

Preparing Activity: USACE

New

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in Agreement with UMRL dated July 2015

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SECTION 35 05 40.17

SELF-LUBRICATED MATERIALS, FABRICATION, HANDLING, AND ASSEMBLY 05/14

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 section has been developed for USACE Civil Works projects.

In accordance with ER 1110-2-109, 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: 503-808-4200).

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 items(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).

PART 1 GENERAL

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

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. 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 fully 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, running surface clearance fits, edge chamfers, etc.

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 bearing component, housing, and associated running surfaces.

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.

1.1 SUMMARY

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

1.2 REFERENCES

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 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.

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 A564/A564M

(2013) Standard Specification for
Hot-Rolled and Cold-Finished Age-Hardening

Stainless Steel Bars and Shapes

ASTM A580/A580M	(2015) Standard Specification for Stainless Steel Wire
ASTM B929	(2005; R 2011; E 2011) Standard Specification for Copper-Nickel-Tin Spinodal Alloy Rod and Bar
ASTM D1002	(2010) Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal)
ASTM D149	(2009; R 2013) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D2240	(2005; R 2010) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D3846	(2008) Standard Test Method for In-Plane Shear Strength of Reinforced Plastics
ASTM D412	(2006a; R 2013) Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D4745	(2014) Standard Specification for Filled Compounds of Polytetrafluoroethylene (PTFE) Molding and Extrusion Materials
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 E18	(2015) Standard Test Methods for Rockwell Hardness of Metallic Materials

U.S. ARMY CORPS OF ENGINEERS (USACE)

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

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.

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

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

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 Notebook, 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

Self-lubricated Component Shop Drawings; G[, [_____]]

Show the complete dimensions, fabrication tolerances, and material callouts.

Self-Lubricated Component Field Installation Drawings; G[, [_____]]

Show the installation and assembly details including alignment tolerances.

SD-03 Product Data

Self-Lubricated Material Product Data; G[, [_____]]

Bonding Adhesive Product Data; G[, [_____]]

SD-07 Certificates

Manufacturer's Experience Record; G[, [____]]
Self-Lubricated Material Manufacturer's Warranty
Release Agreement
FCB Material Certifications

SD-09 Manufacturer's Field Reports

Post-Assembly QC Report
Alignment QC Report
Acceptance Test Report

SD-10 Operation and Maintenance Data

Operation and Maintenance Manuals; G[, [____]]

1.4 MANUFACTURER'S QUALIFICATIONS AND WARRANTY

Self-lubricated material manufacturer[s] [is] [are] required to have a minimum of [10][____] 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 5 previous, separate, similar installations within the last [5] [10] [____] years].

1.5 HANDLING

Handle self-lubricated components and their associated running surfaces in a manner that does not cause damage or affect the surface finish of the components. Perform lifting, and maneuvering of self-lubricated components and their running surfaces with fabric straps or other non-marring rigging. Do not allow self-lubricated materials and their mating surfaces to come into direct contact with chains, shackles, hooks, or wire ropes. Damage to self-lubricated components or their mating surfaces including scratches, nicks, chips, or marring is grounds for rejection of the components.

[1.6 WARRANTY

Provide a warranty from the self-lubricated material manufacturer protecting products against defects in material and workmanship for a minimum of [5] [____] years. Submit the Self-Lubricated Material Manufacturer's Warranty.

]PART 2 PRODUCTS

2.1 GENERAL SELF-LUBRICATED MATERIAL REQUIREMENTS

NOTE: Most graphite is electrically conductive and can cause severe galvanic corrosion with metals including common bearing running surface materials. In general, graphite should be avoided for used as a lubricant in marine applications. However, if a material containing graphite meets the minimum

dielectric strength requirement then it may be ok for the application. Make sure selection of language for graphite and dielectric strength requirements are consistent.

Dielectric strength is an important property of self-lubricated materials. Supplied lubricant metallic bearings rely on the lubricant to prevent galvanic corrosion. Galvanic and other types of corrosion should be avoided as they can jeopardize the performance of a bearing. The Dielectric strength of self-lubricated materials should be adequate to prevent galvanic corrosion.

Excessive water absorption can affect the running clearances and fits of self-lubricated materials. Excessive water absorption should be avoided for successful performance.

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.

The requirement below, for self-lubrication to be continuous and without measurable gaps for the full self-lubricated surface in contact with the mating running surface is especially important for applications that only have small ranges of movement.

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 meet the following requirements:

a. Thermoset polymer approved for use in submerged and marine environments by the material manufacturer.

[b. Self-lubricated materials cannot contain graphite.]

