Acquiring Type Approval for SSV Checkweigher Series

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[Summary] With the 2017 revision of the Weights and Measures Act, automatic catchweighing instruments including checkweighers, used for business trade and weight certification have been classified as specified measuring instruments meant to ensure accurate weight measurements. Aiming to ensure continued business stability, our company's checkweighers must acquire type approval and pass official inspections which meet technical standards for structure and machine error. It is in this regard that we have developed new software for our checkweigher SSV series, resulting in the acquisition of accuracy class XII type approval. Anritsu's world-beating, high-performance SSV checkweighers with dynamic balances support a high-accuracy verification scale interval of 0.05 g and are the first in the industry with this type of approval rating.

1 Introduction

Checkweighers measure the weight of products, such as foodstuffs and pharmaceuticals, within production lines and include a rejection function to remove underweight or overweight products from the line. Conventionally, they have not been subject to usage regulations even when the weight measured by these machines is used for business trading or as certified proof of weight, since they were not classified as a specified measuring instrument required to meet basic standards for structure and machine error.

However, due to the 2017 revision of the Weights and Measures Act, Anritsu checkweighers, which are automatic catchweighing instruments used for trading and certification, were re-classified as specified measuring instruments and, therefore, became required to satisfy basic standards for structure and machine error. In principle, to officially declare the specified measuring instrument as a high-accuracy machine, both the national and local governments require inspection by an approved organization to confirm that the structure and machine error satisfy the requirements of the Weights and Measures Act and apply an official approval seal without which the instrument cannot be used for business trading or certification. Users must apply for this official approval to the specified inspection organization within the validity period. The validity of the official approval seal is either 2 or 6 years (for the case of automatic weighing instruments used by appropriately managed offices). In this regard, checkweighers must be inspected periodically to ensure accurate weight measurement.

Our company has decided that to ensure continued business stability, in preparation for the official inspection, we must have our entire line of checkweighers domestically approved first while preparations for the official inspection must be executed as early as possible. Presently, we have worked mostly on development of new software to satisfy the technical conditions for standards approval and have acquired the first stage of approval in Japan.

This article introduces our approach to the official approval operation and acquiring type approval in Japan.

The JIS B 7607 (automatic catchweighing instrument) technical standard regulates acquisition of type approval and official approval tests. Moreover, we have already acquired the type approval in Europe.

Table 1 Official Approval Introduction Period

Automatic catchweighing instruments	Automatic weighing instruments with type approval (referred to as new balances)	Before April 1, 2024
	Automatic weighing instruments already in use without type approval (referred to as balances in use)	Before April 1, 2027

Important dates to note to ensure continued production are shown in Table 1. Weighing instruments which have already acquired the type approval will be the ones to be shipped by Anritsu for new orders. Those without the type approval, but already in use at factories and will continue to be used until April 1, 2024 must receive and pass the official inspection by April 1, 2027.

2 Revision of Weights and Measures Act

2.1 Background

To solve global technical and administrative problems in the use of weighing machines, the International Organization of Legal Metrology (OILM) was established in 1955. This organization not only maintains and establishes technical standards but also releases international recommendations pertaining to the structure, functions, and inspection methods for weighing machines used for business trading and certification purposes.

Incidentally, a 2017 investigation by the Japanese Ministry of Economy, Trade, and Industry found more than 30,000 automatic weighing instruments (including checkweighers) in use in Japan. As a result, since it seemed likely that the use of automatic weighing instruments for trade and weight certification purposes by businesses would become more commonplace in the future, there was an urgent need to ensure the accuracy of weighing machines. Accordingly, the Weights and Measures Act was reviewed and four classes of automatic weighing instruments, including checkweighers, were classified as specified measuring instruments.

Automatic weighing instruments operate just by executing a specific pre-determined program to obtain weight results and, therefore, do not need a human operator in the weighing process. The revised Act specifies that the four classes of automatic weighing instruments are as follows: automatic catchweighing instruments, hopper scales, automatic filling scales, and conveyor belt scales (Table 2).

