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Replacement of 50 Year Old Drive Motors

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Introduction

Electrical systems will wear out over time and will need to be replaced. This is also true with drive motors that are used for span locks, tail locks or to open and close movable bridges. As technology changes, so do the components that are used on movable bridges. Most of the time, this technology results in improvements in the components that are used which result in a better product or a more efficient product for the end user. Unfortunately this has not been the case with drive motors that were built and installed on movable bridges 50 years or more as compared to motors that are currently in production today. What has changed in motor design and production that would result in a motor that is not as efficient in power output or torque as motors produced today when comparing the motors of today with the motors of years ago? As the designers of movable bridge drive systems, we have an obligation to provide to our clients a drive system capable of operating the bridge under all conditions that have may have previously been experienced. The last thing we want to happen is to get a phone call from a client stating that they could not get the bridge open after a 4 inch snow fall because the drive system that was just installed would trip out on an overload fault and that prior to the new system being installed, the bridge had no problems opening with a snow level of 8 inches.

What Type of Motors Are Used On Movable Bridges?

All motors produced in the United States are produced under NEMA standards. These motors are assigned letters that correspond to specific operating characteristics for specific conditions. These conditions include starting current, starting torque, breakdown torque and slip. Figure 1 details the differences between the different types of motors that are generally available from US motor manufacturers.

NEMA Design	Starting Current	Locked Rotor Torque	Breakdown Torque	% Slip	Applications
A	High to Medium	Normal	Normal	Max 5%	Fans, blowers, & pumps
B	Low	Normal	Normal	Max 5%	Normal starting for fans, blowers Pumps, unloaded compressors, Conveyors, machine tools, misc. machinery. Constant speed load.
C	Low	High	Normal	Max 5%	High inertia starts such as large centrifugal blowers and fly wheels. Loaded starts such as piston pumps, compressors and conveyors. Constant speed loads.
D	Low	Very High		Up to 13%	Very high inertia and loaded starts.

Figure 1

NEMA type D motors are typically used for punch presses, forming machine tools, cranes, hoists, and elevators.

Another type of motor commonly used on movable bridges is the NEMA type M motor or more commonly referred to the wound rotor motor. The type M motor is an induction motor where the operating speed can be adjusted or varied by the use of an adjustable resistor connected to the secondary or rotor of the motor. Wound rotor motors are call this because the rotor is wire wound with the ends of the winding terminated in collector rings so that external resistors can be connected in series with the rotor windings. This enables the motor to operate at slower speeds under full loading by adjusting the external resistor value typically through a drum switch controller or thyristor drive controller. The maximum value of torque, usually between 200% and 250%, is not affected by the changes in the secondary resistance.

Most movable bridge applications that use AC motors will use either the NEMA type D or type M motor depending on the type of speed control that is being used for span operation.

Replacing Existing Bridge Drive Motors

Several things need to be considered when replacing the drive motors, especially when the motors being replaced were built and installed before 1964. The manufacturing process of motors have gone through several changes that resulted in the rating of the motors to be changed from their original configuration. This does not necessarily mean that a 30 horsepower motor installed prior to the changes in the NEMA ratings would not be a 30 horsepower motor available today. Horsepower is still horsepower. NEMA adjusted and changed the ratings of motor twice, the first time in 1952 and the second occurring in 1964. The result of these changes directly affected the amount of horsepower that could be yielded from a specific motor frame and the amount of overloading that the motor can experience during extreme operating conditions. A small motor frame means there is less iron in the motor frame resulting in the motor not being able cool as effectively or handle the same amount of overload capacity. The problem becomes evident if you are rehabilitating a bridge drive system and you are replacing the motors with new ones. If the motor was installed prior to 1952, the motor frame for that motor will be much larger than an equivalent motor of the same horsepower rating produced today. As an example, a 40 horsepower, 900 rpm motor manufactured prior to 1952 would have a NEMA frame of 445 while a 40 horsepower, 900 rpm motor manufactured to day would have a NEMA frame of 365. The 445 frame motor produced today would be rated at 100 horsepower. Just in the motor frame along, this results in a difference in weight from 1300 pounds for the 445 frame to just 700 pounds for the 365 frame. Even though the weight difference is not just in the frame of the motor, the weight change is mostly in the amount of iron within the frame's construction. As the motor frame gets smaller in size, so does the overall performance capabilities of the motor become less.

Figure 2 below shows the changes that have occurred in the frame sized of TEFC motors after being re-rated in 1952 and again in 1964.

