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VEGP U4 Polar Crane, NRC Brake System Questions
Rev. 0 final, 11/09/2020

1. Describe the Braking system utilized on the U4 Polar Crane

The following description applies to the main and auxiliary hoists of the Polar Crane on both Unit 3 and 4. The same braking system is also used on the Cask Handling Crane (both units). The braking system for the Equipment and Maintenance Hatch Hoists are similar. Below is a description of the key components and how they work interactively.

- Conventional Holding Brakes (aka Holding Brakes): Brakes that are applied to the drive motor shaft (see figure and photo next page). This type of brake's primary purpose is to hold the load once it has been stopped by the electrical load control brake. The U4 Polar Crane holding brakes are Bubenzer AC Thruster shoe brakes, model EBN 315-50/50. The holding brakes function is to prevent any hoist rotation when the hoist motor is idle. This is the period of time before, and after, VFD input is provided to the motor. Braking force is provided by a fixed value thruster. The thruster is a spring-loaded shaft that pushes a mechanical linkage which applies braking force to a brake pad/drum that operates similar to the brakes on your car. To remove the braking force, an electrical coil pulls the spring-loaded shaft in turn relieving brake pad/drum compression.

- Electrical Load Control Brake (aka Dynamic Brake): An electrical output function of the Variable Frequency Drive providing 480 VAC power to the hoist motor. When the motor attempts to exceed VFD target rpm due to load pull, the VFD provides appropriate reversing current to the motor to maintain target RPM.

- Emergency Band Brake: This device provides an independent means for reliably and safely stopping and holding the load. The Emergency Brake system is an integral part of the Westinghouse Extra-Safety and Monitoring (X-SAM) system. The X-SAM design incorporates a band brake wrapped around the hoist drum controlled by twin spring loaded thrusters. This is the independent brake that makes the crane braking system single-failure proof; i.e., it is independent from the two braking subsystems described above. The Emergency Brake actuates after a failure in the hoist machinery between the high-speed shafting and the hoist drum. Upon activation from an un-commanded load lowering, the emergency brake system sets and holds the load. The band brake must be manually reset at an independent trolly mounted panel after determining the cause of actuation. The emergency brake is not cycled during the normal duty cycle unless an actuating event signal is provided by one of the numerous X-SAM monitored channels. Holding the load during normal operation is a function of the electronic VFD motor control and the holding brake as previously discussed.

Normal Operation:

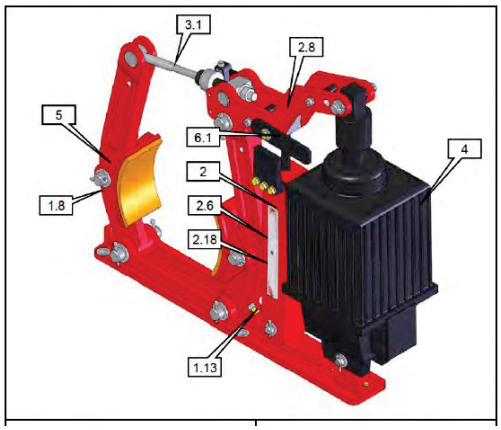
The fundamental sequence of applied braking force is as follows:

- Crane is idle, the Holding Brake is ON.
- The Operator commands hoist either up or down
- The VFD processes the operator command and sends current to the motor.
- The VFD performs a very rapid motor rotation torque check by driving through the brake to ensure that the motor torque applied is adequate to carry the load. This typically occurs with minimal motor shaft rotation.
- Once the VFD is satisfied (by the absence of reverse rotation) that adequate motor torque is available, the VFD provides a signal to apply power to the holding brake, thereby energizing the

brake's thruster and releasing the holding brake to remove any braking force.

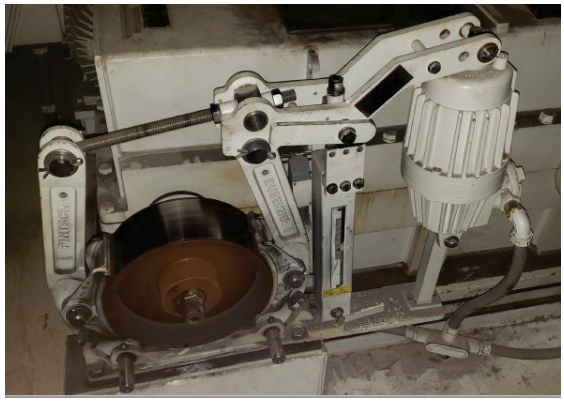
- After cessation of operator command (i.e., joystick neutral), the VFD controls motor direction and speed to near zero, then removes the electrical signal from the brake's thruster which allows the spring-loaded shaft to apply full braking force to the stopped hoist motor. The VFD holds the load until the brake is engaged.

