Hazardous Area

Application Note – Lucid, Luci PM/SR/AR. Indicator IS Barrier Applications.

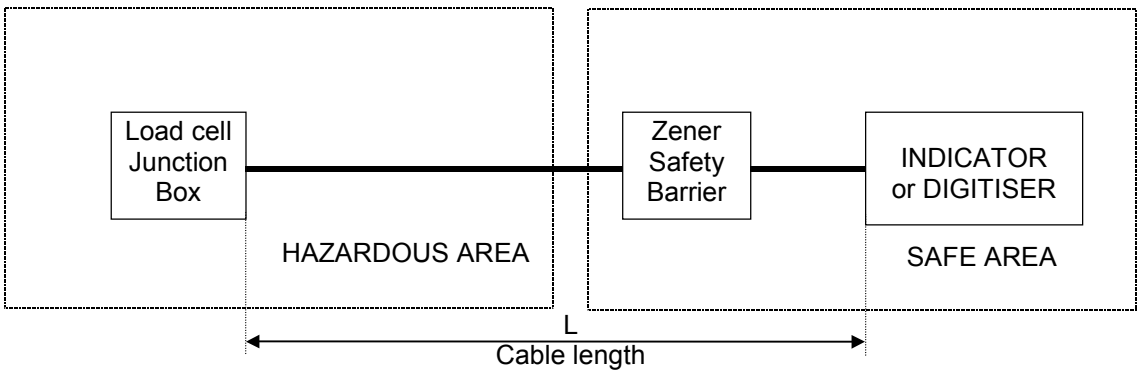
Ian Fellows LIMITED

Introduction

When the weight indicator or digitiser is not Intrinsically Safe (all current Ian Fellows Ltd product), it may not be placed in a Hazardous Area. However, strain gauge load cells are inherently passive devices and 'safe' (although long cables may exceed capacitive and inductive limitations ~ a maximum barrier to loadcell cable length of 100m should be observed; other limitations not withstanding), so may be operated in the Hazardous Area so long as the power delivered to them is strictly limited under any fault condition. Shunt Diode Safety Barriers are used for this purpose, but their use must be according to approved safety practice, and will also impose limitations on cable lengths for a given weighing accuracy.

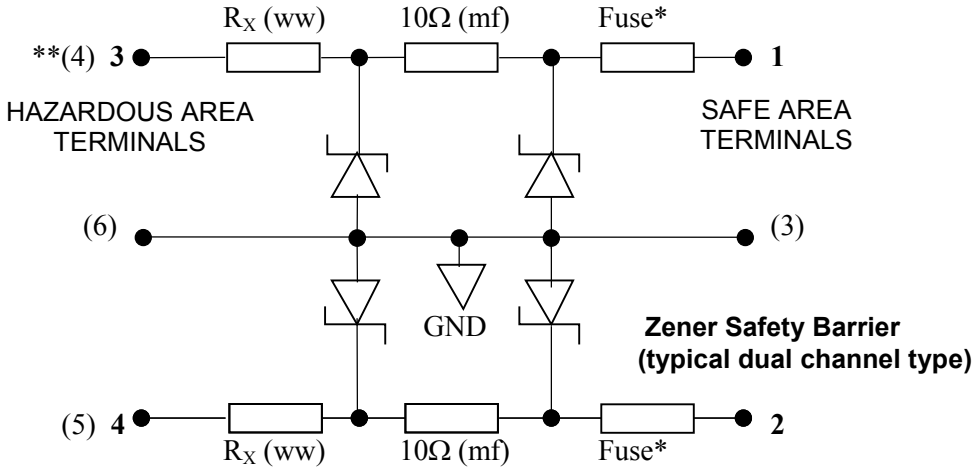
General Considerations

The Hazardous Area is where inflammable gases or vapours are (or may be) present and Intrinsically Safe electrical systems are designed and operated such that any failure will release insufficient spark or thermal energy to cause ignition. This is where the 'bottomworks' and the load cell(s) of the weighing system are located. There may also be remote switches to initiate printing, etc, and/or an intrinsically safe remote indicator for local weight display.
The Safe Area is where there is no danger of flammable gases or vapours. The weight indicator or digitiser is in this area, together with the Safety Barriers that limit voltage and current to the load cell(s) (and any other devices). The Safe Area could be an adjoining room or even a purged or explosion proof enclosure in the Hazardous Area.



Zener Barriers consist of series resistors and shunt zener diodes (see below) and further reduce allowable loadcell cable lengths due to the temperature co-efficient of the series resistor. This limitation can be calculated using the equations within the application notes below. **Note that these limitations strictly apply only to trade approved (certified) installations.** Non trade-approved systems (but still approved for use in hazardous areas, of course) may exceed the cable limits stated; the calculations will enable the installer to precisely quantify any errors. As an example, the value of the series resistor, R_X is 1kΩ for the MTL 764 and 175Ω for the MTL 766; with a tempco of +/- 75ppm/^{o}C. The effect of the 10Ω metal film may be discounted.

The tempco effect of Rx in the MTL 764 Signal barrier can be disregarded because the signal input impedance of the indicator/digitiser is effectively infinite. The only significant effect is the R_X tempco for the Sense barrier. Over a 50^{o}C temperature span, this amounts to 0.7Ω resistance change in the 766's 185Ω series resistance. This is half the sense line cable resistance change allowance for a non-barrier 10,000 division system, but its effect becomes rapidly less for lower resolution systems. This effect is accounted for in the maximum cable length calculations for the schemes shown below.



*Note there is a non-repairable fuse in series with terminals 1 and 2. If the applied voltage exceeds the barrier's rated voltage, the fuse may blow and the barrier is ruined.
**Connector numbers in parenthesis are for corresponding 7000 series devices.

