NEW APPROACHES TO ACTIVE LEVEL CROSSING PROTECTION FOR CANE RAILWAYS

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Abstract

Active level crossing protection systems have been advancing rapidly within the sugar industry over the last ten years with the advent of new, cost effective technology. This technology has given the industry network operators the flexibility to activate a set of level crossing protection signals in almost any situation. Moreover, it has allowed the industry to install these signaling systems at a cost far beneath that of mainline systems. These innovative solutions and train detection systems have provided valuable economic benefits during a period when significant effort has been directed toward increased reliability and reduced maintenance. In particular, this paper reports on the use of hazard analysis (HAZOP) to increase the reliability of level crossing protection systems plus the use of remote communication systems to report failures or other aspects of system performance back to the mill.

Introduction

During 2000 as a step towards uniformity, industry stakeholders developed a Code of Practice for Active Level Crossing Protection Systems on Cane Railways. While the code did not specify types of train detection system, it did however align current sugar industry practices with rail industry ‘best practice’ initiatives and with time will result in Queensland road users being presented with identical visual indications of the presence of a train at the crossing. At the same time, factory personnel have continued to develop technological and analytical initiatives aimed at increasing reliability and reducing operating costs. This paper will discuss some of the tools and emerging technologies available within the industry to aid in the production of a cost effective, reliable activation system for the industry.

Analytical tools (HAZOP)

To address the issue of maintenance costs, personnel availability, varying factory network practices and system reliability, CSR Sugar adopted a new approach to system evaluation for flashing light installations at road/rail level crossings based on Hazard and Operability Analysis (HAZOP) Principles. The aim of this study (Allen, 2000) was to determine the current variability of present system design methodology, gain quantitative data on failure rates, assess compliance of current systems with the Code of Practice and to determine the ‘next phase’ of the signalling system development.
A HAZOP analysis is a method that identifies hazards and the deficiencies that prevent efficient operation. Originally developed for the chemical industry (Tweedale, 1992), the method has since been adopted by a wide range of industries and processes. HAZOP analysis is a proactive rather than reactive approach to system development options and is a technique that allows wide ranging, sometimes radical, suggestions to be considered in order to recognise the possible ways in which hazards or operating problems might arise. To reduce the chance of a hazard or operating problem being overlooked, the analysis is done systematically, with each component and each type of hazard associated with that component being considered in turn (Kletz, 1992). Figure 1 shows a flowchart for a HAZOP procedure for analysing the consequences of a power supply failure.
Fig. 1—HAZOP procedure for power supply failure.

Select a line e.g. Power Supply

Select deviation e.g. Failure of power Supply

Is power supply failure possible?

Is it hazardous or Does it prevent Efficient operation?

Will the train driver Know the supply has failed?

What changes in equipment Will prevent the deviation or Make it less likely or protect Against consequences?

Is the cost of the change justified?

Agree to changes Agree who is responsible For action

Follow up to see if Action has been taken

Move on to next deviation

Consider causes of supply failure

Consider other changes Or agree to accept hazard

Yes

Yes

Yes

Yes

Yes

Yes

Yes

Yes

Yes

No

No

No
Key features of a HAZOP analysis are:

- It is systematic and detailed using a series of guidewords that are repeatedly used for each phase of the analysis to ensure consistency and repeatability.
- It is conducted by a team whose members are most familiar with the project or facility, typically the designers, maintainers, operators and users.
- It concentrates on exploring the consequences of deviations from the usual operating conditions.
- It is the audit of the completed part or sub-assembly such as the power supply of a design and installation.

The HAZOP process has allowed CSR to develop a uniform approach to level crossing signalling systems, road rail interface design and construction, an active level crossing management plan incorporating a prioritised upgrade schedule and a flashing light signal height and configuration. In addition, factory electrical engineers have been able to concentrate on identifying causes for existing system failure modes and to direct more effort into resolving key maintenance issues. Although the HAZOP analysis of flashing light installations has only been in place since 2000 (two seasons), results to date suggest a 38% reduction in maintenance costs have been realised.

