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Enclosed Drives for Movable Bridges – Engineering & Design Considerations

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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. Over the past couple of years we have seen variances in specification requirements for the various responsible or specifying authority such s the DOTs, railroad, US Army DOD, the railroad, and the mass transit authorities.

In general, but not always, movable bridges for highway transportation invoke the requirements of AASHTO (American Association of State Highway and Transportation Officials) specification. Regarding enclosed drives, gearboxes, this specification addresses the rating requirement factors for the overall gearbox and it addresses requirements for some of the internal components such as the bearings and the rotating elements.

Different from many industries, the engineers that specify the equipment and prepare the drawings define the operating parameters and the gearbox ratings by the "rated horsepower and speed". This rating takes into account the service factor (gearbox ratings normally include a 1.5 service factor that is the basis for the rating on the drawing). Depending on the engineers interpretation, this rating may be the basis for the load testing requirements that are recommended by AASHTO.

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 however testing requirements imposed by the authority may result in the requirement to design in a much higher service factor. Most applications require testing to be at 150% of the rated load requirement and some states like Florida may require as much as a 300% load test.

I have reviewed projects where the gearboxes that have been specified by the engineers are undersized based on their own specification. A gearbox that is specified to meet AASHTO requirements will be undersized for the Florida 300% load test requirement. A manufacturer can meet the specification requirements and the component integrity can be compromised during a 300% load test. To reiterate, the catalog rating of the gearbox listed on the drawing will not withstand the test without compromising the integrity of the reducer. As a manufacturer we feel that the basis for the gearbox selection has inconsistencies within the scope of the project which can be misleading and result in an invalid and uncompetitive proposal.

We have been engineering, designing, and manufacturing gearboxes for over 125 years however as with all of the industries that we serve we depend on the OEM equipment designer and the engineers to specify the requirements for the gearbox. We do not profess to be experts in all industry applications however we know a great deal about reducers. We do not presume to understand the nuances of the loads that the lift bridges in various locations throughout the country experience. I am sure that there is a good reason for the 300% load test required for Florida. I believe that the gearbox sizing practices employed during the preparation of the specification and the drawings need to be scrutinized by the engineers. If you want a 3.0 service factor for the gearbox, you need to be more specific make the size selection on that basis.

Again we are not experts in bridge design but many gearboxes appear to be significantly oversized and over rated for the application especially when the frequency and duration of operation is considered. The normal requirement that no components in a gearbox exceed 75% of yield when subjected to 300% of rated motor nameplate load should be sufficient to ensure

longevity of the gearbox. As indicated above, in some cases the gearboxes must be oversized to accommodate the load tests.

We have proposed gearboxes on projects that resulted in being one or two sizes larger than we would normally recommend. If not, load testing may result in overstressed conditions in some components which could lead to premature failure of the gearbox. I have seen examples in specifications that recognize this possibility when they indicate that the coupling manufacturer must confirm that the load test will not over stress any permanent couplings that are installed on the gearboxes for testing. Manufacturers must address the significant testing requirements for gearboxes to ensure that the integrity is not compromised.

To carry this argument a little further, the rating requirements apply to bearing loads as well. AASHTO requires that the L10 bearing life be 40,000 (There is a question whether it applies to rated or transmitted load). For one of the most active bridges in the country, the bridge opens and closes 8,000 times per year. Assuming a typical operation of 90 seconds per operation or 180 seconds/3 mnutes per cycle yields, approximately 24,000 minutes of operation per year, the result is 400 hours of operation per year.

Based on that duty cycle, the life of these bearings is approximately 100 years just based on L10 if the gearbox was operating at 150% motor load each and every cycle. For most bearings the average life is estimated to be as much as 5 times the L10 rating which yields a life of approximately 500 years. Assuming that the motor horsepower selected is correct for the calculated loads required to operate the bridge, most of the operation should be at the nameplate transmitted load further increasing the life expectancy of the bearings several times. Again this applies to a bridge that is very frequently operated. I am not sure that the Romans built bridges intended to last that long.

As far as gearing is concerned, a similar approach applies. Gearboxes will operate successfully and experience long life if the gearbox is properly specified and rated. Typically gearboxes are rated based on the transmitted motor horsepower and the service factor resulting in a rated torque load. Almost all of applications are at a 1.5 service factor or the rated load is 1.5 times the nameplate load of the motor. As recognized above, manufacturers must be careful when sizing the gearbox to ensure that none of the components are subjected to loads that do not overstress the components.

The longevity of the equipment is not only dependent on the design basis but on the maintenance of the equipment. Improper maintenance practices will result in premature failure. Recently we called on a power plant that had the wrong grade of oil in the unit, not viscous enough. Our field inspector was called to the plant, made the determination, and identified premature wear on the gearing and in the bearings resulting from inadequate oil film thickness. The unit was not in imminent danger of failure but the expected life would have certainly been reduced. We recommended an overhaul of the bearings. The gearing was determined to be acceptable but we recommended that a spare gearset be ordered as the expected life of the unit had been compromised.

Manufacturers must engineer and design the gearbox to meet the specification requirements. Reliability and durability of gearboxes can only be achieved if the design parameters are properly specified and the unit is maintained properly. The design parameters include providing the key parameters such as input speed and horsepower, required output speed, duty cycle, environment, external load factors and finally load testing. Once the gearbox is built and tested, it is up to the operator to ensure that the gearbox is properly maintained.

To the manufacturer the requirements may appear to be excessive and simply adding to the cost by requiring a larger gearbox. We manufacturers recognize that oversight of our organizations is required to ensure proper performance and longevity of the bridge and the operating machinery.

The engineering and design requirements also vary by type of bridge and the specifying authority or owner/operator of the bridge. The requirements vary among state departments of transportation. The 300% load test required for many of the Florida bridges appears to be unique, probably due to excessive forces that could result during tropical storms. However a recent project for a Florida bridge had only a 200% load test requirement. In two recent applications for bridges in New Jersey, one did not have a requirement for a load test where another bridge did have a150% load test requirement based on the motor horsepower (not the AASHTO rating).

A consistent application of reasonable standards, specification requirements that reflect the operation and duty cycle of the structure, and normal oversight of the manufactures will ensure that the owner/authority of the movable structure receives a product that is reliable for many decades and that the structure is provided at a reasonable cost.