Application Notes

These notes give typical schematics of applications where the load cell is in a hazardous area and the indicator/digitiser is in the safe area. It examples the use of MTL 700/700P/7000P series barriers, but note that, as the Pepperl + Fuchs Z900/Z900.H series is almost identical; it can be assumed (but the installer needs to verify) that they are interchangeable. A table of the critical parameters is shown below.

Scheme A is the only one explicitly authorized for trade applications, but Scheme B is close enough to be acceptable (and will give both better results and allow the use of 4 cells). Schemes C and D are for the benefit of users who insist on 700P and 7000P series barriers.

Critical values of Barrier types:

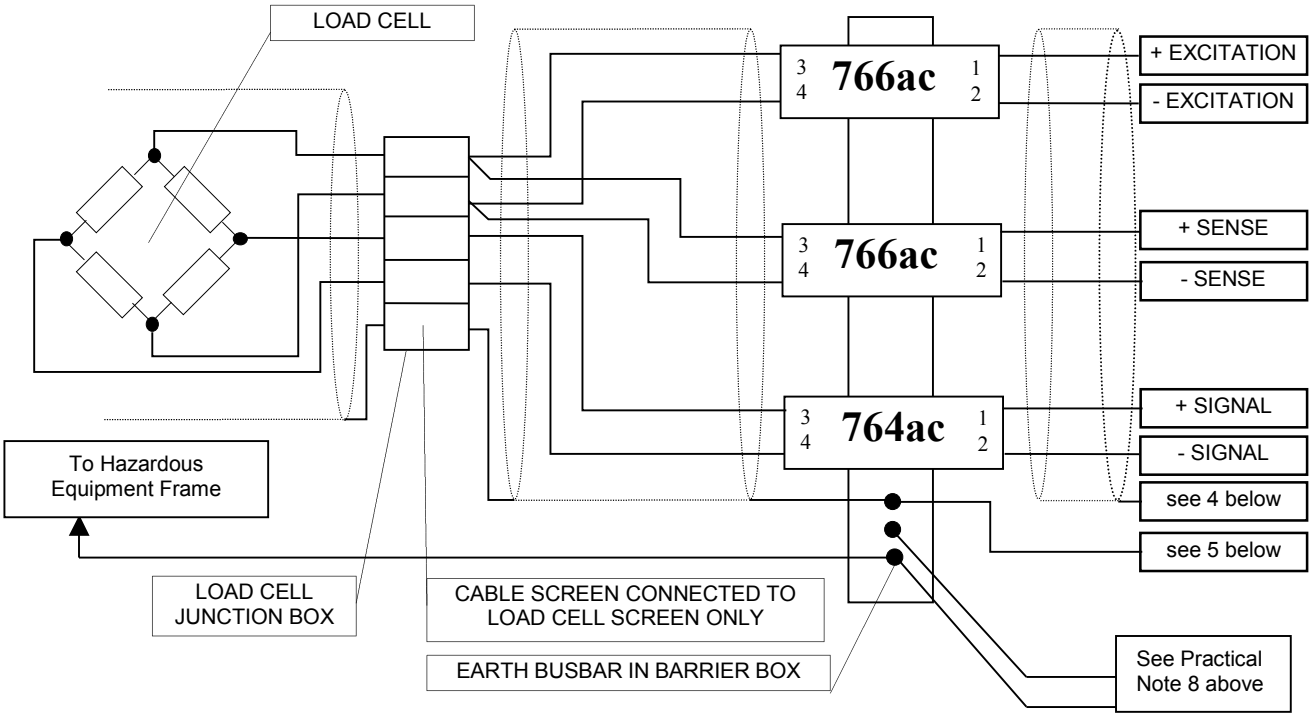
xx	..61		..64		..66	
	Resistance	Voltage	Resistance	Voltage	Resistance	Voltage
7xx	145	6	1075	10	185	10
7xxP	384	7	n/a	n/a	93	9.8
72xx	115	7.2	1048	10	n/a	n/a
70xxP	384	7.2	n/a	n/a	97	9.8
Z9xx	106	6.5	1033	10	166	10
Z9xx.H	380	6.5	n/a	n/a	82	10

General Notes:
1. 700/7000 series are MTL, Z900 series is P+F.
2. Voltage is the maximum that may be applied before significant zener current begins to flow.
3. Generally 'ac' versions are specified in system certificates.
4. Existing 'system' certificates for IIc gases are:
   - Ex842128: 2 x 764ac + 4 x 766ac (i.e. no. of individual *channels,* not barriers)
   - Ex92C2424 2 x 766P + 4 x 761P
   - Ex98E2274 2 x 7066Pac + 4 x 7061Pac
5. No known P+F system certificates, but can assume equivalent parameters will give similar acceptable combinations.
6. All examples are for Class IIc environments. Class IIc is the most hazardous and is for hydrogen atmospheres.
7. Petroleum, dust and other typical industrial environments are usually Class IIb or IIa, where power levels significantly higher than in these examples may be used.
8. Load cells in the applications are assumed to be typical 350Ω types.

