DESIGN CONSIDERATIONS FOR IMPROVED OPERATIONAL PERFORMANCE

PRESENTED AT THE SYMPOSIUM AND EXHIBITION ON MOVABLE BRIDGE DESIGN AND TECHNOLOGY

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Although each owner and designer have their own criteria for design of the electrical control circuit for a movable bridge, there are certain approaches which should be examined so that improved operational performance can be expected. This improvement can be achieved through a re-examination of the human engineering factors required to operate a bridge, a thorough knowledge of the components selected, new products that are applicable to bridge design, and a follow up for maintenance functions.

There are many philosophies in use today for how a bridge operator should control a movable bridge. At one end of the spectrum we have a manual system whereby an operator moves a drum switch and presses a pushbutton for every function, through the opposite end of the spectrum whereby all he does is push one button to start a complete control circuit. In a similar view an operator may have no pilot lights for readout functions or more than sixty lamps which give the status of every circuit.

It is not our goal to say which approach is better. Rather we would like the owners and designers involved to examine what is required from an operator's point of view. Far too often in our quest for a better system design we ignore the people who must operate the bridge and those who must maintain it. What information does the bridge operator need to perform its function? Is this information presented in a logical manner? Does the operator have additional functions such as maintenance or traffic control? Proper design should start with the operator--not end with him.

Each user has different functions for the bridge operator which may be set by union work rules, operator training and operator responsibilities. In some locations operators are permitted to use bypass switches, in others they cannot. In some situations the operator is expected to perform certain maintenance functions such as greasing, cleanup and repair of parts and in other locations it is outside their jurisdiction. Before any design is initiated the designer must be familiar with what the operators role is.

The next step involves the science of human engineering. What is the physical layout of the control desk? Do the controls operate from a left to right sequence or are they scattered on the desk top? Are the indicators or readouts plainly on the desk top? Are the indicators or readouts plainly readable not only at night, but also at midday when sunlight has the ability to wash out any pilot light on a desk? Are the nameplates not only uniform in location--top or bottom of the controlled device--but also as to informational content such as on bypass switches? What does the operator need to know in order to perform his function? Again we are involved with differenct philosophies in bridge operation.

Let us examine these philosophies. A major one is cost. With the need for bridge rehabilitation, the owner is faced with the prospect of having to upgrade many facilities and yet not have the funding to cover them all. A natural tendency is therefore to eliminate as many items from a project as possible. Who can say that a brake released pilot is essential to bridge operation. It may or may not be. Yet this tendency may give the owner potential problems down the road from an operational and maintenance point of view. There is always a trade off involved. Yet before a decision can be made, the owner and designer must know the system and its potential problems.

Another philosophy is the way the movable bridge is actually controlled. We have constructed a control desk where there was one "up" button and one "down" button. Every sequence performed after that was done automatically through limit switches, timers and relays. The simplicity of the operator's function was offset by the complexity of control circuit whereby it became a major task to maintain. A different approach is that where there are pushbuttons for every function such as traffic gates, barrier gates, tail locks and brake release. This particular control desk had sixty four pushbuttons which had to be used every time for bridge operation. Both Bridges were double leaf Bascule type.

Indicators are another area that needs examination. While some desks look like a Christmas tree, others are totally devoid of any information. From pilot lights to span position indicators, an indicator's primary purpose is feedback to let the operator know what is happening. The more information provided, the easier it is to operate and maintain the bridge. All pilots should be selected so that they can be used in a master push to test type circuit so that the bridge operator can depress one button to test all the lamps on the control desk. Somewhere there has to be a common meeting ground for design and application. The results of good design practice should be a system that is easy to maintain and gives the operator the proper tools to efficiently operate the system.

The user or designer will normally specify the types of equipment used on a movable bridge. In reviewing these specifications we must not only be aware of the design limitations that the manufacturers impose, but also in how the equipment under consideration must be applied. At times a contractor may propose a certain device as equal to one that is specified. The question is not that it is as good or it is made by a reputable manufacturer but will it work in the particular application specified. This problem can be seen for example in limit switches where a standard oiltite limit switch may be proposed to replace a railroad type limit switch such as the U-5. Even though the railroad switch is more expensive by a factor of five, its design both from a mechanical and electrical point of view is far superior in certain applications. Its useful life of forty to fifty years will more than offset its original difference in price.

