Engineering White Paper

HOW TO SELECT A WEIGHING INSTRUMENT
PENKO ENGINEERING B.V.

INTRODUCTION

This White Paper discusses the challenges, options and solutions for the industry when for the design of a weighing system instrumentation, electronic equipment, has to be selected. The definition of weighing is: “measuring of mass by means of gravity”. Many finished products are chemical or physical mixtures, of which the formula is based on the molecular mass, what means the mixing ratio is in gram molecules. So out of a chemical point of view preparing mixtures or filling prepackages on weight is chemically correct, in a way you are counting molecules. The instrument is an essential part of a weighing system, it translates the load cell’s signal into digital information, suitable for a read out and further automation.

PURPOSE OF WHITE PAPER

…- is to explain why it is important to select the right instrumentation. The selected type determines the accuracy, functionality and ease of operation of the weighing system as well as the suitability for additional data processing and/or automation of your weighing process.

BACKGROUNG OF INSTRUMENTATION FOR WEIGHING PURPOSES

Principally a modern mass measuring system realizes the conversion of a force, the load resting on the sensor(s), in an electrical signal, see figure 1.

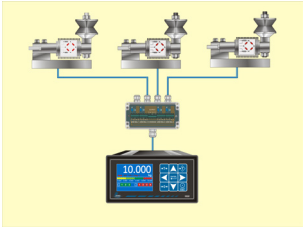

Figure 1. The principle of a weighing system with three load cells, a junction box and an indicator.

The weighing instrumentation is specially designed for utilization with load cells. Every load cell has four strain gauges, resistances that change linearly with the load, see picture 2.

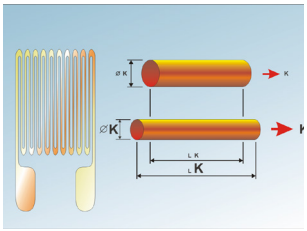

Figure 2. Deformation of the conductor causes a change of its resistance.

The strain gauges are connected in a Wheatstone bridge, see picture 3, in such a way that the changes in resistance are diagonally opposite, see picture 4.

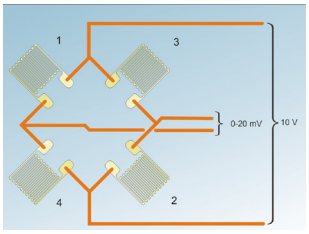

Figure 3. Four strain gauges in a Wheatsone bridge.

This way of operation creates a measurement signal, dependent of the supply voltage. That's why the sensitivity of a load cell is recorded in mV/V. Usual is 2 mV/V, so a power supply of 10 V means between 0 and full load a 0 - 20 mV signal and with a 5 V power supply 0 - 10 mV becomes available. Parallel to the wiring for the supply voltage, we use two extra measuring lines, the so-called sense. This measures the power supply as close as possible to the bridge with train gauges. In the event of changes, for example due to temperature influences on the measuring cable, compensation will automatically take place in one of these two ways, to be precisely

* active, the power supply voltage on the measuring bridge is kept constant or
* passive, the instrumentation compensates the change of the power supply voltage by means of the gain.

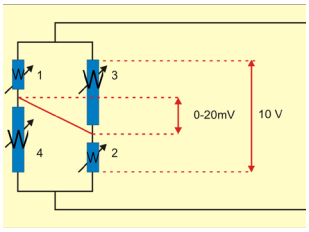

Figure 4. Diagonally changes in resistance offer proper measurement information.

BASIC PRINCIPLE

The voltages mentioned, 10 and 20 mV respectively, become available at full load, the capacity of the load cell. In practice this rarely is the case, for the weighing range only a part of the load cell's capacity is used. The load cell's capacity, not used for the weighing range, is for example necessary for the dead weight, the construction of the weighing arrangement. Specific for the weighing technology is that the part, used for the weighing itself, the so-called utilization, usually can be 30% or more of the carrying capacity wt-thout any loss of accuracy in percentage. Picture 5 shows this for a partial range, utilization, of 30%.

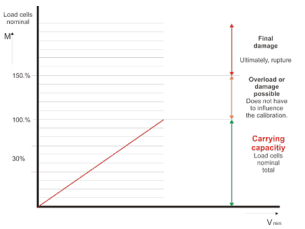

Figure 5. The use of the carrying capacity for dead weight, weighing range (net and tare) and spare capacity.

