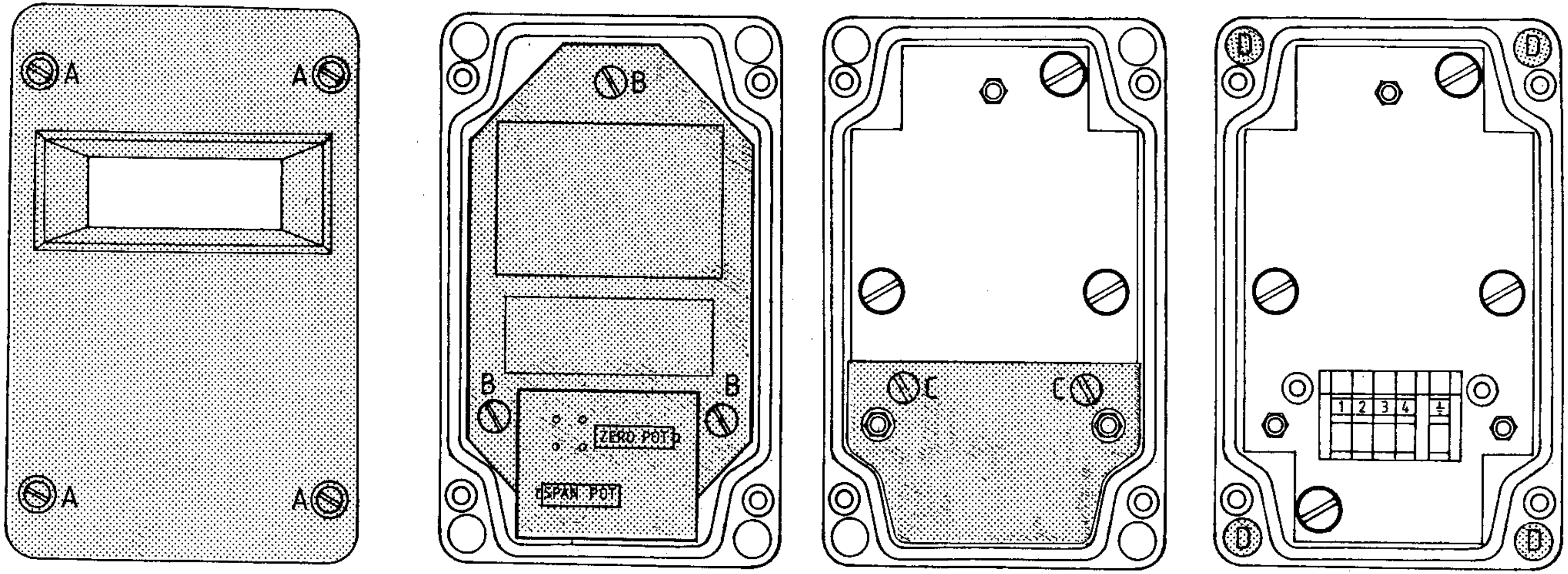
INSTRUCTION MANUAL

BA303B
2-wire 4/20mA digital indicator

BEKA associates

PO Box 39, HITCHIN, HERTS. SG4 8PQ, ENGLAND. TEL:KIMPTON (0438) 832494

Jan 84



Step 1 - Remove the enclosure cover by unscrewing the four captive 'A' screws.

Step 2 - Remove the indicator from the enclosure by unscrewing the three captive 'B' screws, and carefully lifting the assembly from the enclosure using the printed circuit board which carries the two potentiometers as a 'handle'.

Step 3 - Remove the terminal cover from the enclosure by unscrewing the twc captive 'C' screws.

Step 4 - Mount the enclosure on a flat surface and secure with screws or bolts through the four corner 'D' holes. Alternatively, assemble the pipe mounting kit which is supplied with its own instruction sheet.

Fig 1 Simplified exploded view of BA303B showing assembly sequence

2. Operation

The BA303B indicator is a 2-wire device which is powered by the current it is measuring, it therefore does not require an additional power supply and may be used like a conventional moving coil meter. Fig 2 shows a simplified block diagram of the indicator.

