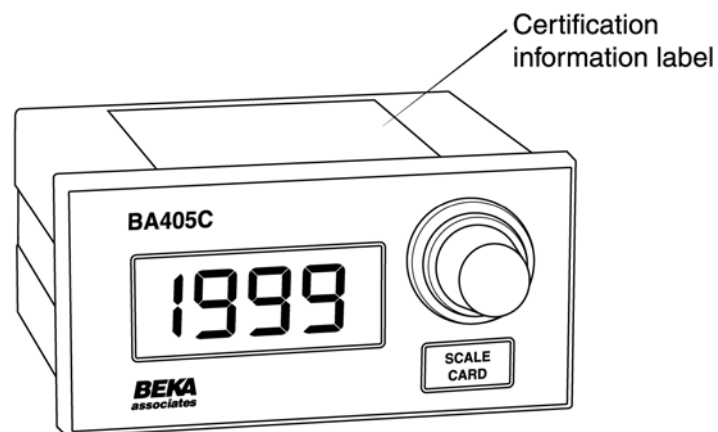


**BA405C**  
**intrinsically safe**  
**2-wire 4/20mA**  
**manual set point**  
**station**

issue 6



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FM Approval for use in the USA

The BA405C is CE marked to show compliance with the  
European Explosive Atmospheres Directive 94/9/EC  
and the European EMC Directive 2004/108/EC

## 1. DESCRIPTION

The BA405C is an intrinsically safe loop powered set point station which enables the current flowing in a 4/20mA loop to be manually adjusted from within a hazardous process area.

The main application of the BA405C is the adjustment of plant parameters. Controller set points, actuator positions or any variable represented by a 4/20mA signal may be manually adjusted.

The BA405C has a high resolution ten turn control allowing accurate adjustment of the 4/20mA current and a 3½ digit indicator to display the 4/20mA current in any linear engineering units. Optional separately powered and loop powered display backlights are available for the display.

The BA405C and the optional display backlights comply with the European ATEX Directive 94/9/EC and have been issued with an EC-Type Examination certificate by Notified Body ITS Testing and Certification Ltd.

For use in the USA the BA405C has intrinsic safety and nonincendive FM Approval - see Appendix 1.

## 2. OPERATION

This instruction manual describes ATEX system design and installation, please refer to Appendix 1 for details of the FM Approval.

Fig 1 shows a simplified block diagram of the BA405C manual set point station. The ten turn control knob enables the current flowing in the loop to be manually set at any value between approximately 3.5 and 21mA. The output resistance of the BA405C is very high so the loop current will be unaffected by changes in the supply voltage.

### Caution

The 4/20mA output should not be used for critical safety applications.

The 3½ digit internal indicator can easily be calibrated on-site to show the loop current in engineering units. For example, in an application where the BA405C is being used to adjust the set point of a speed controller, the internal indicator may be calibrated to display the requested speed in RPM.

Two types of optional display backlighting are available. The loop powered backlight produces green background illumination enabling the display to be read at night or in poor lighting conditions. The separately powered backlight has a bright orange output which enhances daylight viewing.

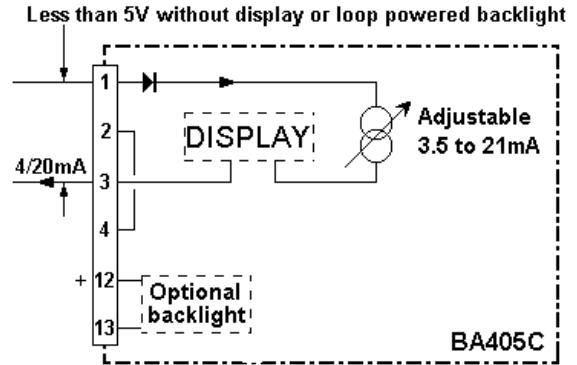


Fig 1 Simplified block diagram of BA405C

## 3. INTRINSIC SAFETY CERTIFICATION

### 3.1 ATEX certificate

The BA405C has been issued with an EC-Type Examination Certificate ITS03ATEX21103 by Notified Body Intertek Testing Services (ITS) confirming compliance with the European ATEX Directive 94/9/EC for Group II, Category 1 G apparatus, EEx ia IIC T5. The instrument bears the Community Mark and, subject to local codes of practice, may be installed in any of the European Economic Area (EEA) member countries. ATEX certificates are also acceptable for installations in Switzerland. This manual describes installations which conform with BS EN60079:Part14 Electrical Installation in Hazardous Areas. When designing systems for installation outside the UK, the local Code of Practice should be consulted.

### 3.2 FM Approval for use in the USA

Please refer to Appendix 1 for information about FM intrinsic safety and nonincendive approval of the BA405C

### 3.3 Safety parameters

The BA405C EC-Type Examination Certificate specifies the maximum input safety parameters for the two 4/20mA terminals 1 and 3, and the equivalent internal capacitance and inductance that appears between the terminals. Using the entity concept and these safety parameters, suitable Zener barriers or galvanic isolators may be selected and the maximum permissible cable parameters calculated.

The following figures are reproduced from the ATEX certificate ITS03ATEX21103

#### Terminals 1 and 3:

(4/20mA output terminals)

Basic BA405C set point station without optional loop powered display backlight.

