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Are the Intrinsically Safe Loops in Your Process Compromised by the CRT in Your Control Room?

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February 26, 1991

Technical Paper

TP91-1

Bailey Seamless, Real-Time Process Management Solutions

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Electrical equipment used where flammable vapors may be present must be designed so that they are not an ignition source. One method of accomplishing this for low power equipment (for example 4-20 mA transmitters and positioners) is to install such equipment in an intrinsically safe loop. These loops are energy limited so that likely faults in the equipment or wiring will not create an ignition capable spark.

The energy limitation for intrinsically safe loops typically is accomplished with an intrinsic safety barrier. The use of barriers eliminates the need to investigate the control equipment connected to the transmitters and positioners. However, the now popular use of cathode ray tube monitors may invalidate the FM, UL, or CSA certification of the barriers and result in a system that would be rejected by inspectors.

The difficulty arises from the fact that the vast majority of intrinsic safety barriers have either a marked or a presumed voltage limit that applies to the control equipment. This limit may be specified as:

Max. safe area voltage 250 V or
Vmax < 250 V r.m.s. or
Unspecified Equipment V < 250 V

The intent of the limit is to inform the user that faults in the control equipment should not result in more than 250 V being applied to the barrier. ANSI/ISA RP12.6 1987 explains this as follows:

> Associated apparatus and control room apparatus connected to it shall not be powered by more than 250 V (rms or dc, line to line or line to ground) and shall not generate any voltage internally in excess of this value.

Similarly, the Appendix F of the Canadian Electrical Code states:

> F3.1.3 Control room equipment ... shall not be powered by more than 250 V rms ac or dc, line to line or line to ground, and shall not generate internally any voltage in excess of these values unless the barrier device or the associated apparatus is specifically approved and marked for a higher voltage or the equipment itself is approved and marked to permit connection.

Since the control equipment should not contain any voltage sources higher than 250 V, the obvious conclusion is that a monitor using a high voltage cathode ray tube (CRT) may not be used if intrinsically safe loops are installed.

This may be a surprising statement to many individuals since CRTs are becoming a way of life in virtually all new installations and retrofits. The intent of this article is to explain the problem and identify solutions being used.

The issue was first brought to the attention of the Instrument Society of America (ISA) SP12 committee by a major manufacturer of process control equipment. This manufacturer ran a simple test in which the high voltage on the cathode ray tube (CRT) was allowed to discharge on to the signal wiring to an intrinsic safety barrier. In order to show the ineffectiveness of the barrier, the discharge was not even made to the signal terminal, but to the signal return terminal (see FIGURE 1). The signal return terminal was then connected to ground with several feet of 12 AWG wire. The resistance of this length of wire was only a small fraction of the maximum one ohm resistance permitted. Although the discharge lasted only microseconds, the high current elevated the barrier ground terminal several hundreds of volts causing the signal return to arc in the hazardous location to grounded metal. The arc was ignition capable.

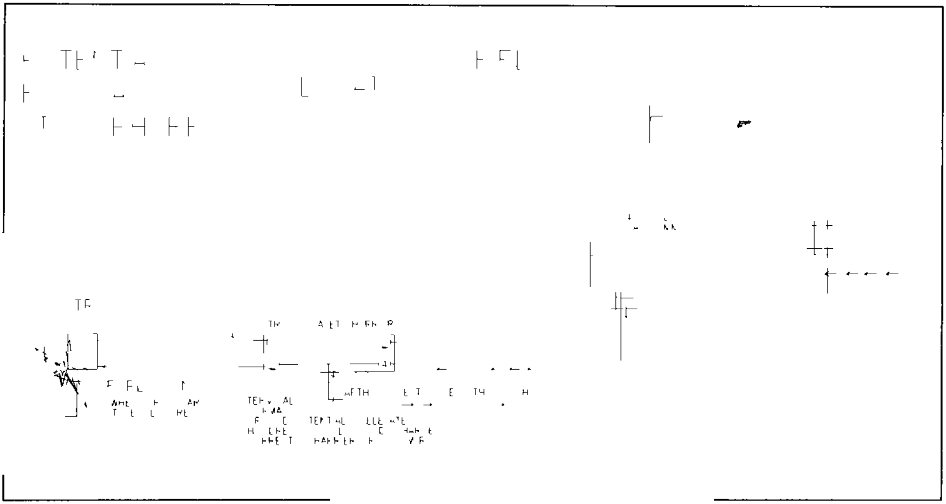

FIGURE 1 Test Circuit Showing CRT Fault Elevating Return Signal and Causing Noise at Field Equipment

The test demonstrated that the barrier components were irrelevant. The arc will occur independent of the zener type, the fusing, the transient limiting, or any other barrier parameter. IT IS NOT POSSIBLE FOR THE INTRINSIC SAFETY BARRIER TO PROVIDE THE NEEDED PROTECTION. The fault current in the ground lead was the problem.

