White Paper

EURAMET Calibration Guideline

Automatic Weighing Instruments

Automatic Weighing Instruments (AWIs) such as catchweighers and checkweighers provide critical quality control in fast-moving processes. Discover how implementing the recently released EURAMET Calibration Guideline 26 (CG-26) can help you ensure the accuracy and reproducibility of these important instruments so that you can optimize processing speed, profitability and compliance.

Content:

METTLER TOLEDO

1 How Will This Guideline Help My Business?

When utilizing an AWI, it is crucial to confirm that it is working correctly and delivering precise results. Inaccurate readings render a dynamic weighing device ineffective, leading to potential issues for the user. Therefore, it is essential to be aware of the device's accuracy and ensure that it is functioning correctly.

EURAMET has recently published guideline CG-26 to address the growing need for the calibration of Automatic Catchweighing Instruments. The purpose of the guideline is to provide a standardized methodology for calibrating any AWI. However, before discussing the specifics of this guideline, it is important to define relevant types of AWIs.

Catchweigher/Checkweigher
Catchweighers determine the mass of random packages in motion in industries like distribution and express parcel shipping. The weights of these packages are used to ensure exact costing and can also factor into calculating container weights for compliance with national and international regulations.

A METTLER TOLEDO catchweighing system

Checkweighers, on the other hand, determine and compare the mass of products in motion with a reference. These instruments are typically used in industries such as pharma/biotech, food & beverage, chemicals, and metals, plastic and electronics component production (MPE) during manufacturing and packaging.

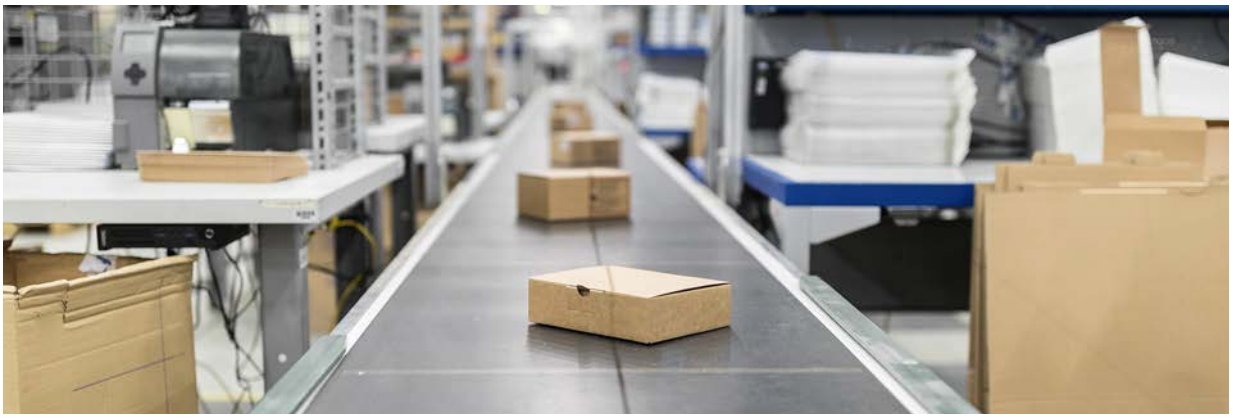
A METTLER TOLEDO checkweighing system

Engineering, machinery and equipment builders may leverage both types of AWIs in system design to help their customers increase productivity and meet compliance requirements:

- Optimize package completeness,
- Reduce transportation costs,
- Prevent chargebacks and rework, and
- Ensure individual products meet quality standards.

Enhancing Your Processes

In short, catchweighing can help to enhance revenue capture and route planning. Checkweighers can help to reduce overfilling, resulting in less product giveaway. At the same time they can confirm that inspected products are inside the required legal limits, or that contents of medicine, food or chemical packages are within specified limits. Accuracy using either type of AWI is critical to support profitability and compliance.



