

AR[®]-HT Composite Bearings Running Against Stellite Sleeves: Proven Success in Circulating Water Intake Pumps (CWIPs) with Saltwater

Background

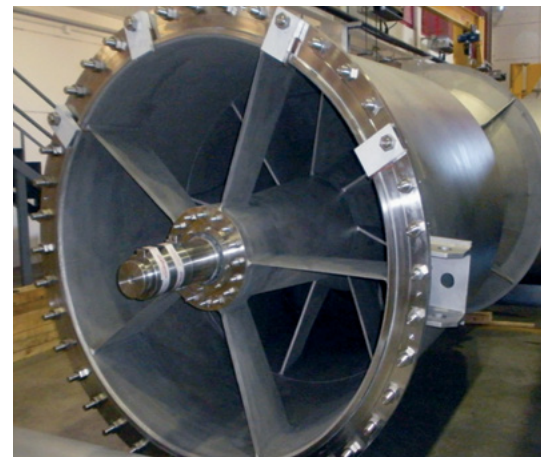
In early 2015, Duke Energy Brunswick, one of the largest electric power generation companies in the U.S., was looking to replace eight CWIPs that reached their end of life.

Based on highly successful experiences spanning many years, Duke Engineering specified Greene Tweed's AR[®]-HT bearings for the new CWIPs.

Flowserve, the pumps' original equipment manufacturer (OEM), was contracted to produce the series of vertical CWIPs.

The vertical pump model is designed to pump high volumes of seawater and has an external flush provided to each of the four composite bearing locations. AR[®]-HT is a proprietary thermoplastic composite material that is designed specifically for use as bushings, bearings, and wear rings in pumps handling abrasive media up to 250°F (120°C). Its properties make it a more reliable material than traditional rubber, ceramic, or bronze.

The Problem



The Duke Brunswick site was looking to upgrade the bearings from cutlass rubber due to de-lamination issues.

Concerns:

- Clogging of injection lines with mud and silt.
- Low-bearing flush alarm on current pumps set to 2 minutes to trip.
- Duke Engineering requested Flowserve to extend alarm time to trip to 15 minutes to allow operators to swap pumps without damage to bearings.

Challenge: Greene Tweed proposed the use of AR[®]-HT bearings – could they survive low-bearing flow conditions for 15 minutes without damage?

Challenge No. 1

Low-Flow Bearing Flush Alarm/Trip Time Extension

Challenge

Provide sufficient time for operations to start the standby pump prior to stopping the pump with the low-bearing flush.

Target Goal

AR⁺-HT bearings must survive a 15-minute interval with "low-flow" bearing flush conditions without significant damage.

Proposed Solution

Design and execute a bearing test program to validate AR⁺-HT composite bearings under the following application parameters:

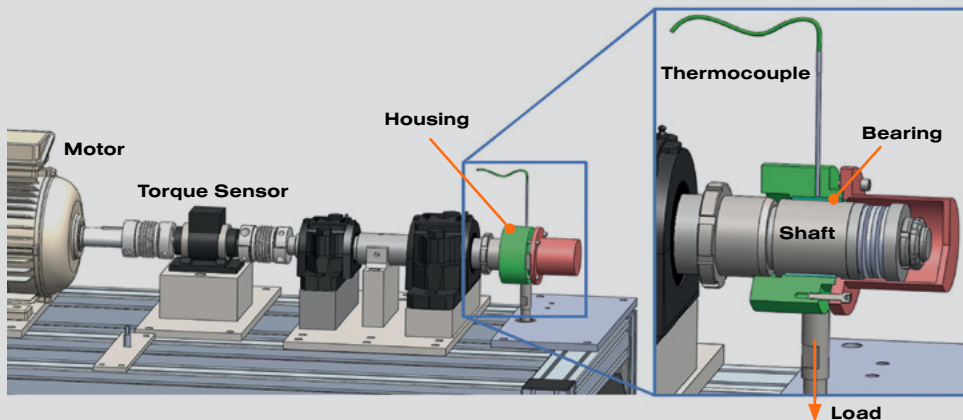
Bearing Configuration

- Bearing material changing from cutlass rubber to AR⁺-HT
- Grooved bearing: ID 7.99" – OD 9.65"

- Journal sleeve and rotating wear ring material: AL6XN with hard facing (Stellite)

Lubrication Water

- Inlet pressure: 15 psig
- Estimated nominal bearing load: 5 psi on projected bearing area
- Temperature: 32°F to 92°F
- Normal flow conditions: 18 gpm
- Low-flow conditions: less than 5 gpm
- Lube water quality: seawater strained to a maximum particle size of 0.057 inches with traces of chemicals (NALCO 1338 ActiBrom and 12.5% sodium hypochlorite solution)



Test Configuration

Because low-flow conditions were difficult to define, Greene Tweed tested all specimens dry as a worst-case scenario.

