Bailey
control systems

Technical Guide

TG99-73

Selecting Field Equipment For Use In Flammable Atmospheres

Introduction

The Chemical Process Industry (CPI) has numerous areas which are potentially explosive or flammable because of gases or dusts in the air. Careful attention must be exercised in the selection and installation of electrical equipment used in these areas to insure hot or arcing components do not ignite the gases or dusts. This Technical Guide provides specific guidelines for using Bailey electronic Transmitters and Positioners in these areas.

Hazardous Locations

Areas in which a flammable (explosive) atmosphere may occur are defined as "Hazardous (Classified) Locations" by the National Electrical Code (NFPA 70). The flammable atmosphere results from the presence of ignitable concentrations of gas, dust, or fibers in the air. Area classification is by Class, Division and Group in North America. (The European system of Zone and Group classification is further detailed in Appendix B).

Class

Hazardous Locations are subdivided into three classes:

Class I for gases
Class II for dusts
Class III for fibers

Division

Each Class is further subdivided into either Division 1 or Division 2.

Division 1 hazardous locations are areas where the flammable atmosphere occurs during normal operation. Examples of Division 1 areas would be around paint spraying operations or where flammable liquids or vapors could escape from open tanks, indoor vents, indoor hose couplings, and inadequately ventilated indoor pumps and valves.

Division 2 hazardous locations are areas where the flammable atmosphere only occurs because of an infrequent failure. Typical failures may be leakage from pump and valve packings, leakage from sealed containers, or failure of purging or ventilating systems.

Group

The flammable materials are divided into groups to help describe the nature of the material and the ease of ignitability. The ease of ignitability is primarily based upon how small the gap must be between flanges on an explosion proof enclosure. Any gases (or dusts) exploding internal to the enclosure must be cooled as they pass out through the enclosure flanges to insure they will not ignite the external flammable atmosphere. Gases which either require a "large" amount of energy to ignite or which have "weak" explosions permit the use of large flange gaps. Gases in Groups A and B ignite at low energy levels with a strong explosion. Thus, they require an enclosure with very small gaps. Groups C and D allow progressively larger gaps.

Division 1 Applications

Bailey transmitters have been designed and certified with two different protection methods to allow their use in “normally” flammable atmospheres These methods are explosionproof enclosure and intrinsically safe installation

The AP Positioners have only been certified for intrinsically safe installation

Explosion Proof

Explosion proof certification assumes that the gas will penetrate the enclosure and will be ignited by the internal electrical circuit The requirement is to prevent the internal explosion from propagating to the outside of the enclosure and igniting the external flammable atmosphere If the atmosphere contains a dust, then this design is referred to as dust ignitionproof Primary design guidelines are

1 Insure that enclosure will withstand an internal explosion (this usually necessitates thick, heavy metal),

2 Insure that hot gases are adequately cooled before they reach the outside of the enclosure (this requires wide flanges and several thread engagement of covers and conduit),

3 Mark the unit to show which flammable atmospheres are permitted

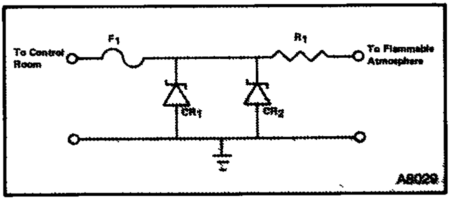
When a transmitter is utilized as explosionproof all wiring must be in rigid conduit that is properly sealed (sealing is done by pouring a special compound into the conduit) This type of installation is time consuming, costly, and difficult to modify once assembled The covers must always be kept fully on the transmitters

Intrinsic Safety

Intrinsic safety certification assumes that even if the dust or gas penetrates the field equipment's enclosure, it will not be ignited because the energy available in the field equipment is less than the energy required to ignite the atmosphere The energy required is greatly dependant upon the material and varies from 17 micro-Joules for hydrogen and 200 micro-Joules for propane to 60,000 micro Joules for coal dust Again, the equipment must be marked to indicate which flammable atmosphere is suitable

Intrinsic safety certification allows the use of ordinary location wiring in place of rigid conduit This makes the circuits much easier to install and modify However since the wiring is not protected by conduit it is assumed that the wires could short, open or ground Therefore, the energy must not only be limited internal to the field equipment, but must also be limited in the field wiring The normal method of doing this is to place an Intrinsic Safety Barrier in a location external to the flammable atmosphere This barrier limits the voltage and the current which can flow in the wiring and in the field equipment

Intrinsic Safety Barriers can be either active or passive A typical passive barrier contains four essential components as shown below



CR1 and CR2 are redundant diodes which prevent the voltage from exceeding a specified value Typical values run from 1 volt for thermocouples to 30 volts for the 24 V dc 4-20 mA transmitters and positioners F1 is a fuse that protects the diodes from open circuit failure R1 is a series resistor to prevent the current from exceeding a specified value The value of this resistor can range from 10 to over 400 ohms The value depends upon the voltage level of the diodes and the group classification of the flammable atmosphere This additional resistance can exceed the drive capabilities of the control system

Active barriers have been designed to overcome this problem of the additional series resistance These barriers draw current from the power supply to amplify or repeat the 4 20 mA signal These barriers still use diodes to limit the voltage but use solid state devices in place of the resistors to limit the current