Implementing Calibration as a part of the Quality Management System, as well as maintenance procedures, can help make sure processes meet both internal and external requirements, such as:

- Weights and measures regulations,
- Legal fill limits,
- Safety regulations, and
- Manufacturing margins.

Confirming the accuracy of AWIs by following the new calibration guidelines can help you reduce unnecessary expenses related to regulatory issues or poorly manufactured products to enhance your processing speed – and your bottom line.

Why Standardize Calibration?

Proper calibration according to EURAMET guidelines can help you:

- Optimize your processes,
- Capture additional shipping revenue,
- Reduce expenses related to rework/waste, and
- Enhance your profitability and compliance.

2 EURAMET and Measurement Consistency

EURAMET stands for the **Eur**opean **A**ssociation of National **Met**rology Institutes. It is an alliance composed of national metrological organizations from the member states of the European Union and the European Free Trade Association. EURAMET has historically been concerned with creating calibration guidelines for weighing instruments used in laboratories, although the Guidelines on the Calibration of Automatic Catchweighing Instruments show an expansion of their scope to include more industrial weighing devices. EURAMET worked closely with manufacturers of these AWIs including METTLER TOLEDO to develop these new guidelines.

Why Standardize Calibration?

The impact of having a standardized process for calibration makes life easier for government regulators, who have a set of guidelines to point manufacturers to follow. Additionally, if an end-user knows that a service provider is following the EURAMET guidelines, they can be secure in knowing the results of a calibration are measured and calculated in a way that is accepted by their local government and international trading partners. Results comparisons between different production lines – even in different countries – are also possible. This allows the assessment of line setups and can identify areas for improvement.

In the past, service providers would need to develop their own calibration guidelines and formulae, which meant results would ultimately be difficult to compare with other methodologies. A service provider using a set of unified, approved guidelines makes comparisons more reliable, which makes it easier for end-users to prove quality, traceability and compliance.

What is Calibration for an AWI?

All weighing devices have an inherent measurement uncertainty, and this measurement uncertainty is evaluated through calibration. Measurement uncertainty refers to the range of potential errors or deviations that can occur during the weighing process which in turn create uncertainty in the measured result.

Calibration is a set of activities carried out on a measurement instrument to understand its behavior by establishing a relationship between known values and associated measurement values. Periodic calibration defines measurement uncertainty to provide you with a basis for comparing results of a given process across time for a given instrument and among production locations so that you have a basis upon which to compare and optimize process results.

When speaking specifically about an AWI, calibration consists of:

1. Determining the reference value of mass of specified dynamic test loads
2. Applying test loads to the instrument under specific conditions
3. Determining the error of measurement and variation of the indications, evaluated by:
   a. Determination of repeatability
   b. Reproducibility
   c. Effect of eccentric loading
4. Evaluating the measurement uncertainty to be attributed to the results.

The result is a number which can be used to gauge the accuracy of the weighing instrument.

Calibration only provides this number. It does not include a verification of legal or customer-specified limits. However, calibration results are critical for confirming a weighing device can meet both internal and external processing standards. They also form a basis for money-saving business activities such as revenue capture and process improvement.

Some industries also have government regulations regarding the accuracy of a product's displayed weight or quantity, and defining the accuracy of a weighing device is critical for compliance. ISO 9001, for example, identifies calibration as a means for establishing the traceability of measurement devices. The traceability of measurement devices means being able to improve the level of confidence in the validity of its measurements.

3 Calibration Process

Calibration is performed by a reputable service provider under specific conditions using specific materials. The conditions and materials for testing an AWI are defined in EURAMET CG-26 as follows.

3.1 Preparing for Calibration

Calibration of an AWI relies on uniform conditions to ensure that any observed variance comes from the system itself and not external environmental factors. Therefore, a significant amount of the guideline is devoted to how a system is prepared for a calibration.

The most important thing to ensure when calibrating an AWI is that it takes place under what the guidelines refer to as normal conditions of use. That means that air flow, stability of the system and any ambient vibrations should all be as they are during a production run.

