SameGram
Guangdong Saiguan Intelligent Equipment Co., Ltd.

Checkweigher Selection & Precision Calibration

A Technical Guide for Production-Line Quality and Net-Content Compliance

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Empowering compliant, cost-efficient production lines worldwide

Contents

1 Executive Summary

A checkweigher is a high-speed, in-line automatic weighing system that measures the weight of every discrete product on a production line and classifies it as under-, accept-, or over-weight — typically actuating a reject device to remove non-conforming items. SameGram's SC1 Series dynamic checkweighers serve the food, beverage, pharmaceutical, chemical, personal-care, hardware, and e-commerce logistics industries, carrying three jobs at once: **regulatory compliance, cost control, and quality assurance**. As global net-content rules tighten (the EU average-weight system and e-mark, U.S. NIST Handbook 44 / NTEP) and as plants adopt MES/ERP traceability, the checkweigher has evolved from a simple "throw-out-the-light-pack" tool into a quality-data hub on the line.

This white paper presents a structured framework for **selecting** a checkweigher and **keeping it accurate** throughout its service life, with particular attention to the European and North American regulatory environments. Its core conclusions:

- Selection is not "buy a scale" — it is an engineering match across four factors: **product, line, regulation, and data**.
- Accuracy is defined by the OIML R51 accuracy class, the verification division **e**, and the dynamic standard deviation together — never by a bare "**±1 g**" marketing claim.
- Calibration is the lifeblood of accuracy: **static calibration is only the start**; dynamic calibration and continuous monitoring sustain long-term compliance.
- Define the **Minimum Detectable Variation (MDV)** first, then work backward to the required division and class — avoiding both over-spec (waste) and under-spec (non-compliance).

> **KEY POINT Who Should Read This**
> Quality managers, process and equipment engineers, procurement decision-makers, and anyone responsible for net-content compliance or line digitalisation. The content bridges principle and practice and can be used directly as a selection-review and calibration-SOP reference.

2 Understanding Checkweighers

2.1 Definition & Operating Principle

A checkweigher — in OIML terminology an **automatic catchweigher** — weighs items automatically as they pass on a conveyor, without interrupting line cadence, and makes a pass/fail decision against preset limits. A SameGram SC1 Series unit combines a high-resolution digital load cell with an adaptive DSP algorithm to deliver high-speed, high-accuracy dynamic weighing, and stores up to 100 product recipes for fast changeover.

The operating sequence is:

- **Product entry** — the upstream conveyor feeds the item onto the feed section, which controls spacing.
- **Photoelectric trigger** — a sensor detects the leading edge and starts the weighing timer.
- **Dynamic weighing** — as the item crosses the weigh conveyor, the load cell captures the signal; the DSP filters and compensates to compute the true weight.
- **Classification** — the result is compared with the configured Under / Accept / Over limits.
- **Rejection** — a non-conforming item triggers the reject device at precise timing.
- **Data logging** — every result is recorded; under/accept/over statistics update in real time.

Feed & Spacing → Weighing Zone (Load Cell + DSP) → Classifier Under / Accept / Over → Accept / Reject Out

Figure 2-1 Checkweigher operating principle (SC1 Series)

2.2 Checkweigher vs. Related Equipment

Aspect	Checkweigher	Non-Automatic Scale (NAWI)	Multihead Weigher	Weigh-Label Scale
Primary use	Inline pass/fail & reject	Static precision weighing by hand	Target-weight combination filling	Weigh + print label inline
On the line?	**Yes, inline**	No	Yes (filling stage)	Yes
Standard	OIML R51 (automatic)	OIML R76 (non-auto)	OIML R61 (gravimetric fill)	OIML R51 (Y)
Key output	PASS/FAIL + data	Weight reading	Combined weight	Weight + label

Table 2-1 Checkweigher vs. related equipment

2.3 Why Checkweighers Matter to Manufacturers

- **Compliance risk** — under-filled packs trigger regulatory penalties and brand damage (EU e-mark, U.S. net-quantity rules, China packaged-goods metrology).
- **Give-away cost** — over-filling is hidden margin loss; a closed-loop checkweigher recovers material.
- **Quality consistency** — real-time drift monitoring warns of process or equipment anomalies early.
- **Data asset** — weight data feeds MES/ERP for traceability, batch control, and continuous improvement.