Fortunately, at the time of this demonstration it was clear that manufacturers ordinarily provided significant separation between the CRTs in the control room and the intrinsic safety barriers in the equipment cabinets. Some manufacturers had several intervening circuit boards and cables such that the energy in the discharge was dissipated destroying these circuit boards. These manufacturers were able to demonstrate that the maximum voltage applied to the barrier during a fault never exceeded 250 V. Other manufacturers separated the CRT from the barriers by a data highway. Each end of the data highway was protected by surge suppressers to absorb line transients. Again, it was possible to show that the maximum voltage reaching the barriers still did not exceed 250 V. In essence, the large fault current had been routed away from the intrinsic safety barrier ground lead to other parts of the system.

An additional consideration is the significant risk to semiconductor devices posed by the high voltage and the energy stored within the CRT. Monitor manufacturers provide arc suppressers around the CRT in order to short circuit arcs or sparks directly to the flyback transformer. Also, it is general practice to ground the second anode return so that as much as possible faults will not propagate outside the enclosure. This directly affects whether or not energy likely will be dissipated internally or externally to the monitor.

A final consideration is the safety hazard caused by the 15,000 to 30,000 second anode voltage. The efforts made to provide user safety by isolating the high voltage also would be expected to provide isolation to reduce the risk of igniting an explosive atmosphere. CRT Monitors primarily fall under the Safety Standards for data processing equipment, UL 478 and CSA C22.2 No. 220. These standards do not contain specific guidelines for segregating the high voltage from the signal circuits, but rely primarily on a dielectric strength test. This provides approximately a 33% test factor. Underwriters Laboratories also requires both that listed wire be used and that the connection to the CRT be securely fastened. Still, these gu de nes do not appear to ensure adequate separat on of c rcu ts ndeed t s not uncommon to see the h gh vo tage second anode ead touch ng or read y ab e to touch other c rcu ts

The Br t sh ndustr a Measur ng and Contro Apparatus Manufacturers Assoc at on (B MCAM) addressed th s ssue n a 1979 nter m code of pract ce They stated the fo ow ng

> The major ty of systems wou d requ re a mu t p c ty of fa ures for the h gh vo tage of the CRT to break through to the barr er term na s Where the r sk of break through to the barr er cannot be read y assessed to be better than 10 ^{16}/annum then add t ona protect on n the form of an adequate y rated h gh vo tage suppresser for each CRT s gna term na shou d be used S nce th s protect on s a secondary safeguard no dup cat on of the components w th n the un t s necessary but the suppresser shou d be capab e of safeguard ng aga nst the fu range of vo tage and current pu ses wh ch can be env saged from the ava ab e power source When a system connected to safety barr ers conta ns a CRT then the safety documentat on shou d conta n a c ear statement that the h gh vo tage s adequate y segregated or made safe by the use of surge suppressers Th s statement may be made e ther by the supp er of the system the CRT manufacturer or the end user

The grow ng need to ocate CRTs outs de of the contro room e ther n the equ pment room or at the process tse f makes t ess ke y that nterven ng equ pment or data h ghways w prov de the needed surge protect on Fundamenta y f the d scharge of the anode s a owed to eave the CRT enc osure there s the poss b ty that an gn t on capab e arc can occur As demonstrated n the exper ment the ground term na s themse ves can be e evated hundreds of vo ts to the po nt that c rcu ts rated on y for a 500 vo t d e ectr c w arc to grounded meta and prov de an gn t on source

The ma n thrust of protect ng CRTs so that they are su tab e for use w th equ pment connected to ntr ns ca y safe oops s e ther to prov de an extreme y good nterna return path w th n the CRT enc osure or to prov de separat on that s un ke y to be defeated At th s t me the cha enge wou d seem to be w th the CRT mon tor manufacturers to des gn un ts n wh ch t s extreme y un ke y that the second anode vo tage wou d arc to s gna w r ng and cause a arge fau t current to ex t the enc osure Ensur ng that fau ts wou d be un ke y to comprom se the bas c nsu at on on the second anode w re cou d be accomp shed by spac ng the second anode w re from other c rcu ts per TABLE 1 enc os ng the second anode w re n a grounded bra ded meta s eeve (bonded at the f yback transformer) or enc os ng the second anode w re n a second protect ve jacket Where none of the above s appropr ate each s gna ead eav ng the enc osure cou d be protected w th n the CRT by a trans ent suppressor

Voltage	Spacing
20 kV	35 mm (1 4)
25 kV	45 mm (1 8)
30 kV	55 mm (2 2)
35 kV	65 mm (2 6)
40 kV	75 mm (3 0)

TABLE 1 Spacings Based Upon FIG 7 of IEC 664A

n conc us on tests performed to date as we as ex st ng f e d exper ence has shown that where cathode ray tube mon tors are not mounted n the same enc osure w th ntr ns c safety barr ers there s no s gn f cant r sk of a fa ure n the mon tor caus ng an unsafe cond t on at the ntr ns c safety barr er However when ntr ns c safety barr ers share a common enc osure w th a CRT then add t ona eva uat on shou d be performed to determ ne whether the h gh vo tage can fau t to s gna c rcu ts and the consequences of such a fau t

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