The selection of an appropriate Intrinsic Safety Barrier cannot be arbitrary The barrier must be evaluated to insure both intrinsic safety and proper performance

1 The intrinsic safety evaluation must verify that the energy limiting features of the Barrier for voltage and current are not compromised by the energy storage components (capacitors and inductors) in the field equipment

2 The performance evaluation must verify that the total loop resistance is low enough to allow the maximum current to flow This is normally 20 mA

Third party verification to insure that various barrier/field equipment combinations are intrinsically safe can be done using either system evaluation or entity evaluation

Intrinsic Safety System Evaluation

System evaluation involves testing a specific field instrument with a specific barrier Fault conditions are introduced into both units and tests are run to determine if ignition of a test gas will occur Under system evaluation, the laboratory certification is maintained only if the customer uses the field instrument with the specific barrier tested by the laboratory

Bailey Positioners and Transmitters have Factory Mutual system approval with specific barriers manufactured by Bailey, Leeds & Northrup Foxboro, Taylor and Westinghouse These specific barriers are designated by the prefix "s' in Tables 1 thru 5

Intrinsic Safety Entity Evaluation

Entity evaluation involves testing the barriers and field equipment independently Each unit is assigned a voltage and current rating (FM) or a voltage and resistance rating (CSA) The customer can select any combination of certified field equipment and certified barrier providing the barrier parameters do not exceed those allowed by the field equipment parameters This concept is relatively new and is further explained in Appendix A

Intrinsic Safety Installation

Intrinsically safe loops are normally wired with routine wiring methods, not rigid conduit Therefore, they are considerably easier to modify Although the same explosionproof enclosure is used on the transmitters the cover and conduit openings do not have to be kept tight (fully sealed or screwed down) unless there are dusts present (Class II and Class III hazardous locations) The additional expense for the barrier can be a major consideration in these installations

Miscellaneous Field Equipment

Other equipment which is frequently used in a flammable atmosphere include thermocouples, RTDs, switches solenoids, lamps, analog meters and digital displays The selection of barriers for these units is discussed in Application Guide 999-14

Division 2 — Applications

Bailey Transmitters have been designed and certified with three different protection methods to allow use in locations which become flammable "by a failure" Both the explosionproof enclosures and the intrinsically safe installations are allowable Each must be implemented with the same strictness as if a Division 1 hazardous location The third method is as nonincendive The Positioners and many of the 7000 line products have also been designed and certified as nonincendive

Nonincendive

Nonincendive certification assumes that the flammable gas, dust, or fibers will only be in the environment as a result of an infrequent failure The field equipment is evaluated to insure that during normal operation, it does not release enough energy in the form of sparks or hot components to cause ignition of the flammable atmosphere It is extremely unlikely then that a failure would occur which would cause a flammable atmosphere to exist at the same time that a fault in the equipment would occur which would be capable of igniting the flammable atmosphere The evaluation to verify a nonincendive rating consists of analyzing all 'arcing parts and all thermally hot parts Arcing parts include relays, switches motors, thermostats, potentiometers, connectors, fuseholders and lampholders The analysis must show that either arcing cannot occur in normal operation or that the arcing is energy limited to a level below the ignition energy of the flammable atmosphere

The advantage of the nonincendive rating is that the installation does not require intrinsic safety barriers nor must the wiring be placed in rigid conduit Typical wiring used is Power Limited Tray Cable (PLTC), a designation assigned by Underwriters Laboratories The usual nonincendive rating obtained for Bailey field equipment is for Class I, Division 2 Groups C and D

References

This summary about hazardous locations is intended to help put the various terms in an overall context The terms have not been rigorously defined For more exacting definitions and specific code, standard and certification requirements refer to the following

ANSI/UL 913 1988 'Intrinsically Safe Apparatus '

ANSI/ISA S12 12 1984 "Electrical Equipment for Use in Division 2 Locations'

CSA C22.2 No. 25 (1966) "Enclosures for Use in Class II Locations"

CSA C22.2 No. 30 (M1986) "Enclosures for Use in Class I Locations"

NFPA 70 (1990) "National Electrical Code"

Bailey Instruction 4576K16 034 (1981) "Type 766 Barrier Units"

Appendix A

Bailey Field Equipment Under Entity Evaluation

The entity evaluation provides a method for specifying independent barrier parameters and independent field equipment parameters. The barrier parameters are normally determined by testing under fault conditions. The field equipment parameters are usually specified by the manufacturer. These field equipment parameters are then used by the testing laboratories to insure that the equipment will not ignite the flammable atmosphere when operated at these parameters. The tests also include induced faults. During these faults, the components in the equipment may be subject to voltages and currents several times the normal levels.

Once the field equipment is certified to the specified parameters, the customer can select any certified barrier that does not exceed these parameters and use the combination without any further evaluation by the testing laboratory.

EXAMPLE: The Bailey BC Transmitter is rated V_{max} = 40 V dc and I_{max} = 332 mA under the Factory Mutual entity method. This would allow the use of any FM entity approved barrier with a V_{OC} rating of 40 V dc or less and an I_{SC} rating of 332 mA or less.