3 Seven Core Dimensions of Selection

Selection is fundamentally "meet line cadence and regulatory accuracy at the lowest total cost." The seven dimensions below must be evaluated together — none in isolation.

3.1 Weighing Range & Division (Max / Min / e / d)

Max (maximum capacity) should exceed the heaviest product plus packaging; **Min** (minimum capacity) is bounded by the accuracy class and is not guaranteed below that point. **e** is the verification scale interval (the legal minimum step); **d** is the display division. For dynamic checkweighing, typically e = d. The smaller the division and the larger the capacity, the harder the sensor and algorithm — and the higher the cost — so balance precision against budget. The SameGram SC1 Series spans **10 g – 6000 g** with a load-cell resolution of 0.01 g.

> **TIP Rule of thumb**
> Keep the nominal pack weight within **20%–80% of capacity**, and choose e so that nominal weight ÷ e meets the division count your class requires. E.g., a 500 g pack at OIML XIII (≥500 e) needs e ≤ 1 g.

3.2 Accuracy Class & Tolerance (OIML R51)

OIML R51-1:2006 divides automatic catchweighers into **Category X** (checkweighing of prepacked goods) and **Category Y** (other automatic weighing, e.g. weigh-label, postal). Category X has four accuracy classes — **XI, XII, XIII, XIV** — each supplemented by a factor **(x)** (1×10□ / 2×10□ / 5×10□; common x = 0.5, 1, 2). Higher class = more divisions = finer application. WELMEC guidance recommends a checkweigher of at least **X(1) or XIII(1)** for prepack inspection.

Accuracy class	Category	Typical application	Max divisions (e)	Common x
XI	X (prepack)	High-value / low-dose: pharma, precision parts	≤ 200,000 e	0.5 / 1
XII	X	General high-speed lines	≤ 100,000 e	1 / 2
XIII	X	General pack check (WELMEC floor)	≤ 10,000 e	1 / 2
XIV	X	Large capacity, lower resolution	≤ 1,000 e	1 / 2
Y(I)–Y(b)	Y (other)	Weigh-label, postal, loose single-load	Per Y ranges	—

Table 3-1 OIML R51 accuracy classes

Maximum permissible mean error (MPE) varies with load and class, expressed in verification divisions e:

Class	Low load	Mid load	High load
XI	≤50,000 e → ±0.5 e	50,000–200,000 e → ±1.0 e	>200,000 e → ±1.5 e
XII	≤5,000 e → ±0.5 e	5,000–20,000 e → ±1.0 e	20,000–100,000 e → ±1.5 e
XIII	≤500 e → ±0.5 e	500–2,000 e → ±1.0 e	2,000–10,000 e → ±1.5 e
XIV	≤50 e → ±0.5 e	50–200 e → ±1.0 e	200–1,000 e → ±1.5 e

Table 3-2 OIML R51 maximum permissible mean error (MPE)

3.3 Throughput & Line Speed

Throughput (units/min) must meet line cadence with a 10%–20% margin. Higher speed leaves less weigh time per item, raising dynamic noise — so speed and accuracy trade off. The SC1 Series reaches **up to 300 units/min** at 10–120 m/min belt speed. If a line demands 400 units/min at very high accuracy, consider **two weighers in parallel** or graded checking rather than running one unit at its limit.

> **CAUTION Speed vs. accuracy**
> On one machine, pushing speed up generally increases dynamic error. If both high speed and high accuracy are mandatory, size for parallel or staged inspection instead of operating at the single-unit extreme.

3.4 Product Physical Characteristics

- **Weight & size** decide weigh-deck dimensions, Max, and belt width.
- **Shape & centre of gravity** — irregular/rolling items need guides or chain/bowl conveying.
- **Packaging** — film and foil cause static or airflow disturbance; specify anti-static design and air curtains.
- **Temperature & density** — frost on frozen goods or residual heat from hot-fill affects readings.

