Installation Manual

SLP33xD-IOL / SWP331D-IOL

Smart Single-Point Load Cell / Weighing Sensor

METTLER TOLEDO

SLP33xD-IOL / SWP331D-IOL

METTLER TOLEDO Service

Essential Services for Dependable Performance of your SLP33xD-IOL / SWP331D-IOL Smart Single-Point Load Cell / Weighing Sensor.

Congratulations on choosing the quality and precision of METTLER TOLEDO. Proper use of your new equipment according to this manual and regular calibration and maintenance by our factory-trained service team ensures reliable and accurate operation, protecting your investment. Contact us for a service agreement tailored to your needs and budget. Further information is available at www.mt.com/service.

There are several important ways to ensure you maximize the performance of your investment:

1. Register your product: We invite you to register your product at www.mt.com/productregistration so we can contact you about enhancements, updates and important notifications concerning your product.
2. Contact METTLER TOLEDO for service: The value of a measurement is proportional to its accuracy – an out of specification scale can diminish quality, reduce profits and increase liability. Regular service from METTLER TOLEDO will ensure accuracy and optimize uptime and equipment life.
    a. Installation, Configuration, Integration and Training: Our service representatives are factory-trained, weighing equipment experts. We ensure that your weighing equipment is ready for production in a cost effective and timely fashion and that the operating staff is trained for success.
    b. Initial Calibration Documentation: The installation environment and application requirements are unique for every industrial scale so performance must be tested and certified. To ensure production quality and provide a quality system record of performance we provide a calibration service. The accuracy is documented in the calibration certification documents.
    c. Periodic Calibration Maintenance: A Calibration Service Agreement provides on-going confidence in your weighing process and documentation of compliance with requirements. We offer a variety of service plans that are scheduled to meet your needs and designed to fit your budget.

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FCC Notice

This device complies with Part 15 of the FCC Rules and the Radio Interference Requirements of the Canadian Department of Communications. Operation is subject to the following conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his or her expense.

Declaration of Conformity is available at http://glo.mt.com/global/en/home/search/compliance.html/compliance/.

IO-Link is an industrial communications networking standard (IEC 61131-9) managed by the industry association Profibus and Profinet International.

Disclaimer

This installation manual is provided solely as guide for individuals who have received technical training and are familiar with the technical manuals of the METTLER TOLEDO products.

If you cannot find the information you are looking for, please contact METTLER TOLEDO Service.

METTLER TOLEDO reserves the right to make Revisions without notice. Subject to technical changes.

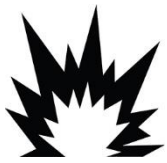
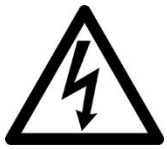
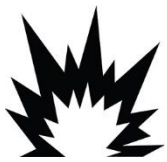
Further documents

In addition to this installation manual, more information is available in the following documents which can be downloaded from ▶ SLP33xD-IOL Product download page.

- SLP33xD-IOL Datasheet
- SLP33xD-IOL Installation Video
- SLP33xD-IOL Quick Installation Guide
- SLP33xD-IOL CAD Drawings
- SWP331D-IOL Datasheet
- SWP331D-IOL Quick Installation Guide
- SWP331D-IOL CAD Drawings

Warnings and Cautions

- READ this manual BEFORE operating or servicing this equipment and FOLLOW these instructions carefully.
- SAVE this manual for future reference.

	**⚠ CAUTION**
	THE SLP33xD-IOL IS INTENDED TO BE USED FOR PROCESS CONTROL AND IS NOT APPROVED AS A SAFETY COMPONENT. WHEN USED AS A COMPONENT PART OF A SYSTEM, ANY SAFETY CIRCUITS MUST BE INDEPENDENT OF THE SLP33xD-IOL.
	**⚠ CAUTION**
	THE SLP33XD-IOL IS NOT INTRINSICALLY SAFE! DO NOT USE IN HAZARDOUS AREAS CLASSIFIED AS DIVISION 1, ZONE 0, ZONE 20, ZONE 1 OR ZONE 21 BECAUSE OF COMBUSTIBLE OR EXPLOSIVE ATMOSPHERES. FAILURE TO COMPLY WITH THIS WARNING COULD RESULT IN BODILY HARM AND/OR PROPERTY DAMAGE.
	**⚠ WARNING**
	WHEN THIS EQUIPMENT IS INCLUDED AS A COMPONENT PART OF A SYSTEM, THE RESULTING DESIGN MUST BE REVIEWED BY QUALIFIED PERSONNEL WHO ARE FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF ALL COMPONENTS IN THE SYSTEM AND THE POTENTIAL HAZARDS INVOLVED. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN BODILY HARM AND/OR PROPERTY DAMAGE.
	**⚠ CAUTION**
	DO NOT INSTALL, DISCONNECT OR PERFORM ANY SERVICE ON THIS EQUIPMENT BEFORE POWER HAS BEEN SWITCHED OFF AND THE AREA HAS BEEN SECURED AS NON-HAZARDOUS BY PERSONNEL AUTHORIZED TO DO SO BY THE RESPONSIBLE PERSON ON-SITE.
	**⚠ CAUTION**
	ONLY PERMIT QUALIFIED PERSONNEL TO SERVICE THE LOAD CELL. EXERCISE CARE WHEN MAKING CHECKS, TESTS AND ADJUSTMENTS THAT MUST BE MADE WITH POWER ON. FAILING TO OBSERVE THESE PRECAUTIONS CAN RESULT IN BODILY HARM AND/OR PROPERTY DAMAGE.
	**NOTICE**
	OBSERVE PRECAUTIONS FOR HANDLING ELECTROSTATIC SENSITIVE DEVICES.

Disposal of Electrical and Electronic Equipment

	In conformance with the European Directive 2012/19/EC on Waste Electrical and Electronic Equipment (WEEE) this device may not be disposed of in domestic waste. This also applies to countries outside the EU, per their specific requirements. Please dispose of this product in accordance with local regulations at the collecting point specified for electrical and electronic equipment. If you have any questions, please contact the responsible authority or the distributor from which you purchased this device. Should this device be passed on to other parties (for private or professional use), the content of this regulation must also be related. Thank you for your contribution to environmental protection.

Table of Contents

1 Introduction

The SLP33xD-IOL includes the latest connectivity standard among the METTLER TOLEDO product portfolio and is one of the fastest single-point load cell with integrated connectivity on the market. The IO-Link communication interface enables the load cell to connect to any PLC or automation system, without using an additional electronic unit beside the IO-Link Master. The SLP33xD-IOL single-point load cell provides weight information, as well as status and condition monitoring to your automation system – rapidly and reliably.

1.1 Clarifications

1.1.1 SWP331D-IOL Weighing Sensor

The SWP331D-IOL Weighing Sensor provides vertical overload protection to the integrated SLP331D-IOL Load Cell. The sensor has an extremely robust design with 100 kg vertical overload protection to ensure mechanical safety from shipment to operation. The SWP331D-IOL Weighing Sensor covers rated capacities from 5 kg to 20 kg.

The SWP331D-IOL weighing sensor has an integrated SLP331D-IOL Load Cell, therefore, the electrical installation, the operation and the data structure is identical to the standard SLP331D-IOL Load Cell. The SWP331D-IOL Weighing Sensor overview is presented in the section 3 Overload Protection.

(a) (b)

Figure 1: Product Family: (a) SLP33xD-IOL Smart Single-Point Load Cell, (b) SWP331D-IOL Weighing Sensor.

The SLP331D-IOL Load Cell is mounted on the baseplate (1). The housing (2) is mounted on the baseplate, while the weighing pan (3) is mounted on the SLP331D-IOL.

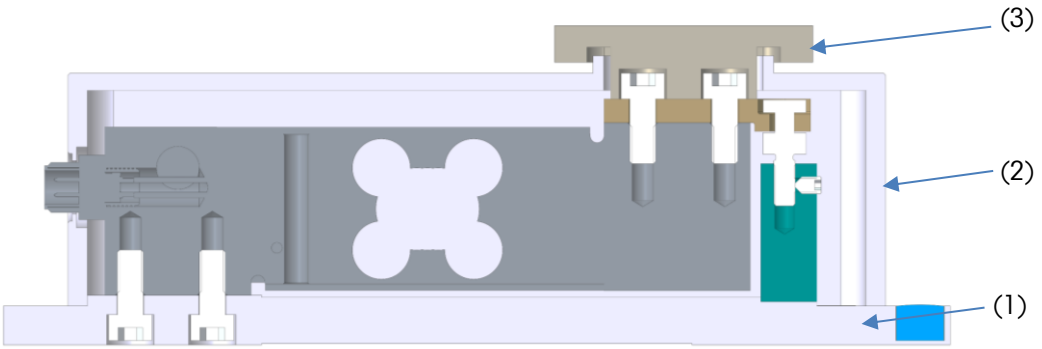


Figure 2: Cross-section view of the SWP331D-IOL Weighing Sensor displaying the integrated SLP331D-IOL Load Cell.

1.1.2 Terminology

- In this guide we use the designation "d" for the minimum measurement interval, which is technically possible, thanks to the advanced on-board digital signal processing (DSP) libraries. For the approved minimum measurement interval according to OIML R60 and Handbook 44 we use the designation ″e″. The technically possible measurement interval or resolution ″d″ is smaller than ″e″.
- In this guide we make the distinction between the terms "calibration" and ″adjustment″. ″Calibration″ is nothing else but comparing the load cell's output signal (weight value) to known reference standards (test weights) and recording the values. ″Adjustment″ implicates that the load cell's output signal (weight value) is adjusted with reference standards in order to show the same values. When the adjustment process is finished, the load cell output signal will display the same weight value of the reference standards within the repeatability error.

1.2 SLP33xD-IOL Overview

Standard SLP33xD-IOL single-point load cell features:

- Mounting holes on opposite ends and sides of the load cell to connect to a:
  - Firm base or foundation supporting the load cell.
  - Weighing pan or other weighing structure which holds the product to be weighed in place for the weighment.
- 5-pin M12 industrial connector for IO-Link connectivity, Class A.

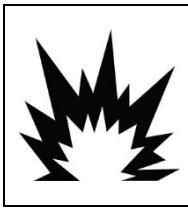
Figure 3: SLP33xD-IOL Connector and LED

- Multicolor LED indicating Smart5™ alarm levels (Green, Blue, Yellow, Orange, Red).
- Printed type plates indicating product number, serial number, country of manufacturing, metrology approval details, and other approvals and declarations.
- Factory adjustment parameters to adjust for environment temperature changes, non-linearity, hysteresis, and creep. By specifying the local acceleration due to gravity (g-value) or equivalently GEO code (METTLER TOLEDO's g-value codes) the load cell is ready to measure.

1.3 Specifications

For detailed specifications see the Datasheet the SLP33xD-IOL Product download page.

1.4 Environmental Protection



⚠ CAUTION

THE SLP33XD-IOL IS NOT INTRINSICALLY SAFE! DO NOT USE IN HAZARDOUS AREAS CLASSIFIED AS DIVISION 1, ZONE 0, ZONE 20, ZONE 1 OR ZONE 21 BECAUSE OF COMBUSTIBLE OR EXPLOSIVE ATMOSPHERES. FAILURE TO COMPLY WITH THIS WARNING COULD RESULT IN BODILY HARM AND/OR PROPERTY DAMAGE.

1.5 Inspection and Shipping Content Checklist

Verify the content and inspect the package immediately upon delivery. If the shipping container is damaged, check for internal damage and file a freight claim with the carrier if necessary. If the container is not damaged, remove the SLP33xD-IOL load cell from its package, noting how it was packed, and inspect it for damage. Do not use the cable for lifting, always lift the aluminum body. If the unit is damaged, do not apply power and contact your local METTLER TOLEDO representative. Take a picture if possible if the unit is damaged for evidentiary purposes. The packaging material has been selected for the lowest environmental impact and can be recycled.

If it is necessary to re-ship the load cell, it is best to use the original shipping box. The load cell must be packed correctly to ensure safe transportation.

Please read the safety instructions before using this device.

Additional documentation can be found online on the SLP33xD-IOL Product download page.

The shipping box includes:

- One SLP33xD-IOL load cell
- Calibration Certificate
- CE Declaration of Conformity (Europe only)
- Quick installation guide

1.6 Model Identification

The SLP33xD-IOL model number is located on the type-plate attached to the load cell along with the serial number. Figure 4 shows an example of the type-plate.

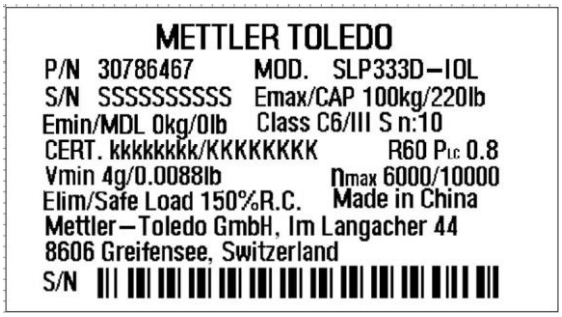


Figure 4: SLP33xD-IOL type plate example.

1.7 Dimensions, Order Information

The SLP33xD-IOL load cell is available in 3 different sizes, SLP331D, SLP332D, and SLP333D. The model family covers rated capacities from 10 kg to 500 kg. Several rated capacities are available in multiple sizes, providing high flexibility for machine builders to select the most suitable model. For dimensions and drawings please visit the SLP33xD-IOL Product download page.

Please note that the cable with M12 connector needs about 100 mm space to avoid any damage. If space in the machine is limited, cables with right angle connectors shall be used.

1.7.1 Electronic in the Load Cell

The SLP33xD-IOL single-point load cell has an onboard electronic, that performs the digital signal processing, adjusts to environmental conditions, and communicates to the automation/control system via IO-Link. Furthermore, the electronic performs all the scale functions such as zero and tare handling and adjustment to external reference weights. The weight value is transmitted to the automation/control system via an IO-Link Master unit, together with status and alarm information.

Figure 5 shows the position of the electronic board in the load cell. Although the board is covered with potting material, contact of these areas with other parts of the machine must be avoided.

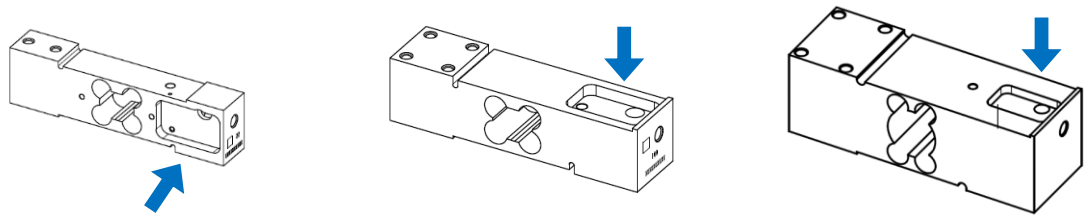


Figure 5: Position of the electronic board in the SLP331, SLP332, and SLP333D load cells-

1.7.2 Order Information

Table 1 lists the item numbers of available load cell models. Please note that each model is available in two accuracy versions, OIML C3 and C6 classes (NTEP 5000/10000).

	Item number					
	SLP331D-IOL		SLP332D-IOL		SLP333D-IOL	
Accuracy / Rated Capacity	OIML C3 / NTEP 5000	OIML C6 / NTEP 10000	OIML C3 / NTEP 5000	OIML C6 / NTEP 10000	C3 OIML / NTEP 5000	C6 OIML / NTEP 10000
10 kg / 22 lb	30801836	30786457				
20 kg / 44 lb	30801837	30786458				
30 kg / 66 lb	30801838	30786459	30801841	30786462		
50 kg / 110 lb	30801839	30786460	30801842	30786463	30801830	30786466
100 kg / 220 lb	30801840	30786461	30801843	30786464	30801831	30786467
150 kg / 330 lb					30801832	30786468
200 kg / 440 lb			30801844	30786465	30801833	30786469
300 kg / 660 lb					30801834	30786470
500 kg / 1100 lb					30801835	30786471

Table 1 : SLP33xD-IOL Sizes and Rated Capacities.

1.8 Communication

The SLP33xD-IOL single-point load cells are IO-Link sensors. IO-Link is a serial, bi-directional point-to-point connection for signal transmission and energy supply. IO-Link sensors are connected to an IO-Link Master unit (not provided by METTLER TOLEDO) which is then connected to any fieldbus or backplane bus system. IO-Link sensors can be used practically in any automation control system.

An IO-Link system consists of the following basic components:

- IO-Link master
- IO-Link device (SLP33xD Load Cell)
- 5-pin M12 Homerun cable
- Engineering tool for configuring and assigning parameters of IO-Link

Figure 6 presents an example of a system architecture with IO-Link. The IO-Link master establishes the connection between the IO-Link devices and the automation system.

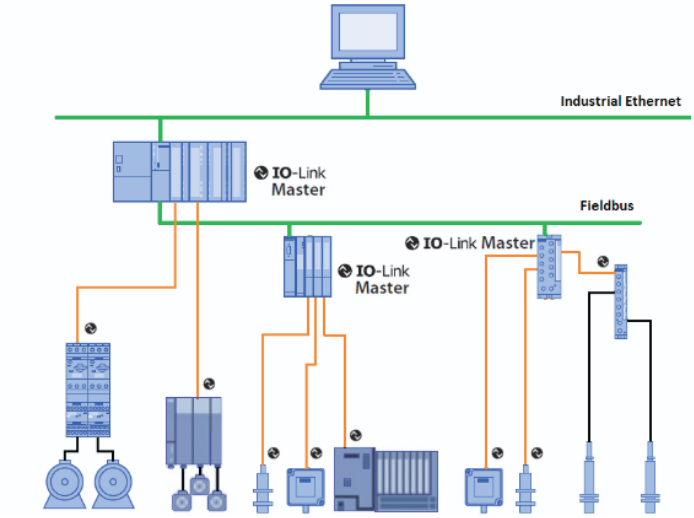
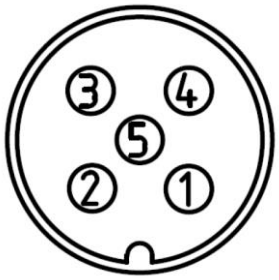


Figure 6 : Example of system architecture with IO-Link.

The SLP33xD-IOL load cells work according to IO-Link Specification V1.1. The SLP33xD-IOL load cells support the fastest, COM3 = 230.4 kbaud data transmission rate. The transmitted cyclic data is 64 bit, which results in a 200 Hz update rate. In other words, the weighing result (plus status information) is transmitted 200 times every second. For more details on data structure see Chapter 3, Operation.

The SLP33xD-IOL load cells are equipped with a 5-pin M12 connector. The load cell can be connected to any IO-Link Master port specified as Class A. Figure 7 shows the pin layout of the M12 plug.



1: L+ (typ. 24 VDC)

2: Not Used

3: L- (0 VDC), connected to the load cell body

4: C/Q (switching and communication line)

5: Not Used

Figure 7: Pin layout of the SLP33xD-IOL load cell

2 Installation

This Chapter is intended to cover the mechanical and electrical installation in a non-hazardous environment. For more information to installation in hazardous environments please refer to additional load cell documentation and details of the hazardous approvals.

2.1 General Considerations

Properly engineered and designed weighing system under consideration of all safety relevant design precautions like wind load resistance, thermal expansion etc. is assumed. Load cell installation requires mechanical and electrical skills and shall only be performed by trained and authorized personnel.

Be cautious when welding in the vicinity of the load cell. Stray current can destroy the load cell; therefore, do not pass welding current through the load cell. Whenever welding on a scale or other machine with load cells, ground the welding device as close to the work as possible. Never weld closer than 1.2 meter (4 feet) to any load cell without removing the load cell.

Regarding the strength of the foundation please consider that the surface supporting the load cell, the weighing pan or other container and the load to be weighed are strong enough to avoid deflection. Deflecting floors or supporting structures can lead to inaccuracy of the weighing result. In case of a weak foundation or deflection please reinforce the foundation and contact your engineering team to get support. To achieve increased stiffness of the weighing system support structure, e.g., attaching / enlarging / thickening stiffening braces can be a good approach.

Unleveled load cells can result in inaccurate results. To achieve high accuracy of your machines and products a general rule of thumb can be applied: horizontal leveling must be within 0.5° in any direction. This is like an upward or downward slope of 1mm (1/32inch) per 100mm (4inches).

