Purchase Specification
For

Propulsion Motor Flexible Coupling

Attachment 1

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1.0 Introduction

This specification establishes the requirements for the manufacture and delivery of a Low Speed Flexible Coupling complete with Flange Adapters, Fasteners and Associated Technical Data to be located indoors at the Naval Surface Warfare Center Carderock Division (NSWCCD), Philadelphia, PA for a prototype, variable speed, electric ship's propulsion motor Land Based Test Site. The Coupling will be used to conduct performance/operational testing of the propulsion motor and will interface with the propulsion motor on its driving end and with a four quadrant electric motor dynamometer on its driven end. The electric motor dynamometer will be installed in tandem with a waterbrake dynamometer. The dynamometers will operate at the same speed (RPM's) as the propulsion motor. The fitted bolts at the adapters' interfaces with the propulsion motor and the dynamometer will be furnished and installed by the Government. The Coupling described in this specification must be capable of continuously transmitting the torque specified herein at the RPMs and parallel offset alignment specified herein. Also, the Coupling must be capable of handling transient torque spikes up to the shear stress failure of the coupling shear pins or shear section.

2.0 Scope

2.1 Equipment and Services to be provided by the Contractor:

2.1.1 The Coupling, Flange Adapters and Fasteners shall be suitable for a horizontal industrial installation and shall be constructed in accordance with the best commercial practices. The Supplier shall be responsible for delivery of the following to NSWCCD-SSES of Philadelphia:

Item	Qty	Description
0001	1 Each	Low Speed Flexible Element Coupling as specified herein.
0002	1 Each	Drive End Flange Adapter. The adapter shall interface with the Government furnished propulsion motor at its driving end. It shall be provided with undersized bolt holes (2.75" diameter) at its propulsion motor interface. The holes will be taper reamed (1/8" on diameter per inch of bolt hole length; with the bolt head, large end, located at the flange adapter) to 2.906" at the interface plane with the propulsion motor shaft flange by the Government at final assembly in the field. The adapter shall be provided with a male spigot that is concentric with its axis of rotation and will fit inside a rabbet at the mating flange interface.
0003	1	Driven End Flange Adapter. The adapter shall interface

		with the Government furnished dynamometer at its driven end. It shall be provided with undersized bolt holes (3.375") at its dynamometer interface. The holes will be taper reamed (1/8" on diameter per inch of bolt hole length; with the bolt head, large end, located at the flange adapter) to 3.500" at the interface plane with the dynamometer shaft flange by the government at final assembly in the field. The adapter shall be provided with a male spigot that is concentric with its axis of rotation and will fit inside a rabbet at the mating flange interface.
0004	2 Each	Flange Spacers, 0.125" thick, peelable shim. One spacer is to be incorporated into the original coupling assembly. The second spacer may be used as required. See sketch SK050-01 attached for the axial locations of the installed and second flange spacers. The bolt holes in the flange spacers shall locate them radially in the coupling assembly.
0005	1 Set	Replacement Shear Pins (or replacement coupling shear section).
0006	1 Each	Bearing to maintain alignment of disconnected coupling parts during coastdown following failure of the shear pins or shear section.
0007	1 Lot	Fasteners for all bolted interfaces, excluding the Fasteners at the flange adapter surfaces that interface with the Government furnished equipment, which will be furnished by the Government. The contractor shall also provide two spare nuts and bolts for each flange connection.
0008	3 Each	The Contractor shall furnish Coupons (Metallurgical Test Samples) from the torque meter spacer tube (part of the spacer piece – measurement section, component 1 on Sketch No. SK050-01) tested to determine the shear modulus and Poisson's ratio of the spacer tube material in accordance with paragraphs 3.2.3 and 3.2.4, respectively. The contractor shall furnish an uncertainty analysis for the shear modulus and Poisson's ratio for the spacer tube material as described in Section 5 of this specification in accordance with paragraph 3.2.6. The Contractor shall also supply three coupons to the Government suitable for independent testing of shear modulus and Poisson's ratio by the Government in accordance with paragraphs 3.2.3 and 3.2.4.
0009	1 Lot	Technical Data (Section 5)

2.1.2 Nothing in this specification shall relieve the Contractor of the responsibility to insure that the design, material, and workmanship are satisfactory for the service intended, or as may be required by common usage and/or good practice.

2.2 Equipment and Services to be provided by the Government:

2.2.1 The Government will install the coupling.

2.2.2 The Government will provide the torsion meter to the contractor for installation on the coupling spacer tube prior to factory balancing of the coupling/torsion meter assembly as required by paragraph 4.12 below.