3.5 Operating Environment

Temperature drift, humidity, vibration (neighbouring equipment/floor), airflow (fans/AC direct blow), dust, and washdown (IP rating) all inject systematic error. Food and pharma lines often require **high-pressure washdown (IP65)** and aggressive cleaners; chemical environments may need **ATEX/IECEx explosion protection** and anti-static, corrosion-resistant build. SC1 offers IP54 as standard and IP65 as an option, in a 304 stainless-steel frame.

> **TIP Environment first**
> If the floor vibrates, prioritise an **independent damped foundation + rigid frame** over simply raising filter gain. If AC blows on the deck, an **air curtain/guard** pays off immediately.

3.6 Rejection & System Integration

Match the reject mechanism to the product: **air-blast / vacuum** for light items, **push-arm / swing-arm** for stable items, **diverter belt / drop-through** for fragile ones. For integration, modern checkweighers should support **Modbus RTU (RS485), Modbus TCP (Ethernet), and TCP data stream**, feeding MES/ERP seamlessly, with **audit trail, user roles, and electronic signatures** to satisfy 21 CFR Part 11. The SC1 Series provides three access levels (Operator / System Administrator / Super Administrator), CSV export to USB, and up to 1,000,000 stored records.

3.7 Regulatory & Industry Compliance

- **Food** — average-weight method (OIML R87), EU e-mark, China packaged-goods metrology.
- **Pharma** — GMP, data integrity (ALCOA+), 21 CFR Part 11.
- **Chemical** — explosion protection, anti-static, corrosion resistance; some regulated substances.
- **Export** — target-market type approval (EU MID, U.S. NTEP).

4 Standards & Regulatory Framework

4.1 OIML R51 (International)

OIML R51-1:2006, *Automatic catchweighers — Metrological and technical requirements and tests*, is the international benchmark for automatic checkweighing. It defines accuracy classes, MPE, maximum permissible standard deviation (MPSD), and test methods (operational, simulation, performance, span-stability). See Tables 3-1 and 3-2.

4.2 European Union — MID (MI-006) & Average Weight

The EU **Measuring Instruments Directive 2014/32/EU** covers automatic weighing instruments under **MI-006**, technically aligned with OIML R51. Checkweighers placed on the EU market require **EU type examination** and carry **CE + M** marking. For prepacked goods, the EU applies the **average-weight system** (Council Directive 76/211/EEC, now 2009/34/EC; OIML R87): the batch average must meet the nominal quantity, with tightened single-pack T1/T2 limits. Per WELMEC Guide 6.4, the controlling checkweigher should be at least **X(1) or XIII(1)**.

4.3 United States — NIST Handbook 44 & NTEP

The U.S. applies **NIST Handbook 44** (Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices) and the **NTEP** (National Type Evaluation Program) for device certification. Notably, the U.S. enforces a **minimum net-quantity** rule per package rather than the EU average-weight model — so a checkweigher used for process control must understand this difference when setting limits. NTEP certification is the recognised path to market acceptance.

4.4 China Metrology (JJG) — for Exporters

For products exported to or sold in China, the *Metrology Law* and relevant **JJG verification regulations** apply to automatic catchweighers used in trade/quantity control, requiring type evaluation and periodic verification. Included here as a reference for global suppliers.

4.5 Sources of Dynamic Weighing Error

Unlike static scales, a checkweigher's error is dominated by dynamic factors — understanding them is the key to both selection and calibration:

- **Mechanical vibration** — conveyor, neighbouring machines, floor transmission.
- **Product impact & bounce** — shock on entering the weigh deck.
- **Airflow disturbance** — fans, AC, air-blast rejection.
- **Electrical noise & thermal drift** — load-cell zero drift, ADC quantisation.
- **Speed inconsistency** — belt slip shifting the weigh window.
- **Product variation** — the true weight spread of conforming product ($\sigma_{product}$).

