Hazardous Area Weighing

Weighing in Hazardous Areas

Safe - Easy - Flexible

Weighing systems are one of the crucial components of both manual and automated manufacturing processes. The safe and efficient measurement, transfer and control of weighing data from hazardous to safe areas helps to reduce costs by improving traceability and overall productivity.

As a quantitative measure, weighing results may be statistically analyzed, archived, tracked / traced, integrated into control systems and used for control feedback loops.

To ensure safe operation in potentially explosive environments, weighing system components must have an appropriate level of protection. Furthermore, weighing signals must be safely and quickly communicated to the control system in the safe area.

This paper takes a closer look at a range of typical weighing system configurations for hazardous areas and their benefits which include enhanced safety, reduced liability / costs, easier tracking / tracing, and better overall productivity.

This document is not an installation guide and should not be used as a reference for installation instructions and control drawings.

Contents

METTLER TOLEDO

1 Introduction

Weighing is one of the most basic and important process variables in a vast majority of manufacturing processes. However, it can be one of the most challenging parameters to control.

Accurate and consistent filling, dosing, and batching reduce variability in the end product, which ensures consistently high quality. To achieve reliable quality and reproducible results requires efficient capture and communication of weighing data to the existing plant network, which can be challenging due to hazardous area requirements.

To prevent any ignition and provide safe operation of electrical weighing systems in hazardous areas, one possibility is limiting energy to safe levels. To achieve low energy and prevent ignition, the main components of weighing systems such as load cells, junction boxes, and weighing terminals are designed for intrinsic safety. Intrinsically safe technology prevents explosions by ensuring that the energy in intrinsically safe circuits is well below the energy required to initiate an explosion.

Intrinsically safe electrical equipment and wiring is designed and certified mostly for use in Zone 1 / Division 1 hazardous areas as long as they are approved for the location. Intrinsically safe circuits often combine elements with the various safety levels. Depending on functionality and the classification of the safety level, the circuit elements can be applied either in hazardous or non-hazardous areas.

This paper sets out to explore the different configurations of weighing systems typically used in hazardous areas Zone 1 / 21 and Division 1, as well as the benefits of ensuring data interface efficiency through the use of robust data-gathering technology.

2 Basic System

In hazardous production areas there are many processes which require simple standalone weighing applications. Filling tanks, drums or bags with only hazardous powders or liquids is one example.

A simple weighing system usually consists of strain gauge (analog) or digital weighing platforms or load cells controlled and monitored directly through a PC installed in a safe area. The weighing signal is interpreted by the hazardous area terminal and transferred to the safe area computer or printer. As all components of the weighing system are intrinsically safe, the weighing system is powered by an intrinsically safe power supply.

Communicating the weighing signal from the Zone 1/21, Division 1 to the safe area requires energy limiting devices referred to as intrinsically safe barriers. These are barriers installed in the safe area that interface with the communication device to prevent excess energy from a fault occurring on the safe side from crossing over to the hazardous area.

Under normal operating conditions, intrinsically safe barriers have no arcing or heat producing contacts and if specially marked can be installed in the Zone 2 / 22, Division 2. In fault conditions, the barriers limit voltage and current to levels that are not sufficient to ignite the hazardous atmosphere.

These barriers consist of three components:
- The zener diode, which limits the voltage to a value referred to as an open circuit voltage (Voc)
- A resistor, which limits the current to a specific value known as a short circuit current (Isc)
- The fuse, which limits the maximum current that can flow through the diodes. When the current flows through diode the fuse will blow. This interrupts the circuit and prevents the diode from failing. As a result, the excess voltage does not reach the hazardous area.

Communication to the safe area requires a safety analysis based on a comparison of intrinsically safe device entity parameters with the any hazardous area approved safety barrier entity parameters.

Intrinsically Safe Weighing Terminal (Intrinsically Safe Apparatus)		Intrinsically Safe Barrier or Communication Module (Associated Apparatus)
Open circuit voltage (V_{oc})	≤	V_{max}
Short circuit current (I_{sc})	≤	I_{max}
Allowed capacitance (C_a)	≥	C_i
Allowed inductance	≥	L_i

Table 1. Entity Parameters of Intrinsically Safe Apparatus and the Associated Apparatus

This determines if the peripheral device is safe for connection to the intrinsically safe equipment.

Entity parameters are usually found on the control drawing of the intrinsically safe device supplied by the manufacturer or on the Examination Certificate (see Table 1). There are some differences in the abbreviations of US Class / Division and Europe Zone classification. The US Class / Division system uses the abbreviation of entity parameters like V_{oc}, I_{sc}, and C_a. In Europe, the safety parameters are referred to as U_o, I_o, C_o, etc.

Figure 1 shows the example of basic system with the direct communication to a PC in a safe area. The intrinsically safe RS232 communication line is simply passing through the grounded intrinsically safe barrier before connecting to the intrinsically safe weighing terminal installed in the hazardous area Zone 1/21, Division 1.