2.2 Mechanical Installation

A load cell is the integrated sensor of a weighing system. Therefore, it needs to be ensured that there is no mechanical interference meaning that there is no other mechanical support of the load, and the load is completely carried by the load cell. As the loadcell is carrying the full load of the weighing system, it is a safety relevant part in the design.

2.2.1 Alignment

The load should be always introduced parallel to the primary loading axis to avoid errors and inaccuracy caused by misalignment, off-center or torsional moments, transverse, and lateral forces.

2.2.2 Mounting considerations

To install the SLP33xD-IOL load cells you need a rigid base plate or support structure and a rigid platter or container. Make sure the deflection of the support and the platter are uniform, and the vertical alignment deviates less than 0.5°. Mount the load cell at the mounting surfaces between the platter and the base plate. The Platter is the load receptor. Ideally the load cell's vertical center line (primary loading axis) is placed at the center of the load receptor.

Loading of the Platter and the baseplate will lead to deflections depending on the stiffness of the components.

The Platter and the Baseplate cannot touch the Load Cell outside of the mounting point as this will cause invalid measurement and performance! Use Spacers to ensure sufficient clearance!

To eliminate mechanical interference, it is recommended to either thicken and/or stiffen the Platter and the Base plate. If this is not possible it is necessary to apply spacers at the mounting points to increase the clearance to the loadcell (see Figure 8).

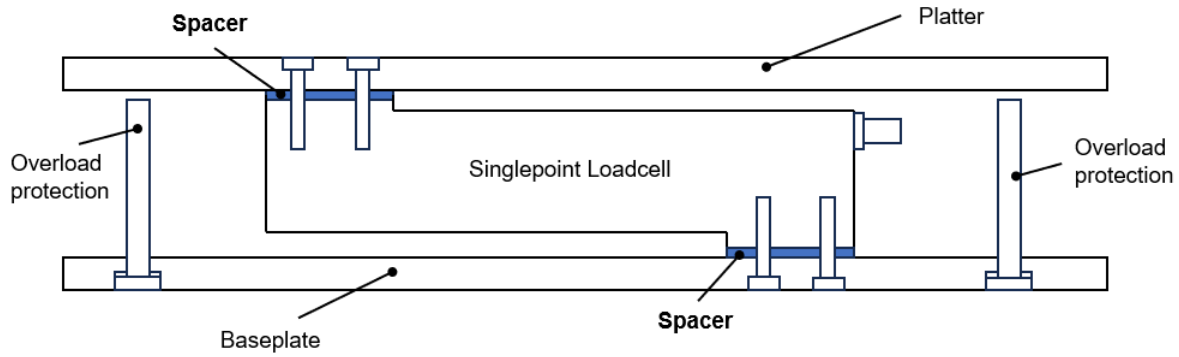


Figure 8: Mechanical installation of single point load cells with overload protection and spacers.

Overload stop protection is recommended for every machine design since the SLP33xD-IOL single-point load cells do not have mechanical overload protection. It can be realized by using threaded stems in the design, see Figure 8. Once the load cell is in place and the mounting bolts are fastened with the recommended torque values, add load up to the scale capacity to the center of the scale. Drive the threaded stem to contact the platter (or with base plate); you will see changes in the weighing measurement. (The load cell must be connected to the PLC or automation system to observe the weighing signal.) Reverse the threaded stem slightly (approx. 30° turn) and lock it with a locking nut.

Spacers must be solid and cover the entire mounting surfaces of the load cell. E.g., just using washers for spacing is not sufficient.

2.2.3 Bolt connection

The Platter and the Baseplate are mounted to the mounting surfaces using stainless steel bolts. If possible do not use countersunk screws, as they can introduce a side force on the load cell. Table 2-1 shows the mounting bolt requirements and sizes as well as the torque required to install the bolts.

	SLP331D-IOL	SLP332D-IOL	SLP333D-IOL
Rated Capacity, kg	10, 20, 30, 50, 100	30, 50, 100, 200	50, 100, 150, 200, 300, 500
Bolt material, grade	Stainless steel, 8.8 or higher		
Bolt thread size	M6		M8
Torque, nominal, Nm (ft-lb)	10 (7.5)		25 (18)

Table 2: SLP33xD-IOL Mounting Bolt and Torque Specifications.

2.2.4 Off-center Loading

SLP33xD-IOL load cells are so called single-point load cells, which means only one load cell is required to build a scale. The single-point load cells are moment insensitive by design and weigh within tolerance regardless of where the load is placed on the platter. The max. platter size in Table 3 indirectly describes the maximum offset of the center of gravity (CoG) of the product to be weighed from the load cell center line (see Figure 9 for details).

	SLP331D-IOL	SLP332D-IOL	SLP333D-IOL
Rated Capacity, kg	10, 20, 30, 50, 100	30, 50, 100, 200	50, 100, 150, 200, 300, 500
Max. platter size mm (in)	400x400 (15.7x15.7)		600x600 (23.6x23.6)

Table 3: SLP33xD-IOL Max. Platter Size Specifications.

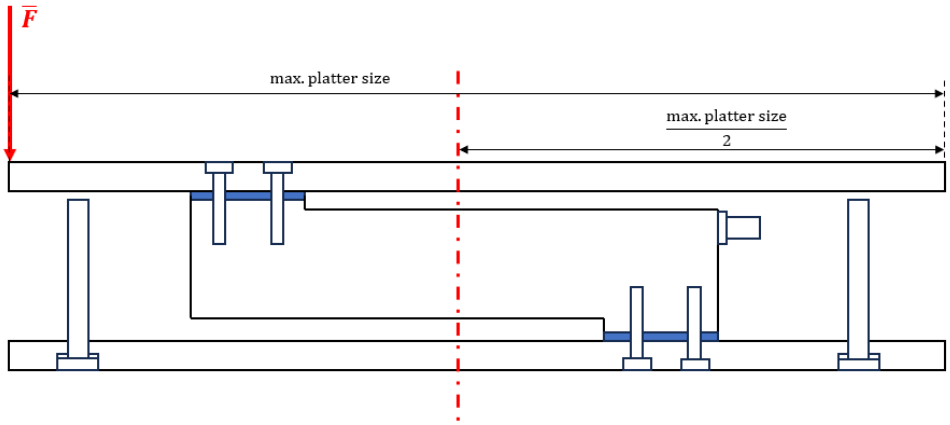


Figure 9: Load to be weighed can be placed withing max. platter size on a single-point load cell.

When designing your machine using SLP33xD-IOL load cells, consider the max. platter size. This gives you the limits for which the center of gravity of the weighing container (platter) and the product together should stay in.

Ideally, the CoG of the platter and the load to be weighed is on the axis of action of the single point load cell. This is in the middle of the load cell. However, the CoG can be anywhere within the max. platter size, it will not impact the measurement accuracy beyond the specified values in the datasheet. The red arrow on Figure 9 shows where the product and therefore the CoG can be placed. Please note that the platter (green plate) is not centered around the mounting holes, but around the center of the load cell.

2.2.5 Reverse Mode

The SLP33xD-IOL load cells can also be installed upside-down, meaning the supporting structure is above the load cell, and the weighing platter or container is hanging underneath. To activate this mode, refer to 'reverse mode' and its description in Chapter 3, Operation. Considerations regarding load introduction, leveling, overload protection, etc. are still valid in the reverse mode.

2.3 Electrical Installation

A load cell is meant to measure mass. Every mass is attracted by the earth gravimetric field, the resulting force is named "load". The load cell transforms the load into an electrical signal. Since the gravity level varies at different locations on earth, also the electrical signal from load cell varies by the location. Thus, adjustment to the location of the load cell is required, the local acceleration due to gravity (g-value) must be specified during installation.

Before said adjustment can be done, the SLP33xD-IOL load cell must be connected to an IO-Link Master unit by an electrical cable equipped with M12 5-pin connectors. Please note that the cable with M12 connector needs about 100 mm space to avoid any damage. If space in the machine is limited, cables with right angle connectors shall be used.

Figure 10: SLP33xD-IOL single-point load cells and cable with M12 connectors.

The next step is to locate and download the IO-Link Device Description file, IODD. For that visit https://ioddfinder.io-link.com/ and search for METTLER TOLEDO. Installation steps of the IODD file in various automation systems can be found on the SLP33xD-IOL Product download page.

Once the SLP33xD-IOL load cell is connected to the PLC or automation system and the IODD file is installed, the local adjustment can take place. For details of the adjustment possibilities and processes see Chapter 3, Operation. It is also possible to enter the local g-value in the SLP33xD-IOL load cell with 6 digits after the comma (9.xxxxxx m/s^2) or to specify the GEO Code. List of GEO Code values based on location information can be found in Appendix A.

The GEO code system was developed with the first electronic scales by METTLER TOLEDO to map the local acceleration due to gravity (g-value) values to an integer parameter. Values of g-factor from 9.77039 to 9.83239 m/s2 correspond to integer numbers from 0 to 31. Table 4 lists the center of each range of the g-factor and the corresponding GEO Code. Appendix A contains the GEO Code values depending on altitude, latitude, and elevation above sea level.

g-value (m/s^2)	GEO Code	g-value (m/s^2)	GEO Code
9.770390	0	9.802295	16
9.772378	1	9.804296	17
9.774367	2	9.806298	18
9,776356	3	9.808300	19
9.778347	4	9.810304	20
9.780338	5	9.812308	21
9.782330	6	9.814313	22
9.784323	7	9.816319	23
9.786316	8	9.818326	24
9.788311	9	9.820333	25
9.790306	10	9.822341	26
9.792302	11	9.824351	27
9.794299	12	9.826361	28
9.796297	13	9.828371	29
9.798295	14	9.830383	30
9.800295	15	9.832396	31

Table 4: Gravity values mapped to integer numbers (GEO Code).

The resolution or step size of the GEO Code system (the difference between two adjacent values) is approx. 0.002 m/s^2. In the SLP33xD-IOL single-point load cells a high-resolution GEO Code system is implemented. Therefore, the GEO Code values can be specified with 2 decimal places. E.g., the GEO Code can be 19.12 or 19.68. The step size of the high-resolution GEO Code system is 0.00002 m/s^2.

In case the actual g-value it is known for the place of installation it is also possible to directly enter it during the configuration of the load cell. This g-value is internally converted into the high-resolution GEO Code system. During the conversion the g-value is rounded to the nearest high-resolution GEO Code value.

2.4 Corner Load Test for Quality Check

Once the mechanical and electrical installation is finished, it is recommended to perform a corner load test. As far as the machine design allows, place a load close to scale capacity in each corner of the weighing platter, or as far as possible from the center of the load cell, but still within the specified max. platter size (see Table 3). The displayed weigh value shall be within the measurement errors specified in the datasheet.

It is also good practice to check the machine's performance on a regular basis by comparing the displayed weight values to known reference standards (test weights). Extending the regular check with corner load test can unveil potential deterioration in the mechanical installation and thus in the weighing performance.

3 Overload Protection

The SWP331D-IOL Weighing Sensor provides vertical overload protection to the integrated SLP331D-IOL Load Cell. The sensor has an extremely robust design with 100 kg vertical overload protection to ensure mechanical safety from shipment to operation. The SWP331D-IOL Weighing Sensor covers rated capacities from 5 kg to 20 kg.

3.1 SWP331D-IOL Overview

The SWP331D-IOL Weighing Sensor consist of the SLP331D-IOL Load Cell mounted on the baseplate (1). The housing (2) is mounted on the baseplate, while the weighing pan (3) is mounted on the SLP331D-IOL.

Figure 11: SWP331D-IOL Weighing Sensor.

The SWP331D-IOL Weighing Sensor features:

- The SLP331D-IOL Load Cell.
- A baseplate supporting the load cell (1), with:
  - Mounting holes for sensor integration.
- The housing (2), including the 100kg vertical (upward and downward) overload protection.
- A weighing pan (3) to holds the product to be weighed in place for the weighment, with:
  - Mounting holes to install the product or the upper mounting plate for the weighment.
- 5-pin M12 industrial connector for IO-Link connectivity, Class A.

Figure 12: SWP331D-IOL Connector and IO-Link connectivity.

- Printed type plates indicating product number, serial number, country of manufacturing, metrology approval details, and other approvals and declarations.
- Factory adjustment parameters to adjust for environment temperature changes, non-linearity, hysteresis, and creep. By specifying the local acceleration due to gravity (g-value) or equivalently GEO code (METTLER TOLEDO's g-value codes) the weighing sensor is ready to measure.
- The sensor is made of high-quality aluminum alloy, it contains less than 1% zinc and copper material to significantly reduce the risk of cross-contamination in Li-ion battery production.

3.2 Specifications

The detailed specifications of the SWP331D-IOL Weighing Sensor are available on the Datasheet on the SWP331D-IOL Product download page.

3.3 Dimensions

Regarding the screw positions for the sensor integration, the technical drawings, the 2D and 3D models of the SWP331D-IOL are available on the SWP331D-IOL Product download page.

Please note that the cable with M12 connector needs about 100 mm space to avoid any damage. If space in the machine is limited, cables with right angle connectors shall be used.

3.4 Mechanical Installation

The mechanical installation of the SWP331D-IOL Weighing Sensor is explained in the Quick Installation Guide on the SWP331D-IOL Product download page.

The single-point load cells are moment insensitive by design and weigh within tolerance regardless of where the load is placed on the platter. The max. platter size in Table 5 indirectly describes the maximum offset of the center of gravity (CoG) of the product to be weighed from the load cell center line.

When designing your machine using SWP331D-IOL load cells, consider the max. platter size. The platter dimension provides the limits for which the center of gravity of the weighing container (platter) and the product together should stay in. The section 2.2.4, including Figure 9, provides detailed information on the design platter design and the maximum offset of the center of gravity (CoG).

Parameter		Unit	SWP331D-IOL
Rated Capacity (R.C.), nominal		kg (lb)	5 (11), 10 (22), 20 (44)
Mounting screw	Material, Grade	-	Stainless Steel, A4-70 / A4-80
	Weighing pan, size/thread	mm (in)	M4
	Base plate, size/thread	mm (in)	4.5
	Torque, nominal	Nm (ft-lb)	1.5 (1.1)
Max. platter size		mm (in)	400x400 (15.7x15.7)

Table 5: SWP33xD-IOL Mounting screw, Torque and Max. Platter Size Specifications.

The platter is mounted on the weighing pan (3) with 4x M4 mounting screws. The baseplate (1) is mounted on the customer mounting plate with 4x M4 mounting screws.

4 Operation

This chapter gives an overview about the functionalities when operating an SLP33xD IO-L single point load cell in a siemens automation system. For different automation systems, e. g. Rockwell, the appearance may differ, but the content is the same.

4.1 Firmware Release Chart

The Firmware Release Chart of the SLP33xD IO-L and SWP331D IO-L products can be downloaded from SLP33xD-IOL Product download page.

4.2 Data Structure

In general, for IO-Link communication protocol, three types of data are exchanged:

- Cyclic data
  - Cyclic process data (process data inputs, output)
- Acyclic data
  - Device parameters (on-request data objects)
  - Events

The Figure 13 present the cyclic and acyclic data exchange of an IO-Link sensor.

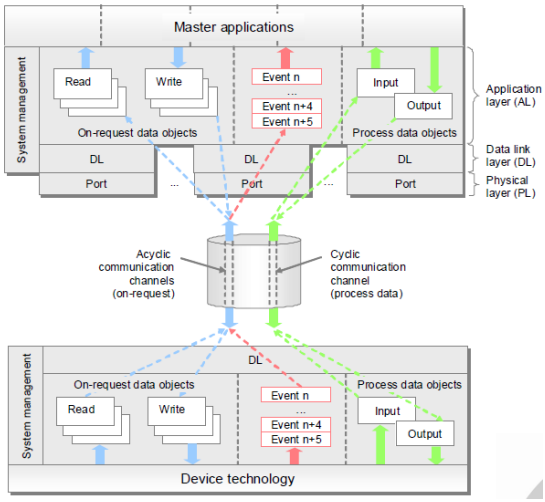


Figure 13: Cyclic and acyclic data exchange of an IO-Link sensor.

1. Process data (process data objects)
   The process data of a device are transferred cyclically in an F-sequence (data frame). The size of the process data is specified by the device. A range of 0 to 32 bytes of process data per device can be transferred (input and output, respectively). The validity of the process data is signaled by PD Valid.

2. Device parameters
   The device parameters are exchanged acyclically and when requested by the IO-Link master. The IO-Link master always sends a prompt to the device first, and then the device answers. Parameter values can be written to the device (Write) and device statuses can be read out from the device (Read) with the help of "on-request data objects", for instance during the system initialization or zeroing.

3. Events
   When an event occurs, the SLP33xD-IOL load cell signals the presence of the event to the master via the Smart5™ alarm management system by switching a bit in the cyclic data. The master then reads out the event code from the acyclic data. Error messages are transmitted from the device to the controller or the HMI via the IO-Link master. The Events codes are explained in the section 4.3.5 Events.

4.2.1 Cyclic Process Data Input structure

The cyclic process data Input structure is listed in the table below. The device description file IODD of the device contains a value for the minimum cycle time of the device. This value indicates the time intervals at which the master may address the device. For the SLP33xD-IOL, the fixed cycle frequency is 200 Hz.

The measured weight value is transmitted in the first four Octets (Octet 0 – 3) as a 32-bit floating-point number. Octets 4, 5, 6 and 7 contain status information about the measured weight value and about the load cell itself. Reserved bits are not used for data transmission.

Process data input	Index 40	Subindex 0	RecordT (64 Bit)
Weight Value		Octet 0 - 3	Float32T (32 Bit)
Device status 1		Octet 4	UIntegerT (8 Bit)
Net Mode			BooleanT (1 Bit)
Motion			BooleanT (1 Bit)
Center of zero			BooleanT (1 Bit)
Smart5 Level5 Alarm			BooleanT (1 Bit)
Data OK			BooleanT (1 Bit)
Heartbeat			BooleanT (1 Bit)
Reserved			BooleanT (1 Bit)
Reserved			BooleanT (1 Bit)
Device status 2		Octet 5	UIntegerT (8 Bit)
Reserved			BooleanT (1 Bit)
Last Adjustment Status			BooleanT (1 Bit)
Factory adjustment active			BooleanT (1 Bit)
Smart5 Level2 Alarm			BooleanT (1 Bit)
Smart5 Level3 Alarm			BooleanT (1 Bit)
Smart5 Level4 Alarm			BooleanT (1 Bit)
Reserved			BooleanT (1 Bit)
Reserved			BooleanT (1 Bit)
Device status 3		Octet 6	UIntegerT (8 Bit)
Process Type			UIntegerT (3 Bit)
New weight update			BooleanT (1 Bit)
Process Status			UIntegerT (4 Bit)
Weight Information		Octet 7	UIntegerT (8 Bit)
Weight Type			UIntegerT (4 Bit)
Weight Unit			UIntegerT (4 Bit)

Figure 14: Process Data Input structure.

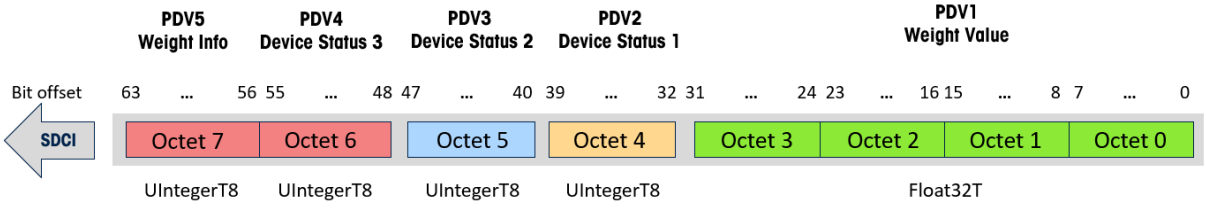


Figure 15 : Schematic representation of Process Data Input structure.

SDCI : "Single-drop digital communication interface for small sensors and actuators", it designates the IO-Link communication protocol in the IEC 61131-9 standard.