Table 2 Classifications of Weighing Instruments

<table>
<tr><td rowspan="5">Specified measuring instrument</td><td>Non-automatic weighing instruments</td><td colspan="2">Stand balances</td></tr>
<tr><td rowspan="4">Automatic weighing instruments</td><td>Automatic catchweighing instruments</td><td>Checkweighers
Weight labelers
Weigh-price labelers</td></tr>
<tr><td colspan="2">Hopper scales</td></tr>
<tr><td colspan="2">Automatic filling scales</td></tr>
<tr><td colspan="2">Conveyor belt scales</td></tr>
</table>

2.2 Use of Checkweigher as Specified Measurement Equipment

One common use of checkweighers used for general business trading and weight certification is mass inspection. ("Mass" referred to here is the weight measured by the weighing instrument.)

Consumers' daily supplies (29 general products including meat, vegetables, fish, etc., hereafter referred to as "specified products"), which commonly require the measurement of some unit (weight or volume) when traded, were identified. Companies selling a specified product indicate the quantity (weight, volume, or area) according to statutory requirements as proof of the sales transaction. Accordingly, it is generally necessary for sellers to inspect product weights to confirm that it does not fall outside the specified weight. A checkweigher is used to set the standard inspection weight and reject products outside this range.

2.3 Official Approval Technology Standards

The official approval technology standards defining inherent structure and machine error are regulated by designated official inspection rules defined in JIS B 7607.

Table 3 lists concrete examples of the accuracy classes for automatic catchweighing instrument defined by JIS. Checkweighers are classified as Category X which, when sorted according to the verification scale interval, is divided into four sub-classes XI, XII, XIII, and XIIII. In addition, these categories are supplemented by a class-designated coefficient (x)*1 specified by the manufacturer (e.g., 0.5 for class XI). The SSVH series of checkweighers aims to pass the accuracy class XII specification standard.

The accuracy class is indicated by the relationship between the verification scale interval and the maximum capacity, and a smaller accuracy class indicates higher resolution. Moreover, smaller class-designated coefficients have a smaller maximum permissible standard deviation (MPSD). Therefore, a balance with both a smaller accuracy class and a smaller class-designated coefficient is a high-accuracy balance with small error.

Table 3 Automatic Catchweighing Instrument Accuracy Classes

Accuracy class	Verification scale interval (e)	Number of verification scale intervals (n = Max/e)	
		Min	Max
XI	0.001 g ≤ e	50000	—
XII	0.001 g ≤ e ≤ 0.05 g	100	100 000
	0.1 g ≤ e	5000	100 000
XIII	0.1 g ≤ e ≤ 2 g	100	10 000
	5 g ≤ e	500	10 000
XIIII	5 g ≤ e	100	1 000

Figure 1 defines what the mean error and standard deviation mean.

Mean error is the average of the absolute error values and standard deviation indicates the variation from the mean value. In other words, the performance is better when both the mean error and standard deviation are small.

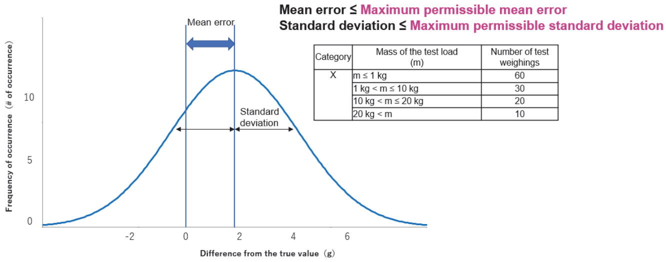


Figure 1 Standard Deviation and Mean Error

*1: The mean and standard deviation (SD) are calculated at the checkweigher weighing test to find the maximum permissible mean error (MPME) and the maximum permissible standard deviation (MPSD). Both these value must not be exceeded. The class-designation coefficient (x) in the MPSD can also be set as the coefficient. For, example, the test is stricter when comparing x = 1 and x = 0.5, because the x = 0.5 allowable value is half the x = 1 value.