2.2.3 The Government will ream the coupling bolt holes at the coupling interface with the driving and driven equipment at assembly.

2.2.4 The Government will disassemble the coupling as necessary to install the bolts at the equipment interfaces. Any special actions that are needed to reestablish the coupling balance during reassembly shall be clearly stated in the Technical Manual provided by the Contractor.

2.2.5 The Government will furnish and install the bolts/nuts at the flange adapter surfaces that interface with the Government furnished equipment.

3.0 Applicable Documents

3.1 The following specifications, standards, and codes, latest edition, form a part of this specification. The design of the items identified in this specification shall be in strict compliance with all applicable sections herein.

3.2 Referenced Specifications, Standards, and Codes

3.2.1 American National Standards Institute (ANSI), Standards B1.1, American (National) Standard Screw Threads; B46.1 Surface Finish

3.2.2 American Petroleum Institute (API), Standard 671, Flexible Couplings

3.2.3 ASTM Standard E 143-02, Standard Test Method for Shear Modulus at Room Temperature

3.2.4 ASTM Standard E132-97, Standard Test Method for Poisson's Ratio at Room Temperature

3.2.5 American Iron and Steel Institute, AISI 4340 Steel

3.2.6 American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME), Performance Test Code (PTC) 19.1, Measurement Uncertainty

4.0 Technical Requirements

4.1 Coupling Configuration

4.1.1 See attached sketch SK 050-01, COUPLING ARRANGEMENT, dated 05-14-04. This sketch provides a conceptual arrangement for the coupling.

4.1.1.1 For normal operating service, a torque meter weighing 140 pounds (component 7 on the conceptual sketch) will be furnished and mounted at final installation by the Government at the center of the 23 inch diameter spacer piece measurement section (component 1 on the conceptual sketch). The distance from centerline to centerline of the torque meter knife edges is 17.641 inches and each knife edge is about 1/8" wide. When installed, the torque meter knife edges will be centered on a location about 8.820" on each side of the transverse centerline of the spacer piece.

4.1.1.2 Prior to normal operational service, for a short period of time and for limited speed/load scenarios, a temporary installation will be used that employs two torque meters on the spacer piece, each identical to the torque meter described above. One of these torque meters will be located on the driving end of the spacer piece. Its knife edges will be centered on locations 8.820 inches and 17.641 + 8.820 = 26.461" from the transverse centerline of the spacer piece. The second torque meter will be located on the driven end of the spacer piece. Its knife edges will also be centered on locations 8.820" and 26.461" from the transverse centerline of the spacer piece. Each torque meter will weigh 140 pounds.

4.1.1.3 No coatings shall be provided on the outside surface of the spacer piece for a 1" wide circumferential strip centered on the four locations of the future torque meters' knife edges as described above. Prohibited coatings at these locations include both anodic corrosion protection coating and chemically resistant paints. The bare spacer piece metal shall be exposed at these four locations. There shall also be no increase or decrease in the outside diameter of the spacer piece metallic surface in way of the uncoated strips. Prior to shipment of the coupling, a non-permanent

removable preservative shall be applied to the uncoated, exposed, external, strip surfaces of the spacer piece. The solvent to be used to remove this preservative shall be specified by the Contractor. This solvent shall not damage the anodic corrosion protection coating or the chemically resistant paint that coats the remainder of the spacer piece.

4.1.2 Coupling Length

4.1.2.1

Free coupling length (excluding spigots on flange adapters), flange to flange, with one flange spacer (item 4) installed:	112 inches

4.1.3 Interface Requirements

4.1.3.1 Driven end

Flange Outer Diameter:	44.5 inches
Bolt Circle Diameter:	38.000 inches
Bolt Hole Diameter:	3.375 inches (will be reamed to 3.500 inches at assembly)
Bolt Holes:	12 (equally spaced)
Male Spigot Diameter:	25.999 +0.000", -0.002"
Male Spigot Length:	0.400 $\pm$ 0.010 inches

4.1.3.2 Drive end

Flange Outer Diameter:	37.200 inches
Bolt Circle Diameter:	32.318 inches
Bolt Hole Diameter:	2.75 inches (will be reamed to 2.906 inches at assembly)
Bolt Holes:	12 (equally spaced)
Male Spigot Diameter:	18.600 +0.000", -0.002"
Male Spigot Length:	1.163 $\pm$ 0.010 inches

4.1.4 Maximum Allowable Static Overhung Moments on the Coupled Motor Shafts

At propulsion Motor Coupling interface is 9430 pound-feet.
At dynamometer Coupling Interface – LATER **(SSES to obtain clarification provided by the load system vendor)**.