[b] [c]. Surfaces of the self-lubricated materials that come into contact with bearing running surfaces must have a minimum dielectric strength of 50V/mm as tested in accordance with ASTM D149.

[c] [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.

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

[[e] [f]. Continuous and without measurable gaps for the full self-lubricated material surface[s] that come into contact with the mating running surface.]

2.1.1.1 Fabric Reinforced Polymer Self-Lubricated Materials

In addition to the general self-lubricated material requirements above

fabric reinforced polymer self-lubricated materials must have the following features and properties:

- a. Base materials must be isophthalic polyester, orthophthalic polyester, vinylester, or epoxy resin.
- b. Polyester reinforcement, or a combination of polyester and polytetrafluoroethylene (PTFE) sheet fabric or fiber strand.
- c. Fabric reinforced polymers rated by the self-lubricated material manufacturer for a minimum dynamic bearing pressure of 69 MPa 10,000 psi applied in a direction perpendicular to the fabric layers.
- d. Fabric reinforced polymers must 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 layers.
- e. Fabric reinforced polymers must have a minimum in-plane shear strength of 69 MPa 10,000 psi as tested in accordance with ASTM D3846.

2.1.2 Sprayed Polymer Coating Self-Lubricated Materials

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

In addition to the general self-lubricated material requirements above sprayed homogeneous coatings must have the following features and properties:

- a. Sprayed polymer coatings must be a minimum of [0.38][0.51][0.64] mm [0.015][0.020][0.025] inches thick after final machining.
- b. Sprayed polymer coatings must be rated by the self-lubricated material manufacturer for a minimum dynamic bearing pressure of 69 MPa 10,000 psi.
- c. Sprayed polymer coatings must have a minimum compressive strength at failure of 241 MPa 35,000 psi as tested by the material manufacturer.
- d. Secure sprayed polymer coatings to the backer material using only the adhesive bond of the polymer material. Do not use keys, keeper plates, and other mechanical methods to secure the sprayed coating to the backer material.
- e. Sprayed polymer coating backer material must be [copper nickel alloy in accordance with ASTM B929, UNS C72900] [stainless steel in accordance with ASTM A564/A564M, UNS S17400, Type 630, Condition [H1025] [H1075] [H1100]] [glass fiber reinforced composite].

2.1.3 Extruded Homogeneous Polymer Self-Lubricated Materials

In addition to the general self-lubricated material requirements above extruded homogeneous self-lubricated materials must have the following features and properties:

- a. Extruded homogeneous polymer materials must be rated by the self-lubricated material manufacturer for a minimum dynamic bearing pressure of 69 MPa 10,000 psi.
- b. Extruded homogeneous polymer materials must 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

NOTE: Plugged bronze style self-lubricated materials are often not a good choice for lock and dam applications. This is due to the fact that they can cause galvanic corrosion if a supplied lubricant is not used. These types of materials are also not ideal for applications with small ranges of movement as the plugs providing the lubrication are intermittently spaced and may not provide full lubrication of the running surface especially for applications that have small ranges of movement.

Spec requirements for dielectric strength to be a minimum of 50V/mm and for self-lubrication to be continuous and without measurable gaps for the full self-lubricated material surface that come into contact with the mating running surface exclude the use of plugged bronze materials. Select the appropriate spec language to provide consistent requirements.

[Plugged bronze self-lubricated materials are not acceptable as they do not meet dielectric strength requirements and do not provide continuous self-lubrication without measurable gaps.]

- a. Base material must be bronze.
- b. Plug materials must be self-lubricating polymer containing polytetrafluoroethylene (PTFE)
- c. Plugged bronze self-lubricated materials must be rated by the self-lubricated material manufacturer for a minimum dynamic bearing pressure of 69 MPa 10,000 psi.
- d. Plugged bronze self-lubricated materials must be rated by the self-lubricated material manufacturer for a minimum compressive yield strength of 103 MPa 15,000 psi.]

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. Delete this section if it does not apply.

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

Means should be taken to clearly identify failure critical bearings especially where a mix of bearing applications (critical and non-critical) is present.

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 bushings 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

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 meet the self-lubricated material requirements above.
- b. The material must have been tested by the procedure defined in CERL TR 99/104.
- c. 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.
- d. The material manufacturer must sign a release agreement allowing public distribution of the material's test results.

2.2.2 Qualified FCB Material

NOTE: For an updated list of material performance scores contact the USACE Hydroelectric Design Center (HDC) (Phone: 503-808-4200).

