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USACE / NAVFAC / AFCEC / NASA **UFGS-35 05 40.17 (August 2020)**

Preparing Activity: USACE **Superseding UFGS-35 05 40.17 (May 2014)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2020
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DIVISION 35 - WATERWAY AND MARINE CONSTRUCTION

SECTION 35 05 40.17

SELF-LUBRICATED MATERIALS, FABRICATION, HANDLING, AND ASSEMBLY

08/20

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SECTION 35 05 40.17

SELF-LUBRICATED MATERIALS, FABRICATION, HANDLING, AND ASSEMBLY
08/20

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NOTE: This guide specification covers self-lubricated bearing materials for waterway and marine construction. These bearing materials are used for lock and dam applications ranging from critical bearing applications to light duty and electro-galvanic isolating applications. This spec has been developed for USACE Civil Works projects.

In accordance with ER 10-1-53, the USACE Hydroelectric Design Center (HDC) in Portland OR is designated as the Mandatory Center of Expertise (MCX) for hydropower engineering and design. HDC's policy is to use self-lubricating materials in hydroturbine applications. For applications involving turbines, consult HDC (Phone: 503-808-4250).

Sections have also been included on self-lubricated bearings used for product lubricated vertical shaft pumps. Product lubricated pump bearings are used for applications that require minimizing or eliminating the exposure to petroleum lubricants to be in compliance with environmental, biological, or other applicable regulations.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

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NOTE: Use this guide specification in conjunction with EM 1110-2-1424 LUBRICANTS AND HYDRAULIC FLUIDS, EM 1110-2-2610 Mechanical and Electrical Design for Lock and Dam Operating Equipment, and EM 1110-2-3105 Mechanical and Electrical Design of Pumping Stations.

Users of this specification should understand that successful performance of self-lubricated materials relies on factors that are not covered under the scope of this specification. These factors include but are not limited to accurate estimation of applied loads, adequate alignment of self-lubricated parts including their housings and running surfaces, and adequate stiffness of housings and running surfaces to match the loading assumptions made.

Designers need to be aware that self-lubricated parts and materials have many differences in properties and behavior from traditional metallic supplied-lubricant bearings. Successful design of self-lubricated bearing systems relies on designers that understand these differences as well as acceptable design practices for self-lubricated materials. Designers unfamiliar with self-lubricated components, at a minimum, should have their designs and assumptions thoroughly checked by qualified individuals familiar with self-lubricated material systems.

It is common for minor design details, such as final tolerances and fits, to be left for the construction contractor to determine (in coordination with the self-lubricated material manufacturer). However, construction contractors typically are not qualified to perform the complete design for self-lubricated bearing systems. As discussed above successful design of self-lubricated bearing systems requires detailed knowledge of both the application and self-lubricated materials. Using construction contractors to perform the design of self-lubricated bearing systems is not recommended.

Designers are responsible to consult self-lubricated material manufacturers to verify that the products being used are appropriate for the application. Self-lubricated material manufacturers should also be consulted to verify the use of other appropriate design details such as bearing wall thicknesses, installation fits, mating materials, surface conditions, running clearance fits, edge chamfers.

Some self-lubricated components are susceptible to damage caused by edge loading. The test procedure outlined in CERL Technical Report 99/104, Greaseless

Bushings for Hydropower Applications tests the edge loading properties of materials with a tapered test sleeve. The slope of the tapered test sleeve is 0.229 degrees (0.004"/1.000"). Actual installations should be held to tighter alignment requirements than this procedure tests for. Define required alignment of self-lubricated components on the contract plans in accordance with an applicable code such as ASME Y14.5 - Dimensioning and Tolerancing.

Consider including self-lubricated material fabricator qualifications and self-lubricated material installation plans as evaluation criteria used to select a contractor.

Include in drawings a complete design indicating the character of the work to be performed and giving the dimensions, quantity, location, assembly details, and installation details of each self-lubricated component, housing, and associated running surface.

Information has been included in this specification for product lubricated pump bearings. This information has been included as many of the materials used to construct these bearings are the same as the materials covered in this specification for other lock and dam applications. This specification assumes the pump manufacturer will be responsible to select the appropriate product lubricated bearings. The information in this specification has been limited to the list of parameters that need to be specified to allow the pump manufacturer to select appropriate bearings. Product lubricated information in this specification should be copied to the applicable pump specification for use.