Practical Notes:

1. The cable length supplied attached to the load cells should normally not be modified and should be specified to reach the loadcell junction box. This cable need not be included in any cable length calculation as it is assumed to have its temperature co-efficient compensated for by the load cell manufacturer.
2. The Barriers are usually supplied in an enclosure similar (but somewhat larger) to the Load cell Junction Box. On trade certified systems it must have an identical method of sealing.
3. It should also be noted that some load cells might not stand the general 500v insulation test (strain gauge to substrate insulation may break down). In such cases it is generally necessary to run a >4mm^2 bonding conductor between the load cell bottomworks and the barrier busbar. BASEEFA further suggest that where the barrier to load cell distance is short and the barrier is securely bonded to an 'equipotential earth', the bonding wire may not be necessary. (The reader is directed to MTL application note AN9003.)
4. An 'Earth Loop' may be created if the barrier to indicator/digitiser cable screen is earthed at the barrier busbar safety earth connection and also (as is strongly recommended on all installations) on entry to the indicator enclosure. The enclosure will almost certainly be returned to the mains earth (usually a neutral 'star' point) creating an electrical interference generating current flow between safety and mains earths *via the load cell cable screen*. This should be broken by not connecting the loadcell cable screen *at the barrier end*. See relevant notes below.
5. Ensure that the barrier assembly is clearly marked with replacement types.
6. Safe and hazardous cables must be segregated by >50mm (separate trunking).
7. Segregation between IS circuits must be >6mm, cables must have 500v/1minute insulation, and be clearly identified (blue) or blue tape every 1m.
8. Two cables >=4mm^2 area, Coded Green/Yellow, taped together with blue tape and taken to two separate earth screws at the Mains Neutral Star point and two separate earth screws at the Barrier Earth Bar. Using two conductors enables easy checking of the required <1Ω safety earth resistance by simply disconnecting one of the two at the barrier busbar and measuring the loop value.
9. **Because standard Ian Fellows Ltd indicators/digitisers have their supply grounds internally connected to its metallic enclosure and/or external supply (if applicable), it is essential to order a suitably modified version for IS use. These are fitted with a Warning Label at Stud (modification number XXX applies). Insulated cases with fully floating DC power supplies may be acceptable.**
10. **Ian Fellows Ltd has made every effort to ensure that this information is correct. However, it is provided as a guide only and, as always, it is the Installers responsibility to ensure that the final system complies with all applicable standards and *has some sort of documentary evidence* (an MTL system certificate or their written approval, for example).**

SCHEME A



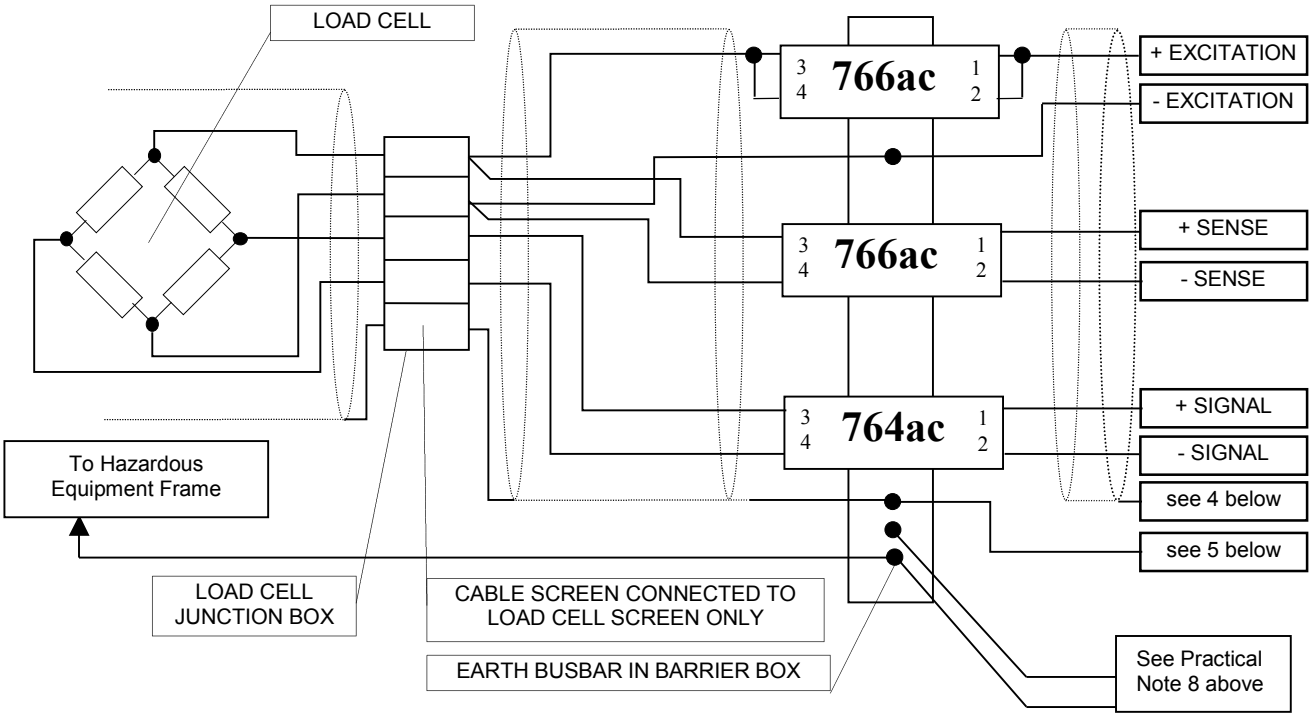
LOAD CELL **JUNCTION BOX** **BARRIER BOX** **INDICATOR**