Certain other devices such as thrustor operated brakes should be applied with design and operational limitations in mind. For example on a Rolling Bascule Bridge the mounting of the thrustor brake is critical. The 8" brake can have no more than a maximum of fifteen degrees off of horizontal for proper operation. The larger brakes can go up to a maximum of forty five degrees. Any brake that is mounted outdoors should be in a Nema 4 watertight enclosure in accordance with manufacturer's recommendations. It should also have space heaters, shaft seals and corrosion resistant fittings. Since the motor that controls the thrustor is not built to Nema standards, it is more succeptible to voltage variations.

The swiftly changing technology that is sweeping other industries is now affecting the bridge industry. Current approaches are rapidly becoming obsolete and new technology from other fields such as the steel and automotive industry make available new devices for our industry. Among these devices are programmable controllers, solid state limit switches, position encoders, graphic displays and fiberoptics for use in submarine cable.

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No other advancement in our field has the impact that a programmable controller has. The programmable controller is a replacement for relays, timers, instrument loops and counters. It gives the designer the flexibility to design a circuit without regard to how many contacts are available on a relay, or how many wires are available in a submarine cable or how much floor space is available in a renovation project. The programmable controller can take various inputs such as limit switches, speed signals, or 4-20 M.A. current loops and process this information internally to arrive at an output sequence. The program for the programmable controller is normally written in ladder logic with the important ability of being able to be changed either in the field at the bridge location or in a remote office where the program can be either transmitted by modem over telephone wires to the project site, or loaded onto a disk which is loaded manually at the site.

This flexibility for change is a tremendous benefit since modifications to the system logic, in most cases, can be made without changing field wiring. If an operational problem should develop after a bridge is in use, the designer or system manufacturer can review the circuitry in his office and have the opportunity to make corrections or improvements to the circuit.

Another benefit of the programmable controller is that during the installation phase when not all the equipment is available for operation, the programmable controller can be temporarily loaded for a preliminary stage of operation using the equipment that is avaiable. As additional equipment becomes available, the program can be modified to include this equipment. This can continue in stages until all of the equipment is in place and operable and the final program is in place and running.

The state of the art in programmable controllers today allows the user to access most major manufacturers using an IBM MS-DOS compatible computer which is normally available in most offices. Various vendors have software available which emulate a terminal that is compatable with General Electric, Westinghouse, Square D, Allen Bradley and other major manufacturers.

All of this sounds great. However there are some application considerations which must be thought of.

While there is a definite application in bridge control systems, the designer must recognize a few drawbacks and compensate for them. Programmable controllers are environment sensitive both from an atmospheric as well as electrical point of view. Most programmable controllers have limited operational temperature ranges as well as preferred humidity ranges as determined by the individual manufacturer. In addition from an electrical point of view, the designer must consider lightning projection, electrical noise, proper grounding, the physical limitations of proximity to other electical devices and redundancy. These devices are noise sensitive and therefore a surge on the line from lightning can knock out the central processor. In the same sense arcing from motor brushes, contactor opening and closings and poor grounding can cause considerable harm.

Many experienced maintenance personnel can jury rig an electro-mechanical device to make it work on a temporary basis. However this is extremely difficult to do on a programmable controller. We believe that it is good engineering practice to have either a redundant controller that can be transferred into the circuit or a simple electro-mechanical bypass system that can be used while the original device is being repaired.

As part of the design package, the designer should also include a modem for communciations with the programmablle controller. This device allows the program to be monitored or changed from a remote location which gives tremendous flexibility for bridge operation. In addition to a modem, the designer should also specify the inclusion of a documentation package. This package as a minimum should include ladder diagram printouts, rung addresses, English contact description, cross-referenced relay number and contact closures and English comments for sub systems or circuits.