In addition, the guideline mandates that instrument functions be free from the effects of contamination or damage prior to calibration. This means that before the calibration process, your service provider should perform a standard preventive maintenance procedure on the AWI to ensure that everything is functioning properly before proceeding.

There are other factors to consider as well, which the guidelines cover in greater detail, but they all boil down to the same basic idea: the AWI being calibrated should be set up and running in the manner it would be during a normal production scenario. Provided the AWI is functioning properly, calibration can begin.

3.2 Performing the Calibration

The Control Instrument

The guideline specifies that a control instrument with a resolution better than or equal to the AWI being tested must be used to determine the reference value of the mass of dynamic test loads. This is either a static scale or the AWI itself if the AWI has a static weighing mode. The guideline also recommends leveraging the AWI as the preferred method, if possible, as this will ensure the resolution of the device being calibrated and the resolution of the control instrument are the same.

Dynamic Test Loads

Dynamic test loads of a given weight are used to test the device. Care is taken to ensure the instrument is being used under normal operating conditions, and that dynamic test loads "preferably be the type of article(s) which are normally weighed on the calibrated instrument" (EURAMET, Guidelines on the Calibration of Automatic Catchweighing Instruments, section 4.3).

By using the products normally seen during production, manufacturers gain a better idea of the variation (i.e. the deviation) to expect for their particular products. However, if this is not possible for any reason, the guidelines lay out five features of test loads to consider:

1. Appropriateness for the intended use of the instrument.
2. Test load shape, material, composition should allow easy handling.
3. Test load shape, material, composition should allow easy estimation of the position of center of gravity.
4. Test load mass must remain constant throughout the period in which the test mass is used for calibration.
5. Test load must be made of a non-hygroscopic, non-electrostatic, non-magnetic material. (ibid)

Additional Test Load Considerations

The guideline strongly recommends that the weight of the test load be determined at the time and place of calibration. If calibration takes place elsewhere – for example, in a permanent laboratory – there are two additional factors to consider:

1. Test load density should be easy to estimate and reported on the calibration report.
2. Test loads of low density may require special attention due to buoyancy. Monitoring of the temperature and the atmospheric pressure may be necessary throughout the period of use of the loads during the calibration. (ibid)

The last point makes the use of the weighing instrument to be calibrated in static mode an excellent way of ensuring these requirements are met, although the guidelines do include calculations for compensating for differences in temperature, should they be necessary.

Determination of Reproducibility

When dealing with AWIs, additional effects can influence calibration results, such as adjustment of the belt or the mechanical hysteresis which can result from stopping and starting the system conveyors.

To address this, the AWI is interrupted between each weighment by stopping and starting the load transport system. The more measurements taken during a cycle, the better the estimation of reproducibility. The following is the minimum number of repetitions required as defined in the calibration guideline:

Nominal mass mg of the test load	Minimum number of repetitions, n
mg ≤ 20 kg	5
20 kg < mg	3

This procedure is repeated in all calibration points with the same test loads.

Determination of Errors and Repeatability

The guideline lays out a simple set of rules for the actual weighing itself. This includes activating any equipment that is nearby the device to help ensure any vibrations or heat caused during operation is the same. The test load is then run across the AWI in a series of consecutive weighments and weight values are recorded. After each run, the device must be zeroed.

As with any statistical calculation, more samples are always preferred to fewer samples. The guidelines acknowledge that weighing multiple large test loads takes more time, so to ensure the calibration process does not take equipment offline for too long, they provide a chart which sets out several weighments to be perform based on test load mass:

Nominal mass mg of the test load	Minimum number of repetitions, n
mg ≤ 10 kg	20
10 kg < mg ≤ 20 kg	15
20 kg < mg	10

This procedure is repeated in all calibration points with the same test loads.