1. Maximum overall cable length, L = ((281/n) - 0.0139) x 13680 x CSA metres.
   ('n' = number of divisions required, 'CSA' = cable cross sectional area. See table 1)
2. Maximum 'hazardous' cable length = 100m (For inductance/capacitance of typical L/C cables).
3. Cable screen must continue through to load cell screen with NO OTHER CONNECTIONS.
4. The indicator/digitiser to barrier section of load cell cable screen *must* be connected to the indicator's metallic enclosure at entry gland (or to the 'LC SCN' terminal of a DIN-cased indicator *only* if it is not housed in an overall conductive cabinet). The screen should not be connected at the barrier earth busbar end.
5. A separate >1.5mm^2 min cable, Green/Yellow, *must be connected* to the Indicator lower ADC Mounting Screw using a solder tag or crimp tag (or 'LC SCN' terminal of a DIN-cased unit) and wired directly to the Barrier Earth Bar.
6. Loadcell excitation voltage is reduced to 5v nominal for a single 350Ω cell, only 3.2v for 2 cells (paralleled at the load cell junction box). The minimum approved active range of a single load cell must be doubled; for two cells; trebled. Two cells or more is not recommended.
7. For trade applications, load cell signal must equal or exceed 1μV per division (scale interval ~ e). I.e. change of loadcell signal must exceed 10mV over active range for a 10,000n system (>3mV for a 3,000n system, etc.).

   $$\text{Loadcell Signal } (\mu v/div) = \frac{C \times e \times R_{LC} \times 10{,}000}{E_{max} \times N \times (R_{LC} + 360N)} \quad \text{(and must be >= 1)}$$

   Where C = Loadcell Rated Output (mV/V)
   e = Scale Interval (smallest division) (in same units as E_{max})
   R_{LC} = Input Resistance of Loadcell (Ω)
   E_{max} = Maximum Capacity of Loadcell (T, kg, g)
   N = Number of Load cells
8. Trade approval reference 'NMi T2532 rev. 5'.
9. BASEEFA System Certificate No. Ex842128.
10. 700P, 7000P or Z900.H series barriers may *not* be substituted.
11. Similar barriers are not available on the 7000 range.

SCHEME B

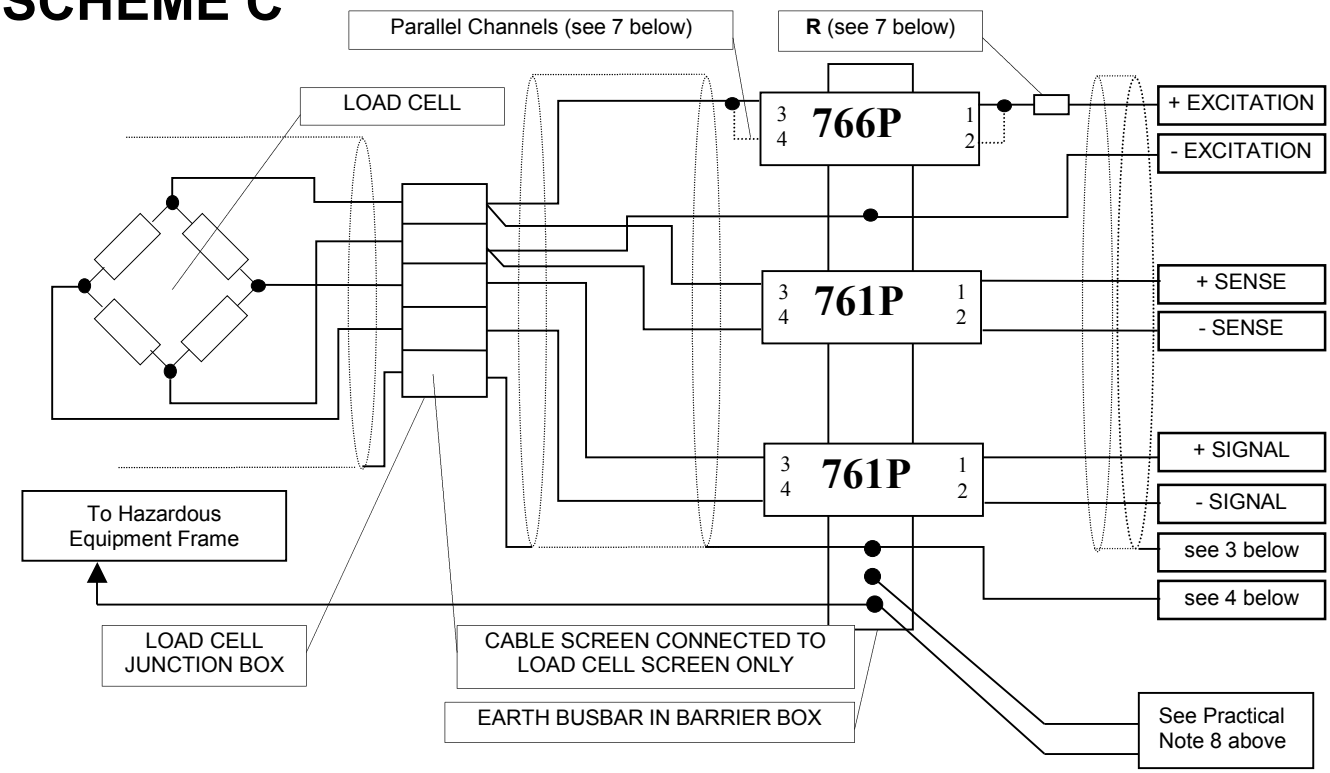


1. Maximum overall cable length, L = ((281/n) - 0.0139) x 13680 x CSA metres.
   ('n' = number of divisions required, 'CSA' = cable cross sectional area. See table 1)
2. Maximum 'hazardous' cable length = 100m (For inductance/capacitance of typical L/C cables).
3. Cable screen must continue through to load cell screen with NO OTHER CONNECTIONS.
4. The indicator/digitiser to barrier section of load cell cable screen *must* be connected to the indicator's metallic enclosure at entry gland (or to the 'LC SCN' terminal of a DIN-cased indicator *only* if it is not housed in an overall conductive cabinet). The screen should not be connected at the barrier earth busbar end.
5. A separate >1.5mm^2 min cable, Green/Yellow, *must be connected* to the Indicator lower ADC Mounting Screw using a solder tag or crimp tag (or 'LC SCN' terminal of a DIN-cased unit) and wired directly to the Barrier Earth Bar.
6. Loadcell excitation voltage is 7.9v nominal for a single 350Ω cell; 6.5v for 2 cells (paralleled at the cell junction box); 5.5v for 3 cells; and 4.8v for 4 cells. The minimum approved active range of a single load cell is 125% of certificate value; 150% for two cells; 180% for 3; 200% for 4.
7. More than 4 cells is impractical unless high resistance cells used.
8. For trade applications, load cell signal must equal or exceed 1μV per division (scale interval ~ e).

