150#RF	Relief	46.			
37.	N5	1	1"	150#RF	Relief	47.			
38.	N6	4	2"x2"x1L	200#	Support	48.			
39.					49.				
40.					50.				
41.					51.				
42.					42.				

STEELS USED MUST BE APPROVED AND ARE LIMITED TO A MAXIMUM YIELD STRESS OF 50,000 PSI.

SIZE	FSCM NO.	REV.
A	11982	
SCALE	10.4 0.2 MWe ACCUMULATOR	SHEET

110-73.