The following list of materials meet FCB requirements:

- [a. CIP Hydro, Columbia Industrial Products, 29538 Airport Rd. Unit A, Eugene, OR 97402. Contact Person: Jessica Leamen, 541-607-3655, jessica@cipcomposites.com]
- [b. TXM-M, ORKOT Engineering Plastics, 901 Phoenix Lake Ave., Streamwood, IL 60107. Contact person: Eric McCorkle, 509-496-3054, eric.w.mccorkle@trelleborg.com]
- [c. D-Glide FT, Drie-D Americas, 25 Elgin St., Grimsby, ONT. Contact Person: Frank Trivieri, 905-309-9558, trivieri@drie-d.com]

- [d. All True Hydro 2069-ATHB, All True Designs, 4660 Main St., Building C, Suite 450, Springfield, OR 97478. Contact Person: Andy Standerfer, 541-357-5263, andys@alltruedesigns.com]
- [e. Karon V - bronze backed, Kamatics Corporation, Post Office Box 3, Bloomfield, CT, 06002. Contact person: Yarrow Banko, 206-420-1840, yarrow.banko@kaman.com]
- [f. Karon V - composite, Kamatics Corporation, Post Office Box 3, Bloomfield, CT, 06002. Contact person: Yarrow Banko, 206-420-1840, yarrow.banko@kaman.com]
- [g. HPF, Glacier Garlock Bearings, P.O. Box 189, 700 Mid Atlantic Parkway, Thorofare, NJ 08086. Contact: 856-848-3200, usa@ggbearings.com]
- [h. HPM, Glacier Garlock Bearings, P.O. Box 189, 700 Mid Atlantic Parkway, Thorofare, NJ 08086. Contact: 856-848-3200, usa@ggbearings.com]
- [i. Devatex 522, Federal Mogul Corporation, 26555 Northwestern Highway, Southfield, MI 48003. Contact Person: Jim Rober, 248-794-7801, jim.rober@federalmogul.com]

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 FCB material qualifications above.

2.3 SELF-LUBRICATED MATERIAL BONDING ADHESIVE

NOTE: Remove this section if a bonding installation method is not being used.

Self-lubricated material bonding adhesives must meet the following requirements. Submit Bonding Adhesive Product Data showing that the minimum requirements listed are met.

NOTE: Designers should be aware that the strength properties of the bonding adhesive may be the limiting factor for the design of self-lubricated bearing systems. The strength properties of the adhesive should be accounted for when designing for a specific factor of safety.

- a. Bonding adhesives must be approved by the adhesive manufacturer for use in submerged and marine environments.
- b. Bonding adhesive must be approved by the adhesive manufacturer for use with the materials that it will be applied to.
- c. After reaching full cure bonding adhesives must have a minimum compressive strength of 52 MPa 7,500 psi as tested in accordance with ASTM D695.
- d. After reaching full cure bonding adhesives must have a minimum tensile

lap shear strength of 28 MPa 4,000 psi as tested in accordance with ASTM D1002.

- e. Bonding adhesive must be approved for service in the temperature range of -34 to 93 degrees C -30 to 200 degrees F.

2.4 SELF-LUBRICATED MATERIAL MATING RUNNING SURFACES

NOTE: Successful operation of self-lubricated components requires a specific running surface hardness and surface finish values. These critical requirements can often be overlooked by contractors and sub-contractors that are not familiar with self-lubricated materials. This section is intended to help highlight the importance of these requirements to contractors.

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 μ m 32 micro-inches surface finish. Surface finishes, typically no rougher than 0.4 μ m 16 micro-inches are required for application that have frequent service. Verify that the surface finish and hardness requirements [indicated][specified] for self-lubricated material running surfaces are in compliance with the self-lubricated material manufacturer's recommendations. If the [indicated][specified] running surface requirements are outside of the self-lubricated material manufacturer's recommendations [notify the Government by submitting a Request for Information] [submit a variance request on the shop drawings].

2.5 Seals

NOTE: The use of physical seals for self-lubricated bushings/bearings is an important consideration for designers. 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).

Testing for debris or contamination tolerance is essentially an abrasion resistance assessment of the material. In general, fabric reinforced polymers have a moderate to high tolerance for abrasion resistance. Sprayed coatings are harder which give them a better tolerance for abrasion resistance. Extruded homogeneous materials are softer and have a lower tolerance for abrasion resistance.

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.

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 polymers are commonly used for dynamic joint seals. PTFE is a very common selection because of its low friction and chemically resistive properties. A bent metal spring or compressed o-ring is typically used to provide positive contact when the joint is assembled. These types of seals are commonly available as off-the-shelf parts from seal manufacturers.