$$\text{Loadcell Signal } (\mu v/div) = \frac{C \times e \times R_{LC} \times 10{,}000 \text{ (and must be >= 1)}}{E_{max} \times N \times (R_{LC} + 360N)}$$

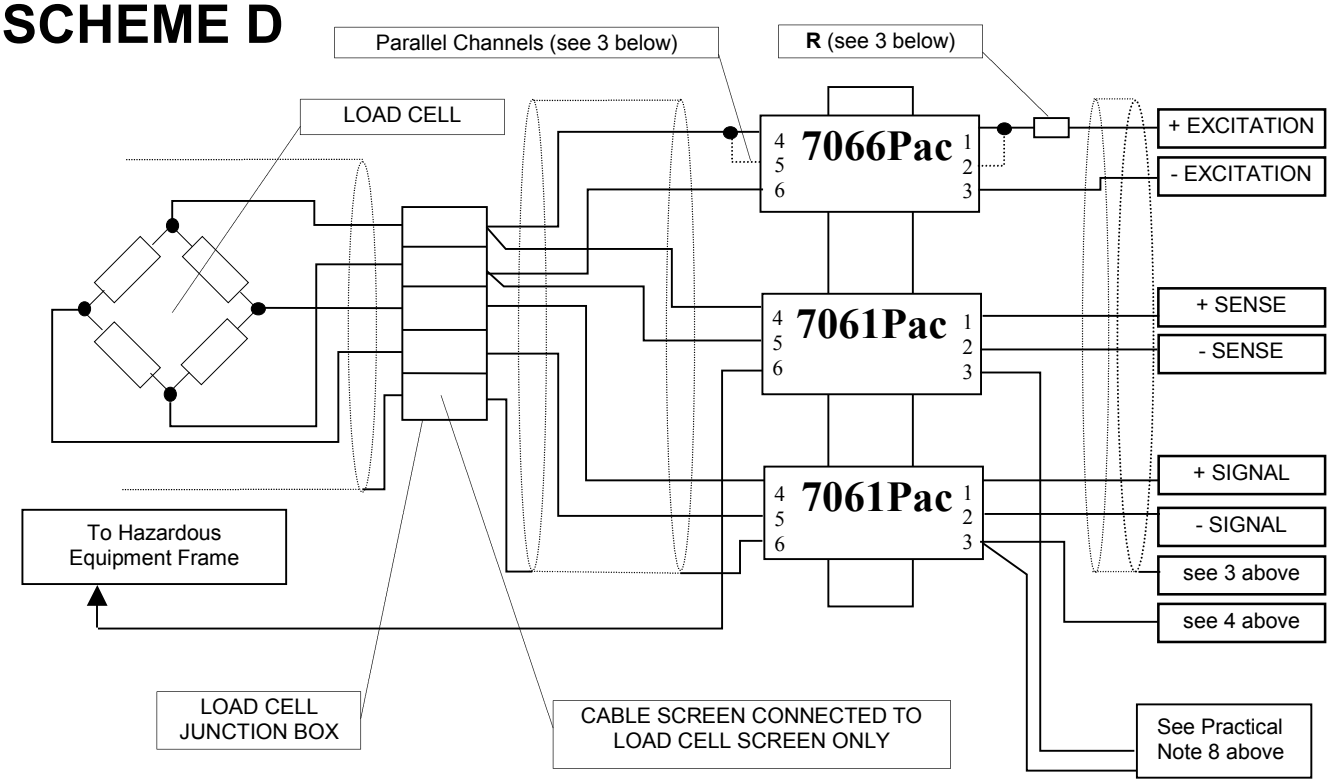
   Where C = Loadcell Rated Output (mV/V)
   e = Scale Interval (smallest division) (in same units as E_{max})
   R_{LC} = Input Resistance of Loadcell (Ω)
   E_{max} = Maximum Capacity of Loadcell (T, kg, g)
   N = Number of Load cells
9. BASEEFA System Certificate No. Ex842128.
10. 700P, 7000P or Z900.H series barriers may *not* be substituted.
11. Similar barriers are not available on the 7000 range.