Benefits of this configuration include:

- Simple application through intrinsically safe RS232x interface
- Cost efficiency
- Precise signal response
- Small barrier footprint

Limitations include:

- Short signal distance (15 - 20m maximum)
- Only one PC can be connected
- Safety barrier requires securely implemented earthing system.

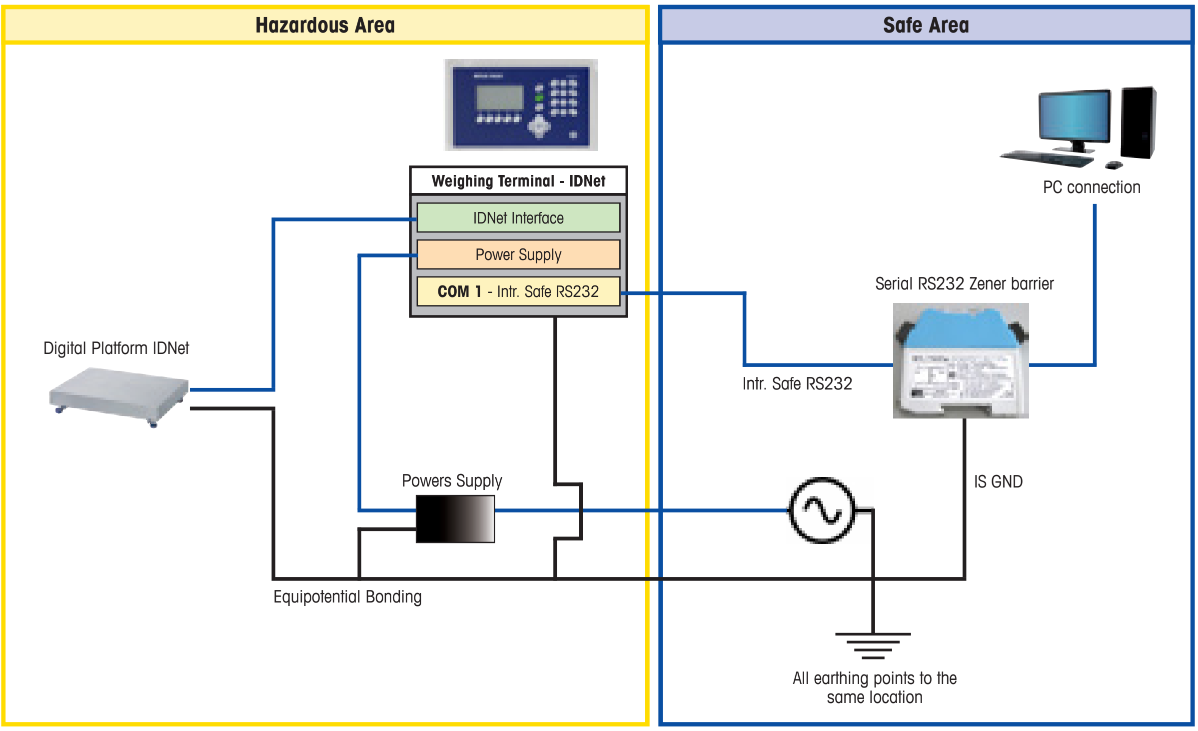


Figure 1. Direct RS232 Communication in the Safe Area

To ensure safe system set-up and function, terminal and the safety barrier entity parameters must be compared. Tables 2 and 3 show this comparison, reviewing both active and passive signals.

Zener Barrier MTL7761Pac **Active**		Weighing Terminal COM 1 RS232 **Passive**
U_o = 9 VDC	≤	U_i = ±10 VDC
I_o = 26 mA	≤	I_i /mA = No limitation
P_o = 58 mW	≤	P_i mW = No limitation
C_o = 4.9 nF	≥	C_i /nF (Negligible) + C_{cable} /nF
L_o = 3.72μH	≥	L_i/μH (Negligible)+L_{cable} / μH

Table 2. Entity Parameters of Zener Barrier - Active

Zener Barrier MTL7761Pac **Passive**		Weighing Terminal COM 1 RS232 **Passive**
U_i = 9 VDC	≥	U_o = ±5.36 VDC
I_i = 26 mA	≥	I_o = ± 18.1 mA
P_i = 58 mW	≥	P_o = 24.2 mW
C_i /nF (Negligible)+C_{cable} /nF	≤	C_o = 4.9 nF
L_i/μH (Negligible)+L_{cable} / μH	≤	L_o = 3.72μH

Table 3. Entity Parameters of Zener Barrier - Passive

Many different safety barriers are available; therefore, take time to know the technical details and entity parameters of any chosen safety barrier solution to ensure safety.

3 Advanced System

In the case of advanced data communication capabilities such as communicating via Ethernet or programmable logic controller (PLC), the amount of transferred data can be increased. This requires a more powerful and sophisticated interface between the hazardous and safe area, as well as more powerful and sophisticated communication modules themselves.

The intrinsically safe current loop interface will perform best when large amounts of data must be communicated from the hazardous to the safe area.