This HAZOP analysis has also provided the additional benefit of having a structured approach to follow when reaching final conclusions on uniformity and, although other issues may arise in the future, an evaluation process consistent with existing management plans can be undertaken.

The HAZOP process, and the recommended outcomes, enabled CSR’s electrical engineers and cane supply managers to develop a strong business case for the uniformity of installations across the CSR Group. It has also enabled CSR to align itself with AS 4292 Part 6, in particular sections 1.5 and 1.6 (Anon., 1997a,b).

**Considerations in system development**

While a HAZOP analysis will reduce the chance of building a system containing potentially unreliable components or features, there are additional requirements that must be met to ensure the reliability and integrity of the electrical components controlling the system.

A key industry standard, guiding developers of software and electronic systems, is AS/IEC 61508 (Anon 1997) ‘Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems’, which sets out the guidelines for designing, expanding, retrofitting or modifying a system. The standard also sets out the guidelines and requirements for developing any software related to safety systems and guides the developer towards industry ‘best practice’. When an electronic system includes functions on which reliability of operations depend, a life cycle approach consistent with AS/IEC 61508 that defines the requirements of all stages of the development should be considered. A typical life cycle model is shown in Figure 2. Adherence to this standard will require a great deal of work to be done in relation to formal risk assessments, system documentation, verification and the setting up of the procedural infrastructure to allow traceability and control of system operation, maintenance and modification.
While a detailed discussion of the application of this standard is outside the scope of this paper, it is important to note that the standard makes frequent reference to the need for accepted engineering practices and the need to document that equipment complies with these standards and practices.
Application to train detection systems

Currently within the sugar industry, there are several alternative train detection systems in operation that provide solutions to the problems associated with track circuit systems. Some of these alternatives may not offer the integrity provided by track circuits located in track structures that contain free draining crushed rock ballast.

Some of the detection systems currently in operation include:

- SRI system.
- Inductive proximity switch systems.
- Inductive loop systems.
- Current loop systems.
- SRI pulsed track systems.
- Voltage loop systems.

There are several reasons why many of the early track circuit detection systems have now been replaced by factory developed ‘point sensing’ systems, e.g., increasing unreliability and the relative simplicity of programming and configuring PLC’s.

Although any one of these systems could appear to be operating reliably at an acceptable maintenance cost, only a qualitative assessment, such as a HAZOP analysis of these systems, would determine their reliability and whether their use is resolving the root causes of track circuit system failure which is poor track construction and drainage conditions.

Remote monitoring and reporting

Several recent developments for active crossings will, when adopted by cane railways, enhance reliability and lead to further reductions in maintenance costs, remote monitoring being the most significant of these. Remote monitoring systems using dedicated land lines have been developed and installed at two crossings at Moreton Mill. A more recent installation at Fairymead Mill has remote monitoring capabilities for use at some future date. The Moreton systems report their status every eight hours or immediately if a fault is detected. The installations, which use PLCs for the control unit, can be interrogated from the mill to determine the nature of the fault. If the fault is one which does not affect the operation of the lights, such as wheel miscounts by the train detection proximity sensors, the PLC can be reset from the mill.

One advantage of the system is that if a fault occurs after normal mill working hours the lights can be deactivated until the next day provided no trains are operating over the crossing during this time. This capability reduces the level of call outs for flashing light signal faults to those necessary to maintain train operations, thus significantly reducing maintenance costs and increasing productivity. These systems do not have the capacity to store data for more than three or four train crossings but are considerably cheaper to build and install compared with that described below. The development technology can also be adapted to use mobile phones, radio or other data transmission means. Data can also be downloaded from the PLC to laptop computers locally if desired.

The control system monitors for a range of system faults which include:

- Low battery supply voltage.
- Lack of continuity of the RX-5 flashing light assembly lamp. (lamp failure)
• Faulty train detection proximity switches or track circuits.
• Reset errors, i.e., the lights do not stop flashing after the passage of a train.

