

# **Field Cabling Guidelines for INTRON-D / INTRON-D *plus* Systems**

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## 1 Introduction

This document provides general guidelines for the field cabling of digital INDUSTRONIC communication and public address systems of type INTRON-D and INTRON-D *plus*.

## 2 Terms and Abbreviations

Ex area	Area in which a mixture of flammable gases or combustible dusts with air can lead to an explosive atmosphere
TC	Telecommunication e.g. TC cable = telecommunication cable
INTERCOM	Generic term for communication technologies such as two-way communication, party line, telephony, radio, etc.
INTRON-D / INTRON-D <i>plus</i>	Fully digital INDUSTRONIC system
LINE	Pair of wires to transmit digitized voice and control signals and to provide phantom power to an intercom station
OFFSHORE	Installation technology with a common grounding plate for cable glands
PA	Equipotential bonding
PE	<i>Protective Earth (Protective Ground)</i>
Central exchange cabinet	Central exchange cabinet holding the central exchange unit

## 3 Applicable Documents and Standards

- System documentation for the respective project
- Wiring calculation guidelines for analog systems: 330-001-015
- VDE 0100: Guidelines for the erection of high voltage systems up to 1000 V
- EN 60950: Information technology equipment – Safety
- EN 62368-1: Safety requirements of audio/video, information and communication technology equipment
- VDE 0165; EN 60079-14: Explosive atmospheres - Electrical installations design, selection and erection
- IEC / EN 60079- ... Ex protection types
- VDE 0800 (Industrial communication networks)
- Installation Guidelines for INDUSTRONIC Radio Systems: 330-013-031

## 4 Cabling Scheme

In INDUSTRONIC systems, usually the following connections must be made via cable:

- Central exchange unit to the intercom station, if applicable with booster amplifier
- Central exchange unit to the speaker circuit
- Central exchange unit to flashing warning beacon(s)
- Central exchange unit to the radio base station
- Central exchange unit to central exchange unit

In order to provide highest safety and availability of INDUSTRONIC systems, cables to the above mentioned terminal devices are generally connected in star topology from the central exchange unit.

Only the cross-connections between the speakers connected in parallel as well as the connections of components directly connected to the intercom station are installed on site. Junction boxes can be used upon customer requests.

The following illustration Fig. 4-1 is a typical wiring diagram (schematic diagram) of a digital intercom system with public address capability and flashing warning beacons:

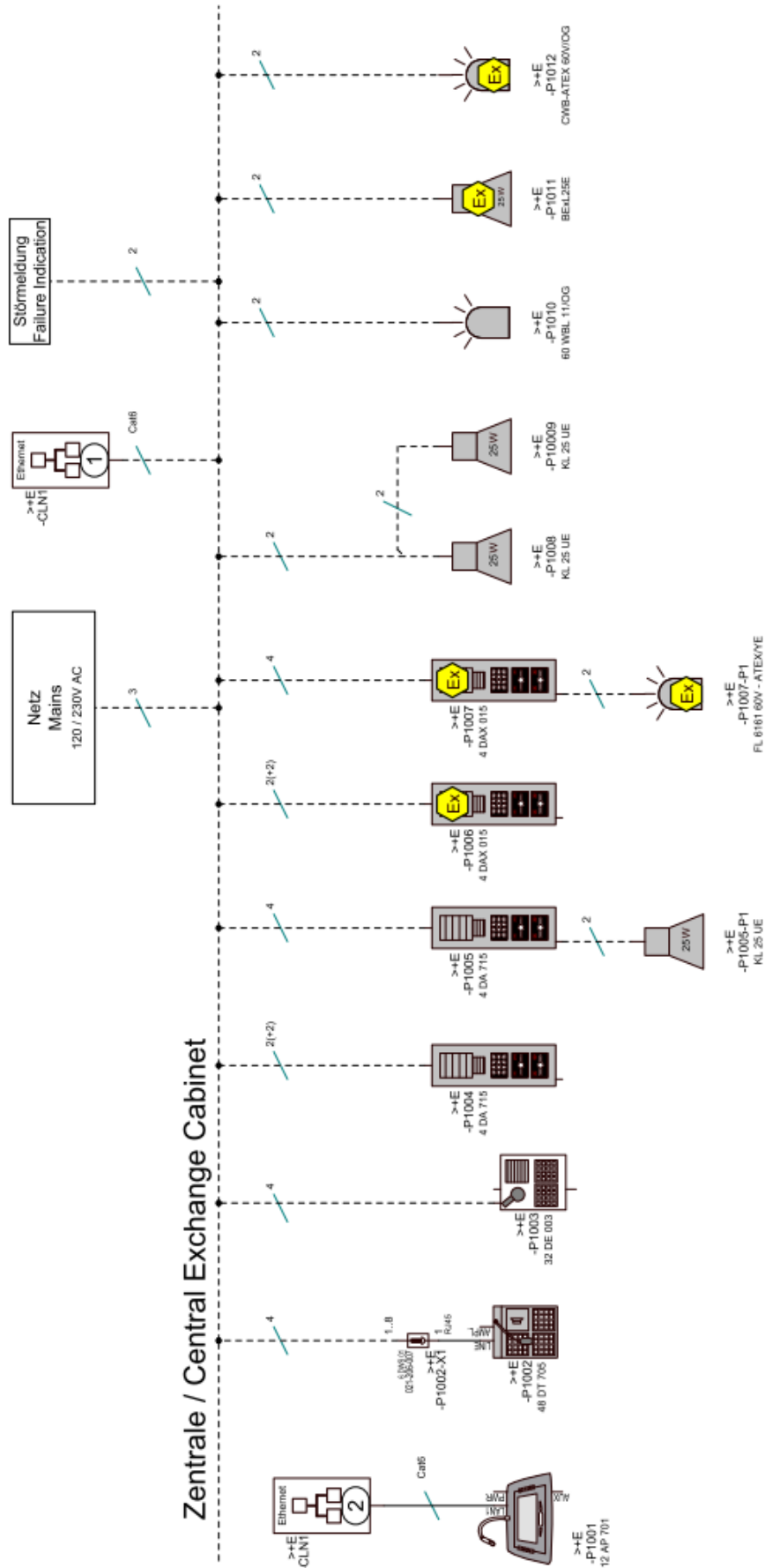


Fig. 4-1: Wiring diagram

For the connection to INDUSTRONIC intercom stations, twisted pair cables must be used.

The number of wires for digital intercom stations connected to INTRON-D / INTRON-D *plus* systems are as follows:

- 2 basic wires (a/b lines including phantom powering)
- + 2 or more additional supply wires if booster amplifiers, accessory units or desktop intercom stations with more than 2 keypads are used (see chapter 7.1, page 21 and chapter 7.2, page 26)
- + 2 additional supply wires for flashing warning beacons. Consider the current consumption as well as the inrush current.

The number of wires for analog intercom stations connected to INTRON-D / INTRON-D *plus* systems are as follows:

- 4 basic wires (+/- for power supply, a/b for AF),
- + 1 supply wire for the booster amplifier (included in the standard calculation)
- + 1 wire for each key provided at the intercom station

## 5 Cable Types Suitable for System Components

Different cable types are used for the various components of the communication system.

Please ensure that cables for the periphery of the communication system must not be installed next to high voltage cables, power cables or cables with high RF or harmonic content (e.g. for thyristor-controlled three-phase drives).

There should be minimum distance of 30 cm (1 ft) to these types of cables.

In Ex areas, observe the requirements of IEC/EN 60079-14, section 9.

### 5.1 Cables for Intercom Stations

#### 5.1.1 General Guidelines

Cables which connect intercom stations with the central exchange unit must generally be designed as twisted pair or star quad cables. Thus potential interference and alternating fields cannot impair the quality of the communication.

