IMG INDUSTRIAL MOISTURE GATE

IMG-W · WOOD LOGS & WOOD CHIPS

Industrial Moisture Gate for Wood Logs

& Wood Chip Moisture Gate on Conveyor Belt — moisture, volume and basic density for every delivery.

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01

About Dunakontroll

Moisture measurement solutions for fibrous materials — born in the paper industry.

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Rooted in the paper industry

1994

Born in Hungary, within the grounds of one of Central Europe’s largest paper mills.

2013

Launch of the first generation of HPNAs.

Global

Strong international presence.

Ownership

Austrian ownership with a lifelong career in the paper industry.

Management

Hungarian management.

Team

Professionals, engineers, mathematicians, physicists and an emeritus professor.

Brand

Rebranding activities.

Industries & product family

According to the client's requirements, **Dunakontroll** creates supplementary moisture content measurement devices for various fibrous materials and grains.

Pulp and Paper

IMG-P

Industrial Moisture Gate for Wastepaper Bales

Wood

IMG-W

Industrial Moisture Gate for Wood Logs

Pulp & Biomass

Chips

Wood Chip Moisture Gate on Conveyor Belt

Pulp & Biomass

IMG-S

Industrial Moisture Gate for Straw

01 · DUNAKONTROLL WORLD MAP

Installations worldwide



02

Importance of basic density

Wood density: key to pulp yield and mill stability.



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Key to pulp yield and mill stability

Critical quality metric

Basic wood density strongly correlates with kraft pulp yield — the most cited wood property in pulp research [1], and a key indicator of overall wood quality [2].

Impact on throughput

Higher-density wood provides more fibre mass per chip volume, maximising digester productivity and reducing specific wood consumption [3].

Cost and efficiency rationale

Wood is the most expensive raw material in pulp production [5]. Variations in wood density translate directly into process variability, with significant impacts on yield and quality [6].

Process stability

Strategic monitoring and control of basic density improves efficiency, yield and product uniformity, supporting stable mill operation and cost control [7][8].

References [1]–[8] on the next slides

What density means on the mill floor

INDUSTRIAL IMPACT

Lower-density wood reduces digester throughput and increases wood usage per ton of pulp [3], while higher density improves daily production and lowers wood cost [4].

KEY BENEFIT

Medium-to-high density wood is preferred by mills: it optimises the balance between digester throughput and specific wood consumption (wood per ton of pulp) [3].

WARNING

Excessive density variability leads to unpredictable process conditions, frequent adjustments and reduced efficiency [4]. Controlled density is a strategic lever for mill performance [8].

References [1]–[8] on the next slide

References

[1] Santos, A., et al. (2018). Key factors affecting wood basic density in eucalyptus and its influence on pulp yield. Journal of Wood Science, 64(5), 455–462.

[2] Gominho, J., et al. (2021). Eucalyptus globulus wood technological properties and their variation with tree age. Forest Ecology and Management, 511, 119858.

[3] Almeida, F.S., et al. (2020). Impact of wood basic density on kraft pulp production: A mill-scale evaluation. Tappi Journal, 19(6), 331–339.

[4] Magaton, A.S., et al. (2019). Eucalyptus wood quality and its impact on kraft pulp production. Industrial Crops and Products, 129, 516–523.

[5] Sixta, H. (Ed.). (2006). Handbook of pulp. Wiley-VCH Verlag GmbH.

[6] Duarte, F.A.S., et al. (2021). The effect of wood supply variability on pulp mill performance. BioResources, 16(2), 3656–3670.

[7] Foelkel, C. (2015). The Eucalyptus wood quality and its impacts on the pulp mill operation. Eucalyptus Online Book, Chapter 41.

[8] Mokfienski, A., et al. (2018). Importance of wood density on pulp production and quality. Ciência Florestal, 28(4), 1444–1456.

03

IMG-W

Industrial Moisture Gate for Wood Logs — the system, measurement process, acceptance criteria, validation framework and benefits.