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1.1 SUMMARY

This section specifies fabrication, handling, cleaning, and installation requirements for self-lubricated materials and their mating running surfaces.

1.2 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also

use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A148/A148M	(2020; E 2020) Standard Specification for Steel Castings, High Strength, for Structural Purposes
ASTM A564/A564M	(2019) Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes
ASTM B584	(2014) Standard Specification for Copper Alloy Sand Castings for General Applications
ASTM B929	(2017) Standard Specification for Copper-Nickel-Tin Spinodal Alloy Rod and Bar
ASTM D149	(2020) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D412	(2016) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D570	(1998; E 2010; R 2010) Standard Test Method for Water Absorption of Plastics
ASTM D695	(2010) Standard Test Method for Compressive Properties of Rigid Plastics
ASTM D2240	(2015; E 2017) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D3846	(2008) Standard Test Method for In-Plane Shear Strength of Reinforced Plastics

U.S. ARMY CORPS OF ENGINEERS (USACE)

CERL TR 99/104	(1999) Greaseless Bushings for Hydropower Applications: Program, Testing, and Results

1.3 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" following a submittal item indicates that the submittal is required for the Sustainability eNotebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING. Locate the "S" submittal under the SD number that best describes the submittal item.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only]. [When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] [Submittals with an "S" are for inclusion in the Sustainability eNotebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Assembly and Installation Plan; G

SD-02 Shop Drawings

Shop Drawings; G

[Field Installation Drawings]; G

SD-03 Product Data

Self-Lubricated Material Product Data; G

[Seal Product Data; G]

SD-07 Certificates

[Manufacturer's Experience Record; G]

[Self-Lubricated Material Manufacturer's Warranty]; G

[FCB Material Certifications; G]

SD-09 Manufacturer's Field Reports

Post-Assembly QC Report

Acceptance Test Report

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G

[1.4 MANUFACTURER'S QUALIFICATIONS

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NOTE: This requirement doesn't't add much value if only FCB materials are being specified because products are limited to a prequalifed list. If only FCB materials are being specified removing this section is recommended.

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Self-lubricated material manufacturer must have a minimum of 5 years experience in manufacturing self-lubricated materials. Submit a Manufacturer's Experience Record which details the number of years the manufacturer has been fabricating self-lubricated materials and a description of at least [five][three][one][_____] previous, separate, similar installations within the last 5 years.

]1.5 HANDLING

Handle self-lubricated components in a manner that does not damage or deform the self-lubricated material. Handle components that are the mating running surfaces of self-lubricated materials in a manner that does not damage or scratch the surface finish of the running surfaces. Do not allow self-lubricated components or their mating running surfaces to come into contact with chains, shackles, hooks, wire ropes, or other rigging that can damage them. Perform lifting, maneuvering, and securing of self-lubricated components and their mating running surfaces with fabric straps or other non-marring rigging. Replace self-lubricated components and components that are the mating running surfaces of self-lubricated components, at no cost to the Government, if they are scratched, nicked,

chipped, marred, or otherwise damaged prior to the Government taking possession of the component.

1.6 SHIPPING AND TRANSPORT

Package self-lubricated components and components that are the mating running surfaces of self-lubricated components in a manner that protects them from damage during shipping and transport. Package self-lubricated components in crates or protective boxes with adequate padding prior to shipping or transport. If self-lubricated components are installed in a larger assembly that does not fit within a crate secure protective coverings over the self-lubricated components prior to shipping and transport.

1.7 SHOP DRAWINGS

Prepare and submit Shop Drawings for the self-lubricated components covered under this specification. Within the shop drawings show the complete fabrication dimensions and tolerances, installed dimensions and tolerances, component details, and material types of the self-lubricated components [and seals]. If the contract drawings only show a fit class or require the self-lubricated material manufacturer to determine the fit then detail the specific dimensions and tolerances of the fit in the shop drawings and indicate they are for Government approval. Show the same unit system on the shop drawings that was used in the contract drawings.

[

1.8 FIELD INSTALLATION DRAWINGS

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NOTE: Removing this section if field installation drawings covering the self-lubricated components are required in a different specification section.