Maximum input safety parameters

U <sub>i</sub>	=	30V dc
I <sub>i</sub>	=	200mA dc
P <sub>i</sub>	=	0.85W

Equivalent capacitance and inductance

C <sub>i</sub>	=	40nF
L <sub>i</sub>	=	0.01mH

#### With loop powered display backlight Terminals 1 and 13

(3 and 12 connected in series)

Maximum input safety parameters

U <sub>i</sub>	=	30V dc
I <sub>i</sub>	=	200mA dc
P <sub>i</sub>	=	0.85W

Equivalent capacitance and inductance

C <sub>i</sub>	=	40nF
L <sub>i</sub>	=	0.03mH

#### Separately powered display backlight Terminals 12 and 13

Maximum input safety parameters

U <sub>i</sub>	=	28V dc
I <sub>i</sub>	=	159mA dc
P <sub>i</sub>	=	0.8W

Equivalent capacitance and inductance

C <sub>i</sub>	=	30nF
L <sub>i</sub>	=	0.01mH

### 3.4 Zones, Gas Groups and T rating

The BA405C and both the optional display backlights have been certified as Group II category 1G apparatus, EEx ia IIC T5. When powered via a compatible Zener barrier or galvanic isolator the BA405C manual set point station 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

#### WARNING installation in Zone 0

When installed in a Zone 0 potentially explosive atmosphere requiring apparatus of Category 1G, the set point station shall be installed such that even in the event of rare incidents, an ignition source due to impact or friction between the aluminium enclosure at the rear of the instrument mounting panel and iron/steel is excluded.

### 3.5 Certification label information

The ATEX certification information is shown on a label fitted in a recess on the top outer surface of the enclosure.



BA405C ATEX certification label

**4. SYSTEM DESIGN FOR HAZARDOUS AREAS**

**4.1 4/20mA loop using Zener barriers**

The required operating voltage depends on which options are fitted as shown below.

Options	Voltage range	Terminals
BA405C Without Options.	6.1 to 30V	1 & 3
BA405C with Loop powered display backlight.	10 to 30V	1 & 13 (3 & 12 joined together)

Fig 2 illustrates a typical application in which a BA405C is being used to adjust the setpoint of a speed controller. To enable the negative side of both the load and the power supply to be earthed, a Zener barrier is required in series with both wires going into the hazardous area.

Any Zener barrier or barriers certified by an EEC approved body to EEx ia IIC, having output parameters equal to or less than the maximum BA405C certified input safety parameters may be used. For this type of application a 28V, 93mA 0.65W (28V 300Ω) device is normally used to power the loop, plus a diode return barrier. These two devices are available as two channels in one package.

The maximum permitted cable parameters are those specified on the Zener barrier certificate less the set point stations equivalent input capacitance or inductance Ci & Li.

When designing the loop it is necessary to establish that the maximum voltage drop caused by the manual set point station, both Zener barriers, the load and cable resistance is always less than the minimum supply voltage.

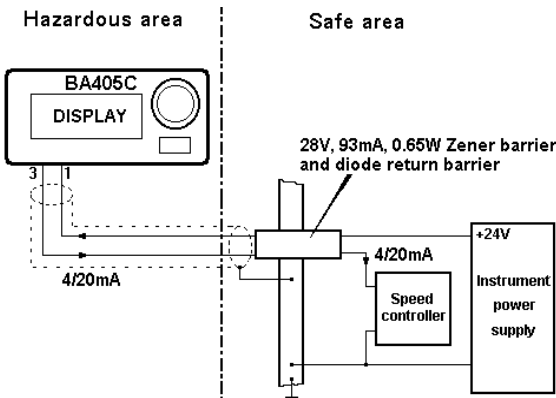


Fig 2 Typical application using barriers

In this example:

Minimum operating voltage of BA405C 6.1V

Maximum voltage drop caused by 28V 93mA, 0.65W Zener barrier (340Ω end-to-end resistance x 20mA)

Maximum voltage drop caused by diode return barrier 1.3V

Maximum voltage drop caused by 250ohm load (250ohms x 20mA) 5.0V

Maximum voltage drop caused by Cable resistance (10ohms x 20mA) 0.2V

Total maximum voltage drop 19.4V

The power supply voltage must therefore be above 19.4V, but below 25.5V which is the maximum working voltage of a typical 28V Zener barrier. If the optional loop powered backlight was included in the circuit this introduces a further 3.9V drop so that the supply voltage would have to be regulated between 23.3 and 25.5 See section 4.3.2.

**4.2 4/20mA loop using Galvanic Isolators**

Galvanic isolators, although more expensive than Zener barriers, do not require a high integrity earth connection. For small systems where a high integrity earth is not already available, the use of galvanic isolators often reduces the overall installation cost.

The example described in section 4.1 can be simplified by the use of galvanic isolators as shown in Fig 3.

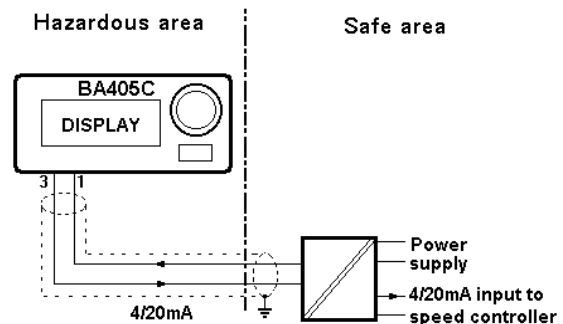


Fig 3 Typical application using a galvanic isolator

Any galvanic isolator certified EEx ia IIC by an EEC approved body with output parameters equal to or less than the maximum BA405C certified input parameters may be used.