EXAMPLE: The Bailey BC Transmitter is rated by CSA to be suitable for any certified barrier that does not exceed 30 volts and has a series resistance of at least 250 ohms. CSA has also certified the BC for barriers with less resistance if the voltages are appropriately lower such as 40 ohms minimum if the voltage does not exceed 10 volts.

The primary advantage of entity certification is that the user is given flexibility in the initial selection of the barriers and field equipment and then maintains the flexibility of replacing field equipment with newer or better units.

Bailey field equipment has been designed and certified to be used with the broadest range of barriers.

CSA Entity Listing

The entity parameters assigned by CSA are the maximum voltage and minimum resistance that the associated barrier may have. The parameters selected for the field equipment are usually based on actual barrier parameters; this is in contrast to the FM system discussed later. As a consequence several sets of parameters must be selected to cover the range of available barrier ratings. The sets of Maximum Voltage/Minimum Resistance ratings usually selected are 32V/400 ohms, 28V/270 ohms, 22V/150 ohms, and 10V/40 ohms for Groups A thru G flammable atmospheres. The resistance can be lower if Group A and B gases are not of concern. The sets of ratings for Group C thru G flammable atmospheres are 33V/200 ohms, 28V/120 ohms and 10V/40 ohms. Table 8 lists the sets of barrier parameters certified for the various Bailey products. Different parameter sets were primarily due to different barriers being available when the submittals were made. The barriers compatible with Bailey field equipment from an intrinsic safety evaluation are shown in Table 7.

V_{max} is the maximum allowed supply voltage which may be applied to the barrier. Voltages above the tabulated value may cause permanent damge. Re-e is the end to end resistance of the barrier. This is the maximum possible resistance that the barrier adds to the loop. Both V_{max} and Re-e are used to verify the performance of the barrier/field equipment combination.

FM Entity Listing

The entity parameters assigned by FM are the maximum voltage (V_{max}) and the maximum current (I_{max}) that the field equipment can "safely" receive. Barriers are assigned an open circuit voltage (V_{oc}) and a short circuit current (I_{sc}). Barriers which have a V_{oc} exceeding the V_{max} rating or an I_{sc} exceeding the I_{max} rating may not be used. Since the lower voltage barriers have higher current outputs, the ratings assigned to the field equipment are not representative of an actual barrier. The parameters selected for Bailey Transmitters and Positioners are 40 V_{max} and 332 mA_{max}. The barriers compatible with Bailey field equipment from an intrinsic safety evaluation are shown in Table 6 resolve this problem. The barriers compatible with Bailey field equipment from an intrinsic safety evaluation are shown in Table 6.

Performance Evaluation of Barrier/Field Equipment

The barriers which are acceptable under the FM and CSA entity requirements must now be evaluated to insure that the additional resistance added to the loops will not be excessive.

Active barriers minimize the problem and often provide more load handling capability than the basic system. Examples of active barriers are MTL's 322 and

2441 for transmitters and MTL's 2442 for positioners. In addition, some barriers are suited more for systems other than Bailey's. Foxboro, Honeywell and Taylor systems provide either grounded returns or lower feedback voltages to insure that their barriers can be used with typical transmitters and positioners. Intrinsic safety loops with these barriers are shown in Figures 1-4, 7, and 9.

Barriers used in transmitter loops often provide a 250 ohm resistor internal to the barrier. This converts the 4-20 mA signal to a 1-5 V dc signal and eliminates the series resistance of the return barrier from the 4-20 mA loop. These barriers are shown in Figures 3 and 5. Eliminating the series resistance of the return barrier can also be accomplished by mounting a 250 ohm resistor to the return barrier as shown in Figure 6.

The power supply is often critical in intrinsically safe loops. If the voltage is too high it will destroy the barrier by 'blowing' the nonrepairable internal fuse. Yet, if the voltage is too low, the 20 mA current cannot be achieved. Normally, a 24 V, ±1 V supply is sufficient for Group A/B flammable atmospheres only if active barriers are used. Passive barriers will usually require a 25 or 26 volt power supply. The regulation/stability of the supply should be ± 0.1 volts.

Bailey controllers in the NETWORK 90® and 7000 systems utilize a 250 ohm reference resistor in the return leg. This requires that the lower barrier be a minimum of 5 volts. A grounded return leg may not be used. In order to minimize the resistance in the return barrier, a low voltage barrier or a barrier with diode returns is used.

Tables 1 thru 5 show the matching requirements for functional performance. The primary specification tabulated is the allowed cable resistance. Each 1 ohm of allowed cable resistance is equivalent to 200 feet of 14 AWG wire, 125 feet of 16 AWG wire or 30 feet of 22 AWG wire. The use of the optional EMICO 35 WT meter is equivalent to 15 ohms of cable resistance.

Table 1 is for transmitters used with Bailey systems. Cable resistance is dependent upon the power supply voltage.

Table 2 is for transmitters used with non-Bailey systems. Cable resistance is not always dependent upon the power supply voltage.

Table 3 is for AP7 Positioners used with Bailey systems. Cable resistance is dependent upon the system drive capabilities which is 750 ohms for 7000 line, 600 ohms for standard NETWORK 90 systems, and 850 ohms for NETWORK 90 systems with 26 volt power supplies.

Table 4 is for AP7 Positioners used with non-Bailey systems. Cable resistance is again dependent upon the system drive capability.

