

1. Introduction

This application guide describes the BA354D and BA358C intrinsically safe 4/20mA loop powered rate totalisers. These are ATEX certified instruments which bring the simplicity and reliability of BEKA loop powered indicators to flow measurement. Requiring no additional power supply, they may be connected in series with the output of any 4/20mA flow transmitter to provide an accurate local display of the flow rate and total flow.

Also available in this range of instrumentation are the BA354ND for use in Zone 2 hazardous areas and the BA554D and BA558C for safe area applications. Table 1 shows all the models in the range.

2. Description

The BA354D and BA358C are functionally identical, differing only in their enclosures. The BA354D is housed in a rugged IP66 GRP enclosure and is intended for field mounting, the BA358C is housed in a 144 x 72mm DIN panel mounting enclosure.

These instruments simultaneously display rate and total flow on a high contrast liquid crystal display shown in Fig 1. Rate and total may be in the same or different engineering units and the total display can be reset to zero locally, or by closure of a remote contact.

The BA354D and BA358C models comply with the European ATEX Directive and have been certified intrinsically safe for installation in all Zones and for use with all gas groups. The instruments introduce less than a 1.1V drop in the 4/20mA loop and the two input terminals comply with the requirements for simple apparatus.

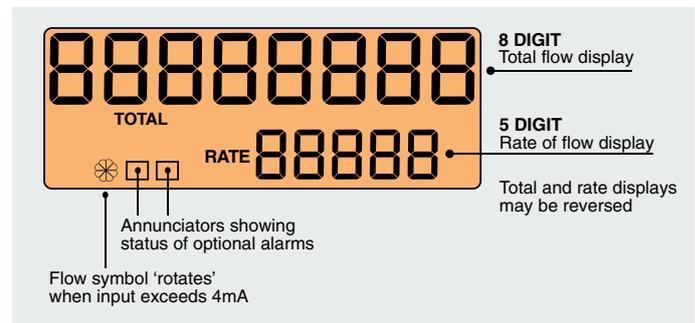


Figure 1 instrument display

This allows the BA354D and BA358C to be connected in series with almost any certified intrinsically safe 4/20mA flow loop.

If the input current falls below approximately 3mA, or the loop power supply is disconnected, the total display and all programme parameters are stored in permanent memory. The total display is automatically recovered and the instrument continues totalising when the input current is restored.

A selectable square root function enables the rate totalisers to display flow in linear engineering units when used with non-linearised differential pressure flowmeters.

Optional alarm outputs and backlighting are certified as separate intrinsically safe circuits which do not affect the instrument measurement circuit.

Model	BA354D	BA358C	BA354ND	BA554D	BA558C
					
Mounting & enclosure	Field GRP	Panel 144 x 72	Field GRP	Field GRP	Panel 144 x 72
Protection	IP66	IP65 front IP20 rear	IP66	IP66	IP65 front IP20 rear
Separate terminal compartment	Yes	No	Yes	Yes	No
Displays	Rate 4 1/2 digits 9.5mm high Total 8 digits 14mm high } can be reversed				
Certification	Intrinsically safe ATEX Group II Category 1G EEx ia IIC		Type nL for use in Zone 2 ATEX Group II Category 3G EEx nL	Not Certified Only for use in safe areas	
Options	Backlight Root extractor Internal calibrator Alarms Lineariser External keypad	Yes Standard Standard Yes Yes Standard	Yes Standard Standard Yes Yes Yes	Yes Standard Standard Yes Yes Yes	Yes Standard Standard Yes Yes Standard

Table 1: All the models in this range of instruments

Detailed specifications for all models are available from BEKA associates sales department, or may be downloaded from the BEKA web site at www.beka.co.uk

3. Intrinsic Safety Certification

3.1 European certification

The BA354D and BA358C comply with the European ATEX Directive 94/9/EC and have been issued with Group II, Category 1G EEx ia IIC T5 EC-Type Examination Certificates. Subject to local codes of practice, both instruments may be installed in any of the European Economic Area (EEA) member countries. ATEX certificates are also acceptable for installations in Switzerland.

