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RAFT RIVER GEOTHERMAL

PUMP DISASSEMBLY AND INSPECTION

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Idaho Falls, Idaho 83415**

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ABSTRACT

This report summarizes the disassembly and postoperation inspection of the Peerless geothermal water pump used in the RRGE-1 well at the Raft River Geothermal Test Site. Disassembly was hampered by scale that froze some of the pump bearings onto the impeller shaft after operation ceased. The pump appeared otherwise in generally excellent condition after more than 1600 h running time in a geothermal environment. Most postoperation diameters of rotating parts were still within factory tolerance. The few out-of-tolerance bearing diameters could not be attributed to wear and could have been out of tolerance when received. This possibility points to a need for preoperation quality-control inspection of the bearings.

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CONTENTS

ABSTRACT.....	ii
ACKNOWLEDGMENTS.....	iii
PUMP DESCRIPTION	1
PUMP DISASSEMBLY AND INSPECTION	2
CONCLUSIONS	6
REFERENCES.....	7

RAFT RIVER GEOTHERMAL PUMP DISASSEMBLY AND INSPECTION

This report summarizes the disassembly and inspection of the Peerless Model 11, MBG pump, Serial Number 239763, used at the Raft River Geothermal Test Site in the RRGE-1 well. The disassembled RRGE-1 pump was inspected for wear and scale formation.

The pump had been operated intermittently beginning in August 1981 and ending June 15, 1982. Total running time was 1660 h at a typical flow of 54 L/s (850 gpm). During this operating period, there was no indication of decreased pump efficiency. After pump shutdown, the well was flowed intermittently. On July 32, 1982, the pump was removed from the well and on July 24 it was placed in storage. At this time, the entire pump shaft assembly could still be rotated freely by hand. Disassembly and initial inspection were performed on October 25 and 26, 1982.

The pump operating environment had been moderately severe: typically, the pumped geothermal water was ~280°F and contained ~1700 mg/L total dissolved solids and ~750 mg/L chloride. The pumped water was relatively free of sand.

PUMP DESCRIPTION

The Peerless pump discharge head model designation was 8 x 8 x 16-1/2 [0.2-m (8-in.) discharge head]; the pump was rated for flows of 32 to 95 L/s (500 to 1500 gpm). The vertical lineshaft turbine pump was driven by a 370-kW (500 hp) surface mounted motor. The 281-m (920-ft) lineshaft extended from the surface to an adapter section which connected to the 23-stage impeller shaft section. The impeller shaft consisted of two sections: a longer 4.3-m (14-ft) upper section coupled to a shorter 3.6-m (11-ft, 10-in.) lower section. The intake section at the bottom of the pump screened gravel and sand from the pumped water.

Figure 1 shows a typical pump stage, consisting of a cast-iron bowl with integral vanes and a cast iron impeller positioned on the 400 series stainless steel impeller shaft. A tapered steel lock bushing fastens the

impeller on this shaft and a pressfit bronze bearing (bowl bearing) fastens the bowl to the shaft. Hex nuts fasten each stage to adjacent stages.

A pressurized lubricant feed and bearing flush system (Figure 2) provides lineshaft lubrication down to the top bowl bearing. An enclosing shaft, sealed at the discharge head end by a system of ring seals and packing rings (Figure 3), isolates this lubricated lineshaft section from the unfiltered pumped geothermal water. The lower end of the enclosing shaft is sealed by the system of four bearings in the pump adaptor.

The lineshaft lubricant was a highly diluted mixture of Mobilmet C250 (Mobile Oil Corporation water-soluble cutting oil) in filtered geothermal water. The lubricant pump was adjusted to deliver 0.26 mL/s (0.25 gph) of Mobilmet C250 for a total lubricant flow of 0.2 L/s (3 gpm).

The bowl bearings are lubricated by unfiltered pumped geothermal water, although seepage of lubricant from the lineshaft section to the impeller shaft section may aid in lubrication of these bearings.

PUMP DISASSEMBLY AND INSPECTION

The pump was disassembled according to the manufacturer's instructions.^{1,2} The bowl flange butts, corresponding impellers, and taper lock bushings were match marked for proper reassembly. The top of the pump adapter (Figure 4) was marked Bowl 1, and the first bowl below the adapter was marked Bowl 2.

