Governor Oil Pump Condition Assessment

By Alan Fox, American Governor Company

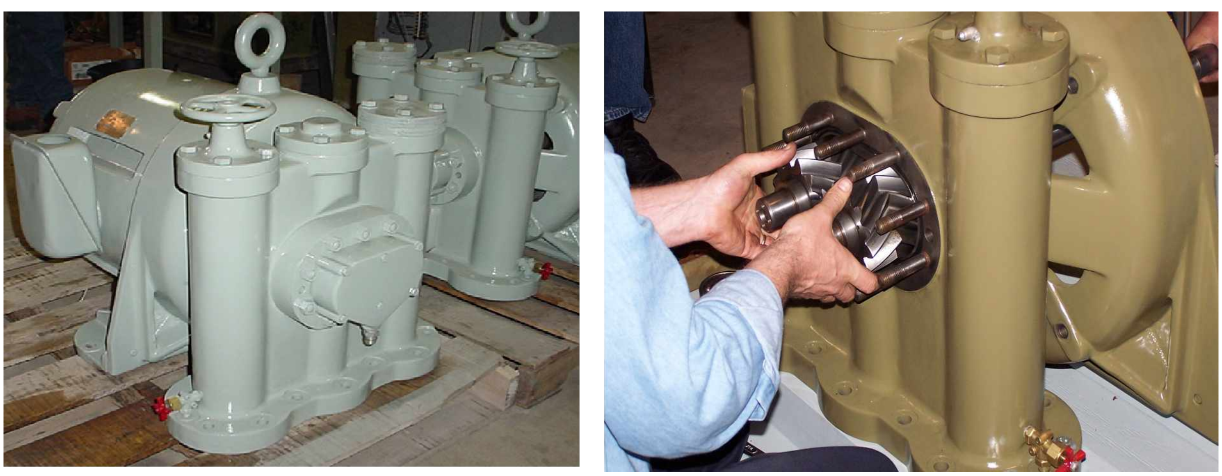
ABSTRACT

Through recent years of digital governor retrofits, one component is typically forgotten - the governor's oil pressure system. Lack of simple recommended OEM pump maintenance is causing catastrophic failures. Our company has performed three times the number of Woodward XX pump repairs as the original manufacturer did. This paper will detail the cause and type failures observed, discuss non-invasive condition monitoring methods, and suggest ways to prevent the failures.

INTRODUCTION

Typically the muscle of any legacy governor, the hydraulic pressure system, can be overlooked during (and after) a “maintenance-free” governor conversion. Although most digital governor conversions reduce the number of mechanical components in the controls section, the governor oil pressure systems that are often retained during the conversion may be neglected. These oil systems, some of which have been in service 50 years or more, were engineered to last the life of the plant with scheduled preventative maintenance. It is this preventative maintenance that is so important to keeping these systems running trouble-free.

While this paper focuses on the Woodward XX Herringbone Gear Pump, the information presented here may be applied to almost any other style of pumping system. The unique herringbone gear design of the XX pump produced the high flow needed while reducing the output pressure pulses common to straight-cut gear designs. The XX pump features an internal check valve, internal pressure relief valve and an integral unloader system. The XX pump was manufactured in capacities up to 500 gallons per minute.



Woodward XX Herringbone Gear Pump

Our pump specialists worked for Woodward for many years. They are seeing more than three times the number of failed pumps now as when they worked for the OEM. From the evidence we have seen, these failures are not due to gear failure or design defects but to lack of simple maintenance practices. Included below are descriptions and photographs of several different types of failures. These could have been avoided by regular replacement of the four pump motor bearings and the motor bearing.

Some customers have expressed a desire for non-invasive monitoring and testing methods for these pumps. Several methods are described. While none have proven 100% dependable, these still-developing technologies are described and discussed.

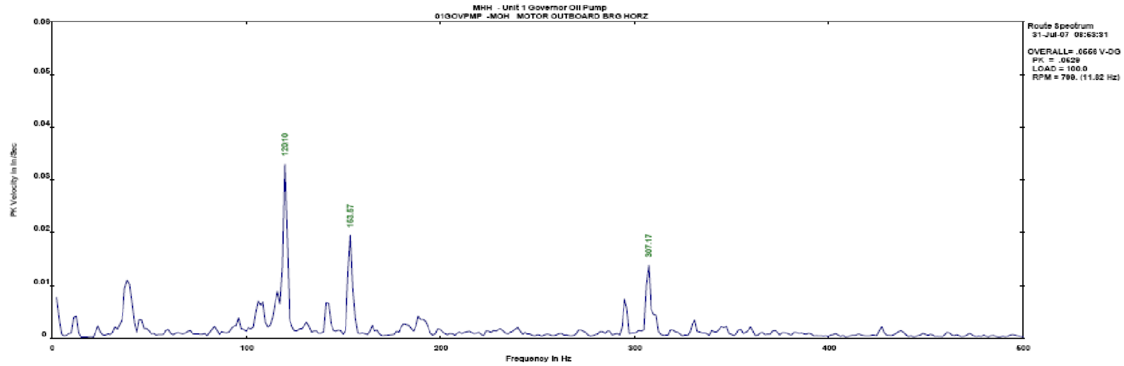
MAINTENANCE STRATEGIES

There are three categories of mechanical maintenance:

- **Predictive** – determination of condition through testing
- **Preventative** – time based
- **Reactive** – run until failure

Predictive maintenance includes several methods of monitoring technology including vibration analysis, ultrasound, oil analysis, wear-particle analysis, and thermography. From the types of damage we have seen, we would have expected that vibration monitoring would prove to be effective in establishing pump-motor condition.

The following figures display the vibration data of a pump that we repaired in late 2007. Figure 1 data was taken a few months before failure. Figure 2 was taken after the repaired pump was placed back into service.



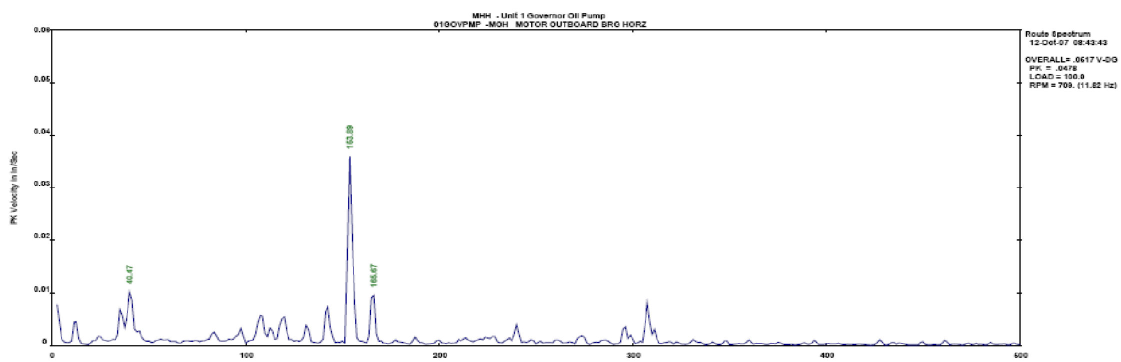
LIST OF SPECTRAL PEAKS

Equipment: (MHH) Unit 1 Governor Oil Pump
Meas. Point: 01GOVPMP -MOH --> MOTOR OUTBOARD BRG HORZ
Date/Time: 31-Jul-07 08:53:31 RPS= 11.82 Units=In/Sec PK

PEAK NO.	FREQUENCY (Hz)	PEAK VALUE	ORDER VALUE	PEAK NO.	FREQUENCY (Hz)	PEAK VALUE	ORDER VALUE
1	11.94	.0047	1.010	13	141.86	.0079	12.004
2	23.69	.0023	2.005	14	153.57	.0198	12.996
3	32.93	.0023	2.786	15	165.10	.0024	13.971
4	39.30	.0125	3.326	16	181.82	.0031	15.386
5	45.61	.0041	3.859	17	189.23	.0046	16.013
6	83.40	.0024	7.058	18	295.36	.0078	24.994
7	96.06	.0039	8.129	19	307.17	.0145	25.993
8	106.77	.0078	9.035	20	330.82	.0037	27.994
9	108.22	.0078	9.158	21	345.53	.0025	29.239
10	115.88	.0094	9.806	22	346.98	.0025	29.362
11	120.10	.0331	10.163	23	359.75	.0022	30.443
12	130.85	.0033	11.073	24	427.32	.0023	36.161

TOTAL MAG	SUBSYNCHRONOUS	SYNCHRONOUS	NONSYNCHRONOUS
.0484	0.0 / 0%	.0281 / 34%	.0213 / 19%
(ELECTRICAL=	.0331 / 47%	FLOOR= .0151	SPEC CREST= 2.86)

Figure 1



LIST OF SPECTRAL PEAKS

Equipment: (MHH) Unit 1 Governor Oil Pump
Meas. Point: 01GOVPMP -MOH --> MOTOR OUTBOARD BRG HORZ
Date/Time: 12-Oct-07 08:43:43 RPS= 11.82 Units=In/Sec PK