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As a next step the data must be digitized. This way readable weight information, suitable for further processing and automation, is displayed. The digitization takes place in display units or divisions. All our instruments are suitable for 10 000 divisions. So, see figure 6, if the scale shown here would have a capacity from 0 to 10,000 kg, the weight can be displayed per 1 kg.

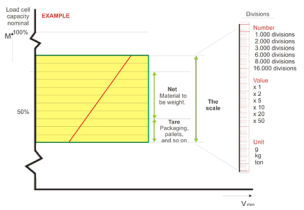

Figure 6. The digitalisation of the weight.

However, the load cells are a limitation. The current types have an accuracy between 3 000 and 6 000 divisions (0.03 to 0.017% of the weighing capacity). It should be noted that the above-mentioned accuracies relate to the entire weighing system, ie the combination of the load cell(s) and the weighing instrumentation. This is because a kind of addition, the apportioning of errors, is used in the assessment of this. This method is set out in the following table 1, derived from OIML recommendation R76 of 2006.

Performance criteria	Load cell	Electronic indicator	Connecting elements, etc.
Combined effect*	0.7	0.5	0.5
Temperature effect on no load indication	0.7	0.5	0.5
Power supply variation	0	1	0
Effect of creep	1	0	0
Damp heat	0.7**	0.5	0.5
Span stability	0	1	0

* Combined effects: non-linearity, hysteresis, temperature effect on span, repeatability, etc. After the warm-up time specified by the manufacturer, the combined effect error fractions apply to modules.
** According to OIML R 60 valid for SH tested load cells (PLC = 0.7).
The sign "0" means "not applicable"

So this table shows, creep is fully attributed to the load cell(s) and variations of the supply voltage to the electronics. 70% of temperature effects is attributed to the load cell(s) and 50% to the weighing instrumentation.

Another factor is the resolution. Where the instrument shows up to 10 000 parts, internally it calculates with 16 777 216. The measuring speed is also important; the number of times that the instrument determines the digital data per unit of time. The combination of both properties offers surprisingly good results. Thanks to the use of smart filters and sufficient computing capacity, this not only offers a stable display under almost all applications, including dynamic ones. Moreover, it makes fast dosing and filling processes controllable. See figure 7, with a slow measuring system with a low resolution, the uncertainty for switching off lies in the red area. A fast system with a high resolving power reduces the uncertainty for switching off to the green square.

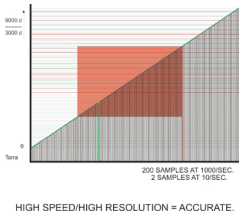

Figure 7. The improvement of the dosing accuaracy when using a high measuring speed and internal resolution.

If the weighing system in question is used for commercial applications it must be approved in accordance with the directive for non-automatic weighing instruments 2014/31/EU or, if it is an automatic operating system, the one for measuring instruments 2014/32/EU. For these applications, most instruments have an evaluation certificate. The normative document for non-automatic weighing instruments is EN45501, based on OIML (International Organization for Legal Metrology) recommendation R76. For the automatic weighing systems, for the various applications, OIML recommendations are used as normative documents.

The selection criteria

The selection criteria are successively:

- are a read out and control buttons required?
- is there a need for control functions and, if so, which ones?
- which digital/analog outputs are required?

When there is no need for a read out with push buttons and control functions, a digitizer will suffice. Digitizers have all the aforementioned features and offer a wide selection of outputs, both digital and analog. In this way the weighing information can be transferred directly, quickly and reliably to an overhead system.

When a read out and push buttons are required, but no control functions, you can select out of the range of indicators. These are available for panel mounting as well as in industrial enclosures. These instruments also offer you the aforementioned high resolution and measurement speed. Furthermore, various digital outputs can be selected for the fast and safe transfer of weighing information to overhead systems.

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Control functions logically require controllers. Hereby you have the choice between fixed programmed and freely programmable versions. Standard programs are available for a number of standard applications, such as filling purposes (photo 1), check weighing (photo 2), continuous totalization with belt scales, (photo 3) and the like.

Photo 1. A gravimetric filling installation.