Provide seals for the [_____] [bearing] [bushing] meeting the following requirements.

2.5.1 Static Seals

Static seals must be synthetic ethylene propylene elastomeric o-rings and 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
300 percent Modulus	6 MPa 900 psi (minimum)	ASTM D412

2.5.2 Dynamic Seals

Dynamic seals must be [molded PTFE] [_____] with energizing springs fabricated from stainless steel or elastomeric o-rings. PTFE must [be carbon filled and] meet the following material requirements:

PHYSICAL TEST	TEST VALUE	TEST METHOD SPECIFICATION
Durometer Hardness (Shore Type D)	60 to 70	ASTM D2240
Tensile Strength at Break	20 MPa 3000 psi (minimum)	ASTM D4745
Specific Gravity	2.0 minimum	ASTM D4745
Elongation at Break	200 percent minimum	ASTM D4745

[2.6 Centering Wires

NOTE: Remove this section if a bonding installation
method is not being used.

Wires used to center the [bushing] [bearing] during bonding must be 300 series stainless steel and meet the requirements of ASTM A580/A580M condition A.

]2.7 PRODUCT LUBRICATED PUMP BEARINGS

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

Submerged pump bearing must be product lubricated and meet the following requirements:

- a. Bearings must be fabricated from an elastomeric material or polymer composite material and not require petroleum lubricants for operation.
- b. Bearings must operate in water that may contain [sand] [silt] [vegetative trash].
- c. Bearing must not require service or replacement for [50,000] [_____] operating hours.

]2.8 TEST FITTING

Test the fit of self-lubricated components with their mating surfaces prior to transporting components on site.

PART 3 EXECUTION

3.1 FABRICATION

Fabricate self-lubricated components and their running surfaces from the materials, dimensions/tolerances, and qualities indicated.

3.2 ALIGNMENT REQUIREMENTS

NOTE: 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 much tighter alignment requirements than this procedure tests for. Required alignment of self-lubricated components should be defined in accordance with an applicable code such as ASME Y14.5 - Dimensioning and Tolerancing.

Use this paragraph to define alignment requirements of self-lubricated components and mating parts. These requirements could also be shown on drawings. Use an applicable dimensioning and tolerancing code such as ASME Y14.5 to define alignment requirements.

[_____.]Submit Alignment QC Report showing the results of the field measurements taken to verify the required alignment of installed components.

3.3 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][bonding 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.

3.4 INTERFERENCE FITTING OF SELF-LUBRICATED MATERIALS

3.4.1 Preparation of Interference Fit Surfaces

Remove coatings from bushing/bearing housing surfaces prior to interference fitting. Remove coatings including paint, galvanizing, and anodizing from the interference fit surfaces prior to assembling the joint. Clean interference fit surfaces of the bushing/bearing and housing of oil, grease, cutting fluids, or other substances prior to assembling the interference fit.

3.4.2 Press-Fitting

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.

3.4.3 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. Ensure shrink-fit components are fully seated prior to allowing the parts to return to ambient temperature.

3.5 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 amount of wear that is expected for the service life of the self-lubricated material. Install fasteners so that no part of the fastener extends beyond the fully

worn running surface of the self-lubricated material.

[3.6 BONDING SELF-LUBRICATED MATERIALS

**NOTE: Remove this section if a bonding installation
method is not being used on the self-lubricated
components.**

3.6.1 Protection of Work

Perform bonding of self-lubricated materials in a controlled environment. Perform bonding in a temperature controlled building that allows protection from the elements. [Exceptions to this requirement may be allowed, at the discretion of the Contracting Officer, for cases where the size of components prevents feasible transportation to an offsite location.]In cases where outdoor installation of self-lubricated materials is necessary, protect the bonded surfaces and work area from the weather.

3.6.2 Preparation of Bonding Surfaces

Prepare surfaces to be bonded, including degreasing and abrading, in accordance with the bonding adhesive manufacturer's recommendations. Prepare the bond joint so that the adhesive bonds only to the parent materials of each component. Remove surface coatings such as paint, galvanizing, and anodizing from the surfaces to be bonded using an approved method prior to applying the adhesive. Clean surfaces to be bonded of oil, grease, cutting fluids, and substances that may affect the quality of the bonded joint. Only clean self-lubricated materials with cleaners that are approved for use by the self-lubricated material manufacturer.