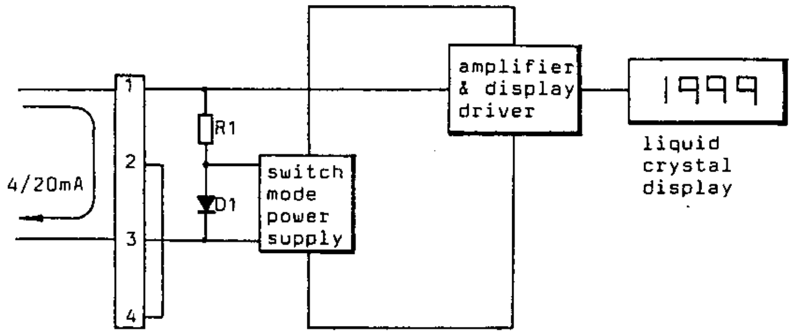


Fig 2 Simplified block diagram of BA303B

The 4/20mA current flows through resistor R1 and forward biased diode D1. The voltage developed across D1 is multiplied by the switch mode power supply and used to power the amplifier and liquid crystal display. The voltage developed across R1, which is proportional to the 4/20mA input current, provides the input signal to the display amplifier. Low power MOS semiconductors are used throughout the indicator. The total power consumption is less than 3 milliwatts which enables the voltage drop introduced into the 4/20mA loop to always be less than 1.1V.

3. Application

The BA303B indicator will operate in any non hazardous 4/20mA current loop providing that the loop can tolerate the additional 1.1V drop introduced by the indicator. For hazardous area applications it is also necessary to ensure that the intrinsic safety output parameters of the loop do not exceed those specified on the BA303B certificate. These limits are not restrictive and in practice the BA303B may be connected to almost all certified 4/20mA current loops without the need for additional certification. However, it is necessary to consider each hazardous area application carefully to ensure that the installation of the BA303B indicator will not degraded the safety of the loop.

The following examples illustrate some common applications.

3.1 Electrical system design for non-hazardous area installations

The BA303B is connected in series with the 4/20mA current loop and introduces a voltage drop, or burden, of up to 1.1V at 20mA. When designing a loop it is therefore necessary to add this voltage to the other voltage drops caused by transmitters and loads, and to ensure that the sum of all the voltage drops is less than the minimum power supply voltage. Fig 3 shows a process loop where a 2-wire transmitter is driving a controller.

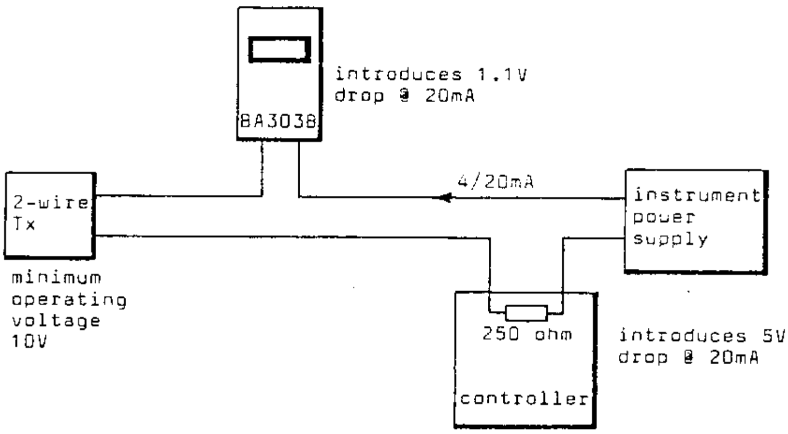


Fig 3 Non hazardous area control loop

Considering the total voltage drop around the loop:

Minimum operating voltage of 2-wire Tx	10.0V
Maximum voltage drop caused by controller	5.0V
Maximum voltage drop caused by BA303B indicator	1.1V
Maximum voltage drop caused by cable resistance	0.4V
	16.5V

The instrument power supply must therefore have a minimum output voltage at 20mA of greater than 16.5V

The BA303B may also be driven directly from any instrument with a 4/20mA output to provide a remote indication. Fig 4 shows a BA303B connected to the auxiliary 4/20mA output of a gas analyser. Again it is only necessary to ensure that the voltage capability of the auxiliary 4/20mA output is greater than the voltage drop of the indicator plus any voltage drops caused by cable resistances.