Applications with a variety of designs, such as mixing room controllers and grading on weight, can be made “custom-made” using freely programmable instruments.

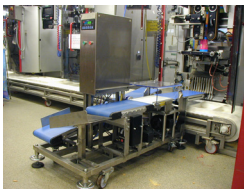

Photo 2. A check weigher.

Photo 3. A continuously totalising beltweigher.

To simplify the selection of the right communication with an overhead system or the corresponding process control approach for you, image 8 shows you three options.

1. The data transfer, from a digitizer or an indicator, takes place analogously, by example 0/4 - 20 mA. This means the conversion from analogue to digital takes place in the PLC. This conversion usually is meant for general measurement, so on a percentage basis, where the weighing technique operates in part of pro milles. Additionally it makes you for the control of your weighing process dependent on the cycle time of the PLC. This factor is a variable, influenced by the number of instructions the PLC has to handle.

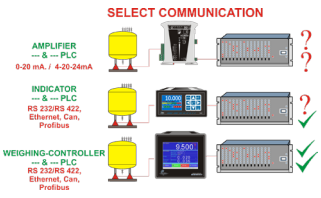

Figure 8. This way you select the communication.

2. The data transfer, from a digitizer or an indicator, takes place digitally. This ensures you of high quality, at „weighing instruments level“, measurement data. The PLC however controls the weight control. As a result, you remain dependent on the cycle time of the PLC, a variable, influenced by the number of instructions it has to handle.
3. The royal way, a weighing controller supervises the weighing process and simultaneously takes care for the data transfer to and from an overhead system. As a result, the weighing process is checked in the control system, based on high-quality weighing information. Doing so, there are no differences in time due to data transmission and switching decisions are not affected by the cycle time of the PLC. The weigher therefore does where it is meant for.

Competitive Advantage

A high resolution filtering system combined with high speed – high accuracy measuring, offers smart weighing results for any operation environment.
All instruments are designed and manufactured with an accuracy of 10 000 d. The combination of measuring at high speed (1.600 conversions/s) with a high internal resolution (16 777 216), smart filters and sufficient computing capacity, make all instruments suitable for any dosing, mixing, blending and filling application. The combination of the high resolution and conversion speed guarantees the best achievable weighing and dosing accuracy, even when dosing at high speed, and thus prevents wastage because of wrong compositions.

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PRODUCT SOLUTIONS, DIGITIZERS

MODEL SGM700

The SGM700 range of digitizers is a compact device for use as standalone converter between the load cell(s) and any PENKO controller. A selection can be made, depending on the model, out of portal Ethernet (TCP) with protocols Modbus, FINS, Ethernet-IP and ASCII, portal RS232/422 with protocol Modbus and ASCII as well as portal Profibus with protocol Profibus-DP. Protocols for printers, web browsers, and configuration software between PENKO devices are available on Ethernet (TCP), CAN, RS232/422 and USB portals.

Photo 4. Dizigitizer type SGM700

MODEL SGM800.

The SGM800 range of digitizers is a compact device for use as standalone converter between the load cell(s) and any PENKO controller. Type SGM800 possesses evaluation certificates, making this converter fit for trade applications. All models have three inputs and four outputs. A selection can be made, depending on the model, out of portal Ethernet (TCP) with protocols Modbus, FINS, Ethernet-IP and ASCII, portal RS232/422 with protocol Modbus and ASCII as well as portal Profibus with protocol Profibus-DP. Protocols for printers, web browsers, and configuration software between PENKO devices are available on Ethernet (TCP), CAN, RS232/422 and USB portals.

Photo 5. Dizigitizer type SGM800

PRODUCT SOLUTIONS, INDICATORS

MODEL 1020

The basic indicator is compact, durable and user friendly. It offers 3 inputs and 4 outputs as well as Ethernet and USB communication portals. As an option the 1020 allows for an analogous output and communication portals including RS232 and RS422/485 with protocol Modbus and ASCII as well as optional portal Profibus with protocol Profibus-DP. Protocols for printers, web browsers, and configuration software between PENKO devices are available on CAN, RS232, RS422/485 and USB portals.

