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"Replacement of a Combined Pneumatic/Electric Control System with an All-Electric PLC Control System"

by

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Replacement of a Combined Pneumatic/Electric Control System to an all Electric Control System with PLC on a Swing Span

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PROJECT: BNSF Railroad Bridge 37.0 over the Snohomish River in Everett, Washington

INTRODUCTION: HNTB in partnership with the Burlington Northern Santa Fe Railroad have completed a major rehabilitation of the electrical control and drive system on the 1921 vintage, single track, 260 foot swing span. The rehabilitation was a staged three phase, five year project. All construction services and equipment installations were performed by BNSF personnel.

HISTORY: The existing electrical control and drive system consisted of a combination of pneumatic control for the easer bars, endlifts and center wedges with wound rotor motors for the main drive system. The pneumatic system had a long history of operational problems and unreliability. The wound rotor motors had previously been rewound at least twice.

SOLUTION: The solution was to replace the existing pneumatic system and electrical system with a new electrical control system that would utilize a Programmable Logic Controller, Motor Control Center and Soft Start Motor Controllers. Each of the pneumatic systems for the easer bars, endlifts and center wedges were to be replaced with electric motors and new machinery. The wound rotor motors would be replace with new main drive motors and the addition of new auxiliary drive motors utilizing standard squirrel cage motors. During the installation of the new electrical system, a new horizontal rim bearing system was installed and new control house was constructed on top of the swing span.

PAPER AND PRESENTATION OBJECTIVES: This paper primarily focuses on the staged activities of installing the new electrical system while maintaining the existing electrical system over the 5 year construction period, in addition to the temporary interfacing of the two electrical systems in order to maintain a safe operation of the span. Major issues that relate to the equipment selection, sequence of installation and navigation closures will also be presented. During the final stage closure period, BNSF forces worked from 7 a.m. to dark for seven days. The rail operation was interrupted each day from approximately 9:30 a.m. until 6:00 p.m.. Detail of the coordination and the interfaces that occurred during the construction stages will be presented in combination with a picture presentation. The following outlines the presentation:

Introduction:	2 minutes
Project History:	3 minutes
Phase 1 Installation:	3 minutes
Phase 2 Installation:	2 minutes
Phase 3 Installation:	3 minutes
PLC and Drive Systems:	5 minutes
Conclusion:	2 minutes
Questions:	7 minutes

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INTRODUCTION

In partnership with the Burlington Northern Sante Fe Rairoad, HNTB has completed a major renovation to their bridge which is located on a major North-South route between the Port of Seattle and Canada. The Bridge 37.0 is a 77 year old, 260 foot swing span located in Everett Washington. The existing operational system consisted of a pneumatic air system used to control the easer bars, endlifts and center wedges with a mechanical drive system using two wound rotor motor. The rehabilitation was to be a staged three phase, five year project and all construction services and equipment installations were to be performed by the BNSF personnel.

The objective of this paper is to inform the reader of the key elements involved in the design and construction of the three phase project. This paper will discuss the design concept and the construction sequencing to complete the rehabilitation of BNSF Bridge 37.0

HISTORY

The original bridge structure was built in 1921. The original bridge machinery and electrical control system was replaced in the early 1960's and consisted of a pneumatic system which controlled the endlifts, center wedges and rail locks. The bridge electrical system consisted of the orginal wound rotor motors with about 75% of the existing control system replaced with new relays and motor starters. The pneumatic system had developed many air leaks resulting in numerous maintenance requirements. The electrical control system had a mix of control voltages consisting of 480, 240 and 120 volt systems. The pneumatic system and electrical control system had deteriorated to a level that resulted in numerous maintenance requirements, bridge operational failures and train delays.

INSPECTION

HNTB conducted an inspection of the bridge and determined that the existing pnuematic system was in a state of disrepair and would require complete replacement with either a new pneumatic system or a new mechanical system. The pneumatic system had been a source of continual problems for the railroad resulting in numerous maintenance calls and multiple train delays. The electrical control system had been modified many times over the years and was a mix of electrical equipment with different levels of control voltages.

In addition to the new turning machinery and electrical control system being recommended for rehabilitation, the inspection determined that the center pivot bearing allowed the span to rotate in an elliptical pattern resulting in the span to not rotate back to its original starting position.

SOLUTION

The solution was to replace the pneumatic system with a new mechanical system and the control system with a PLC based control system and new drive motors. The new systems were required to be incorporated into the bridge over a five year period in three stages with minimum bridge closures and minimum train delays. The existing electrical control system and pneumatic system would need to remain in service and be phased out over the five year period. The existing control house was determined to be inadequate to allow the existing system remain in service while the new control system was installed. This would require the construction of a new control house in a new location but would not be able to be installed until the third phase of work when the new drive machinery was scheduled to be installed.

In addition to the new turning machinery and control system, a new horizontal force carrying rim around the outside of the pivot pier, new rack gear and horizontal force rollers would need to be installed.

PHASE 1 INSTALLATION

The first phase of the rehabilitation would be the replacement of pneumatically operated easer bar and endlift systems with new operating machinery and electrical controls utilizing a PLC for centralized control providing a "one button" style of operation. Since the wedge machinery and drive machinery was not scheduled to be replace until later phases, the pneumatic system would be required to remain operational until after phase 2 when the wedge machinery was scheduled to be replaced. The existing air compressor was determined to be unreliable for service until the phase 2 work. After careful evaluation of the existing bridge structure, balance conditins and the existing control system, it was deterimined that a small building would be placed on one side of the bridge to house the new air compressor system and a small platform would be erected on the other side of the bridge for the location of the temporary electrical cabinets that would contain the new motor starters and PLC equipment. Two electrical cabinets would be provided, one for the motor starters and distribution panel and the other for the PLC equipement. The new equipment would be in service in the temporary cabinets for approximately 2 years.