Holding brakes are set whenever the hoist motor is not in motion. This occurs regardless of the presence of crane electrical power. The sequence for brake operation during normal operation is described in the previous response. In instances of brake slippage or brake failure, the X-SAM Emergency Band Brake actuates to secure the load.



The holding brake assembly figure from the vendor manual (Reference 3) is shown to the right. The brake lining is yellow. The number 5 points to one brake shoe, the second brake shoe is across from it. The photo is of the as-built U4 Polar Crane Auxiliary Hoist holding brake.

2. How do the brakes satisfy the single failure criterion?



The Unit 4 Polar Crane was certified as single-failure proof in ICN ND-18-0804 submitted 7/27/2018 (reference ITAAC 2.3.05a.i, Index 343, ML18211A623). The bases for the conclusion are in References 1 and 2 listed later in this document. The single-failure proof design of the brake system was described under question 1 above.

The Vogtle 3&4 UFSAR Section 9.1.5.1.2 describes commitments for mechanical handling systems (which includes the cranes and hoists noted above) to industry standards including NUREGs 554 and 612, ASME NOG-1, and references to ANSI B30.2

3. Identify the operating conditions that cause the control system to set the holding brake

Any of the following conditions will set the Holding Brake:

- Aux hoist controller is returned to neutral,
- ESTOP button pressed,
- Loss of power (fails to the engaged position)

4. Describe how the braking issue was discovered.

The initiating issue was reported in Condition Report 50064388. The Crane Operator reported an unexpected X-SAM actuation. The Operator contacted Maintenance thereby initiating troubleshooting. The operator and riggers indicated that the approximately 7,000-pound load appeared to have drifted slightly down at command stop. Maintenance and Engineering witnessed slight input shaft rotation after command stop was applied indicating possible brake friction issues. The Holding Brake settings were measured and determined to be out of spec. The Holding Brake was subsequently adjusted and verified to hold the load.

Holding Brake Adjustment Verification using a torque Wrench:
The holding brake is mounted on the outboard side of the reduction gear box high speed input shaft. The motor is mounted on the inboard side of the same shaft. The shaft has an integral hex shape to receive a wrench socket on the brake side. The motor torque required at the input shaft to make a lift at 100% capacity is determined during machine design and is available on request. Theoretically, setting the brake to a torque value higher than that what would be required to lift 100% would hold the load when the brake was applied. Using the "Brake Torque" method, a calibrated torque wrench is set to the 125% value, attached to the input shaft, then torque is applied to ensure the wrench "clicks" before shaft rotation is realized. Shaft rotation before the wrench clicks indicates insufficient brake torque. Additionally, Bubenzer brakes are equipped with visible scales indicating applied braking force when the brake is engaged (reference illustrations in Bubenzer manual).

5. Describe the delamination observed

Brake de-lamination was noticed during the initial inspection and adjustment following X-SAM actuation. One of the two shoes was found with one corner starting to pull away from the base. Upon detailed inspection, the brake liners are riveted to the shoes. The perceived "delamination" was determined to be heat induced distortion.

Pictures of the brake shoes were sent to the brake manufacturer to gain input for the potential cause of the observed condition. The manufacturer's representative noted the difference in the thickness of the lining from top to bottom; the lining at the top of the shoe being much thicker than the bottom. He attributed this difference to possibly the alignment of the brake not being uniform, causing the bottom lining of the shoe to drag on the wheel. The drag then resulted in the lining on the bottom of the shoe to wear more and create excessive heat, which would impact the base of the liner at the connection with the shoe. Follow-up field inspection confirmed the manufacturer's assessment and determined that the brake liner is riveted to the shoe. The face of the liner against the shoe became distorted from the heating caused by the alignment and uneven wear.