3.6.3 Bonding

Mix and apply the bonding adhesive in accordance with the adhesive manufacturer's recommendations. Unless the adhesive manufacturer recommends otherwise, apply the adhesive evenly and completely across both bond surfaces prior to assembling the joint. Use a bonding procedure that prevents adhesive from coming into contact with the running surfaces of the self-lubricated materials. Prior to starting the bonding process, have a solvent or other cleaner approved by the self-lubricated material manufacturer on-hand and accessible. Quickly and completely clean off adhesive that ends up on self-lubricated material running surfaces during the bonding process.

3.6.3.1 Maintaining Dimensions of Bushings/Bearings During Bonding

While unsupported, self-lubricated materials have a tendency to slightly sag under their own weight creating an out-of-round condition. Prior to bonding bushings or bearings in place, check the diameter of the running surface of the bushings/bearings to verify they are within the dimension requirements shown. If the diameter is out of the required dimension, provide and use jigs or other devices, which do not harm the material, to maintain the required dimensions during bonding. Assemble bushings and bearings with the axis in a vertical orientation where feasible to minimize the possibility of bearing sag and non-conforming radial tolerances.

3.6.3.2 Bushing/Bearing Centering Wires

Use centering wires for situations that require assembly of bushings/bearings axis in a horizontal orientation. Place centering wires in the clearance between bushing/bearing outer diameter and housing inner diameter. Use centering wires that have a diameter equal to the radial clearance between bushing/bearing and housing. Use a minimum of eight wires evenly spaced around the circumference of the bushing/bearing. After the adhesive is fully cured cut centering wires flush with the surfaces of the bushing/bearing and file any sharp edges smooth.

3.6.3.3 Flanged Bushings/Bearings

Unless indicated otherwise, bond flanges of bushing/bearing to their associated housings.

3.6.4 Curing of Bonding Adhesive

Do not load self-lubricated materials until the bonding adhesive has fully cured. Follow the adhesive manufacturer's recommendations to achieve full cure of the adhesive.

[3.6.5 Accelerating Cure of Bonding Adhesives

NOTE: The amount of time to reach full cure for many bonding adhesives can be reduced at increased temperatures. This is a common practice for many adhesives but should be performed with an awareness of the issues identified in the specification language below. Remove the section below if accelerated curing is not being used.

Perform accelerated curing of bonding adhesives by increasing the temperature of the components to a maximum temperature that does not harm the self-lubricated materials or other components. Many self-lubricated materials cannot be heated past approximately 100 degree F without post curing and potentially shrinking or distorting the material. Consult the self-lubricated material manufacturer for the maximum temperature that can be used for accelerating the cure of the bonding adhesive. Perform heating of components in a manner that brings the entire bonded joint up to the desired cure temperature. Consider heat sinks in the components that may increase the amount of time that is required to heat the bond joint up to the desired temperature. Open flame must not be used to heat or pre-heat components for bonding.

]3.7 VERIFYING DIMENSIONS AFTER ASSEMBLY

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 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. Submit a Post-Assembly QC Report detailing the measured dimensions after assembly and showing compliance with the approved Assembly and Installation Plan.

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.

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

Following the completion of installation, checkout, adjustment, [[and setting the] [limit switches], [controls], [interlocks],] perform acceptance testing on each self-lubricated bearing system. Develop an acceptance test report form to record the acceptance testing results. For acceptance, operate the [gate] [bearing system] through [three][_____] complete cycles to satisfy the Contracting Officer that the requirements of the contract have been met and that the performance of the bearing system

is satisfactory for the purpose intended.

Upon successful completion of the field tests, the bearing system and [related components] [accessory items and equipment] will be examined by the [Contracting Officer] [Project Personnel], and if found to comply with the contract it will be accepted by signature by all parties. Signatures and Acceptance will not occur until all found deficiencies have been corrected. Submit the Acceptance Test Report documenting the testing performed, findings of the testing, and correction of issues.

3.10 OPERATION AND MAINTENANCE MANUALS

[In addition to the requirements of Section 01 78 00 CLOSEOUT SUBMITTALS, include] [Provide] 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. Self-lubricated Component Shop Drawings.
- b. Self-Lubricated Component Field Installation Drawings.
- c. Self-Lubricated Material Product Data.
- [d. Bonding Adhesive Product Data.]
- [d] [e]. Self-Lubricated Material Manufacturer's Warranty.
- [e] [f]. FCB Material Certifications.
- [f] [g]. Post-Assembly QC Report
- [g] [h]. Alignment QC Report
- [h] [i]. Acceptance Test Report

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. The training must cover all pieces of equipment and 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. The recording shall be MPEG-2 or MPEG-1 format to be compatible with common DVD players in the United States.]

-- End of Section --