2.4 Criteria for Passing Technology Standards (Structure/Machine Error)

The following two conditions must be met to pass the official standards. This model type approval must be inspected by the National Institute of Advanced Industrial Science and Technology as listed in Table 4. In addition, periodic inspections by local-government testing organizations are also required.

(1) Structure must pass technology standards (records, materials, performance)

(2) Machine error must not exceed official tolerance

Table 4 Inspection Classifications

Type approval	Inspection equipment maker must receive inspection by National Institute of Advanced Industrial Science and Technology
Official inspection	Product maker (user of inspection equipment) must receive inspection by local government inspection organization.

(1) Type approval

Test items such as lightning surges, electromagnetic immunity, resistance to electrical stress at high and low temperatures, etc., are hard to implement in a normal user's production environment. However, official type approval can be acquired from a representative model previously meeting the same technical standards for machine error, durability, environmental resistance, etc. beforehand.

(2) Official inspection

The machine error inspection is done by running repeated measurements of actual product to confirm that the MPME (official tolerance) found from the standard deviation determined by the relationship between the accuracy class and verification scale interval is not exceeded. In addition, the mean difference between the inspection result and the true weight of the inspected product (measured using an external, calibrated balance) must not exceed the official verified tolerance. The verified tolerance is determined by the verification scale interval *e* and the weight of the inspected product, equaling in value to 0.5e, 1e, or 1.5e. The measurement result error becomes smaller as the verification scale interval is narrower and the accuracy class is smaller. However, high performance can be easily adversely affected by factors in the surrounding environment, such as high temperature at the installation location, temperature change, power-supply voltage fluctuations, vibration from surrounding equipment and the nearby environment, breezes from air-conditioners, etc. As a result, it is essential to select a checkweigher taking both the installation location and inspected-product weight clearance into account and choosing the necessary specifications regarding the inspection-equipment scale, measured weight range, and best weighing accuracy.

3 Checkweigher

3.1 Purpose of Checkweigher Introduction

Checkweighers are used to measure the weight of all products — such as foodstuffs and pharmaceuticals — passing along a production line, and to reject underweight and overweight products by outputting a rejection signal to a downstream rejector. Its purpose is to sort products based on weight and to check if there are contents missing, and also to improve yield by preventing the production of overweight products which use excess raw materials, thereby decreasing losses in raw and packaging materials, the prices of which have increased recently. Moreover, checkweighers can be used in accurate product measurement, feedback control (paired with downstream fillers), data-driven production line management, and monitoring production defects, making checkweighers essential in a production line.

3.2 Checkweigher Structure and Operating Principle

Figure 2 shows the structure of a checkweigher composed mainly of the weighing instrument, conveyor, operation panel, and frame sections.

Figure 2 External Views of Checkweigher (KWS6003BP03)

Figure 3 shows the basic operating principle of a checkweigher. Products to be weighed are conveyed from upstream equipment to the auxiliary conveyor, then onto the balance conveyor where an optical sensor positioned between the auxiliary and balance conveyors will detect the presence of a product to be weighed, thereby commencing the measurement cycle. During transitions between conveyors, a product tends to become unstable and, thus, weight measurement is set to start after a fixed time delay to compensate. After each inspection, products are evaluated on a pass-fail system based on a predefined reference weight. No Good (NG) products which failed are removed from the line by sending a rejection signal to a connected downstream rejector.

