

Development of the Next-Generation Flagship Checkweigher Series

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[Summary]

Anritsu developed a new flagship checkweigher, with an industry-leading sorting performance of up to 1000 pieces/minute and a maximum measurement accuracy of $3\sigma \pm 0.006$ g. The biggest challenge to achieving these ultra-fast weighing speeds is improving responsivity. This was resolved by designing a force-balance type weighcell with a new built-in filter processing and digital feedback control, and by optimizing the weighing conveyor's center of gravity. The diameter of conveyor rollers was reduced to 5 mm, improving product transfer stability. The weighcell pedestal was separated from the checkweigher frame and was made as a truss structure, achieving 1.75 times higher natural frequency when compared to the previous checkweigher series, and as a result, reducing the impact of vibration from external sources. The rejector unit was equipped with a built-in rejector timing correction function, improving line yields by decreasing sorting errors caused by conveyance of disordered products.

1 Introduction

Checkweighers (CW) are used mostly on food and pharmaceutical production lines to measure the mass of every product. They are coupled with a rejector unit that then removes defective products, those that failed to meet the specified mass criteria from the line. There are several purposes for introducing a CW in a production line, from sorting of underweight/overweight/missing products, to minimizing filling losses by providing feedback control to the filler machine. Anritsu entered the CW market in 1964, and since then has been producing models that meet the needs of the changing times, maintaining a strong presence in Japan's domestic market.

More recently, there is a demand for increased production line productivity, a result of rising labor costs due to worker shortages and shorter working hours due to social reforms. As an example, the latest packing machines on the production lines for individually packed candies and pharmaceuticals can handle more than 800 pieces per minute. This requires the surrounding machinery to match the maximum performance of the packing machines. Production line operating rates are also increasing, and more lines are running for 24 hours a day. Implementing high operating rates requires machines that can run for long periods without failure, and that can undergo maintenance for a minimal downtime. There is also an increasing need for high accuracy weighing: to improve yields to offset the rising costs of raw materials, and to cut losses due to rejection of faulty products.

To meet these market needs, Anritsu has developed its 9th generation flagship CW, the AW9 series, using its dynamic weighing technologies accumulated from over 50 years of experience (Figure 1). Achieving a maximum sorting performance of 1000 pcs/minute and a maximum measurement accuracy of $3\sigma \pm 0.006$ g, it is a machine designed to support ultra-fast production lines. Furthermore, it has an easy-to-clean and high-reliability design that features tool-free assembly/disassembly, reducing downtimes which leads to improved productivity. This article introduces the technical approach to developing this series.



Figure 1 External View of the AW9 Series Checkweigher

2 Basic Structure and Operation Principle of the AW9 Series Checkweigher

2.1 Basic Structure

As shown in Figure 2, the AW9 series is configured with a weighcell and three belt conveyors of the infeed, the weighing, and the rejector units. The weighcell is located under the belt conveyor of the weighing unit.

2.2 Weighing Unit (Weighcell)

The weighcell converts the load due to the mass of the weighed product to a readable measurement value. A force-balance type weighcell supporting high-speed weight measurement is designed for the AW9 series.

2.3 Conveyor

Products are conveyed by the three belt conveyors of the infeed, the weighing, and the rejector units. During measurement, since there must only be one product on the weighing unit to get a stable reading, the infeed unit conveyor adjusts the fed product interval so that products to be weighed are carried onto the weighing unit conveyor at a constant interval.

2.4 Rejector Unit

The rejector unit separates under/overweight products from correct-weight products based on the measurement results. It uses an air jet mechanism, and both two and three-direction rejection are supported.

2.5 Operation Unit

The operation unit is for displaying the measurement values, evaluation results, statistical data, etc., as well as for setting operation parameters. It uses a high-visibility 15-inch color LCD touch panel. It can also be rotated and tilted; its position can be adjusted depending on the usage conditions.