Removal of some of the impellers and bowls was difficult because scale buildup had frozen Bearings 7, 11, and 15 on the impeller shaft and caused other bearings to bind. Tapping with a lead hammer freed these bearings.

Figure 5 shows the typical appearance of the chalky gray, flake scale found in all bowl sections. All of this scale (bowl scale) was collected and composited for analysis. A thin layer of similar scale coated the inside surface of the bowl bearings and adapter bearings.

A brown-gray oily residue on the outside surface of the tube nut assembly and on the adapter bearings was also collected for analysis.

After disassembly, pump part diameters that would indicate wear or corrosion were measured to ± 0.0003 in. with a micrometer: (a) the diameters of the bowl impeller registers (Figure 6) and impeller skirts, (b) the inside and outside diameters of the bronze bowl bearings (Figure 6), and (c) the impeller shaft diameters at the corresponding bronze bearing locations. Table 1 gives these measurements.

Figure 4 gives the postoperation inside diameters of the four bronze bearings in the pump adapter. The outside diameter of these bearings was not measured but had ample press fit on removal.

On November 1, 1982, with the assistance of Peerless Company representatives, the pump parts were visually examined and the factory tolerances (Figures 4 and 6, Table 1) were compared to the recorded postoperation diameters. Except for the parts discussed below, the postoperation diameters were considered acceptable for reassembly of the parts.

The postoperation inside diameters of the bowl bearings, Table 1, reflect the thin layer of scale noted above. Except for Bearings 7, 21, and 22, the inside diameters of these bearings were slightly smaller than the minimum factory tolerance limit. However, even with the scale coating, the inside diameters of Bearings 21 and 22 were still larger than the tolerance limit and the corresponding positions on the impeller shaft were scored, as indicated by lower-than-tolerance shaft diameters. This damage made the short lower section of the shaft unacceptable for reassembly. Bearings 21 and 22 also had lower-than-tolerance outside diameters and spin marks (Figure 7) on the outside surface, indicating the press fit of these bearings was insufficient to hold them in place in the bowl casting. Although the postoperation Bearing-7 diameter was within tolerance, it was estimated to be larger than the tolerance limit if the scale were removed.

Except for Impeller 2 and Bowl 2, the pump bowls and impellers were unusually free of visible damage such as sand cut. Impeller 2 had some physical damage on several vanes and Bowl 2 had similar damage.

The post-operation resistance of the pump motor winding was 500 to 1000 M Ω . No evidence of damage was visible on the top or bottom motor bearings.

TABLE 1. FACTORY TOLERANCES AND POSTOPERATION DIAMETERS OF RRGE-1 PUMP PARTS

	Bowl ^b	Diameter ^a (in.)				Bronze Bowl Bearing	
		Impeller Skirt	Impeller Register	Impeller Shaft ^b			
					Inside	Outside	
Postoperation diameters	2	5.738	(5.756)	1.936	(1.9455)	--C	
	3	5.738	(5.756)	1.936	(1.945)	--C	
	4	5.739	5.757	1.936	(1.946)	--C	
	5	5.738	5.757	1.936	(1.9455)	--C	
	6	5.738	(5.7565)	1.936	(1.9465)	--C	
	7	5.738	5.758	1.936	1.947	--C	
	8	5.738	5.757	1.936	(1.9455)	--C	
	9	5.738	5.7575	1.936	(1.945)	--C	
	10	5.738	5.758	1.936	(1.9455)	--C	
	11	5.7385	5.7585	1.936	(1.9455)	(2.3125)	
	12	5.737	5.757	1.936	(1.9455)	--C	
	13	5.737	5.759	1.936	(1.9455)	--C	
	14	5.737	5.759	1.936	(1.944)	2.314	
	15	5.737	5.7585	1.936	(1.946)	--C	
	16	5.738	5.758	1.936	(1.946)	--C	
	17	5.7385	5.759	1.936	(1.9455)	--C	
	18	5.738	5.758	1.936	(1.946)	--C	
	19	5.737	5.759	1.936	(1.9455)	--C	
	20	(5.7365)	5.758	1.936	(1.943)	--C	
	21	5.738	(5.756)	(1.934)	(1.954)	(2.313)	
	22	5.737	(5.756)	(1.932)	(1.955)	(2.313)	
	23	(5.736)	5.757	1.936	(1.943)	--C	
	24	5.7375	(5.756)	1.936	(1.945)	--C	
Factory tolerances	2-24	5.737-5.739	5.757-5.760	1.935-1.937	1.947-1.949	2.314-2.315	

a. Out-of-tolerance diameters are enclosed in parentheses.

b. As marked on disassembly; Bowls 2 through 14 were on the long (upper) impeller shaft section; Bowls 15 through 24 were on the short (lower) impeller shaft section.

c. Not measured; determined to be in tolerance by difficulty of removal.