NEMA THREE-PHASE FRAME ASSIGNMENTS

TEFC MOTORS - GENERAL PURPOSE

RPM NEMA Program HP	1800 Orig.	1800 1952 Re-rate	1800 1964 Re-rate	1200 Orig.	1200 1952 Re-rate	1200 1964 Re-rate	900 Orig.	900 1952 Re-rate	900 1964 Re-rate
1	203	182	143T	204	184	145T	225	213	182T
1 1/2	204	184	145T	224	184	182T	254	213	184T
2	224	184	182T	225	213	182T	254	215	213T
3	225	213	182T	254	215	213T	284	254U	215T
5	254	215	184T	284	254U	215T	324	256U	254T
7 1/2	284	254U	213T	324	256U	254T	326	284U	256T
10	324	256U	215T	326	284U	256T	364	286U	284T
15	326	284U	254T	364	324U	284T	365	326U	286T
20	364	286U	256T	365	326U	286T	404	364U	324T
25	365	324U	284T	404	364U	324T	405	365U	326T
30	404	326U	286T	405	365U	326T	444	404U	364T
40	405	364U	324T	444	404U	364T	445	405U	365T
50	444S	365US	326T	445	405U	365T	504U	444U	404T
60	445U	405US	364TS	504U	444U	404T	505	445U	405T
75	504S	444US	365TS	505	445U	405T			444T
100	505S	445U	405TS			444T			445T
125			444TS			445T			
150			445TS						

Figure 2

Another example would be you are going to rehabilitate a bridge that has the original motors that were installed in 1948. During your inspection, you note the motor nameplate data is very difficult to read but it is determined that the motor rpm is 900 rpm and the motor frame is a 405. From the data in Figure 2, this would indicate the motor as rated at 25 horsepower. To be sure the client will get all of the original power that was once available and that the bridge will be able to operate under all conditions that could have been experienced over the past 58 years, the equivalent motor frame to replace this motor would be a 60 horsepower rated motor. Motors with a designated horsepower rating manufactured prior to the NEMA re-rating would typically be capable of larger overloading with capabilities in excess of 250% for short durations. Motors manufactured after the re-rating are typically not capable of the same amount of overloading for the same horsepower rating. Why is this the case? Motors made today do not have the same amount of iron in the motor frame which directly correlate to the level of overloading and heat dissipation that a motor can handle. In addition, if using a solid state drive controller, overloads are typically limited to 150% for one minute before the drive controller would fault.

The same process described above can be uses if the existing motors are AC and the type of drive system that is being used for the replacement is a DC drive. Determine the equivalent AC motor horsepower requirement by comparing the motor frame from existing to current frame sizes and then use an equivalent horsepower rated DC motor for the new application.

Other Considerations for Motor Replacement

Generator Operation

If the existing distribution system includes a standby generator set or if the client has a trailer mounted generator set, the new electrical loads will need to be recalculated to verify the existing equipment will be capable of handling the new loads under all operating conditions. If the new drive system will be using electronic solid state drive controllers when under generator power, you need to also consider the effect of harmonic distortion from the operation of the drive controller. If you may recall, harmonics are a result of nonlinear loads created by the voltage and current manipulations within the solid state drive controllers for AC and DC motors. Recall what nonlinear loads are. Devices such as variable frequency drives, UPS systems, high density lighting controls, or any device which contains Silicon Controlled Rectifiers (SCR's), are considered nonlinear. The drive controllers of today's technology contain SCR's, commuted circuits, transformers, diodes and high speed switching components. These are nonlinear because they will alter the sinusoidal waveform and produce frequencies other than the applied source frequency. The results are can cause heating effects within the generator.

Replacement Motor Compatibility

Since the new motor could be a larger motor frame that the existing motor, be sure there is adequate space for the motor to be installed and that the existing support frame will be large enough for the new motor unless a new support frame is being provided with the new motor. Providing adequate space for the new motor includes checking and verifying the new motor can be installed and still meet all requirements established by the NEC, section 110-16. In addition, the height of the motor shaft for the new motor may not be the same as the existing motor which would require the frame to be modified or a new frame provided.

With larger motor frames there could be larger motor shafts for coupling to existing machinery. Although this is typically not a problem to have new couplings provided and bored to fit the shafts, there is always the remote possibility the new coupling may not be capable of being bored to fit a particular shaft due to the range a coupling can be bored to.

If the motor is the only component being replaced, the existing conductors may not be large enough for the larger motor due possible increase in motor current.

When replacing a drive motor that was controlled from a drum switch controller with a motor that will be controlled from a solid state drive controller, the new motor will need to be inverter duty rated so that the motor windings are capable of handling the signals from the drive controller.

Summary

The replacement of a drive motor, whether it is a main drive motor auxiliary drive motor or span lock motor is something that need to be performed with care and consideration. The loads or torque output the existing motor had previously been exposed to needs to be not less than or equal to the loads or torque output the new motor will be subjected to. If space is limited, as often is, in the bridge machinery area, verify the new motor, which will be physically larger than the existing motor will fit in the space and still provide adequate servicing clearances. Verify the shafts will still be in alignment with the existing machinery and that shaft sizes of the new motor and existing machinery are compatible.

An "in kind" replacement of older motors may not provide the owner with the same level of torque output that has previously existed. Replacement can no longer be horsepower for horsepower without an thorough evaluation of the replacement motor, motor frame and installation consideration.