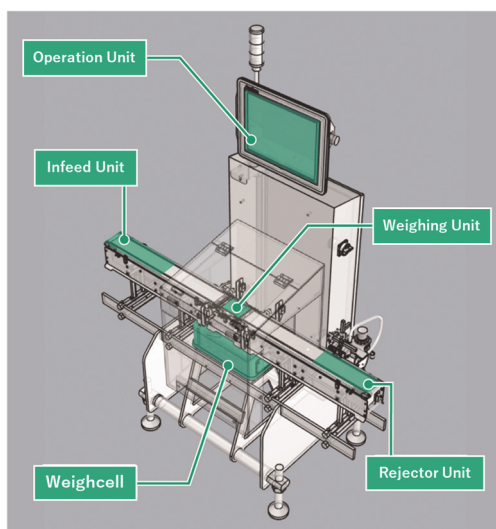


Figure 2 Structure of the AW9 Series Checkweigher

2.6 Basic Operation Principle¹⁾

Figure 3 shows the basic CW operation principle.

An optoelectronic sensor located at the gap between the infeed unit conveyor and weighing unit conveyor detects the passage of the product to be weighed, and measurement is made after the weight signal stabilizes at a certain time interval. These measurement values are evaluated as having passed or failed based on the set limits, and under/over-weight products are removed by the rejector unit.

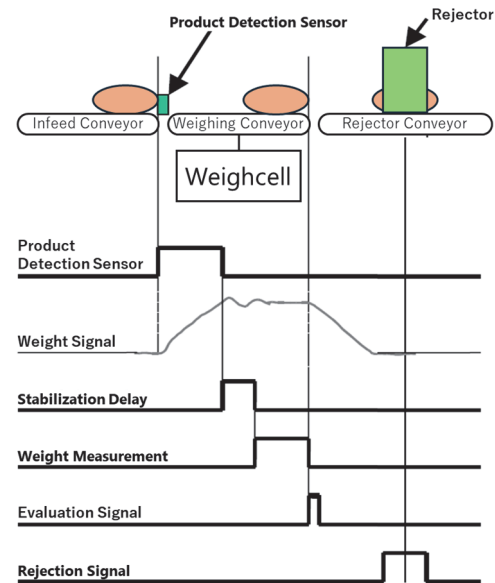


Figure 3 Basic Operation Principle

3 Development Concept

The development of the AW9 series focused on the following key issues to meet market requirements.

- (1) Ultra-Fast, High-Accuracy Weighing
 - Upgrade the maximum sorting performance to 1000 pcs/minute from 600 pcs/minute of the previous CW series
 - Achieve $3\sigma \pm 0.006$ g maximum measurement accuracy
 - Ensure accurate sorting performance that matches fast weighing
 - Improve resistance to external vibrations that cause reduced measurement accuracy
- (2) Reduced Downtime
 - Implement a design with better cleanability and IP54 water resistance
 - Improve sanitary design by using solid materials and fully welded parts
 - Use long-life mechanical parts

- Support tool-free assembly/disassembly
- (3) Improved Operability
- Use a large, high-visibility display for better operability

4 Development Points and Implementation

4.1 Ultra-Fast, High-Accuracy Weighing

Figure 4 shows the weight signal waveforms when a product is weighed multiple times. In comparison to the previous CW series that has a measurement range of about 1.5 g, the AW9 series has a lower range of 0.4 g, achieving higher measurement accuracy. This section introduces the design of a new force balance weighcell and conveyors, technologies that made ultra-fast and high-accuracy weighing possible.

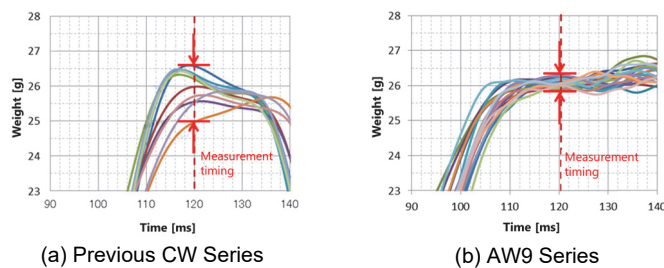


Figure 4 Comparison of Measurement Range

4.1.1 Improved Balance Responsivity

With the filter function of the previous CW series, when sorting performance exceeds 600 pcs/minute, the delay time increases to the point where obtaining correct measurements becomes difficult. In the AW9 series, the number of stages in the analog filter built into the weighcell is reduced by one and the cutoff frequency is optimized for ultra-fast weighing. As a result, the delay time is reduced by 24% when compared to the previous CW series, making ultra-fast weighing possible (Figure 5). The window functions of the digital filter are also increased, enabling automatic selection to achieve optimal weighing depending on product mass and belt speed, making high-accuracy weighing possible.