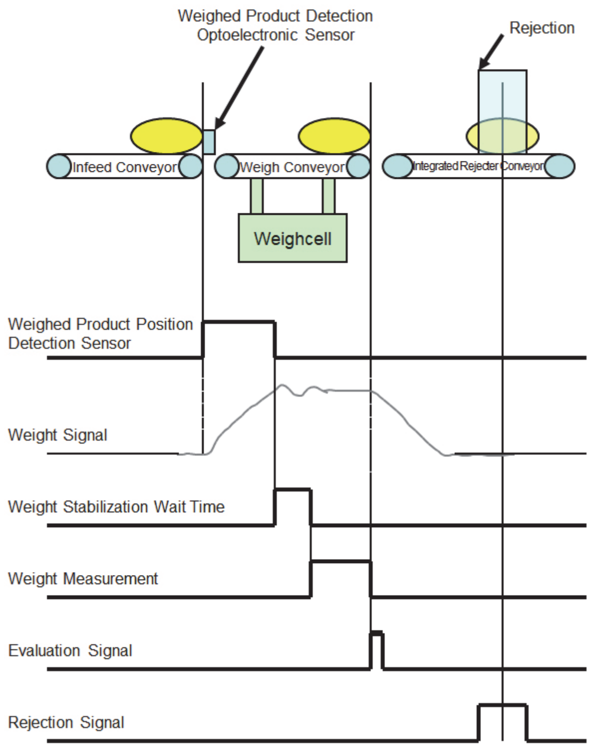


Figure 3 Basic Operation Principle

3.3 Role of Each Unit

3.3.1 Weighing Instrument Unit

The weighing instrument unit is located under the balance conveyor and is in charge of converting the product load mass to weight and transmitting this information to the operation panel where it will be displayed, making it a core part of the checkweigher. Types used commonly are either the electromagnetic weighing instrument or the load cell (strain gauge), each having different applications. Although the electromagnetic type is expensive, it has excellent response time and accuracy, making it ideal for high-speed, high-accuracy measurements. A load cell, on the other hand, consists of an elastic material attached with a strain gauge, a simpler mechanism compared to the electromagnetic balance, making it relatively less expensive and less accurate. Load cells are used where high accuracy is not the primary requirement. Note, however, that no matter the type of weighing instrument used, the zero point and span will change with respect to the ambient temperature. Because of this, to assure stable measurement irrespective of temperature at the installation location, Anritsu checkweighers have a calibration function that mitigates the impact of all temperature changes across the entire measurement range.

3.3.2 Conveyor Section

The conveyor section is composed of both the conveyor loaded above the weighing instrument unit (referred to as balance conveyor) and the auxiliary conveyor. In the balance conveyor, although only one product must be stably conveyed and weighed at a time, products are continuously being transported within the production line. It is the important function of the auxiliary conveyor, therefore, to adequately space one product from another and to match the speed of products being fed from the production line with the speed of the balance conveyor. Balance conveyors, which are selected according to the dimensions of the product to be weighed and the processing performance of the system, can be chosen from a wide range of models.

3.3.3 Operation Unit

The operation unit allows users to set measurement-related parameters and displays weight measurement, pass/fail evaluation, and statistical data among others.

4 Development Points

This section explains our current development concept and the software developed to obtain type approval.

4.1 Development Concept

Considering the official inspection and the actual operation of machines to be used for type approval acquisition, the two software development concepts formed are as follows:

(1) Support for JIS B 7607 technical standard

(2) Inspection support function

For the JIS B 7607 technical standard support, a multi-interval function, a function to restrict the weight range used (also referred to as operating weight range restriction parameter), and a function to display checkweigher specifications (also referred to as on-screen equipment specifications display) are to be provided. For the inspection support, we decided to develop a function to shorten the official inspection time.

4.2 Multi-interval Function

The multi-interval function is a function which automatically switches the checkweigher's scale according to the product weight. On the other hand, the multi-range function is a function in which the weight range and scale are set beforehand and will change only after the product has been set.

The multi-interval function was developed to satisfy one of the customers' various needs — to support multiple products with different weights in a single production line.

Figure 4 illustrates how the multi-interval function was able to satisfy this need. In comparison to heavyweight products, lightweight products require stricter quality control standards and a finer scale setting. Therefore, should lightweight products be weighed in weight range 1 of the multi-range example shown in Figure 4, the weight resolution would be inadequate and could lead to inaccurate measurement readings. Conversely, in the multi-interval example shown in Figure 4, the entire measurement range is divided into partial measurement ranges with different scales. The partial measurement range is automatically determined according to increases and decreases in the applied weight load, thereby enabling support for higher-resolution measurement of lightweight products and providing the means to accurately measure a variety of products even within a single production line.

One more advantage of the multi-interval function in comparison to the multi-range function is its ability to reduce inspection time. With the multi-range function, each weight range is considered a separate weighing instrument, and inspection must be performed for each. In contrast, since the multi-interval is treated as a single weighing instrument, the number of test conditions is significantly less, thereby reducing the inspection time as well.

