TECHSUMMARY January 2021

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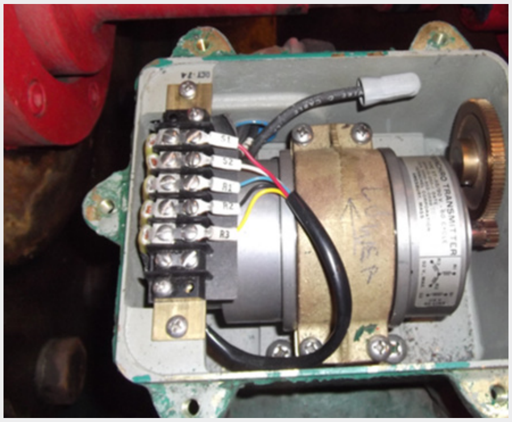
Skew Detection System Replacement on Vertical Lift Bridges

INTRODUCTION

Louisiana has more than 140 movable bridges with over 40 of them being vertical lift bridges. For a tower drive vertical lift bridge, failure to maintain level operation over its length or width are known as span longitudinal or transverse skew, which when occurring, can lead to jamming of the movable span in its guides and potentially catastrophic bridge failure. Vertical lift tower drive skew indication and monitoring was historically satisfied with the use of a differential Selsyn (see Figure 1). However, this legacy technology is nearly obsolete and alternative approaches to detecting and monitoring skew conditions for tower drive vertical lift bridges are necessary. Current industry practice is moving towards the replacement of legacy Selsyn systems with skew control, monitoring, and indication through the use of encoders, resolvers, inclinometers, or other devices, typically through programmable logic controller (PLC) systems and commanding necessary tower drive adjustments to mitigate skew conditions.



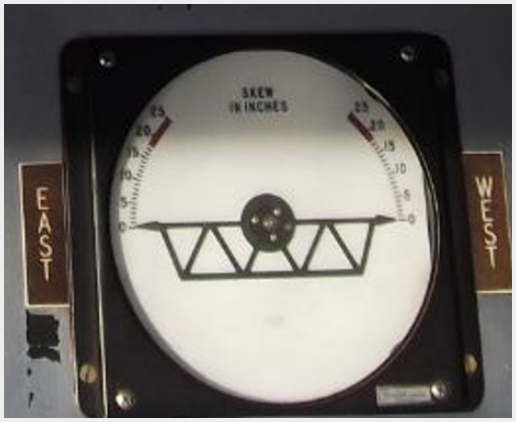


Figure 1
Differential Selsyn

OBJECTIVES

The objective of this work was to provide an evaluation of alternatives for replacing the legacy technology skew monitoring and indication system. The primary goal was to select an effective skew monitoring and indication system that minimizes training for existing DOTD maintenance personnel. In addition, the ideal system would provide the bridge operator with specific information as to the skew status of the bridge and means to address it with minimal disruption to bridge operation.

SCOPE AND METHODOLOGY

This work included a literature review for existing skew systems in use as well as research into modern skew control, monitoring, and indication alternatives as well as a comparison between alternatives and the existing legacy technology system. Literature and information were compiled from the principal investigator's experience, the experience of bridge operators and maintenance personnel on existing vertical lift

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bridges, the design documents from existing vertical lift bridges, and from bridge control system vendors who have knowledge and experience providing skew systems for control, monitoring, and indication.

CONCLUSIONS

Few published documents document skew monitoring and indication options, but maintenance personnel, operating personnel, and control vendors all confirm obsolescence of the differential Selsyn technology. The industry is moving towards replacement of Selsyn systems with encoders, resolvers, inclinometers, or other devices. Apart from inclinometers, there is little industry experience with other direct skew measurement technologies such as string potentiometers or lasers. Encoders and resolvers are indirect skew measurement tools commonly used. Control systems utilizing PLCs are common for bridge control, though many owners retain functional and effective relay control systems and prefer them to PLCs for ease of maintenance. All reviewed skew monitoring and indication alternatives are sufficiently accurate for the desired function, but there is an advantage to direct skew measurement versus indirect measurement as they are not susceptible to errors due to counterweight rope slippage over counterweight sheaves, though they are subject to environmental conditions. Of direct skew alternatives, the inclinometer has advantages in reduced maintenance and improved reliability and durability. When properly specified and applied, inclinometers will achieve the desired accuracy, reliability, and maintainability without computations to determine movable span skew. Of alternatives for indirect skew measurements, the encoders offer an advantage compared to resolvers as they are less susceptible to reliability issues.

The industry has moved towards PLCs for bridge control. They can provide the necessary computation power to enable skew condition calculations based on machinery position inputs and provide indication and control functionality beyond the capability of a relay logic system. An owner's preference for a relay logic system does not preclude the use of inclinometers or encoders, as this may be achieved using a "SMART" relay, which has limited but adequate computing capability, is relatively inexpensive, and may be easily replaced with a pre-programmed spare in the event of failure.

RECOMMENDATIONS

For replacement of skew control for tower drive vertical lift bridges, the following solutions are provided for consideration:

1. ***Direct skew measurement using inclinometers and SMART relays.*** The inclinometers would be used for control and for indication and alarm purposes as well as back-up trip functionality for an ultimate skew condition. For control, the inclinometer output would be used to control independent tower drives to correct and eliminate skew. An inclinometer would be specified for harsh environments, a means of temperature compensation, enough precision for the length of the movable span, properly protected from EMI where wireless systems are used, and specified and integrated to account for expected vibration. The inclinometer should only be functional during bridge operation, eliminating the effects of vibration and transient physical noise from vehicular traffic. Further, the inclinometer should be provided with a damping algorithm to damp out short duration transient events during operation.
2. ***Indirect skew measurement using absolute encoders and a SMART relay to provide skew control.*** This control function would be used for control of the tower drives to correct and eliminate skew. This indirect measurement may be used to provide indication of the span position and to alarm and trip the system in the event of an over skew condition. The installation should be provided with an automatic means of resetting absolute encoders at the end of each bridge operating cycle thereby eliminating the accumulative effect of rope slippage during multiple bridge operations.
3. ***A hybrid solution would utilize two independent forms of skew monitoring, direct inclinometer measurements, and indirect absolute encoder measurements.*** These would be combined to provide the desired functionality but also used as a check of one against the other, redundancy, and to enable them to be utilized for bridge auxiliary or emergency drives to enhance operating reliability.