The maximum permitted cable parameters for the loop should be calculated by subtracting Ci & Li for the BA405C from the cable parameters specified on the galvanic isolator certificate.

When designing the loop it is necessary to establish that the supply voltage between terminals 1 & 3 of the BA405C set point station always exceeds the minimum operating voltage shown in section 4.1

**4.3 Optional Backlights**

The BA405C set point station can be supplied with two different backlights. The loop powered backlight produces green background illumination enabling the display to be read at night or in poor lighting conditions. No additional power supply, IS interface or field wiring are required, but the minimum operating voltage drop of the set point station is increased to 11.1V.

Alternatively, the separately powered backlight has a bright orange output which enhances daylight viewing, but it requires an additional IS interface and field wiring.

**4.3.1 Separately powered backlight**

This backlight is segregated from the measuring circuit and has been certified as a separate intrinsically safe circuit.

The maximum input safety parameters are

Maximum input		
Ui	=	28V dc
Ii	=	159mA dc
Pi	=	0.8W

Equivalent capacitance and inductance

Ci	=	30nF
Li	=	0.01mH

Any Zener barrier or isolator certified EEx ia IIC by an EEC approved body which has output parameters equal to, or less than, the maximum input parameters specified above may be used. Most installations would use a 28V, 93mA 0.65W (28V 300Ω) device as shown in Fig 4.

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 will not be significantly reduced until the current falls below 20mA.

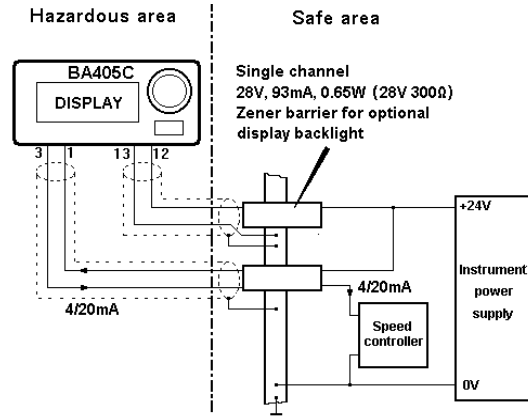


Fig 4 Separately powered backlight

The separately powered backlight requires a minimum supply voltage of 14V, The backlight current can be calculated from:

$$\text{Backlight current} = \frac{V_{\text{supply}} - 14}{\text{End-to-end resistance of barrier\#}}$$

# Or output resistance of galvanic isolator

Two BA405C separately powered backlights may be powered in parallel from a single 28V 300Ω Zener barrier or galvanic isolator, but the display brilliance will be reduced.

**4.3.2 Loop powered backlight**

The loop powered backlight is connected in series with, and powered by, the 4/20mA current from the set point station. This eliminates the need for a separate Zener barrier or galvanic isolator and for additional wiring, thus significantly reducing the installation cost.

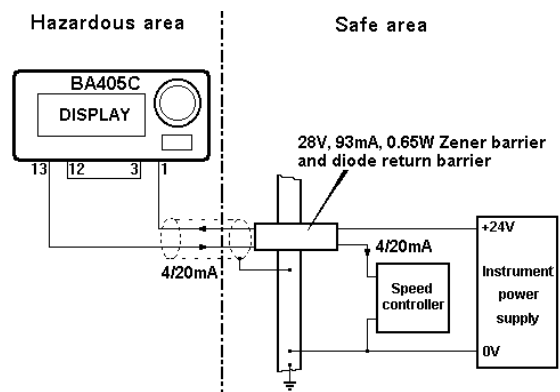


Fig 5 Loop powered backlight

Fig 5 shows how the loop powered backlight should be connected in series with the set point station. Any Zener barrier or galvanic isolator certified EEx ia IIC by an EEC approved body may be used providing the output safety parameters do not exceed:

U<sub>o</sub> = 30V dc  
 I<sub>o</sub> = 159mA  
 P<sub>o</sub> = 0.8W

The maximum permitted cable parameters for the loop should be calculated by subtracting C<sub>i</sub> & L<sub>i</sub> for the BA405C with a loop powered backlight from the cable parameters specified on the Zener barrier or galvanic isolator certificate.

Inclusion of the loop powered backlight increases the minimum operating voltage of the BA405C to 10V

**5. INSTALLATION**

**5.1 Location**

The BA405C is housed in a robust aluminium enclosure with a polyester front panel and a Noryl bezel. The front panel provides IP65 protection and a gasket seals the joint between the instrument and the panel. The BA405C may be installed in any panel providing the environmental limits shown in the specification are not exceeded. The front of the instrument should not be cleaned with, or exposed to solvents.

Please refer to BEKA associates if high vibration is anticipated.

Fig 6 shows the enclosure dimensions and the recommended panel cut-out sizes.

**5.2 Installation Procedure**

- a. Insert the BA405C set point station into the panel aperture from the front. Ensure that the gasket is correctly positioned under the bezel.
- b. Fix two panel mounting clips to opposite sides of the instrument and tighten until the indicator is secured as shown in Fig 7.
- c. Connect the panel wiring to the rear terminal block as shown in Fig 6. To simplify installation, the terminals are removable so that the panel wiring can be completed before the instrument is installed.