Table 5 is for AP8 Positioners (servo portion only). There is no maximum loop resistance specification. The total loop resistance does affect the drive current. The drive current greatly affects the speed of operation. Therefore, the tabulated specification is the drive current and not the allowed cable resistance. The cable resistance is assumed to be 10 ohms. The AP8 feedback portion is a 4-20 mA position transmitter. Barrier selection is done from Tables 1 and 2.

Definition of Terms Used in Figures and Tables

Rc	Resistance of all cables and wiring in the 4-20 mA loop Table 1 tabulates Rc for various supply voltages Table 2 tabulates Rc for a 24 volt supply Table 3 tabulates Rc for various Bailey systems Table 4 tabulates Rc for non-Bailey systems Table 5 assumes Rc to be 10 ohms
Rd	Maximum total loop resistance active barrier can drive
Rp	Maximum internal resistance of Bailey Positioner
Rr	Maximum added resistance by return barrier
Rs	Maximum added resistance by supply barrier
Rt	Maximum loop resistance (sum of Rc, Rs, Rr, and Rp)
V_{max}	Maximum allowable voltage to the barrier
V_{out}	Minimum output voltage from active barrier to drive loop
V_{ps}	Voltage of system power supply (nominal 24 V dc)

Appendix B

European System For Classifying Explosive Atmospheres

The European classification system for hazardous locations is substantially different from the North American system. It contains the Zone 0 concept in which the flammable atmosphere is assumed to be present on virtually a continuous basis This would occur in the air space above the tank containing a flammable liquid The European system has not effectively treated explosive dusts or fibers at this time although work is in process The following table compares the classification for various gasses

[illegible]	North American Class I	European
acetylene	Group A	Group IIC
hydrogen	Group B	Group IIC
ethylene	Group C	Group IIB
propane	Group D	Group IIA
methane (mines)	Group D	Group I

Markings used to designate the various protection methods are as follows

Ex	ia	intrinsically safe for Zone 0
Ex	ib	intrinsically safe for Zone 1
Ex	n	nonincendive for Zone 2
Ex	d	flameproof (same as North American Explosionproof)
Ex	DIP	dust-ignitionproof

TABLE 1 Transmitter Intrinsic Safety Loops CI
(Compatible with Bailey NETWORK 90® and 7000 systems)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Type of Certification by Transmitter					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250	28.0	50	170	220	270	eC-G	—	sC-G	—	eC-G	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250	28.0	[illegible]	175	225	275	eC-G	—	eC-G	—	eC-G	—
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250	[illegible]	[illegible]	[illegible]	55	105	eA-G	eA-G	eA-G	eA-G	eA-G	eA-G
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	115	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]	[illegible]	—	—	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	115	[illegible]	—	25	75	125	eC-G	eC-G	eC-G	eC-G	eC-G	eC-G
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	115	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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Gould	2	[illegible]	190	[illegible]	75	28.0	—	97	147	197	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Taylor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Taylor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Taylor	[illegible]	[illegible]	[illegible]	[illegible]	240	[illegible]	—	110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Taylor	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Transmation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—

KEY eA-G (entity certified Groups A thru G)
aC G (system certified Groups A thru G)
eC-G (entity certified Groups C thru G)
sC-G (system certified Groups C thru G)
eD (entity certified Group D only)
sA D (system certified Groups A thru D)

TABLE 2 — Transmitter Intrinsic Safety Loops
(Compatible with non-Bailey systems)

[illegible]

KEY eA-G (entity certified Groups A thru G)
eC-G (entity certified Groups C thru G)
sA-G (system certified Groups A thru G
sC-G (system certified Groups C thru G)

TABLE 3 — Positioner Intrinsic Safety Loops
(Compatible with Bailey NETWORK 90® and 7000 systems)

AP63 POS T ONER (132 ohms)

[illegible]

AP73 POSIT ONER (350 ohms)

[illegible]

TABLE 4 — Positioner Intrinsic Safety Loops (Compatible with non-Bailey systems)

AP73 POS T ONER (350 ohms)

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
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KEY eA-G (entity certified Groups A thru G) sA G (system certified Groups A thru G)
eC-G (entity certified Groups C thru G) sC G (system certified Groups C thru G)

TABLE 5 — Positioner Intrinsic Safety Loops (Compatible with Bailey NETWORK 90® and 7000 systems)

AP83 POSITIONER (650 ohms) Servo portion only [4-20 mA Transmitter for feedback needs separate barriers]

The resistance Rp of the AP83 Positioner is dependant upon the dip switch setting

The minimum resistance of 650 ohms is obtained by closing all four switches
The speed of operation is greatly dependant upon the series resistance and the operating temperature
At 25 degrees C the approximate time from 0 to 100 % travel is as follows

5 seconds @ 34 mA drive current
15 seconds @ 17 mA drive current
25 seconds @ 13 mA drive current
50 seconds @ 10 mA drive current

Fault analysis of the Return Barriers must assume their outputs are shorted together through the low resistance of the motor coil resistor (45 ohms), therefore, they must be higher resistance than normal or contain blocking diodes