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Prepare and submit Field Installation Drawings for the self-lubricated components covered under this specification. In the field installation drawings show the self-lubricated components in their installed configuration and show the post installation dimensions, tolerances, and alignment requirements.

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1.9 WARRANTY

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NOTE: Consider adding minimum warranty claim response times based on the criticality of the system. For example, failures resulting in delays to navigation or the inoperability of systems integral to flood protection equipment should require faster response times. Also consider basing the warranty period on how much time it will take for a system to operate to an extent where you're confident the bearing is working properly.

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Guarantee self-lubricated components for a period of [2] years from the date of acceptance. Guarantee replacement parts for [2] years from date of replacement. Provide warranty against defective materials, design, and workmanship. In cases where the equipment manufacturer's advertised minimum guarantee is in excess of 2 years, it remains in force for its

full period. Upon receipt of notice from the Government of failure of a self-lubricated components during the warranty period, provide new replacement self-lubricated components [promptly][within 4 weeks][_____] at no additional cost to the Government. Submit the Self-Lubricated Material Manufacturer's Warranty.]

[1.10 SELF-LUBRICATED COMPONENTS

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NOTE: This section can be used to identify the self-lubricated materials the Contractor must provide under this contract. Failure Critical Bearings (FCB) should be clearly identified especially where a mix of FCB and non-FCB applications are present. If self-lubricated materials are called out both in the specifications and contract drawings make sure to use verbatim language for the component names in each document.

****

Self-lubricated components covered under this specification are listed below or shown on the contract drawings. In addition, self-lubricated components that the Government has designated as a Failure Critical Bearing (FCB) are listed below or shown on the contract drawings. FCB requirements are outlined in sections below. Self-lubricated components that are not designated as FCB must meet the general self-lubricated material requirements detailed in section 2.1 below. Provide the following self-lubricated components:

TABLE 1:

Self-Lubricated Component Name	Quantity Required	Failure Critical Bearing (FCB)
[Component 1 name] [Example: Trunnion Bushing]	[____]	[Yes][No]
[Component 2 name] [Example: Thrust Washer]	[____]	[Yes][No]
[Component 3 name] [Example: Gate Connection Bushing]	[____]	[Yes][No]

]

PART 2 PRODUCTS

2.1 GENERAL SELF-LUBRICATED MATERIAL REQUIREMENTS

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NOTE: The operating temperature range requirement is based on what would likely be seen in a typical lock and dam application. This range is commonly achievable for self-lubricated materials.

A self-lubricated material's water absorption and thermal expansion behavior should be accounted for by following the material manufacturer's recommendations on interference and clearance fits. Use the water absorption requirement if there's a special need for your application to limit the expansion behavior of a material. If the

manufacturers recommendations are being followed for fits the water absorption language can be removed.

Dielectric strength is an important property of self-lubricated materials as galvanic corrosion can jeopardize the performance of the bearing. Supplied lubricant metallic bearings rely on the lubricant to prevent galvanic corrosion. Designers should consider the sensitivity of their application to galvanic corrosion and use the dielectric strength requirement below if prevention of galvanic corrosion in needed (a dielectric strength of 50V/mm should prevent galvanic corrosion for civil works applications). Remove the dielectric strength requirement if the self-lubricated material will have bronze surfaces in contact with the mating running surface of the bearing (such as a plugged bronze self-lubricated material).

Graphite is an electrically conductive material and can cause severe galvanic corrosion with other electrically conductive materials such as metals used for bearing running surfaces. However, If a self-lubricated material containing graphite meets the minimum dielectric strength requirement then it should prevent galvanic corrosion in a typical marine environment.

The requirement for self-lubrication to be continuous and without measurable gaps for the full self-lubricated surface in contact with the mating running surface may be needed for applications that regularly only have small ranges of movement. For these applications plugged bronze or other types of materials that don't meet this requirement may not be the best choice for successful performance. If the range of movement is large enough this requirement may not be relevant and can be removed.

****

Submit Self-Lubricated Material Product Data showing the material[s] selected for use are in compliance with the requirements of this specification. Self-lubricated materials must:

a. Be approved by the material manufacturer for use in [submerged and marine environments][environments exposed to all weather conditions][_____].

b. Have an operating temperature range of [-34] [_____] to [93] [_____] degrees C [-30] [_____] to [200] [_____] degrees F.

c. Be approved by the material manufacturer for a dynamic bearing pressure of69 MPa at least 10,000 psi.

