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technical note

SALT WATER CORROSION TEST OF ROLLING SURFACE BEARING
SWIVELS

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Port Hueneme, California

INTRODUCTION

Project YD 512-12, Salt Water Corrosion Test of Rolling Surface Bearing Swivels, was authorized by BUDOCKS letter P-311/fzr, NP/Pt Hue/N8, dated 15 April 1952. The project developed from test, ashore of the Miller ball bearing swivel used as a component of weight handling gear. Technical Note N-069 dated 3 March 1952 reported results of this test and recommended that the Miller ball bearing swivel be accepted for use with weight handling equipment ashore.

Although the suitability of the Miller swivel for use with gear subject to sea water immersion was of primary interest, investigation of the qualifications of other makes of rolling surface bearing swivels for this use was desired by the Bureau. A canvas of supply sources produced only one other, the Flexo roller bearing swivel. Accordingly, only the Miller and Flexo swivels were considered and two identical samples of each were procured and tested.

In addition to Laboratory tests, some information concerning the experiences of the U. S. Coast Guard and the State of California, Department of Fish and Game, with the Miller swivel was obtained. This information is included in this report.

DESCRIPTION OF SWIVELS TESTED

The Miller swivel is a product of the General Machine and Welding Works Inc., Pomona, California. This make of swivel is equipped with three angular contact ball bearing sets which provide for free rotation of the swivel under load, and transmission of load thrust to the swivel barrel. The swivels tested by the Laboratory are manufacturer's Model G, Type 3 (eye and eye connections), rated by the manufacturer at 72,000 lbs "maximum load" and 24,000 lbs "working load". The G-3 swivel weighs approximately 41 lbs, is 4 inches in diameter, 14 1/2 inches in overall length, and is designed for use with 1 inch wire rope or equivalent. Swivels number 1 and 3 of Figure 1 are the Miller swivels after more than one year immersion in sea water. Figure 2 shows the same swivels disassembled.

Figure 3 is a Miller Model C, Type 10 (eye and clevis connections) swivel used for approximately three years by the State of California, Department of Fish and Game. This swivel is 2 inches in diameter, is rated at 15,000 lbs "maximum load", 5000 lbs "working load", by the manufacturer, and is for use with 1/2 inch wire rope or equivalent.

The U. S. Coast Guard had a Miller Model H, Type 2 (clevis and clevis connections) swivel in service for about 2 years as part of the mooring gear of the Diamond Shoals Lightship. This swivel is a 5 inch diameter, 1 1/2 inch wire rope size, rated by the manufacturer at 140,000 lbs "maximum load" and 46,200 lbs "working load".

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The Flexo swivel is manufactured by the Flexo Machine Company of Chicago, Illinois. This make of swivel is equipped with a roller thrust bearing and a tapered roller bearing for both thrust and radial loads. The swivels tested by the Laboratory are Flexo number 400. This swivel weighs about 40 lbs, is 4 inches in maximum diameter, 14 1/2 inches long, and is rated by the manufacturer at 46,000 lbs "maximum safe load". It is designed for use with 1 inch wire rope or equivalent. Swivels number 2 and 4 of Figure 1 are the Flexo swivels after one year immersion in sea water. Figure 4 shows the Flexo swivels disassembled.

DESCRIPTION OF TESTS

As a matter of expediency, the two Miller and two Flexo swivels purchased by the Laboratory were tested in San Francisco Bay in conjunction with the Laboratory's Anchor Development Project NY 420 010-5.

One each of the Miller and Flexo swivels was used as a portion of the gear for mooring a 5 x 12 pontoon barge in approximately 30 feet of water. Two sets of ground tackle were used in the mooring; each consisted of 200 feet of wire rope connected at one end to the barge and at the other end to a spherical buoy. A short length of wire rope connected the buoy to one of the swivels and another length of wire rope joined the swivel and a 30,000 lb anchor lying on the bottom of the bay. Each set of tackle was so assembled that each of the two swivels were immersed in approximately 5 feet of water for a period of 12 months. Items 3 and 4 of Figure 1 are these two swivels.

Swivels 1 and 2 of Figure 1, the second of the two Miller and two Flexo swivels, were hung from the side of the barge and allowed to rest on the bottom of the bay in approximately 30 feet of water for nearly 14 months.