Usually, the cables do not require further shielding. For guidelines on shielded or armored cables, please refer to chapter 6.4, page 14 and chapter 6.5, page 14.

Cables are installed according to local regulations, e.g. in flat cable trays or cable conduits.

Depending on the length of the cables, some wires of the intercom station have to be connected in parallel. For further instructions on this subject, please refer to chapter 7, page 20 regarding digital intercom stations as well as to document 330-001-015 for analog intercom stations.

#### 5.1.2 Installing Cables Outdoors

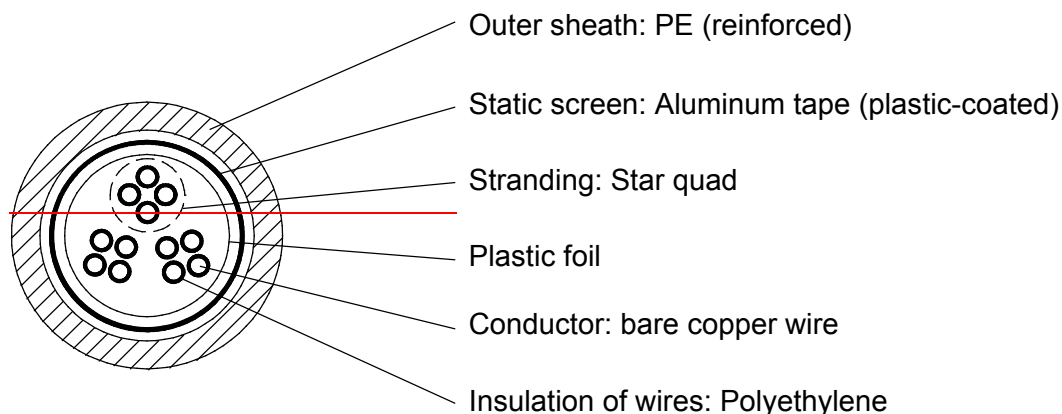
Possible cable types:

- Outdoor telecommunication cable, e.g. A2Y(L)2Y
- Outdoor telecommunication cable, with petrolatum as protection against the ingress of water in longitudinal direction, e.g. A2YF(L)2Y
- Instrumentation and control cable, twisted pairs, with reinforced outer sheath, e.g. RE-2Y(ST)Yv

To achieve the ranges specified in chapter 7, page 20, cables with a wire insulation made of polyethylene (PE) or halogen-free material should be used. Cables with PVC insulation generally have a higher mutual capacitance which limits the range significantly.



Example: Outdoor telecommunication cable **A2Y(L)2Y ... with star quad stranding:**



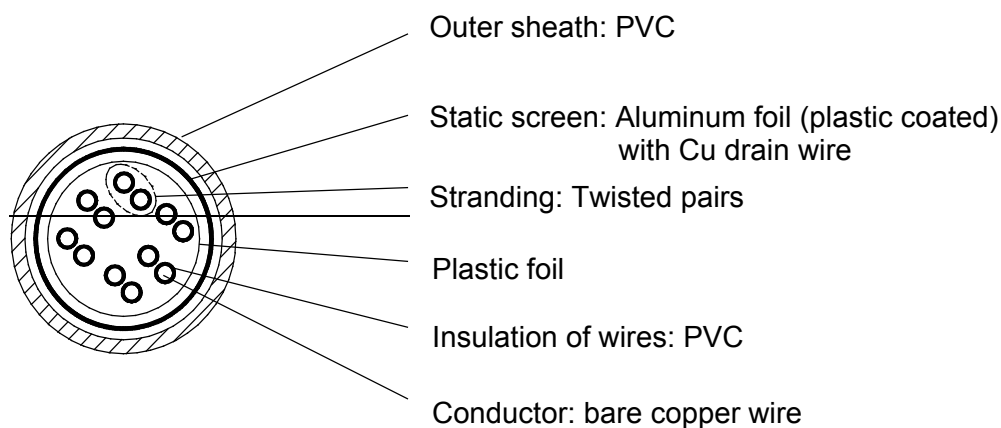
Please note: In case of star quad stranding, two opposite conductors form a pair (not the adjacent conductors).

### 5.1.3 Installing Cables Indoors

Possible cable types:

- Indoor telecommunication cable, J-Y(St)Y ... x2x0.8 (0.6) Lg
- Indoor telecommunication cable, halogen-free, J-H(St)H ...x2x0.8 (0.6)
- Cable for fire alarm systems, J-H(ST)H ...x2x0.8 BD
- Any type of multi-conductor, twisted, shielded or unshielded telecommunication cable

Example: Indoor telecommunication cable. **J-Y(St)Y ... x2x0.8 (0.6) Lg**



### 5.1.4 Installing Cables in Explosive Areas

Make sure to comply with the requirements of the EN/IEC 60079-14 standard. Also comply with the requirements in terms of characteristic values for flame propagation according to the IEC/EN 60332-1 standard.

Permanently installed cables must have an extruded bedding and non-hygroscopic fillers. Outdoor communication cables of type A2YF(L)2Y .... x2x0,8 ST III Bd filled with petrolatum can be used in Ex zones 1 and 2 if additional measures are taken when installed outdoors to prevent a potential flame propagation, e.g. installation in trenches filled with sand (see IEC/EN 60079 14, chapter 9).

As an alternative, outdoor communication cables with additional flame-retardant outer sheath can be installed in explosive areas, e.g. A2YF(L)2YY... .

Furthermore, instrumentation and control cables with twisted pairs and reinforced outer sheath can be used, e.g. RE-2Y(ST)Yv.

According to EN/IEC 60079-14:2008, free wires ending in the Ex "e" compartment of devices to be installed in explosive areas must be properly insulated using terminals suitable for this type of ignition protection. Using insulating tape for insulation or terminating at terminals without Ex certificate is not permitted. Cables leading to DX(E) or DXG intercom stations must have an appropriate design to connect all wires to the existing terminals (max. 5 pairs). Two wires of the same conductor type and diameter can be connected to one terminal up to a cross section of 1 mm<sup>2</sup>.

If the number of wires or the wire cross section exceeds the values stated, the cable must terminate in a junction box with an appropriate number of terminals.

The intercom station must be connected using a cable with a smaller number of wires.

## 5.2 Cables for Speakers

The 100-V technology is used to transmit loudspeaker signals over longer distances with little loss.

Possible cable types:

- Outdoor power cable of type NYY-0
- Light or heavy sheathed flexible cable with rubber or neoprene sheath (H05-RR, H05-RN, H07-RR, H07-RN)
- Halogen-free sheathed flexible cable H07-ZZ
- Instrumentation and control cable, twisted pairs, to avoid electromagnetic interference
- Outside of the Ex area: outdoor telecommunication cable between intercom station and additional speaker

For further information on the number of wires and the range, refer to chapter 7.4, page 31.

In Ex areas, observe the requirements of IEC/EN 60079-14, section 9. Speakers must be connected to the local equipotential bonding system. For this purpose, either use the external ground terminal or connect the internal terminal to the nearest protective ground connection (e.g. junction box, equipotential busbar). Grounding via the cable to another equipotential bonding area is not permitted.

### 5.3 Cables for Flashing Warning Beacons

For flashing warning beacons with 48 V / 60 V technology which are connected to an intercom station, telecommunication cables can be used outside the Ex area (see chapter 5.1, page 8).

Otherwise use cables as specified for speaker applications (see chapter 5.2, page 10). If the flashing warning beacon is operated with mains voltage (115 V / 230 V), observe the electric strength of the cable. The guidelines for the ground connection are the same as for speakers (see chapter 5.2, page 10).

### 5.4 Cables for 48 V / 60 V Battery Supplies

Due to the possibly high short-circuit current, higher requirements must be met concerning the cabling of battery cabinets or racks. Feed lines of battery blocks on separate battery racks must be protected by a two-pole fuse directly at the battery block (e.g. via low-voltage HRC fuse) observing the necessary safety distance to the batteries. Short-circuit proof cables which are also resistant to oil and acid must be installed between the battery and the fuse.