Photo 6. Indicator type 1020

MODEL FLEX-2100

This three-in-one device combines a stunningly-simple touchscreen interface, a core of sophisticated hardware and a clever calibration system. It offers 8 inputs/8 outputs and communication via an Ethernet (TCP) portal with the protocols Modbus, FINS, Ethernet-IP and ASCII, portals RS232, RS422/ RS485 with the protocols Modbus and ASCII. Protocols for printers, webbrowsers and configuration software between PENKO-instruments are available on Ethernet (TCP), CAN, RS232/422 and USB. Additional options are an analogue output and a portal Profibus with protocol Profibus-DP.

Photo 7. The type FLEX-2100 range of instruments

MODEL FLEX

This most versatile apparatus is an all-in-one compact, reliable and user friendly indicator, suitable for non-automatic weighing. The communication of the FLEX includes portals Ethernet (TCP) with the protocols Modbus, FINS, Ethernet-IP and ASCII, portals RS232 and RS422/RS485 with the protocols Modbus and ASCII, as well as optionally a portal Profibus with protocol Profibus-DP. Protocols for printers, webbrowsers and configuration software between PENKO-instruments are available on Ethernet (TCP), CAN, RS232/422, and USB, making it highly suitable for complex weighing applications. Extra digital and analogue inputs/outputs are optional. The FLEX range has all the features of model FLEX-2100.

Photo 8. The type FLEX range of instruments

MODEL FLEX MultiChannnel

This most versatile apparatus possesses all the features of the models FLEX and FLEX-2100 with additionally the capacity to show the results of up to four weighing systems in one instrument simultaneously.

Photo 9. The multi-channel instrument type FLEX

PRODUCT SOLUTIONS, CONTROLLERS WITH STANDARD PROGRAMS

MODEL SGM800.

The SGM800 range of digitizers is a compact device for use as standalone controller in network configurations with specific control-functions. Standard software is available for gravimetric filling installations, check weighers and belt weighers (continuously totalizing). The way of operation you find in the applicable white papers. All models have three inputs and four outputs. A selection can be made, depending on the model, out of portal Ethernet (TCP) with protocols Modbus, FINS, Ethernet-IP and ASCII, portal RS232/422 with protocol Modbus and ASCII as well as portal Profibus with protocol Profibus-DP and/or an analogous output. Protocols for printers, web browsers, and configuration software between PENKO devices are available on Ethernet (TCP), CAN, RS232/422 and USB portals.

Photo 10. Controller type SGM800

MODEL 1020

The basic controller is compact, durable and user friendly. Standard software is available for gravimetric filling installations, check weighers and belt weighers (continuously totalizing). The way of operation you find in the applicable white papers. It offers 3 inputs and 4 outputs as well as Ethernet and USB communication portals. As an option the 1020 allows for an analogous output and communication portals including RS232 and RS422/485 with protocol Modbus and ASCII as well as optional portal Profibus with protocol Profibus-DP. Protocols for printers, web browsers, and configuration software between PENKO devices are available on CAN, RS232, RS422/485 and USB portals.

Photo 11. Controller type 1020.

MODEL FLEX-2100

This three-in-one device combines a stunningly-simple touchscreen interface, a core of sophisticated hardware and a clever calibration system. Standard software is available for gravimetric filling installations, check weighers, belt weighers (continuously totalizing), hopper weighers (discontinuously totalizing) and negative dosing (Loss in Weight). The way of operation you find in the applicable white papers. It offers 8 inputs/8 outputs and communication via an Ethernet (TCP) portal with the protocols Modbus, FINS, Ethernet-IP and ASCII, portals RS232, RS422/RS485 with the protocols Modbus and ASCII. Protocols for printers, webbrowsers and configuration software between PENKO-instruments are available on Ethernet (TCP), CAN, RS232/422 and USB. Additional options are an analogue output and a portal Profibus with protocol Profibus-DP.