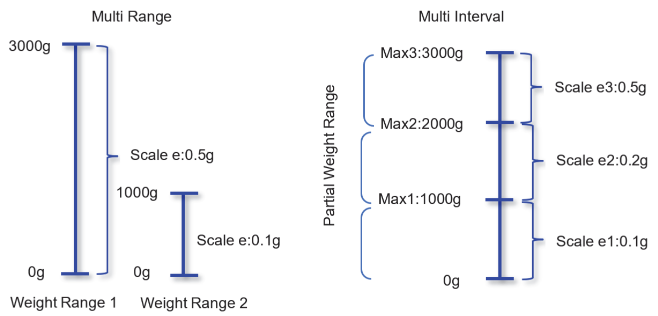


Figure 4 Multi-range/Multi-interval Functions

4.3 Operating Weight Range Restriction Parameter

Inspection of machine error is normally conducted at the following four points: minimum capacity, maximum capacity, and two additional points at which the tolerance for error changes, and requires up to 60 measurement data for each point. Restricting the operating weight range, like in Figure 5, however, reduces the number of points at which machine error will be inspected. For example, restricting the operating weight range to a range where tolerance for error is constant consequently disregards the need for evaluation at points other than the declared minimum capacity and maximum capacity. This is where the weight range restriction parameter can be utilized well. In addition, it can also be used in the test for eccentricity — a test using a load weighing 1/3 of the maximum capacity and which can be omitted if the said load is outside the declared operating weight range.

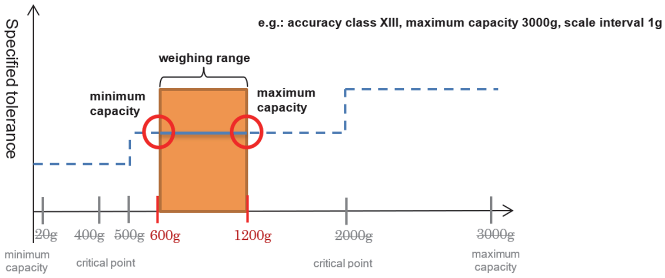


Figure 5 Reducing Errors by Controlling Measured Weight Range

Through this software development, the upper and lower limits of the operating weight range can now be set, so that the reference value can be set only within these limits after acquiring the equipment specifications label. Using this operating weight range restriction function, therefore, improves the inspection work efficiency because it allows for a more controlled operating weight range, and reduces both the number of test conditions and the number of measurement points during the official inspection of machine error.

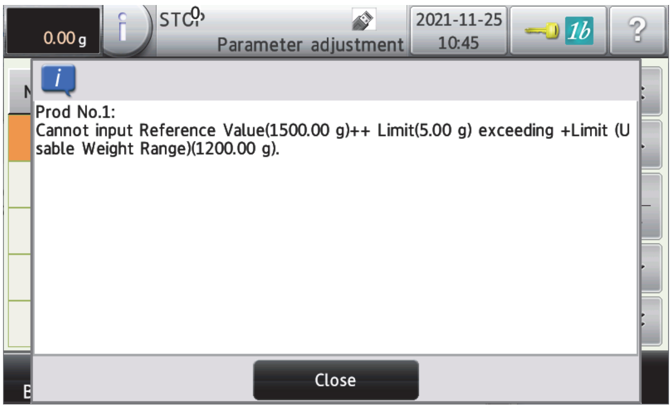
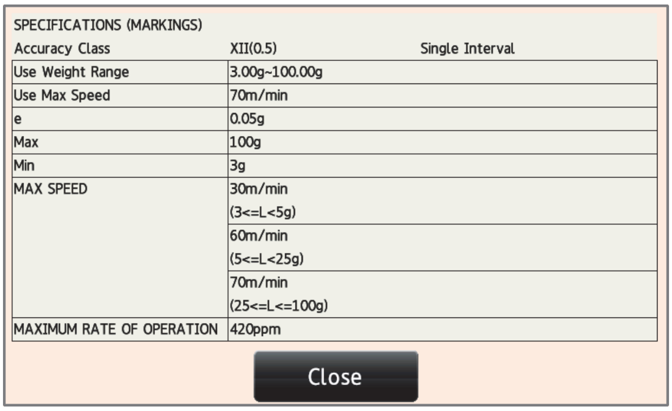