SCHEME C



1. Maximum 'hazardous' cable length = 100m (For inductance/capacitance of typical L/C cables).
2. Cable screen must continue through to load cell screen with NO OTHER CONNECTIONS.
3. The indicator/digitiser to barrier section of load cell cable screen *must* be connected to the indicator's metallic enclosure at entry gland (or to the 'LC SCN' terminal of a DIN-cased indicator *only* if it is not housed in an overall conductive cabinet). The screen should not be connected at the barrier earth busbar end.
4. A separate >1.5mm^2 min cable, Green/Yellow, *must be connected* to the Indicator lower ADC Mounting Screw using a solder tag or crimp tag (or 'LC SCN' terminal of a DIN-cased unit) and wired directly to the Barrier Earth Bar.
5. The 766P (used in the excitation supply) has a recommended maximum input voltage of 9.8v. +EXCITATION is nominally 10v but actually between 9.5 and 9.8v.
6. 766P barriers are substantially lower resistance (93Ω per channel) than 766 non-P type.
7. The system certificate forces use of 761P barriers for sense. The working voltage for these is only 7v (NB 6.5v if the P+F 961 series is used). Therefore, +SENSE *must* be kept at or below this value. Depending on load cell resistance (i.e. number of cells), may need to add external resistance 'R' or parallel two 766P channels as shown dotted.
   1 x 350Ω cell:
   Use 1 channel of 766P only (2 and 4 not connected on 766P)
   Add R = 100Ω (Metal film, minimum 0.25W, tolerance unimportant).
   2 x 350Ω cells:
   Use 1 channel of 766P only (R is not required).
   3 x 350Ω cells:
   Use 1 channel of 766P only (R is not required) ~ excitation voltage will be 5.6v.
   Or - use 2 parallel channels of 766P (R is not required) ~ excitation voltage will be 7.1v.
   (NB Only if using MTL barriers. Link 1 to 2 and 3 to 4 as shown dotted above.)
   4 x 350Ω cells:
   Use 2 parallel channels of 766P (R is not required) ~ excitation voltage will be 6.5v.
   6 x 350Ω cells:
   Use 2 parallel channels of 766P (R is not required) ~ excitation voltage will be 5.5v.
8. Not trade approved. Some loss of temperature specification may be experienced at highest resolutions due to the higher series resistance of the 761P sense barriers (384Ω instead of the approved 766's 185Ω). ***Do not substitute a 766 in place of the specified 761P.***
9. BASEEFA System Certificate No. Ex92C2424.
10. Similar barriers are available in the MTL7000P range (see Scheme D below).

SCHEME D



LOAD CELL **JUNCTION BOX** **BARRIER BOX** **INDICATOR**

1. This is effectively identical to Scheme C; refer to the above notes.
2. Barrier connections 3 and 6 are linked together and to safety earth busbar.
3. The system certificate forces use of 7061Pac barriers for sense. The working voltage for these is only 7.2v (NB 6.5v if the P+F 961.H series is used). Therefore, +SENSE *must* be kept at or below this value. Depending on load cell resistance (i.e. number of cells), may need to add external resistance 'R' or parallel two 7066Pac channels as shown dotted.
   1 x 350Ω cell:
   Use 1 channel of 766P only (2 and 4 not connected on 766P)
   Add R = 100Ω (Metal film, minimum 0.25W, tolerance unimportant).
   2 x 350Ω cells:
   Use 1 channel of 766P only (R is not required).
   3 x 350Ω cells:
   Use 1 channel of 766P only (R is not required) ~ excitation voltage will be 5.6v.
   Or - use 2 parallel channels of 766P (R is not required) ~ excitation voltage will be 7.1v.
   (NB Only if using MTL barriers. Link 1 to 2 and 3 to 4 as shown dotted above.)
   4 x 350Ω cells:
   Use 2 parallel channels of 766P (R is not required) ~ excitation voltage will be 6.5v.
   6 x 350Ω cells:
   Use 2 parallel channels of 766P (R is not required) ~ excitation voltage will be 5.5v.
4. BASEEFA System Certificate No. Ex98E2274.
5. ***Do not substitute a 766 in place of the specified 7061P***

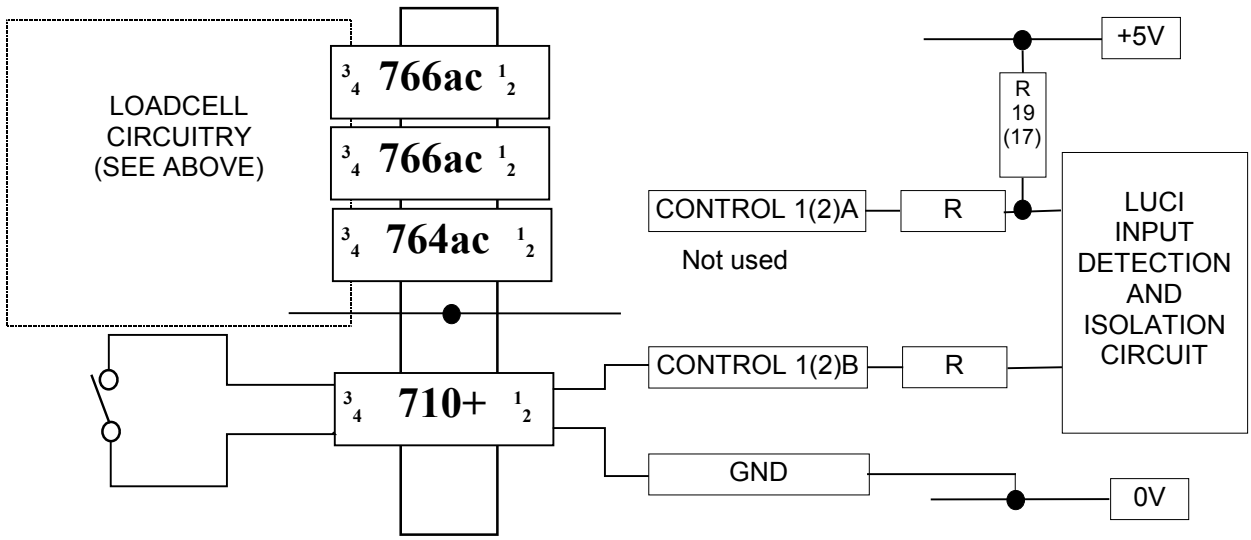
Below is a simple spreadsheet with typical examples of maximum lengths 'L' of load cell cable between load cell junction box and indicator/digitiser for various combinations resolution (n) and CSA of cable. This is only appropriate to Schemes A and B for trade (certified) compliance. Note that it is acceptable to 'double' (or 'treble') up sense cables (the only critical ones) in order to increase the cross sectional area.