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One pass, three key values

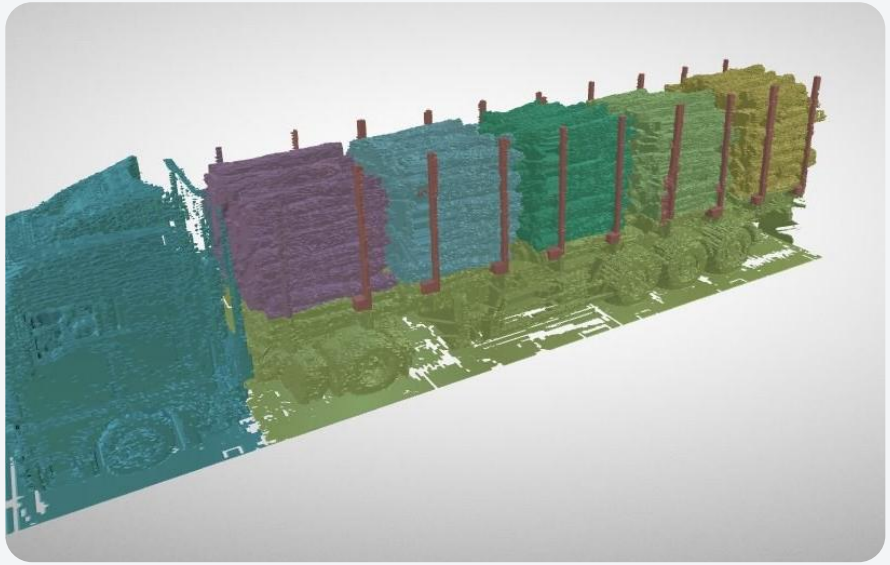
Moisture content
of large quantities of wood logs

Stereo & solid volume
of the whole truck load

Basic density
of the load

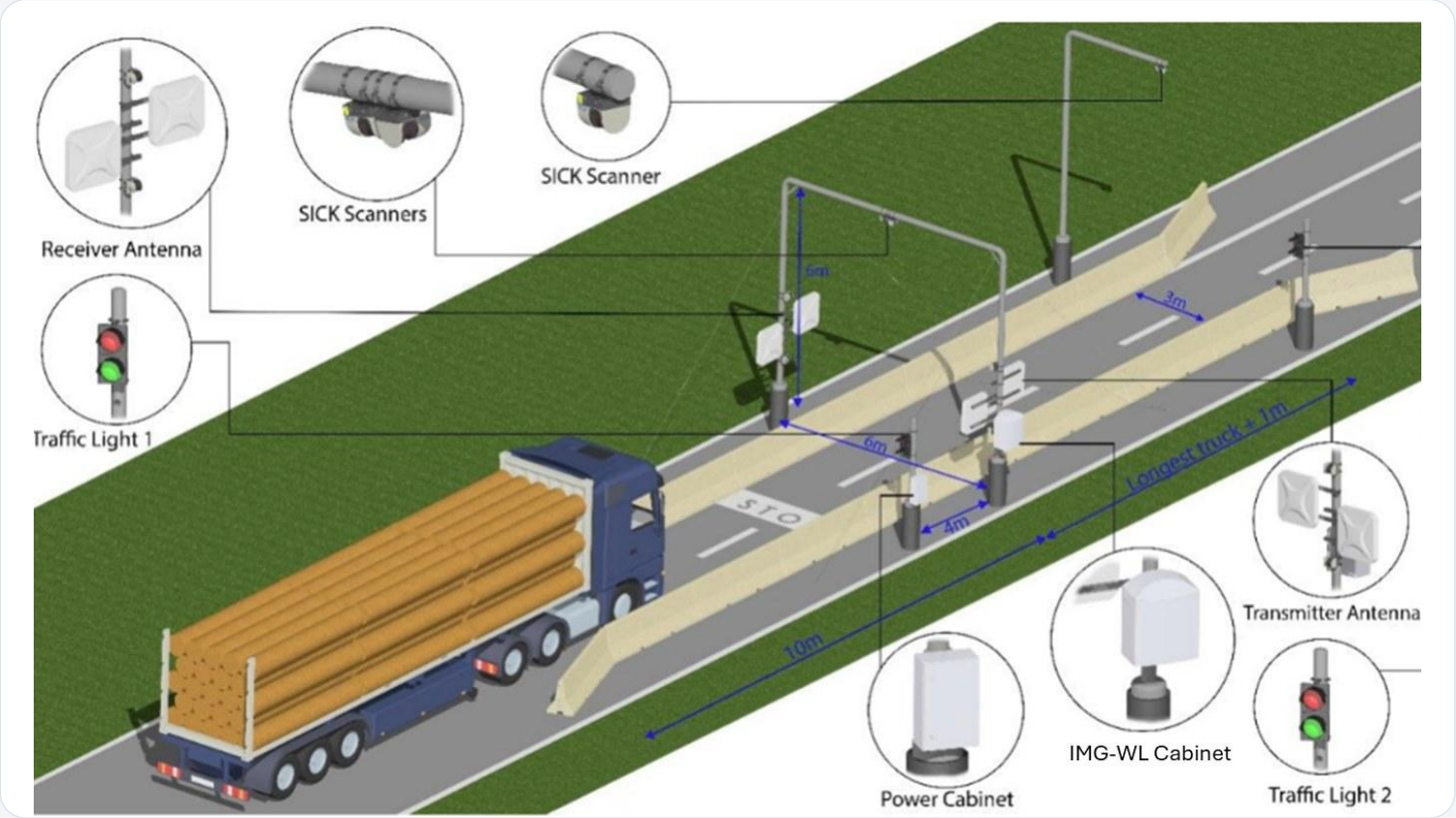
- Assesses **large quantities** — the entire load at once
- In a **representative** manner
- In a **short time** (< 1 min)
- **Without human intervention** — staff cannot influence the measurement results

Data is sent to the **ERP system** via the IT communication channel — significantly increasing the efficiency of management processes and serving as basic information for forestry.