Octet 4

- Net Mode: The SLP33xD-IOL load cell can deliver gross or net Weight Value.
    - False (0): Gross weight value is transmitted.
    - True (1): Net weight value is transmitted.
- Motion: It provides information about the changes in weight value.
    - False (0): no motion, the weight value is stable.
    - True (1): the weight value is changing, unstable.
- Center of zero:
    - False (0): Current weight value is not within ±1/2d of zero.
    - True (1): Current weight value is within ±1/2d of zero.
- Smart5 Level5 Alarm: If a Level5 (Red) Alarm is active, this bit changes to True (1).
    - False (0): no active Level5 Alarm.
    - True (1): Level5 Alarm active.
- Data OK: The load cell delivers valid weighing data, which means the Digital Signal Processing unit is working.
    - False (0): Current weight value is unavailable for user.
    - True (1): Current weight value is available for user.
- Heartbeat: The bit changes from 0 to 1 and from 1 to 0 in every second. It indicates that the load cell is working and transmitting data. This bit can be used during troubleshooting or can be monitored constantly by the control system to ensure the load cell is working.

Octet 5 contains factory adjustment information. Once the customer does the adjustment, an indication bit will be set. Once this bit is set, the load cell is no longer valid for legal for trade application. It can only be reset by Mettler Toledo authorized service personnel. Octet 5 also contains the Smart5 status information. If a Smart5 alarm is raised, the respective bit flips to True (1) in Octet 5.

- Last Adjustment Status.
    - False (0): The last adjustment has failed.
    - True (1): The last adjustment is successful.
- Factory adjustment active.
    - False (0): load cell is no longer valid for legal-for-trade.
    - True(1): factory calibration is active -> ok for legal-for-trade applications.
- Smart5 Level4 Alarm:
    - False (0): No Level4 alarm active.
    - True (1): Level4 alarm active.
- Smart5 Level3 Alarm:

- False (0): No Level3 alarm active.
- True (1): Level3 alarm active.

- Smart5 Level2 Alarm:
  - False (0): No Level2 alarm active.
  - True (1): Level2 alarm active.

Octet 6

- Process Type, 3 bits:
  - None (0): Normal mode, no zero/tare/adjustment operation.
  - Zero (1): Zeroing is in process.
  - Tare (2): Taring is in process.
  - Adjustment (3): Adjustment is in process.
  - Parameter Setting (4): Set parameters values (e.g. change unit).
- New weight update, 1 bit:
  - Reserved.
- Process Status, 4 bits: Information on the Process status (e.g. Adjustement, Tare, Zero).
  - Successful (0): The process is finished and successful.
  - In progress (1): The process is ongoing.
  - User action required (2): User needs to place weight on the load cell.
  - Failed (3): The process is failed.
  - Aborted (4): The process is aborted by user.
  - Timeout (5): The process is timeout.
  - Function not supported (6): The input is not supported (e.g. Unsupported command value).
  - Out of range (7): Parameter value is out of range.

Octet 7

- Weight Type, 4 bits: It provides information about the type of the weight value.
  - Gross weight (0): Gross weight value is transmitted (Default).
  - Tare weight (1): Tare weight value is transmitted.
  - Net value (2): Net weight value is transmitted.

- Weight Unit, 4 bit: It provides information about the unit of the weight value.
    - g (0): The unit of the weight value is gram.
    - kg (1): The unit of the weight value is kilogram.
    - mg (3): The unit of the weight value is milligram.
    - lb (7): The unit of the weight value is pound.

4.2.2 Cyclic Process Data Output structure

The cyclic process data Output structure is listed in the table below. The device description file IODD of the device contains a value for the minimum cycle time of the device. This value indicates the time intervals at which the master may address the device. For the SLP33xD-IOL, the fixed cycle frequency is 200 Hz.

The argument value is transmitted in the first four Octets (Octet 0 – 3) as a 32-bit floating-point number. An argument is a value passed to a function or subroutine to customize its behavior. Octets 4 and 5 contain channel mask information, the 16 bits are reserved. Reserved bits are not used for data transmission. Octets 6 and 7 contain command values. The commands correspond to data type that can be Write Only (WO) and triggered by a button. The value of the system commands (e.g. 160) corresponds to the Subindex value, the Index (DEC) value is 2.

Process data ouput			**RecordT (64 Bit)**
Command Value		Octet 0 - 3	Float32T (32 Bit)
Channel Mask		Octet 4 - 5	UIntegerT (16 Bit)
Reserved		Bit 0 - 15	BooleanT (1 Bit)
Description	Command	Octet 6 - 7	IntegerT (16 Bit)
Report Rounded Gross Weight (Default)	0		IntegerT (16 Bit)
Report Rounded Tare Weight	1		IntegerT (16 Bit)
Report Rounded Net Weight	2		IntegerT (16 Bit)
Write Tare Register (Preset Tare)	201		IntegerT (16 Bit)
Tare Stable	400		IntegerT (16 Bit)
Clear Tare	402		IntegerT (16 Bit)
Tare Immediately	403		IntegerT (16 Bit)
Zero Stable	401		IntegerT (16 Bit)
Zero Immediately	404		IntegerT (16 Bit)
Change Unit	700		IntegerT (16 Bit)
Change weighing environment	291		IntegerT (16 Bit)
One-Click adjustment	297		IntegerT (16 Bit)
Cancel operation	2004		IntegerT (16 Bit)

Figure 16: Process Data Output structure.

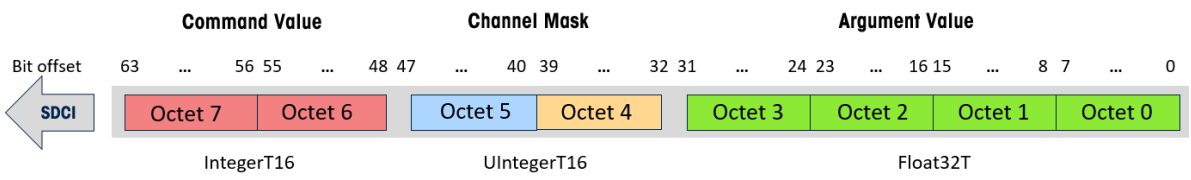


Figure 17: Schematic representation of Process Data Output structure.

Octet 6

- Report Rounded Gross Weight (Default): Command value (0), 16 Bit:
    - Rounded gross weight value is transmitted (Default).
- Report Rounded Tare Weight: Command value (1), 16 Bit:
    - Rounded tare weight value is transmitted.
- Report Rounded Net Weight: Command value (2), 16 Bit:
    - Rounded net weight value is transmitted.
- Write Tare Register (Preset Tare): Command value (201), 16 Bit, requires an argument value:
    - Enter the known weight value to be assigned as Preset Tare weight.
- Tare Stable: Command value (400), 16 Bit:
    - Tare weight value is transmitted as soon as the weight value is stable.
- Clear Tare: Command value (402), 16 Bit:
    - Set back the weight value to Gross Weight.
- Tare Immediately: Command value (403), 16 Bit:
    - Tare weight value is immediately transmitted.
- Zero Stable: Command value (401), 16 Bit:
    - Set the weight value to zero and transmitted as soon as the weight value is stable.
- Zero Immediately: Command value (404), 16 Bit:
    - Set the weight value to zero and immediately transmitted.
- Change Unit: Command value (700), 16 Bit, requires an argument value:
    - g (0): The unit of the weight value is gram.
    - kg (1): The unit of the weight value is kilogram.
    - mg (3): The unit of the weight value is milligram.
    - lb (7): The unit of the weight value is pound.
- Change weighing environment: Command value (291), 16 Bit, requires an argument value:
    - 0: Very stable
    - 1: Stable
    - 2: Standard
    - 3: Unstable
    - 4: Very unstable

- One-Click adjustment: Command value (297), 16 Bit, requires an argument value:
    - Input the gross weight applied on Load Cell for the adjustment.
- Cancel operation: Command value (2004), 16 Bit:
    - The operation is aborted.

4.2.3 Acyclic data

All information that are not included in the 64 Bits of cyclic process data input are acyclic data, exchanged when requested by the automation control system via the IO-Link master.

The reading and writing of acyclic data enable the automation control system to write the device parameter to the SLP33xD-IOL load cell or read parameters, measured values, diagnostics and events data of SLP33xD-IOL load cell.

The automation control system requires function blocks that enables to communicates with the IO-Link master to perform the following tasks:

- (Re)configuration of an IO-Link device
- Diagnostics and Events of an IO-Link device
- Executing of IO-Link port functions
- Saving / recovering of IO-Link device parameter

The data on an IO-Link load cell are exchanged using a specified index and sub-index range. The values for index and sub-index as well as the structure of the data record for SLP33xD-IOL load cell can be found in the description of the IODD file.

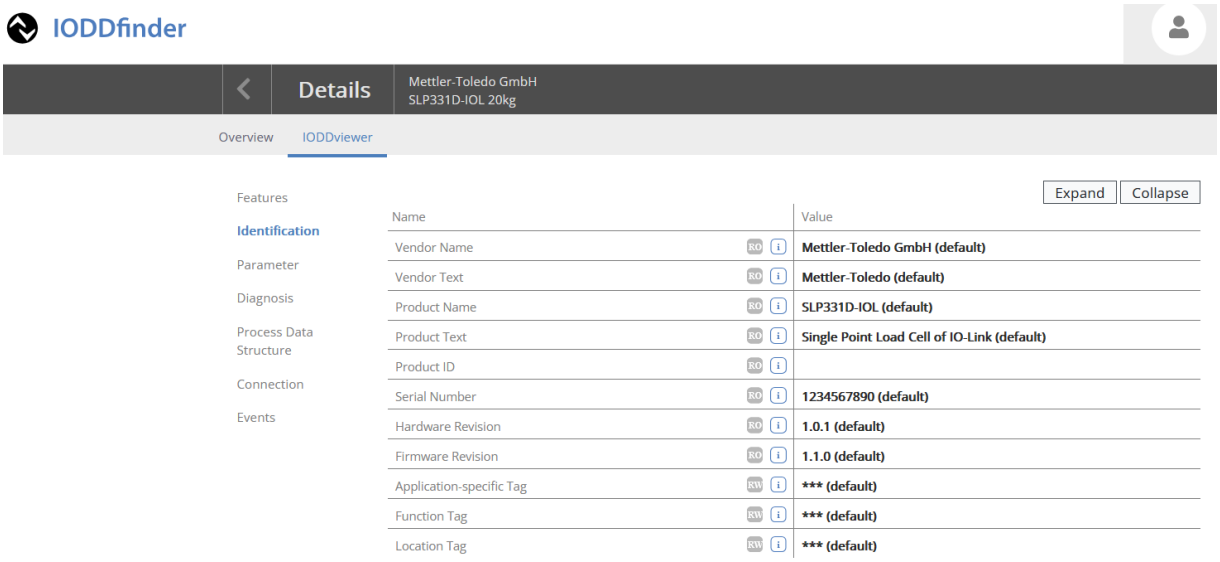
4.3 IODD Explanation

To operate IO-Link sensors, an electronic device description, the IODD file, needs to be imported to the control system. This file contains information about the device's identity, parameters, process data, diagnosis data, communication properties and the structure of the user interface.

The link to the IODD file of the SLP33xD Load Cell can be found on the SLP33xD Product download page.

The IODDfinder website is a service of the IO-link community. It is a centralized, multi-vendor database for description files (IODDs). In addition, this platform shows an overview of all IO-link devices. Detailed information on the device functions and value ranges are described in the following subsections.

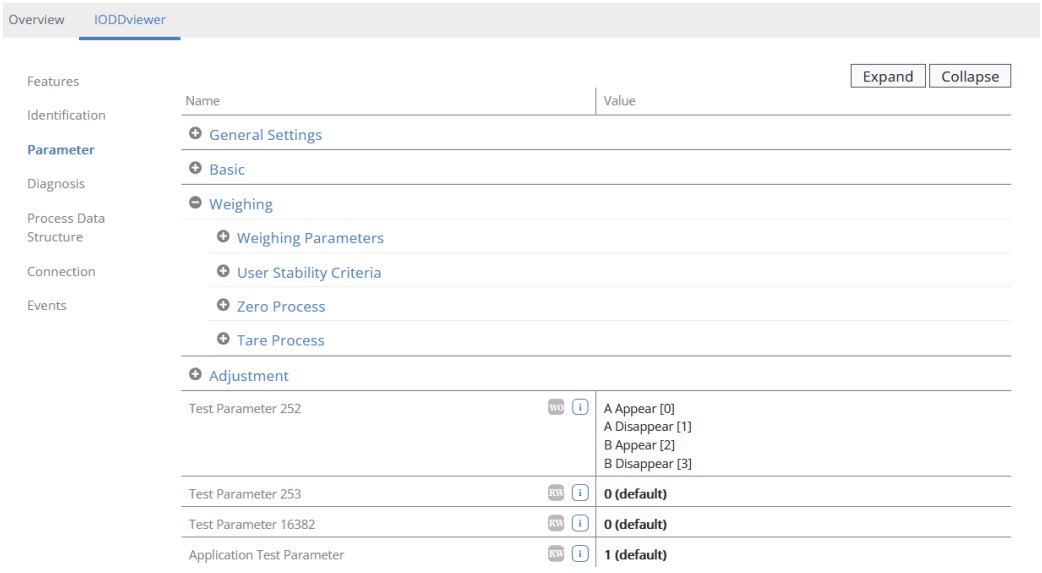
4.3.1 Identification



Parameter	Index	Subindex	Data Type	RW
Vendor name	Index 16	Subindex 0	StringT (19 Byte)	RO
Factory setting	Mettler-Toledo GmbH			
Vendor text	Index 17	Subindex 0	StringT (14 Byte)	RO
Factory setting	Mettler-Toledo			
Product Name	Index 18	Subindex 0	StringT (11 Byte)	RO
	SLP33xD-IOL			
Product Text	Index 20	Subindex 0	StringT (33 Byte)	RO
Factory setting	Single Point Load Cell of IO-Link			
Product ID	Index 19	Subindex 0	StringT (3 Byte)	RO
	331, 332, or 333, depending on the model			
Serial Number	Index 21	Subindex 0	StringT (10 Byte)	RO
	xxxxxxxx			
Hardware Version	Index 22	Subindex 0	StringT (5 Byte)	RO
	x.x.x			
Firmware Version	Index 23	Subindex 0	StringT (5 Byte)	RO
	x.x.x			
Application Specific Tag	Index 24	Subindex 0	StringT (32 Byte)	RW
Factory setting	***			
Function Tag	Index 25	Subindex 0	StringT (32 Byte)	RW
Factory setting	***			
Location Tag	Index 26	Subindex 0	StringT (32 Byte)	RW
Factory setting	***			

Table 6: SLP33xD-IOL vendor and device identification variables.

4.3.2 Parameters

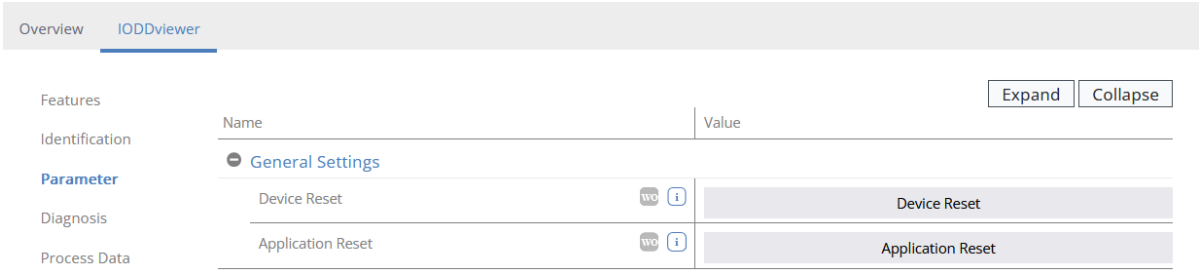


These fields are only used by METTLER TOLEDO for internal testing purposes during production.

Parameter	Index	Subindex	Data Type	RW
Test Parameter 252	Index 16	Subindex 0	UIntegerT (8 Bit)	WO
Value Range	0 = A Appear 1 = A Disappear 2 = B Appear 3 = B Disappear			
Test Parameter 253	Index 17	Subindex 0	UIntegerT (8 Bit)	RW
Factory setting	0			
Test Parameter 16382	Index 18	Subindex 0	UIntegerT (32 Bit)	RW
Factory setting	0			
Application Test Parameter	Index 20	Subindex 0	UIntegerT (32 Bit)	RW
Factory setting	1			

Table 7: SLP33xD-IOL internal test parameters.

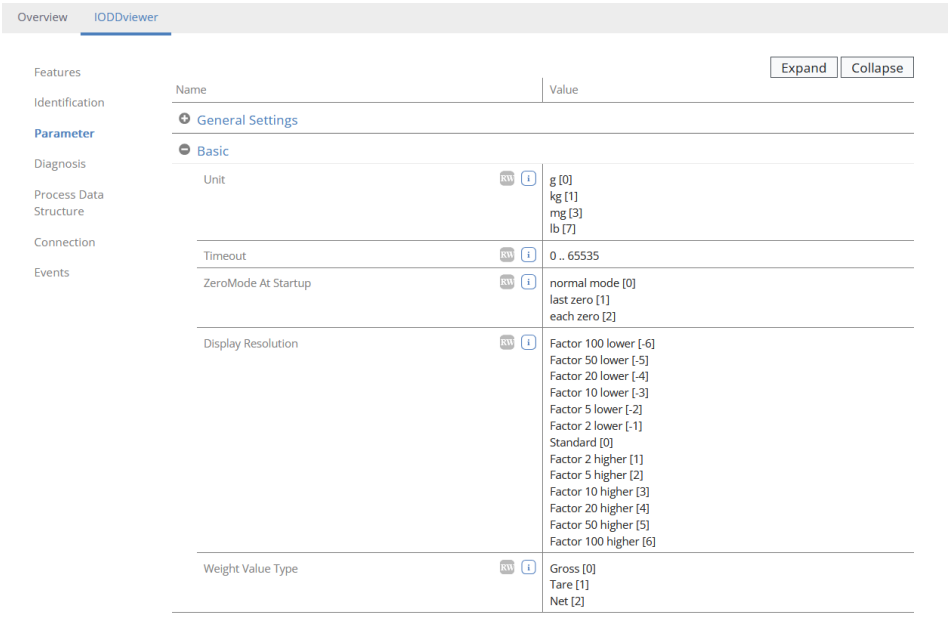
4.3.2.1 General Setting



System Commands	Text	Description
128	Device Reset	Reset the load cell
129	Application Reset	Reset the application

Table 8: SLP33xD-IOL reset command.

4.3.2.2 Basic



Parameter	Index	Subindex	Data Type	RW
Unit	Index 545	Subindex 0	UIntegerT (8 Bit)	RW
Weight value type within the Process Data Input (Defined in 3.1). The default value is 1 (kg).				
Value range	0 **1** 3 7	g **kg** mg lb		
Zero Mode at Startup	Index 565	Subindex 0	UIntegerT (32 Bit)	RW
In normal mode 0, the device specifies a new zero reference point at startup as soon as a stable condition has been achieved. In mode 2, the device will use the saved zero value. The default value is 0 (Normal mode). In mode 3, the device uses the zero measure in production when there is no load on the load cell.				
Value range	**0** 2 3	**Normal mode** Start with saved zero Start with production zero		
Display Resolution*	Index 784	Subindex 0	IntegerT (8 Bit)	RW
This parameter increases/decreases the weight value resolution up to factor 100. The default value is 0(Standard).				
Value range	-6 -5 -4 -3 -2 -1 **0** 1 2 3 4 5 6	Factor 100 lower Factor 50 lower Factor 20 lower Factor 10 lower Factor 5 lower Factor 2 lower **Standard** Factor 2 higher Factor 5 higher Factor 10 higher Factor 20 higher Factor 50 higher Factor 100 higher		
Weight Value Type	Index 258	Subindex 0	UIntegerT (16 Bit)	RW
Weight value type within the Process Data Input (Defined in 3.1). The default value is 0 (Gross weight).				
Value range	**0** 1 2	**Gross weight** Tare weight Net weight		

Table 9: SLP33xD-IOL basic parameters.