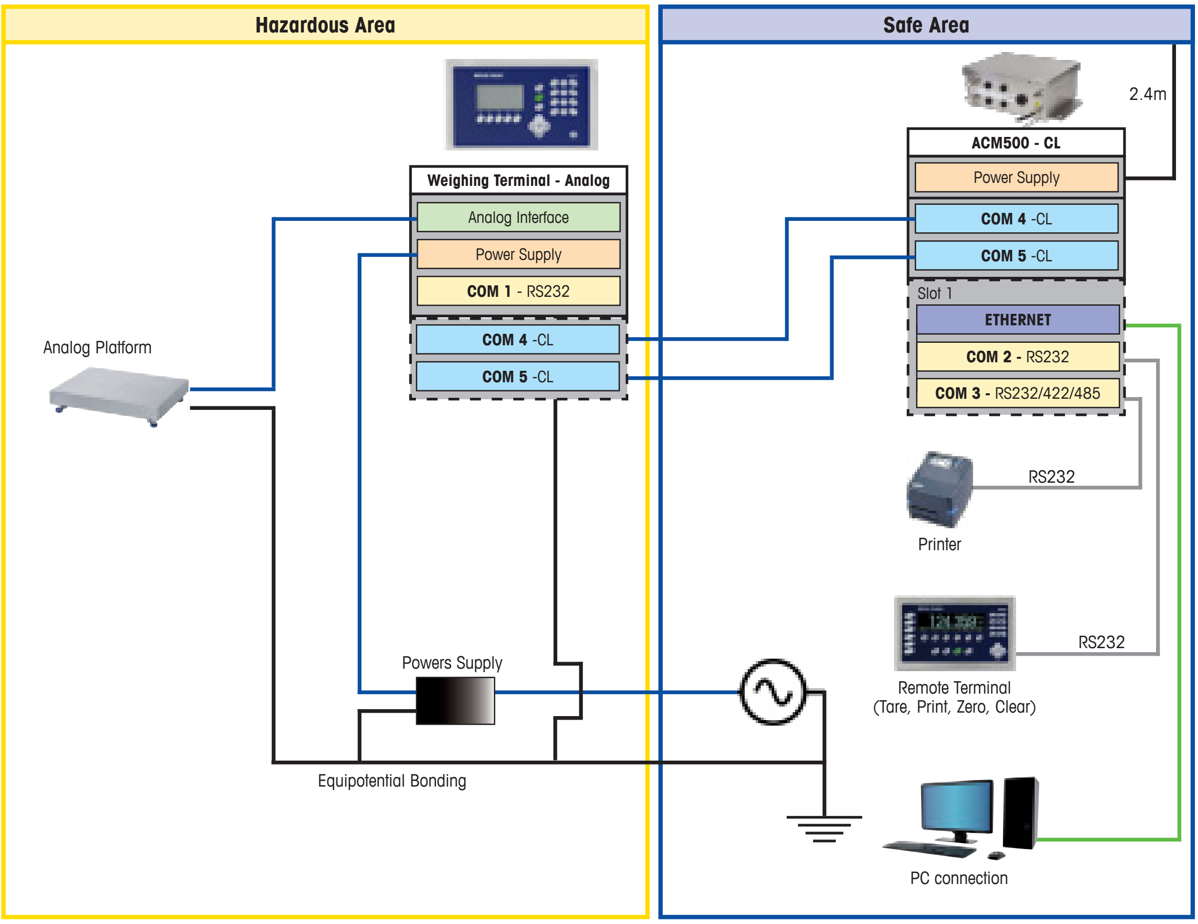
Figure 2 shows an example of advanced system set-up. Safe area communication is achieved by the intrinsically safe communication module whose functional principal is based on a current loop interface.

The current loop interface provides one or two full channels of bidirectional communication and is designed to use a copper wire cable. High speed transmitters and receivers are used to increase data throughput. When combined with the communication module and its options, this permits remote operation in the safe area with Ethernet and PLC interfaces at distances up to 300 meters (1000 ft.) from the intrinsically safe weighing terminal.

The benefits of this configuration:
- Long signal (up to 300m maximum)
- Enhanced high speed data communication

Limitations include:
- Bigger barrier footprint requirements
- Additional wiring

The enhanced set-up allows large amounts of data to be gathered from the hazardous area zone 1 /21, Division 1 and integrated with standard PLC interfaces such as EtherNet/IP, Profibus, DeviceNET, and ModbusTCP efficiently. To ensure safe communication to the hazardous area, hazardous-area certified cable glands must be used on all intrinsically safe connections. Standard communication to a safe area PLC and Ethernet typically uses the standard, factory installed cable gland.