6. When SNC stated the U4 polar crane brakes would require replacement in the near future what did you mean?

A Work Order is being planned to replace the U4 polar crane auxiliary hoist brake shoes. The parts are on order, a delivery date is being pursued. The replacement will occur when the parts are received.

7. Describe how further degradation is being monitored and the confidence level the braking system will remain capable of supporting the max design load going forward

The following actions are considered collectively regarding confidence in the capability of the Polar Crane hoists and braking systems.

Standard crane operator practice verifies proper Holding Brake function at the beginning of every lift. It is standard practice to lift a rigged load several inches, then hold for a given period of time to ensure the rigging is adequate, load is level, and drift is non-existent. The use of this practice identified the need to adjust the U4 polar crane auxiliary hoist holding brake.

Specific to the U4 polar crane aux hoist holding brake, the brake is considered degraded but functional. The brake is functional since it is able to provide the torque called out in the crane manufacturers design. Because brake adjustment adequately restored brake function, and adequate brake material is present, the crane was returned to service.

For the observed deficiency with the U4 Polar Crane aux hoist, the SNC Maintenance crane SME has been checking the brake setting via the brake force scale on the brake frame every two weeks, with no evidence of drift observed since the last adjustment. This is being done as an interim action until the brake shoes are replaced.

The monthly PM is being revised to include more specific inspection attributes that provide an adequate monthly inspection interval for brake condition. The PM revision is expected to be implemented in November.

References in this document:

1. WEC_SV0_000005, "Vogtle Unit 3 MH01 Polar Crane Supporting References to Topical Report EDR-1", July 13, 2018
2. SV3-MH01-VQQ-009, Rev.0, "Quality Release and Certificate of Conformance for SV3 AP1000 Polar Crane Shipment"
3. SV4-MH01-MYR-001 rev. 2, Domestic AP1000 Polar Crane Operations and Maintenance Manual (the Bubenzer Brake Manual starts on Page 1196)

Other references for background:

1. SV4-MH01-VMM-001 rev. 5, Domestic AP1000 Polar Crane Operations and Maintenance Manual
2. SV4-MH-01-T1-001, rev 5, Domestic AP-1000 Polar Crane Site Initialization Procedure
3. SV4-MH01-VTP-002 rev. 5 Domestic AP-1000 Polar Crane Site Acceptance Test
4. NUREG-0554, Single-Failure-Proof Cranes for Nuclear Power Plants

Excerpt from NUREG-0544

4.2 Hoist Braking System

Mechanical holding brakes in the hoisting system (raising and lowering) that are automatically activated when electric power is off or mechanically tripped by overspeed devices or overload devices in the hoisting system will help ensure that a critical load will be safely held or controlled in case of failure in the individual load-bearing parts of the hoisting machinery.

Each holding brake should have more than full-load stopping capacity but should not have excessive capacity that could cause damage through sudden stopping of the hoisting machinery. A minimum brake capacity of 125% of the torque developed during the hoisting operation at the point of brake application has been determined to be acceptable.

The minimum hoisting braking system should include one power control braking system (not mechanical or drag brake type) and two holding brakes. The holding brakes should be applied when power is off and should be automatically applied on overspeed to the full holding position if a malfunction occurs. Each

holding brake should have a torque rating not less than 125% of the full-load hoisting torque at point of application (location of the brake in the mechanical drive). The minimum number of braking systems that should be operable for emergency lowering after a single brake failure should be two holding brakes for stopping and controlling drum rotation.

The holding brake system should be single failure proof; i.e., any component or gear train should be dual if interposed between the holding brakes and the hoisting drums. The dynamic and static alignment of all hoisting machinery\ components, including gearing, shafting, couplings, and bearings, should be maintainedthroughout the range of loads to be lifted, with all components positioned and anchored on the trolley machinery platform.

Manual operation of the hoisting brakes may be necessary during an emergency condition, and provision for this should be included in the design conditions. Adequate heat dissipation from the brake should be ensured so that damage does not occur if the lowering velocity is permitted to increase excessively. It may be necessary to stop the lowering operation periodically to prevent overheating and permit the brake to dissipate the excess heat. Portable instruments should be used to indicate the operations. If a malfunction of a holding brake were of the load become necessary, the holding brake condition before any lowering is started.