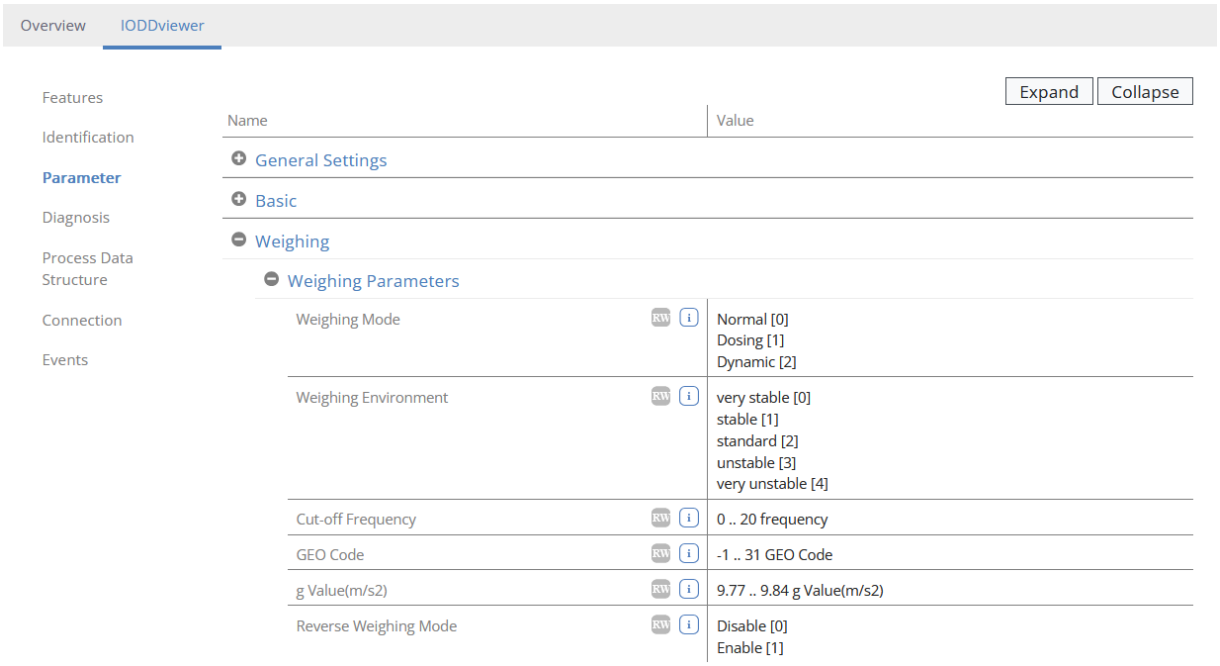
* Clarification on Display Resolution:

Type	SLP331D						SLP332D				SLP333D					
Capacity (Unit: kg)	5	10	20	30	50	100	30	50	100	200	50	100	150	200	300	500
Resolution (C3) (Unit: g)	0.05	0.1	0.2	0.2	0.5	1	0.2	0.5	1	2	0.5	1	1	2	2	5
Resolution (C6) (Unit: g)	0.01	0.02	0.05	0.1	0.1	0.2	0.1	0.1	0.2	0.5	0.1	0.2	0.5	0.5	1	1

Table 10 : Definition of display resolution for SLP33xD-IOL.

4.3.2.3 Weighing

4.3.2.3.1 Weighing Parameters

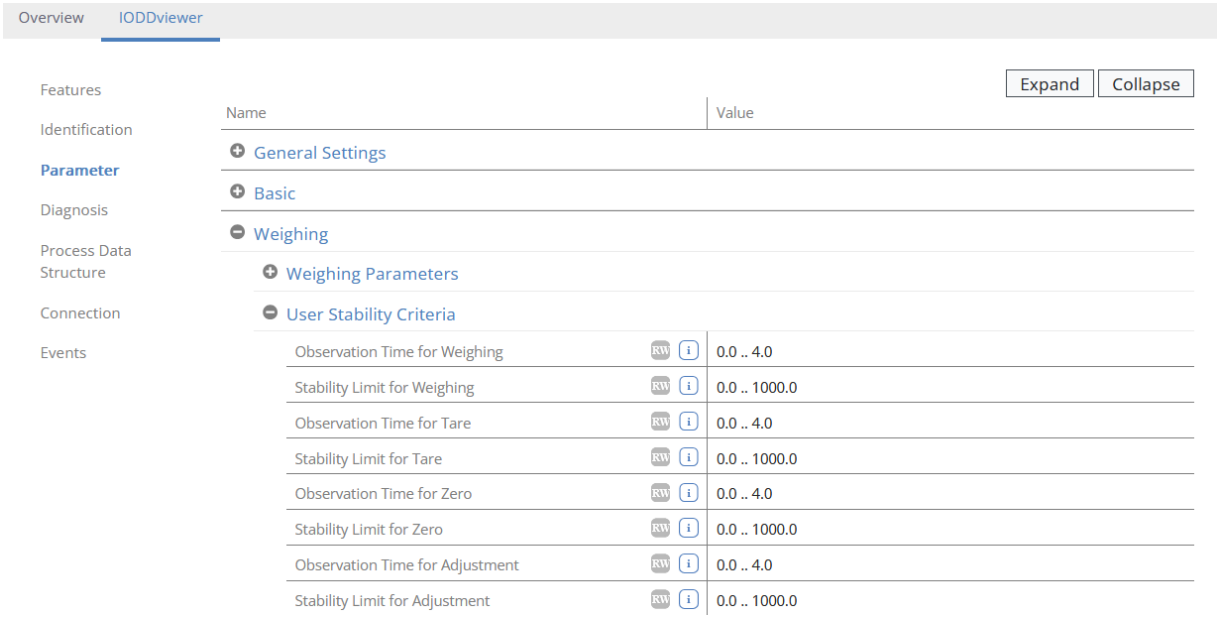


Parameter	Index	Subindex	Data Type	RW
Weighing Mode	Index 513	Subindex 0	UIntegerT (8 Bit)	RW
Gets or sets the current weighing mode setting. The default value is 0 (Normal weighing).				
Value range	**0** 1 2	**Normal weighing** Filling/Dosing, Reserved Dynamic weighing		
Weighing Environment	Index 514	Subindex 0	UIntegerT (8 Bit)	RW
Current environment condition setting. The more unstable the environment, the greater the filtering strength. The default value is 2 (Standard).				
Value range	0 1 **2** 3 4	Very stable environment Stable environment **Standard environment** Unstable environment Very unstable environment		
Cut-off Frequency	Index 1025	Subindex 0	Float32T (32 Bit)	RW
Set the cut-off frequency of the fixed filter. The unit is Hertz (Hz). This parameter will only be activated when the weighting mode is set to 2. The default value is 0 (Disabled).				
Value range	**0** 0.001 ~ 20.0	**Disabled** Cut off frequency		
GEO Code	Index 256	Subindex 0	IntegerT (8 Bit)	RW
GEO code. The default value is 12.				
Value range	-1 0 ~ 31	Disabled GEO Code		
g Value (m/s2)	Index 256	Subindex 0	Float32T (32 Bit)	RW
Local high-precision gravity acceleration value. Users configure either GEO code or g Value. The default value is 9.794299.				
Value range	9.770390 ~ 9.832396			

Reverse Weighing Mode	Index 1028	Subindex 0	UIntegerT (8 Bit)	RW
This parameter is used to set the weighing system to the reverse weighing mode, e.g., when the load cell is mounted on an overhead structure. This weighing mode is specially designed for the vertical compression type digital load cell which is used by the customer as a tension type load cell. The default value is 0 (Disabled).				
Value range	**0** 1	**Disabled** Enabled		

Table 11: SLP33xD-IOL weighing parameters.

4.3.2.3.2 User Stability Criteria

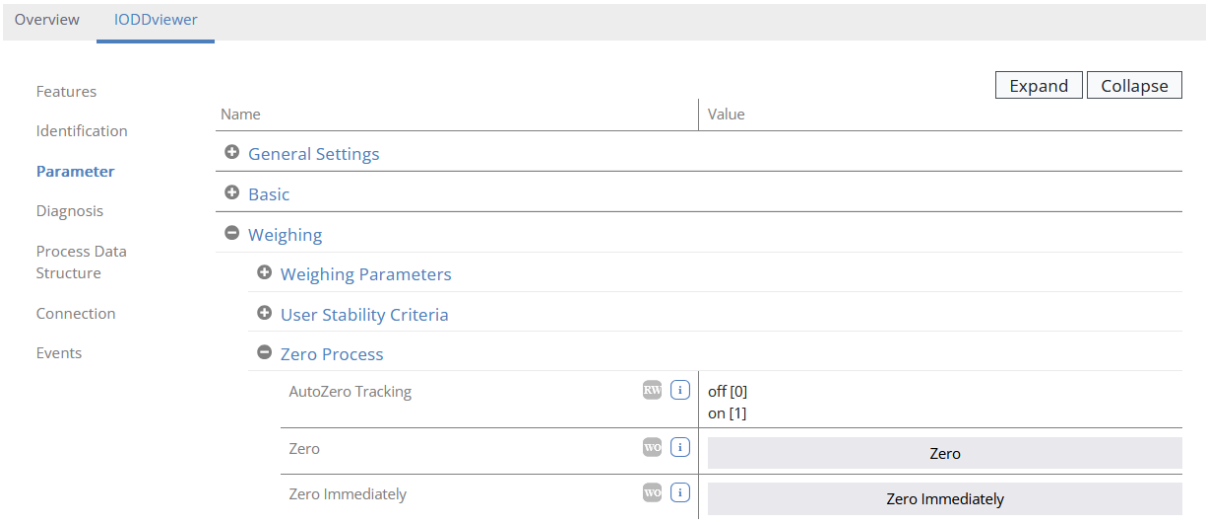


Parameter	Index	Subindex	Data Type	RW
Observation Time for Weighing	Index 1029	Subindex 0	Float32T (32 Bit)	RW
It is used to modify the current user-defined weighing stability judgment condition - measurement time, in seconds (s)				
Value range	0.0 – 4.0	seconds		
Stability Limit for Weighing	Index 1030	Subindex 0	Float32T (32 Bit)	RW
It is used to modify the current user-defined weighing stability judgment condition - Allowable deviation, unit: display resolution value (d, that is, the minimum division value displayed)				
Value range	0.0 – 1000.0	d		
Observation Time for Tare	Index 1031	Subindex 0	Float32T (32 Bit)	RW
It is used to modify the current user-defined tare stability judgment condition - measurement time, in seconds.				
Value range	0.0 – 4.0	seconds		
Stability Limit for Tare	Index 1032	Subindex 0	Float32T (32 Bit)	RW
It is used to modify the current user-defined tare stability judgment condition - Allowable deviation, unit: display resolution value (d, that is, the minimum division value displayed)				
Value range	0.0 – 1000.0	d		
Observation Time for Zero	Index 1033	Subindex 0	Float32T (32 Bit)	RW
It is used to modify the current user-defined zero stability judgment condition - measurement time, in seconds				

Value range	0.0 – 4.0	seconds		
Stability Limit for Zero	Index 1034	Subindex 0	Float32T (32 Bit)	RW
It is used to modify the current user-defined zero stability judgment condition - Allowable deviation, unit: display resolution value (d, that is, the minimum division value displayed)				
Value range	0.0 – 1000.0	d		
Observation Time for Adjustment	Index 1035	Subindex 0	Float32T (32 Bit)	RW
It is used to modify the current user-defined adjustment stability judgment condition - measurement time, in seconds				
Value range	0.0 – 4.0	seconds		
Stability Limit for Adjustment	Index 1036	Subindex 0	Float32T (32 Bit)	RW
It is used to modify the current user-defined adjustment stability judgment condition - Allowable deviation, unit: display resolution value (d, that is, the minimum division value displayed)				
Value range	0.0 – 1000.0	d		

Table 12: SLP33xD-IOL user stability criteria.

4.3.2.3.3 Zeroing Process

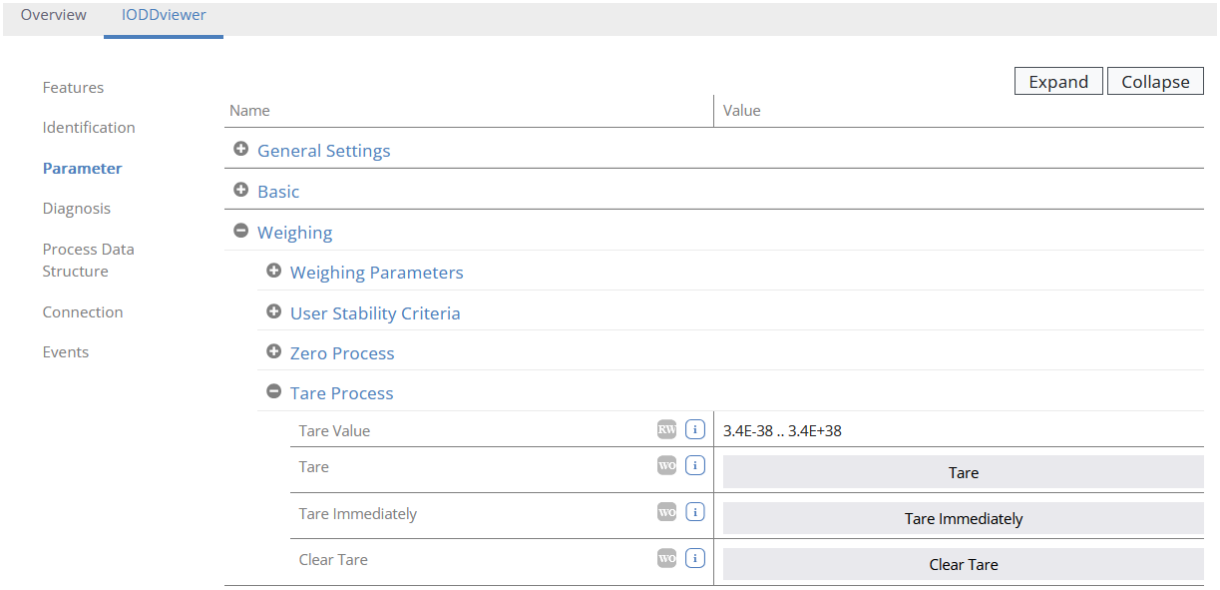


Parameter	Index	Subindex	Data Type	RW
AutoZero Tracking	Index 515	Subindex 0	UIntegerT (8 Bit)	RW
Setting of automatic zero tracking function.				
Value range	**0** 1	**Disabled** Enabled		

System Commands	Text	Description
160	Zero	Sets a new zero with the stable weight value.
161	Zero Immediately	Sets a new zero immediately, regardless of device stability

Table 13: SLP33xD-IOL zeroing process commands.

4.3.2.3.4 Tare Process

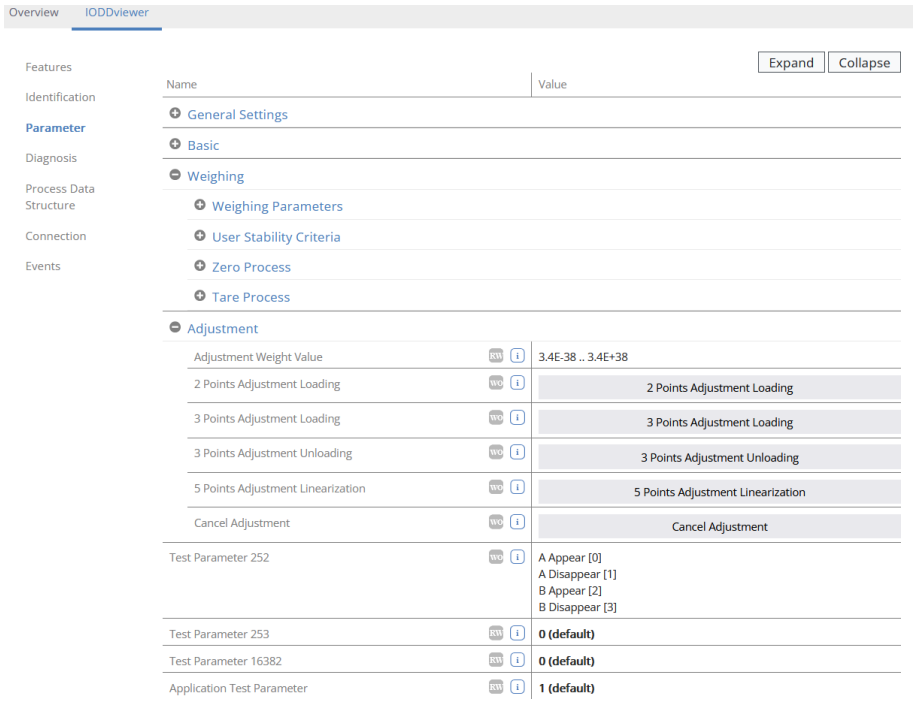


Parameter	Index	Subindex	Data Type	RW
Tare Value	Index 1280	Subindex 0	Float32T (32 Bit)	RW
Read current tare value, write preset tare value in kg. The Rated Capacity depends on the actual load cell model. Rated Capacity can be as high as 500 kg for SLP333D-IOL.				
Value range	0.0 to Rated Capacity			

System Commands	Text	Description
162	Tare	Sets a new tare value with the next stable weight value
163	Tare Immediately	Tare the device immediately and independently of device stability.
164	Clear Tare	Clear the tare value

Table 14: SLP33xD-IOL tare Process.

4.3.2.4 Adjustment



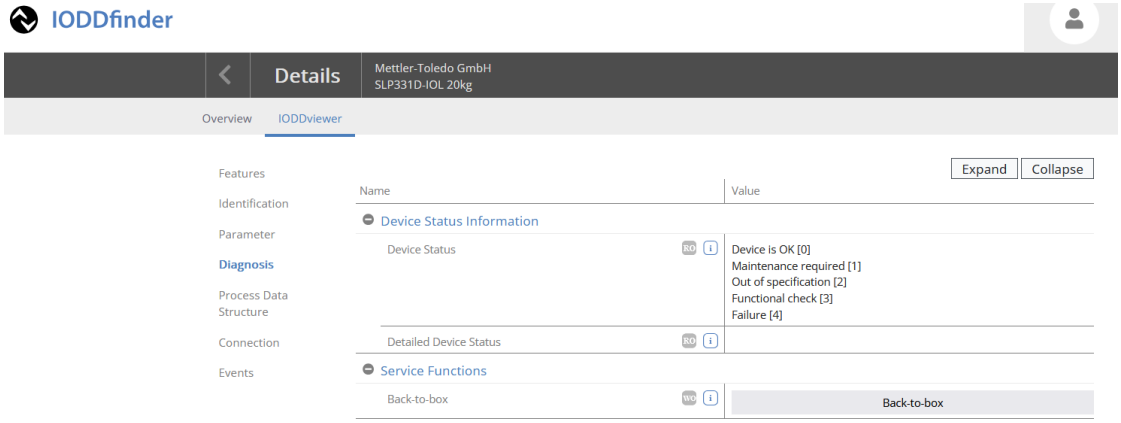
Parameter	Index	Subindex	Data Type	RW
Adjustment weight value	Index 537	Subindex 0	Float32T (32 Bit)	RW
Adjustment weight value in the unit set by user (g, kg, etc.).				
Value range	Values are accepted between 1% of Rated Capacity and 100% Rated Capacity, in the unit set by user, e.g., g or kg. E.g., a 10 kg load cell can be adjusted with reference weights between 0.1 kg and 10 kg. Values below 1% of Rated Capacity are not accepted for adjustment.			
Load weight for one-click Adjustment	Index 1037	Subindex 0	Float32T (32 Bit)	RW
Load weight value in kg.				
Value range				
Display weight for one-click Adjustment	Index 1038	Subindex 0	Float32T (32 Bit)	RW
Display weight value in kg.				
Value range				

System Commands	Text	Description
176	2 Points Adjustment Loading	
177	3 Points Adjustment Loading	
178	3 Points Adjustment Unloading	
179	Cancel Adjustment Process	
180	5 Points Adjustment Linearization, loading and unloading	

Table 15: SLP33xD-IOL adjustment process.

4.3.3 Diagnostics

4.3.3.1 Device Status Information



Parameter	Index	Subindex	Data Type	RW
Device Status	Index 36	Subindex 0	Float32T (32 Bit)	RO
Indicator for the current device condition and diagnosis state				
Value range	**0** 1 2 3 4 5 to 255	**Device is OK** Maintenance required Out of specification Functional check required Failure, load cell must be replaced Reserved		
Detailed Device Status	Index 37	Subindex 1	Float32T (32 Bit)	RO
List of all currently pending events in the device.				
Detailed Device Status	Index 37	Subindex 2	Float32T (32 Bit)	RO
List of all currently pending events in the device.				
Detailed Device Status	Index 37	Subindex 3	Float32T (32 Bit)	RO
List of all currently pending events in the device.				
Detailed Device Status	Index 37	Subindex 4	Float32T (32 Bit)	RO
List of all currently pending events in the device.				