Connecting cables between the power supply cabinet and other central exchange cabinets are protected inside the power supply cabinet. It is not necessary to protect the other ends of the cables. For battery blocks, the cable cross section depends on the current consumption and the fuse protection. Typically, halogen-free rubber-sheathed cables of type NSHXAFÖ LSZH-FR with a cross section between 2.5 mm<sup>2</sup> and 50 mm<sup>2</sup> are used. Refer to the system documentation where the actually used cable cross section is indicated.

### 5.5 Fiber-optic Cables

INDUSTRONIC offers components for INTRON-D / INTRON-D *plus* systems which can be used to set up sub systems (satellites) or to connect with other systems. These components are connected via fiber-optic cables.

Fiber-optic cables are immune to electromagnetic interference. Existing fiber-optic cables, e.g. for crane applications, can be used.

Please observe the following:

- For each route, two optical fibers are required which must be exclusively available for the INTRON-D / INTRON-D *plus* system.
- Depending on the component type, use graded-index fibers with a core/cladding diameter of 50/125 μm or 62.5/125 μm or single-mode fibers with 9/125 μm.
- Use only one fiber type for one connection.
- Maximum cable length of 3 km for graded-index fibers per connection
- Max. allowed attenuation:  
  - < 12 dB @ 62.5/125 μm / < 7dB @ 50/125μm
  - < 15 dB @ 9/125 μm
- Observe the relevant cable installation and assembly specifications of the cable manufacturer
- Avoid bending points and joints if not absolutely required
- Do not apply any mechanical stress to the cables and the connectors of the INTRON-D / INTRON-D *plus* components

## 5.6 Antennas and Antenna Cables

INDUSTRONIC offers radio components with which, for example, intercom stations located in cranes and vehicles as well as hand-held devices can be integrated into the communication system.

When installing these radio components, observe the following:

- When selecting a location for the antennas of the base stations and the antennas of the corresponding mobile stations allow for “visual contact”.
- Make sure that the antenna cables are properly installed.
- Do never bend the antenna cable below their bending radius, not even during installation. The radius depends on the cable type used.
- Depending on the antenna type, the antenna must be installed on a counterpoise (metal ground screen).
- Cables between the central exchange unit and the radio base station have the same requirements as cables to intercom stations. Cables with mains voltage for locally supplied devices must be rated accordingly.

For detailed installation instructions refer to the INDUSTRONIC document 330-013-031.

## 5.7 Cables between Two Central Exchange Units

Electrical and optical interfaces are available to directly connect two INDUSTRONIC systems. The Ethernet interface can also be used to interconnect the systems over the network.

For direct electrical or optical connections, use cables according to chapter 5.1, page 8 or chapter 5.5, page 11. When connecting the systems to a network, the cable type is defined by the network interface.

## 6 Grounding Concept / Equipotential Bonding


### 6.1 Central Exchange Unit / System Voltage

Grounding serves as protection against dangerous voltages.

For central exchange cabinets containing live components, all electrically conductive parts must be grounded according to IEC/EN 60950 or IEC/EN 62368-1.

Grounding the cabinet housing ensures the shielding of the electronic components contained in the cabinet.

Any side panels, roofs and doors of INDUSTRONIC central exchange cabinets are already electrically connected to each other as standard.

The protective earth conductor provided in the mains cable must be connected to the central grounding point. The protective earth conductor can be either connected to the ground bar (marked with ) or to the ground terminal (yellow/green).

If components with mains supply are installed inside the cabinet which together generate an increased leakage current against ground, a warning label is provided near the mains connection. The ground connection must then be redundant and the central grounding point must be connected to the building's equipotential bonding system via a separate line before commissioning.

The system voltage for INDUSTRONIC systems is typically 60 VDC or 48 VDC. This system voltage is usually not grounded to avoid interference and ground loops. If surge protection devices are used for connected intercom station lines, the negative pole of the supply voltage must be grounded. Otherwise, there is the risk that the system voltage separates from the ground potential and that the surge arresters are triggered.

### 6.2 Peripheral Equipment

Electrical devices which are operated with a dangerous voltage must generally be connected to a protective conductor. Excluded from this are totally insulated devices such as INDUSTRONIC intercom stations or flashing warning beacons without ground connection.

### 6.3 Grounding of Devices in Ex Areas

According to EN 60079-14, all (not totally insulated) stationary electrical devices with metal housing (parts) and external conductive parts must be connected to the equipotential bonding system (ground) in Ex areas.

These include INDUSTRONIC peripheral equipment such as speakers, flashing warning beacons, acoustic hoods and junction boxes as well as any system-specific special parts. Depending on the device, the connection can be made via the internal or external protective conductor terminal.

The protective conductor terminal must only be connected to the local equipotential bonding system. A connection to another equipotential bonding system (e.g. an armored cable or protective conductor inside a cable) is not permitted.

## 6.4 Shielded Cables

As already mentioned in chapter 5.1.1, page 8, shielding of cables to INDUSTRONIC terminal devices is not required. If, however, shielded cables are to be used due to customer requests or specifications, ensure that any cables from the central exchange unit to the terminal device are continuously shielded.

The shielding can be designed as a global shield or individually for each pair of wires. In the central exchange unit, the shield is connected to ground potential (if possible to a separate instrumentation circuit ground). In junction boxes, the shield coming from the central exchange unit must be distributed to the outgoing cables via bridged terminals. If possible, the shield should be connected to an insulated terminal inside the terminal device (intercom station, speaker, flashing warning beacon).

If the cable is additionally armored, the shield must remain isolated from the armor in all cable sections.

## 6.5 Use of Armored Cables

### 6.5.1 General

If armored cables are to be used to the intercom stations according to customer requests, the following applies:

- The armor should at least be connected at one cable end (if applicable by means of a suitable cable gland) with the equipotential bonding system.
- The armor must only be connected to the equipotential bonding system on both sides within one equipotential bonding area.
- Outside of Ex areas, the armor may end insulated within a cable gland. Ensure that the armor has no electrical contact with the cable gland.
- In junction boxes for the ground connection, usually ground connection plates (offshore plates) are used which connect the integrated metal cable glands with each other. From there, establish a connection to the local equipotential bonding.

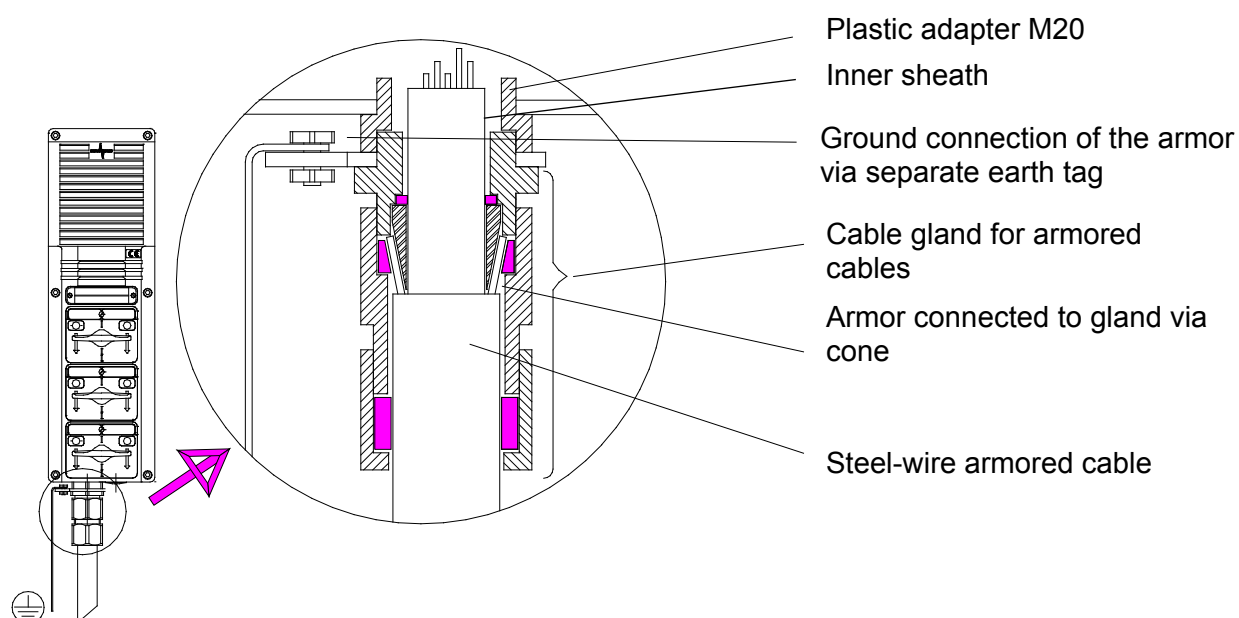
Additionally, the following points must be considered in Ex areas (EN 60079-14 section 6.4):