Figure 5 shows the swivel test site. All swivels were placed in the water on 18 August 1953. At approximately 3 month intervals, each swivel was raised for surface inspection. On 20 August 1954, swivels 3 (Miller) and 4 (Flexo) were permanently removed from the water, although the Miller remained in use for about one month as part of a strain gage rig used in the anchor tests. This swivel was subjected to loads up to 50,000 lbs while used with the strain gage. On 8 October 1954, swivels 1 (Miller) and 2 (Flexo) were removed from the water and all four swivels were returned to Port Hueneme where they were disassembled and inspected. Figures 2, 4, 6, 7, 8, and 9 show various parts of the swivels and the condition of these parts after the prolonged immersion in sea water.

The Miller swivel used by the State of California, Department of Fish and Game, was opened for inspection on 13 January 1955. This swivel, at this Laboratory since August 1952, had not previously been opened. The manufacturer, in sending the swivel to the Laboratory, stated that the swivel had been in and out of water continuously for a period of about 3 years and that at times it was subjected to depths as great as 300 fathoms.

DISCUSSION

All four of the Miller and Flexo swivels tested by the Laboratory performed well during the period of submersion. When raised for inspection, neither swivel showed evidence of damaging exterior corrosion. After several days exposure to the air, however, severe corrosion of the surfaces of the male and female halves of the barrel joints of the Flexo swivels (Figure 6) made these swivels inoperative. The extent of the freezing action of this corrosion was such that about 2000 foot lbs force was required to break the joint for disassembly. These swivels will not be usable again unless the joint is cleaned up, and some machining might be required to accomplish this.

On disassembly, water was found in both Flexo swivels. Water had penetrated the grease with which the bearings were packed and had caused some corrosion of the bearings. Corrosion was slight in the case of swivel No. 4 (5 foot submergence) and greater in swivel No. 2 (30 foot submergence). Figure 8 shows the difference in corrosion of the thrust bearings of the two swivels. Figure 9 is the tapered roller bearing from swivel No. 2. Corrosion of this bearing was more extensive than that of swivel No. 4, although both bearings rolled freely.

A small amount of moisture had penetrated to the bearings of Miller swivel No. 1 resulting in some corrosion although the bearings rolled freely. There was no interior corrosion of the Miller swivel No. 3 and no other evidence of moisture was found. One set of ball bearings from each of the two Miller swivels is shown in Figure 7 for comparison.

Figure 9 is the disassembled Miller C-10 swivel used by the State of California, Department of Fish and Game. As is evident from the appearance of the bearings, moisture had penetrated to and corroded these. Two of the three bearings were corroded to the extent that the inner and outer races could not be rotated by hand with respect to each other. The exterior surfaces of the bearing races were bright, however, and the swivel rotated easily when not under load. Subsequent to making the photograph, Figure 3, the bearings were oiled and the swivel reassembled and subjected to a 6800 lb load. Although rotation under load was not entirely free at the first attempt, continued turning of the load seemed to free the swivel completely. When disassembled after test, all bearings were turning freely and rust had been washed from between the bearing races by the oil.

The Miller H-2 swivel tested by the U. S. Coast Guard apparently suffered more severely from corrosion than any of these tested and/or inspected by the Laboratory. According to a report furnished by U. S. Coast Guard Headquarters, this swivel, which was submerged to a depth of about 100 ft, operated satisfactorily while in the water, but became inoperative from corrosion of the bearings after exposure to air at conclusion of test. It was also reported that the threads on the clevis pins and in the clevis pin nuts were severely corroded. The Coast Guard

reports loss of a Miller swivel in 1952 due, possibly, to corrosion of the clevis pin or clevis pin nut threads, and recommends that either a riveted type clevis pin be used or the ends of the standard pin be peened over to prevent nuts from backing off.

It can be seen from Figures 2 and 4 that interior corrosion of all four swivels tested by the Laboratory was not severe, and although Laboratory tests were limited in duration, evidence obtained indicates that both makes of swivels will operate satisfactorily for a lengthy period of submergence. It is probable that the greater ease of water access to the bearings of the Flexo swivel would cause disabling bearing corrosion sooner than in the case of the Miller swivel. The condition of continuous submergence does not, however, appear to be the critical condition, as far as the effects of corrosion are concerned. In most uses, if not all, it is probable that the swivel will be raised occasionally either because of the nature of its use or for routine inspection. This exposure of the swivel alternately to sea water and to air will constitute the critical condition bearing on the life of the swivel as far as corrosion effects are concerned. The Flexo swivel would not be satisfactory under these conditions, in its present design, due primarily to the susceptibility of the male-female barrel joint to severe corrosion and secondarily to the comparative ease of water, and presumably, air penetration to the swivel interior. The design of the Miller swivel, on the other hand, is such that only corrosion of the bearings has an appreciable affect on swivel performance, and such corrosion is inhibited, to a much greater extent than in the case of the Flexo swivel, by moisture seals. Although the effectiveness of these seals apparently varies inversely as the depth of water to which they are subjected, they do constitute a definite point of superiority over the seal-less swivel. If a seal completely moisture proof at high pressure could be provided for the Miller swivel, there would be no question as to its suitability for service involving deep water immersion.