The scale and oily residue were analyzed by X-ray diffraction and scanning electron microscopy (SEM) to determine crystallinity and elemental composition. X-ray diffraction of the scale showed calcite was the only crystalline material present; the remaining material was amorphous. X-ray diffraction also showed that 90% of this sample occurred as flakes; the remainder, as rods. The elemental composition of these flakes and rods, analyzed by SEM, is shown in Table 2. The flakes contain predominantly iron oxide, some calcite, and silica. The rods are mainly calcite containing some iron oxide and silica.

X-ray diffraction of the oily residue indicated poorly formed calcite was the only crystalline material present. The sample consisted of two main phases: a lighter oily phase and a small amount of a heavier water phase that contained settled solid particles. The SEM elemental analysis of these particles and the bulk sample, Table 2, shows this sample contains some geothermal water and iron oxide.

TABLE 2. ELEMENTAL ANALYSIS OF SCALE AND OILY RESIDUE FROM RRGE-1 PUMP (wt%)

<u>Element</u>	<u>Bowl Scale</u>		<u>Oily Residue</u>	
	<u>Flakes</u>	<u>Rods</u>	<u>Settled Particles</u>	<u>Bulk</u>
Fe	72	17	9	86
Si	14	19	6	6
Ca	6	38	11	1
Al	1	9	--	--
Cu	4	9	--	--
Mn	2	--	--	1
S	1.5	2	2	--
Cl	0.5	2	38	6
Mg	--	1	--	6
Na	--	0.4	20	1
K	--	4	14	--

CONCLUSIONS

- The general condition of the pump was excellent, considering the severe chemical operating environment. None of the damage visible on the impellers or bowls was enough to impair pump performance. The good general condition of the pump bearings indicated that the bearing lubrication system operated as designed and may have extended pump life.
- The out-of-tolerance diameters of Bowl Bearings 7, 11, 21, and 22 cannot be definitely attributed to wear since no other bearings showed evidence of the same degree of wear. Because the bronze bowl bearings were bought by the pump manufacturer from an outside supplier, the bearing measurements were probably only spot inspected. These measurements were also not checked when the pump was received, pointing to a possible need for improved preoperation quality control inspection of the pump parts.
- The top and bottom pump motor bearings were in excellent condition and the winding-to-ground reading gave no indication of undue motor wear.
- Although the scale on the inner surface of the bowl bearings had not affected pump performance, a further increase in scale thickness could have affected the ease of rotation of the impeller shaft. Scale was likely to have formed when the pump was shut down and the well was not being flowed, or during storage of the pump.
- No conclusions were drawn on the source or effects of the oily residue. Further analysis of the residue would be needed to determine its source. The most likely sources are the Mobilmet C250 or packing grease.

REFERENCES

1. Peerless Pump Service Instructions; Vertical Turbine Pumps, Enclosed Lineshaft Construction, Bulletin B-2633120, Peerless Pump Company, 1200 Sycamore Street, Montebello, CA 90640.
2. Peerless Pump Bowl Disassembly, Inspection, Repair, and Reassembly, Bulletin B-129, Peerless Pump Company, 1200 Sycamore Street, Montebello, CA 90640.

Figure 1. Typical pump stage, RRGE-1 pump. (Figure used with permission of the Peerless Pump Co.)

Figure 2. Lubricant feed and bearing flush system, RRGE-1 pump.

Figure 3. Discharge head seal system for enclosed lineshaft lubrication system, RRGE-1 pump. (Figure used with permission of the Peerless Pump Co.)

Figure 4. Pump adapter and adapter bearings, RRGE-1 pump.

Scale formed in bowl (bottom)

Scale formed in bowl (top)

Scale formed on impeller

Figure 5. Typical appearance of scale formed on impellers and bowls of RRGE-1 pump.

Figure 6. Factory tolerances for bowl bearings and impeller registers for RRGE-1 pump.

Figure 7. Typical appearance of spin marks on Bronze Bowl Bearings 21 and 22 from RRGE-1 pump.