[d. Have a water absorption of less than [0.1][0.2][0.3] percent increase in weight for long term immersion as tested in accordance with ASTM D570.]

[e. Have a minimum dielectric strength of 50V/mm, as tested in accordance

with ASTM D149, for surfaces of the self-lubricated materials that come into contact with bearing running surfaces .]

[f. Be continuous and without measurable gaps for the full self-lubricated material surface that contacts the mating running surface.]

2.1.1 Fabric or Fiber Reinforced Polymer Self-Lubricated Materials

In addition to the general self-lubricated material requirements in section 2.1 above fabric or fiber reinforced polymer self-lubricated materials must:

a. Be fabricated with isopthalic polyester, orthophthalic polyester, vinylester, or epoxy resin.

b. Have polyester reinforcement, or a combination of polyester and polytetrafluoroethylene (PTFE) sheet fabric or fiber strand.

c. Have a minimum compressive yield strength of 103 MPa 15,000 psi as tested in accordance with ASTM D695 with the load applied perpendicular to the fabric/fiber layers.

d. Have a minimum in-plane shear strength of 69 MPa 10,000 psi as tested in accordance with ASTM D3846.

2.1.2 Polymer Coating Self-Lubricated Materials

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NOTE: Coating thickness and backer material selection vary with each application. Consult self-lubricated material manufacturers for appropriate selections for your application.

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In addition to the general self-lubricated material requirements in section 2.1 above polymer coated self-lubricated materials must:

a. Have a minimum of [0.38][0.51][0.64] mm [0.015][0.020][0.025] inches self-lubricated coating thickness after final machining.

b. Have a minimum compressive strength at failure of 241 MPa at least 20,000 psi as tested by the material manufacturer.

c. Have a coating backer material fabricated from [copper nickel alloy in accordance with ASTM B929, UNS C72900][copper alloy in accordance with ASTM B584] [stainless steel in accordance with ASTM A564/A564M, UNS S17400, Type 630, Condition [H1025] [H1075] [H1100]] [glass fiber reinforced composite].

d. Have an mechanical bond strength developed between the self-lubricated coating and backer material as the primary method of securing the self-lubricated coating. Mechanical fasteners, keys, or other keepers are not acceptable to retain the self-lubricated coating or transfer load between the coating and backer.

2.1.3 Extruded Homogeneous Polymer Self-Lubricated Materials

In addition to the general self-lubricated material requirements in section 2.1 above extruded homogeneous self-lubricated materials must:

b. Have a minimum compressive yield strength of 138 MPa 20,000 psi as tested in accordance with ASTM D695.

2.1.4 Plugged Bronze Self-Lubricated Materials

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NOTE: Plugged bronze self-lubricated materials can result in galvanic corrosion in a marine or submerged environment when used against a dissimilar metal such as a stainless steel. Make sure that galvanic corrosion behavior is considered in the design if using a plugged bronze material.

The self-lubricated plugs used in plugged bronze materials are intermittently spaced and may not be ideal for applications with small ranges of movement. Discuss the required plug spacing with self-lubricated material manufacturers and require a plug spacing that accommodates the minimum range of movement for your application.

Optional requirements in section 2.1e (dielectric strength requirement) and 2.1f (requirement for self-lubricated material to be continuous and without measurable gaps for the full self-lubricated material surface)exclude the use of plugged bronze materials. Remove these sections if using a plugged bronze material.

The specific alloy selected for the base material will depend on a variety of factors, such as corrosion resistance, wear, velocity, hardness requirements, machineability. Consult with manufacturers to determine the specific recommended alloys for your application.

****

In addition to the general self-lubricated material requirements in section 2.1 above plugged bronze self-lubricated materials must:

a. Have a base material fabricated from [a copper alloy in accordance with ASTM B584][an aluminum bronze in accordance with ASTM A148/A148M][_____].

b. Have self-lubricating plug recesses machined perpendicular to the bearing surface extending at least 0.25 inches deep.

c. Have a self-lubricating plug material appropriate for the application that provides the primary lubrication for the bearing.

d. Utilize a self-lubricating plug material that does not cause galvanic corrosion with the mating running surface material.

e. Have self-lubricating plugs arranged in a uniform overlapping pattern

spaced no greater than 69 MPa[[10][15][20] deg][[0.5][0.75][1.0] inches] apart in the direction of bearing movement and extending no further than 0.25 inches from the edge of the bearing surface.

f. Have a minimum compressive yield strength of 103 MPa20,000 psi, as rated by the self-lubricated material manufacturer.