3.1 · THE SYSTEM

The gate at a glance



MAIN COMPONENTS

- Receiver & transmitter antennas
- SICK 3D scanners
- Traffic lights 1 & 2
- IMG-W cabinet
- Power cabinet

3.1 · THE SYSTEM

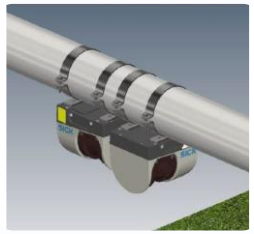
Two sensing systems, one result



MEASURES WATER

Microwave system

The system produces multiple polarised, low-energy electromagnetic fields that identify alterations induced by water, offering insights into the cargo’s water content.

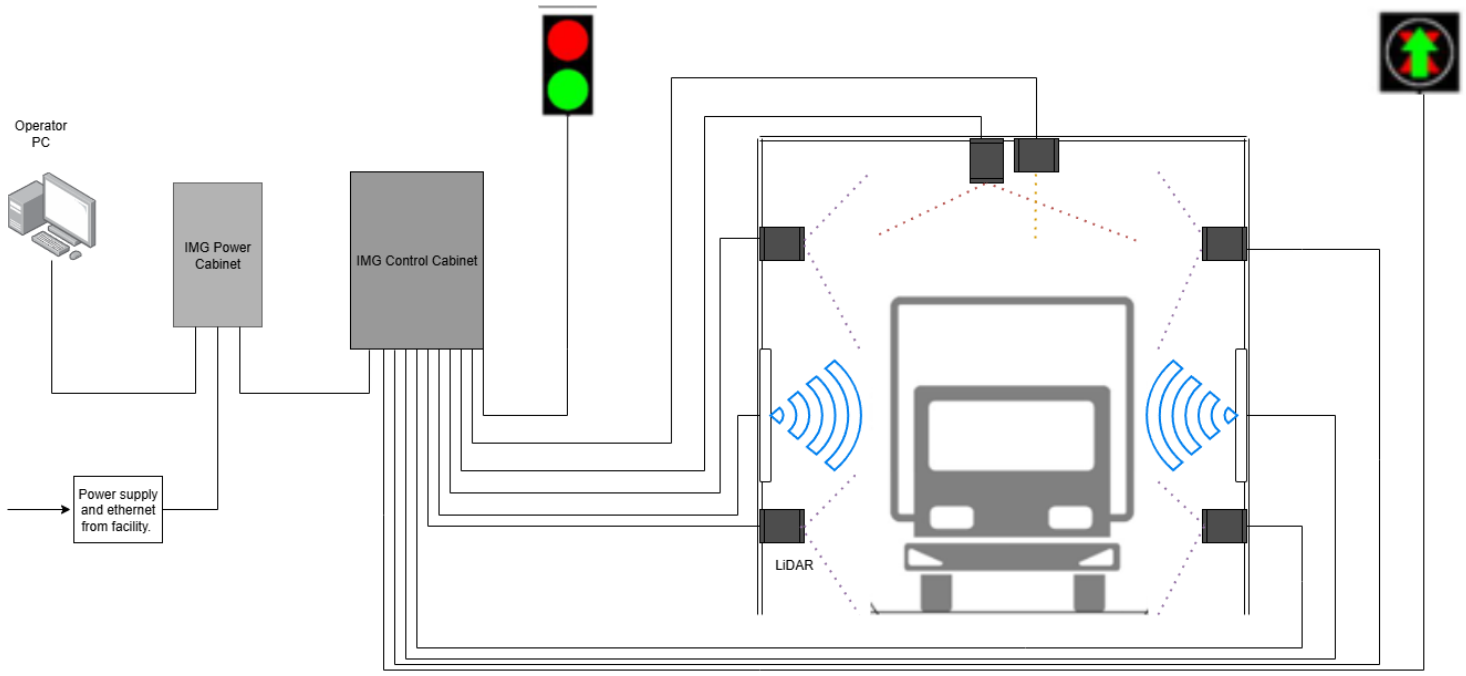


MEASURES GEOMETRY

3D optical system

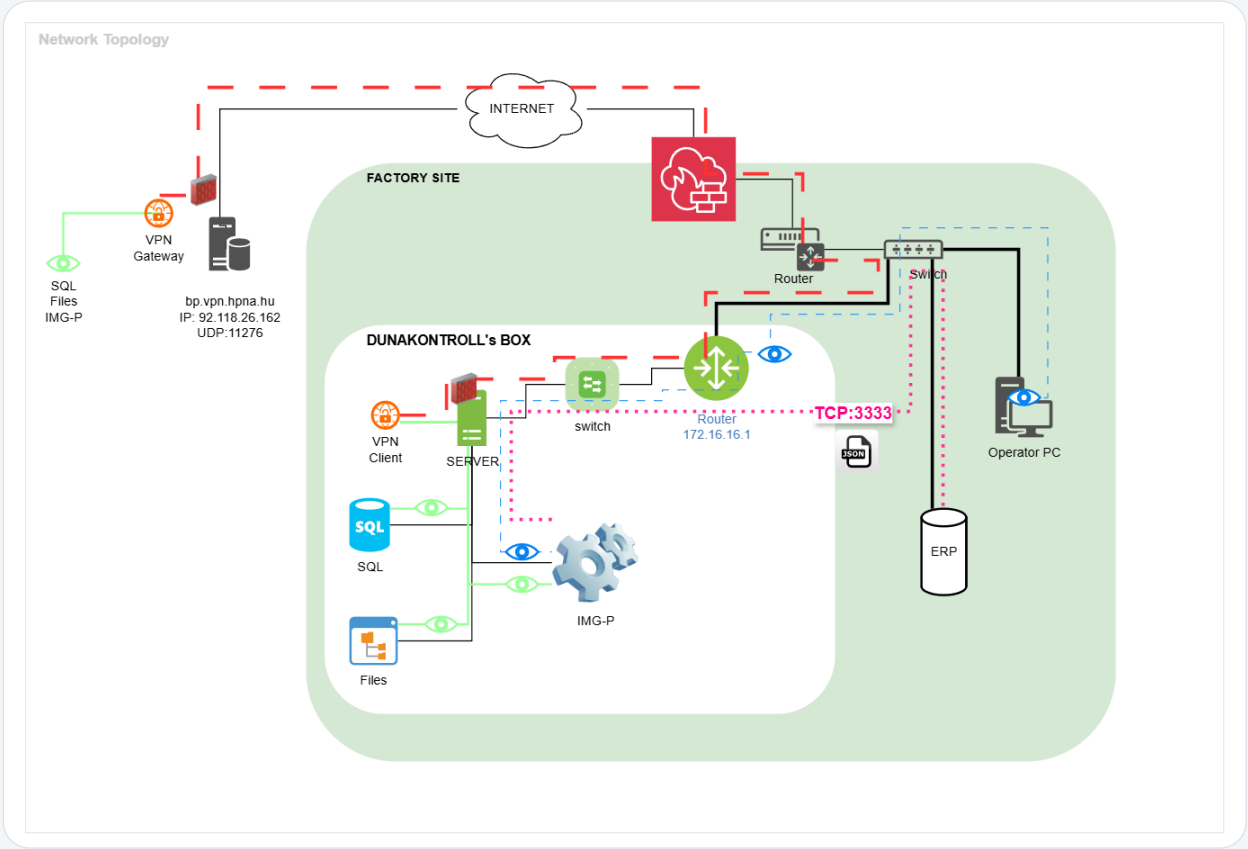
Collects physical data on the cargo — width, length, height, velocity, structure, start and end points, and platform dimensions. This data controls the microwave system and helps calculate the cargo volume.

Circuit diagram



Note: All 6 scanners are installed at the 1st gate, and Scanner #7 is installed at the 2nd gate.

IT communication scheme



Dunakontroll's box on site

Server, SQL database, file storage and the IMG software behind its own router and firewall.

ERP integration

Results are passed to the mill's ERP as JSON over TCP (port 3333).

Operator PC

Connected through the factory switch.

Secure VPN link

Encrypted connection between the site and Dunakontroll.

3.2 · MEASUREMENT PROCESS

Manual or automatic, in five steps

1

Data entry

Manual: entered through the Dashboard.
Automatic: sourced from the ERP system.

2

Start measurement

Manual: operator clicks START.
Automatic: triggered by the ERP, card-reader kiosk, ANPR camera, etc.

3

Measurement

Fully autonomous. Traffic lights direct the truck; the 3D optical system tracks its position in the zone.

4

Data processing

When the truck leaves the zone, the system calculates the average moisture content of the load.

5

Display & send

The result is shown on the Dashboard and sent to the ERP system if connected.