This guide describes installations which conform with BS EN60079: Part 14:1997 Electrical Installation in Hazardous Areas. When designing systems for installation outside the UK, the local Code of Practice should be consulted.

3.2 4/20mA input

In Europe, sources of energy which do not generate more than 1.5V; 100mA and 25mW are, for intrinsic safety purposes, considered to be simple apparatus (Clause 5.4 of EN50020:2002).

Although the BA354D and BA358C rate totalisers do not themselves comply with the requirements for simple apparatus, the EC Type-Examination Certificates specify that the voltage, current and power at the 4/20mA input terminals (1 & 3) will not exceed those specified for simple apparatus. This allows these rate totalisers to be connected into any intrinsically safe 4/20mA loop providing the output safety parameters of the loop, which are defined by the Zener barrier or galvanic isolator, do not exceed:

U _o	=	30V dc
I _o	=	200mA
P _o	=	0.85W

For this reason the BA354D and BA358C rate totalisers only have an EC Type-Examination Certificate (apparatus certificate). No system certificate has been issued, or is required, for the 4/20mA input.

Note: Connection to the reset terminals and the optional display backlight are defined by the system certificates.

The EC-Type Examination Certificate specifies the maximum equivalent capacitance and inductance between the two 4/20mA input terminals:

C _i	=	20nF
L _i	=	10µH

To determine the maximum permissible cable parameters these figures must be subtracted from the maximum cable capacitance and inductance permitted by the certificate for the Zener barrier or galvanic isolator powering the loop.

3.3 Reset terminals RS1 and RS2

The total flow display can be reset to zero by temporarily connecting terminals RS1 and RS2 together. This may be accomplished in the hazardous area by any mechanically operated switch which can withstand a 500V insulation test to earth. Most industrial push-buttons are acceptable.

The output safety parameters of the reset terminals are:

U _o	=	5V dc
I _o	=	1.3mA dc
P _o	=	1.6mW

The maximum permissible capacitance and inductance which may be connected to these terminals is very large. Therefore any practical length and type of cable may be used to connect the reset switch to the instrument.

Alternatively, the rate totaliser may be programmed so that the total display is reset to zero when the *Up* and *Down* push-buttons are operated simultaneously for more than 2 seconds.

To reset the total display from the safe area a Zener barrier, galvanic isolator or intrinsically safe relay is required to transfer the contact closure into the hazardous area. The maximum input safety parameters of the reset terminals RS1 and RS2 are:

U _i	=	28V dc
I _i	=	98mA
P _i	=	0.65W

and the maximum equivalent capacitance and inductance between them is:

C _i	=	1.2nF
L _i	=	0µH

Any positive Zener barrier with output parameters less than these limits may be used. The maximum permissible cable capacitance is that specified by the barrier certificate less C_i. Again this is unlikely to be restrictive.

Alternatively, one of the positive diode return Zener barriers listed in the rate totaliser system certificate may be used - see Fig 3. These are mainly two channel devices consisting of a 28V 300ohm channel to power the 4/20mA loop, plus a diode return barrier for the reset circuit.

Almost any intrinsically safe relay, with certification permitting the contacts to be connected into the hazardous area, may also be used to reset the total display from the safe area.

3.4 Zones, gas groups and T rating

Both instruments and all accessories have been certified as Category II Group 1 G EEx ia IIC T5 (Tamb -40 to 60°C).

When connected to a suitable system the rate totalisers and accessories may be installed in:

Zone 0	explosive gas air mixture continuously present.
Zone 1	explosive gas air mixture likely to occur in normal operation.
Zone 2	explosive gas air mixture not likely to occur, and if it does will only exist for a short time.

Be used with gases in groups:

Group A	propane
Group B	ethylene
Group C	hydrogen

Having a temperature classification of:

T1	450°C
T2	300°C
T3	200°C
T4	135°C
T5	100°C

In an ambient temperature between -40 and +60°C.

Note: Although certified safe at -40°C, the instruments are only guaranteed to function between -20°C and +60°C

This allows the BA354D and BA358C rate totalisers to be installed in all Zones and to be used with most common industrial gases.