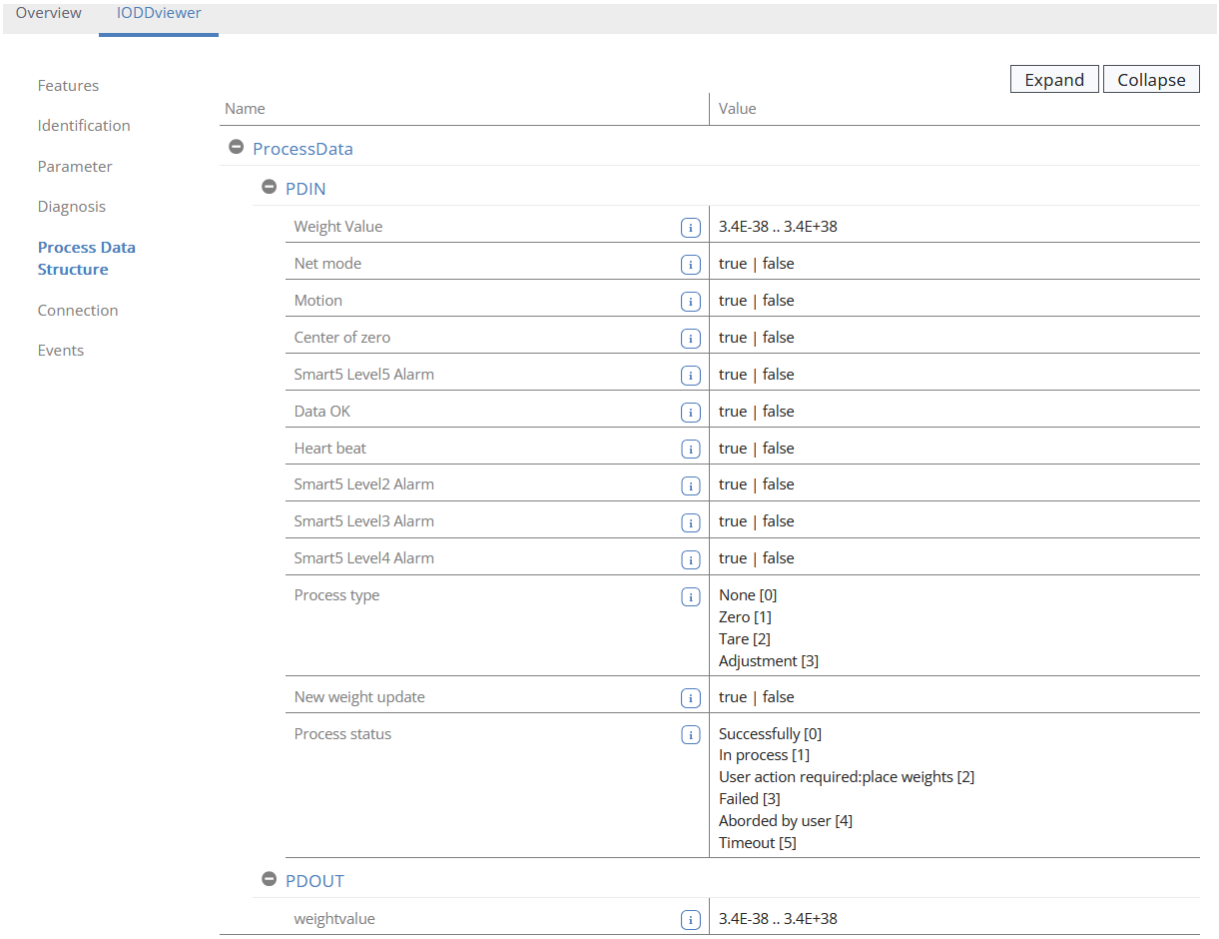
Table 16: SLP33xD-IOL device status information.

4.3.3.2 Service Functions

System Commands	Text	Description
131	Back-to-box	Set all parameters to factory default values. Factory reset

Table 17: SLP33xD-IOL service functions commands.

4.3.4 Process Data Input for IO-Link Master unit



4.3.4.1 Process Data Input (PDIN)

Parameter	Index	Subindex	Data Type	RW
Weight value	Index 40	Subindex 1	Float32T (32 Bit)	RO
Weight value in kg, 32-bit floating point				
Net mode	Index 40	Subindex 2	BooleanT (1 Bit)	RO
Value range	0 1	The displayed weight value is gross weight The displayed weight value is net weight		
Motion	Index 40	Subindex 3	BooleanT (1 Bit)	RO
Value range	0 1	Current weight value is stable Current weight value is unstable		
Center of zero	Index 40	Subindex 4	BooleanT (1 Bit)	RO
Value range	0 1	Current weight value is not within ±1/2d of zero Current weight value is within ±1/2d of zero		
Data OK	Index 40	Subindex 6	BooleanT (1 Bit)	RO
Value range	0 1	Current weight value is unavailable for user Current weight value is available for user		

Heartbeat	Index 40	Subindex 7	BooleanT (1 Bit)	RO
Value range	0 - 1	Switches every second from 0 to 1 and back from 1 to 0		
Process type	Index 40	Subindex 11	UintegerT (3 Bit)	RO
Value range	0 1 2 3	None Zero Tare Adjustment		
Process status	Index 40	Subindex 13	UintegerT (4 Bit)	RO
Value range	0 1 2 3 4 5	Successfully In progress User action required: place weight Failed Aborted by user Timeout		

Table 18: SLP33xD-IOL Process Data Input.

4.3.4.2 Process Data Output (PDOUT)

Commands	Text	Argument Value (Y/N)	Parameter value
0	Report Rounded Gross Weight (Default)	N	
1	Report Rounded Tare Weight	N	
2	Report Rounded Net Weight	N	
201	Write Tare Register (Preset Tare)	Y	Preset tare value
291	Change weighing environment	Y	0: Very stable 1: Stable 2: Standard 3: Unstable 4: Very unstable
297	One-Click adjustment	Y	Load weight value
400	Tare with Motion limit	N	
401	Zero with Motion limit	N	
402	Clear Tare	N	
403	Tare Immediate	N	
404	Zero Immediate	N	
700	Change Unit	Y	0: g 1: kg 3: mg 7: lb
2004	Cancel operation	N	

Table 19: SLP33xD-IOL Process Data Output.

4.3.5 Events

Code	Name	Description
0x8000 32768d	Device application error - no details	Service has been refused by the device application and no detailed information of the incident is available
0x8011 32785d	Index not available	Access occurs to a not existing index
0x8012 32786d	Subindex not available	Access occurs to a not existing subindex
0x8020 32800d	Service temporarily not available	Parameter is not accessible due to the current state of the device application
0x8021 32801d	Service temporarily not available local control	Parameter is not accessible due to an ongoing local operation at the device
0x8022 32802d	Service temporarily not available device control	Parameter is not accessible due to a remote triggered state of the device application
0x8023 32803d	Access denied	Write access on a read-only parameter
0x8030 32816d	Parameter value out of range	Written parameter value is outside its permitted value range
0x8033 32819d	Parameter length overrun	Written parameter length is above its predefined length
0x8034 32820d	Parameter length underrun	Written parameter length is below its predefined length
0x8035 32821d	Function not available	Written command is not supported by the device application
0x8036 32822d	Function temporarily unavailable	Written command is not available due to the current state of the device application
0x8040 32832d	Invalid parameter set	Written single parameter collides with other actual parameter settings
0x8041 32833d	Inconsistent parameter set	Parameter inconsistencies were found at the end of block parameter transfer, device plausibility check failed
0x8082 32898d	Application not ready	Read or write service is refused due to a temporarily unavailable application
0x8041 32833d	Inconsistent parameter set	Parameter inconsistencies were found at the end of block parameter transfer, device plausibility check failed
0x8CA1 36001d	Cell overload than operation limit	Cell overload than operation limit = 150% capacity
0x8CA2 36002d	Bridge detection error	Strain gauge bridge detection error
0x8CA3 36003d	Factory parameters error	Factory parameters error
0x8D05 36101d	Humidity detection (LC) error	Humidity detection (LC) error
0x8D69 36201d	Cell overload than normal limit	Cell overload than normal limit = 110% capacity or higher load
0x8D6A 36202d	Cell underload	Cell underload, load is below -110% rated capacity
0x8D6B 36203d	Temperature detection (NiPt/PT) error	Temperature detection (NiPt/PT) error
0x8D6C 36204d	Temperature Gradient detection (NiPt/PT) error	Temperature Gradient detection (NiPt/PT) error
0x8D6D 36205d	Temperature detection (LC) error	Temperature detection (LC) error

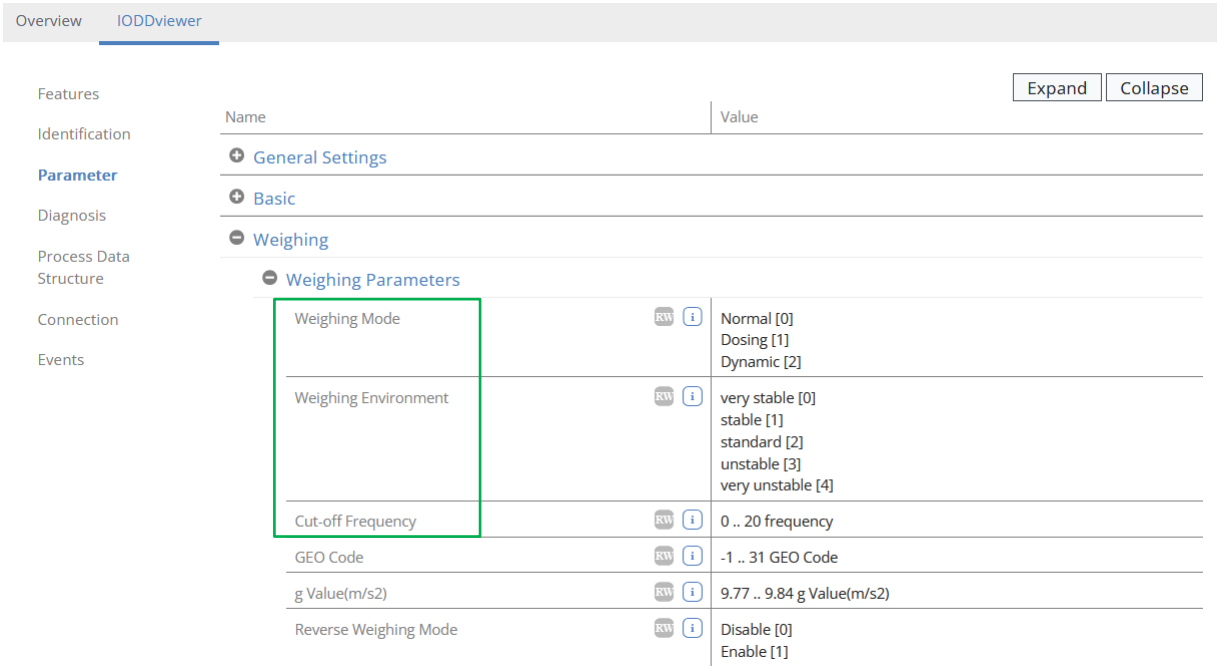
0x8D6E 36206d	Temperature Gradient detection (LC) error	Temperature Gradient detection (LC) error
0x8D6F 36207d	Voltage detection (AD) error	Voltage detection (AD) error
0x8D70 36208d	Humidity Gradient detection (LC) error	Humidity Gradient detection (LC) error
0x8D71 36209d	Adjustment failure	Adjustment failure
0x8DCD 36301d	Load times detection alarm	Load times detection alarm
0x8DCE 36302d	Zeroing failed, out of range	Zero failed, out of range

Table 20: Event code and associated description.

Some events related to Smart5 alarms, for that see section 4.6 Smart5™ Alarms. There are recommended actions for each Smart5 alarm.

4.4 Filter Settings

There are three parameters related to filter setting, the path is "Parameter"-"Weighing"-"Weighing parameters".



Parameter	Index	Subindex	Data Type	RW
Weighing Mode	Index 513	Subindex 0	UIntegerT (8 Bit)	RW
Gets or sets the current weighing mode setting. The default value is 1(Stable).				
Value range	0 1 2	Normal weighing Filling/Dosing, Reserved Dynamic weighing		
Weighing Environment	Index 514	Subindex 0	UIntegerT (8 Bit)	RW
Current environment condition setting. The more unstable the environment, the greater the filtering strength. The default value is 2(Standard).				
Value range	0 1 2 3 4	Very stable environment Stable environment Standard environment Unstable environment Very unstable environment		
Cut-off Frequency	Index 1025	Subindex 0	Float32T (32 Bit)	RW
Set the cut-off frequency of the fixed filter. This parameter will only be activated when the weighting mode is set to 3. The default value is 0(Disabled).				

Table 21: SLP33xD-IOL filter settings.

"Weighing Mode" is related to the static weighing or dynamic weighing.

Value	Application
1	Normal weighing. Static filtering algorithm with long settling time for highest precision.
2	Reserved.
3	Dynamic weighing. Dynamic filtering algorithm for unstable weighing objects.

Table 22: SLP33xD-IOL weighing mode filter settings.

"Weighing Environment" is related to the filter strength. User can choose the proper value according to the application environment. When the environment is very stable, user should choose lower value (0); when the environment is unstable, for example in a vibrational environment, user should choose higher value (4). The higher value means stronger filter.

"Cut-off frequency" is only valid when "weighing mode" is set to 2 (Dynamic weighing). Users can set the cut-off frequency directly to get the best filter effect.

4.5 Adjustment Process

Modern single-point load cells with onboard microprocessor and digital signal processing (DSP) can adjust for changes in the environment temperature, as well as for non-linearity and hysteresis effects. In many cases by specifying the local gravity (for details see Chapter 2, Installation) the SLP33xD-IOL load cell is ready to measure and will deliver accurate results. However, it is possible to adjust the load cell after the installation to account for mechanical effects, which are not (and cannot be by nature) considered in the factory adjustment parameters. Before the adjustment process is described in detail, the background of strain gage load cell adjustment is reviewed.

4.5.1 Strain gage load cell raw behavior

Measuring mechanical deformation by means of resistance changes in strain gages organized in a Wheatstone-bridge is a several decades old principle to weigh. Ideally, the load cell (the sensor) response should be a straight line, resulting the exact weight of the applied load. In reality, the response curve is not a straight line, and it depends on the loading direction, increasing or decreasing load. The behavior can be characterized with non-linearity and hysteresis parameters, see Figure 18.

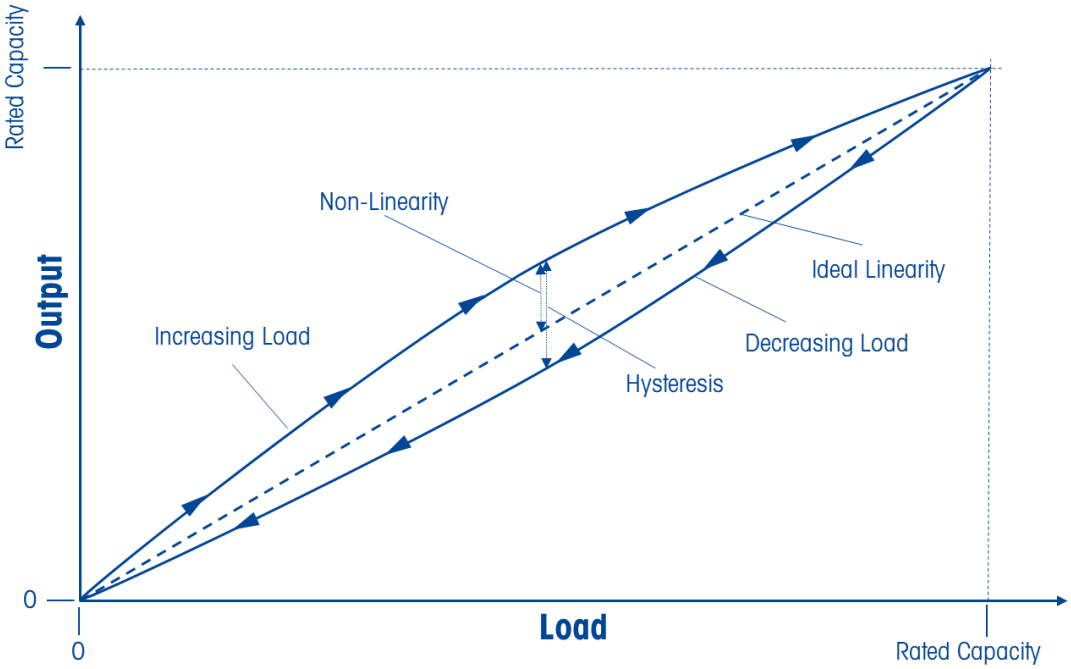


Figure 18: Response curve of a typical aluminum strain gage load cell to increasing and decreasing loads (loading and unloading curves, respectively).

4.5.2 Load cells with onboard adjustment

Modern load cells are manufactured with onboard microprocessor and digital signal processing (DSP) capabilities. Thanks to these units, the response curve of the load cell can be adjusted in the factory, and the effects of non-linearity and hysteresis are significantly reduced. Furthermore, the load cell can adjust to changes in the environment temperature as well as for creep effects. This results in increased accuracy, and the response curve of a modern load cell is very close to the ideal straight line.

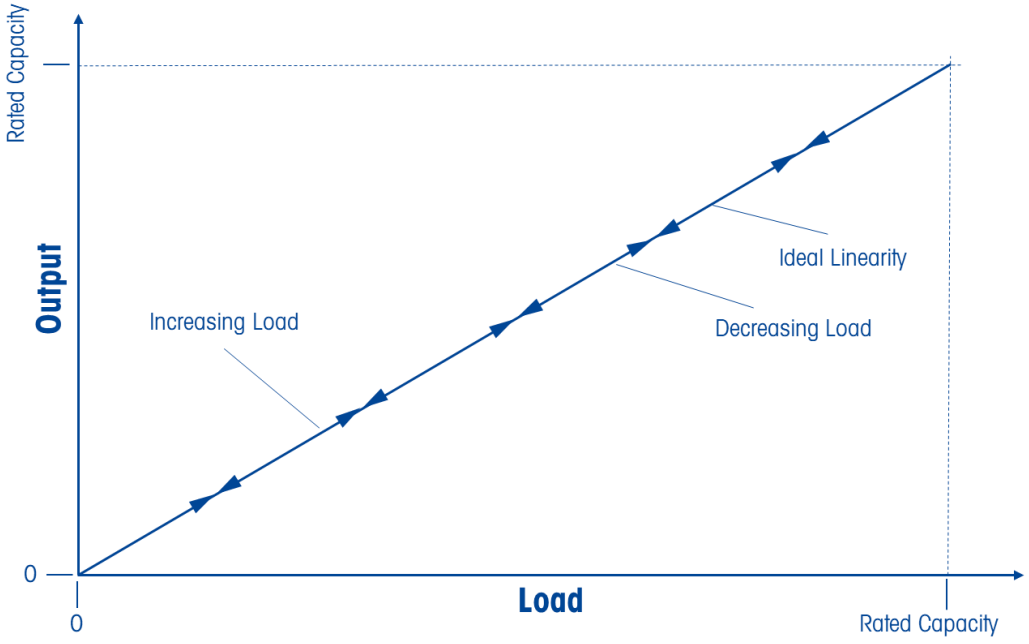


Figure 19: Modern load cells use onboard microprocessor and DSP libraries to achieve better accuracy, and to provide a linear response curve.

4.5.3 Changes when the load cell is installed

In various machine designs the installed single point load cells experience a different mechanical environment, unlike the setup during factory calibration. Depending on the design, a different pre-load is applied, and the weighing structure installed on the load cell might cause bypass forces dropping the calibration accuracy. The adjustment parameters defined during factory calibration might not provide the expected accuracy performance, thus a new set of parameters is required.