> **KEY POINT Key insight**
> The checkweigher measures "true weight + equipment noise + disturbance." Its own standard deviation $\sigma_{equipment}$ must be far smaller than the product weight spread $\sigma_{product}$ — otherwise it cannot tell "truly light" from "measured wrong." This is exactly where MDV design begins.

5 Precision Calibration Methodology

Calibration fixes the relationship between the device reading and the true value using traceable standards (weights/test pieces). For a checkweigher it has two stages — **static calibration** and **dynamic calibration** — and neither alone is sufficient.

5.1 Pre-Calibration Conditions

- **Warm-up** ≥ 5 minutes after power-on so electronics and the load cell reach thermal equilibrium.
- **Level & foundation** — weigh deck levelled, damped, free of external pull.
- **Stable environment** — temperature, airflow, vibration within rated conditions.
- **Zero** — no load on the deck; confirm a stable zero.
- **Traceable standards** — calibration weights with valid certificates (F1/F2 recommended).

5.2 No-Load (Zero) Calibration

With the belt running and no product present, capture the zero reference. Always perform zero calibration **before** span calibration — an incorrect zero invalidates the span.

5.3 Loading (Span) Calibration

Place a known calibration weight (typically **50%–80% of full span**) at the centre of the running weigh belt, enter its nominal value, and capture the span reference once the reading stabilises. This removes system gain error — but it still does **not** prove dynamic accuracy.

5.4 Dynamic Compensation

Dynamic compensation closes the gap between static and in-line reality. At true operating speed, pass several known-weight samples, compare the average dynamic reading against a static reference, and adjust the **Dynamic Compensation Value**. Example from SameGram SC1 practice: static reference average 100.5 g, dynamic reading average 99.8 g, deviation −0.7 g → set Dynamic Compensation Value to **+0.7 g**, then re-verify.

Step	Value
Static reference weight (average)	100.5 g
Dynamic reading (average)	99.8 g
Deviation	−0.7 g
Set Dynamic Compensation Value to	**+0.7 g**

Table 5-1 Dynamic compensation worked example (SC1 Series)

5.5 Calibration Frequency & Record-Keeping

Frequency depends on risk and stability — typically **1–4 times per year**, more often in regulated industries (pharma, export). Every calibration must be recorded: standard certificate No., environmental parameters, each point's reading, correction factor, operator and reviewer, timestamp — all within an **audit trail**. Document the calibration SOP as evidence for system audits. The SC1 maintenance plan verifies full-span calibration monthly and certified-weight verification annually.

CAUTION Compliance note

In regulated industries, calibration is an **evidence problem**, not just a technical one. A non-traceable, non-tamper-evident calibration record is treated as no calibration at all.

6 Verification & Routine Accuracy Monitoring

6.1 Test Weight Method

Periodically pass a known-weight standard (test weight / check standard) through the checkweigher at line speed and compare the reading to the true value. An out-of-tolerance result triggers alarm or withdrawal from service. Recommended per shift or at fixed intervals as online verification.

6.2 Control Charts & SPC

Plot the test-weight mean and range on **X-bar / R control charts** to monitor whether the process stays in control. Continuous upward/downward or out-of-limit trends signal load-cell drift, belt wear, or environmental change — intervene early before a sudden out-of-tolerance event.

6.3 MDV & False Reject / Give-Away

Minimum Detectable Variation (MDV) is the smallest weight difference the device can reliably resolve, empirically MDV ≈ **2–3 × dynamic standard deviation (σ_dynamic)**. Reject limits should sit at least one MDV away from the spec limit, leaving a **zone of indecision** so borderline-conforming items are kept and only clearly non-conforming ones rejected — balancing false reject (good product scrapped) against give-away / escape.

Metric	Meaning	Design impact
σ_dynamic	Device dynamic weighing std. dev.	Smaller is better; sets MDV
MDV	Min detectable ≈ 2–3 σ	Lower bound of reject-limit gap
False reject	Good product wrongly rejected	Cost & customer complaints
Escape	Bad product wrongly passed	Compliance & brand risk

Table 6-1 Core accuracy-monitoring metrics

KEY POINT Setting principle

Do not place reject limits flush against the specification limit. Keep a ≥ **MDV buffer (zone of indecision)** between spec and reject limits: keep borderline-good, reject only clearly-bad, and balance false reject against escape.