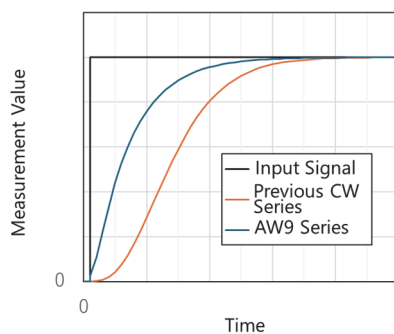


Figure 5 Comparison of Step Input vs Response

In addition, the weighcell feedback control contributes to high-accuracy weighing by changing parameters according to the product type, the conveying conditions, and the installed weighing conveyor. In the previous CW series, fine adjustment of parameters is not supported because analog circuits are used, which prevents optimization according to varying conditions. In contrast, the AW9 series uses digital circuits, so while the circuit board area remains the same size as the previous CW series, the parameter adjustment range is about 300 times bigger, and the resolution is about 9000 times better. As a result, settings can now be adjusted to fit with various conditions, making optimized control possible (Figure 6).

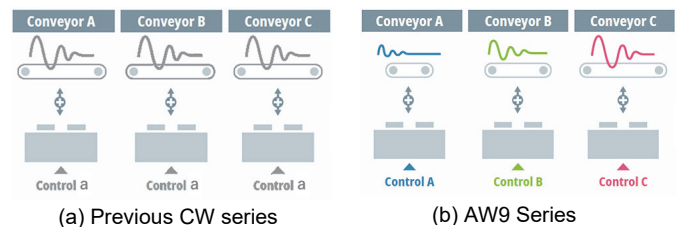


Figure 6 Optimum Feedback Control

4.1.2 Improved Responsivity Through Center of Gravity Optimization and Mass Reduction of Conveyor

Although the previously mentioned feedback control parameters can be optimized to fit every specific conveyor, in order to further increase responsivity, the center of gravity (CoG) of the weighing conveyor should be positioned near the center of the weighcell to minimize any unbalanced load. To change the position of the CoG, the restrictions in the positioning of the weighing conveyor must be solved and the design principle of the previous CW series needs to be changed. In the AW9 series, a new design principle is adopted, where it is standardized to have both an infeed conveyor and a rejector conveyor, with the weighing conveyor positioned in between. This configuration shifts the CoG of the conveyor closer to the center of the weighcell (Figure 7). In addition to shifting the CoG, reducing the mass of the conveyor is also effective in improving responsivity, thus the weighing conveyor is made lighter by 22% in comparison to the previous CW series. A model with compact conveyor of belt width 70 mm and length 100 mm, targeted for smaller products, is also added to the lineup of the AW9 series.