A comparison of Figures 2 and 4 makes obvious another advantage of the Miller swivel, i.e., its simplicity of design. This factor would seem to work in favor of the Miller swivel regardless of the service to which it was put.

Data presently available permits no definite conclusion as to life span or maintenance requirements of rolling surface bearing swivels used in sea water. This data does indicate, however, that such swivels, if continuously submerged, will operate effectively for at least three years (the longest period of submergence so far experienced) without repairs or servicing. The data available also indicates that swivels removed from the water for any length of time should be disassembled, inspected and serviced prior to placing back in the water.

CONCLUSION

The Flexo swivel, though apparently satisfactory for underwater use, as long as it remains submerged, is not suitable for alternate wetting and

drying due to its susceptibility to disabling corrosion.

The Miller swivel appears to be suitable for either continuous submergence, or alternate wetting and drying, under conditions of very shallow submergence, and is considered suitable for use when these conditions obtain and when a swivel with free swivelling action under load offers decided advantages over the conventional mooring swivel. For service involving alternate wetting and drying under conditions of deep submergence, the Miller swivel is the most suitable of the rolling surface bearing swivels tested. Swivel construction is comparatively simple and rugged and such as to minimize moisture penetration and subsequent internal corrosion. For completely satisfactory service at depths greater than approximately five feet, positive high pressure moisture seals are necessary, however, and in the absence of these, swivel use should be accompanied with a careful inspection and maintenance program.

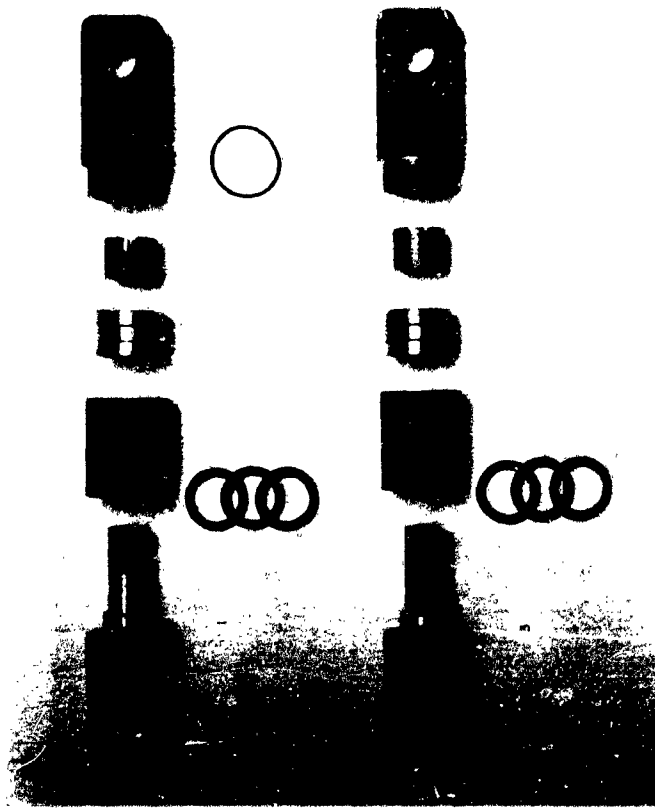


Figure 2. Laboratory tested Miller G-3 swivels disassembled.

- Item 1. Miller swivel immersed in 30 feet of water.
- Item 3. Miller swivel immersed in 5 feet of water.