The BA303B incorporates protective components to prevent it being damaged by non-repetative transient currents of up to 30A for 15mS. However, when connected to long overhead or underground cables it may be necessary to install a surge protection unit close to the indicator, if it is considered that the cable is likely to be subjected to high transient currents from lightning or electrical switch gear.

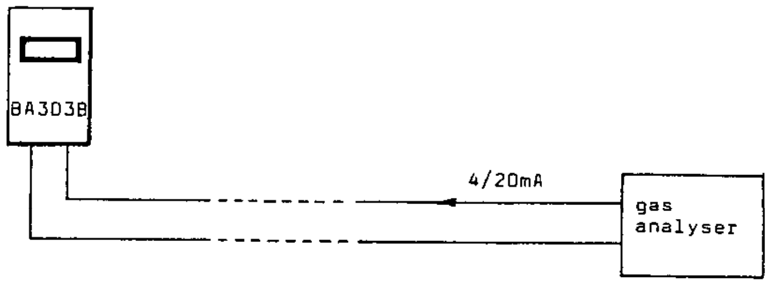


Fig 4 BA303B providing remote indication of gas analyser output

3.2 Explanation of intrinsic safety certification

The BA303B digital indicator has been certified intrinsically safe by BASEEFA to BS5501:Part 1:1977 EN50 014 and BS5501:Part 7:1977 EN50 020. The indicator bears the Community Mark and, subject to local Codes of Practice, may be installed in any of the CENELEC member countries. ie. Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxemburg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. This instruction manual describes installations which conform with the UK Code of Practice BS5345:Part 4:1977. When designing systems for installation outside the UK the local code of practice should always be consulted.

A reduced copy of the BASEEFA apparatus certificate for the BA303B is included as Appendix 1 of this manual; full size copies are available from BEKA Associates.

The BA303B intrinsic safety certificate states that:

> 'For intrinsic safety considerations the output parameters at the apparatus terminals do not exceed those specified in Clause 1.3 of BS5501:Part 1:1977 EN50 014.'

Clause 1.3 of BS5501:Part 1 says:

> 'Devices in which none of the values 1.2V, 0.1A, 20uJ or 25mW are exceeded need not be certified or marked'

This type of apparatus is known as non energy-storing or simple apparatus.

The BASEEFA certificate is therefore saying that although the BA303B contains energy-storing components, it has been designed such that the energy which can be released via the two terminals is less than that specified in Clause 1.3 of EN50 014. The indicator may therefore be installed into certified intrinsically safe loops without invalidating the original certification of the loop. For this reason the BA303B only has an apparatus certificate, no system certificate has been issued, or is required, because the system certificate of the loop into which the indicator is connected remains valid.

The BASEEFA apparatus certificate allows the BA303B indicator to be connected to any intrinsically safe circuit whose output parameters do not exceed the following:

$I_{max:out} = 215mA$

$W_{max:out} = 1.1W$

The equivalent resistance at the BA303B terminals is:

15.4 ohms minimum in normal operation.

24.0 ohms maximum under fault conditions.

In practice these requirements are not restrictive and allow the BA303B to be connected to almost all intrinsically safe 4/20mA loops. The following example illustrates how to determine if a particular loop complies with the requirements. Fig 5 shows the equivalent circuit of an intrinsically safe measurement loop incorporating a 2-wire transmitter, BA303B indicator and a two channel Zener barrier. Imax:out is the maximum current which can flow around the loop under fault conditions and is defined by the characteristics of the Zener barrier. In a loop protected by two barriers, or by a two channel barrier, each barrier or channel should be considered separately.

The safety description of a Zener barrier specifies the maximum voltage of the terminating Zener diode and the minimum resistance of the terminating resistor. Imax:out for each barrier or channel is therefore:

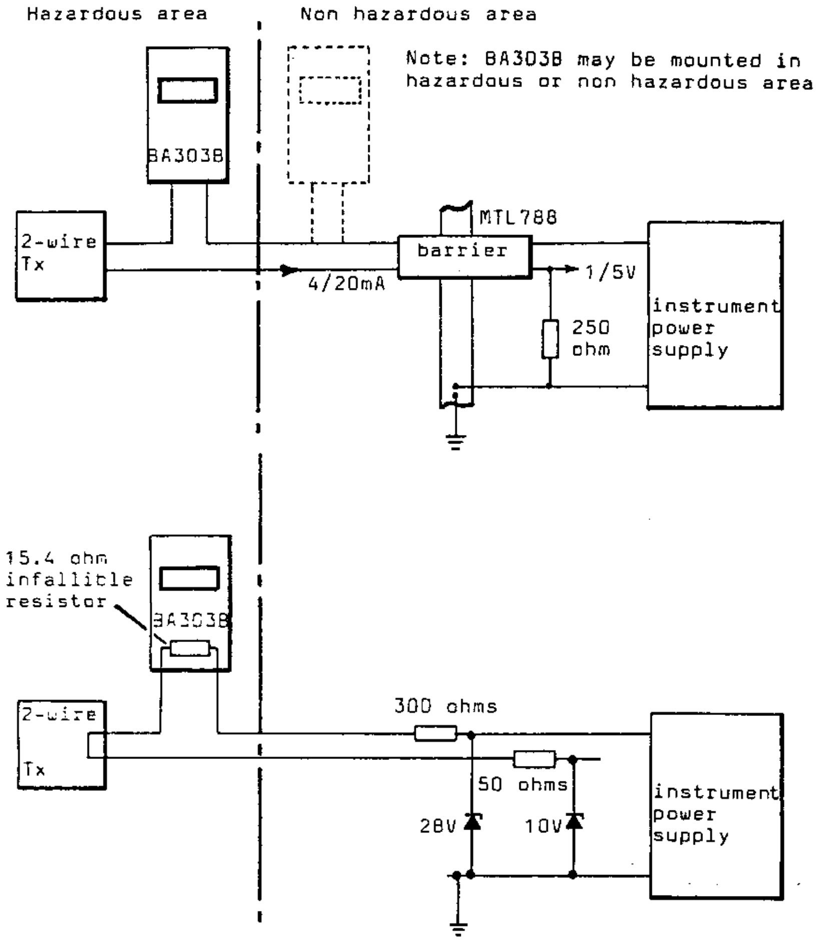
$$\text{Imax:out} = \frac{\text{maximum voltage of terminating Zener diode}}{\text{minimum resistance of terminating resistor + 15.4 ohms}}$$

The equivalent resistance of the BA303B may be added to the terminating resistance because it is an infallible resistance which will increase under fault conditions. The resistance of other instruments and loads in the loop must be considered to be zero unless they have also been certified as infallible.

Wmax:out is the maximum power which can be transferred into the hazardous area by each Zener barrier or channel when perfectly matched, therefore:

$$\text{Wmax:out} = \frac{\text{maximum voltage of terminating Zener diode X Imax:out}}{4}$$

Fig 5 shows how these calculations are applied for a two channel barrier, and Appendix 2 lists some of the popular barriers which may be used. Other intrinsically safe power sources should be assessed in the same way as a Zener barrier.



Equivalent Circuit

MTL788 safety description (from manufacturers specification)

	Max Zener voltage	Min terminating resistance
28V channel	28.0V	300.0 ohms
10V channel	10.0V	50.0 ohms

Considering 28V channel

$$Imax{:}out = \frac{28.0}{300.0 + 15.4} = 88.78mA$$

$$Wmax{:}out = \frac{28.0 \times 88.78}{4} = 0.62W$$

Considering 10V channel

$$Imax{:}out = \frac{10.0}{50.0 + 15.4} = 152.91mA$$

$$Wmax{:}out = \frac{10.0 \times 152.9}{4} = 0.38W$$

All calculated figures are below the maximum permitted output parameters specified on the BA303B apparatus certificate; the indicator can therefore be connected to the loop without the need for additional certification.

Fig 5 Example of calculations required to establish if a BA303B may safely be connected to an intrinsically safe loop

The BA303B has been certified EEx ia IIC T4, which means that when connected to a suitable system, it 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 or vapours in gas groups:

Group A	propane
Group B	ethylene
Group C	hydrogen

Having a temperature classification of:

T1	$450^{o}C$
T2	$300^{o}C$
T3	$200^{o}C$
T4	$135^{o}C$

This means that the BA303B may be installed in all Zones, and used with most common industrial gases except carbon disulphide & ethyl nitrate.