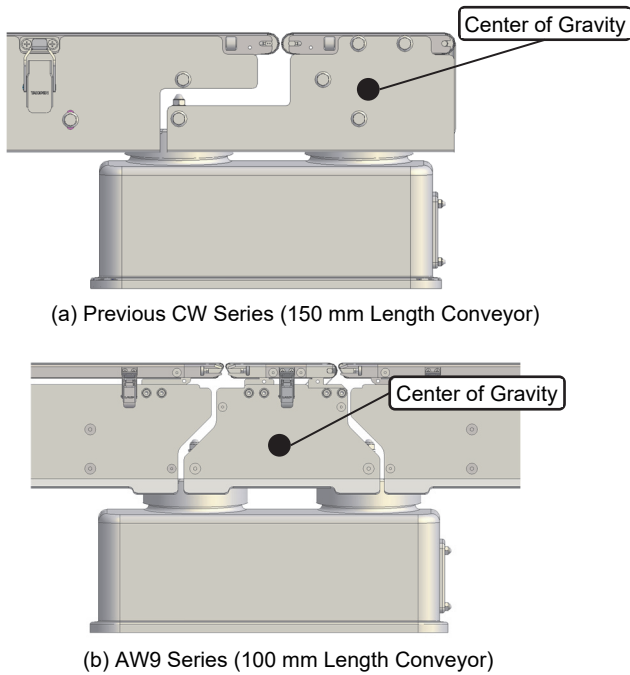


Figure 7 Weighing Conveyor

4.1.3 Improved Product Transport Stability and Conveyor Vibration Reduction Through Smaller Rollers

When products to be weighed are transported from the infeed conveyor to the weighing conveyor, stable weighing can be prevented by discrepancies in the measurement timing due to the orientation of the product becoming disordered, or by vibrations caused when products bump as they pass through the gap between the conveyors. These effects become more pronounced as conveying speeds become faster. To reduce these issues, the gap between the conveyor rollers should be minimized. In the AW9 series, the diameter of rollers at the gap between the infeed conveyor and weighing conveyor is reduced from the previous CW series' 18-mm to 5-mm (Figure 8). As a result, the orientation of products remains stable as they pass through the gap between the conveyors, even at ultra-fast sorting performance of 1000 pcs/minute, making high-accuracy weighing possible. Moreover, high-accuracy weighing of tall products with relatively poor stability is also possible.

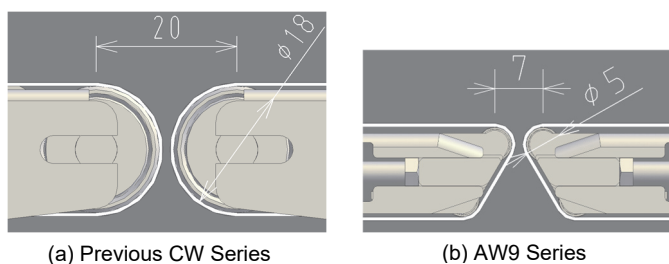


Figure 8 Gap Between the Infeed and the Weighing Conveyors

There is also the innate vibration generated from the rollers and the belt of the weighing conveyor itself, which contributes to the dispersion of measurement values. By reducing the diameter of the rollers, the frequency of the generated vibration increases at the same conveyor speed. Since the attenuation effect of the weighcell filter function is greater on higher frequencies, the dispersion of measurement values due to conveyor vibration is reduced by as much as 45% when compared to the previous CW series (Figure 9).

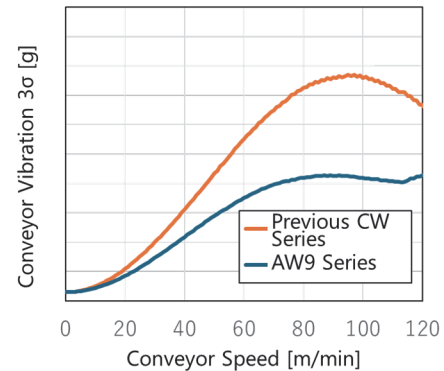


Figure 9 Dispersion of Measurement Values due to Conveyor Vibration

4.2 Air Jet and Rejector Timing Correction Function

4.2.1 Effect of Air Jet on the Measurement Values

When using an air jet mechanism on a checkweigher, the effect on the measurement values due to airflow and pressure change while air is being blown becomes an important consideration. This effect is influenced by the orientation of the air nozzle and its distance from the weighing unit. And by finding the optimum balance between these influencing factors, high-speed sorting performance coupled with high-accuracy weighing is achieved (Figure 10).

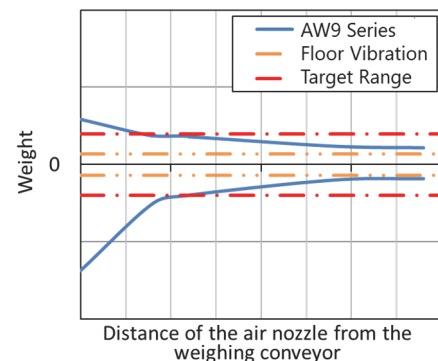


Figure 10 Dispersion of Measurement Values While Air is Being Blown

4.2.2 Rejector Timing Correction Function

As conveying speeds increase, the orientation and spacing between products can also become more disordered. When this happens, there will be variation in the time between when the product passes through the product detection sensor and when it reaches the rejector, leading to sorting errors. In the previous CW series, a sorting confirmation function is equipped to detect sorting errors, removing any product affected regardless of its measurement value. However, this approach reduces yields in the production line.

In the AW9 series, in addition to improved product transfer stability due to the conveyor design, there is now also a built-in rejector timing correction function (Figure 11).