Suitable barriers are limited to the following

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Drive current for various voltages #		
									[illegible] mA	[illegible] mA	[illegible] mA
MTL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.3	[illegible]	17	20	[illegible]
MTL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.3	[illegible]	17	20	22
STL	[illegible]	[illegible]	[illegible]	377	[illegible]	[illegible]		1717	12	13	14
STL	[illegible]	[illegible]	[illegible]	377	[illegible]	[illegible]	2.0	[illegible]	17	19	21
Stahl	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	41	2.0	[illegible]	21	[illegible]	[illegible]
Stahl	[illegible]	[illegible]	[illegible]	212	8901/33-275/000/30	41	2.0	913	20	22	25

\# 1 5 volts is subtracted for the voltage drop across the solid state contacts in the NETWORK 90 digital outputs

TABLE 6 — 1984 FM Entity Approved Intrinsic Safety Barriers

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
STAHL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABLE 7 — 1984 CSA Blue Book Listing Intrinsic Safety Barriers

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	27	[illegible]	28.0	344
			[illegible]	40	10.0	260
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28.0	373
			[illegible]	40	10.0	52
[illegible]	[illegible]	[illegible]	27	150	28.0	162
			[illegible]	40	10.0	250
[illegible]	[illegible]	[illegible]	[illegible]	150	28.0	168
			[illegible]	40	10.0	52
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	268
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25.5	118
[illegible]	[illegible]	[illegible]	[illegible]	100	15.0	180
[illegible]	110	[illegible]	[illegible]	[illegible]	9.4	80
	[illegible]	[illegible]	[illegible]	[illegible]	27.0	340
	[illegible]	[illegible]	[illegible]	[illegible]	27.0	340
			[illegible]	[illegible]	9.4	80
	[illegible]	[illegible]	[illegible]	100	[illegible]	N/A
	[illegible]	[illegible]			32.0	N/A
	[illegible]	[illegible]			[illegible]	N/A
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
			[illegible]	40		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	377
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	212
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	219
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	7.3	113
	[illegible]	[illegible]	[illegible]	[illegible]	26.0	140
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	180
	[illegible]	[illegible]	[illegible]	[illegible]	7.7	78
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	400
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	400
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	175
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	175
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	240
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	300
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	282
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	282

TABLE 8 — CSA Certified Parameters for Allowed Barriers

	[illegible]			[illegible]							[illegible] suitable for Groups C — G				
Number	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30V 120 ohm	30V 150 ohm	33V 280 ohm
[illegible]	[illegible]		no		X	X		X		X		X		X	X
[illegible]	[illegible]		no		X	X		X		X		X		X	X
BD	[illegible]	EFG	yes		X	X		X		X	X			X	
EC10	[illegible]	EFG	yes	X			X		X				X		X*
[illegible]	[illegible]	EFG	yes		X	X		X		X	X			X	
RG	[illegible]	FG	yes	X	X		X				X			X	