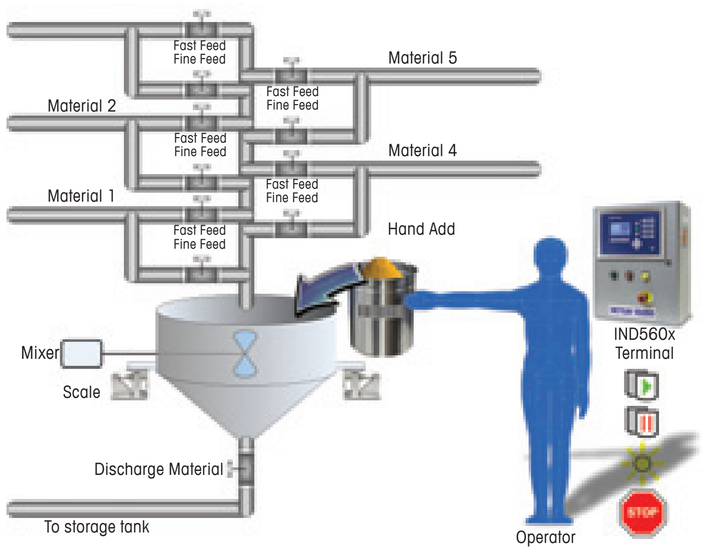


Picture 2. Current Loop Communication

4 Process Control

Handling, filling, dosing, blending or batching of hazardous liquids or solids requires precise control. Small process changes can have a big impact on end product quality. Variations in proportions, speed, flow, turbulence, and many other factors must be carefully and consistently controlled to produce the desired end product with a minimum of raw materials and energy. Process control through discrete internal Inputs / Outputs (I/Os) keeps the weighing process running within specified limits and allows more precise target limits to be set to maximize profitability and ensure quality and safety.

Remote I/O technology can be a cost-efficient and flexible solution for data control in processing plants. However, good management of this type of system is particularly critical for hazardous areas where explosion protection measures for all system components are generally required.



Active / Active Control

In the case of active / active control (Figure 3), both active inputs and active outputs are installed in the hazardous area. Signal inputs are powered internally by the weighing terminal and are designed to be used with simple switches housed within the hazardous area.

Signal outputs are also powered by the weighing terminal and provide 12V switching at 50mA total. These outputs are intended for use with extremely low power, intrinsically safe solenoids or piezo fluid control valves.

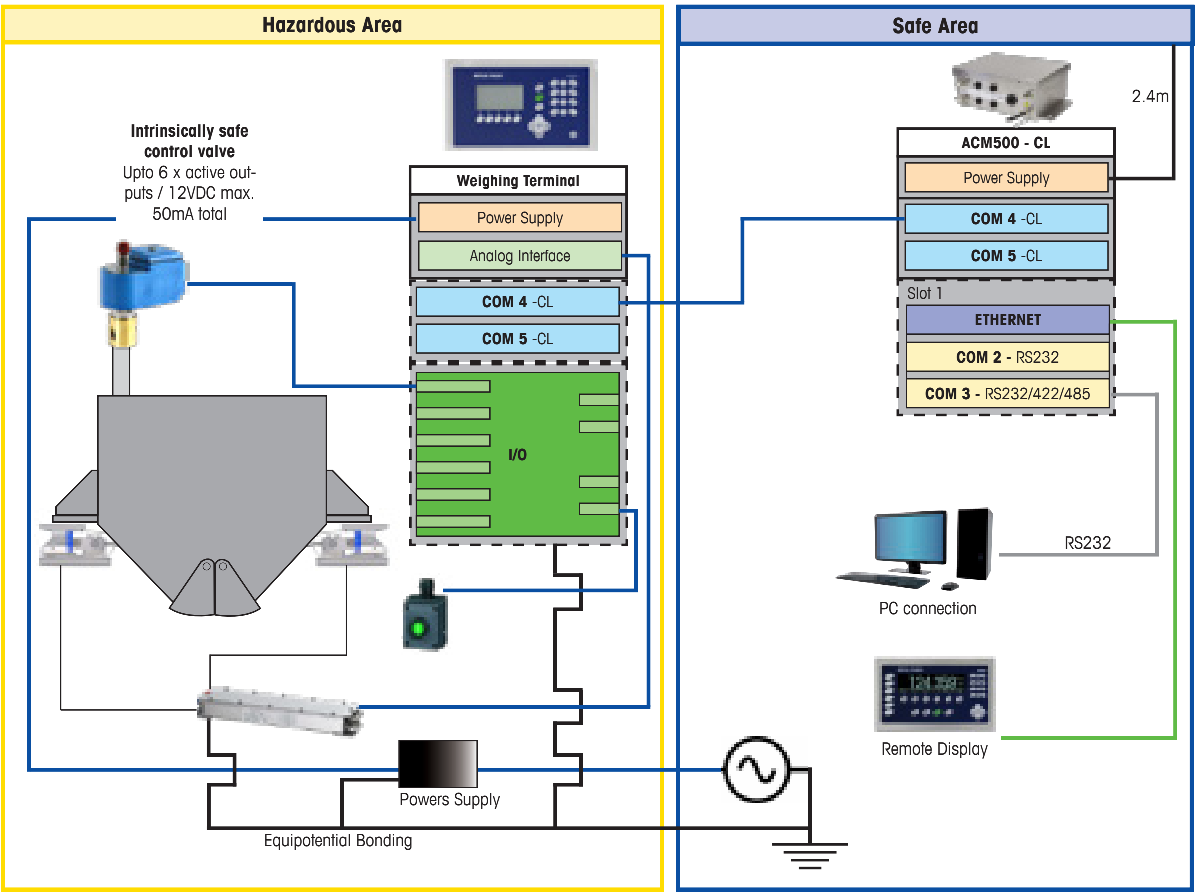


Figure 3. Active / Active Control with Internal Discrete I/O Module

Entity parameters of the I/O module must be compared to the output entity values of the intrinsically safe weighing terminal (see Table 4).