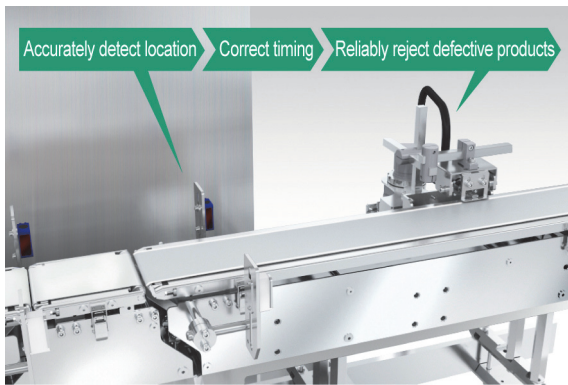


Figure 11 Rejector Timing Correction Sensor

An optoelectronic sensor mounted at the rejector unit detects the passage of weighed products, and the rejector timing correction function calculates the remaining time until the products reach the rejector. By using this calculated time to adjust the rejector timing, the rejector activates at a definite time interval after products pass through the optoelectronic sensor (Figure 12). With this function, yield is improved by reducing sorting errors caused by conveyance of disordered products.

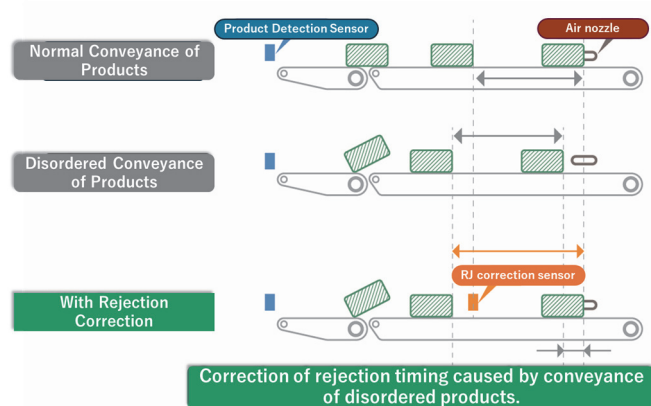
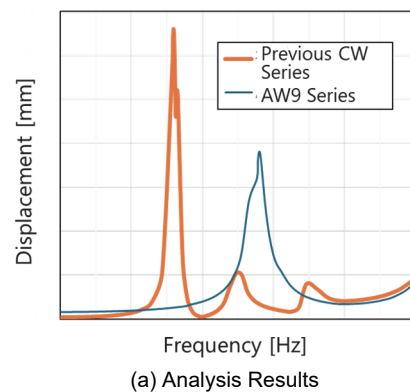


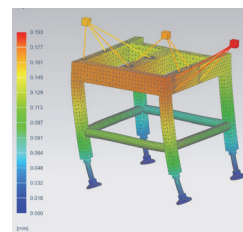
Figure 12 Rejector Timing Correction Operation

4.3 Countermeasures for External Vibration

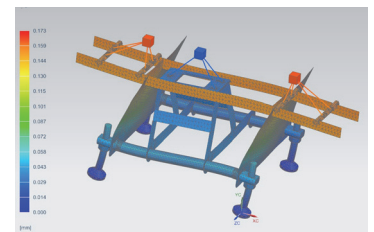
Vibration has a large negative impact on the measurement accuracy of a weighcell. In a production line, surrounding equipment transmits vibration through the floor, and components from the CW itself such as conveyors transmit vibration through the frame, making it impossible to completely eliminate the effects of vibration. In the AW9 series, the weighcell pedestal is separated from the CW frame, reducing the amount of vibration being transmitted from vibration sources to the weighcell. Additionally, the weighcell pedestal is made as a truss structure, increasing the rigidity in all the X, Y, and Z directions, and as a result improving the weighcell responsivity and filter attenuation effect. Figure 13 shows the dynamic response analysis results. The natural frequency of the frame is 1.75 times higher when compared to the previous CW series and the displacement of the weighcell pedestal is reduced by 42%.



(a) Analysis Results



(b) Previous CW Series



(c) AW9 Series

Figure 13 Dynamic Response Analysis Results and Contour Diagram of the Frame

4.4 Reducing Downtime

To reduce downtime, the development of the AW9 series is focused on the following: shortening of cleaning time by improving on sanitary design, and reducing parts replacement frequency by using highly durable parts, primarily on the moving components of the conveyors. Particularly for the cleanability, special attention is paid to the sanitary requirements listed in Table 1. This section explains the details.