**5.3 EMC**

The BA405C complies with the requirements of the European EMC Directive. For specified immunity all wiring should be in screened twisted pairs with the screen earthed within the safe area. The enclosure may be earthed locally by securing a tag under one of the rear panel corner fixing screws,

**Cut-out Dimensions**

DIN 43 700  
 92.0 +0.8/-0.0 x 45.0 +0.6/-0.0

To achieve an IP65 seal between BA405C and instrument panel  
 90.0 +0.5/-0.0 x 43.3 +0.5/0.0

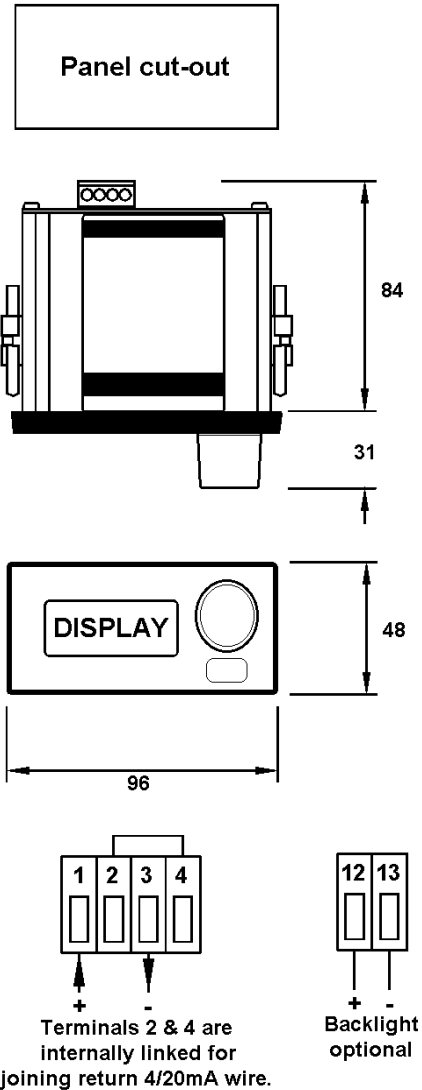


Fig 6 BA405C Dimensions

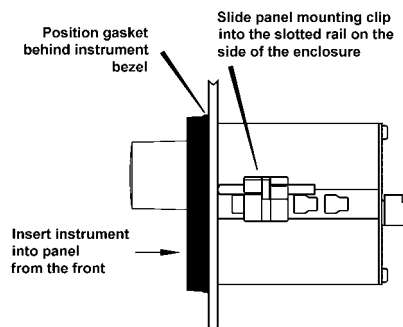


Fig 7 Fitting panel mounting clips

## 6. CALIBRATION

The BA405C output current does not require any calibration, the front panel multi-turn control will always adjust the output current between approximately 3.5 and 21mA.

### 6.1 Internal display

The internal display requires calibrating so that the 4/20mA loop current is shown in the required engineering units.

The BA405C will be supplied with the display calibrated as requested at time of ordering. If calibration is not requested, the display will be set to show 00.0 with 4.000mA loop current and 100.0 with 20.000mA loop current.

The display is calibrated by plug-in links and two multi-turn potentiometers which are accessible through holes in the rear panel. To gain access to the links the rear panel must be removed as shown in Fig 8.

For maximum accuracy the display should be calibrated using a traceable current measuring device with an accuracy greater than 4 $\mu$ A.

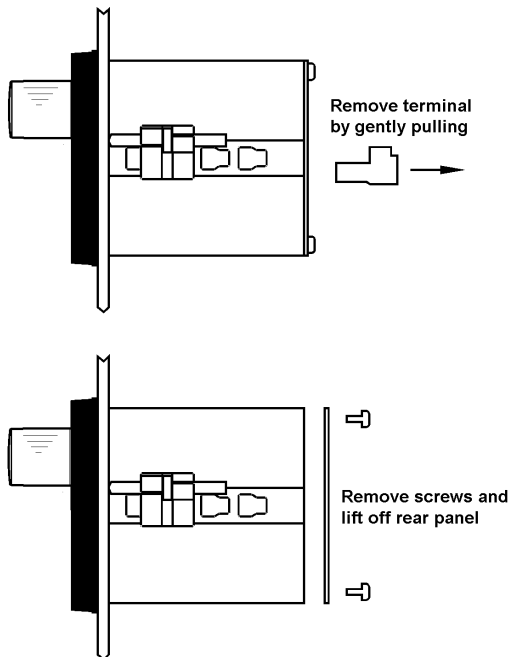


Fig 8 Removal of rear panel

#### 6.1.1 Zero adjustment

Zero is defined as the number displayed when the BA405C output is 4.000mA, and may be adjusted between -1000 and 1000. The zero potentiometer has two ranges 0 to 500 and 500 to 1000. The polarity of the zero is defined by the position of the suppression / elevation links.

Fig 9 shows the position of the zero links and zero potentiometer.

#### Suppression / elevation links

Elevation	Positive zero	0 to 1000
or Suppression	Negative zero	0 to -1000

#### Zero link

	0 to 500
or	500 to 1000

#### 6.1.2 Span adjustment

Span is defined as the difference between the number displayed at 4.000mA and the number displayed at 20.000mA output. The span potentiometer has four ranges defined by the span links, and may be adjusted to any number between 0 and 1999.

Fig 9 shows the position of the span links and span potentiometer.