Test Results

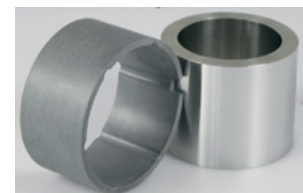
	Before Test	Test 1 (15 min)	Test 2 (30 min)	Test 3 (60 min)
Test Results: 5 psi load	Inner Diameter	Inner Diameter	Inner Diameter	Inner Diameter
Bearing 1	2.706" (68.72 mm)	2.706" (68.72 mm)	2.706" (68.72 mm)	2.706" (68.73 mm)
Bearing 2	2.706" (68.72 mm)	2.706" (68.72 mm)	2.706" (68.72 mm)	2.706" (68.72 mm)
Test Results: 10 psi load				
Bearing 3	2.705" (68.70 mm)	2.705" (68.70 mm)	2.705" (68.71 mm)	2.705" (68.71 mm)
Bearing 4	2.706" (68.73 mm)	2.706" (68.73 mm)	2.706" (68.74 mm)	2.706" (68.74 mm)

The inner diameter of the bearings measured in inches (") and millimeters (mm) before and after testing.

Journal bearing #1 after third test (105-minute test duration)



Sample 1 and its sleeve **before** cleaning



Sample 1 and its sleeve **after** cleaning

Challenge No. 2

Shaft Sleeve Metallurgy Selection



Background

Saltwater is extremely corrosive to standard steels. Due to potential corrosion issues with saltwater, Duke Engineering specified AL6XN Super-Austenitic SS for the pump case and shaft.

Metallurgy Selection - Case & Shaft

AL-6XN® / UNS N08367 – Super-Austenitic SS

- 6.3% molybdenum
- 25+ years of proven seawater service
- Practical immunity to chloride stress cracking
- 50% stronger than stainless

Shaft sleeves required a detailed evaluation.

Experience has shown that a harder shaft/sleeve can extend bearing system life in abrasive media services.

It was agreed that a sleeve material with a minimum HRC40 hardness would be specified.

Flowserve Engineering considered the following six options:

- 1 Direct Laser Deposition (DLD) of Stellite 6 (40 – 45HRC) on AL6XN
- 2 Direct Laser Deposition (DLD) of Stellite 12 (46 – 51HRC) on AL6XN
- 3 Ultimet (UNS R31233) applied to austenitic steel
- 4 Chrome oxide applied by HVOF/plasma spray
- 5 Hastelloy C-22HS (ASTM B637 – 12N07022) with three post-treatment options
- 6 Solid Stellite 12

Sleeve Metallurgy Selection Results

Of the options considered, several were discounted due to lack of experience and incomplete results. Solid Stellite 12 shaft sleeves were specified as a result of their previous experience and meeting the hardness recommendations of the shaft sleeve material.

The combination of Greene Tweed's AR®-HT bearings and Stellite 12 solid sleeves were selected for this application.

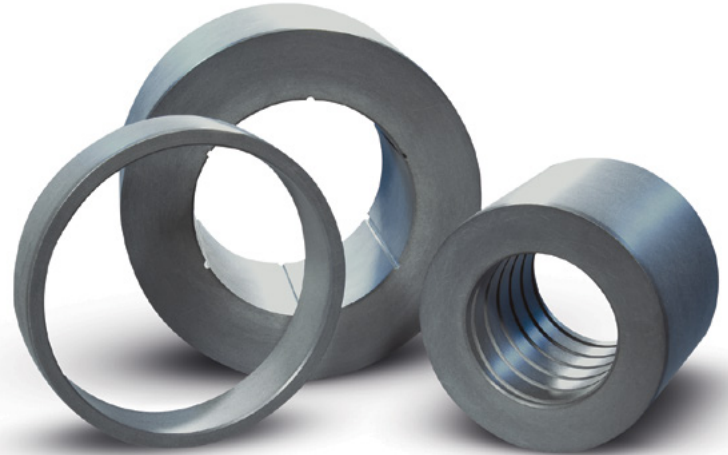
The Solution

Material Selection Conclusions

- A combination of AR®-HT bearings and Stellite 12 solid sleeves was selected for this application.
- Testing demonstrated that AR®-HT bearings can resist wear and maintain clearances for greater than 105 minutes in dry run condition (no lubricant), thereby allowing the low-bearing flush alarm extension to 15 minutes.
- All pumps upgraded with this combination of AR®-HT bearings and the solid Stellite shaft sleeves were successfully installed and commissioned starting in 2016.

Duke Experience with Flowserve CWIPs to Date

- No maintenance on the Flowserve CWIPs with Greene Tweed's AR®-HT bearings has been required since their installation in 2016!
- Vibration levels are consistently low and smooth running.
- Since the bearing system is no longer the maintenance limiting factor of the CWIPs, the PM frequency is anticipated to be extended beyond the current 15 years.
- AR®-HT bearings and Stellite 12 sleeves were also specified on the service water pumps (SWPs) at the Duke Brunswick site and have achieved identical results to date.
- The CWIPs and SWPs performance to date has led to the same AR®-HT and Stellite 12 specification on the upcoming replacement of the circulating water ocean discharge pumps.



AR®-HT – Grooved bearing, bushing, and wear ring

No maintenance on the Flowserve CWIPs with Greene Tweed's AR®-HT bearings has been required since their installation in 2016!

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