Note; If the certification of the system to which the indicator is connected is more restrictive, then these limitations also apply to the indicator. eg. If the system is only certified for use with gases in Groups A & B, then the indicator may also only be used in these gases.

The BA303B BASEEFA certificate also specifies the maximum equivalent capacitance and inductance which can occur between the two terminals of the indicator.

These are:

$$C_{eq} = 15nF$$

$$L_{eq} = 2uH$$

These figures should be subtracted from the maximum cable capacitance and inductance permitted by the system certificate of the loop into which the BA303B is installed. In practice this is not restrictive as both reactances are small compared to most permitted cable parameters. Only when 'high voltage' barriers are used with IIC gases will the permitted cable capacitance and hence the cable length, be significantly reduced.

3.3 Electrical system design for hazardous area installations

The BA303B is connected in series with the 4/20mA current loop and introduces a voltage drop, or burden, of up to 1.1V at 20mA. When designing a loop it is therefore necessary to add this voltage to the other voltage drops caused by the Zener barrier and loads, and to ensure that the sum of these voltage drops is less than the minimum power supply voltage. - see Fig 6.

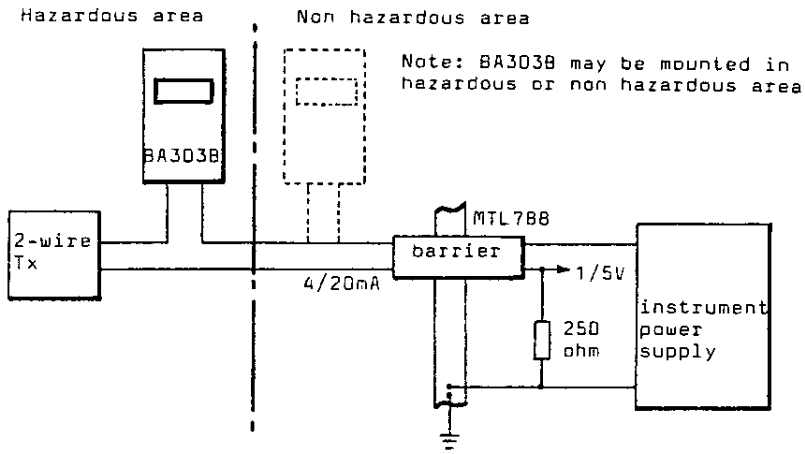


Fig 6 Hazardous area measurement loop

Total voltage drop around loop shown in Fig 6.

Minimum operating voltage of 2-wire Tx	10.0V
Maximum voltage drop caused by 250 ohm load	5.0V
Maximum voltage drop caused by 28V 300 ohm barrier (340 ohms end to end resistance X 20mA)	6.8V
Maximum voltage drop caused by 10V 50 ohm barrier (85 ohms end to end resistance X 20mA)	1.7V
Maximum voltage drop caused by cable resistance (10 ohms X 20mA)	0.2V
Total maximum voltage drop around the loop	23.7V

The instrument power supply voltage must therefore be above 23.7V, but below 25.5V which is the maximum working voltage of the 28V 300 ohm channel of the Zener barrier.

The BA303B may be driven via an intrinsically safe interface from any instrument with a 4/20mA output to provide a remote indication in a hazardous area. The type of interface is not critical providing that it complies with the maximum output parameters specified on the BA303B certificate. Either a certified intrinsically safe isolator, or a Zener barrier may be used.

If one side of the 4/20mA signal may be earthed, then a single channel Zener barrier provides the lowest cost solution. If the 4/20mA signal is not isolated, then two Zener barriers, a two channel Zener barrier or a certified intrinsically safe isolator must be used. Again it is necessary to ensure that the voltage capabilty of the 4/20mA signal is sufficient to drive the indicator plus voltage drops introduced by the intrinsically safe interface.

Fig 7 shows the two alternative barrier circuits which may be used.