[2.2 FAILURE CRITICAL BEARINGS (FCB)

****
NOTE: This section designates additional performance, testing, and QC requirements for critical bearings. These requirements come with additional cost and should be used for applications where the critical nature of the application justifies the additional cost. Remove this section if it does not apply.

Definition of a failure critical bearing can be tailored as necessary for a specific project.
****

Failure critical bearings are bearing or bushing applications where failure could potentially result in damage to critical systems or, applications where repair or replacement of a failed bearing or bushing would result in a loss of service or operation of a critical system. The designation FCB means failure critical bearing. FCB's are determined by the Government and are identified on the Contract drawings or in the Contract specifications.

2.2.1 FCB Material Qualifications

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NOTE: CERL TR 99/104 is available through the Defense Technical Information Center (dtic.mil).
****

The following is required for a material to be considered acceptable for FCB applications:

a. The material must have been tested by the procedure defined in CERL TR 99/104.

b. The material must receive a performance score of 350 or above for both wet and dry testing as evaluated by the USACE Hydro Electric Design Center (HDC) in Portland, Oregon, using the bearing rating system in CERL TR 99/104 Appendix F.

c. The material manufacturer must sign a release agreement allowing public distribution of the material's test results.

2.2.2 Approved FCB Materials

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NOTE: For an updated list of material performance scores contact the USACE Hydroelectric Design Center (HDC) (Phone: 503-808-4250).
****

The following list of materials meet FCB requirements:

TABLE 2:

FCB Material Name	Manufacturer	General Material Construction
Triboglide 15M+	ACM Composite Bearings Americas	Fabric Reinforced Polymer
All True Hydro 2069-ATHB	All True Designs	Fabric Reinforced Polymer
CIP Hydro	Columbia Industrial Products	Fabric Reinforced Polymer
Devatex 522	Federal Mogul Corporation	Fiber Reinforced Polymer
Devatex 552	Federal Mogul Corporation	Fiber Reinforced Polymer
HPF	Glacier Garlock Bearings	Fabric Reinforced Polymer
HPM	Glacier Garlock Bearings	Fabric Reinforced Polymer
HPMB	Glacier Garlock Bearings	Fabric Reinforced Polymer
P302-PTFE (previous name: D-Glide FT)	GrayGo International (previous name: Drie-D Americas)	Fabric Reinforced Polymer
Karon V - bronze backed	Kamatics Corporation	Polymer Coating - Bronze Backed
Karon V - composite backed	Kamatics Corporation	Polymer Coating - Composite Backed
C417	Trelleborg Sealing Solutions (previous name: Orkot Engineering Plastics)	Fabric Reinforced Polymer
TXM-M	Trelleborg Sealing Solutions (previous name: Orkot Engineering Plastics)	Fabric Reinforced Polymer

Submit FCB Material Certifications from the material manufacturer stating that the chemical formulations, manufacturing processes and overall structure of the materials supplied are identical to those of the bearings that meet the approved FCB materials above.

]2.3 VERIFICATION OF FABRICATION DETAILS

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NOTE: The surface finish and hardness of the mating component of a self-lubricated material has a large effect on the successful operation of that self-lubricated material. Running surfaces typically need to be fabricated with a Rockwell hardness number between 30 and 40 on the Rockwell C scale (HRC 30 - HRC 40) in accordance with ASTM E18. Self-lubricated materials in applications with infrequent service typically require no rougher than a 0.8 µm 32 micro-inches surface finish. Surface finishes, typically no rougher than 0.4 µm 16

micro-inches are required for application that have frequent service. These requirements can often be overlooked by contractors and sub-contractors that are not familiar with self-lubricated materials.

****

Verify that the fabrication and installation details shown meet the self-lubricated material manufacturer's recommendations. Specifically, verify that:

a. Surface finish and hardness requirements shown for self-lubricated material mating running surfaces are in compliance with the self-lubricated material manufacturer's recommendations.

b. Self-lubricated material clearance fits, interference fits, and tolerances shown comply with the self-lubricated material manufacturer's recommendations.