#### Span links

	000	to	500
or	500	to	1000
or	1000	to	1500
or	1500	to	1999

#### 6.1.3 Decimal point

A dummy decimal point may be displayed between any of the four digits. The position or absence of this decimal point is determined by the position of the decimal point link shown in Fig 9. When calculating the required span and zero setting the decimal point should be ignored.

#### 6.1.4 Reverse action

Normally the BA405C display increases as the loop current increases, but this can be reversed. Please contact BEKA associates for details.



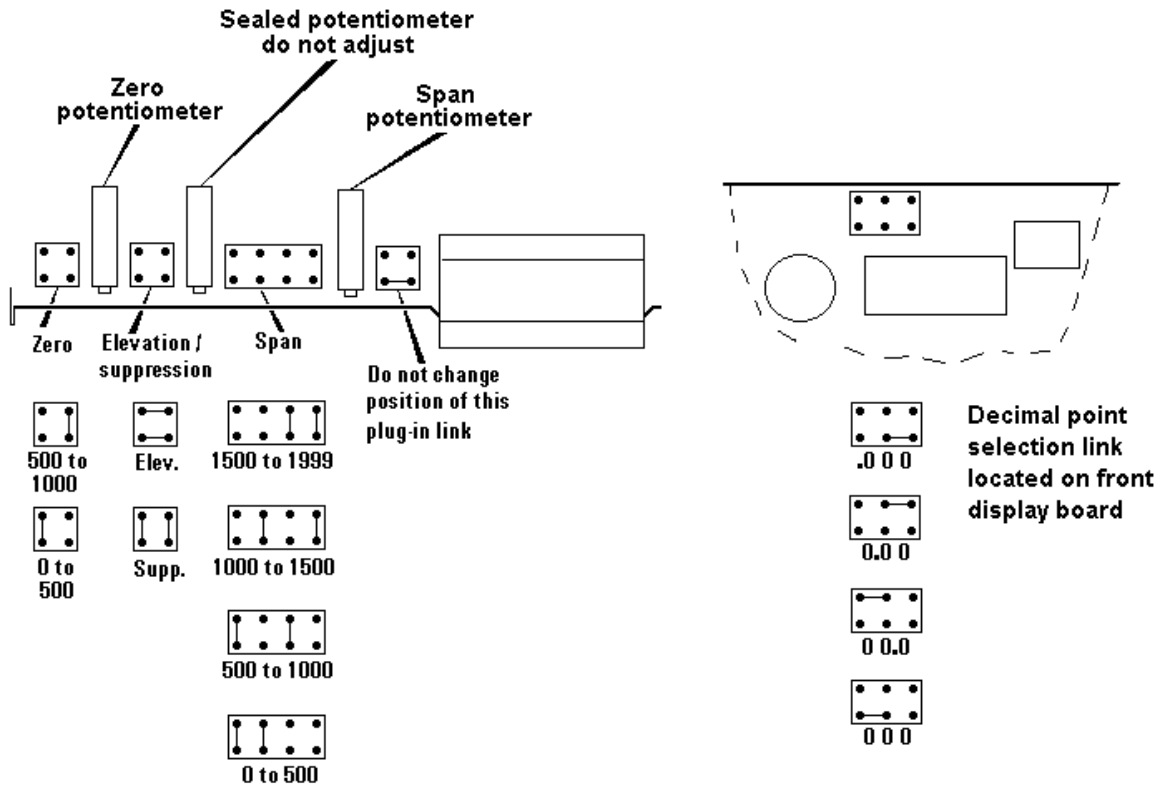


Fig 9 Position of calibration plug-in links and potentiometers

**6.1.5 Calibration example**

A BA405C set point station is required to display 25.0 with a 4.000mA output and 115.0 with a 20.000mA output.

- i.e. A zero of positive 250 *Ignoring decimal point.*
- A span of 900
- A dummy decimal point in position 00.0

The following adjustments are required:

- Step 1 The BA405C is required to display a positive zero therefore the suppression / elevation links should be put in the elevation position.
- Step 2 The required zero is 250, therefore the zero link should be put in the 0 to 500 position.
- Step 3 The required span is 900, therefore the span links should be placed in the 500 to 1000 position.
- Step 4 A dummy decimal point is required between the least two significant digits, therefore the decimal point link should be placed in the 00.0 position.

- Step 5 Adjust the BA405C front panel control until the output current measured by external ammeter is 4.000mA. The zero potentiometer at the rear of the BA405C should then be adjusted until the BA405C displays 25.0
- Step 6 Adjust the BA405C front panel control until the external current measured by an external ammeter is 20.000mA. The span potentiometer at the rear of the BA405C should then be adjusted until the BA405C displays 115.0
- Step 7 Repeat steps 5 and 6 until both calibration points are correct. The span and zero controls are almost independent so it should only be necessary to repeat each adjustment twice.

### 6.1.6 Over and under-range

The BA405C can display numbers between -1999 and 1999. If this range is exceeded the three least significant digits will be blanked. Under-range is indicated by -1 and over-range by 1.