Table 1

e (divisions)	CSA =	0.22mm^2	0.5mm^2	1mm^2	1.5mm^2	2.5mm^2
10,000		43m	97m	194m	291m	485m
8,000		64m	145m	290m	435m	
6,000		99m	225m	450m		
5,000		127m	289m			
4,000		169m	385m			
3,000		240m				
2,000		381m				

Lengths greater than 500m are not shown (not recommended in any case).

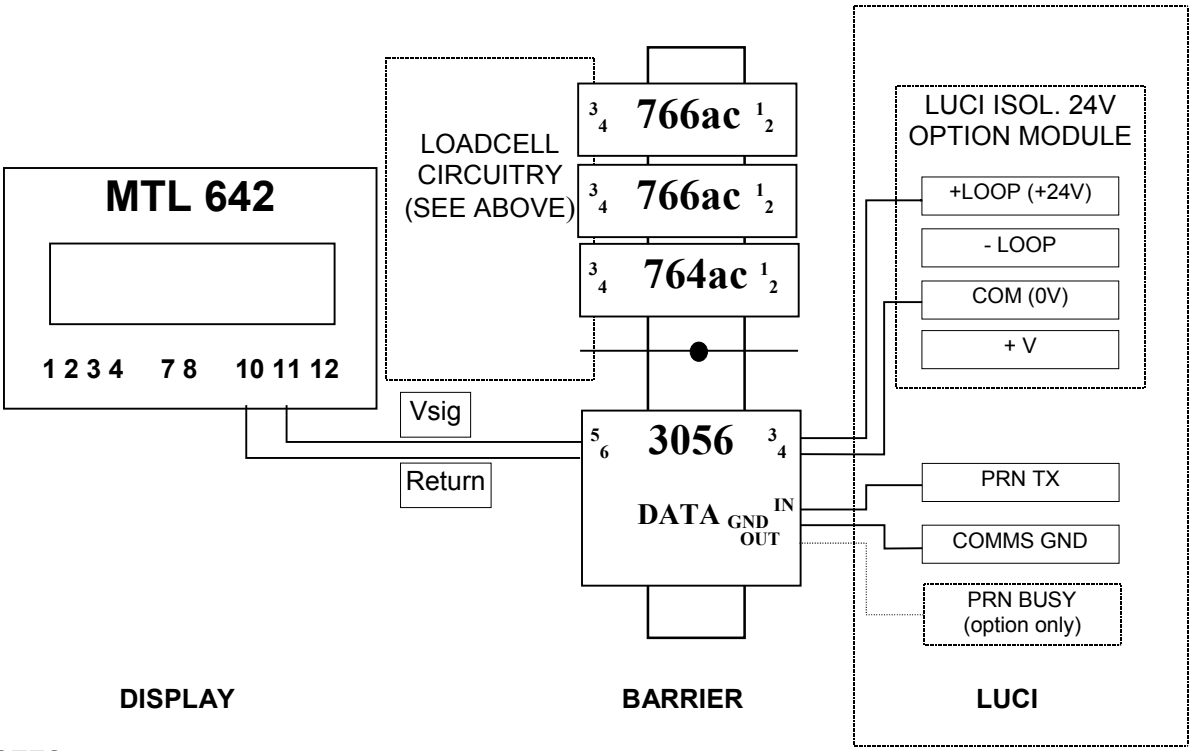
CONTROL INPUT CONNECTION



Notes:

1. Maximum 'hazardous' cable length (barrier to switch) = 100m for typical cable. If longer distances are required, the cable specification, particularly its inherent capacitance and inductance, must be examined to ensure I.S. limitations for stored energy are not breached.
2. Conductors to each switch MUST run as a close coupled pair (pref. multicore).
3. It is recommended that screened cable be used (connect screen to safety barrier earth only).
4. More than one switch circuit may be used, but each circuit must be independent in the hazardous area.
5. There must be no interconnection between switch and *any other* circuitry in the hazardous area.
6. Conductors must have minimum 0.25mm insulation and withstand a test voltage of 500v (EN 50 039).

USE OF MTL 642 REMOTE INDICATOR



NOTES:

1. MTL 642 is 2 x 16 full alphanumeric character display.
2. The MTL 3056 isolating interface is mounted in the Barrier Box.
3. The display is limited to ambient temperatures from 0 to 50°C (storage -20 to 70°C).
4. Zone 0, IIC, T4 Hazardous Area environment.
5. One indicator per system only.
6. No provision has been made to use the MTL 642 external switch inputs or the Alarm facility.
7. Similar limitations on maximum length of 'hazardous' cables apply; typically 100m.
8. It is recommended that screened cable be used.
9. The 24v isolated supply option must be installed in the LUCID.