4.1.5 Spacer Piece Between Flexible Diaphragms

4.1.5.1 The spacer piece O.D./I.D. in way of the torsionmeter are 23.000" ±0.005", and 18.750" ± 0.005", respectively.

4.1.5.2 The O.D./I.D. of the spacer piece shall be concentric within ± 0.002" T.I.R.

4.1.5.3 The minimum length of continuous uniform spacer piece section required in way of the torsionmeter is 68".

4.1.5.4 The maximum inside/outside surface finish of the spacer piece shall be 63 microinches in accordance with Paragraph 3.2.1, above.

4.1.5.5 The spacer tube part of the spacer piece measurement section (see Sketch SK050-01, attached) shall be constructed of seamless/homogenous AISI 4340 steel. See paragraph 3.2.5 above. The only welds allowed are at the spacer tube's interface with its end flange and flexible diaphragm.

4.1.6 Adapter Fasteners Installation Access Holes

Access holes shall be provided in the large diameter disk of both the drive end and driven end adapters to allow installation of the bolts that fasten the adapters to the propulsion motor and dynamometer. The Government will disassemble the coupling as necessary to install these bolts.

4.1.7 Jacking Taps

Three jacking taps shall be provided in each adapter to facilitate disengaging the adapter spigots from the rabbets at the equipment interfacing surfaces.

4.1.8 Shear Pin or Shear Section Assembly

The coupling assembly shall include a shear pin or shear section assembly which will shear at 27.0×10^6 to 30.0×10^6 in-lbs torque. The shear pins are to be replaceable without requiring coupling disassembly. Special tools required to remove and install shear pins shall be provided. If a shear section is provided it shall be replaceable by disassembly of the flanged joints at the ends of the shear section only. The design is to incorporate a coast down bearing (spark free design) in the coupling assembly to support the assembly halves in the event pins are sheared.

4.1.9 Flange Spacers

The coupling assembly shall include two 0.125-inch thick flange spacers. One flange spacer is to be incorporated between a pair of coupling assembly flanges during original assembly. This spacer is to provide a means to increase the coupling's axial stretch by unpeeling lamina from, or machining of, this spacer. The second spacer shall be provided in the event that the coupling assembly stretch needs to be decreased as a result of the machinery alignment. Bolting at the spacer flange locations should be able to accommodate removal of the original 0.125-inch spacer and also the use of second 0.125-inch spacer.

4.2 Coupling Operating Conditions

Maximum Continuous Power	36,500 KW (48,947 HP)
Speed	127 RPM
Maximum Continuous Torque	24,290,431 pound-inches
Coupling Service Factor	To be recommended by the contractor based on the information provided in paragraph 4.3 below.
Coupling Rating	To be recommended by the contractor based on the maximum continuous coupling torque and the recommended service factor.
Transient torque for shear pins or shear section failure	27,000,000 pound-inches, or as recommended by the Contractor and approved by the Government.
Transient torque limit for shear pins or shear section failure	30,000,000 pound-inches, or as recommended by the Contractor and approved by the Government.
Maximum transient short circuit system torque	43,564,723 pound-inches. See paragraph 4.3.1.3 below.

4.3 Service Factor

4.3.1 The following is provided for the contractor's use in developing a service factor for the coupling:

4.3.1.1 The propulsion motor can operate from 0 to 127 RPM in both the clockwise and counterclockwise directions.

4.3.1.2 The first dynamometer is a four quadrant load motor. It can absorb up to ½ the full power output of the propulsion motor.

Its power input shaft is capable of transmitting the full power output of the propulsion motor.

4.3.1.3 During a short circuit, this dynamometer can develop 31,419,507 pound-inches of transient torque when operating at full load. When added to the waterbrake full load torque of 12,145,216 pound-inches, the maximum torque imposed on the flexible coupling is 43,564,723 pound-inches. It is expected that the shear section (or shear pins) in the coupling would fail at between 27,000,000 and 30,000,000 pound-inches.

4.3.1.4 The second dynamometer is a water brake. It is capable of absorbing ½ the full power output of the propulsion motor.

4.3.1.5 Both dynamometers operate at the same RPM as the propulsion motor.

4.3.1.6 The Government plans to couple the two tandem dynamometers together using an existing contoured diaphragm flexible coupling owned by the Navy. Its torsional stiffness is 228 x 10^6 lb-in/RAD. The rotational inertia of the electric motor dynamometer rotor is 82.20 x 10^6 pound inches^2. The rotational inertia of the waterbrake dynamometer rotor (with entrained water at full power) is 27.95 x 10^6 pound inches^2.