## 7. MAINTENANCE

### 7.1 Fault finding during commissioning

If a BA405C set point station fails to function during commissioning the following procedure should be followed:

Symptom	Cause	Solution
No loop current	Incorrect wiring or no power supply	Check wiring and power supply polarity
BA405C displays 1	Positive over-range	The display has been incorrectly calibrated & is trying to show a number greater than 1999.
BA405C displays -1	Negative over-range	The display has been incorrectly calibrated & is trying to show a number less than -1999.
Unstable loop current	Insufficient supply voltage	Check that voltage between terminals 1 & 3 is greater than 6.1V, or 10V between terminals 1 & 13 if a loop powered backlight is fitted.
Unstable display	Power supply has voltage ripple	Reduce ripple

### 7.2 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 test equipment should be used unless a gas clearance certificate is available.**

If a BA405C fails after it has been functioning correctly, the following procedure should be followed:

Symptom	Cause	Solution
No loop current	Wiring or power supply fault	Check wiring and power supply
Unstable loop current	Insufficient supply voltage	Check that voltage between terminals 1 & 3 is greater than 6.1, or 10V between terminals 1 & 13 if fitted with a loop powered backlight.
Unstable display	Power supply has developed voltage ripple	Reduce ripple

If this procedure does not reveal the cause of the fault, it is recommended that the BA405C manual set point station is replaced with a spare instrument.

### 7.3 Servicing

We recommend that faulty BA405C set point stations are returned to BEKA associates or to our local agent for repair.

### 7.4 Routine maintenance

The mechanical and electrical condition of the instrument should be regularly checked. Initially annual inspections are recommended, but the inspection frequency should be adjusted to suit the environmental conditions.

### 7.5 Guarantee

Set point stations which fail within the guarantee period should be returned to BEKA associates or our local agent. It is helpful if a brief description of the fault symptoms is provided.

### 7.6 Customer comments

BEKA associates is always pleased to receive comments from customers about our products and services. All communications are acknowledged and whenever possible, suggestions are implemented.

## 8. ACCESSORIES

### 8.1 Scale card

The BA405C has a window below the control knob to accommodate a scale card. Set point stations can be supplied with a printed scale card showing any units specified at the time of ordering e.g. °C, mBar, RPM. If a printed scale card is not requested, a blank card will be supplied.

Scale cards can easily be marked on site as follows:

- a. Remove the rear terminal block(s) and the rear panel as shown in Fig 8.
- b. Remove the end cap from the front panel control knob using a thin bladed screwdriver. This will reveal a screw collet which secures the control knob to the shaft. Loosen the collet by turning the brass split screwhead anti clockwise and then carefully pull the control knob from the shaft.
- c. Pull the electronic assembly from the rear of the enclosure.
- d. Remove the blank scale card(s) and mark with the required legend. Replace scale card(s) taking care to align them within the front panel window.
- e. Slide the electronic assembly into the rear of the enclosure and carefully guide the control shaft through the front panel seal. Replace the rear panel and terminals.
- f. Replace the control knob and tighten the collet screw. Finally push the knob end cap into place.

### 8.2 Tag strip

The BA405C can be supplied with a thermally printed tag strip on the rear panel. This tag strip is not visible from the front of the instrument after installation.

## APPENDIX 1

### FM Approval for use in the USA

#### A1.0 Factory Mutual Approval

For installation in the USA the BA405C has FM Intrinsic Safety and FM Nonincendive approval, project identification 3026081. Copies of the Certificate of Compliance are available from BEKA associates sales office and [www.beka.co.uk](http://www.beka.co.uk).

#### A2.1 Intrinsic safety approval

The BA405C is approved to the FM Class 3610 intrinsic safety standard for use in indoor and outdoor hazardous (classified) locations. Installations must comply with BEKA associates Control Drawing CI405-27 which is attached to this Appendix, ANSI/ISA RP12.06.01 'Installation of Intrinsically safe Systems for Hazardous (Classified) Locations' and with the National Electrical Code ANSI/NFPA70.

The BA405C has a T4 rating at ambient temperatures up to 60 °C and may be used with the following gases:

Intrinsic Safety	
Division 1 or 2	
Class I	Group A & B Group C Group D
Zone 0, 1 or 2	
Class 1	Group IIC Group IIB Group IIA