3.5 Optional alarms

Both rate totalisers can be supplied with two single pole solid state dc alarm outputs powered from the 4/20mA input current. No addi-

tional supply is required. Each alarm output is galvanically isolated and has been certified as a separate intrinsically safe circuit which, like the 4/20mA input, complies with the requirements for simple apparatus. This allows each alarm output to switch any intrinsically safe circuit protected by a Zener barrier or galvanic isolator with output parameters not exceeding:

$$\begin{aligned} U_o &= 28\text{V dc} \\ I_o &= 159\text{mA} \\ P_o &= 0.8\text{W} \end{aligned}$$

The EC-Type Examination certificate specifies the maximum equivalent capacitance and inductance between the terminals of each alarm output:

$$\begin{aligned} C_i &= 40\text{nF} \\ L_i &= 20\mu\text{H} \end{aligned}$$

To determine the allowable cable parameters, these figures must be subtracted from the maximum cable capacitance and inductance permitted by the certificate for the circuit being switched.

3.6 Optional display backlighting

Both rate totalisers can be supplied with LED backlighting to improve display contrast when the instrument is installed in a poorly illuminated area. The backlight is segregated from the measuring circuit and is powered from a separate supply via a Zener barrier or a galvanic isolator.

4. Grand total

In addition to the total display, the rate totalisers have a sixteen digit grand total counter which is not reset to zero when the total display is reset. The grand total is stored in the same engineering units as the total display and can only be reset to zero from within the programme menu. The contents of the grand total counter may be viewed while the rate totaliser is operating as shown below.

Push button	Instrument displays
<i>E +</i> <i>Up</i>	Least significant eight digits of grand total.
<i>E +</i> <i>Down</i>	Most significant eight digits of grand total.

5. System Design for Hazardous Areas

5.1 Transmitter loops

The BA354D and BA358C rate totalisers may be connected in series with almost any certified intrinsically safe 4/20mA current loop and calibrated to display the flow and total flow. There are three design steps:

1. Select the BA354D for field mounting or the BA358C for panel mounting.
2. Check that the output safety parameters of the 4/20mA measurement loop, which are defined by the Zener barrier or galvanic isolator, are less than:

$$\begin{aligned} U_o &= 30\text{V dc} \\ I_o &= 200\text{mA} \\ P_o &= 0.85\text{W} \end{aligned}$$

3. Ensure that the 4/20mA loop can support the additional 1.1V required to operate the rate totaliser.

Fig 2 illustrates how a BA354D or BA358C rate totaliser may be connected in series with a 2-wire intrinsically safe flow transmitter protected by a Zener barrier.