The electrical control system was designed to provide a "one button" control concept that would permit the bridge operatior to Lock and Unlock the bridge with individual push buttons. This one button concept would control the new easer bars, new endlifts and existing pneumatic wedge operators. Once the three systems have completed there movements in the required sequence of operation, an interlock would be sent to the existing drive system to permit the bridge to rotate.

After a study of the wide range of alternatives for the construction sequence, the final method of inplementation was determined. This method would consist of performing as much of the construction as possible prior to the actual closure of the bridge to river traffic and the reduction of train traffic that would be allowed by the railroad operations department. All electrical cabinets would be installed on the new platform and all conduit and wire would be installed to the ends of the spans to junction boxes so that final connections would occur during the equipment change-out.

The new control system was established around a standard control voltage of 120VAC and much of the existing control system that would remain was operating at a voltage of 480VAC. This required further evaluation and the used of interposing relays in order to permit the two systems to be operationally compatible.

The railroad operations departments agreeded to allow 6 hours of track time between the hours of 9:00am to 3:00pm to permit the installation of the new easer bar and endlift machinery. There was no closure requested from the US Coast Guard and the bridge remained open to navigation during the entire construction sequence. The endlift and easer bar machinery was installed and become operational in 5 days during the first weed of November, 1995.

Since the BNSF personnel were going to be doing the installation of the new equipment, the design plans needed to be done in a method that was much different that the type prepared for a contractor. The design drawings were required to be prepared in the form of shop drawing that would typically be received from a contractor

PHASE 2 INSTALLATION

The second phase of the project consisted of the installation if the new wedge operators, the removal of the existing pneumatic system and modifying the PLC program to accomodate the operation of the new mechanical wedge operators. In addition, once the new wedge operators were in operation, the existing overhead power lines connected to the slip ring assembly located on the top of the swing span was removed and replaced with a new utility service feed via a new submarine cable. This was required in order to prepare the span for the installation of a new control house to be located on top of the span and for the work to be completed in the next phase.

During the period between the phase 2 work and the beginning of the phase 3 work, a new generator building was constructed on shore to provide standby electrical power to the bridge. Once the generator building was completed, the electrical utility service was transfer from the overhead cables to the submarine cables. The new control house was built off site and was completly finished inside complete with new MCC, PLC cabinet, control console and all interior lighting and wiring.

Once the new control house was mounted on to the span, the railroad electricians began the process of transferring the PLC system and motor control from the track level cabinets to the new MCC and PLC in the new control house. Once this was completed, all motor control for the endlifts, wedges and easer bars. The new PLC equipment was provided with extra rack space in order to permit the installation of the existing I/O cards from the track level equipment.

The installation of the wedge machinery occured in May, 1997 over a 2 day period.

PHASE 3 INSTALLATION

Phase 3 consisted of removing the existing 2 wound rotor drive motors, open gearing and modifications to the center turning ring. All this was accomplished while the bridge remained in operation and open to both train and river traffic with the exception of 5 days of closure to river traffic.

The phase 3 work was split into two components consisting of removing one half of the rack, one drive motor and machinery and installing new drive machinery, a new main drive motor and new auxiliary drive motor. During this part of the construction, the bridge was operated on the remaining single drive motor using one half of the center rack. Once the new equipment was installed, the bridge was closed to navigation and the remaining main drive motor, auxiliary drive motor, turning machinery and center rack was installed. The center rack was set and aligned the grouted in place before attempting to move the bridge. During this period, final connections were make to the electrical equipment and checked for proper operation. Once the center rack was secured, the bridge reopened river traffic.

Druing this phase of the work, the BNSF personnel worked form 7:00 am to dark for seven days while the bridge was closed to navigation. During this seven day period the rail traffic was interrupted from approximately 9:30 am to 6:00 pm to facilitate the installation of the new drive machinery and drive motors.

PLC AND DRIVE SYSTEMS

The control system used an Allen Bradley PLC 5/20 processor. The system was programmed to automatically draw all easer bars, pull both end lifts and pull both wedges. Once the system has confirmed that all systems have properly unlocked the bridge, the bridge operator can start both of the main drive motors to open the bridge. The main drive motors were controlled by individual Allen Bradley Bulletin 150 SMC-2 Plus soft start motor controllers. The soft start motor controllers were programmed to permit the approach speeds of the drive motors to be 15% of the motor base speed of 1800 RPM. In addition, the PLC was programmed to monitor the operation of the bridge at all times and to alert the bridge operator via an alarm panel to potential problems. The new control system also provided to the operator span position via digital display units that were accurate to one tenth of degree using a Gemco model 1994R decoder display with a 1000 count resolver encoder. The resolver encoder was mounted to the new main gear reducer at the factory resulting allowing the unit to be properly aligned and ready for electrical connection reducing critical down time during the period the bridge was closed to navigation.

CONCLUSION

Each phase of the start-up presented minimum problems and took less that 12 hours for phase 1, 3 hours for phase 2 and 4 house for phase 3. The disruption to rail traffic was kept to a minimum and resulted in only minor train delays. System was completed in October 1997 and has proved to be a highly reliable system. The success of this project can directly be attributed to the efforts of the design team and the BNSF personnel involved with the installation of the equipment over the five year period. The careful analysis and planning of the constuction sequence resulted in a minimum of inconvenience to the mariners and train delays to the railroad. The bridge has been in operation under the new system for about 1 year and has experienced less than the normal problems expected with a new mechanical and electrical drive system.