CORE DATA **Truck ID · Net weight · Wood type**

Automatic mode integrates with the mill's ERP (e.g. SAP) for greater efficiency.

A report for every truckload

EXAMPLE OUTPUT · TICKET-LEVEL REPORT

Measurement	
Date / Time	7/31/2024 16:48
Ticket number	202407311648
Plate no.	ABC123
Wood type	Eucalyptus
Supplier	Supplier 1
Load weight	25 000 kg
Solid volume	33 m³
Dry matter content	14 425 kg (57.7 %)
Moisture average	42.3 %
Basic density	437.1 kg / m³

42.3 %
moisture average

437.1
basic density, kg/m³

33 m³
solid volume

PROFILE · PER-STACK MOISTURE DISTRIBUTION



This example uses the extended-dataset configuration.

3.2 · MEASUREMENT PROCESS

Reported data fields — two tiers

For every truckload the IMG-W records a structured report combining logistics & quality data with optional volumetric analysis — for routine commercial settlement and advanced quality / yield optimisation.

Basic dataset

Standard logistics & quality data — every load

- ✓ Load ID
- ✓ Gross & tare weights (kg / t)
- ✓ Supplier
- ✓ Truck plate number
- ✓ Wood type
- ✓ Average gross moisture content (%)

Primary use: commercial settlement, weight reconciliation, supplier KPIs.

Extended dataset

Advanced volumetric analysis — optional add-on

- ✓ Gross moisture per stack (%)
- ✓ Basic density (kg/m³)
- ✓ Fill factor (ratio)
- ✓ Average log diameter (DSE)
- ✓ Green density (kg/m³)
- ✓ Stacked / stereo volume (m³/st)
- ✓ Solid volume (m³)

Primary use: pulp-yield forecasting, density-based pricing, fibre-quality optimisation.

Also an input to the GUM-compliant uncertainty budget — fill factor and stacked/solid ratio quantify within-load heterogeneity (Type B).

3.3 · HANDOVER ACCEPTANCE CRITERIA

Measurement accuracy

After calibration, measurement accuracy — and therefore reliability — is verified: IMG-W results are compared with the agreed counter-measurement equipment and methodology.

230

labelled samples per species

2.0–3.5 %

relative load-by-load standard deviation, typical — depending on material and validation conditions

≤ ±5 %

declared relative tolerance band, supported by the GUM uncertainty budget ($u_{c,rel} \approx 2.4$ %, $U_{rel} \approx 4.8$ % at $k = 2$)

INTERPRETATION OF THE ±5 % TOLERANCE BAND

It applies to the **entire IMG-W ↔ control-sample comparison chain** — not an instrument-only error. The dominant uncertainty is usually not IMG-W repeatability, but the **representativeness of the control sample** and natural moisture heterogeneity within the log load. Contractual accuracy therefore depends on a documented, representative control-sampling and laboratory protocol (see the annex “Measurement performance, measurement uncertainty, and validation”).

3.3 · ACCURACY — STATISTICAL CLARIFICATION 1/3

±5 % is a relative tolerance band

WHAT THE 5 % FIGURE MEANS

Not the standard error of the mean (SEM = σ / √n cannot exceed the standard deviation). It is a **relative maximum expected load-level deviation**: ± 5 % of the measured moisture value at 95 % confidence — a combined (Type A + Type B) uncertainty, equivalent to the relative expanded uncertainty Urel = k · uc,rel with k = 2 (ABNT/INMETRO GUM 2003, NIT-DICLA-021 2020). Per DOQ-CGCRE-008 (2020), absolute and relative uncertainties must be reported unambiguously.

CORRECT INTERPRETATION OF THE FIGURES

Parameter	Value
Measuring range (M)	max. 80 % gross moisture
Confidence level	95 % · k ≈ 2
Relative standard deviation, load-by-load vs. control	2 % – 3.5 % (rel.), depending on control-method error
Max. load-level deviation (95 % CI · ≈ Urel = k · uc,rel)	≤ ± 5 % (relative)

WORKED EXAMPLES · ± 5 % RELATIVE CONVERTS TO

@ 20 % m.c.
± 1.0 pp
[19 %, 21 %]

@ 30 % m.c.
± 1.5 pp
[28.5 %, 31.5 %]

@ 50 % m.c. · typical Eucalyptus
± 2.5 pp
[47.5 %, 52.5 %]

@ 80 % m.c.
± 4.0 pp
[76 %, 84 %]

VIM 2012 (IPQ/INMETRO) · ABNT NBR ISO/IEC 17025:2017 · ABNT/INMETRO GUM (3rd ed., 2003) · DOQ-CGCRE-008 · NIT-DICLA-021

3.3 · ACCURACY — STATISTICAL CLARIFICATION 1/3

What the stated deviation includes

IT IS — a combined relative comparison uncertainty (uc,rel)