PEAK NO.	FREQUENCY (Hz)	PEAK VALUE	ORDER VALUE	PEAK NO.	FREQUENCY (Hz)	PEAK VALUE	ORDER VALUE
1	11.89	.0053	1.006	13	153.89	.0362	13.023
2	24.34	.0020	2.060	14	165.67	.0110	14.020
3	35.44	.0074	2.999	15	187.64	.0016	15.878
4	40.47	.0111	3.425	16	221.25	.0016	18.723
5	44.45	.0032	3.761	17	224.26	.0018	18.978
6	83.27	.0028	7.046	18	228.13	.0020	19.305
7	97.32	.0033	8.235	19	240.05	.0040	20.314
8	108.10	.0066	9.148	20	273.24	.0020	23.122
9	112.94	.0036	9.557	21	295.77	.0039	25.029
10	119.44	.0062	10.107	22	298.46	.0020	25.256
11	131.64	.0041	11.140	23	307.61	.0082	26.031
12	141.99	.0081	12.015	24	310.98	.0032	26.316

TOTAL MAG	SUBSYNCHRONOUS	SYNCHRONOUS	NONSYNCHRONOUS
.0445	0.0 / 0%	.0403 / 82%	.0184 / 17%
(ELECTRICAL=	.0040 / 1%	FLOOR= .0141	SPEC CREST= 2.37)

Figure 2

Although the data above demonstrates some differences in amplitude and spectral peaks, there were no conclusive indicators to predict the unit was near failing. It is interesting to note, however, that the frequencies of the highest amplitude were 13 and 26 times the operating speed. This pump was provided with OEM recommended Double-Row, Max-Capacity bearings with 13 balls.

Typical vibration instrumentation systems are quite complex, and require ample training and practice to accurately interpret the collected data. Further experimentation and evaluation is needed to determine if vibration can provide useful predictive data.

We also recommend an annual Oil Analysis, including particle analysis. Lab analysis of system oil will determine the condition and lubricity of the system oil. In addition to this, particle analysis will reflect the condition of the equipment based on the quantity of suspended particles.

In addition the methods and techniques described above, we are beginning to experiment using Thermography in an effort to see if this is a viable method to identify pumps in need of maintenance.

There does not appear to be a fail-safe single method that can predict a governor oil pump failure. If there were a single concise method to predict hours or days before failure, it would be a very popular topic, and for sale by bearing manufacturers!

Preventative maintenance was initially the tried and trusted method to prevent equipment failures. This is a time-based method to replace wear items within a specified run-time. In many power plants, there are fewer individuals, and less time to perform scheduled maintenance than in previous years. In addition, legacy governor pumping systems were built so ruggedly, and ran so well, that some preventative maintenance schedules have been ‘stretched’ into non-existence. Experience proves however, that even the best of the best components, over time, will eventually fail from material fatigue. Another reality to be considered is the fact of fewer plant personnel, and in many cases, unmanned stations. These trends make a proactive maintenance program imperative, since it may be unlikely to notice, for instance, growing pump train noise over time.

Reactive maintenance, or the run-to-failure approach, is the most costly method for maintaining these pumping systems. As failures occur, there is normally cascading damage, beyond the initial component failure. This is especially true with bearing failures. In our experience, the typical repair cost to return the pump to OEM specifications has proven to be eight to ten times the cost of a preventative bearing replacement job.

TYPES OF FAILURES AND THEIR RESULTS

As shaft bearings begin to fail, critical alignment suffers and if left unattended can result in extreme damage to shafts, gears, wear plates, as well as pump casting damage that is very difficult to address.

The most common result of bearing failure is galling, defined as: “A condition whereby excessive friction between high spots results in localized welding with subsequent splitting and a further roughening of rubbing surfaces of one or both of two mating parts”

The following photographs illustrate some of the most common areas of damage.