* 150 ohm Va ue

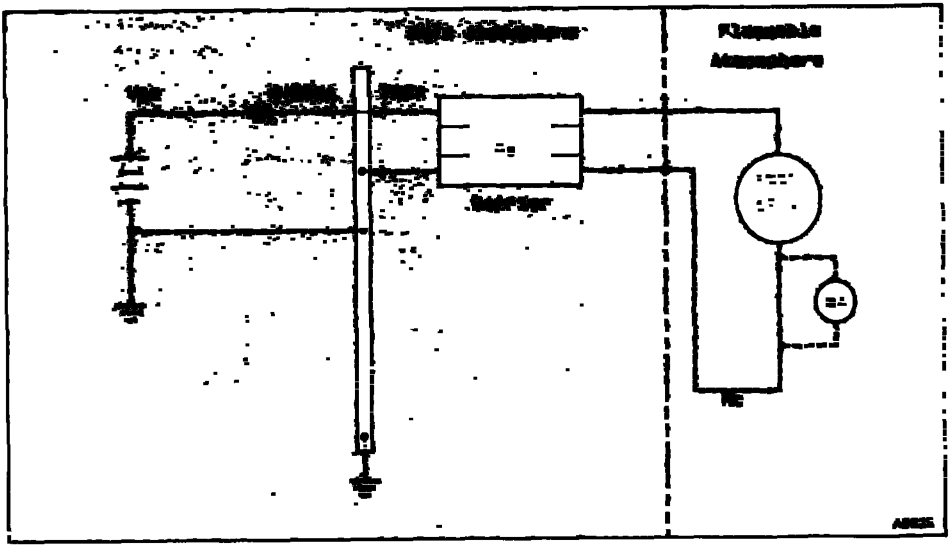

FIGURE 1 — Transmitter with Single Barrier and Grounded Return

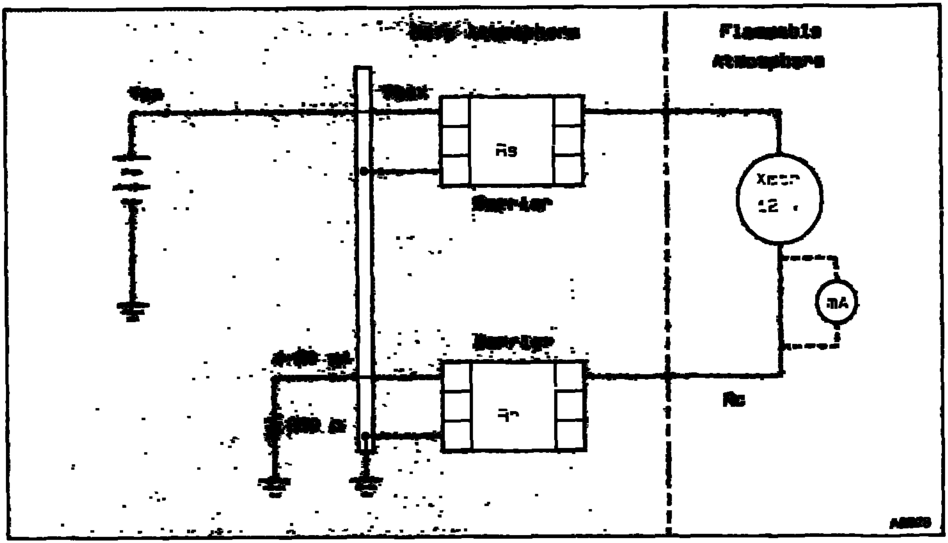

FIGURE 2 — Transmitter with Return Barrier and 4 to 20 mA Signal to Controls

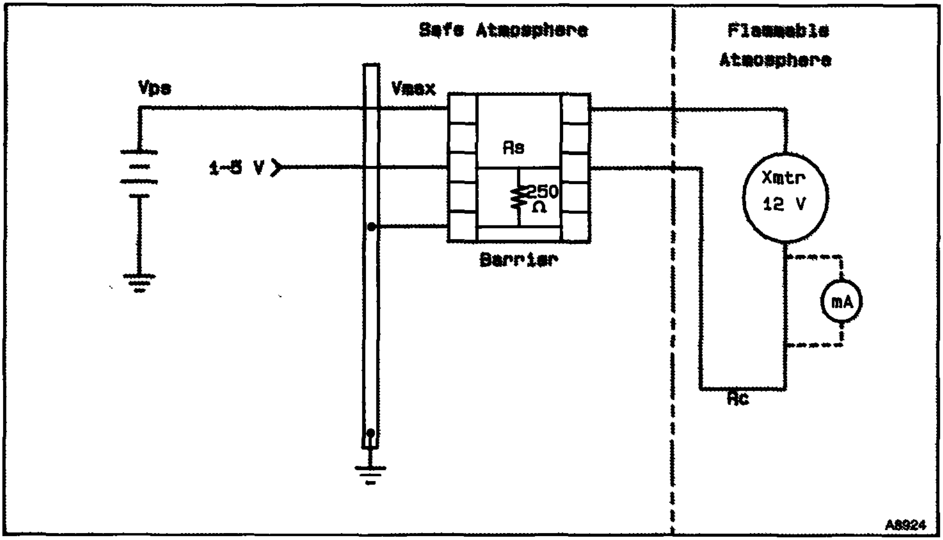

FIGURE 3 Transmitter with Dual Channel Barrier and 1-5 V Signal to Controls