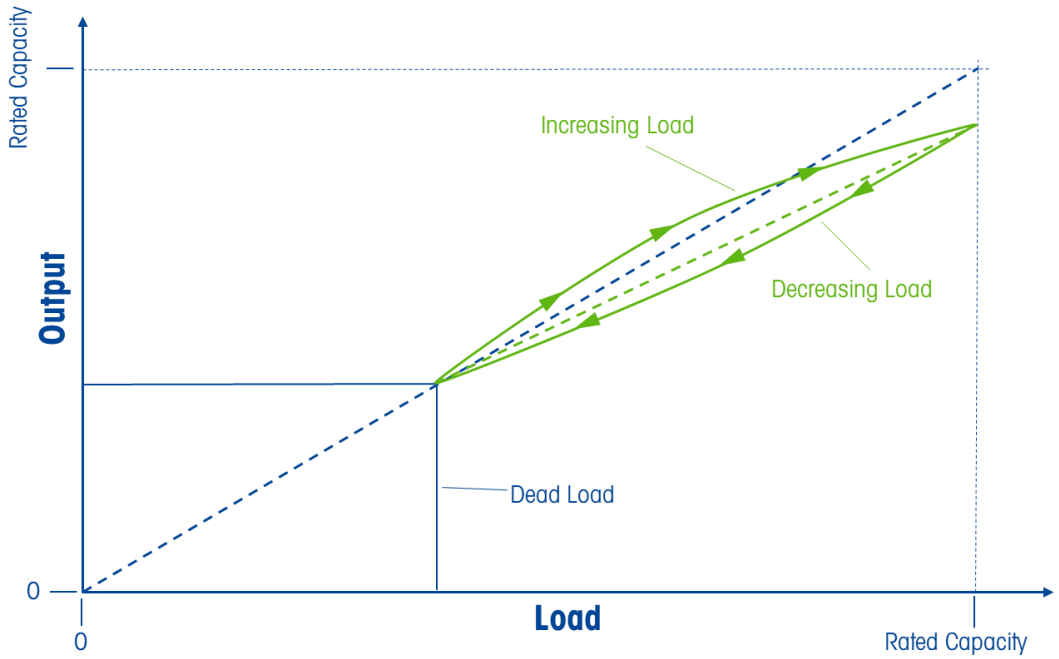


Figure 20: Impacts of the mechanical environment can reduce measurement accuracy.

4.5.4 TwinCal™, loading and unloading adjustment

Thanks to TwinCal™, an extended adjustment process supported by the new SLP33xD-IOL single-point load cells, the weighing accuracy of the load cell can be optimized after installation, and the impact of the mechanical integration on accuracy can be eliminated. TwinCal™ allows to calibrate and adjust the full loading and unloading cycle, and thus remove the unwanted effects of the mechanical environment on linearity and hysteresis. This will result in new parameters for non-linearity and hysteresis adjustment, thus increasing the weighing accuracy of the machine. Other parameters defined during factory calibration (adjustment for environment temperature changes, creep) will remain in place.

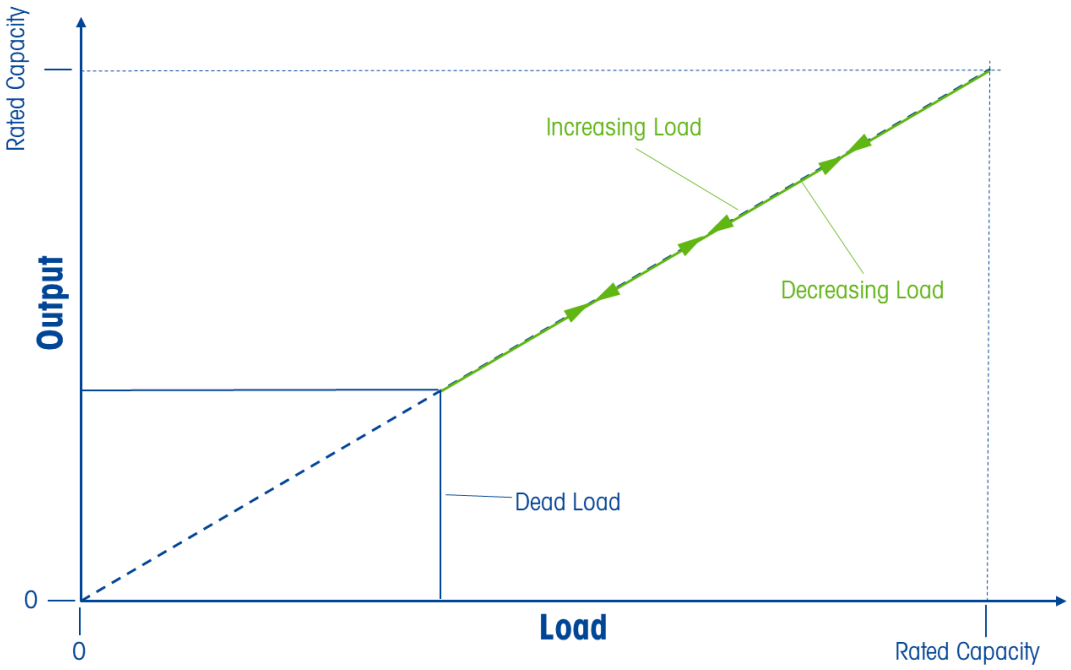


Figure 21 Optimal accuracy achieved after a full cycle adjustment.

Furthermore, depending on the application, there is the possibility to select the best suited adjustment curve. E.g., for loss-in-weight feeders, the unloading curve provides the optimal measurement performance. By doing that, the accuracy can be further improved.

4.5.5 Cancel all ongoing calibration processes

Click the button: "CANCEL ADJUSTMENT", and then all ongoing process will be closed.

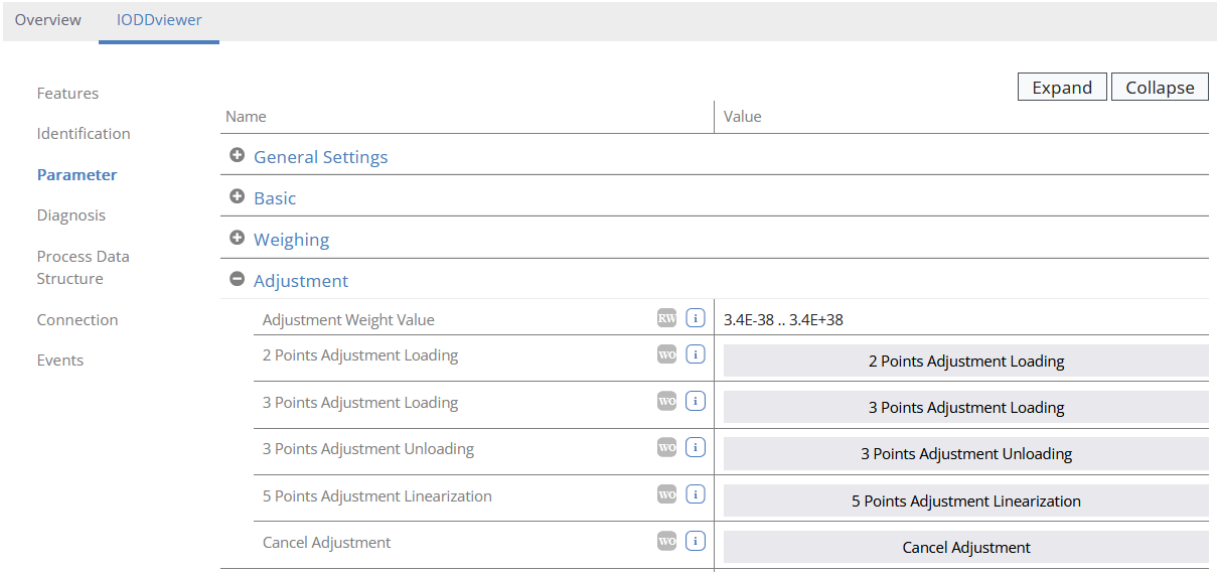


Figure 22: Adjustment menu.

4.5.6 2-points adjustment

Step 0: Start the process

Set the adjustment weight value defined in Section 3.2.2.4 Adjustment.

Click the button "2 POINTS ADJUSTMENT LOADING" in Figure 22 to start the adjustment process.

Step 1: Empty the scale

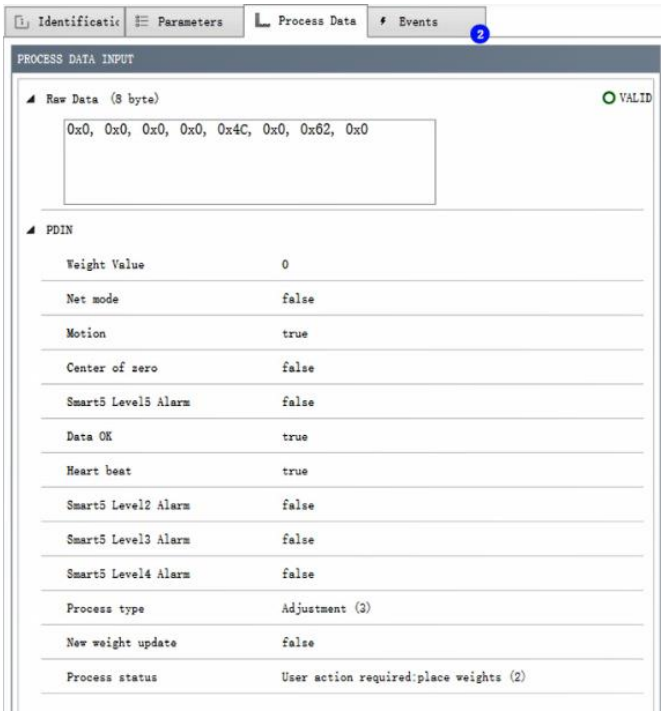


Figure 23: Empty the scale.

If there is weight on the scale, please empty the scale as shown in the figure above, and then the "Process status" will change to "In process".

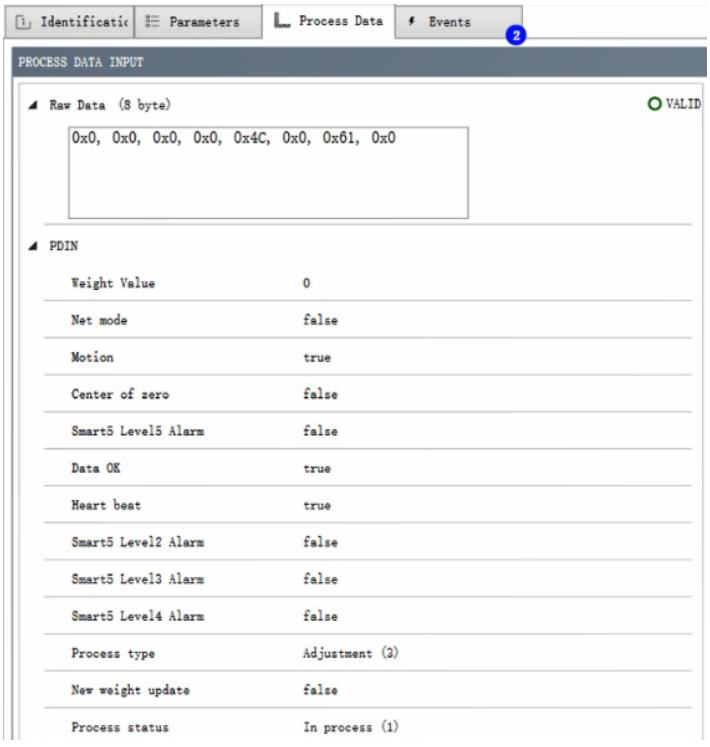


Figure 24: In process (Empty the scale).

Step 2: Load weight

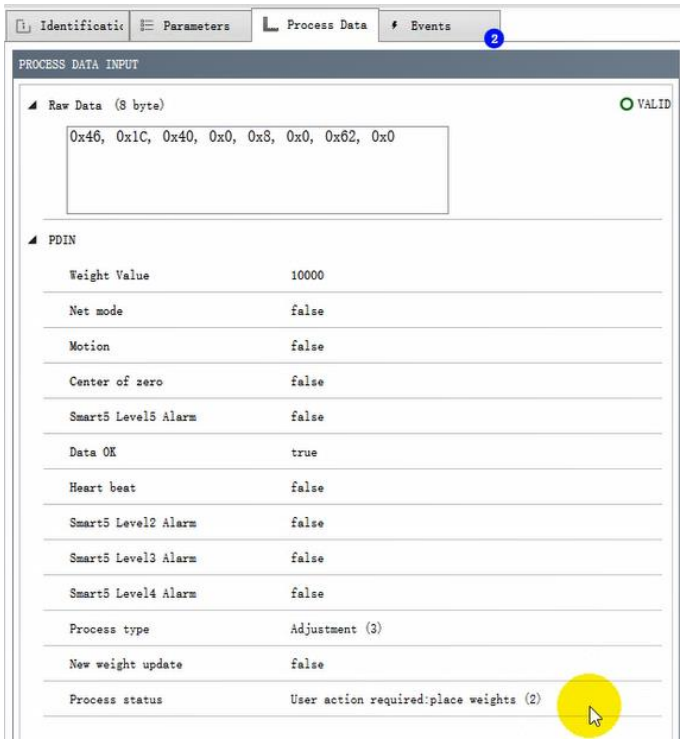


Figure 25: Load weight on the Load Cell.

Please follow the prompts to load the adjustment weight and wait for a few seconds for the reading to stabilize.

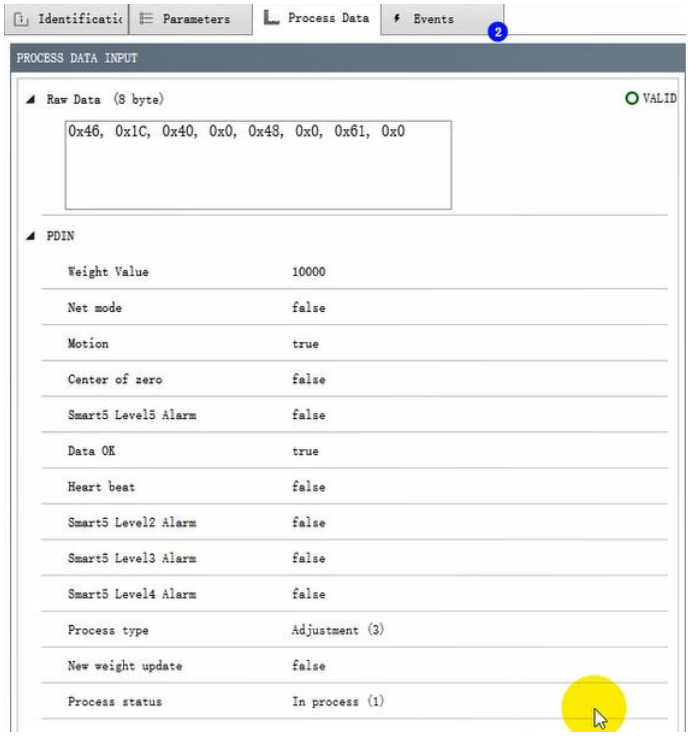


Figure 26: In process (Load weight).

The "Process status" will change to "In process".

Step 3: Unload the weight

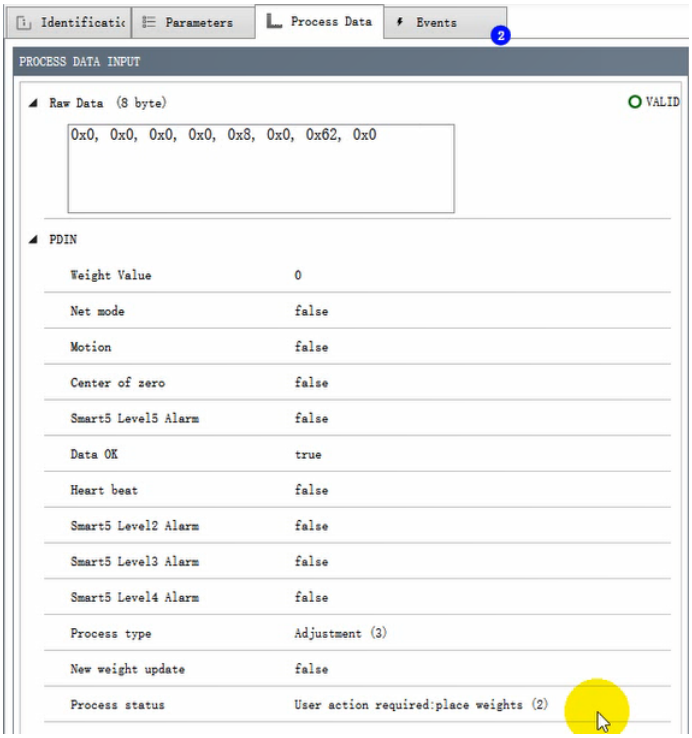


Figure 27: Unload the weight.

Please empty the scale again.

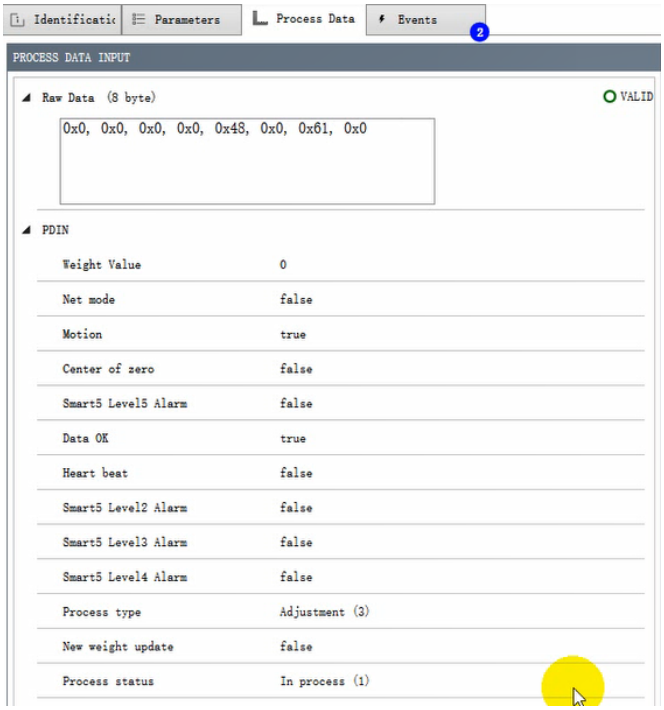


Figure 28: In process (Unload the weight).

Step 4: End of adjustment process

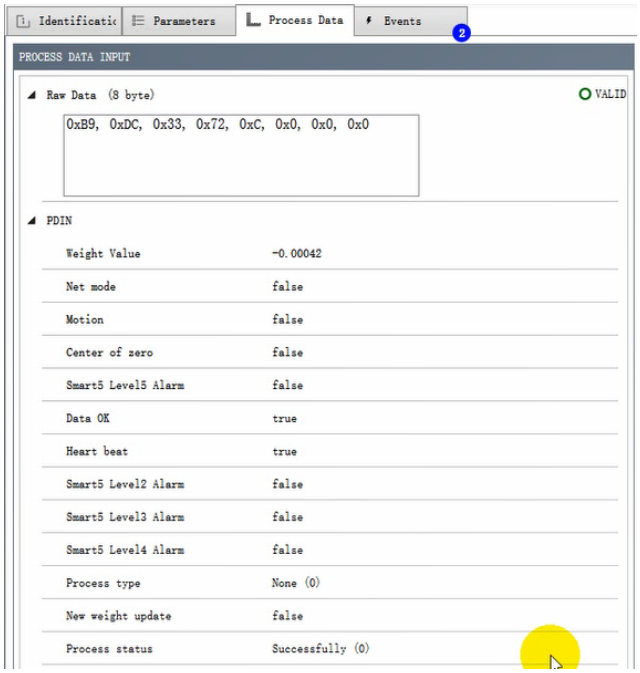


Figure 29: Successful adjustment.

4.5.7 3-Points adjustment (loading)

Step 0: Empty the scale and start the process

Please empty the scale and then click the button "3 POINTS ADJUSTMENT LOADING" in Figure 22 to start the adjustment process.

Step 1: Load weight 1

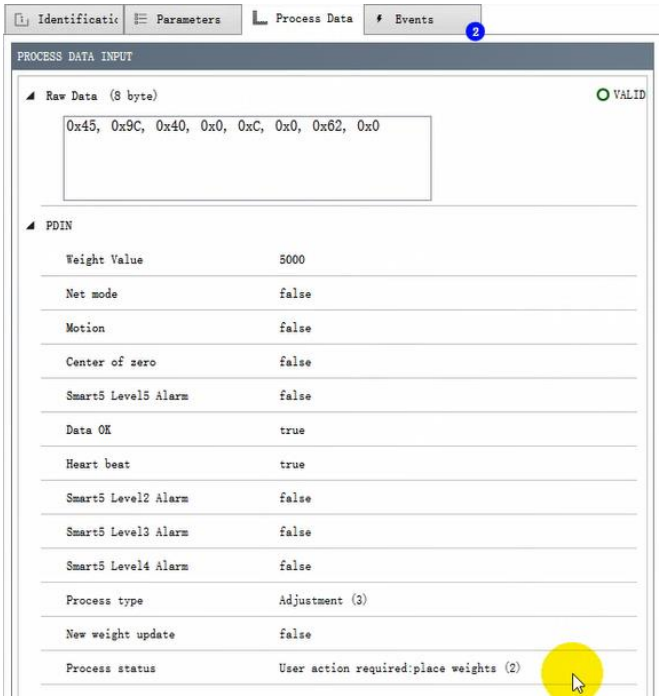


Figure 30: Load weight 1.