Figure 3 - Pump Gear Damage

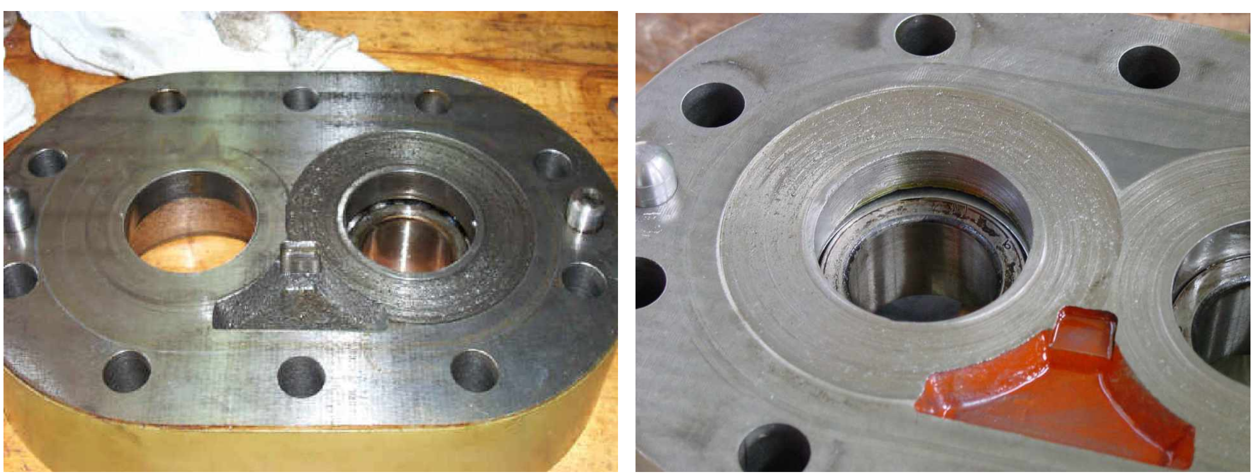


Figure 4 - Bearing Wear Plate Damage

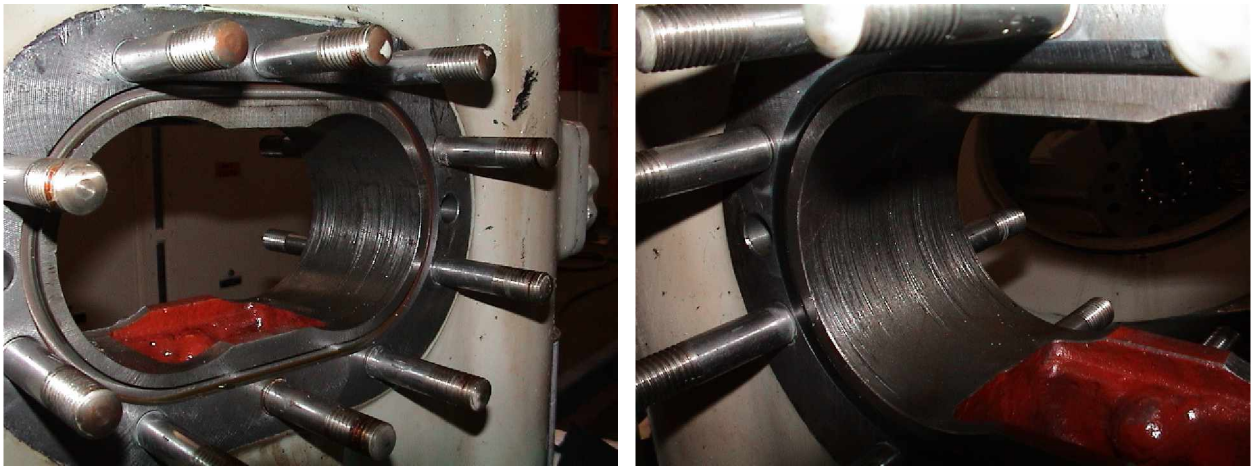


Figure 5 - Pump Gear Pocket Damage

Figure 6 - this pump stopped, the rotor didn't

REPAIR CONCERNS

The **correct** replacement bearings and parts must always be used for overhauls. For example, only Maximum Capacity open bearings should be used.

The bearing on the right is a standard duty bearing with 8 balls. The bearing on the left is a maximum capacity bearing with 13 balls. The difference in load carrying capacity is clear.

The *gear damage* shown in the photos above *(Figure 3)* can be repaired, but the picked-up metal is ‘work-hardened’, and is extremely difficult to remove. Bearing *wear plate* damage *(Figure 4)* is more easily resurfaced, but both of these repairs can change the geometry of the pump, and critical tolerances. In the process of repair, several factors must be considered such as end clearance, gear apex centering, (magnetic) motor centering, and in some cases depth of the O-Ring groove.

Severe gear *pocket damage (Figure 4)* is almost always fatal to the pump. Since these are Positive-Displacement pumps and depend on a close gear to pocket clearance, deep scoring in this area will often prevent the pump from ever priming or building pressure.

Another point to consider after pump failure is the possible contamination of the complete oil system. Metal shavings entrained in the governor oil will significantly reduce the life-cycle of extremely close tolerance components and can damage pilot valves, servo bores and other governor system components.

REPLACEMENT

Because the pumps we are addressing are no longer produced, when damaged beyond repair the only in-kind replacement is a reconditioned unit, when available. Since a new replacement pump of this design is not available, a retrofit or substitution may be the only answer. The process of fitting new replacement pumps, typically large screw pumps, requires new mounting arrangements, new unloader systems, custom suction and discharge piping to mate with existing governor piping, as well as addressing motor-starter and wiring locations.

CONCLUSION

Our experience shows that the cost of damage repair is eight to ten times the cost of regular scheduled maintenance. This extra cost, in addition to lost generation, forced outage, and unit availability expenses, confirms that scheduled preventative maintenance is a tremendous value. The “Lesson Learned” is simple: Preventative Maintenance WILL insure the continued service of your XX pump for years to come.

AUTHOR
Alan Fox is a Regional Manager with American Governor Company. He has worked for American Governor Company, Governor Control Systems, and Woodward Governor Company. He has over 15 years of application experience with Hydro, Steam, and Gas Turbines, as well as large diesel and natural gas engines.