I/O Module Active		Connect Device Passive
U_o = 5.88 DCV	≤	U_i / V
I_o = 2 mA	≤	I_i /mA
P_o = 2.94 mW	≤	P_i mW
C_o = 100 nF	≥	C_i /nF +C_{cable} /nF
L_o = 100 µH	≥	L_i/µH+L_{cable} / µH

Table 4. Entity Parameters of the I/O Module

In the safe area, communication with peripheral devices such as PC, remote terminal, or printer is possible through the intrinsically safe module with wide range of interfaces such as Ethernet or RS232/422/485.

Active / Passive Control

In the active input / passive output set-up (Figure 4), active input controls are installed in the hazardous area. The passive outputs are usually high voltage solenoids which are not approved for hazardous location use and must therefore be considered for installation in the safe area. Passive inputs allow connection of an external intrinsically safe voltage supply to power switches or other simple devices to trigger the input.

Both active inputs and passive outputs are powered by the intrinsically safe weighing terminal which is installed in hazardous area. The terminal in turn is powered through the external intrinsically safe power supply which meets hazardous area requirements.

Using the discrete I/O option with passive outputs requires a higher activation voltage to power the intrinsically safe control terminal. Because the simple switch for active inputs is installed in the hazardous area, the power coming from high voltage solenoids needs to be intrinsically safe.

The ability to manage high voltage solenoids or other controls in the hazardous area is provided through protective devices such as an isolated safe-switch amplifier. This amplifier combines a safety barrier with a high level voltage control. Passive outputs remain isolated while providing signals to switch the higher AC or DC voltage through the amplifier.

I/O Module - Passive Output		Switch Amplifier
U_i = 15 V	≤	U_o / V
I_i = 40 mA	≤	I_o / mA
P_i = 150 mW	≤	P_o mW
C_i / nF +C_{cable} = 10 nF	≥	C_o /nF
L_i/µH+L_{cable} =10 µH	≥	L_o / µH

Table 5. Entity Parameters of the I/O Module Output

An isolated switch amplifier combines a safety barrier with higher-level voltage control. The entity parameters of the switch amplifier must be compared to the entity parameters of the intrinsically safe weighing terminals (see Table 5).