Determination of Effect of Eccentric Loading

The Dynamic Eccentricity Test provides an assessment of the AWI across the entire weighing surface, such as guide rails. Ideally, test loads are guided onto the conveyor using the existing handling device. However, if no product handling system exists, there needs to be an eccentricity test. The conveyor is divided into a front and back half, and the test load is run an equal number of times over the back half and the front half.

As with the normal test weighments, the weight of the test load determines the number of repetitions, as seen in the table below:

Nominal mass mg of the test load	Minimum number of repetitions, n
mg ≤ 10 kg	6
10 kg < mg ≤ 20 kg	5
20 kg < mg	3

This procedure is repeated in all calibration points with the same test loads.

3.3 Calibration Results

Once the results from the weighments along with any other measurements of environmental concerns including temperature are collected, the calculation of measurement uncertainty can begin.

According to the International Vocabulary of Basic and General Terms in Metrology (VIM), measurement uncertainty is an estimate characterizing the range of values within which the true value of a measurand lies. According to the EURAMET CG-26, measurement uncertainty of an AWI is calculated based on:

- Standard uncertainty of error of measurement
  - Standard uncertainty of the indication of the automatic weighing instrument
  - Standard uncertainty of the reference value of mass
- Expanded uncertainty at calibration
- Standard uncertainty of a weighing result
  - Standard uncertainty of a reading in use
  - Standard uncertainty from environmental influences
- Expanded uncertainty of a weighing result
  - Errors accounted for by correction
  - Errors included in uncertainty

There are several values which need to be calculated using the formulas from the guideline. Some of the required calculations are listed below.

Error of Measurement for Test Loads

For each test load L_{Tj}, the error of measurement E is calculated as follows:

$$E = \bar{I} - m_{ref}.$$

Where the mean value of several indications, $\bar{I}$ is calculated as:

$$\bar{I} = \frac{1}{n}\sum_{i=1}^{n} I_i$$

And m_{ref} is the reference value mass, is the quantity, which will be used in connection with the test load to quantify the performance of the catchweigher.

Repeatability

From the n indications I_i for a given test load L_{Tj}, the standard deviation $s(I)$ is calculated:

$$s(I) = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(I_i - \bar{I})^2}$$

Where the mean value of indications, $\bar{I}$ is calculated as:

$$\bar{I} = \frac{1}{n}\sum_{i=1}^{n} I_i$$

Reproducibility

From the five (5) indications I_i, $1 \leq i \leq 5$, for a given test load L_{Tj}, the maximum difference between the indications $\Delta I_{rpd,max}$ is calculated as follows:

$$\Delta I_{rpd,max} = I_{i,max} - I_{i,min}$$

3.4 Issuing the Calibration Certificate

After calibration, results are recorded and a complete calibration certificate is produced by the service technician or laboratory performing the calibration.

An official calibration certificate is broken into three sections: general information, information about the calibration procedure, and the results of measurement. The information presented in each section is outlined below.

General Information

This section indicates the name of the calibration laboratory or service provider performing the calibration, including accreditation information, the certificate date of issue and signatures from the authorized testing personnel. Also included under this section is information about the client and the system manufacturer and model being calibrated.

Information about the Calibration Procedure

This section includes all information about the calibration procedure, starting with the date measurements were taken and the site of calibration (including the environmental conditions at the time of calibration). The complete settings of the AWI are also listed, along with (at minimum) where to find information on how the test load's reference mass was determined, along with a complete description of the test load.