Figure 6 Controlling Reference Value Change with Usage Weight Range

4.4 On-screen Equipment Specifications Display

When inspecting structural verification notations, the accuracy class and verification scale interval of a machine need confirming. These specifications are customarily printed on a metal label and is attached to the checkweigher before shipment. However, the operating weight range and maximum operating speed, which are notations specified in JIS B 7607, are not determined at the time of shipment, but are determined at the time of initial verification. Therefore, nameplates cannot be made before shipment and can be made only at most from the time of the official inspection. Making the nameplates may take some of the time dedicated for preparation and operation instead.

To solve this issue, we developed the software such that the official inspection specifications (Figure 7) can be displayed on the operation panel. Access to this function is password-protected and only designated users may change the specifications. Because of this feature, inspection specifications can easily be checked and edited anytime through the operation panel's screen, shortening the time and work of the official inspection.


SPECIFICATIONS (MARKINGS)

Accuracy Class	XII(0.5)	Single Interval
Use Weight Range	3.00g~100.00g	
Use Max Speed	70m/min	
e	0.05g	
Max	100g	
Min	3g	
MAX SPEED	30m/min (3<=L<5g)	
	60m/min (5<=L<25g)	
	70m/min (25<=L<=100g)	
MAXIMUM RATE OF OPERATION	420ppm	

Close

Figure 7 Equipment Specifications Screen

4.5 Inspection Support Function

Inspection items are enumerated in Table 5. The maximum permissible mean error (MPME) and maximum permissible standard deviation (MPSD) are measured from the test loads from the corresponding number of test weighings. The number of weighings is dependent on the load and, at most, a maximum of 60 weighings may be required. Accordingly, the official inspection time may require several hours. Since the official inspection is carried out on an actual production line, the line must be stopped for several hours, resulting in losses in line production.

It is in relation to this that the inspection support function was developed. This function reduces the inspection time by displaying up to 60 weight values together with an indication of whether the corresponding maximum permissible mean error (MPME) and maximum permissible standard deviation (MPSD) passed or failed according to JIS technical standards.

Table 5 Inspection Types and Items

Inspection Item (Updated June 2019)		Category X New	Category X Existing
Structure	(1) Descriptive markings	○	○
Machine error	(2) Max. permissible mean error	○	○
	(3) Max. permissible error	—	—
Structure (separately defined performance)	(4) Max. permissible stand. deviation	○	○
	(5) Range of dynamic setting	○	—
	(6) Accuracy of zero-setting	○	○
	(7) Accuracy of tare setting	○	—
	(8) Eccentric loading effect	○	—
	(9) Alternative rate of operation	○	—
	(10) Stability of equilibrium	○	—
	(11) Matching of display and printer	○	—
	(12) Protection of components parts and pre-set controls	○	—

4.5.1 Individual Weight Display Function

The number of weighings is dependent on the test sample's weight and, at most, a maximum of 60 weighings may be required. With the individual weight display function, evaluations with this many weighings can still be performed easily. With this function, more than 60 weight values can be displayed on the screen at a time, arranged in the order it was detected by the balance conveyor. This allows, therefore, for errors to be identified in real-time, such as when two products are simultaneously fed to the balance conveyor at the same time (referred to as double-product feed error). Additionally, the weighing values can be saved in a USB flash drive or printed out on a printer, so as to be used as inspection evidence later on.