- In Ex areas, the armor must be connected to the local equipotential bonding system. Insulating the armor from ground requires great care to avoid dangerous sparks and is therefore not recommended.
- Metal cable glands for armored cables, which are installed in metal housings (e.g. warning beacons), are electrically connected to the ground connection of the device due to their design and can be grounded locally from this connection.
- Metal cable glands which are installed in plastic housings due to customer requests (e.g. speakers or INDUSTRONIC intercom stations of the DAX series) must be grounded with additional grounding rings which are placed between the cable gland and the housing or by means of special cable glands with external ground connection.

- At the INDUSTRONIC Ex intercom station, do never mount metal cable glands directly to the metal enclosure of the terminal compartment as the device is totally insulated.  
Use plastic adapters (size according to the thread of the intercom station) which insulate the cable gland from the device. The metal gland must be grounded locally. This is either realized via an additional earth tag placed between the cable gland and the adapter (see example) or a special cable gland with integrated earth tag.
- Per entry at the device, only one adapter is allowed for expansion or reduction. Cascading is not allowed.

**Example:**

Cable gland at the INDUSTRONIC Ex intercom station of type DX with inner and outer sealing for steel-wire armored cable, locally grounded via separate earth tag and ground conductor.



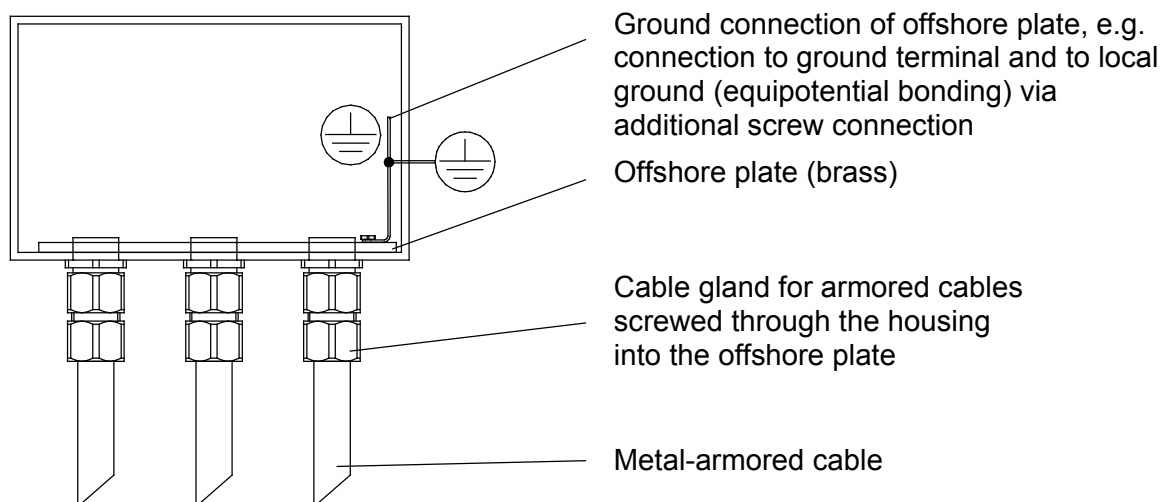
### 6.5.2 Grounding via Ground Connection Plates (Offshore Plates)

Offshore plates are brass plates located in the junction box with cut threads into which the glands are screwed in and thus grounded.

If armored cables are used together with junction boxes, metal cable glands of the outgoing and if applicable of incoming cables are electrically connected to each other at the junction box via these offshore plates and are connected to local ground (equipotential bonding). This is only allowed within one equipotential bonding area.

#### Example:

Plastic junction box for offshore applications with metal Ex cable glands for armored cables, grounded via inserted offshore plate.



### 6.5.3 Use of Armored Cables across several Equipotential Bonding Areas

When using armored cables, the equipotential bonding areas on site must be observed. When connecting one equipotential bonding area to another ensure that the armor of the incoming cables is electrically insulated from the armor of the outgoing cables.

The following pages show these cabling examples:

- Intercom stations for outdoor and Ex areas connected via armored and additionally shielded cables (see Fig. 6-1, page 17).
- Speakers and warning beacons for outdoor and Ex areas connected via armored cables (see Fig. 6-2, page 18).



