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Enclosed Drives for Movable Bridges Specification Consistency

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INTRODUCTION

As a manufacturer of engineered enclosed drives, we are accustomed to variances in specification requirements depending on the industry and the function of the gearbox. The duty cycle of these units can vary significantly from heavy shock load on a coal crusher where the service factor can exceed 2.0 to a coiler in a steel mill that can have a service factor of 1.0.

AGMA, the American Gear Manufacturer's Association, has established service factor guidelines for many of the applications. Most of the movable bridge applications call for a 1.5 service factor. Based on the expected duty cycle and the typical operation of the reducer, the application of the service factor will ensure a durable gearbox with an expected long life.

For enclosed bridge drives, the specifications that have been imposed on the gearbox manufacturers vary widely depending on the specifying authority, the DOT, railroad, Coast Guard, and the Army Corps of Engineers, and the engineering design firm. I will address the differences and the potential impact on the overall cost of the project. Some of the affected areas are listed below:

- Material requirements
- Testing Requirements
- Fabrication requirements
- Quality inspection records

The differences in the requirements result in cost variances from project to project. In the minds of many gearbox manufacturers they sometimes result in cost increases that might have been otherwise avoided. This paper will address some of the different requirements, discuss possible reasons for the differences, and assess the potential cost impact on the project.

MATERIAL REQUIREMENTS

The overall engineering and design of the gearboxes are the responsibility of the manufacturer of the gearbox. The various authorities and engineering firms that are responsible for the design of the bridge impose requirements on the gearbox manufacturer that are not necessarily the current common practice of the manufacturer or the industry. These requirements included restrictions material for both rotating and stationary components.

Probably the most significant requirement is for the gearing to be "through-hardened" gearing (which Nuttall Gear produces as their standard design) as opposed to carburized and ground gearing. For helical gearing the specifications of the various authorities appears to be fairly consistent in the exclusion of carburized and ground gearing. However, the specifications will vary on bevel gearing either for the differential or for a right angle input. Imposing the "through-hardened" gearing requirement for bevel gearing severely limits the availability of the gearing and typically increases the cost and lead-time.

Gear case fabrication requirements tend to vary from authority to authority. Most applications require that the cases be fabricated as opposed to cast however some impose welding to the

requirements of AWS D1.1 (more common) and some AWS D1.5. We have not experienced a significant difference in the costs.

associated with either specification however the manufacturer who sources his fabrications is limited to a reduced number of shops that are qualified to AWS D1.5. Most specifications do not address the case material and the ones that do call out ASTM A36 steel, a very commonly applied case material. We have been told that the requirement for AWS D1.5 applies to the structural welds and that the case welding is to be determined by the gearbox manufacturer. In any event, the conservative approach is to assume AWS D1.5.

Many of the specifications require that welds be ultrasonic-UT inspected. We normally take exception to the requirement and recommend that the welds be magnetic particle-MP inspected because the UT inspection is not feasible. I believe that the specification requirements apply to the larger structural welds on the bridge but most of the specifications are not typically clear on the issue.

The most common material called out for key stock is ASTM A668 steel. Another standard that is applied is ASTM A829 which has a higher yield strength that the one commonly specified for bridges. I have not determined why lower strength steel would be preferred however this requirement is common. In addition, the practice results in increased costs because the result is custom engineered and manufactured keys. In most cases this requirement is only applied to the shaft extensions and not keys that are internal to the gearbox.

TESTING REQUIREMENTS

All authorities require run tests and all require that the unit be observed for signs of unusual vibration, noise, oil leaks, and elevated temperatures. Some authorities require that the noise levels be no more than a given decibel level measured at a given distance.

As a gear manufacturer we typically do not have testing facilities that allow us to isolate the background noise including the motor and other equipment from the gearbox. Most of the units are fairly low speed and a noise level below 90 decibels is not a problem. The decibel levels vary among different authorities.