- IMG-W whole-load measurement (Type A repeatability, % of reading)
- Relative uncertainty of the reference method — gravimetric oven drying per ABNT NBR 14660
- Sampling & sample-preparation uncertainty (Type B, relative)
- Natural moisture heterogeneity within the truckload

IT IS NOT

- An absolute ± 5 percentage-point deviation on the moisture scale
- The standalone instrumental error of the IMG-W system
- The statistical standard error of the mean (SEM = σ / √n)
- The dispersion of moisture values across the truckload population

3.3 · ACCURACY — STATISTICAL CLARIFICATION 3/3

Uncertainty budget at 50 % MC

Type A + Type B components per GUM · IMG-W vs. FHP reference (oven-dry gravimetric) · p.p. at 50 % MC, wet basis

#	Component	Method	Type	Distribution	Value a (±) [p.p.]	Divisor	ui [p.p.]	ui rel. (%)	Ui (k=2) [p.p.]	ui² [p.p.²]	Share of uc²
1	Sensor noise (measured sr)	IMG-W	A	Normal	0.25	1	0.250	0.50	0.500	0.06250	2.70 %
2	Calibration curve residual (species-specific)	IMG-W	B	Normal (k=2)	0.50	2	0.250	0.50	0.500	0.06250	2.70 %
3	Log temperature effect	IMG-W	B	Rectangular	0.35	√3	0.202	0.40	0.404	0.04083	1.76 %
4a	Density-independent compensation residual (within species)	IMG-W	B	Rectangular	0.20	√3	0.115	0.23	0.230	0.01333	0.58 %
	IMG-W subtotal						**0.423**	**0.85**	**0.846**	**0.17916**	**7.74 %**
4b	Density–moisture covariation (sample not mass-weighted)	FHP	B	Rectangular	0.60	√3	0.346	0.69	0.692	0.12000	5.18 %
5	Log heterogeneity (radial & longitudinal moisture gradient)	FHP	B	Rectangular	1.50	√3	0.866	1.73	1.732	0.75000	32.40 %
6	Sampling representativeness (Gy; selection of sampled logs)	FHP	B	Rectangular	1.70	√3	0.981	1.96	1.963	0.96333	41.61 %
7	Gravimetric reference (oven-dry determination)	FHP	B	Normal (k=2)	1.10	2	0.550	1.10	1.100	0.30250	13.07 %
	FHP subtotal						**1.461**	**2.92**	**2.922**	**2.13583**	**92.26 %**
	Total (IMG-W + FHP)						**1.521**	**3.04**	**3.043**	**2.31500**	**100.00 %**

U = 2 × 1.521 ≈ ± 3.04 p.p.

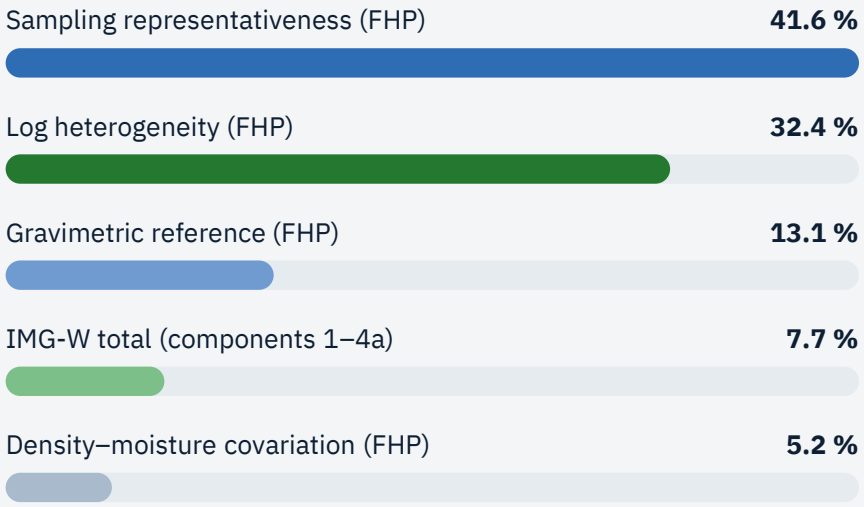
≈ ± 6.1 % of reading at 50 % MC (k = 2, ≈ 95 %). **IMG-W alone: ± 0.85 p.p. (7.7 % of uc²)** — the FHP reference side contributes 92.3 % of the variance.

uc = √Σ ui² · U = k · uc, k = 2 ≈ 95 % confidence · rectangular: ui = a / √3 · normal (k=2): ui = a / 2 · ui rel. = ui / 50 % MC

3.3 · ACCURACY — STATISTICAL CLARIFICATION 3/3

From relative uncertainty to tonnes

CONTRIBUTION TO uc² @ 50 % MC



Largest reducible source: **sampling representativeness (41.6 %)** — selection of sampled logs. Reference side (FHP) = 92.3 % of uc²; IMG-W = 7.7 %.