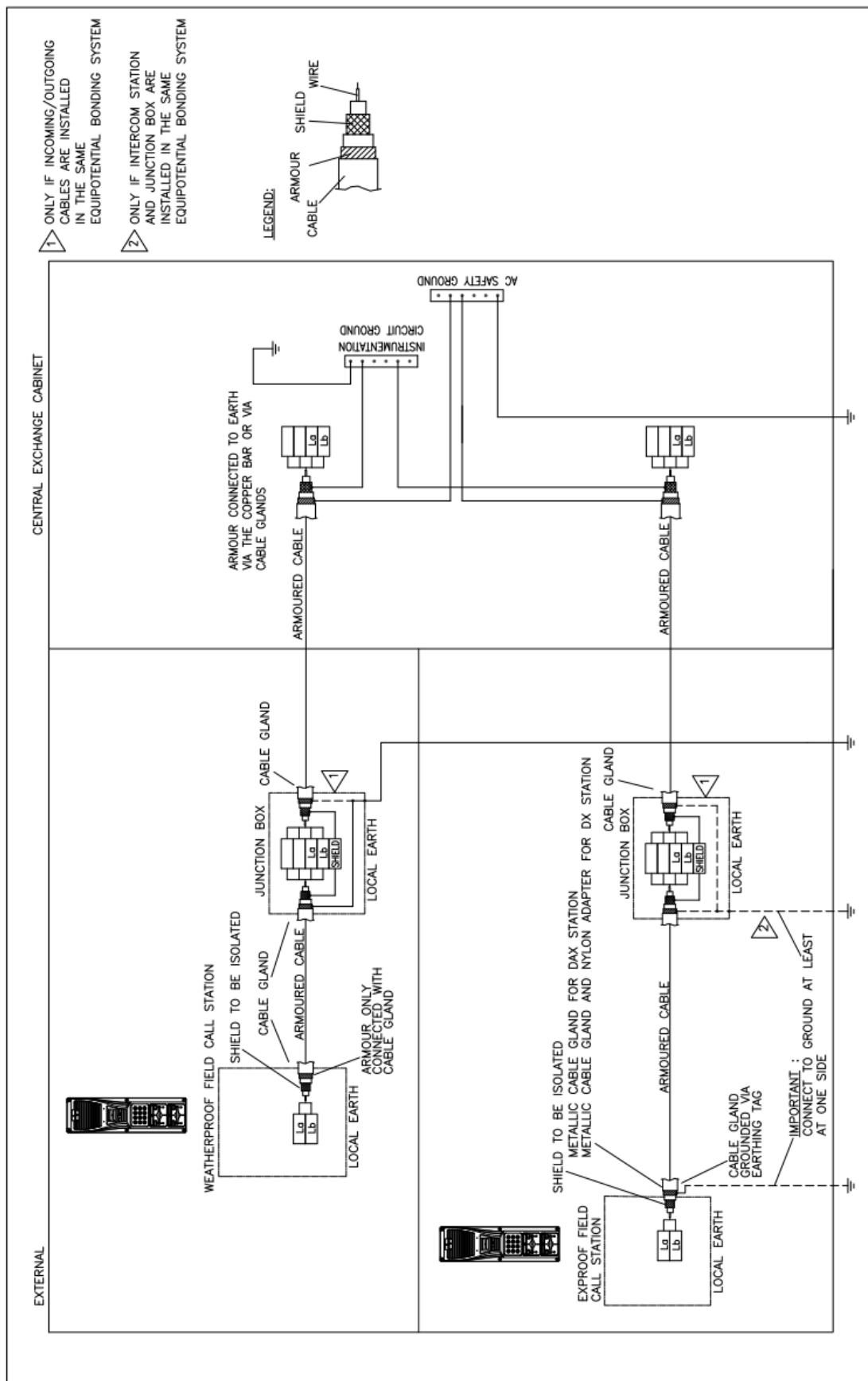


Fig. 6-1: Cabling example of intercom stations

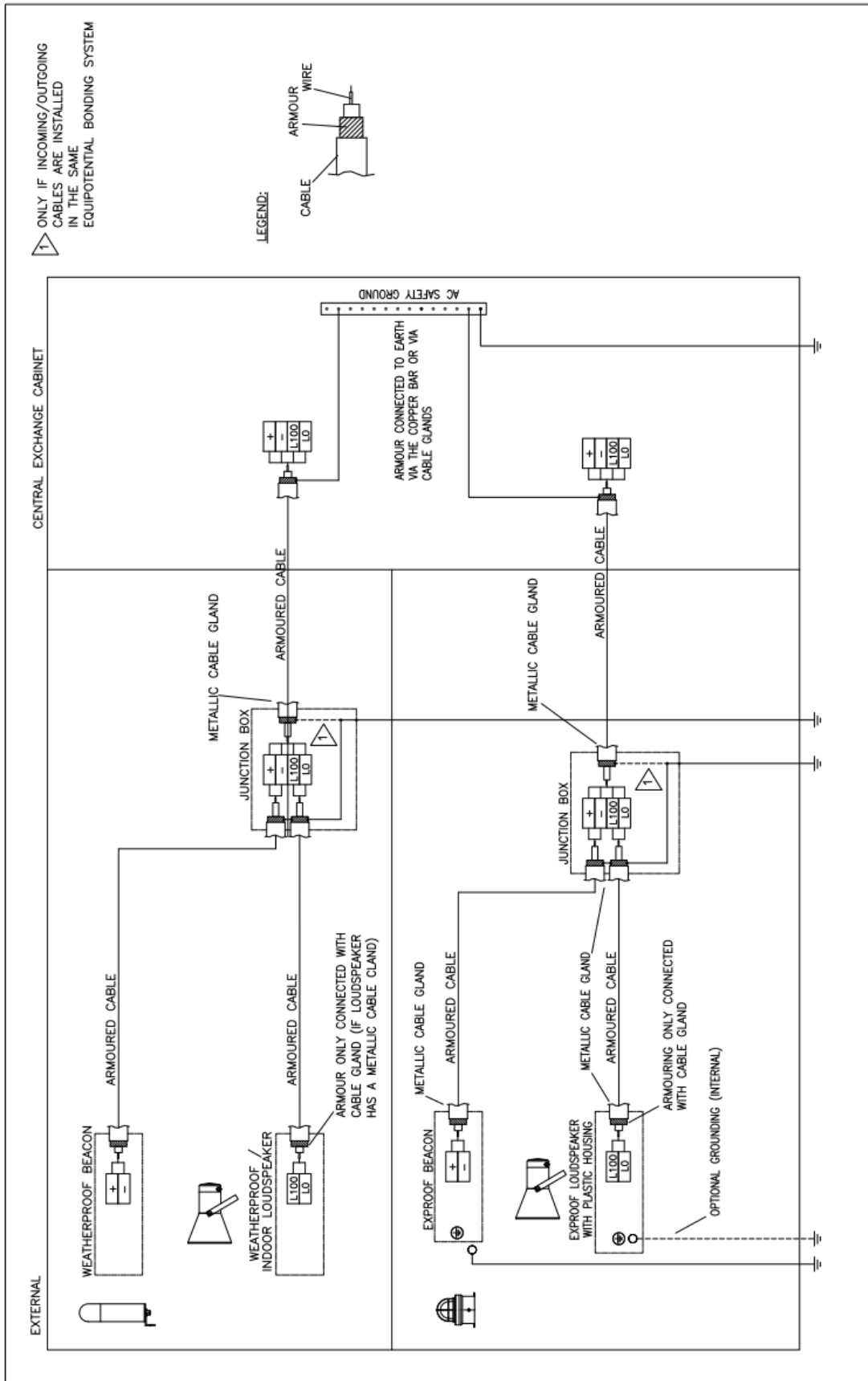


Fig. 6-2: Cabling example of speaker and flashing warning beacons

#### 6.5.4 Selection of Gland for Armored Cables

When selecting the gland, the following parameters must be specified:

- For which device, which input?
- What has to be sealed:
  - Only the outer sheath
  - Outer and inner sheath
- Type of armor: Double steel tape armor (DSTA), single wire armor (SWA), wire braid
- Cable outside diameter
- If applicable, inner sheath diameter
- Environmental requirements (temperature range, IP rating)
- Industrial or Ex design (Ex-d, Ex-e)

Note that for large-volume glands, only one entry per housing side may be possible.

## 7 Wire Requirement Tables for Digital Intercom Stations and Speakers

### Wires for additional power supply

To connect a digital intercom station, usually two wires are required. We recommend, however, connecting at least four wires to each intercom station, even if they are not required at the time of the first installation.

### Safety notice:

To avoid downtimes and resulting costs due to a wire break, INDUSTRONIC recommends providing additional spare wires, especially for larger distances e.g. >1000 m (0.62 mi).

Consider the maximum number of wires allowed in cables connected to Ex devices (see chapter 5.1.4, page 10).

### Note on the clamping range of the terminals inside the terminal devices:

INDUSTRONIC supplies a wall socket for desktop intercom stations. Wires with a maximum cross section of 0.5 mm<sup>2</sup> (0.8 mm diameter) can be connected to this socket. In case of larger wire cross sections, a terminal box (e.g. junction box) must be installed in front of the wall socket to reduce the cross section.

The other terminal devices contain terminals with a clamping range of up to 2.5 mm<sup>2</sup> to which two wires of the same type with a cross section of up to 1 mm<sup>2</sup> can be connected.

### General note on intercom station cables

Intercom station cables must be designed as twisted pair or star quad cables. Especially in case of cables used for measurement and control technology, make sure that the wires are twisted in pairs.

### Note on cable lengths for operation of booster amplifiers

Depending on the cable length used, the output power of the booster amplifier may be reduced. The cable lengths specified in the tables below correspond to a volume decrease of about 2.5 dB.

For cable lengths exceeding these values, the booster amplifier still works, but the volume decreases considerably. The specifications in the tables regarding the operation with a booster amplifier refer to a connected speaker with a rated power of 25 W. For speakers with a lower rated power, the volume decrease is less.

Depending on the system voltage 48 V or 60 V used, the wire requirements may vary. We therefore conducted separated calculations.