If these fabrication and installation details are outside of the self-lubricated material manufacturer's recommendations [notify the Government by submitting a Request for Information] [notify the Government by submitting a variance request on the shop drawings] [notify the Contracting Officer Representative].

2.4 Seals

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NOTE: The use of physical seals for self-lubricated bushings/bearings is an important consideration for designers. Designers should remember that for a traditional greased bronze bearing the grease is not only lubricating but is also helping to seal the bearing. Self-lubricated materials provide their own lubrication but do not provide their own seal.

Adding a physical seal can help keep debris and contaminants out of the bearing which keeps friction low and minimizes the potential for abrasive wear.

In general, it's recommended that physical seals are used for critical bearings. However, other factors that should be considered when making this decision include the potential for debris or contaminants to enter the bushing/bearing, the bushing/bearing's natural tendency to evacuate debris or contaminants, and the abrasion resistance characteristics of the chosen material construction(s).

There are many acceptable materials and configurations that can be used for physical seals. The material choices presented here have been used in self-lubricated material bushing/bearing designs and are provided here as sample seal materials for consideration. Tailor this spec section to the types of seals selected for the design.

Elastomeric o-rings are commonly used for static joint seals. These are designed to be compressed with the assembly of the joint to provide positive

contact to exclude debris, and other contaminants. Low friction polymer lip seals are commonly used for dynamic joint seals. PTFE is a very common selection because of its low friction, ability to run without grease or oil, and chemically resistive properties. A bent metal spring or compressed o-ring is typically used to energize the lip seal (provide positive contact) when the joint is assembled. These types of seals are typically readily available from seal manufacturers as they are commonly used on mechanical shafts and cylinders.

****

Submit Seal Product Data showing the seals selected for use are in compliance with the requirements of this specification.

2.4.1 Static Seals

Static seals must be synthetic ethylene propylene elastomeric o-rings meeting the following material requirements:

PHYSICAL TEST	TEST VALUE	TEST METHOD SPECIFICATION
Durometer Hardness (Shore Type A)	65 to 75	ASTM D2240
Tensile Strength	10 MPa 1450 psi (minimum)	ASTM D412
Elongation at Break	150 percent minimum	ASTM D412
200 percent Modulus	6 MPa 900 psi (minimum)	ASTM D412

2.4.2 Dynamic Seals

Dynamic seals must:

a. Be lip seals or face seals designed to exclude [rainwater][silt][heavy splash and mist][debris and contaminants] from the self-lubricated bearing.

b. Be suitable for use in a [submerged][high splash][outdoor]environment.

c. Be energized with springs fabricated from stainless steel or elastomeric o-rings to provide positive contact between the components being sealed.

d. Be molded or extruded from a polytetrafluoroethylene (PTFE) resin with appropriate fillers to achieve the performance requirements appropriate for the self-lubricated material seal application.

e. Be suitable for running without external lubrication.

[2.5 PRODUCT LUBRICATED PUMP BEARINGS

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NOTE: If used, this section should be copied into an applicable pump specification. If pump bearings are not being used remove this section.

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Submerged pump bearing must be [product lubricated][externally supplied water lubricated] and meet the following requirements:

a. Fabricated from an elastomeric material or polymer composite material and not require petroleum lubricants for operation.

b. Operate in [brackish][fresh] water that may contain [sand] [silt] [vegetative trash].

c. Does not require service or replacement for [50,000] [_____] operating hours.]

PART 3 EXECUTION

3.1 FABRICATION

Fabricate self-lubricated components and their mating running surfaces to the materials, dimensions, tolerances, and qualities shown. Fabricate self-lubricated components in accordance with the self-lubricated material manufacturer's recommendations.

3.2 TEST FITTING

Test the fit of self-lubricated components with their mating surfaces [in the presence of the Contracting Officer Representative] prior to transporting components on site.

3.3 INTERFERENCE FITTING OF SELF-LUBRICATED MATERIALS

3.3.1 Preparation of Interference Fit Surfaces

Prior to interference fitting:

a. Remove coatings such as paint, galvanizing, and anodizing from the interference fit surfaces of the bushing/bearing housing.

b. Clean the interference fit surfaces of the bushing/bearing and housing of oil, grease, cutting fluids, or other substances.

c. Prepare the interference fit surfaces of the bushing/bearing in accordance with the self-lubricated material manufacturer's recommendations.