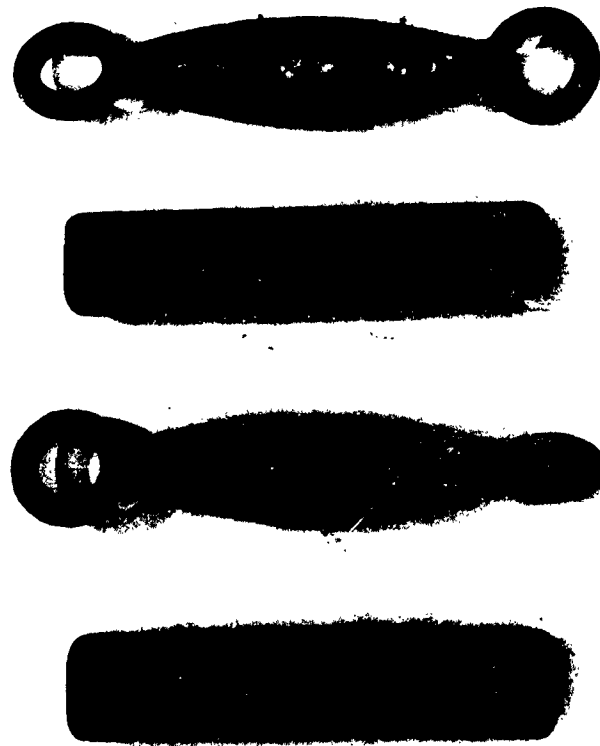


Figure 1. Laboratory tested swivels after removal from water.

- Item 1. Miller G-3 swivel immersed in 30 feet of water for nearly 14 months.
- Item 2. Flexo 400 swivel immersed in 30 feet of water for nearly 14 months.
- Item 3. Miller G-3 swivel immersed in 5 feet of water for 12 months.
- Item 4. Flexo 400 swivel immersed in 5 feet of water for 12 months.

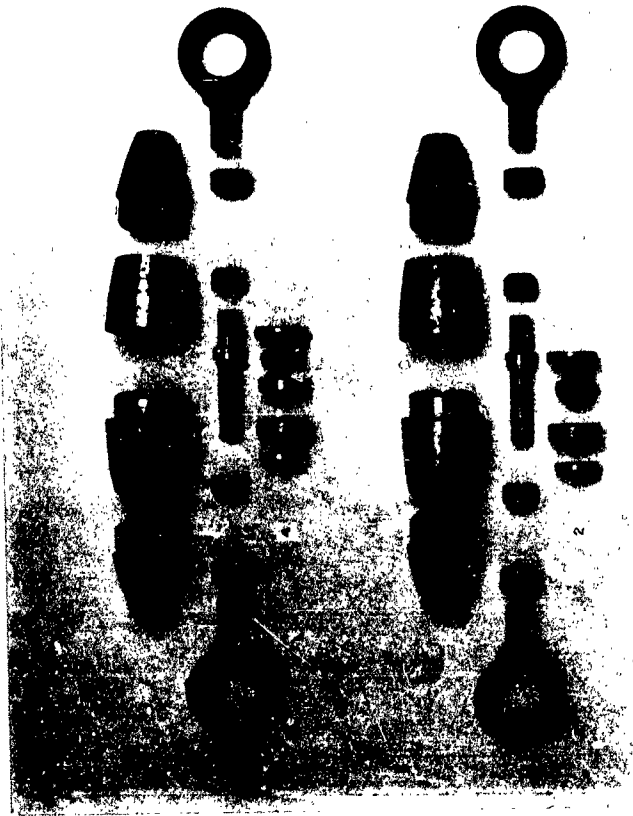


Figure 4. Disassembled Flexo 400 swivels tested by the Laboratory.
Item 2. Flexo swivel immersed in 30 feet of water.
Item 4. Flexo swivel immersed in 5 feet of water.

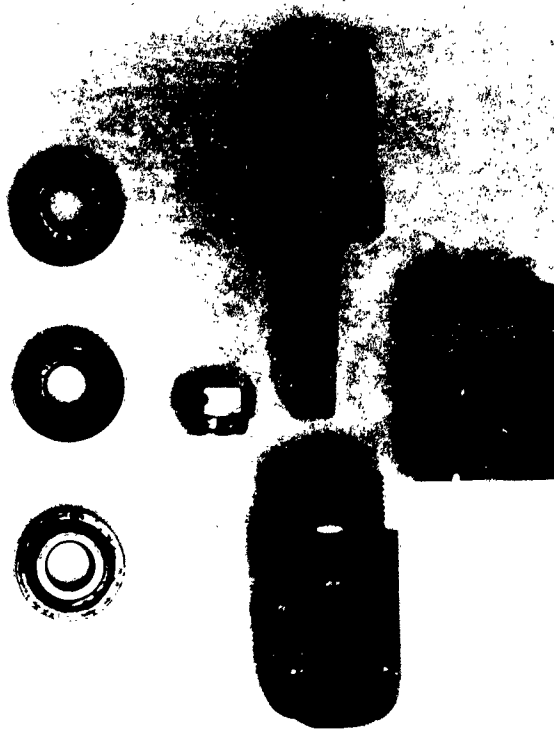


Figure 3. Disassembled Miller C-10 swivel used by State of California, Department of Fish and Game.