BUSINESS INTERPRETATION — RELATIVE → ABSOLUTE

Measured moisture	U ≈ ±6.1 % rel.	Absolute band	DM impact, 30 t
35 %	± 2.13 pp	32.87 – 37.13 %	≈ ± 0.64 t
45 %	± 2.74 pp	42.26 – 47.74 %	≈ ± 0.82 t
50 % · typical Eucalyptus	± 3.04 pp	46.96 – 53.04 %	≈ ± 0.91 t
60 %	± 3.65 pp	56.35 – 63.65 %	≈ ± 1.10 t
65 %	± 3.96 pp	61.04 – 68.96 %	≈ ± 1.19 t

WORKED EXAMPLE @ 50 % M.C.

uc 1.52 pp (3.04 % rel.) → U ± 3.04 pp [46.96, 53.04 %] · IMG-W alone: U ± 0.85 pp · FHP reference: U ± 2.92 pp · 1 pp ≈ 0.30 t dry matter per 30 t load

Auditor-ready @ 50 % MC: uc ≈ 1.52 pp (3.04 % rel.) → U ≈ ± 3.04 pp ≈ ± 6.1 % rel. (k = 2)

3.3 · HANDOVER ACCEPTANCE CRITERIA

Consistency over time

Measurement **consistency** refers to the **precision** and **repeatability** of the measurements taken over time.

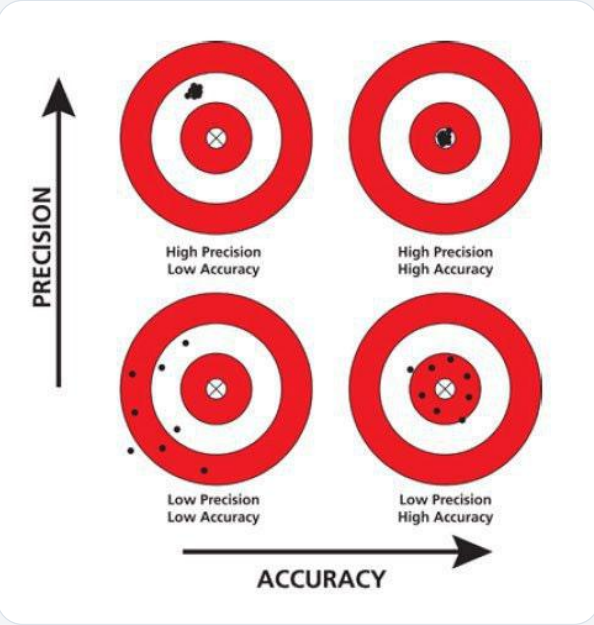
6×

The same truck drives through the gate six times.

- The average moisture content is calculated.
- The highest and lowest values are excluded for a more accurate central tendency.
- The ±6% relative range of the average is compared with the measured values.

±6%

max. relative deviation of each passage from the average



3.4 · VALIDATION FRAMEWORK

Three distinct levels of validation

1 Scientific principle

Is the method scientifically sound?

Dielectric properties
Water significantly affects the dielectric properties of wood, chips and biomass

Measurable relationships
Microwave attenuation and phase shift correlate with moisture content

Peer-reviewed
Multiple scientific publications validate the approach

Key benefit: an established scientific foundation with measurable physical relationships.

2 Site-specific system

Does the system perform as intended?

Operational validation
IMG performance at the specific site conditions

Configuration testing
System setup and calibration verification

Performance metrics
Accuracy, repeatability, reproducibility

Key benefit: validated performance under real operating conditions.

3 Independent verification

Can external experts certify results?

External audit
Independent laboratory or expert evaluation

Documentation
Signed validation reports and certificates

Compliance
ISO/IEC 17025 accreditation standards

Key benefit: defensible, auditable evidence for commercial and legal decisions.