7 Industry Selection Guide

The table below gives a starting point for typical industries; final parameters must be calculated from the actual product and line. The SC1 Series covers all listed ranges.

Industry	Typical unit weight	Recommended class	Speed	Key concern
Food / snack	50–2000 g	XIII(1)/XII(1)	80–400 /min	Dust, vibration, washdown (IP65+)
Pharma / health	5–500 g	XI(1)/XII(1)	60–300 /min	Traceability, 21 CFR Part 11
Chemical / powder	100 g–25 kg	XIII(1)/XII(1)	30–200 /min	Ex-proof, anti-static, corrosion
Hardware / parts	1–5 kg	XII(1)/XIII(1)	50–250 /min	Metal interference, impact
Logistics / e-com	50 g–30 kg	XIII(1)	40–300 /min	Irregular parcels, dimensional weight

Table 7-1 Typical industry selection reference (SC1 applicable)

> **TIP On "recommended speed"**
> Speeds above are single-unit ranges. If actual cadence exceeds the top, evaluate parallel or graded checkweighers rather than sacrificing accuracy at a single unit's extreme.

8 Selection Decision Process

Advance selection review in seven steps; each step's output feeds the next:

- ① **Define the product** — weight range, dimensions, shape, packaging, density/temperature.
- ② **Fix the line** — cadence (units/min), belt speed, product pitch, space and upstream/downstream interface.
- ③ **Set the regulation** — target market (China/EU/US), industry rule (food/pharma/chemical), required class (≥ X(1)/XIII(1)).
- ④ **Derive accuracy** — from net-content spec and MDV, compute required e, Max/Min, and class.
- ⑤ **Match the environment** — IP rating, explosion protection, damping, air curtain, temperature/humidity.
- ⑥ **Choose reject & comms** — reject type, MES/ERP interface, audit and access control.
- ⑦ **Plan verification & calibration** — dynamic calibration method, test weights, control chart, calibration cadence.

> **KEY POINT One-line decision**
> First set the **accuracy floor** (regulation + MDV), then the **speed ceiling** (line cadence), then pick the model with the strongest **environment fit and data capability** within budget.

9 Common Selection Mistakes

- **Trusting a bare "±1 g" claim** — not stated at which speed, range, or class; not comparable.
- **Bigger capacity = better** — oversized capacity raises e and lowers resolution, losing accuracy.
- **Ignoring dynamic calibration** — assuming static calibration equals in-line accuracy, causing real out-of-tolerance.
- **Sizing at the speed limit** — running at the extreme wears faster, raises noise, shortens life.
- **Exposing the environment** — ignoring vibration/airflow/washdown, leaving the device "born deficient."
- **No data interface** — weight data not traced, missing quality improvement and compliance evidence.
- **Buy-only, no-maintain** — no calibration plan or control chart; accuracy silently decays over time.

10 Maintenance & Lifecycle Management

A checkweigher's value lies in long-term stability, not just at delivery. Build a preventive-maintenance + data-monitoring regime:

- **Daily** — test-weight verification, clean deck/belt, inspect reject action.
- **Weekly** — check belt tension/tracking, rollers, fasteners, pneumatic fittings.
- **Monthly** — full-span calibration with calibration weight, lubricate bearings/chain.
- **Quarterly** — clean control cabinet interior, replace air filter.
- **Annual** — full load-cell performance check, belt replacement if worn, certified-weight verification, firmware review.
- **Change control** — re-calibrate and re-verify after any product change, re-parameterisation, or relocation.

> **KEY POINT Maintenance = compliance**
> In pharma and export scenarios, a documented verify–calibrate–monitor loop is both quality assurance and direct evidence for passing system audits (GMP / MID / ISO 9001). Always apply Lockout/Tagout (LOTO) before maintenance.