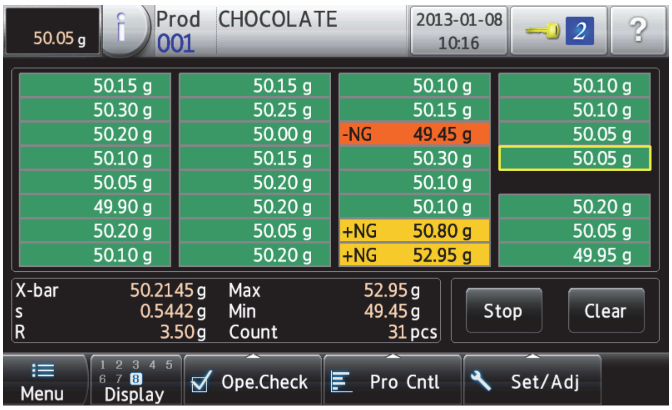


Figure 8 Individual Weight Display Function

4.5.2 Accuracy Check Function in Accordance with JIS B 7607

The accuracy check function is a standard built-in function of the SSV checkweigher series and is used by line operators to confirm operation before and after product manufacturing. Since the standard checkweigher accuracy is evaluated as Repeated Weighing Accuracy 3σ + Deviation $\leq$ Control Accuracy, it is different from the JIS values (MPSD and MPME). This accuracy check function performs the pass/fail evaluation by checking the accuracy in accordance with JIS B 7607. Since it can be executed by production line operators, it is useful for pre-inspections conducted prior to official inspections.

5 Pre-Inspection General Evaluation

After developing this software, the following two general evaluations were performed to confirm that the checkweigher functions and technical requirements were satisfied.

(1) Structural (notations and performance) compliance with technical standards

(2) Machine error not exceeding official tolerance

Structural compliance was confirmed by checking that the zero- point change at 5, 15, and 30 minutes after starting was within 0.25e.

The test for eccentricity confirms that the MPME and MPSD standards are satisfied by measuring for a specified number of test times a test load weighing 1/3 of the maximum capacity and positioned halfway from the belt center to the front of the belt, and halfway from the belt center to the back of the belt.

Machine error, on the other hand, is measured by choosing four test weights (maximum and minimum weights + two intermediate weights) and measuring for the specified number of test times at the maximum operating speed. The measurement results are used to confirm that the MPME and MPSD are satisfied.

After evaluating the results of the above two items, the official test is judged to have been passed and the checkweigher receives official approval.

6 Approach Before Model Type Approval

Type approval testing can take a long time from 1 to 3 months. Because we are the first in this industry to make an application, there were many uncertain parts in the type approval examination tests. However, we were able to shorten the verification process by replacing the test order as necessary, by correctly understanding the test method and identifying factors that affect the performance of the checkweigher during the preliminary verification done in-house.

After obtaining type approval, the official inspection must be passed before shipping. This development executed shipping inspection on the assumption that the official inspection would surely be passed. Additionally, to help shorten the official inspection time, we developed an official inspection support function assuming operation of the full-scale official approval inspection from the development stage. However, there are still some undecided items in the type approval tests and official inspection. Therefore, by participating in the planning and revision of JIS B 7602 by the Ministry of Trade, Economy, and Industry, and the National Institute of Advanced Industrial Science and Technology, Anritsu has contributed to more realistic operation of inspection equipment from the viewpoint of a test-equipment manufacturer by incorporating concerns about official inspection tests of weighing equipment with multiple weighing instruments and simulated work plans.

7 Conclusion

Using our company's strengths in electromagnetic weighing instruments, we have built the checkweigher SSV series with world-beating, best-of-class weighing accuracy (0.05 g verification scale interval) that have now become one of the first models in the industry to receive accuracy class XII type approval. This high-performance class type approval supports precision weight inspections on users' production lines and increases yield. At the same time, we have developed functions to shorten official inspection work times, helping improve producers' line productivity.

We will continue to develop products that contribute to the SDGs by improving the production efficiency of manufacturers, ensuring the safety and security of consumers through proper weighing, and reducing the loss of raw materials.

References

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2) Atsushi Iida, Junichi Tamura, Kenta Yamada, Kohei Suzuki, Hironori Sato, Takamasa Ito, Hirotaka Anzai, Mark Bajo: "Development of SSV Series Multilane Checkweighers", Anritsu Technical Review No.27 (Sep. 2019)

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