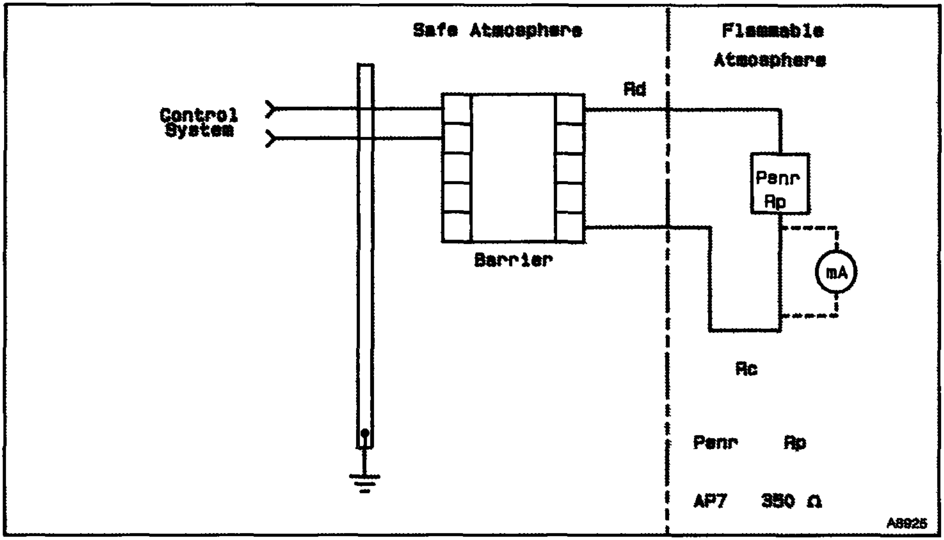

FIGURE 4 — Transmitter with Active Barrier

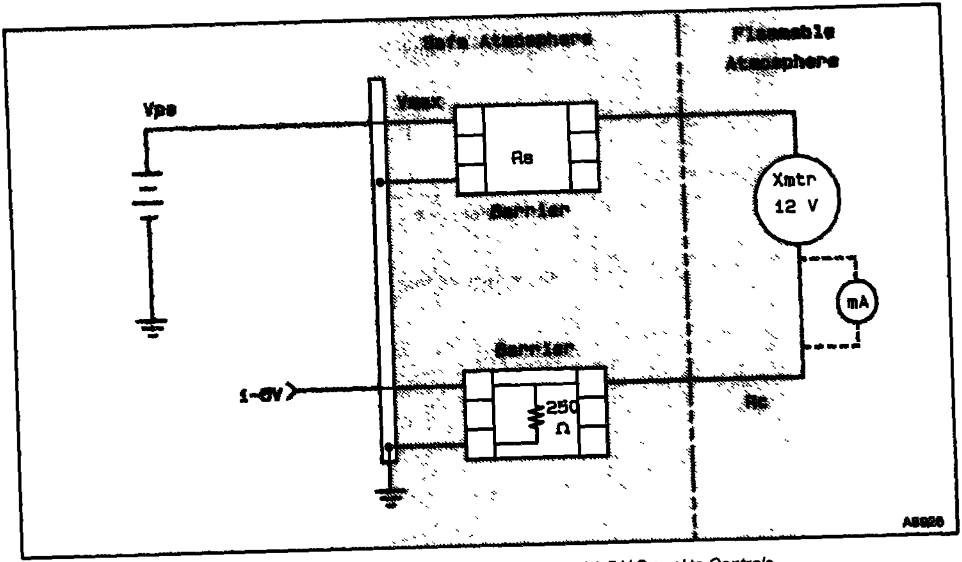

FIGURE 5 — Transmitter with Return Barrier and 1-5 V Signal to Controls

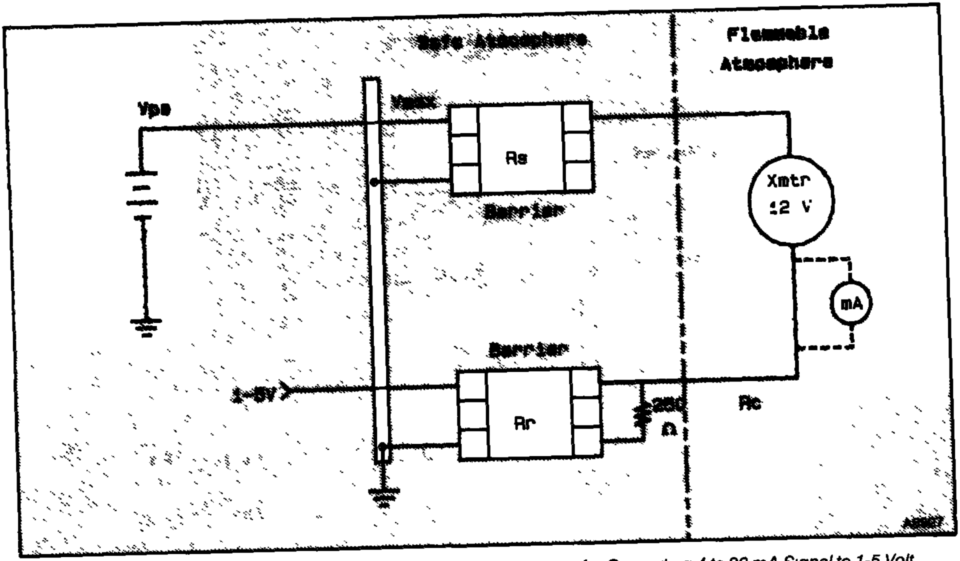

FIGURE 6 Transmitter with Return Barrier and External Resistor for Converting 4 to 20 mA Signal to 1-5 Volt