Measurement Results

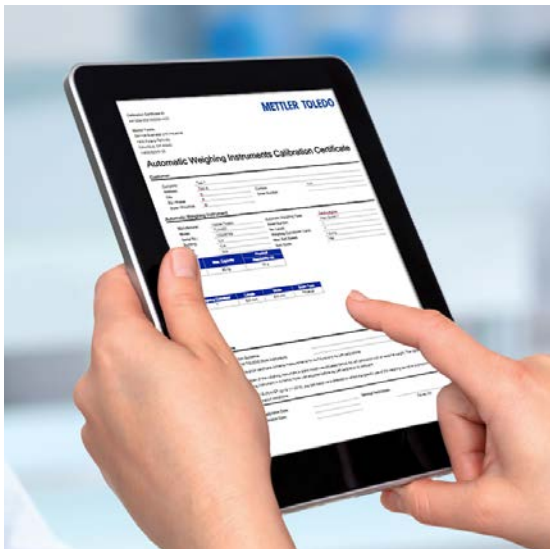
This last section includes separate entries for:

- the reference value of mass,
- the mean value of indications, and
- mean errors of indication for applied test loads.

It also includes:

- the complete number of repetitions for each measurement,
- details of each measurement procedure,
- the standard deviations determined from the testing, and (if applicable),
- the same information for all eccentricity testing.

Should any indications or errors not be determined by a standard reading – that is, a reading performed according to the calibration guidelines – a warning stating the reported uncertainty is smaller than a normal reading should be present.



Example: Partial calibration certificate.

4 How to Use Your Calibration Results

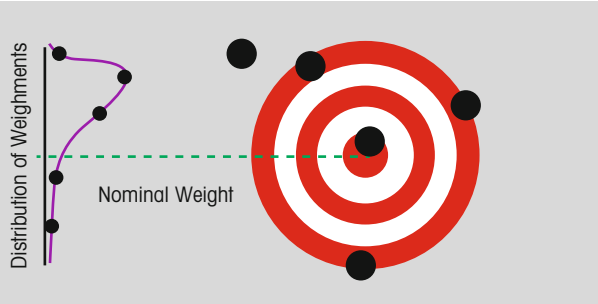
Once calibration is complete and the measurement uncertainty becomes a known quantity, the question becomes what to do with that information. Making use of this number – that is to say, drawing any conclusions about what the number implies, or deciding whether adjustments to equipment or production processes need to be made – is up to the end-user of the equipment. While the EURAMET Calibration Guideline is a great step forward it is important to note that calibration has also certain limitations. There are a few aspects which need to be considered in order to maximize its value, like applying of adjustments, as found as left testing, verification against tolerances or system functionality test.

Enhance Compliance and Profitability

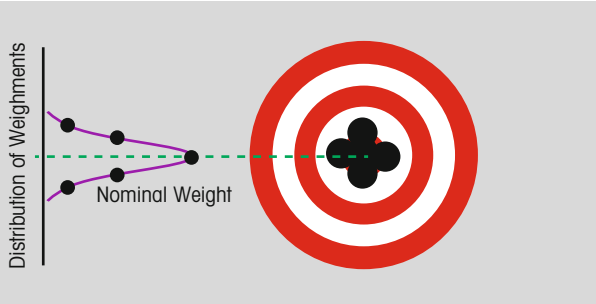
As noted, one of the most valuable benefits of defining measurement uncertainty via calibration for checkweighers and catchweighers is assuring compliance with internal or external limits, such as weights and measures regulations. These regulations are in place to make sure customers are getting the amount of product they paid for, but every regulation has its own range of acceptable values, like defined in OIML, NIST or any other. While not required by the calibration standard, verification against tolerances is highly recommend in order to improve the value and ease of use of the calibration data. For catchweighers, the highest value may come from being able to accurately cost distributed items, which can enhance profit margins.

Modern weighing instruments can produce highly accurate results, helping manufacturers save money. For example, a weighing discrepancy of a few tenths of a gram might be allowed under the regulations governing sale of a product, so a checkweigher with a tenth of a gram's worth of measurement uncertainty would be acceptable. Likewise, for shipping, exact weights can make sure shipping fees are accurate to account for fuel usage and other processing expenses.