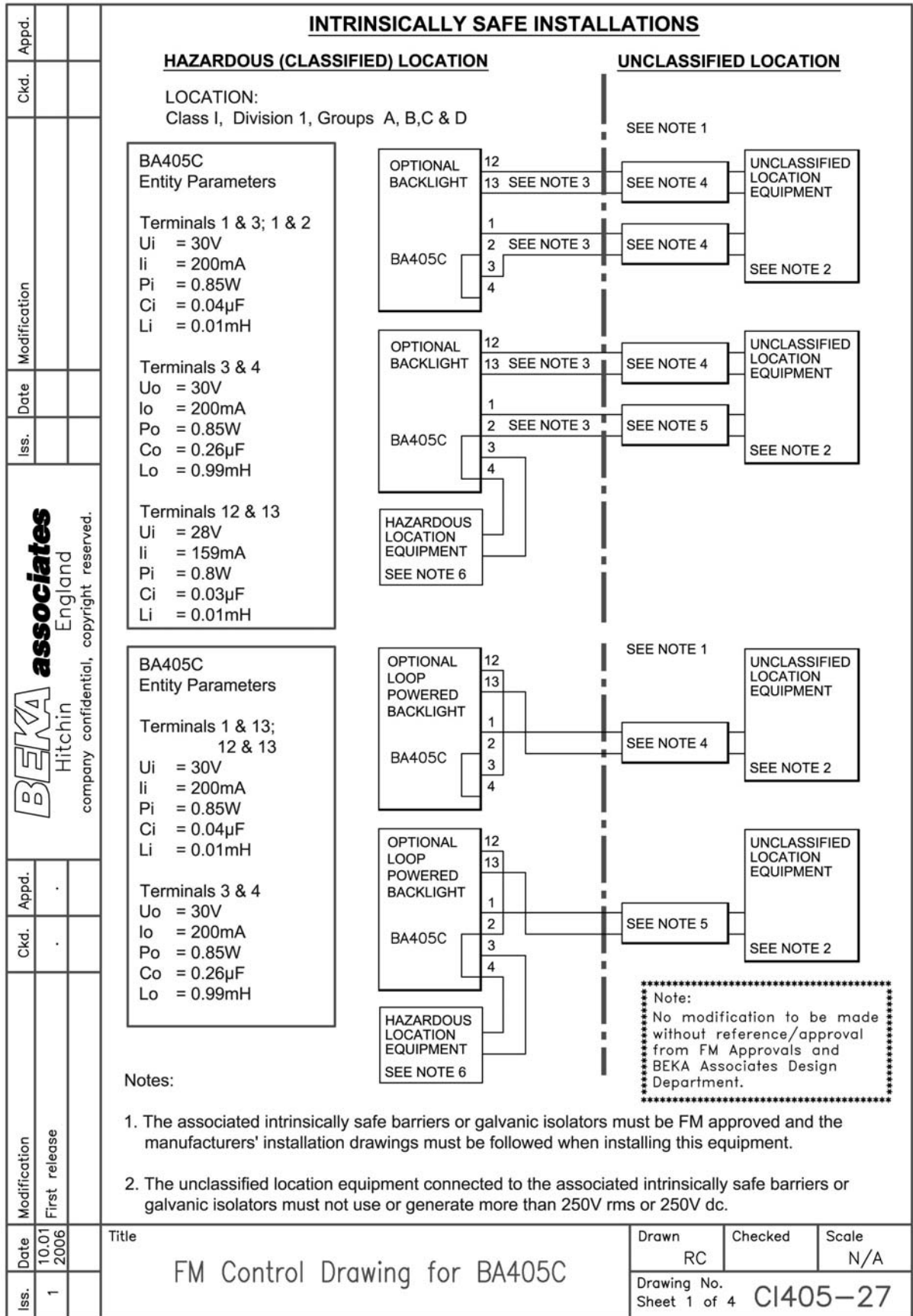
The FM entity parameters are similar to the ATEX parameters. The intrinsically safe systems shown in this manual may therefore be used for installations in the USA providing the Zener barriers or galvanic isolators are FM Approved. All installations must comply with BEKA associates Control Drawing CI405-27.

#### A2.2 Nonincendive approval

The BA405C is FM Class 3611 nonincendive approved allowing it to be installed in Division 2 indoor and outdoor hazardous (classified) locations without the need for Zener barriers or galvanic isolators. US installations must comply with the BEKA associates Control Drawing CI405-27, which is attached to this Appendix, and with the National Electrical Code ANSI/NFPA70.

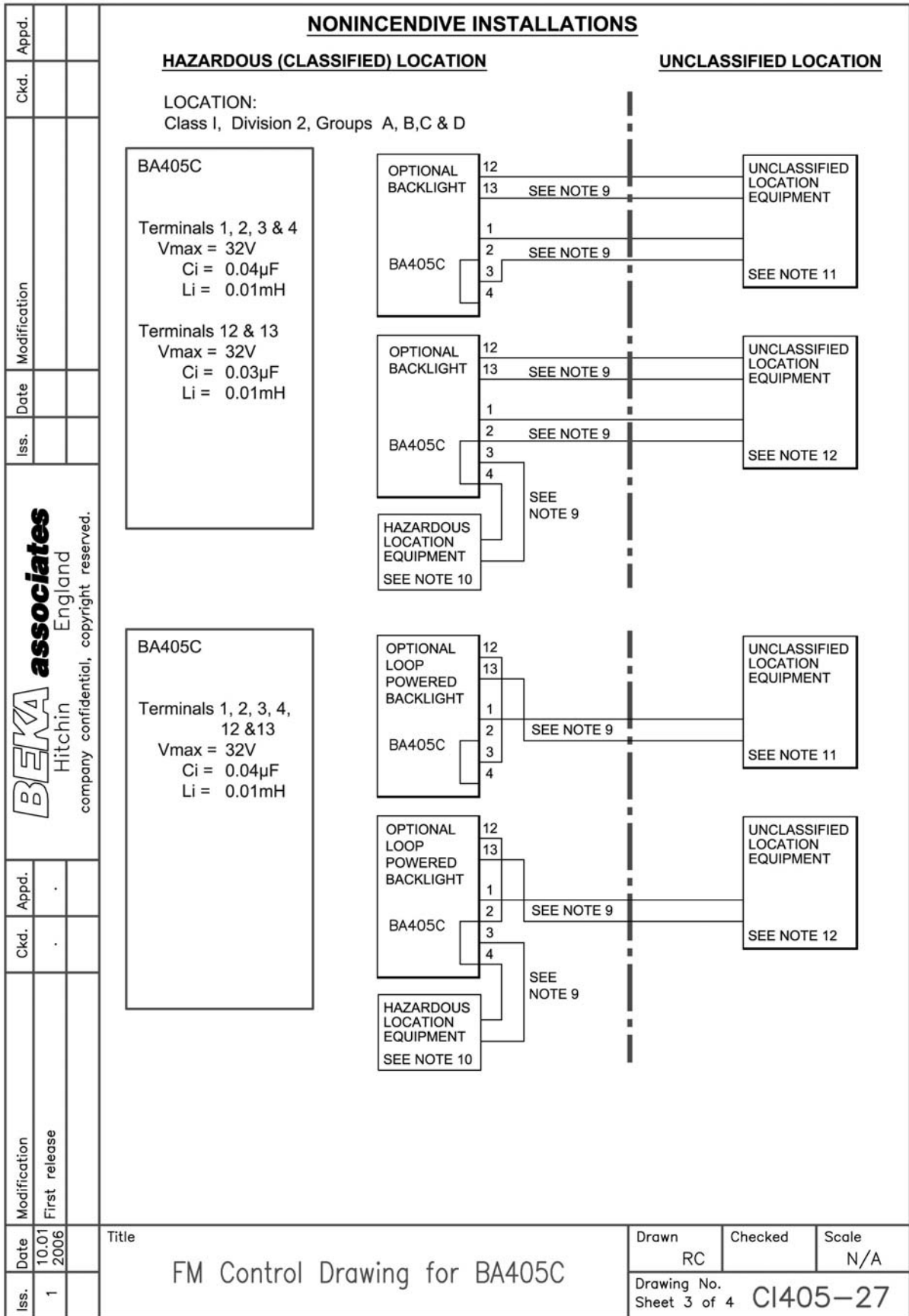
The BA414DF has a T4 rating at ambient temperatures up to +60°C and may be used with the following gases:

Nonincendive	
Division 2	
Class I	Group A & B Group C Group D
Zone 2	
Class I	Group IIC Group IIB Group IIA



Iss.	Date	Modification	Ckd.	Appd.	<p>3. Installation should be in accordance with ANSI/ISA RP 12.06.01 "Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations" and the National Electrical Code ANSI/NFPA 70.</p> <p>4. One single channel or one channel of a dual channel barrier or galvanic isolator with entity parameters complying with the following requirements:</p> <table border="0"> <tr> <td>Uo or Vt</td> <td>equal to or less than</td> <td>Ui</td> </tr> <tr> <td>Io or It</td> <td>equal to or less than</td> <td>li</td> </tr> <tr> <td>Po</td> <td>equal to or less than</td> <td>Pi</td> </tr> <tr> <td>La</td> <td>equal to or greater than</td> <td>Lcable + Li</td> </tr> <tr> <td>Ca</td> <td>equal to or greater than</td> <td>Ccable + Ci</td> </tr> </table> <p>5. One single channel or one channel of a dual channel barrier or galvanic isolator with entity parameters complying with the following requirements:</p> <p>CAUTION: THESE REQUIREMENTS MUST BE FOLLOWED FOR NEW INSTALLATIONS OR MODIFICATIONS TO EXISTING INSTALLATIONS</p> <table border="0"> <tr> <td>Voc or Vt</td> <td>equal to or less than</td> <td>The lowest Vmax of the FM Approved apparatus installed in the respective loop.</td> </tr> <tr> <td>Isc or It</td> <td>equal to or less than</td> <td>The lowest Imax of the FM Approved apparatus installed in the respective loop.</td> </tr> <tr> <td>Po</td> <td>equal to or less than</td> <td>Pmax</td> </tr> <tr> <td>La</td> <td>equal to or greater than</td> <td>The sum of the cable inductances and the internal inductance Li of each FM Approved apparatus installed in the respective loop.</td> </tr> <tr> <td>Ca</td> <td>equal to or greater than</td> <td>The sum of the cable capacitance and the internal capacitance Ci of each FM Approved apparatus in the respective loop.</td> </tr> </table> <p>6. Hazardous (classified) location equipment may be simple apparatus or FM Approved equipment with entity parameters meeting the requirements of note 5.</p> <p>7. When mounting BA405C in an enclosure to maintain IP65 front panel rating:</p> <p>Minimum panel thickness should be    2mm (0.08inches) Steel        3mm (0.12inches) Aluminium</p> <p>Outside panel finish should be smooth, free from particle inclusions, runs or build-up around cut-out.</p> <p>Panel cut-out should be    43.5 x 90.0mm -0.00 +0.5        (1.71 x 3.54 inches -0.00 +0.02)</p> <p>Edges of panel cut-out should be deburred and clean</p> <p>Each panel mounting clip should be tightened to between:    20 and 22cNm (1.77 to 1.95 inLb)</p>	Uo or Vt	equal to or less than	Ui	Io or It	equal to or less than	li	Po	equal to or less than	Pi	La	equal to or greater than	Lcable + Li	Ca	equal to or greater than	Ccable + Ci	Voc or Vt	equal to or less than	The lowest Vmax of the FM Approved apparatus installed in the respective loop.	Isc or It	equal to or less than	The lowest Imax of the FM Approved apparatus installed in the respective loop.	Po	equal to or less than	Pmax	La	equal to or greater than	The sum of the cable inductances and the internal inductance Li of each FM Approved apparatus installed in the respective loop.	Ca	equal to or greater than	The sum of the cable capacitance and the internal capacitance Ci of each FM Approved apparatus in the respective loop.
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