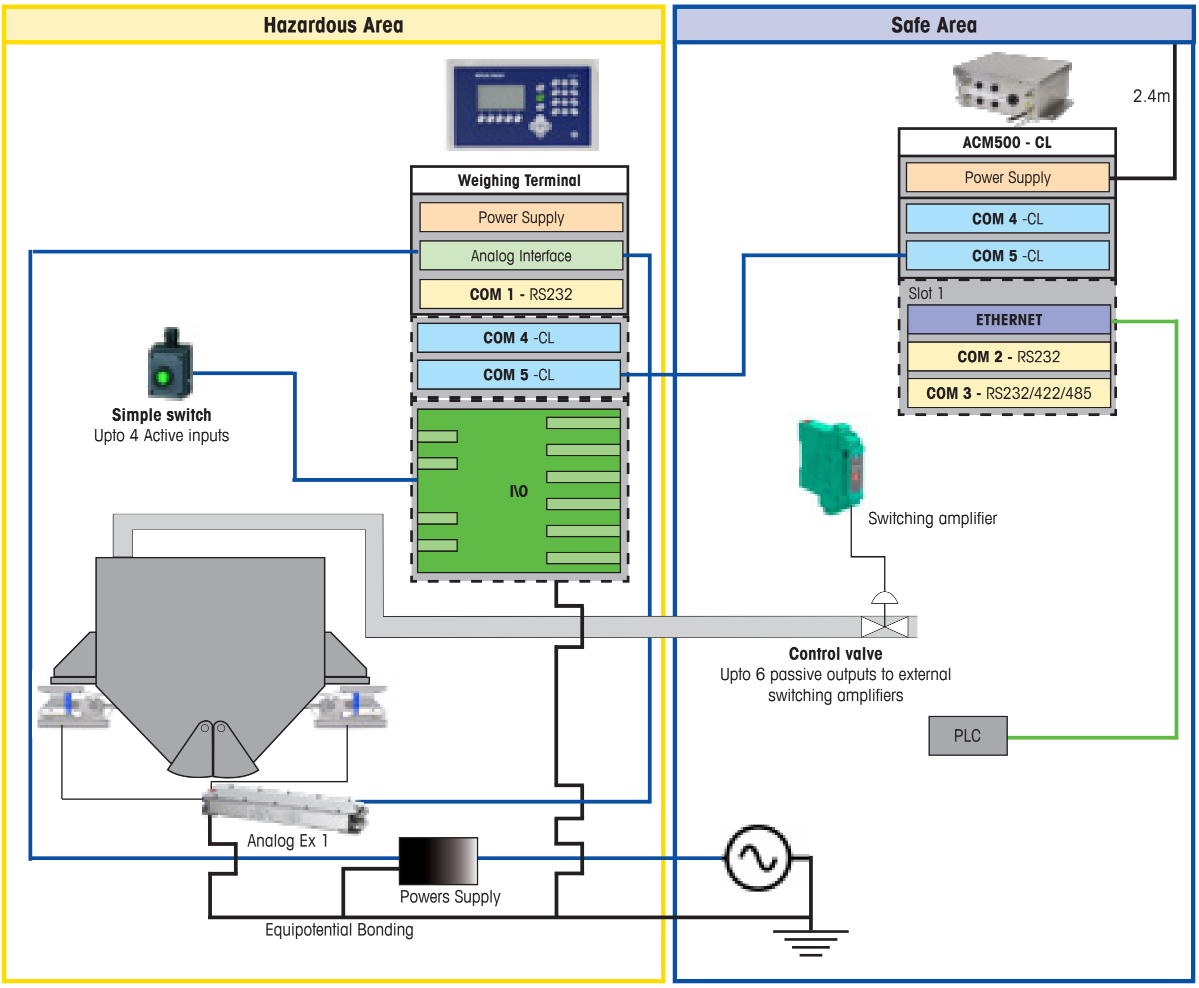


Figure 4. Active Input / Passive Output Valve Control

Passive Input / Passive Output Control

Passive inputs can be used when the input signal is coming from the safe area or some other type of active device such as a PLC. The protective switch amplifier provides controls passive outputs and high voltage solenoids or other controls in the safe area. The external switch amplifier receives a high voltage and converts it into an intrinsically safe voltage to send to the weighing terminal in the hazardous area. Passive outputs remain isolated while signaling to switch the higher AC or DC voltage through the switch amplifier.

The simple switch can be protected by the galvanically isolated type of barrier. The barrier provides complete isolation and limits the high voltage coming from the switch, converting it to intrinsically safe voltage before sending it back to the I/O module in the hazardous area (Figure 5).