4.3.1.7 A test is planned for the propulsion motor to test it from full power ahead to crash astern. There will be a torque reversal in the coupling during this test. The torque will not exceed the maximum continuous coupling torque during the crash astern test.

4.4 Operating Temperature

The coupling operates at ambient temperature of 105° F or less.

4.5 Angular Capability

The angular capability of each flexible element is at least ¼ degree.

4.6 Coupling Parallel Offset Capability

The parallel offset capability is at least 0.350".

4.7 Axial Compression/Extension Capability

To be provided by the Contractor.

4.8 Angular Capability of the Flexible Elements

To be provided by the contractor.

4.9 Axial Stiffness of the Coupling

To be provided by the contractor.

4.10 Angular Stiffness of Each Diaphragm Assembly

To be provided by the contractor.

4.11 Torsional Stiffness of the Coupling

To be provided by the contractor.

4.12 Balancing

The coupling components and coupling assembly shall be balanced by the Contractor in accordance with the document referenced in paragraph 3.2.2 above. In addition, each coupling component and the assembled coupling (including the Government furnished torsion meter) shall be statically and dynamically balanced using a machine that has a minimum detectable unbalance below the maximum unbalance of:

$$U = 0.177\ W$$

Where U = Maximum allowable unbalance in oz-inch
W = Weight of shaft section in lbs

4.13 Site Conditions:

4.13.1 Location: Indoor

4.13.2 Ambient Temperature Range: 45°F to 105°F

4.13.3 Relative Humidity Range: 5% to 100%

5.0 Technical Data

5.1 Drawings:

Three copies of final assembly drawings, section drawings, and parts lists are to be submitted and approved by the Government prior to delivery of the coupling. Review and approval of final drawings will be provided 14 days after receipt of the drawing package by the Government.

5.2 Test Data

Copies of the factory test data specified in paragraphs 6.1, 6.2, and 6.3 below shall be submitted to the Government prior to delivery of the coupling.

5.3 Technical Manuals

Two (2) copies of the coupling technical manuals containing coupling drawings; component drawings; installation, operation, maintenance, inspections and instructions, and special tools data, shall be furnished at the time of delivery of the coupling. The manual shall be standard commercial quality and coverage for the coupling furnished.

5.4 Uncertainty Analyses

Two (2) copies of the uncertainty analyses for the shear modulus and Poisson's ratio for the spacer tube material in accordance with paragraph 3.2.6 shall be submitted to the Government prior to delivery of the coupling.

6.0 Inspection and Testing

6.1 Testing of the equipment shall be performed by the Contractor to ensure that the equipment is fully functional and structurally and mechanically sound. The Government reserves the right to perform equipment inspections at the Contractor's facility where such inspections are deemed necessary to assure supplies and services conform to the prescribed requirements.

6.2 The Contractor shall measure and report the inside and outside diameters of the uncoated spacer piece – measurement section (Component 1 on attached Sketch No. SK050-01) at five cross sectional planes along its length. These five planes are located at the transverse centerline of the spacer piece, ten inches off this centerline in both directions, and ten inches from each end of the spacer piece. The inside and outside diameters shall be measured to an accuracy of $\pm$ 0.005 inches at 0, 45, 90, and 135 degrees at each plane.

6.3 The contractor shall provide the laboratory test data of the shear modulus and Poisson's ratio for the torque meter spacer tube material as required by item 8 under paragraph 2.1.1, above. The Contractor shall supply three coupons to the Government suitable for independent testing of shear modulus and Poisson's

ratio by the Government in accordance with paragraphs 3.2.3 and 3.2.4. The coupons for testing shall:

- be from the same heat and lot of steel,
- have the processing parameters as the processing parameters used on the spacer tube so that there is the same amount of deformation in the coupons as there is in the spacer tube, and,
- have a hardness which does not differ from the hardness of the spacer tube by more than 1 point on the Rockwell C scale.

7.0 Shipping

7.1 The Government will provide a release for shipping to the Contractor following approval of the final drawings by the Government.

7.2 Packaging

7.2.1 Equipment shall be packed for shipping in a manner that will ensure acceptance and safe delivery at destination. Supplier is responsible for damage during shipment.

7.2.2 Each package shall be marked with the Contract Number, Contract Item Number and Purchase Specification Number TS050-12.

7.3 Shipping Address: Naval Surface Warfare Center
Carderock Division
Ship Systems Engineering Station
901 Admiral Peary Way
Naval Business Center
Philadelphia, Pa 19112
Attn: Howard Feinstein, Code 9112
Phone: (215) 897-8895
Cell: (215) 837-1787