Table 1 List of Sanitary Requirements

Requirement
Minimize microbial growth.
Prevent accumulation of water on surfaces.
Ensure the ease of cleaning.
Use only materials specified in regulations for parts in contact with foods.

4.4.1 Cleanability

Considering regular washdowns and exposure to water, the frame is designed to prevent the growth of microbes. This is accomplished by using solid materials, by reducing flat surfaces as much as possible, and by incorporating fully welded joints. In addition, the surface contact between the parts of the conveyors is minimized and the chassis and the windshield covers are made to have inclined surfaces, preventing water and dust accumulation. The AW9 series has an IP54 rating, guaranteeing protection against dust and water splashes.

4.4.2 Usage of Long-Life Mechanical Parts

To meet the demand for increased productivity, production lines running for 24 hours a day have been increasing. In response, motors with higher capacity than the ones in the previous CW series are used. By increasing the load margin for conveyance, the heat generated by the motor during operation is reduced, leading to increased lifespan. Lastly, two choices for motor capacity are added to the lineup of the AW9 series, allowing optimized selection depending on product mass and specific conveying conditions.

4.4.3 Tool-free Assembly/Disassembly

The newly designed high-speed air jet and product guides are fixed in place using clamp levers and thumb screws, allowing for their easy removal. The conveyor body is attached to the conveyor frame using catch clips, and the tension of the conveyor belt is adjusted using thumb screws. Everything can be removed and disassembled completely without tools, facilitating the quick cleaning of the conveyors (Figure 14).

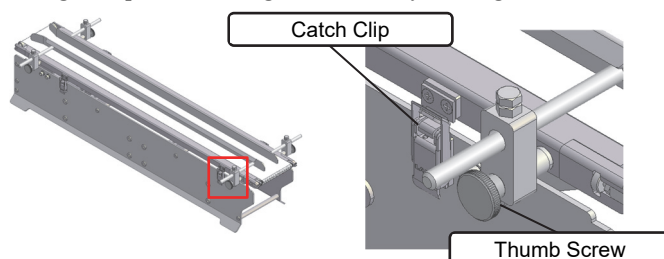


Figure 14 Tool-Free Assembly/disassembly

4.5 Improved Operability

A high-visibility 15-inch color LCD touch panel is used to easily view and quickly understand the operating status of the machine, the production conditions, and the presence of errors/alarms. This section introduces some of the operation screens.

(1) Statistics Screen

This screen is used to confirm various types of information, such as the overall and the passed products statistics. It can also be used to confirm the production start time, total mass measured, average mass, standard deviation, etc., allowing the detailed checking of production conditions (Figure 15).



Figure 15 Statistics Screen

(2) Magnified Measurement Display Screen

This screen is configured in such a way that the measurement values and the evaluation results (pass/underweight/overweight) can be easily viewed by the user, even at a distance. Information regarding sorting performance can also be confirmed here (Figure 16).



Figure 16 Magnified Measurement Display Screen

(3) IO Timing Adjustment Screen

This screen is used to check signals from the sensors and the rejectors. Rejector timing can also be confirmed here, making it easy to make timing adjustments for each individual product. Sampling cycle can be selected from 1 ms/5 ms/10 ms (Figure17).

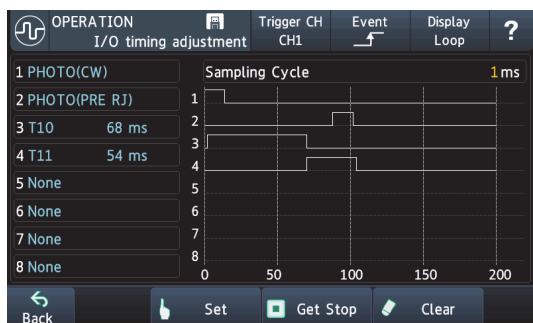


Figure 17 IO Timing Adjustment Screen

(4) Rejector Timing Correction Adjustment Screen

This screen is used to automatically adjust rejector timing correction related parameters by feeding the target product multiple times. This simplifies the usage of the RJ timing correction function (Figure 18).