The purpose of this package is to give the maintenance person a roadmap to how the programmable controller is functioning. Since every manufacturer has a different approach to how his controller functions, this documentation package is important for a thorough understanding of how the system operates.

Another device that has application to our industry is the solid state limit switch. This limit would replace the conventional span limit switch that normally has eight to ten contacts. The solid state limit switch is in reality an absolute position encoder connnected to a solid state matrix board.

The contact position settings are dialed into the matrix Board so that adjustment for contact opening and closing is done from the control house rather than from the bridge leaf. The benefits of this device are that it eliminates half of conductors normally needed for control, the settings are more accurate than those made with a conventional switch and adjustment is more convenient. If a programmable controller is being used, then an absolute position encoder is all that is needed for span control and indication.

One of the highest cost compenents of a bridge rehabilitation is the cost of replacing the submarine cable. The technology is now available whereby data transmission in the form of digital signals can be multiplexed and distributed using fiber optic cables. Instead of the usual submarine cable that has three or more power conductors along with a possible hundred control conductors, we can replace it with one having the same power conductors and only a few fiberoptic conductors. Not only would the cost of the submarine cable be reduced, but other problems such as turning radius and terminal cabinet dimensions would be eliminated.

While fiber optic cable is in use today, it will be another year before the input and output convertors are reliable enough for bridge application. It is a device that is worth considering today since considerable economy can be realized by standardization of submarine cables. This cable could be purchased by the user and stored in a central location. At the time of installation, the owner could disburse a precut exact length to a contractor for a particular bridge. Not only would there be a cost reduction by eliminating individual set up charges, but buying in larger quantities would also have a reduction in unit price per foot prices.

One of the major components of any bridge system is a proper maintenance program. Yet it is a component that is overlooked. The maintenance function can be broken down into two functions; emergency repair and preventative maintenance. Emergency repair has a goal of repairing the bridge as quickly as possible in order to get it running again. In order for this to happen many items must come together. These items include the availability of replacement parts, system documentation and proper training. The electrical installation on most movable bridges costs in excess of one half million dollars. Not to spend an additional ten thousand dollars for parts and training is being penny wise and pound foolish.

In looking at the design of control systems for movable bridges, the designer should incorporate certain items which would aid the maintenance personnel in the performance of their job. For example, these items would include neon indicators placed in parallel with the relay coil, check sum circuits that would localize a problem or fault to a subsystem, or a separate diagnostic system that would monitor the control system. If copying machines and automobiles can include diagnostic indicators, why not bridge systems! The technology is available for appliation. It is just a matter of applying it.

There are now or soon to be available devices that will lower the installed and operating costs of a movable bridge as well as increasing the reliability of the system. Balanced against these savings will be the need for adequate training and documentation. For maintenance personnel. This training and documentation must be very complete to be effective. It must not be limited to just a description of each device from a mechanical standpoint, but should also include a complete system description on a functional basis. This should not be a couple of pages on the operation of the bridge but should be an item description of the entire system.

The user is purchasing a system. This type of documentation is only available if there is one source that is supplying this equipment as a system. When the parts of system are purchase separately, it is then up to the electrical contractor to supply the system documentation as he becomes the system supplier. In most cases this is a hit or miss proposition.

Training sessions that involve at least three days are mandatory. As our control systems get more complex it is necessary to review these systems with the appropriate people. Too often the contents of an operation and operation and maintenance manual are not enough. The systems supplier should have a training course that covers operator training, maintenance training, diagnostic functions, and schedules for performance of routine functions. However, you will not receive this type of training unless it is specified in detail in the project specifications.

When the system supplier holds these operator and maintenance courses, also have him videotape them for future reference. It does not have to be a Hollywood production. Just set up the camera and let it roll. These videotapes are invaluable for future use. As there is a continual turnover of personnel and to have a ready-made training course for a particular bridge can aid in the training of replacements.

In closing there are a number of ways of increasing operational performance. Many of them do not add to the project cost. It is the responsibility of everyone from the owner, designer, system manufacturer and contractor to try and achieve this goal.