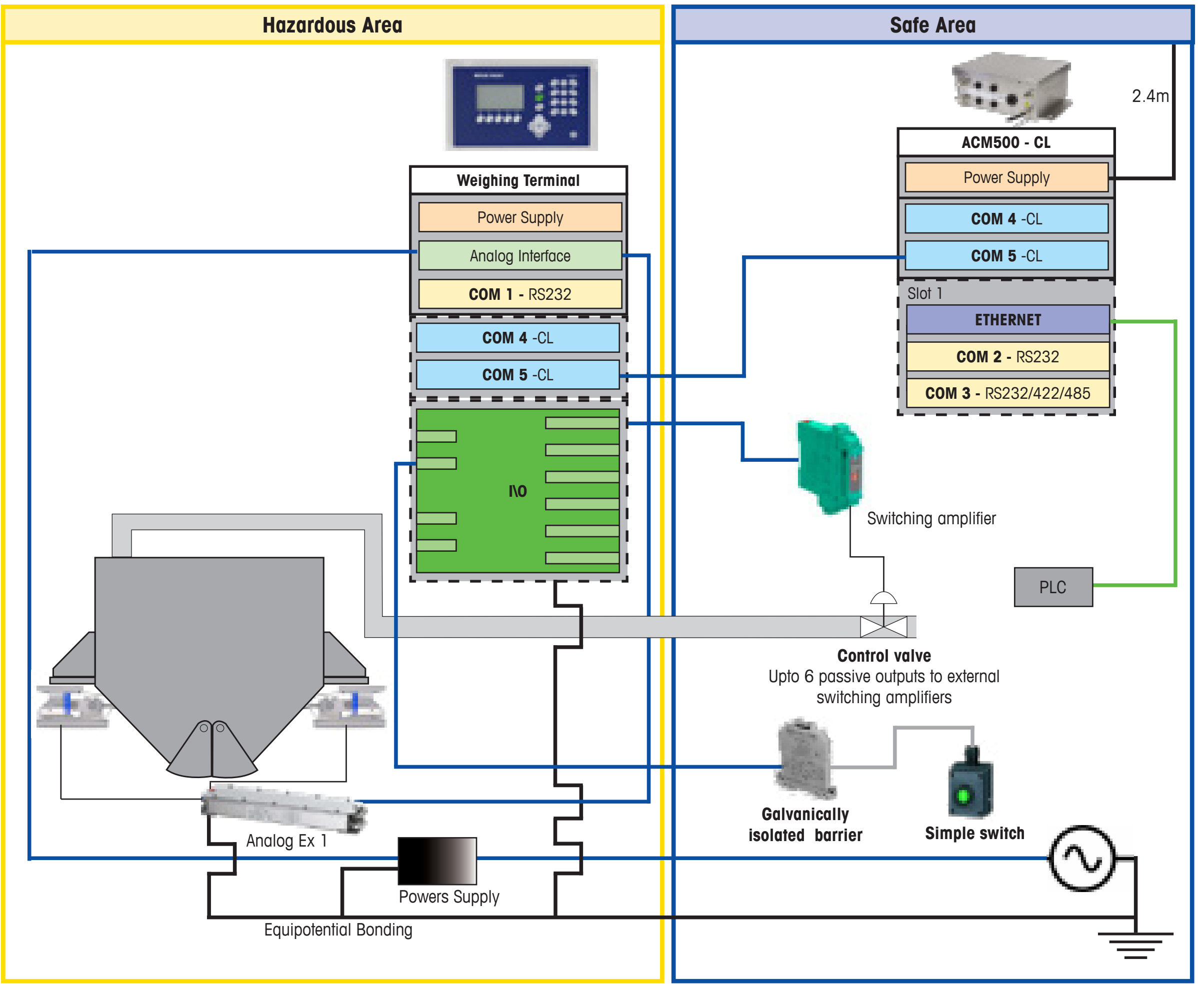


Figure 5. Passive Input / Passive Output Valve Control

The entity values of the safety barrier or the external power supply must be compared to the entity parameters of the intrinsically safe weighing terminal passive inputs (see Table 6).

Intrinsically Safe Terminal Passive Input Parameters		Galvanically Isolated Barrier
U_i = 30 V	≤	U_o / V
I_i = 50 mA	≤	I_o / mA
C_i / nF +C_{cable} = 10 nF	≤	C_o /nF
L_i/µH+L_{cable} =10 µH	≥	L_o / µH

Table 6. Entity Parameters of the Passive Input

5 Fully Integrated Process Control

To increase efficiency, reduce variability and ensure maximum safety, fully integrated process control is the method of choice. For example, in multipurpose plants where several components are filled, mixed, blended and dispensed at the same time, an internal I/O system supporting 12 inputs and 18 outputs is the right choice.

To achieve the maximum number of I/Os, safe area active remote modules can be used. These modules are not approved for installation in the hazardous area. Active remote modules are capable of switching the high voltage to control the energy in the hazardous area and require advanced intrinsically safe communication modules which serve both as a safety barrier and provides enhanced Ethernet communication. The current loop interface provides two-channel bidirectional communications to the hazardous area. Weighing data can be stored on the PC through the Ethernet communication or the system can be connected to the PLC using Profibus (Figure 6).