## 7.1 Wire Requirements for Intercom Stations with 48 V System Voltage

When a system voltage of 48 V is used, the booster amplifier integrated in the intercom stations does not provide the full output voltage of 100 V. In this case, the connected 25-W speaker can still reach an output power of approx. 19 W which corresponds to a volume decrease of approx. 2.5 dB.

Note on cable lengths for operation with up to 55 V without using batteries:

If a 48-V system is constantly operated with a voltage of 54 V to 55 V, the cable lengths stated in the following tables can be multiplied by a factor of 1.5.

Depending on the cable type and cable length, the number of wires is calculated as follows:

### 7.1.1 Telecommunication Cables with 0.5 mm Diameter, 48 V

Intercom station types	Cable length in km																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Up to 48 DT(E) 705	2	2	2	4	4	4	6	6	6											
with booster ampl.	4	4	6	8	8															
From 64 DT(E) 705	4	4	4	4	4	6	6	6												
with booster ampl.	4	4	6	8	8															
.. DTM x1x	2	2	2	2	4	4	4	4	6	6	6	6								
with booster ampl.	4	4	6	8	8															
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2											
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4			
with booster ampl.	4	4	6	8	8															
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2			
with booster ampl.	4	4	6	8	8															
8 DIO x1x	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4			
	Number of required wires																			

### 7.1.2 Telecommunication Cables with 0.6 mm Diameter, 48 V

Intercom station types	Cable length in km																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Up to 48 DT(E) 705	2	2	2	2	2	4	4	4	4	6	6	6	6	6						
with booster ampl.	4	4	6	6	8	8	8													
From 64 DT(E) 705	4	4	4	4	4	4	4	4	6	6	6	6	6							
with booster ampl.	4	4	6	6	8	8	8													
.. DTM x1x	2	2	2	2	2	2	4	4	4	4	4	6	6	6	6	6	6			
with booster ampl.	4	4	6	6	8	8	8													
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2	2								
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4
with booster ampl.	4	4	6	6	8	8	8													
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	6	6	6	8	8	8												
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4
Number of required wires																				

### 7.1.3 Telecommunication Cables with 0.8 mm Diameter, 48 V

Intercom station types	Cable length in km																			
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
Up to 48 DT(E) 705	2	2	2	2	4	4	4	4	6	6	6	6								
with booster ampl.	4	4	6	6	8	8														
From 64 DT(E) 705	4	4	4	4	4	4	4	6	6	6	6									
with booster ampl.	4	4	6	6	8	8														
.. DTM x1x	2	2	2	2	2	4	4	4	4	4	6	6	6	6	6					
with booster ampl.	4	4	6	6	8	8														
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2									
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4
with booster ampl.	4	4	6	6	8	8														
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	6	6	8	8													
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4
Number of required wires																				

### 7.1.4 Instrumentation and Control Cables with 0.75 mm<sup>2</sup> Cross Section (Ø 1 mm), 48 V

Due to the higher signal attenuation of this cable, the maximum cable length is 2 km.  
With this cable, up to 2 wires are allowed to be inserted into one terminal.

Intercom station types	Cable length in km																				
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	
Up to 48 DT(E) 705	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4
with booster ampl.	4	4	4	4	4	4	6	6	6	6	6	6									
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
with booster ampl.	4	4	4	4	4	4	6	6	6	6	6	6									
.. DTM x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4
with booster ampl.	4	4	4	4	4	4	6	6	6	6	6	6									
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2						
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4
with booster ampl.	4	4	4	4	4	4	6	6	6	6	6	6									
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	4	4	4	6	6	6	6	6	6	6								
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of required wires																					

### 7.1.5 Instrumentation and Control Cables with 1.5 mm<sup>2</sup> Cross Section (Ø 1.4 mm), 48 V

Due to the higher signal attenuation of this cable, the maximum cable length is 1.5 km. With this cable, not more than 1 wire is allowed to be inserted into one terminal.

Intercom station types	Cable length in km																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Up to 48 DT(E) 705	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4								
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4								
.. DTM x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4								
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4								
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	4							
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
Number of required wires																				



### 7.1.6 Instrumentation and Control Cables with 2.5 mm<sup>2</sup> Cross Section (Ø 1.8 mm), 48 V

Due to the higher signal attenuation of this cable, the maximum cable length is 1 km. With this cable, not more than 1 wire is allowed to be inserted into one terminal.

Intercom station types	Cable length in km																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Up to 48 DT(E) 705	2	2	2	2	2	2	2	2	2	2										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
.. DTM x1x	2	2	2	2	2	2	2	2	2	2										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2										
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
8 DIO x1x	2	2	2	2	2	2	2	2	2	2										
Number of required wires																				

## 7.2 Wire Requirements for Intercom Stations with 60 V System Voltage

Note on cable lengths for operation with up to 68 V without using batteries:

If a 60-V system is constantly operated with a voltage of 66 V to 68 V, the cable lengths stated in the following tables can be multiplied by a factor of 1.5.

Depending on the cable type and cable length, the number of wires is calculated as follows:

### 7.2.1 Telecommunication Cables with 0.5 mm Diameter, 60 V

Intercom station types	Cable length in km																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Up to 48 DT(E) 705	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	6	6	6	6	6
with booster ampl.	4	4	4	6	6	6	8	8	8	8										
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6
with booster ampl.	4	4	4	6	6	6	8	8	8	8										
.. DTM x1x	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	6	6
with booster ampl.	4	4	4	6	6	6	8	8	8	8										
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4
with booster ampl.	4	4	4	6	6	6	8	8	8	8										
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	6	6	6	6	8	8	8	8									
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4
Number of required wires																				

### 7.2.2 Telecommunication Cables with 0.6 mm Diameter, 60 V

Intercom station types	Cable length in km																			
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
Up to 48 DT(E) 705	2	2	2	2	2	2	4	4	4	4	4	6	6	6	6	6				
with booster ampl.	4	4	6	6	8	8	8													
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6				
with booster ampl.	4	4	6	6	8	8	8													
.. DTM x1x	2	2	2	2	2	2	2	4	4	4	4	4	4	6	6	6	6	6	6	
with booster ampl.	4	4	6	6	8	8	8													
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2									
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4
with booster ampl.	4	4	6	6	8	8	8													
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	6	6	6	8	8	8												
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of required wires																				

### 7.2.3 Telecommunication Cables with 0.8 mm Diameter, 60 V

Intercom station types	Cable length in km																			
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
Up to 48 DT(E) 705	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4	4	4
with booster ampl.	4	4	4	4	6	6	6	6	8	8	8	8	8							
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	6
with booster ampl.	4	4	4	4	6	6	6	6	8	8	8	8	8							
.. DTM x1x	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4
with booster ampl.	4	4	4	4	6	6	6	6	8	8	8	8	8							
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	4	6	6	6	6	8	8	8	8	8							
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	4	6	6	6	6	6	8	8	8	8	8						
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of required wires																				

## 7.2.4 Instrumentation and Control Cables with 0.75 mm<sup>2</sup> Cross Section (Ø 1 mm), 60 V

Due to the higher signal attenuation of this cable, the maximum cable length is 2 km. With this cable, up to 2 wires are allowed to be inserted into one terminal.

Intercom station types	Cable length in km																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Up to 48 DT(E) 705	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6	6	6
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6	6	6	6
.. DTM x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6	6	6
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6	6	6
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	6	6	6	6
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of required wires																				

## 7.2.5 Instrumentation and Control Cables with 1.5 mm<sup>2</sup> Cross Section (Ø 1.4 mm), 60 V

Due to the higher signal attenuation of this cable, the maximum cable length is 1.5 km. With this cable, not more than 1 wire is allowed to be inserted into one terminal.