3.3.2 Press-Fitting

Press fit self-lubricated components in accordance with the material manufacturer's recommendations. Do not use hammer blows or other impact type loading to press fit self-lubricated components. Use a method to press fit self-lubricated components that provides a smooth and constant force such as a hydraulic or other style of press. Protect components from damage during the press fitting process.

3.3.3 Shrink-Fitting

Perform shrink fitting by lowering the temperature of the inner component to a point where the outside diameter shrinks adequately to avoid interference with the outside part. Use a method to lower the temperature of self-lubricated materials that is approved by the self-lubricated material manufacturer and submitted with the Assembly and Installation Plan. Ensure shrink-fit components are fully seated and prevented from moving prior to allowing the parts to return to ambient temperature.

3.4 MECHANICAL FASTENING OF SELF-LUBRICATED COMPONENTS

Install self-lubricated components in accordance with the approved Assembly and Installation Plan. Use [300 series stainless steel fasteners] [_____] to install self-lubricated components unless otherwise noted. Install fasteners [with a thread locker and] to a torque value that does not damage or distort the self-lubricated materials. Determine the self-lubricated material manufacturer's maximum allowable amount of wear for the self-lubricated component. Install fasteners so that no part of the fastener extends beyond the fully worn running surface of the self-lubricated material.

3.5 BONDING INSTALLATION

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NOTE: Installation of self-lubricated materials using bonding adhesives have had mixed results for previous installations. In general, bonded installations are much more challenging to perform successfully. Previous challenges have included difficulties with working with bonding adhesives, maintaining component alignment during bonding, and performing accelerated temperature curing of bonding adhesives without post-curing the self-lubricated materials. Overall, bonding installations require a high level of skill and craftsmanship to perform successfully and these qualifications are extremely difficult to specify in a contract. In addition, there's typically no advantage to a bonded installation over interference fitting or mechanical fastening. Therefore, bonded installations are not recommended.

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Installing self-lubricated materials with a bonding adhesive is not permitted.

3.6 INSTALLATION PLAN

Submit an Assembly and Installation Plan showing the proposed method to assemble and install the self-lubricated components. Include pre-assembly fabrication dimensions, a description of the [interference fitting procedure][mechanical fastening procedure including installation torques], post-assembly dimensions, installation procedure,[seal installation procedure including any methods to temporarily support the seals during assembly,] method to measure and confirm the alignment requirements. Government approval of the plan does not relieve the requirement to provide a successful installation.

3.7 VERIFYING DIMENSIONS AFTER INSTALLATION

****

NOTE: The inner and outer diameter of self-lubricated bushings can change significantly after interference fitting. Consult the self-lubricated material manufacturer for pre-interference fit dimensions to achieve the desired post-interference fit dimensions. Manufacturer's can typically accurately predict the pre-interference fit dimensions required. However, sometimes post-interference fit machining is required to meet final dimensions.

Some self-lubricated materials are fabricated with a layer of premium grade material applied only at the running surface of the part. This is a common practice and can be used to significantly reduce material costs. If this practice is used an adequate thickness of premium grade material needs to be provided to allow post-interference fit machining.

****

After [shop assembly] [field installation], measure self-lubricated components to verify contract required dimensions and alignment requirements are met. If assembly dimensions are not met, machine or hone the self-lubricated materials to achieve the required dimensions. Perform machining and honing of self-lubricated components in accordance with the self-lubricated material manufacturer's recommendations. Some self-lubricated materials are fabricated with a layer of premium grade material applied only at the running surface of the part. Provide enough premium grade material at running surfaces to allow for post-assembly machining. After completing the installation photograph the [bearing/bushing][self-lubricated component] showing the installed condition. Submit a Post-Assembly QC Report detailing the measured dimensions and alignment tolerances after assembly and showing compliance with the approved Assembly and Installation Plan. [Include color photographs of the [bearing/bushing][self-lubricated component] showing the installed condition.]

3.8 ASSEMBLY OF MATING COMPONENTS

3.8.1 Cleaning

Prior to final installation, clean self-lubricated materials and their running surfaces of oil, dirt, and debris using a method recommended by the self-lubricated material manufacturer.