Figure ABC shows an AWI whose results are very inaccurate and not repeatable. The results are not grouped together or near the centre of the target. Generally, if a result such as this occurs, a part of the process has failed and requires immediate attention. Figure XYZ shows a checkweigher whose results are accurate and repeatable. All results are closely grouped around the center of the target:



Graphic ABC: Inaccurate and Not Repeatable
High Standard Deviation, High Mean Error



Graphic XYZ: Accurate and Repeatable
Low Standard Deviation, Low Mean Error

Calibration identifies this weighing behavior, which is the basis to determine corrective actions. This helps to achieve more highly precise weighments and can save producers money, in terms of meeting fill regulations, or shippers, in terms of accurate revenue capture.

Manage Equipment Performance / Lifetime

A particularly high level of measurement uncertainty can be a sign that either more regular service of the AWI is needed or replacement with a more reliable instrument is required. Experienced service providers will be able to provide this context and may even include a comparison of the results with local or even global weights and measures regulations. They may also provide comparisons with other equipment being used within a given industry. Enhanced service planning via reliable calibration exercises can also extend the life of AWIs. Excessive (and expensive) downtime can be avoided, and timely replacement of wear parts and instruments themselves can help you avoid loss of revenue due to inaccurate weighing or out-of-spec products.

Leveraging Calibration Results

The object of calibration for AWIs is the indication of the instrument in response to an applied load with reference value of mass of the test load and their interpretation. Several tests are performed to determine the errors of indications, repeatability of indications, and the effect of eccentric application of a load on the indication. While the guideline itself does not require comparing "As Found" and as left measurements, for measurement and quality management purposes, it may be interesting to collect results of the machine as found, before performing maintenance and repair, and then collect the so called "As Left" calibration or verification results. Leveraging the As Found calibration information helps to make necessary adjustments to the correction factors and other settings to ensure the As Left calibration results are optimized to enhance the compliance and performance of the AWI.

5 Conclusion: Calibrate for Confidence

Ultimately, the proper execution of a calibration and verification of the results requires a service provider that is an expert in the process. A poorly executed calibration will not deliver expected calibration benefits. Always remember that a standard calibration has certain limitations which need to be considered in order to maximize its value, like verification of results or testing of system functionalities. For checkweighers, this can be achieved with a Performance Verification.

Calibration also takes time. A qualified and experienced service provider will work with you to schedule service in a way that minimizes any production/processing disruption. They will also work efficiently to keep downtime to a minimum.

As the world's leading manufacturer of weighing equipment and measurement devices, METTLER TOLEDO has the necessary knowledge, experience and capabilities to deliver an optimized calibration experience. With the breadth of our instrument portfolio and a depth of knowledge gained from more than 100 years of metrology experience, we are your source for calibration and maintenance of nearly any measurement device. Additionally, our network of authorized service providers means an experienced factory trained technician is available to visit production/process locations just about anywhere you operate.

METTLER TOLEDO Service technicians and authorized service providers are equipped with specialized and proprietary tools that are a perfect match to calibrate your instruments and maintain precision and accuracy over their entire life-time. You will always receive detailed calibration documentation that provides you with the necessary measurement data and test results in a way that is structured and easy-to-use. Fully traceable certificates will satisfy your auditor and provide the information you need to manage equipment performance.

In short, METTLER TOLEDO Service will help you make sure your processes:

- deliver accuracy,
- maintain peak performance,
- enable excellent compliance,
- capture additional revenue,
- avoid fines and recalls, and
- give you peace of mind.

Appendix: Applications and Benefits of Automatic Weighing Instruments (AWIs)

Catchweighing

Distribution Centers

Distribution centers must manage complex inventory, order fulfillment, and shipping processes. Accurate automated catchweighing enables accurate product formulation, optimizes completeness checks, reduces transportation costs, and improves logistics efficiency. Packages can be automatically sorted and directed to the correct carrier to reduce errors and increase productivity, resulting in faster and more reliable deliveries. Properly calibrated AWIs can help distribution centers:

- optimize package completeness,
- reduce transportation costs,
- prevent back charges,
- protect margins,
- enhance profitability, and
- extend the usable lifetime of equipment.