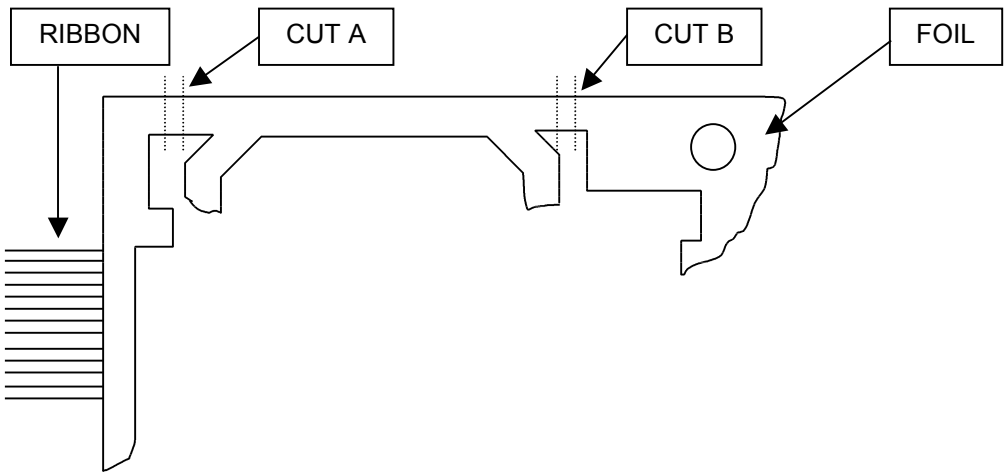
- Select MTL Address 50, 9.6kB, 1 Stop bit, No parity, 8 Data bits.
- SW setting 1-10 ~ OFF ON ON ON ON ON OFF OFF OFF ON (0 1)
- Set LUCI **'Pr_For_' 'CtrL' HP** to **2021b4c** (2 02 1B 4C = STX STX ESC L ~ inhibits any reply).
- Ensure that a carriage return and line feed are sent after both lines.
- Send a 'blank' (a couple of spaces) after a weight string to 'kill' any previous 'x10' digits.
- Transmission of an alarm message may be initiated automatically by selecting Product **'CodE' TR** to **99** and put a suitable 'alarm' text string into **'St2A/St2b' SC/SD**.

The LUCI ISOL Supply is approx. 27volts but can only source about 30mA. The MTL 624 & 3056 will operate from 7V to 30V and requires only 8mA this is suitable but care should be taken if any other use, for this supply, is contemplated.

LUCID Modification for I.S.

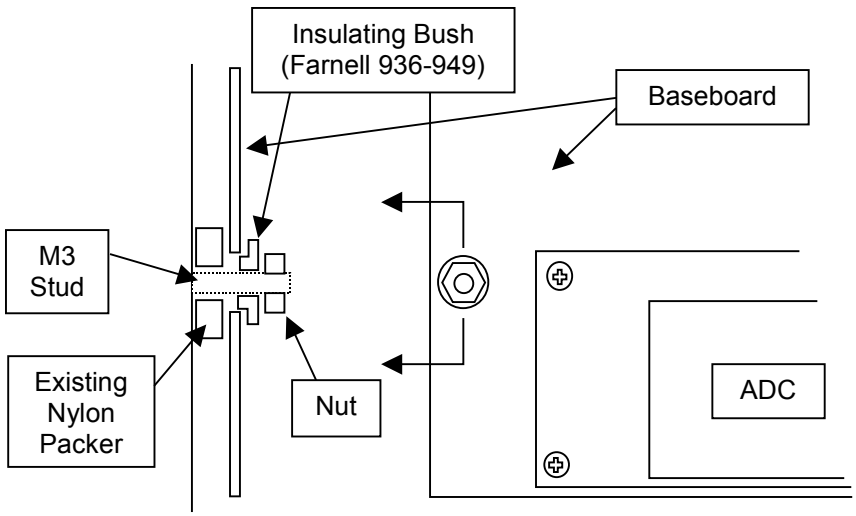
For IS working, it is necessary to modify the standard LUCID in order to isolate the internal circuit ground. This is subsequently bonded to the Barrier Safety Earth via a >1.5mm conductor (see schemes above) and the modification prevents ground loop conditions between Safety Earth and Mains Supply Earth. The factory normally carries out these modifications, but details are shown below for information.

1. Remove the Display PCB 13-E- 680 and modify by cutting the two foil tracks shown below on the 'front' (7-segment display) side; top left-hand corner.
   Note that the Rev B version only requires 'cut A'; there is no foil where 'cut B' would be made.
   Rev C requires no action (ground plane now isolated from 0V).



2. Remove the short green/yellow striped earth cable between the display mounting stud and the baseboard mounting stud next to the Analogue-to-Digital Converter (ADC) sub-module (middle left-hand side), and the long cable that runs from the same stud and the bottom right-hand corner incoming supply earth stud. Replace both cables with a longer single cable between right-hand corner incoming supply earth stud and the display stud; omitting the previous intermediate connection to the baseboard stud near the ADC module.

3. Modify the baseboard mounting stud assembly next to the ADC module as shown, in order to isolate the PCB copper groundplane from the stud.
   Fit a warning label next to the bush to ensure it is not omitted during future disassembly.



Cross-section

4. Reassemble and test the isolation using an ohmmeter on its highest resistance range. Measure between the case and the ADC 'can'. Measurement should be 'infinity'.

DIN-Case Modification

The mains powered DIN-cased unit is easily isolated by withdrawing the baseboard/power supply assembly and disconnecting the intermediate green/yellow wire link to the power supply PCB mounting screw. The connection between the baseboard and the display panel must remain, and the now disconnected tag must be securely taped up so that it cannot cause a short.
In the case of a DC powered unit (no internal power supply module), the installer must check that the external supply is fully floating. External power supplies may only be a maximum of 230v ac input for connection to barrier systems; 415v input is not allowed.
The installer must also be vigilant that there are no other connections between the LUCID's internal signal grounds and earth. This is particularly crucial as many DIN-cased versions do not have isolated comms (serial and printer) ports. As a final check, test the isolation as in 4 above, measuring between 'DC-' and a known local earth (the overall metal enclosure, for example). (Check for volts first, before switching to measure resistance!)