11 Product Spotlight: SameGram SC1 Series

Figure 11-1 SameGram SC1 Series Dynamic Checkweigher

The SC1 Series is SameGram's high-precision inline checkweigher for industrial lines, combining a high-resolution digital load cell with an adaptive DSP algorithm for high-speed dynamic weighing. Key features:

- **High speed** — belt speed up to 120 m/min; throughput up to 300 units/min.
- **High accuracy** — dynamic accuracy ±0.1 g – ±2.0 g (product- and speed-dependent).
- **100 recipes** with quick switchover and auto-learning for fast setup.
- **Adaptive DSP filtering** to suppress vibration; manual dynamic compensation.
- **Flexible reject** — air-blast, push-arm, swing-arm.
- **Connectivity** — RS485 Modbus RTU, Ethernet Modbus TCP, TCP data stream; USB CSV export.
- **Robust build** — 304 stainless steel frame; IP54 standard, IP65 optional.
- **Compliance-ready** — three-level access control, audit trail, up to 1,000,000 records.

Representative specifications:

Parameter	SameGram SC1 Series
Weighing range	10 g – 6000 g (model dependent)
Dynamic accuracy	±0.1 g – ±2.0 g (product & speed dependent)
Belt speed	10 – 120 m/min (adjustable)
Max throughput	Up to 300 units/min
Load-cell resolution	0.01 g
Display resolution	0.1 g (g) / 0.001 kg (kg)
Recipes / sorting levels	Up to 100 / 1–7 levels

Parameter	SameGram SC1 Series
Data memory / export	Up to 1,000,000 records / USB (CSV)
HMI	7" / 10" colour TFT touchscreen
Communication	RS485 Modbus RTU, Modbus TCP, TCP stream
Frame / IP rating	304 stainless steel / IP54 std, IP65 opt.
Power	AC 220 V ±10%, 50/60 Hz, 200–500 W
Ambient	0 – 40 °C, 20 – 85 % RH

Table 11-1 SC1 Series representative specifications

12 Appendix

12.1 Glossary

Term	Definition
Max	Maximum capacity
Min	Minimum capacity (below this, accuracy not guaranteed)
e	Verification scale interval (legal minimum step)
d	Display division
MPE	Maximum permissible error (mean)
MPSD	Maximum permissible standard deviation (dynamic)
MDV	Minimum detectable variation ≈ 2–3 σ_dynamic
Checkweigher	Automatic catchweigher
OIML R51	Automatic catchweighers international recommendation
MID MI-006	EU automatic weighing instruments directive
NTEP	U.S. National Type Evaluation Program
DSP	Digital signal processor (real-time filtering)

Table 12-1 Glossary

12.2 Key Formulas

- **Weighing error**: E = I − L (I = indication, L = true load).
- **MPE (mean)**: ±0.5 e / ±1.0 e / ±1.5 e per Table 3-2.
- **MPSD**: x × σ_table(m), where x is the class factor.
- **Confidence interval**: M ± c·σ, c = 2 (95.45%) or 3 (99.73%).
- **MDV**: ≈ 2–3 × σ_dynamic (recommend ≥ 2 × MPSD).
- **Division count**: n = Max / e (sets the achievable accuracy class).

12.3 SameGram Support

SameGram Equipment Co., Ltd. provides checkweigher selection consulting, custom integration, dynamic calibration, and lifecycle support for food, pharma, chemical, and logistics customers — built on OIML R51, MID, and NIST frameworks to help you achieve quality and cost wins within compliance.

> **TIP Get support**
> For a selection calculation or on-site calibration plan tailored to your product and line, contact the SameGram technical team — we deliver a grounded assessment based on the framework in this paper.

References

OIML R 51-1:2006 (Automatic catchweighers); EU 2014/32/EU (MID, MI-006); NIST Handbook 44; WELMEC Guide 6.4; OIML R 87 (average quantity); applicable national JJG verification regulations. Product data: SameGram SC1 Series Instruction Manual V2.0 (June 2026).

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