These fault records are transmitted via modems and landlines to an identical PLC at the factory that records the faults and provides a visual alarm. The factory PLC will also initiate an alarm state if the field unit fails to communicate at or after the prescribed time interval, thus ensuring that there has not been a complete failure of the whole crossing system.

**Data transfer for the Moreton crossings**

Data from the field PLC is transferred in the form of a multiple byte fixed length string. Each bit of the data string corresponds to an alarm state for a certain item. The more complex part of the PLC programming is the data transfer system. Each PLC had to be programmed at code level to activate the modem, set the data transfer rate, confirm connection, send the data string and disconnect from the landline. This involves being able to send commands to the modem in the form of Hayes commands. Error programming is somewhat involved as the PLC needs to have a defined outcome for events such as the landline being busy, losing connection during transfer or the failure of the remote PLC to respond. For future installation, replacing the factory PLC with a standard desktop personal computer will be a cheaper option that will also simplify the communication and data transfer protocols and enhance the type of data transmitted and its display at the factory. SMS text messaging directly to maintenance workers via mobile telephones would also provide significant advantages such as a quicker response to system failures needing immediate attention.

**Alternative system**

A system developed in New South Wales (Anon., 2000), monitors the status of the crossing warning system, logs events such as the number of operations, reports warning or failure conditions either locally within the crossing equipment or remotely to a central control centre. Typical items monitored include track circuits, power supplies, battery condition, lamp continuity and circuit integrity. Event logging retains information relating to the previous 10,000 events or changes to equipment status. This number represents about 150 train passes over the crossing. These monitoring systems can also be programmed to remotely test crossing items such as battery condition if required. In operation, the monitor scans all its inputs every 250 ms. If a fault or change is detected then a new record which displaces the oldest previously logged record is added to the log. A daily status report is automatically sent to the central control office. Because radio and mobile telephones are frequently used, these transmissions usually occur in the early hours of the morning when other traffic is at a minimum.

**Innovations**

As cane railways move towards in-cab data receive and transmission, the system discussed could easily be adapted to provide locomotive drivers with in-advance indications of the operational status of flashing lights. To avoid unnecessary transmissions, only the status of those light installations located on the route of a particular locomotive would be displayed on the in-cab monitor.

External test switches are also used by railway systems for crossing monitoring. These switches, which are accessed by track maintenance staff, provide only a limited indication of the status of the crossing equipment. In addition to the off position, the three position switch activities all lights (position 2) and checks battery charge (position 3). Inoperative lights or low battery volts
must be reported for action by qualified staff. Additional switch positions, which puts a battery load indicator in circuit and closes a relay to simulate the train detection circuits, would enhance the installation.

Davis (1998) recommended that amber rotating beacons be installed on the tops of poles supporting the RX-5 assemblies. Although the initial intention for these beacons was to provide an economic solution for notifying train drivers that the flashing light signals were operating, their presence has enhanced the visibility of the crossing to approaching road users. It is too early at this stage to make definitive statements regarding the effectiveness of these beacons, but a reduction in incident reports for Burdekin Mills has been realised (Ballard, 2001).

One innovative approach to crossings in environmentally sensitive areas is the use of locomotive type horns mounted on each of the posts supporting the flashing light signals. The sound output from each horn is directed towards the approaching road traffic each side of the crossing. The start and cut off points for the horns are triggered from the train detection systems.

**Summary**

The number of active level crossing systems on cane railways will increase as cane land expansion occurs and urban developments continue to grow. The need to maintain these installations in a cost effective manner becomes more critical with time. The HAZOP approach has been used successfully to guide factory technical personnel in the development of viable and acceptable solutions to address these needs. Remote monitoring and central reporting can further enhance level crossing system performance and reliability. Such remote sensing systems have shown benefits in increasing effective reliability by minimising the duration of periods when the systems are faulty. In addition they have reduced call-outs, especially when flashing light installations can be switched off remotely at crossings over which no trains will pass until the following working day.

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**REFERENCES**