Intercom station types	Cable length in km																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Up to 48 DT(E) 705	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4					
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4					
.. DTM x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4					
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4					
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
with booster ampl.	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4					
8 DIO x1x	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2					
Number of required wires																				

## 7.2.6 Instrumentation and Control Cables with 2.5 mm<sup>2</sup> Cross Section (Ø 1.8 mm), 60 V

Due to the higher signal attenuation of this cable, the maximum cable length is 1 km. With this cable, not more than 1 wire is allowed to be inserted into one terminal.

Intercom station types	Cable length in km																			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
Up to 48 DT(E) 705	2	2	2	2	2	2	2	2	2	2										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
From 64 DT(E) 705	4	4	4	4	4	4	4	4	4	4										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
.. DTM x1x	2	2	2	2	2	2	2	2	2	2										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
.. DA(E) 0x5	2	2	2	2	2	2	2	2	2	2										
.. DA(E) 7x5	2	2	2	2	2	2	2	2	2	2										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
.. DX(E) xx5	2	2	2	2	2	2	2	2	2	2										
with booster ampl.	4	4	4	4	4	4	4	4	4	4										
8 DIO x1x	2	2	2	2	2	2	2	2	2	2										
Number of required wires																				

### 7.3 Radio Applications

Wire diameter 0.8 mm:

System voltage	Cable length	Wires for a/b line	Wires for power supply	Total
<b>48 VDC</b>	0 to 300 m	2	2	4
	300 to 700 m	2	4	6
	700 to 1000 m	2	6	8
<b>60 VDC</b>	0 to 500 m	2	2	4
	500 to 1300 m	2	4	6
	1300 to 2500 m	2	6	8
<b>68 VDC</b>	0 to 700 m	2	2	4
	700 to 1800 m	2	4	6
	1800 to 2900 m	2	6	8
<b>110 / 230 VAC</b>	0 to 2500 m	2	*	2

\*) The voltage is supplied in a decentralized way and according to local regulations.

### 7.4 Speaker Cables

Cabling between the central exchange unit and the speakers or speaker zones.

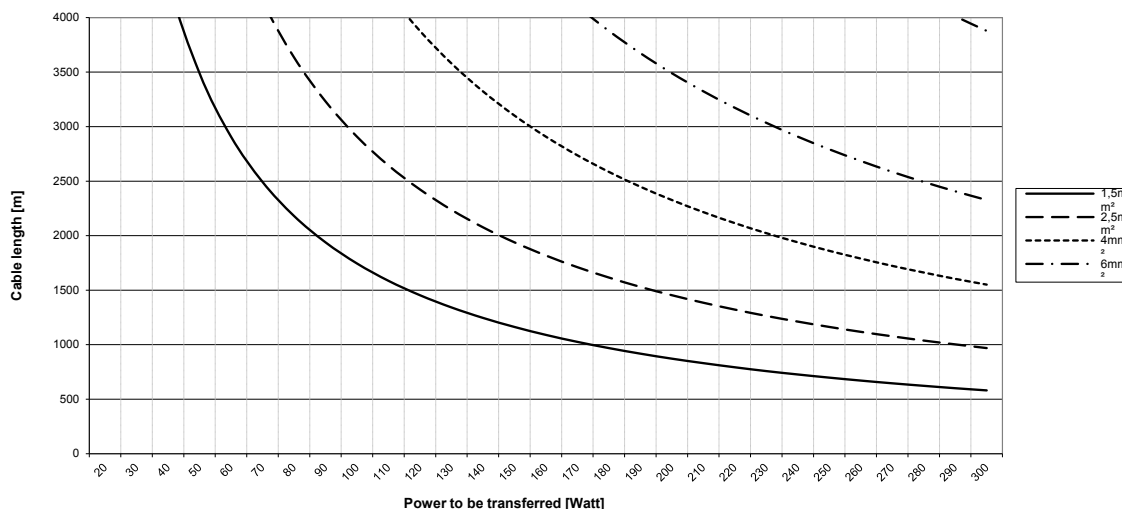
Depending on the cable length and the power, the cable cross section is calculated as follows:

-3 dB power loss for public address and voice applications

Cable length	Power to be transferred					Conductor cross section
	30 W	50 W	100 W	150 W	250 W	
0 to 700 m	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	
700 to 1000 m	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	2.5 mm <sup>2</sup>	
1000 to 1900 m	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	2.5 mm <sup>2</sup>	4 mm <sup>2</sup>	
1900 to 2800 m	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	2.5 mm <sup>2</sup>	4 mm <sup>2</sup>	6 mm <sup>2</sup>	
2800 to 4000 m	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	4 mm <sup>2</sup>	6 mm <sup>2</sup>	10 mm <sup>2</sup>	

A power loss of -3 dB is only audible in voice applications when being compared directly and corresponds to a volume difference of -3 dB. For alarm applications, we recommend not exceeding a power loss of -2 dB.

Cable diagram for a power loss of -3 dB

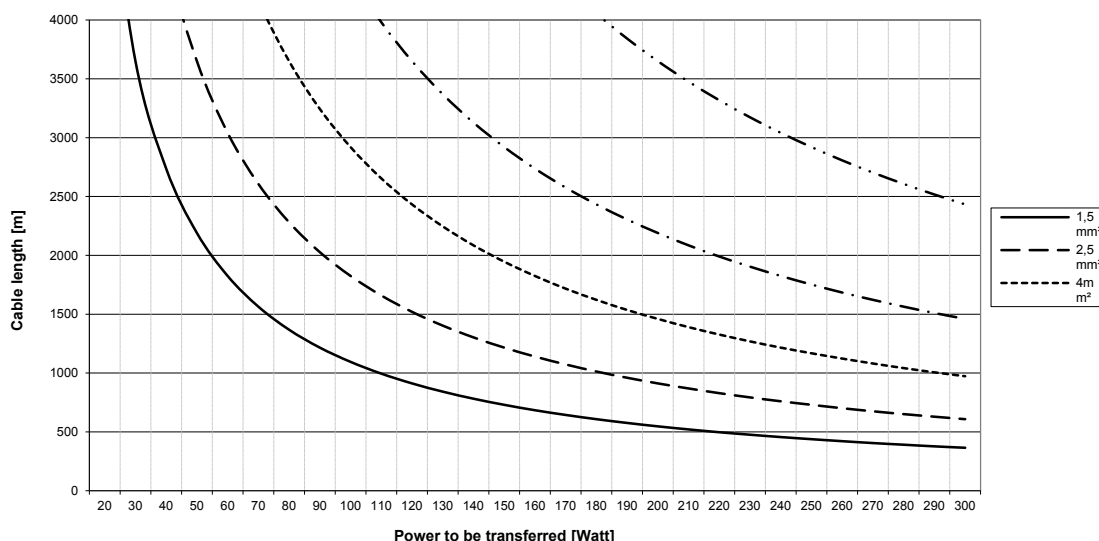


-2 dB power loss for emergency and alarm applications

Cable length	Power to be transferred					Conductor cross section
	30 W	50 W	100 W	150 W	250 W	
0 to 400 m	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	Conductor cross section
400 to 1100 m	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	2.5 mm <sup>2</sup>	4 mm <sup>2</sup>	
1100 to 1700 m	1.5 mm <sup>2</sup>	1.5 mm <sup>2</sup>	2.5 mm <sup>2</sup>	4 mm <sup>2</sup>	6 mm <sup>2</sup>	
1700 to 2900 m	1.5 mm <sup>2</sup>	2.5 mm <sup>2</sup>	4 mm <sup>2</sup>	6 mm <sup>2</sup>	10 mm <sup>2</sup>	
2900 to 3600 (4400) m	1.5 mm <sup>2</sup>	2.5 mm <sup>2</sup>	(6 mm <sup>2</sup> )	(10 mm <sup>2</sup> )		

For alarms and evacuation scenarios it is important that most of the amplifier output power also arrives at the speakers. Therefore, the maximum power loss should be -2 dB for these types of applications. This corresponds to a volume difference of -2 dB.