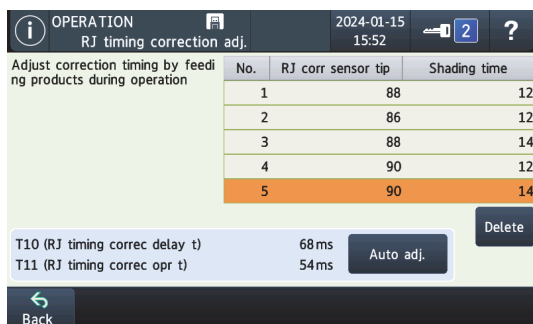


Figure 18 Rejector Timing Correction Adjustment Screen

5 Main Specifications

Figure 19 shows the AW9 series' external dimensions diagram, and Table 2 lists the main specifications.

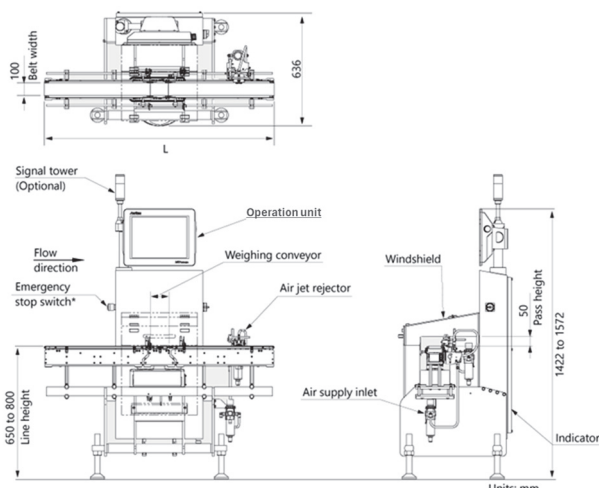


Figure 19 KWA7241APANN External Dimensions Diagram

6 Conclusion

Anritsu has successfully developed its flagship AW9 checkweigher series with a weighcell and conveyors

optimized for ultra-fast weighing. It boasts an industry-leading sorting performance of up to 1000 pcs/minute and a maximum measurement accuracy of $3\sigma \pm 0.006$ g. This flagship model is the ideal solution for product quality assurance and productivity improvement on food and pharmaceutical production lines. With its aim to continue providing new value to its customers, Anritsu will focus on developing new models and expanding the lineup of the AW9 series.

References

- 1) A.Iida, J.Tamura, K.Yamada, K.Suzuki, H.Sato, T.Ito, H.Anzai, M.Bajo: "Development of SSV Series Multilane Checkweighers" Anritsu Technical Review No.27, pp.17-24 (Sept. 2019)

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Table 2 Main Specifications

Model		KWA7241AP■N△	KWA7242AP■N△	KWA7243AP■N△	KWA7244AP■N△	KWA7245AP■N△
		■: A (High-speed airjet)/N (no rejector) △: C (CE marking compliance)/N (No optional standards compliance)				
Weighing Range		1.2 to 660 g				
Display Scale		0.002 g				
Max. Sorting Performance		1000 pcs/minute	900 pcs/minute	720 pcs/minute	540 pcs/minute	400 pcs/minute
Max. Measurement Accuracy (3σ)		±0.006 g				
Display		15-inch touch panel color TFT LCD				
Operation Method		Touch panel				
Max. Displayed Mass		660.9 g				
Supported Product Variety		200 product types				
Rejector Stages		2 (3 as option)				
Weighing Conveyor Length		100 mm	120 mm	150 mm	200 mm	270 mm
Supported Product Dimensions	Width	20 to 70 mm	20 to 100 mm			
	Length	24 to 90 mm	24 to 100 mm	24 to 130 mm	24 to 180 mm	24 to 240 mm
	Height	5 to 90 mm	5 to 100 mm	5 to 130 mm	5 to 180 mm	5 to 240 mm
Belt Speed		110 m/minute	132 m/minute	165 m/minute	180 m/minute	
Power Supply		AC100 to 120 V +10%/–15% or AC200 to 240 V +10%/–15%, 50/60 Hz single phase				
Power Consumption		140 VA				
Air Supply		0.5 to 0.9 MPa				
Mass		155 kg				
Operating Environment		0° to 40°C (≤5°/h change) Relative humidity 30% to 85% with no condensation				
Protection Class		IP54				
External Finish		Stainless Steel (SUS304)				
Data Output		USB2.0/Ethernet (10BASE-T, 100BASE-TX)				

Publicly available