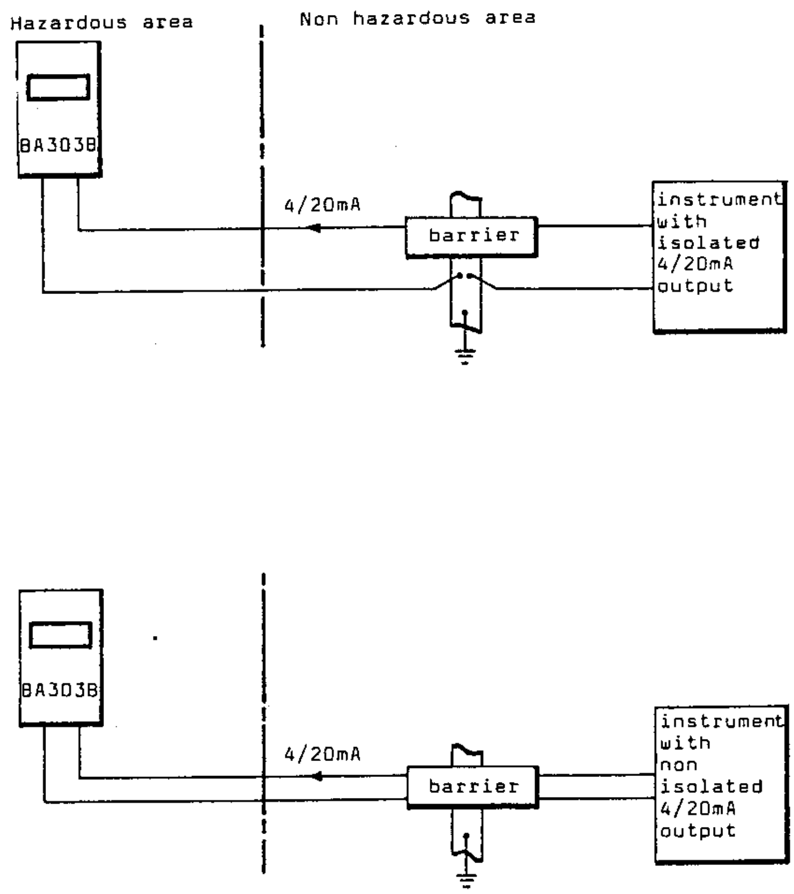


Fig 7 Alternative circuits for remote indication in hazardous area

4. Installation

4.1 Location

The BA303B 4/20mA digital indicator is housed in a robust aluminium die-cast enclosure which is epoxy painted and sealed with a neoprene gasket. To simplify installation the field wiring terminals are located in the enclosure so that it can be installed and wired without the indicator in place. The enclosure also contains a 3.3V Zener diode to maintain the continuity of the 4/20mA loop when the indicator is not fitted.

A simplified exploded diagram of the indicator and enclosure is shown in Fig 1.

The enclosure can be directly mounted onto any flat surface using the four corner 'D' holes, or can be clamped to pipework using the accessory pipe mounting kit. Whichever technique is used, it is important to choose a location which ensures that the indicator always remains within the environmental limits shown in the specification, and that the display window is not exposed to continuous direct sunlight.

When correctly installed the enclosure will provide IP65 (hoseproof) protection, however, when the BA303B is mounted outside it is recommended that a hood or flexible transparent cover be provided to prevent standing water accumulating on the gasket and display window.

4.2 Installation procedure

- i Remove the enclosure cover by unscrewing the four captive 'A' screws.
- ii Remove the indicator from the enclosure by unscrewing the three captive 'B' screws, and carefully lifting the assembly from the enclosure using the printed circuit board which carries the potentiometers as a 'handle'.
- iii Remove the terminal cover from the enclosure by unscrewing the two captive 'C' screws.
- iv Mount the enclosure on a flat surface and secure with screws or bolts through the four corner 'D' holes. Alternatively assemble the pipe mounting kit which is supplied with its own instruction sheet.
- v Fit a cable gland or conduit fitting into the M20 x 1.5 hole at the bottom of the enclosure; ensure that the screw thread does not protrude too far into the terminal compartment.
- vi Connect the field wiring to the terminals as shown in Fig 8. The earth terminal, which is internally connected to the enclosure die-casting, should be connected to a local earthing point to ensure personnel safety. This earth connection is not associated with the intrinsic safety of the indicator.
- vii Replace terminal cover. Note: When the indicator is installed in a hazardous area it is mandatory that the terminal cover be fitted.
- viii Replace the indicator in the enclosure and evenly tighten the three 'B' screws.
- ix Replace the enclosure cover and evenly tighten the four 'A' screws.