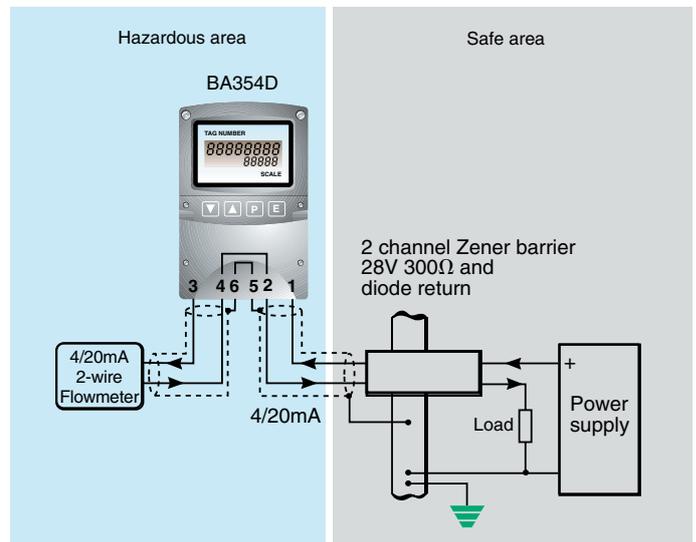


Figure 2 BA354D displaying rate of flow and total flow in hazardous area

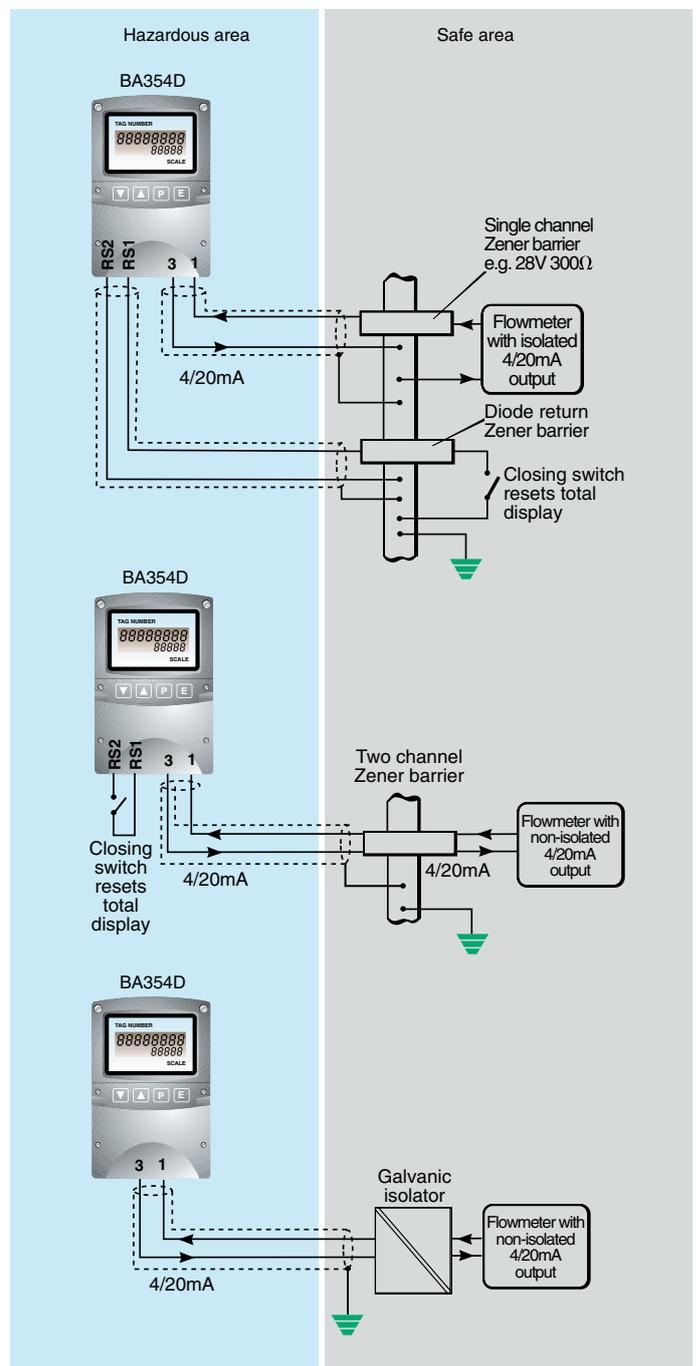


Figure 3 Alternative circuits for remote indication in a hazardous area

5.2 Remote indication

When the flowmeter is located in a safe area, the BA354D and the BA358C may be driven via an intrinsically safe interface to provide a remote indication of rate and total flow within a hazardous area. The type of interface is not critical; either a Zener barrier or a galvanic isolator may be used, but again U_o , I_o and P_o must not exceed 30V dc, 200mA and 0.85W.

Fig 3 shows three alternative circuits which may be used. If one side of the 4/20mA current loop may be earthed, a single channel Zener barrier provides the lowest cost protection. If the 4/20mA signal is not isolated, two Zener barriers, a two channel Zener barrier or a galvanic isolator must be used. Again it is necessary to ensure that the voltage capabilities of the 4/20mA signal is sufficient to drive the indicator plus the voltage drop introduced by the intrinsically safe interface.

5.3 Application of alarms

Both rate totalisers can be supplied with two single pole solid state alarm outputs. Each may be programmed as a high or a low, rate or total alarm with a normally open or a normally closed 'contact'. Fig 4 illustrates the conditions available and shows which are fail safe. i.e. output is in alarm condition ('contact' open) when the 4/20mA input current is zero.