[3.8.2 Seal Installation

****

NOTE: Delete this section if physical seals are not used.

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Install seals in accordance with the approved Assembly and Installation

Plan. [Temporary support of seals for assembly/installation may be performed with cyanoacrylate adhesive applied in small amounts at several locations equally spaced around seal grooves.]

]3.8.3 Final Installation

Do not force components together in a manner that causes binding of the running surfaces of the components. Do not use lubricants to assemble self-lubricated components unless otherwise specified.

[3.9 ACCEPTANCE TESTING

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NOTE: Remove if acceptance testing is covered under a different spec section. Tailor the acceptance testing to your specific application. It's recommended that the designer develop a checklists for all testing or verifications need to ensure the bearing system is functioning correctly. It's also recommended that acceptance testing is witnessed and signed off by all concerned parties such as the customer or stakeholders.
****

[Notify the Contracting Officer in writing at least [14] calendar days before performing acceptance testing. Perform acceptance testing in the presence of the Contracting Officer unless waived in writing.] Create an acceptance test report form to document the procedure to perform the test operation and monitoring required in this section. Verify the following requirements have been completed prior to starting acceptance testing:

[a. Self-lubricated component installation is complete and components of the bearing system have been fully assembled.]

[b. The self-lubricated component installed dimensions, tolerance, and alignments have been measured and found to comply with the installation requirements shown.]

[c. The Post-Assembly QC Report has been finalized and approved by the Government.]

[d. Fasteners and have been installed and torqued to their final values.]

3.9.1 Test Operation and Monitoring

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NOTE: Use this section to describe the cycling that needs to be performed for the bearing system. Some general examples are provided but this section needs to be tailored to your specific application.
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[In the presence of the Contracting Officer Representative][operate the [bearing system] through [5][10][_____] rotation cycles][operate the [bearing system] for [1 hour][2 hours][_____]][Perform test operation at [_____] load and [_____] speed]. During test operation monitor the [bearing system] for:

[a. Evidence of bending, warping, permanent deformation, cracking, or malfunction of components.]

[b. Abnormal noise, stick-slip movements, vibration, or overheating of the self-lubricated components.]

[c. Evidence of bearing movement or deformation.]

Stop test operation immediately if any of these deficiencies are observed. Investigate and correct deficiencies prior to proceeding with test operations. After completing test operation the [Contracting Officer Representative] will examine the [bearing system] and, if found to comply with the contract requirements, it will be accepted [by signature by all parties]. [Signatures and acceptance will not occur until deficiencies have been corrected.]

3.9.2 Test Report

Upon successful completion [and signoff] of the acceptance tests submit an Acceptance Test Report documenting the test operations performed, the monitoring checks performed, deficiencies discovered and their resolution, [and showing final signoff by all parties].

]3.10 OPERATION AND MAINTENANCE MANUALS

[In addition to the requirements of Section 01 78 00 CLOSEOUT SUBMITTALS,] [Provide][five][three][_____][printed and bound][PDF format] [legible] copies of the following information in the Operation and Maintenance Manuals. All information must be the most current and approved copy, reflecting any changes made during the construction process:

a. Shop Drawings.

[b. Field Installation Drawings.]

c. Self-Lubricated Material Product Data.

[d. Seal Product Data.]

[e. Self-Lubricated Material Manufacturer's Warranty.]

[f. FCB Material Certifications.]

g. Post-Assembly QC Report

h. Acceptance Test Report

[i. Photographs showing the installed self-lubricated components]

[j. Guidance for when self-lubricated components need to be replaced]

3.11 TRAINING

Provide field training conducted by the [self-lubricated material manufacturer] [erecting engineer] for operating staff after each system is functionally complete but prior to final acceptance. The training must be given for a period of not less than [four][_____] hours. Cover [operation], [inspection], and [maintenance] of [the self-lubricated

bearing systems] include the items contained in the operation and maintenance manuals. Do not perform training until operation and maintenance manuals have been approved. Provide [four weeks] [_____] advance notice of the scheduled training. [Record video and audio of training conducted and provide two CD-ROM copies of the training. Provide MPEG-2 or MPEG-1 format to be compatible with common DVD players in the United States.]

-- End of Section --