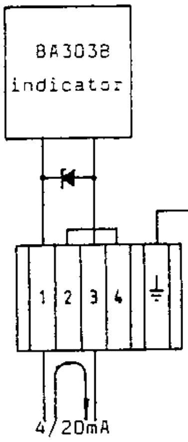


Fig 8 Terminal connections

5. Calibration

The BA303B digital indicator will be supplied calibrated as requested at time of ordering. If calibration is not requested, the indicator will be set so that it displays 0 to 1000 for a 4 to 20mA input. However, all calibration controls and links are accessible when the enclosure cover is removed so the indicator can easily be recalibrated on site.

5.1 Calibration controls

The location of all calibration controls and links are shown in Fig 9.

<u>Zero adjustment</u>
Zero is defined as the figure displayed by the indicator with a 4.000mA input current.
The zero may be adjusted to any figure between -1000 & 1000.
The position of the suppression/elevation links determines whether a positive or negative number is displayed, and the zero potentiometer sets the exact displayed figure.
It is recommended that a pair of long nosed pliers be used to extract and insert the links.

<u>Span adjustment</u>
Span is defined as the difference between the number displayed with a 4.000mA input and the number displayed with a 20.000mA input.
The span may be adjusted to any number between 100 and 1000 by the span potentiometer.

<u>Decimal point</u>
The position of the displayed decimal point is defined by the position of the decimal point selection link.
It is recommended that a pair of long nosed pliers be used to extract and insert this link.

5.2 Calibration example

The BA303B is required to display:

25.0 with 4mA input
115.0 with 20mA input

ie. A zero of 250 positive
A span of 900
A decimal point at position dp3

The following adjustments are required:

Step 1 The BA303B is required to display a positive zero, therefore the suppression/elevation links should be put in the elevation position.

2 The decimal point is required between the least two significant digits, therefore the decimal point selection link should be put in position dp3. See Fig 9.

3 With 4.000mA input current adjust the zero potentiometer until the indicator displays 25.0.

4 With 20.000mA input current adjust the span potentiometer until the indicator displays 115.0.

5 Repeat steps 3 and 4 until both calibration points are correct. The span and zero controls are almost independent, it should therefore only be necessary to repeat each adjustment two or three times.