Please follow the prompts to load half adjustment weight and wait for a few seconds for the reading to stabilize.

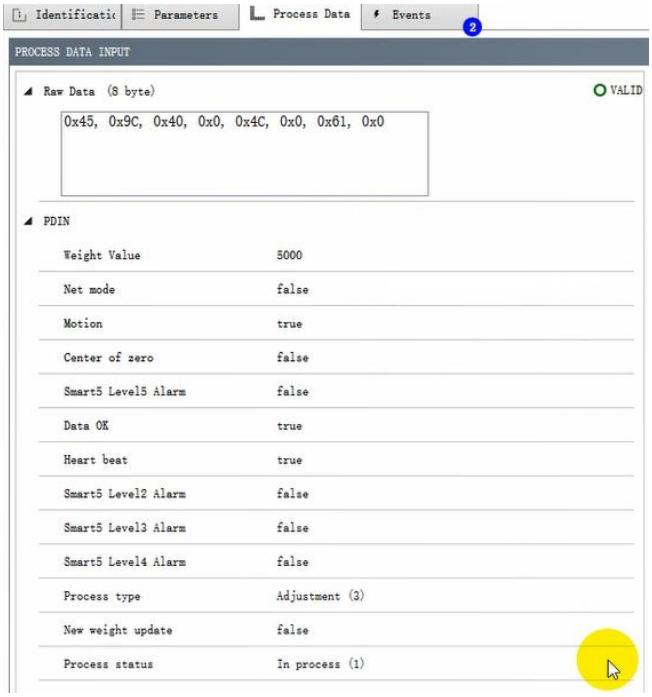


Figure 31: In process (Load weight 1).

Step 2: Load weight 2

Figure 32: Load weight on the Load Cell.

Please follow the prompts to load full adjustment weight and wait for a few seconds for the reading to stabilize.

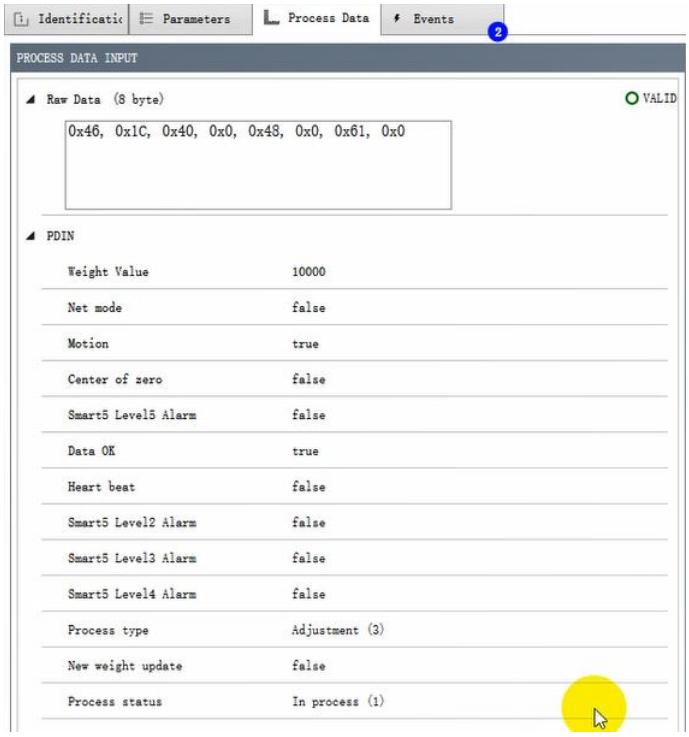


Figure 33: In process (Load weight 2).

Step 3: End of adjustment process

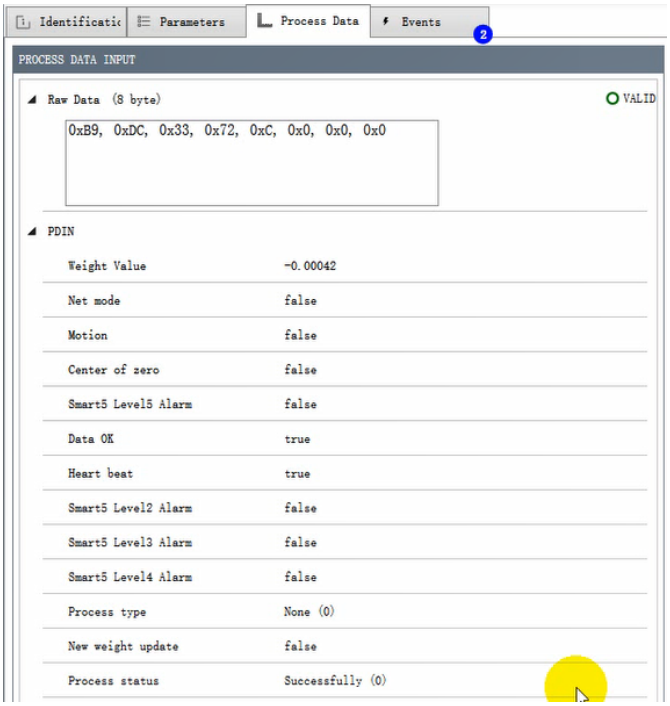


Figure 34: Successful adjustment.

4.5.8 3-Points adjustment (unloading)

Step 0: Load weight (full capacity) on the scale and start the process

Please load the full adjustment weight on the scale and then clink the button "3 POINTS ADJUSTMENT UNLOADING" in Figure 22 to start the adjustment process

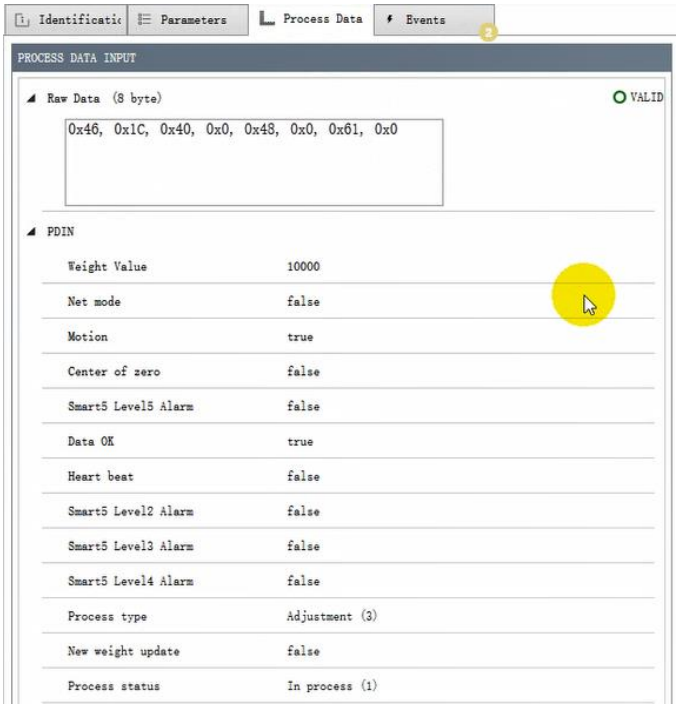


Figure 35: In process (Load weight - full capacity).

The "Process status" will change to "In process".

Step 1: Unload weight 1

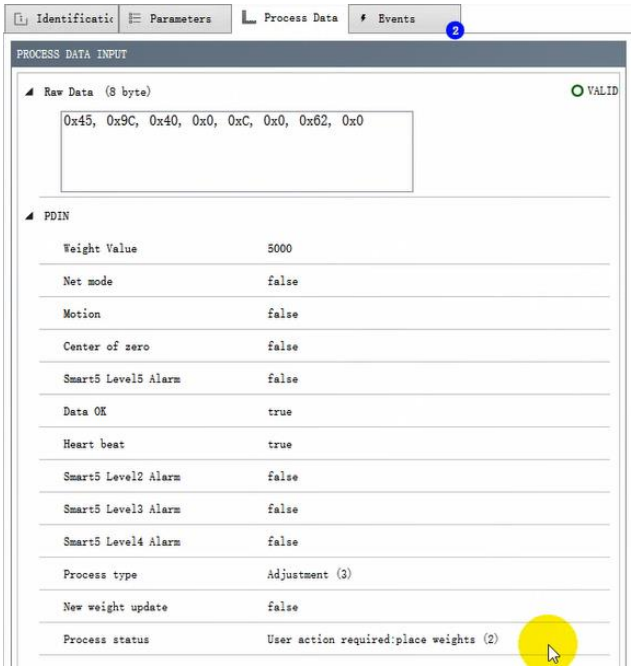


Figure 36: Unload weight 1.

Please unload weight and let the weight on the scale become half capacity and wait for a few seconds for the reading to stabilize.

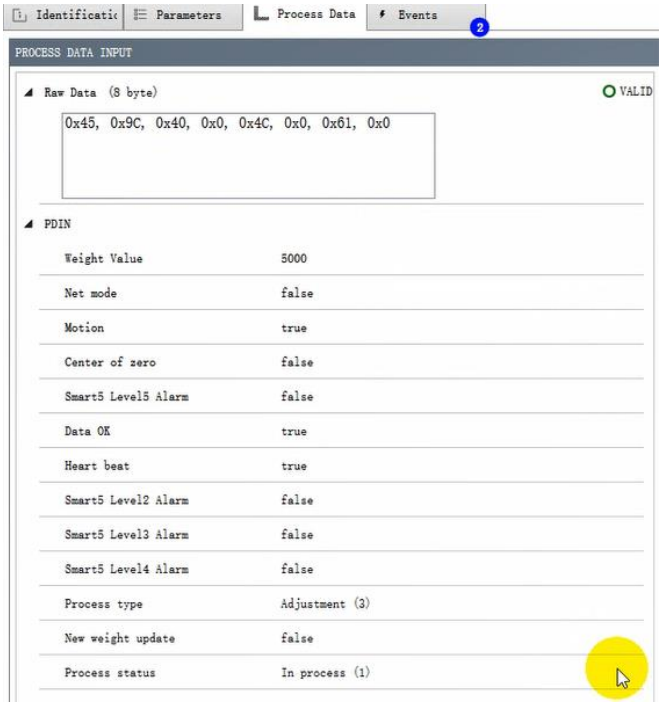


Figure 37: In process (Unload weight 1).

Step 2: Unload weight 2

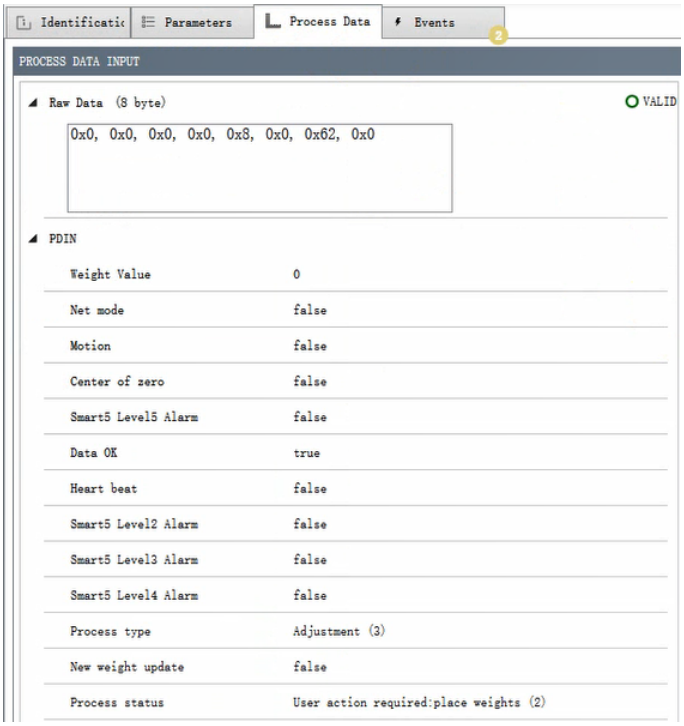


Figure 38: Unload weight 2.

Please empty the scale and wait for a few seconds for the reading to stabilize.

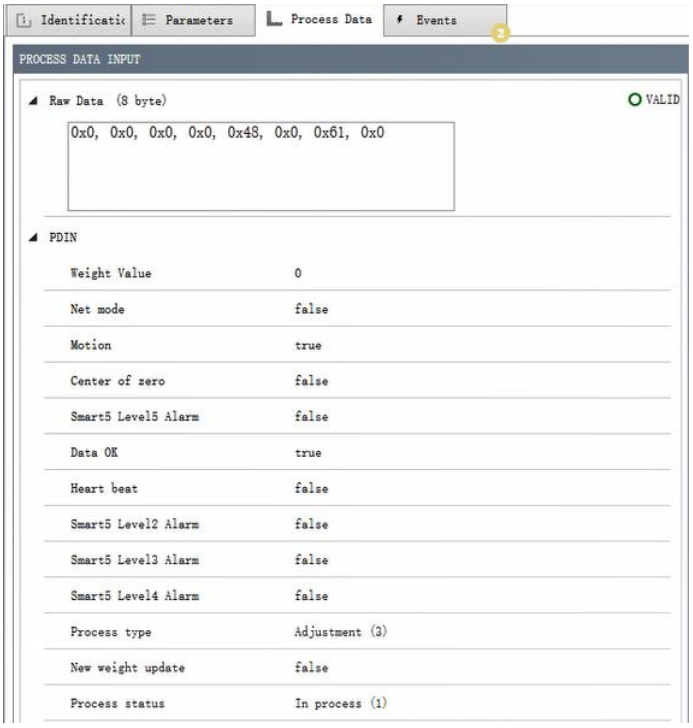


Figure 39: In process (Unload weight 2).

Step 3: End of adjustment process

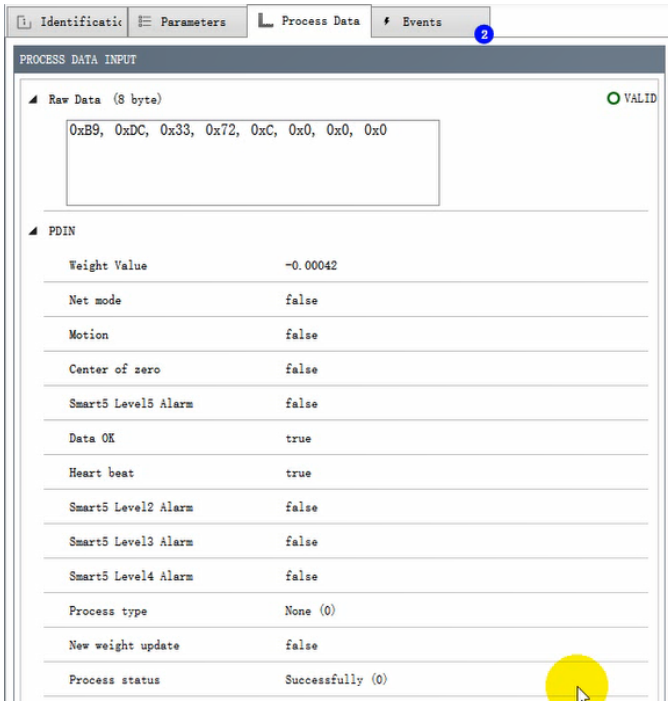


Figure 40: Successful adjustment.

4.5.9 5-point Adjustment Linearization, Loading and unloading adjustment, TwinCal™

Step 0: Empty the scale and start the process

Please empty the scale and then clink the button "5 POINTS ADJUSTMENT LINEARIZATION" in Figure 22 to start the adjustment process.

Step 1: Load weight 1

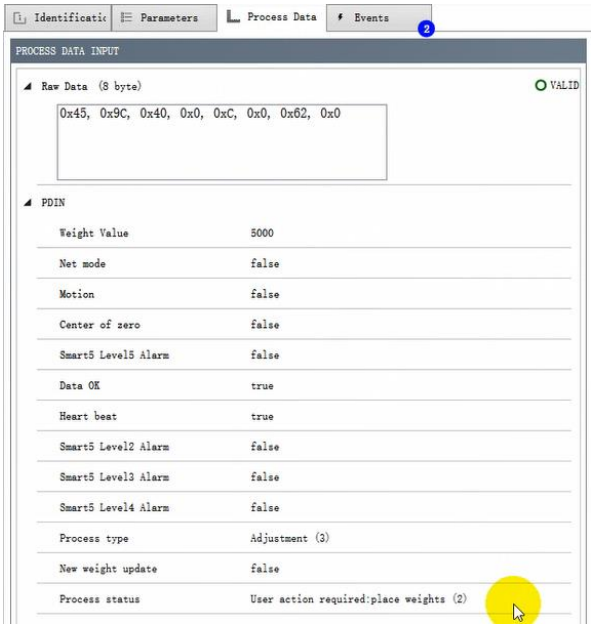


Figure 41: Load weight 1.

Please follow the prompts to load half adjustment weight and wait for a few seconds for the reading to stabilize.

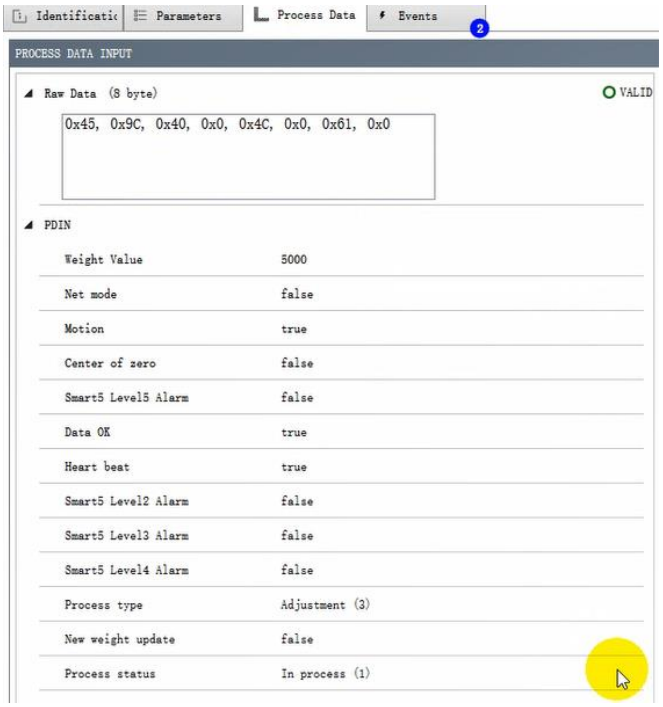


Figure 42: In process (Load weight 1).

Step 2: Load weight 2

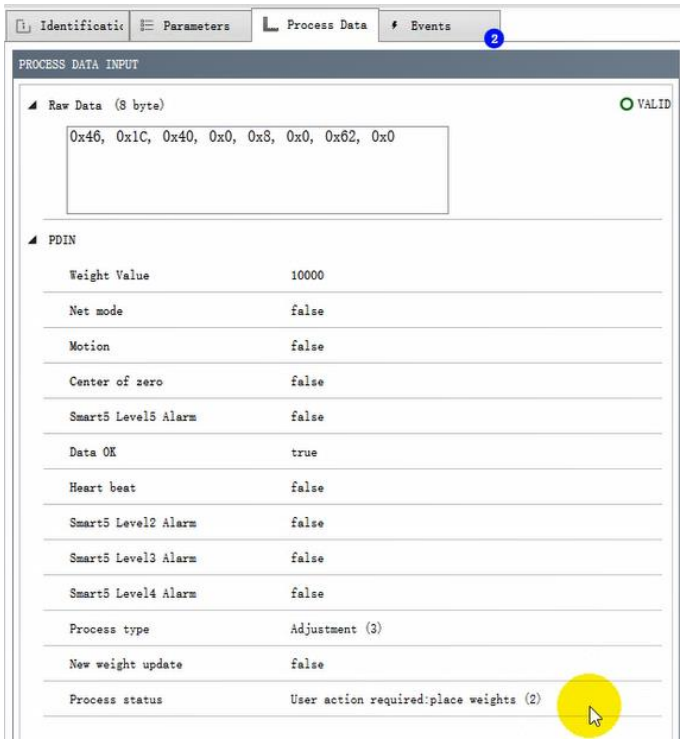


Figure 43: Load weight 2.