Parcel Express Shippers

Parcel management involves efficient package delivery across multiple locations. Accurate automated catchweighing enables accurate parcel measurement. This ensures that correct weights are calculated, leading to more accurate pricing and delivery charges. Particularly when paired with automated dimension capture, accurate catchweighing can help express shippers:

- streamline operations,
- enable better route planning,
- reduce delivery costs,
- enhance revenue capture, and
- improve customer satisfaction.

Checkweighing

Food and Beverage Producers

Food checkweighers prevent under- and over-filled food packages from reaching customers. Automated food checkweighing technology boosts quality control, which can support timely batch release and help manufacturers meet tight production timelines while maintaining consumer safety. Automated checkweighers can help food manufacturers:

- heighten processing efficiency,
- reduce product waste and disposal fees,
- check package completeness,
- avoid fines and recalls, and
- ensure satisfied consumers.

Chemical Manufacturers

Similar to food manufacturers, chemical manufacturers are concerned with product consistency, performance and safety. Accurate automated checkweighers can help chemical producers:

- maintain safety in harsh production environments,
- meet regulatory guidelines,
- ensure accurate filling of caustic substances,
- limit operator exposure to hazardous materials, and
- reduce or eliminate errors that can lead to unsafe situations for employees or customers.

Pharma and Biotech Producers and Packagers

Pharmaceutical checkweighers are sophisticated, automatic systems that weigh and reject any products or packages that are out of specification. Our pharma checkweighers are accurate enough to spot even the slightest weight change to help pharma producers:

- prevent over-filled or under-filled goods,
- minimize the risk that unsafe products reach consumers,
- maintain compliance with industry standards such as FDA 21 CFR,
- eliminate fines and recalls, and
- protect brand image.

Metals, Plastic and Electronics (MPE) Producers

Original equipment manufacturers, whether they work with metals, plastics or electronics, all depend on accurate incoming and outgoing goods weights to help manage production inventory. Interim components or final products may also need to be weighed either individually or in lots. Packages may also need to be inspected for completeness. AWIs are sometimes paired with other inspection devices to help MPE producers:

- assure product / package completeness,
- verify coatings or cavities in manufactured parts,
- ensure specifications are met across production facilities,
- determine whether parts will function in context as intended, and
- lower costs related to waste and rework.

Engineering, Machinery & Equipment (EME) Builders

EME builders implement AWI solutions that are tailored to their customers' unique needs so that the systems they produce can deliver accuracy and compliance. By integrating weighing systems with other technologies such as warehouse/inventory management, transportation systems and process inspection equipment, these specialists help their customers:

- optimize load capacity,
- ensure measurement accuracy,
- minimize manual interventions,
- reduce handling errors,
- deliver better service to customers, and
- stay ahead of competition.

About METTLER TOLEDO

METTLER TOLEDO is a leading global manufacturer of precision instruments. The Company is the world's largest manufacturer and marketer of weighing instruments for use in laboratory, industrial and food retailing applications. The Company also holds top-three market positions for several related analytical instruments and is a leading provider of automated chemistry systems used in drug and chemical compound discovery and development. Additional information about METTLER TOLEDO can be found at www.mt.com.

Product Inspection Equipment – Checkweigher Solutions

METTLER TOLEDO is a leader in the field of automated checkweighing technology. Our solutions increase process efficiency for manufacturers while supporting compliance with industry standards and regulations. Our systems also deliver improved product quality which helps to protect the welfare of consumers and reputation of manufacturers.

C31 StandardLine

C33 PlusLine

C35 AdvancedLine

C35 AdvancedLine Pharma

Industrial Equipment – Catchweigher Solutions

METTLER TOLEDO is also a leader in the field of automated catchweighing technology. Our solutions optimize package completeness checks, reduce transportation costs, and improve logistics efficiency for warehouses, distribution centers and parcel express carriers.

TLW360

TLW450

XS100 DualScale

TLX Advanced

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