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Figure 5. Swivel test site in San Francisco Bay. Test barge is to the right of the center of the photograph.



Figure 6. Male and female halves of Laboratory tested Flexo 400 swivel showing joint corrosion. This swivel was immersed in 5 feet of water.

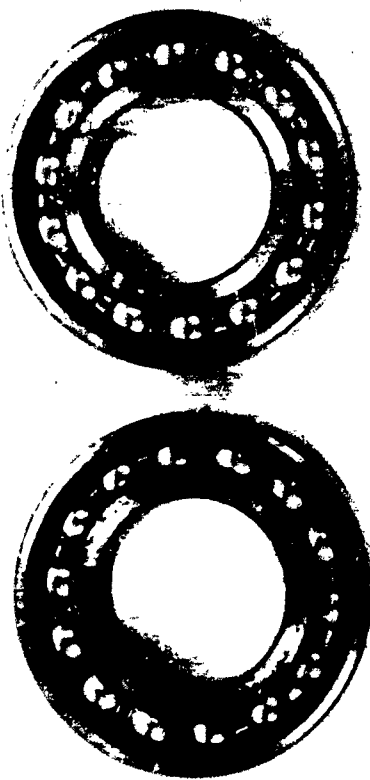


Figure 7. Ball bearings from Laboratory tested Miller G-3 swivels.
 Item 1. Bearing from swivel immersed in 30 feet of water.
 Item 3. Bearing from swivel immersed in 5 feet of water.

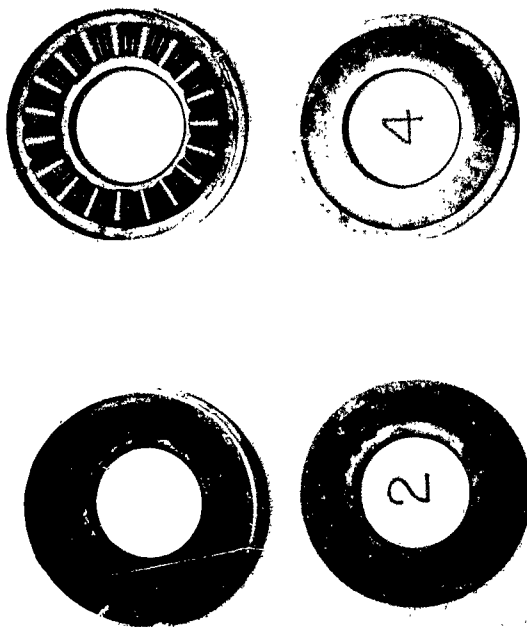


Figure 8. Thrust bearings from Laboratory tested Flexo 400 swivel.
 Item 2. Bearing from swivel immersed in 30 feet of water.
 Item 4. Bearing from swivel immersed in 5 feet of water.

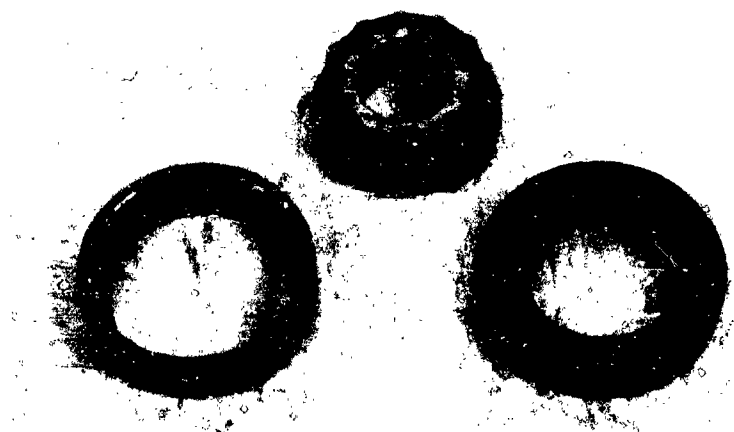


Figure 9. Tapered roller bearing, bearing cup and grease seal from Laboratory tested Flexo 400 swivel immersed in 30 feet of water.