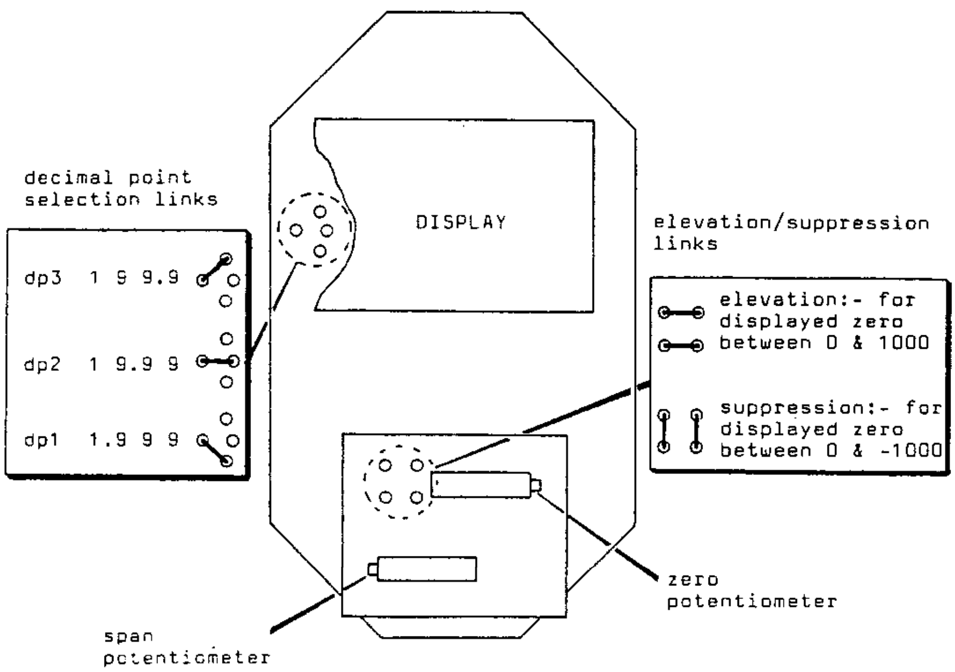


Fig 9 Location of calibration controls & links

5.3 Over and underrange

If the display range of the BA303B is exceeded ie. below -1999 or above 1999, the three least significant digits will be automatically blanked. Underrange is therefore indicated by a -1 display, and overrange by a 1 display. If the display range is not exceeded, the BA303B will produce accurate results outside the normal 4/20mA input current range. Although not guaranteed, most BA303B indicators will operate from 3 to 25mA.

6. Maintenance

6.1 Fault finding during commissioning

If a BA303B indicator fails to function during commissioning the following procedure should be used.

Symptom	Cause	Solution
No display	Incorrect wiring to indicator.	Correct wiring error, indicator will not be damaged by reversed connections.
	Indicator not correctly installed in enclosure.	Check that the three 'B' screws are tight, but do not overtighten. Ensure that connecting surfaces are clean. Note: The voltage drop caused by the enclosure is about 3.3V without the indicator. This falls to 1V with the indicator correctly installed in the enclosure.
Indicator displays 1	Positive overrange.	The indicator has been incorrectly calibrated and is trying to display a number greater than 1999.
Indicator displays -1	Negative overrange.	The indicator has been incorrectly calibrated and is trying to display a number less than -1999.
Unstable display. More than ±1 digit of jitter.	4/20mA input current contains large ripple current.	Reduce ripple content.
	Insufficient voltage to operate indicator. ie. less than 1.1V	Check supply voltage & voltage drops caused by all components within the loop.

6.2 Fault finding after commissioning

> ENSURE PLANT SAFETY BEFORE STARTING MAINTENANCE
>
> Live maintenance is permitted on intrinsically safe equipment installed in a hazardous area, but only certified intrinsically safe electrical test equipment should be used unless a gas clearance certificate is available.

If a BA303B indicator fails after it has been operating correctly the following procedure should be used.

Symptom	Cause	Solution
No display; no voltage across terminals	Short or open circuit in wiring, or fault in indicator.	Check all wiring.
No display; between 3 & 4V across terminals	Indicator not correctly installed in the enclosure.	Remove indicator from the enclosure, clean connecting surfaces on pillars & indicator. Replace indicator & tighten three 'B' screws. Do not over tighten.
Unstable display. More than ±1 digit of jitter.	4/20mA current has developed large ripple component.	Find source of ripple.
	Insufficient voltage to operate indicator ie. less than 1.1V	Check supply voltage & voltage drops caused by all components within the loop.

If the above procedure does not reveal the cause of the fault, it is recommended that the indicator is removed from the enclosure and replaced with another unit. If the second unit functions correctly the fault is within the original indicator. if the BA303B is still faulty it is likely that the fault is within the enclosure assembly.

6.3 Servicing

The BA303B uses a high density construction technique and is partially potted, it is therefore difficult to service to component level in the field. The BA303B has therefore been designed so that the indicator can easily be replaced without disturbing the field wiring. All standard BA303B indicators are interchangeable and a single spare instrument is therefore able to replace any indicator which fails. BEKA Associates and most distributors maintain a stock of indicators which can be used if a customer is unable to justify a spare unit on site.

BEKA Associates recommend that, except under exceptional circumstances, faulty BA303B indicators are returned to the factory or local agent for repair. However, if this is not possible BEKA Associates will provide a service sheet for the instrument.

If a repaired indicator is to be used in a hazardous area it is essential that the servicing has not degraded the safety of the instrument. The current Code of Practice for Selection, Installation & Maintenance of Electrical Apparatus for use in Potentially Explosive Atmospheres, BS5345:1977, permits on-site maintenance providing that the repairs are inspected by a second competent person and recorded. BEKA Associates again strongly recommend that faulty units should be returned to the factory for repair to ensure that the certification requirements are complied with.

6.4 Warranty

Indicators which fail within the warranty period should be returned to BEKA Associates or the local distributor from whom the instrument was purchased. It is helpful if a brief description of the fault symptoms can be provided.