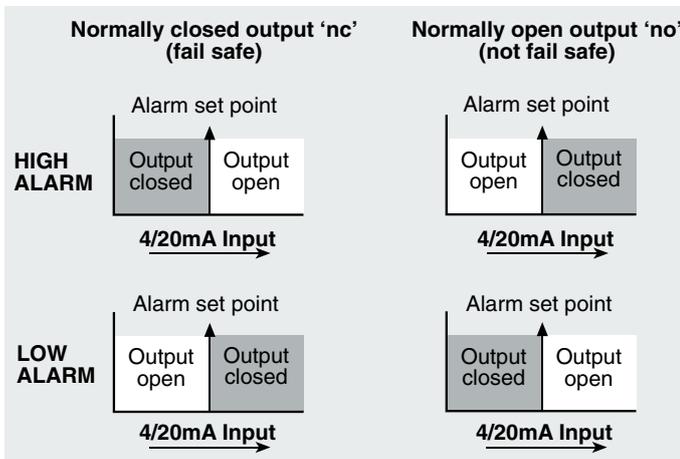


Figure 4 Alarm outputs

These alarms are not suitable for critical safety applications such as emergency shut down systems.

Each alarm output is galvanically isolated and may be used to switch any certified dc circuit which complies with the intrinsic safety requirements specified in section 3.5. The equivalent electrical circuit of each alarm output is shown in Fig 5. Both outputs are polarised and will only pass current in one direction.

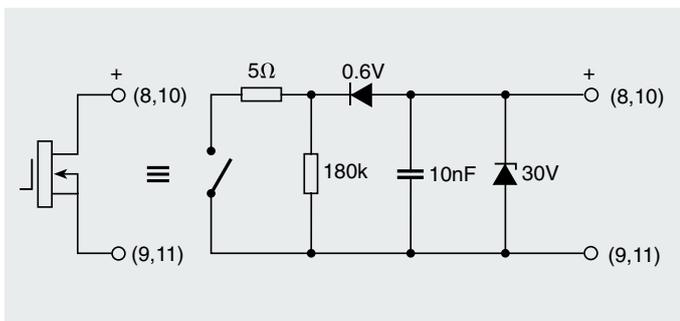


Figure 5 Equivalent circuit of each alarm output

The alarm 'contacts' may also be used to switch safe area loads via a Zener barrier or a galvanic isolator. Almost any switch transfer galvanic isolator or Zener barrier may be used, providing output safety parameters are less than 28V, 159mA and 0.8W.

Fig 6 shows a BA358C rate totaliser displaying the output from a flow transmitter and calculating and displaying the total flow. Alarm one has been programmed as a low flow alarm. If the flow rate drops below the alarm setpoint the hazardous area sounder is activated. The second alarm has been programmed as a high total flow alarm. When total flow exceeds the total alarm set point the pump in the safe area is stopped.

Resetting of the total display is accomplished from the safe area via a certified intrinsically safe relay.

When an alarm output is used to activate a annunciator such as the sounder in this application, the rate totaliser P push-buttons may be programmed to operate as an alarm 'accept' button. This allows the operator to silence the alarm for a pre-programmed time. If the alarm condition still exists at the end of the silence time, the alarm is reactivated.