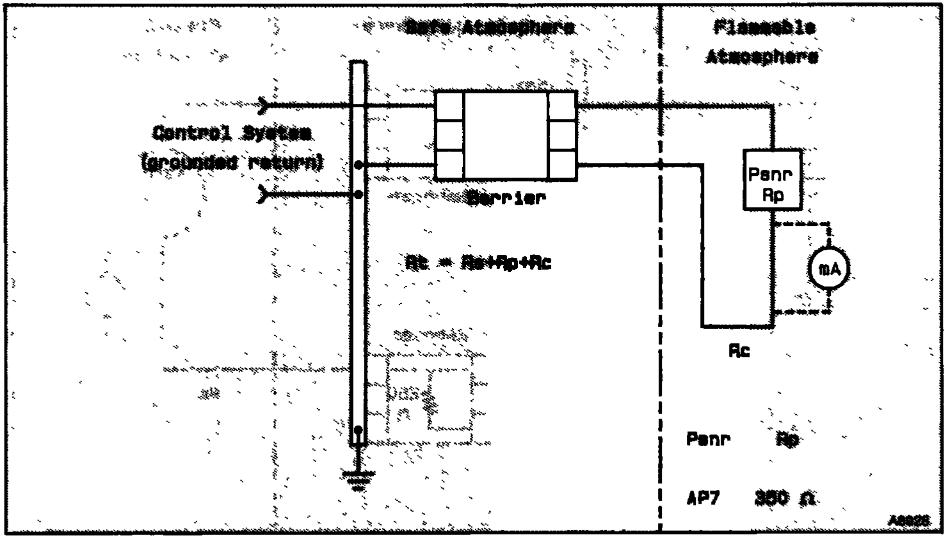

FIGURE 7 Positioner with Single Barrier and Grounded Return

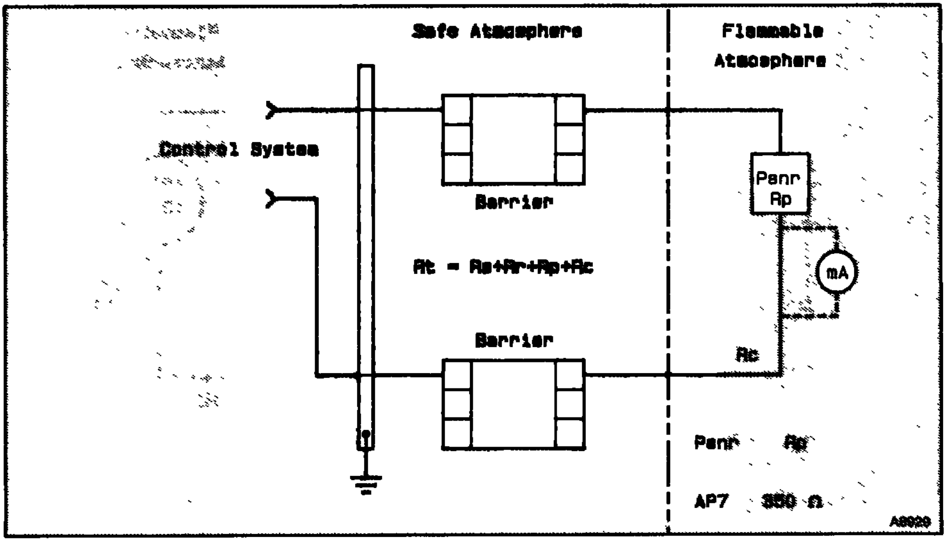

FIGURE 8 Positioner with Return Barrier for Bailey-type Controls

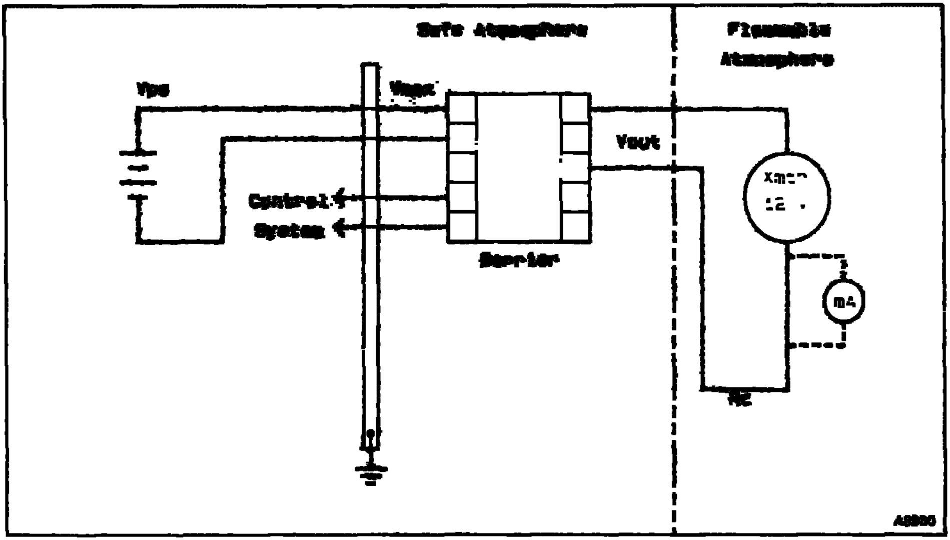

FIGURE 9 Position with Active Barrier

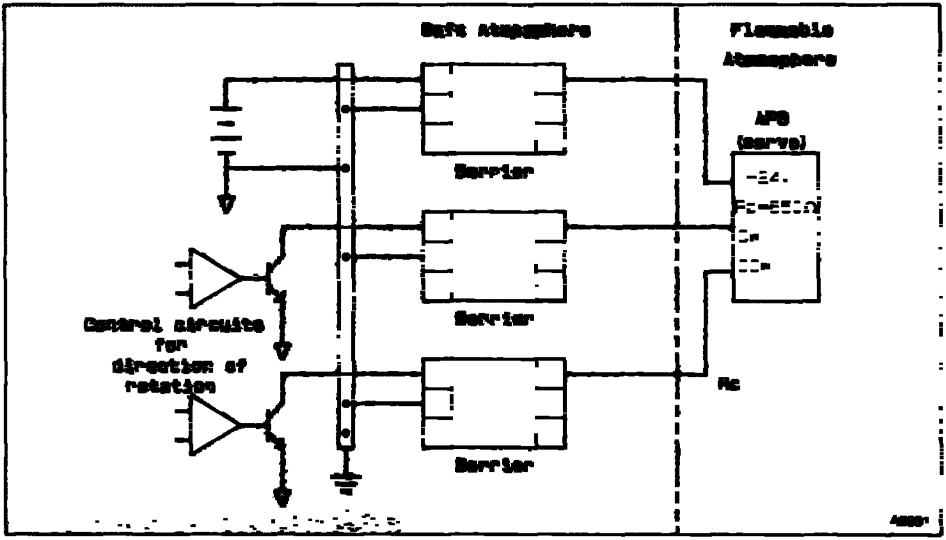

FIGURE 10 — AP8 Positioner (Servo) with three Barriers

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