Testing requirements will include a no-load spin test to allow units to be observed not to leak or have any unusual noise or vibration problems. Normally the no load run test will go until unit temperatures stabilize (temperatures measured at the bearing caps rather that on the shaft). Authorities have specified no-load tests of ½ hour, 1 hour, 2 hours and even as much as 4 hours in each direction. Again as a manufacturer, we typically look for conditions to stabilize during run tests.

After successful completion of a no-load test, the units are normally required to load tested. Depending on the authority, the test may be one or more of the following:

100% load for one hour each direction
150% load for one hour each direction

200% load for ½ hour in each direction
300% load for a certain number of revolutions of the output shaft
Locked rotor test for differentials.

Following the load test the following requirements may be imposed:

Disassembly and inspection of internals including bearings
Check for gear tooth contact (some have contact requirements and some do not)
Reassemble and fill with oil to check for leaks
Reassemble and spin test for ½ hr in each direction checking for unusual noise, vibration, and leaks.

COATINGS AND PAINT

I have observed various requirements from not being specified at all to a requirement for inorganic zinc based primer and a two part top coat. The first generally allows the gearbox manufacturer to apply a universal primer that can be covered by almost any primer or top coat on the market. Some specifications suggest that the gearbox manufacturer apply their standard. However in the case of the inorganic zinc based primer, this option is not only difficult but time consuming and expensive. In the state of New York, the facility applying this system has to be qualified. In addition, it becomes more difficult because the top coat has to be applied within a relatively short time after application of the primer.

For some applications the primer is required to be applied by a brush. I have seen where a paint system that has application qualifications are required to be brushed and the manufacturer of the system specifies that the paint be sprayed.

Protective coatings for the non painted surfaces also vary. In one case, the specification requires a coating that becomes extremely hard and typically has to be removed by bead blasting, not what you want to do to a coupling fit on a shaft extension. In this case, a different grade of preservative needs to be applied that has a reasonable life such as 6 months to a year, but can be removed with a solvent and rags.

QUALITY DOCUMENTATION

Documentation requirements appear to be fairly consistent among authorities. These requirements include chemical and physical CMTRs for all components, rotating and stationary. This requirement applies to gearing, shafts, and case material. Generally CMTRs are not requested for individual components that make up each roller bearing.

All rotating components are subject to ultrasonic examination prior to machining and a magnetic particle examination after machining.

Gearing is required to be inspected for lead, profile, tooth spacing, and runnout on a qualified gear checker such a MAAG machine. These measurements determine the quality of the gear. The difference in authorities is that some authorities require AGMA Q8, some Q9, and some

Q10, per AGMA 6010-E88 which by the way is not the most current version of AGMA. Regardless, the manufacturer must submit gear calculations for approval by the engineers prior to production and the measurements simply verifies that the component meets or exceeds the requirements of the design.

MISCELLANEOUS

Some engineering firms and authorities prefer to specify more components than others. Examples are as follows:

- Shaft seals may be double grease packed, taconite, single lip seals, and labyrinth with a lip seal.
- Breathers are typically required to be hygroscopic or moisture trap.
- Bearings may be grease packed and some specifications actually call out for roller bearings. Many specifications require minimum L10 bearing life ratings that typically are 40,000 hours.
- Some applications will specify a sight glass such as bull's eye or they may require that the sight gauge be located such that the normal level is in the middle of the glass (good practice).
- Almost all applications require that the units be splash lubricated or an oil bath and not be required to have a circulating or pressurized system.

SUMMARY / CONCLUSIONS

Most gearbox manufacturers are experts in engineering, designing, and manufacturing gearboxes. We are not experts in all of the processes and applications in the various industries that we support including heavy movable structures such as lift bridges. We recognize that the load and environmental requirements as well as other application factors can vary in different locations around the country and the world. We depend on the process or application engineer define those requirements.

That being said, consideration might be given to consolidate and standardize requirements endorsing requirements that satisfy the engineers, consider the application differences including the environmental conditions, recognize advances or improvements in gear manufacturing technology, and address cost without compromising quality and reliability required for each application.

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