Please follow the prompts to load the full adjustment weight and wait for a few seconds for the reading to stabilize.

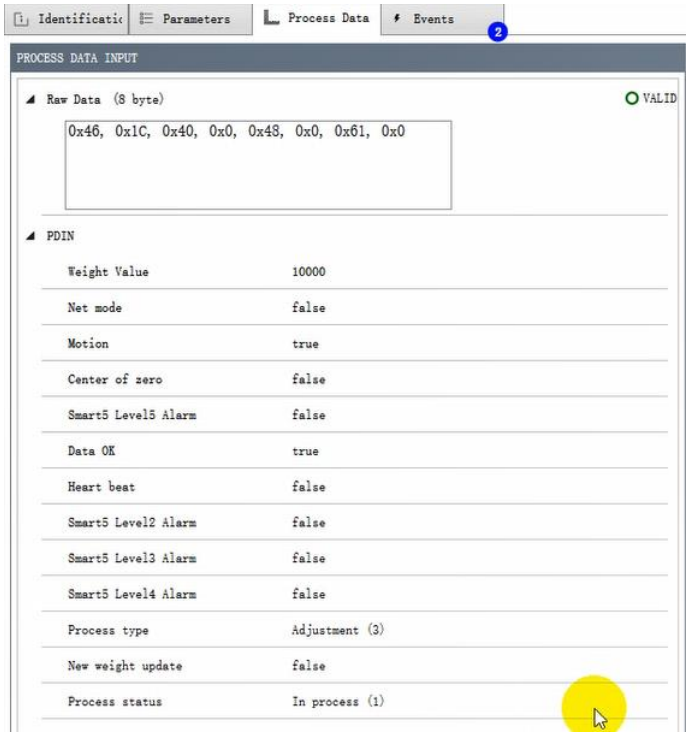


Figure 44: In process (Load weight 2).

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Step 3: Unload weight 1

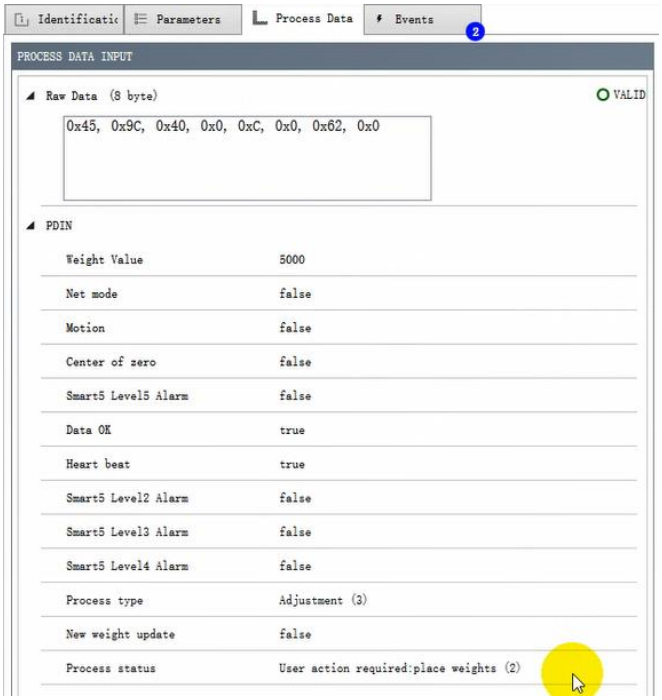

Figure 45: Unload weight 1.

Please unload weight and let the weight on the scale become half adjustment weight and wait for a few seconds for the reading to stabilize.

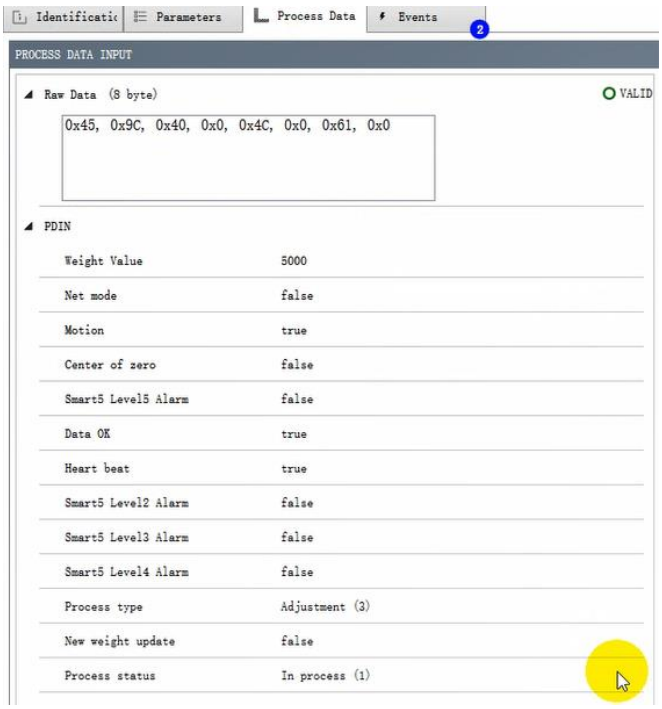

Figure 46: In process (Unload weight 1).

Step 4: Unload weight 2

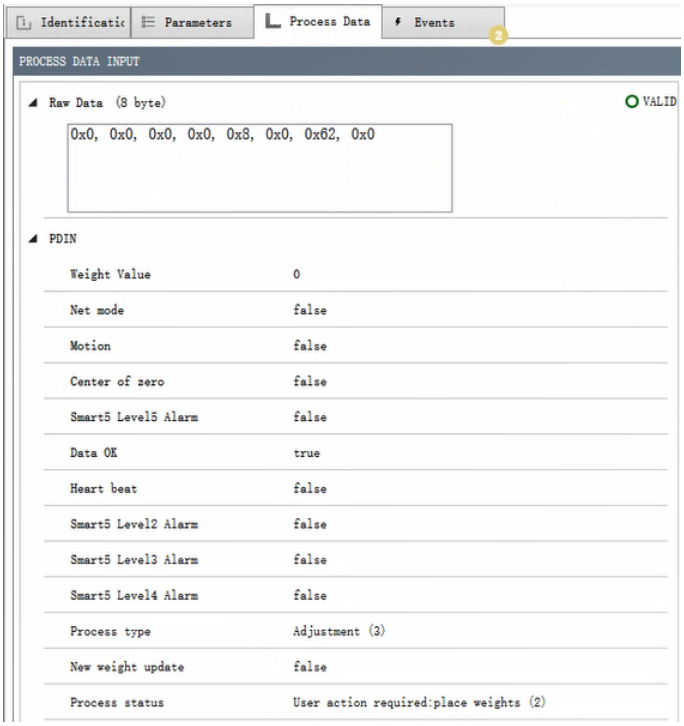

Figure 47: Unload weight 2.

Please empty the scale and wait for a few seconds for the reading to stabilize.

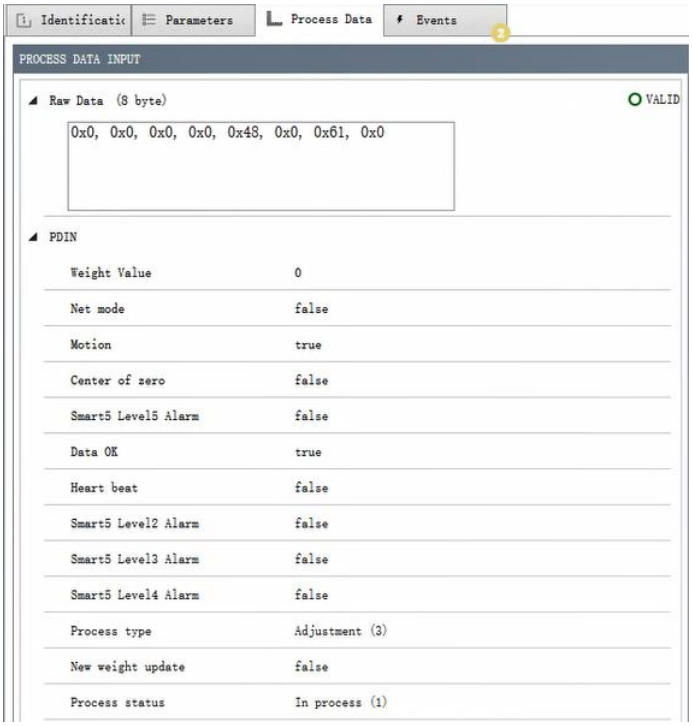

Figure 48: In process (Unload weight 2).

Step 5: End of adjustment process

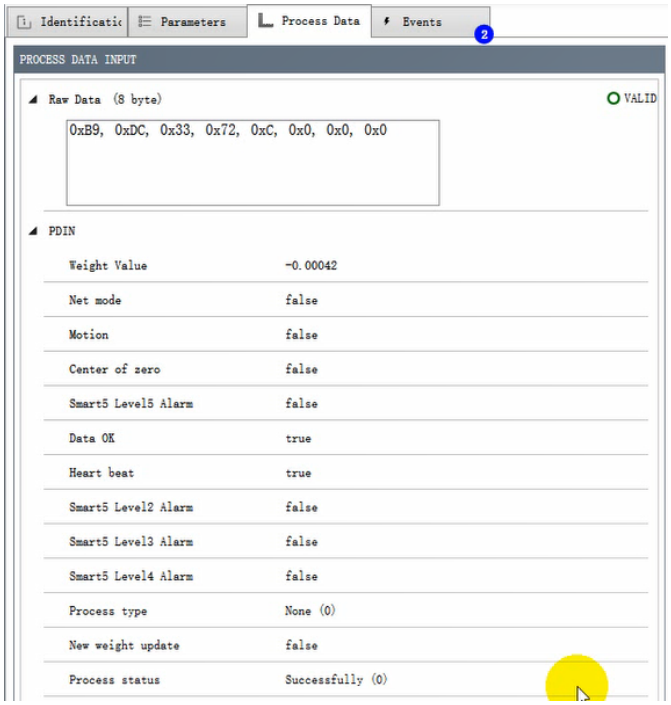

Figure 49: Successful adjustment.

4.6 Smart5™ Alarms

SMART5™ alarm management system is aligned with industry standards, such as NAMUR NE107, ISA TR 18.2.2 201; and IEC 62682.

SMART5™ monitors equipment operating status, logs events, and communicates error status to the customer, providing alarm and error message collection functions.

The SMART5™ status of the sensor is demonstrated by means of 5 different colored indicators, which are also reflected in real time in the device status word (corresponding to the SMART5™ bit). SMART5™ status of the sensor is categorized according to the figure below.

Graphical Indication	Rank	Type	Description	Result
	5	Catastrophic weighing error	Wrong weight / equipment Failure.	Alarm stops operation: Clearing the alarm will not reset the condition – the device must be repaired/replaced to eliminate the alarm.
	4	Imminent failure	Wrong weight / equipment failure expected based on predictive algorithms and sensors like temperature, humidity.	Alarm indicates failure is imminent within a period of one week or more. The alarm can be reset but will re-occur each day until the cause is eliminated.
	3	Out of specification	Wrong Operator Actions or device / application is operating out of specification.	Alarm and log the event. Alarms are only generated / transmitted at the request of the customer.
	2	Predictive Alarm	Routine test, Calibration or Preventative maintenance must be undertaken.	Alarm and log the event. Alarms are only generated / transmitted at the request of the customer.
	1	Normal Condition	Unit is operating correctly.	No Action required.

Table 23: Description of the SMART5™ status and colored indicators.

The user can read the SMART5™ level 2 to 5 bits from Process Data Input.

Event codes show the specific alarms that appear and require different responses.

Level	Event Code	Description	Recommended Actions
5	0x8CA1	Sensor load exceeds 150% of rated capacity range	Call MT service for a replacement sensor. The sensor is very likely damaged.
	0x8CA2	Sensor bridge damage	Call MT service for a replacement sensor. The strain gages and/or Wheatstone bridge is damaged.
	0x8CA3	Factory parameter error	Call MT service for a replacement sensor. Factory parameters compromised.
4	0x8D05	Sensor humidity out of range	Move the sensor/machine to a low humidity environment
3	0x8D71	Adjustment error	Attempt adjustment again, something went wrong during the previous adjustment process.
	0x8D6B 0x8D6D	Sensor temperature is outside the normal range (-10~40 °C)	Check the temperature around the sensor. If the temperature is in range, call MT service, the load cell might be damaged.
	0x8D69	Sensor load exceeds 110% of rated capacity	Identify the cause of the overload. Check sensor performance, calibration may be required. If the performance is normal, continue to use it. If the performance is not normal, replace the sensor with a new one.
	0x8D6A	Sensor underload	Identify the cause of the underload. Check sensor performance, calibration may be required. If the performance is normal, continue to use it. If the performance is not normal, replace the sensor with a new one. Call MT service for replacement.
	0x8D6F	Supply voltage out of range	Check supply voltage
	0X8D6C 0x8D6E	Sensor temperature gradient changes out of range	Temperature changes too quickly, stabilize temperature in the room where the machine with the load cell is installed and wait 30 minutes before using it.
	0x8D70	Sensor humidity gradient changes out of range	Humidity changes too quickly, wait 30 minutes before using it
2	0x8DCE	Zeroing failed, out of range	Unload the sensor, zero it again
	0x8DCD	Sensor loading counter reached 1 M weighing events	Sensor performed at least 1 million weighing measurements, check sensor performance, e.g., by placing known reference weight on it.

Table 24: Event codes linked to the SMART5™ specific alarms.

5 GEO-CODES

When the SLP33xD-IOL is calibrated with test weights it assumes the currently entered GEO code as its base line. From there on one can relocate the load cell (and the machine) without the need to retest again, by just entering a new GEO code.

If the load cells will not be relocated after test weight calibration or a test weight calibration will be done after relocation, the GEO code has no relevance.

5.1 Transferring Factory Calibration to Other Locations

The GEO code feature provided in the SLP33xD-IOL permits calibration readjustment due to changes in elevation or latitude without reapplying test weights. The load cell comes with the factory calibration at GEO code 12. To achieve proper weight readings the GEO code must be changed to the current location. As a machine manufacture one might change the GEO code twice; first to the own location where the machines are built and then again to the end-users' location to achieve correct measurements also there.

5.2 On-site Adjustment

1. Use the GEO code chart in Table 25 to determine the GEO code for the altitude and latitude where the load cell is currently located and where it will be calibrated with test weights.
2. Enter this GEO value into the GEO code parameter in the section 4.3.2.3.1 Weighing Parameters. This step is required if the scale shall be relocated again w/o test weight calibration.
3. Immediately after entering the GEO code, perform a zero and span adjustment using accurate test load.
4. If the scale will be shipped to a different location without recalibration on-site, you need to change the GEO code to the altitude and latitude of the new location before using it there.

Using the GEO code value for adjustment is not as accurate as re-applying certified test loads and re-calibrating the scale in a new location.

Latitude North or South, in Degrees and Minutes	Height Above Sea Level, in Meters										
	0	325	650	975	1300	1625	1950	2275	2600	2925	3250
	325	650	975	1300	1625	1950	2275	2600	2925	3250	3575
	Height Above Sea Level, in Feet										
	0	1060	2130	3200	4260	5330	6400	7460	8530	9600	10660
	1060	2130	3200	4260	5330	6400	7460	8530	9600	10660	11730
0° 0'–5° 46'	5	4	4	3	3	2	2	1	1	0	0
5° 46'–9° 52'	5	5	4	4	3	3	2	2	1	1	0
9° 52'–12° 44'	6	5	5	4	4	3	3	2	2	1	1
12° 44'–15° 6'	6	6	5	5	4	4	3	3	2	2	1
15° 6'–17° 0'	7	6	6	5	5	4	4	3	3	2	2
17° 10'–19° 2'	7	7	6	6	5	5	4	4	3	3	2
19° 2'–20° 45'	8	7	7	6	6	5	5	4	4	3	3
20° 45'–22° 22'	8	8	7	7	6	6	5	5	4	4	3
22° 22'–23° 54'	9	8	8	7	7	6	6	5	5	4	4
23° 54'–25° 21'	9	9	8	8	7	7	6	6	5	5	4
25° 21'–26° 45'	10	9	9	8	8	7	7	6	6	5	5
26° 45'–28° 6'	10	10	9	9	8	8	7	7	6	6	5
28° 6'–29° 25'	11	10	10	9	9	8	8	7	7	6	6
29° 25'–30° 41'	11	11	10	10	9	9	8	8	7	7	6
30° 41'–31° 56'	12	11	11	10	10	9	9	8	8	7	7
31° 56'–33° 9'	12	12	11	11	10	10	9	9	8	8	7
33° 9'–34° 21'	13	12	12	11	11	10	10	9	9	8	8
34° 21'–35° 31'	13	13	12	12	11	11	10	10	9	9	8
35° 31'–36° 41'	14	13	13	12	12	11	11	10	10	9	9
36° 41′–37° 50′	14	14	13	13	12	12	11	11	10	10	9
37° 50′–38° 58′	15	14	14	13	13	12	12	11	11	10	10
38° 58′–40° 5′	15	15	14	14	13	13	12	12	11	11	10
40° 5′–41° 12′	16	15	15	14	14	13	13	12	12	11	11
41° 12′–42° 19′	16	16	15	15	14	14	13	13	12	12	11
42° 19′–43° 26′	17	16	16	15	15	14	14	13	13	12	12
43° 26′–44° 32′	17	17	16	16	15	15	14	14	13	13	12
44° 32′–45° 38′	18	17	17	16	16	15	15	14	14	13	13
45° 38′–46° 45′	18	18	17	17	16	16	15	15	14	14	13
46° 45′–47° 51′	19	18	18	17	17	16	16	15	15	14	14
47° 51′–48° 58′	19	19	18	18	17	17	16	16	15	15	14
48° 58′–50° 6′	20	19	19	18	18	17	17	16	16	15	15

Latitude North or South, in Degrees and Minutes	Height Above Sea Level, in Meters										
	0	325	650	975	1300	1625	1950	2275	2600	2925	3250
	325	650	975	1300	1625	1950	2275	2600	2925	3250	3575
	Height Above Sea Level, in Feet										
	0	1060	2130	3200	4260	5330	6400	7460	8530	9600	10660
	1060	2130	3200	4260	5330	6400	7460	8530	9600	10660	11730
50° 6′–51° 13′	20	20	19	19	18	18	17	17	16	16	15
51° 13′–52° 22′	21	20	20	19	19	18	18	17	17	16	16
52° 22′–53° 31′	21	21	20	20	19	19	18	18	17	17	16
53° 31′–54° 41′	22	21	21	20	20	19	19	18	18	17	17
54° 41′–55° 52′	22	22	21	21	20	20	19	19	18	18	17
55° 52′–57° 4′	23	22	22	21	21	20	20	19	19	18	18
57° 4′–58° 17′	23	23	22	22	21	21	20	20	19	l9	18
58° 17'–59° 32'	24	23	23	22	2\2	21	21	20	20	19	19
59° 32'–60° 49'	24	24	23	23	22	22	21	21	20	20	19
60° 49'–62° 9'	25	24	24	23	23	22	22	21	21	20	20
62° 9'–63° 30'	25	25	24	24	23	23	22	22	21	21	20
63° 30'–64° 55'	26	25	25	24	24	23	23	22	22	21	21
64° 55'–66° 24'	26	26	25	25	24	24	23	23	22	22	21
66° 24'–67° 57'	27	26	26	25	25	24	24	23	23	22	22
67° 57'–69° 35'	27	27	26	26	25	25	24	24	23	23	22
69° 5'–71° 21'	28	27	27	26	26	25	25	24	24	23	23
71° 21'–73° 16'	28	28	27	27	26	26	25	25	24	24	23
73° 16'–75° 24'	29	28	28	27	27	26	26	25	25	24	24
75° 24'–77° 52'	29	29	28	28	27	27	26	26	25	25	24
77° 52'–80° 56'	30	29	29	28	28	27	27	26	26	25	25
80° 56'–85° 45'	30	30	29	29	28	28	27	27	26	26	25
85° 45'–90° 00'	31	30	30	29	29	28	28	27	27	26	26

Table 25: GEO Adjustment Values.

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