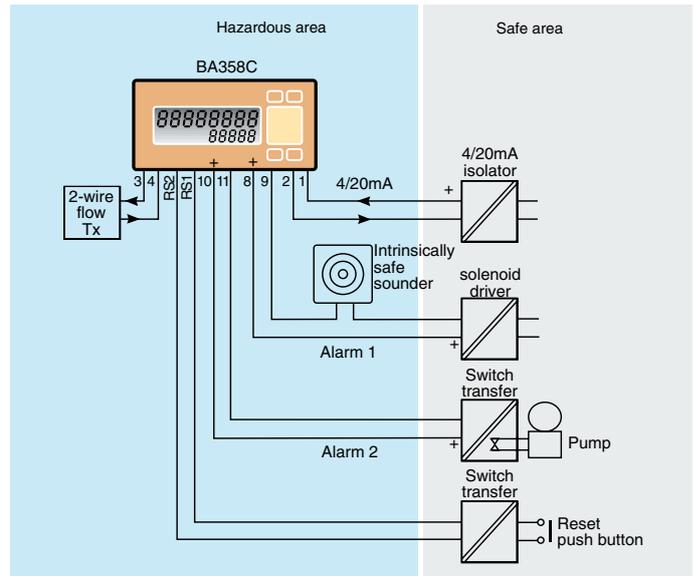


Figure 6 Typical application of BA358C with alarm outputs

5.4 Powering display backlight

The optional backlight has been certified as a separate intrinsically safe circuit and must be powered from the safe area via a Zener barrier or a galvanic isolator as shown in fig 7. The display brilliance depends upon the current flowing through the backlight which is determined by the supply voltage and the end-to-end resistance of the Zener barrier or output resistance of the galvanic isolator. Brilliance is not significantly reduced until the current falls below 20mA.

$$\text{Backlight current} = \frac{V_{\text{supply}} - 18}{\text{End-to-end resistance of Barrier}^*}$$

*or output resistance of galvanic isolator

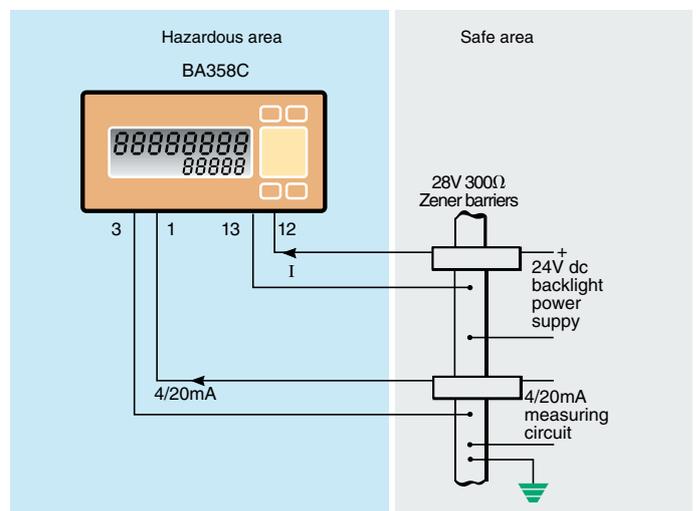


Figure 7 Backlight power supply

6. Calibration

Both rate totalisers are programmed and calibrated via four push-buttons. These are located on the front of the BA358C panel mounting instrument, and behind a protective cover on the BA354D field mounting model. If frequent adjustments are necessary the BA354D may be supplied with external push-buttons.

To prevent unauthorised or accidental adjustment the programme and calibration functions menus may be protected by a user selectable four digit security code.

The main instrument calibration functions are described below.

Rate display

The 4/20mA input current which represents rate of flow is displayed on the 4½ digit 9.5mm high display. Although 4mA normally represent zero flow, the instrument can be calibrated to display any figure between 0 and 20000. Similarly the display at 20mA input can be set anywhere between 0 and 20000.

A 'real' decimal point may be positioned between any of the digits in the rate display or it may be omitted. The position of this decimal point will affect totalisation. i.e moving the decimal point one digit to the right will increase totalisation by a factor of ten.

To linearise the output from differential flow transmitters root extraction may be selected.

Total display

Total flow is displayed on the eight digit 14mm high display which is updated twice every second. The arithmetic relationship between the rate and total displays is defined by two serial dividing factors.

The rate timebase divides the rate display by 1, 60 or 3,600 depending upon whether the rate display represents flow per second, per minute or per hour.

A further division by the 'total scale factor', which is adjustable between 0.0001 and 65535, allows the total display to be in almost any engineering units.

Percentage clip-off

To prevent totalisation of very low flow rates which over long periods may result in significant totalisation errors, the rate display may be forced to zero when the flow rate falls below a selectable percentage. The threshold may be adjusted between 0 and 10% of maximum flow for linear inputs and between 5 and 10% of maximum flow for square law inputs.