Cable diagram for a power loss of -2 dB





## 8 Cable Gland Sizes and Cable Diameters

### 8.1 Cable Gland Sizes

The following table states data on standard cable glands for typical INDUSTRONIC devices:

Device	Equipped with cable glands	Permitted cable outside diameters Ø	Further cable glands, not equipped
<b>Dig. Ex intercom station . D(A)X . . .</b>	2x M20 1x M25	4 – 13 mm 5 – 17 mm	
<b>Dig. intercom station . DA . . .</b>	2x M20 1x M25	4 – 13 mm 5 – 17 mm	
<b>Dig. intercom station . DAU . . .</b>	Blind gland		2 x ½"
<b>Dig. expansion housing . DAZ ...</b>	2 x M20	4 – 13 mm	1 x M25
<b>Dig. wall socket 6 DWS ..</b>	10 break-out openings	0 – 8 mm	
<b>Dig. booster amplifier 25 DVT ..</b>	1x rubber bush	0 – 20 mm	1 x rubber bush
<b>Dig. control device 1 DES . . .</b>	1x rubber bush	0 – 20 mm	1 x rubber bush
<b>Dig. I/O board . .8 DIO 1xx.</b>	2 x M20	6 – 12 mm	
<b>DDSI 103</b>	3 x M20	8 – 13 mm	1x M20
<b>Flashing warning beacons</b>	See the respective dimensional drawing		
<b>Speakers</b>	See the respective dimensional drawing		
<b>Explosion-proof horn speaker DSP25EexmNT</b>	1x M20 1x M20	6 – 12 mm 6 – 12 mm	1x M20 1x M20
<b>Explosion-proof horn speaker DSP15</b>	1x M20	7 – 14 mm	1x M20
<b>Explosion-proof horn speaker DB425W</b>			
<b>Explosion-proof horn speaker ExL25</b>			2x M20
<b>Explosion-proof horn speaker DB4B</b>			2x M20

## 8.2 Technical Data on Telecommunication Cables

The following data are typical for telecommunication cables to INDUSTRONIC intercom stations. If non-European standard cables are used, the following values should also be reached:

Technical data	A2Y(L)2Y .. x2x0.6	A2Y(L)2Y .. x2x0.8	J-Y(St)2Y .. x2x0.6	J-Y(St)2Y .. x2x0.8
<b>Design</b>	Star quad	Star quad	Twisted pair	Twisted pair
<b>Minimum bending radius for permanent installation</b>	10 x cable diameter	10 x cable diameter	10 x cable diameter	10 x cable diameter
<b>Temperature range during installation</b>	-5 °C to +50 °C	-20 °C to +50 °C	-5 °C to +70 °C	-5 °C to +70 °C
<b>after installation</b>	≤ +70 °C	≤ +70 °C	-5 °C to +70 °C	-5 °C to +70 °C
<b>Peak operating voltage (not for high voltage purposes)</b>	225 V	225 V	300 V	300 V
<b>Test voltage wire/wire</b>	500 V	500 V	800 V	800 V
<b>wire/shield</b>	2000 V	2000 V	800 V	800 V
<b>Conductor diameter</b>	0.6 mm	0.8 mm	0.6 mm	0.8 mm
<b>Conductor cross section</b>	0.28 mm <sup>2</sup>	0.50 mm <sup>2</sup>	0.28 mm <sup>2</sup>	0.50 mm <sup>2</sup>
<b>Attenuation at 800 Hz</b>	1.0 dB/km	0.8 dB/km	1.7 dB/km	1.1 dB/km
<b>Capacitance unbalance K1</b>	98 % < 400 pF/300 m	98 % < 400 pF/300 m	80% < 300 pF/100 m	80% < 300 pF/100 m
<b>Capacitance unbalance K9-12</b>	98% < 100 pF/300 m	98% < 100 pF/300 m	90% < 100 pF/100 m	90% < 100 pF/100m
<b>Mutual capacitance at 800 Hz</b>	52 nF/km	52 nF/km	100 nF/km	100 nF/km
<b>Insulation: specific volume resistance</b>	5 GΩ x km	5 GΩ x km	100 MΩ x km	100 MΩ x km
<b>Loop resistance</b>	130 Ω/km	73.2 Ω/km	130 Ω/km	73.2 Ω/km
<b>VDE standard</b>	VDE 0816	VDE 0816	VDE 0815	VDE 0815
<b>Applications</b>	Underground installation, installation in cable conduits not to be installed in areas with high risk of fire	Underground installation, installation in cable conduits not to be installed in areas with high risk of fire	For permanent installation on and under plaster in dry and damp rooms	For permanent installation on and under plaster in dry and damp rooms
<b>Impedance at 800 Hz</b>	≈ 720 Ω	≈ 520 Ω	Not specified	Not specified

## 9 Conversion to Anglo-American Dimensions (AWG)

Dimensions for copper conductors based on the US American system are usually indicated as AWG numbers. The following table lists the most important AWG sizes and their conversion:

AWG no.	Diameter	Cross section	AWG no.	Diameter	Cross section
<b>1</b>	7.35 mm	42.4 mm <sup>2</sup>	<b>12</b>	2.05 mm	3.31 mm <sup>2</sup>
<b>2</b>	6.54 mm	33.6 mm <sup>2</sup>	<b>14</b>	1.63 mm	2.08 mm <sup>2</sup>
<b>4</b>	5.19 mm	21.2 mm <sup>2</sup>	<b>16</b>	1.29 mm	1.31 mm <sup>2</sup>
<b>6</b>	4.12 mm	13.3 mm <sup>2</sup>	<b>18</b>	1.024 mm	0.823 mm <sup>2</sup>
<b>8</b>	3.26 mm	8.37 mm <sup>2</sup>	<b>20</b>	0.813 mm	0.519 mm <sup>2</sup>
<b>10</b>	2.59 mm	5.26 mm <sup>2</sup>	<b>22</b>	0.643 mm	0.324 mm <sup>2</sup>

Other conversion factors for general / electrical measures:

Anglo-American measure	European Conversion (SI units)	Anglo-American measure	European Conversion (SI units)
<b>1 inch (in. ")</b>	25.4 mm	<b>1 pF per foot</b>	3.28 pF/m
<b>1 foot</b>	0.305 m	<b>1 μF per mile</b>	0.62 μF/km
<b>1 yard</b>	0.914 m	<b>1 megohm per mile</b>	0.62 MΩ/km
<b>1 mile</b>	1.61 km	<b>1 decibel per mile</b>	0.62 dB/km
<b>1 MCM</b>	0.5067 mm <sup>2</sup>	<b>1 ohm per 1000 ft</b>	3.28 Ω/km
<b>1 square inch</b>	645.16 mm <sup>2</sup>	<b>1 ohm per yard</b>	10.936 Ω/km
		<b>1 pound (lbs)</b>	0.454 kg

## Document History and Imprint

Revision	Author	Approved	Changes
01	H. Kuhn	E. Eehalt	
04-01/2002	E. Eehalt	W. Lenz	Supplemented: chapter 7 and 8
05-06/2002	M. Amend	W. Lenz	Supplemented: Speaker cables chapter 7
06-12/2002	E. Eehalt	W. Lenz	Supplemented: Antennas, fiber optic cables; grounding guidelines
07-08/2005	E. Eehalt	W. Lenz	Supplemented: chapter 7.4 speaker cables
08-06/2008	R. Amrhein	W. Lenz	Number of wires for flashing warning beacons, grounding of acoustic hoods, battery cables, cables in Ex areas
9-10/2010	M. Holzhäuser	R. Amrhein	New CI / CD; supplemented: cahpter 5.1.4
10-11/2017	S. Glaab	R. Amrhein	Wire requirements for 48 V system voltage, general revision of chapter 2 to 6

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