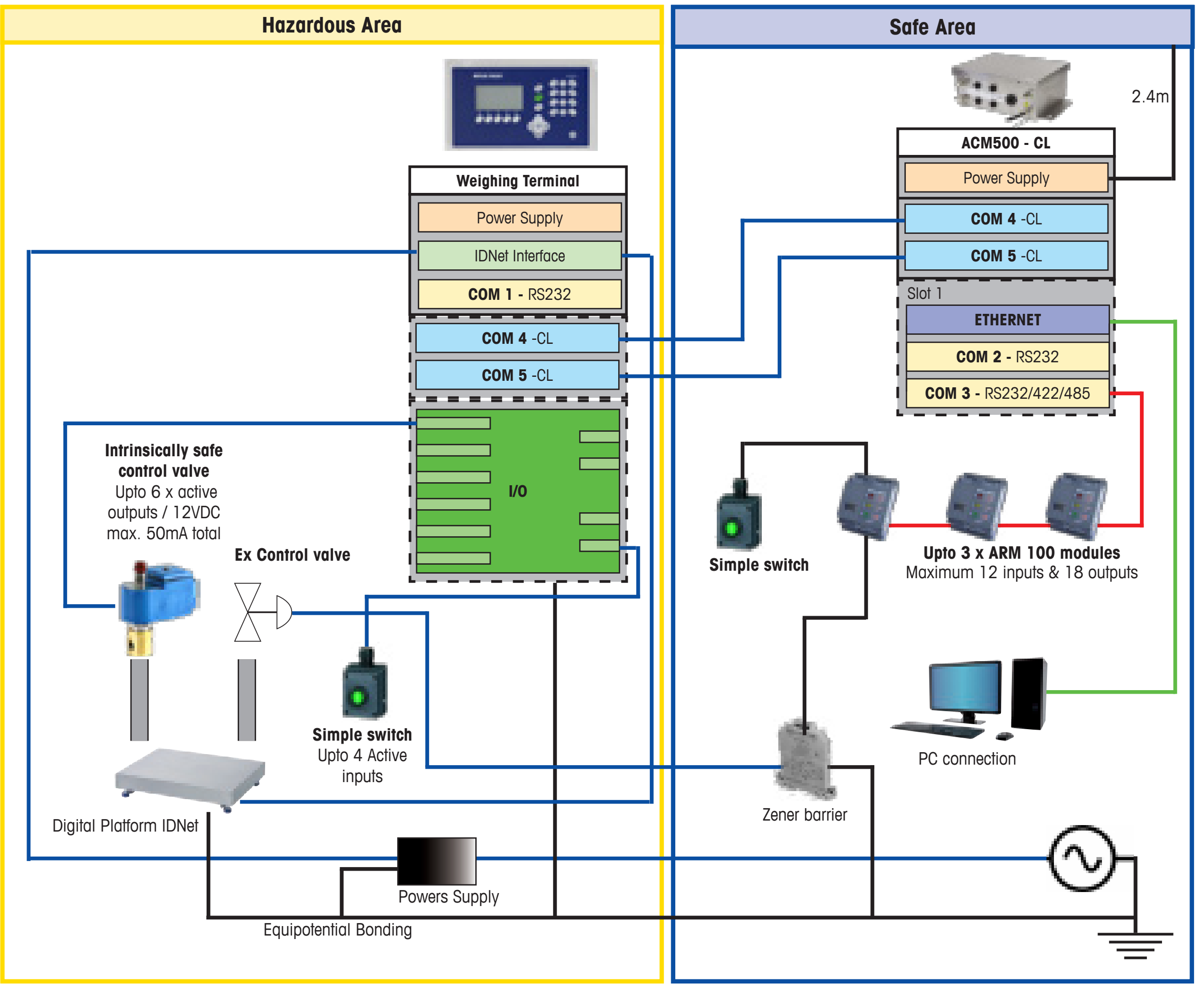


Figure 6. Fully Integrated Process Control

6 Optional Safe Area Peripherial Communications

Depending on weighing process requirements and degree of automation, different communication possibilities allow efficient communication to the safe area.

When defining data transfer requirements to efficiently communicate weighing results to higher level manufacturing execution systems (MES) or enterprise resource planning (ERP) systems, several points must be considered:

- What type of information will be communicated between the weighing terminal and automation system?
- What triggers initiate data transfer and how frequently will communication be made?
- What are the present data format requirements? Are those requirements flexible?
- What is the current communication medium? Are there other viable options?
- How might data format requirements or the communication medium evolve in the foreseeable future?

The key to data integration is having the correct connection to your wider control system. Whether it is a PLC, MES or an ERP system, connection requirements for hardware and software differs. Options include fieldbus interfaces, such as analog output, Profibus, DeviceNet or EthernNet/IP; and data interfaces such as Ethernet TCP/IP or serial interface communication.

When purchasing a new weighing system, the data integration capabilities must match the data requirements of the wider manufacturing system.

METTLER TOLEDO offers two different possibilities of communication in the safe area that can meet these system requirements.

The basic ACM 200 communication module approved for the safe area installation provides the connective link between the weighing system installed in the certified hazardous area and the computer, printer or remote control terminal in the safe area. This module provides a flexible choice between different communication interfaces such as RS232, RS422, RS485 and CL20mA.

Advanced weighing applications require enhanced control as well as enhanced safe area communication. The communication module ACM500 plays an important role for such application types providing a number of optional interfaces from RS232 to PLC data integration.

If PLC data integration is not required, PC-based serial or Ethernet TCP/IP data communication options become viable.

7 Summary

Weighing is an important parameter of many manufacturing processes, and it requires special attention when conducted in hazardous areas. Though weighing system components may be both intrinsically safe and non-intrinsically safe depending on where and how they are used, it is crucial to ensure they have an appropriate level of safety and provide required communication possibilities.

The system must be selected, configured and installed in strict accordance with hazardous area regulations and standards. For some applications, a simple standalone weighing system with relatively simple communication optionality is adequate; for other, more advanced applications with requirements of enhanced data communication, the system configuration can be more complex.

METTLER TOLEDO has a long history of developing intrinsically safe weighing equipment and offers a range of solutions to monitor, register and efficiently communicate weighing data safely. Expert advice may be a good starting point to prevent explosion risk and ensure the kind of accurate, reliable weighing that improves productivity and profits.

8 Additional Resources

- METTLER TOLEDO IND560x Brochure
  www.mt.com/IND560x

- METTLER TOLEDO APS768x Power Supply
  www.mt.com/APS768x

- METTLER TOLEDO ACM500 Communication Module
  www.mt.com/ACM500

- METTLER TOLEDO Hazardous On-Demand Webinar Basic
  www.mt.com/ind-haz-basics

- METTLER TOLEDO Hazardous On-Demand Webinar Advanced
  www.mt.com/ind-haz-advanced

- METTLER TOLEDO Hazardous Catalog
  www.mt.com/ind-hazcat

- METTLER TOLEDO (2013), "Intrinsically Safe Solutions: Accurate Weighing in Hazardous Areas", Greifensee, Switzerland, 1-10
  www.mt.com/ind-intrinsic-safe

- METTLER TOLEDO (2013), "Safety Competence – Hazardous Area Regulations and Standards", Greifensee, Switzerland, 1-18
  www.mt.com/ind-haz-safety

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