Photo 12. The type FLEX-2100 range of instruments

MODEL FLEX

This most versatile apparatus is an all-in-one compact, reliable and user friendly controller, suitable for automatic weighing applications. Standard software is available for gravimetric filling installations, check weighers, belt weighers (continuously totalizing), hopper weighers (discontinuously totalizing) and negative dosing (Loss in Weight). The way of operation you find in the applicable white papers. The FLEX offers an expandable number of inputs and outputs, including remote ones , the communication includes portals Ethernet (TCP) with the protocols Modbus, FINS, Ethernet-IP and ASCII, portals RS232 and RS422/RS485 with the protocols Modbus and ASCII, as well as optionally a portal Profibus with protocol Profibus-DP. Protocols for printers, webbrowsers and configuration software between PENKO-instruments are available on Ethernet (TCP), CAN, RS232/422, and USB, making it highly suitable for complex weighing applications. Extra digital and analogue inputs/outputs are optional. The FLEX range has all the features of model FLEX-2100.

Photo 13. The type FLEX range of instruments

PRODUCT SOLUTIONS, CONTROLLERS WITH STANDARD PROGRAMS

MODEL FLEX-2100

This three-in-one device combines a stunningly-simple touchscreen interface, a core of sophisticated hardware and a clever calibration system. It offers 8 inputs/8 outputs, an integrated PLC for free programming and communication via an Ethernet (TCP) portal with the protocols Modbus, FINS, Ethernet-IP and ASCII, portals RS232, RS422/RS485 with the protocols Modbus and ASCII. Protocols for printers, webbrowsers and configuration software between PENKO-instruments are available on Ethernet (TCP), CAN, RS232/422 and USB. Additional options are an analogue output and a portal Profibus with protocol Profibus-DP.

Photo 14. The type FLEX-2100 range of instruments

MODEL FLEX

This most versatile apparatus is an all-in-one compact, reliable and user friendly indicator/controller, suitable for all automatic weighing applications. The FLEX offers an integrated PLC for free programming, an expandable number inputs and outputs, including remote ones, the communication includes portals Ethernet (TCP) with the protocols Modbus, FINS, Ethernet-IP and ASCII, portals RS232 and RS422/RS485 with the protocols Modbus and ASCII, as well as optionally a portal Profibus with protocol Profibus-DP. Protocols for printers, webbrowsers and configuration software between PENKO-instruments are available on Ethernet (TCP), CAN, RS232/422, and USB, making it highly suitable for complex weighing applications. Extra digital and analogue inputs/outputs are optional. The FLEX range has all the features of model FLEX-2100.

Photo 15. The type FLEX range of instruments

MODEL FLEX MultiChannnel

This most versatile apparatus possesses all the features of the models FLEX and FLEX-2100 with additionally the capacity to control up to four weighing systems in one instrument simultaneously and, where necessary, cross linked.

Photo 16. The multi-channel instrument type FLEX

MODEL RIO700 AND RIA700

Types RIA700 and RIO700 are universal, compact, remote I/O sets, meant as extensions for the controllers type FLEX. For mapping to the controller no software changes are required. The display shows the live input and output status. When the connection fails, the display shows an error and the outputs are switched off. The RIO and RIA 700 are easy DIN-rail mountable. They can be used single or as a buslink system. Up to 40 RI0/RIA's can be connected into one buslink system. RIO700 offers 8 digital inputs and 8 digital outputs, RIA700 4 analogous inputs and 2 analogous outputs.

Photo 17. The analog extension set type RIA

Photo 18. An overview of the instruments and controls

CONCLUSION

If properly selected and put into operation, each of these instruments forms a reliable, accurate, basis for any industrial weighing system.
Determining the weight for monitoring, regulation or recording the production procedures within strict accuracy requirements, remains a challenge throughout the processing industry and will vary from one manufacturer to another. Consideration not only needs to be given to challenges of the risk of under or over filling, prevention for wrong compositions or too high or too low material flows, but each product or raw material – particularly natural ones – has its own density and volume, influencing the control process.

For the selection of the ideal instrument for an industrial application, product or manufacturer, there is no “one-size-fits-all” solution. Engineers at PENKO work out the best and most effective way this can be done for you.

Following White Paper will discuss Load Cells, the Mounting of Load Cells, Non Automatic Weighing Systems, Weighing Systems for Maritime Applications, Check Weighing Systems, Gravimetric Filling Systems, continuous totalizing with Loss-in-Weight and Belt Weighing, discontinuous totalizing with Hopper Weighers, Grading Systems by means of Weighing, the selection of Software, Prepackages, Mixing chamber controllers for the processing industry, Mixing control in concrete plants, bakeries, confectionery plants and feed mills.

For more information:www.penko.com