Each level addresses one aspect of credibility: scientific foundation, operational performance, external verification

3.4 · VALIDATION FRAMEWORK

What “good” validation looks like

Documented — Verified

- Clear measurement procedures
- System configuration recorded
- Calibration history maintained

Repeatable — Verified

- Consistent results under same conditions
- Minimal variation in measurements
- Statistical control established

Reproducible — Verified

- Different operators get similar results
- Cross-laboratory validation
- Equipment independence

Unbiased — Verified

- No systematic errors detected
- Random error within limits
- Blind testing conducted

Known uncertainty — Verified

- Measurement uncertainty quantified
- Confidence intervals established
- Error sources identified

Fitness for purpose — Verified

- Suitable for intended use
- Decision-making quality
- Regulatory compliance

Documented · repeatable · reproducible · unbiased · known uncertainty · fit for purpose

3.4 · VALIDATION FRAMEWORK

Independent third-party audit (optional)

Why independent validation matters

Resolves disputes
Pre-agreed protocols with independent audits give defensible, auditable evidence that resolves commercial and technical disputes better than unilateral claims.

Stronger evidence
A signed report from an accredited laboratory or metrology expert carries more weight in technical, commercial and legal contexts.

Documentation gap
NKFIH / IP documents support R&D merit but are not site-specific accuracy certificates.

Site validation requires a documented on-site protocol following ISO 18135 and ISO 18134.

Implementation path forward

Collaborative protocol
Co-develop and sign a site-specific validation protocol that both parties accept, ensuring transparency.

Third-party selection
Choose a mutually accepted independent party — accredited lab, metrology expert or university — to conduct validation.

1. Pre-agreed protocol
2. Parallel measurements
3. Statistical evaluation
4. Signed report

Pre-agreed protocols and independent verification provide stronger evidence than unilateral claims

3.5 · ADVANTAGES & BENEFITS

Gate vs. traditional methods

Industrial Moisture Gate — closed, automated process	Traditional wood moisture measurement
✓ Automated measurement system	– Manual or laboratory based
✓ Non-destructive	– Invasive
✓ Measures large quantities — the entire load at once	– Measures at selected points or a very limited quantity
✓ Measures in a representative manner	– Is NOT representative
✓ Fast — measures in less than 1 minute	– Time-consuming
✓ Each delivery can be measured	– Based on sampling
✓ Does not require human intervention	– Requires dedicated staff, leaving room for human error
✓ Instant data exchange with the mill's ERP system	– Stand-alone measurement, limited data integration possible

IMG-W system features and gains

01 Enhanced process efficiency and profitability

Continuous density and moisture measurement — with the integrated conveyor belt system — lets mills optimise cooking conditions, reduce alkali and steam consumption and increase fibre yield, lowering energy and chemical costs per tonne of pulp.

02 Stabilised production and quality

Accurate, real-time wood data reduces process variability, improving digester selectivity, pulp strength and yield consistency while minimising unplanned adjustments.

03 Operational transparency and traceability

Seamless integration into the mill's IT and procurement systems supports predictive, data-driven control of incoming raw materials, faster truck and chip handling and better production planning.

04 Strategic insight for forestry

Measured and modelled density and moisture data feed long-term forest management — better genetic and harvest planning for a steady, optimal raw-material profile.

05 Strengthened supplier partnerships

Transparent data sharing builds trust and accountability with growers and wood suppliers, encouraging fair, quality-based procurement.

06 Corporate sustainability goals

Resource efficiency, reduced waste and fair supplier engagement directly support corporate sustainability and responsible sourcing objectives.

04

Wood Chip Moisture Gate on Conveyor Belt

Assessing moisture content and determining the basic density of raw materials during pre-processing enables the adjustment of manufacturing processes, leading to cost optimisations and ensuring the quality of the end product.

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04 · WOOD CHIP MOISTURE GATE

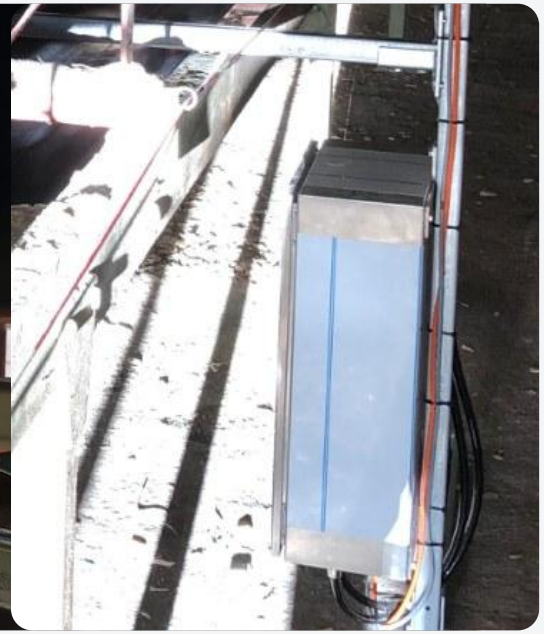
System components



2D LiDAR scanners



Transmitter & receiver antennas



System cabinet



Power cabinet

Wood Chip Moisture Gate on Conveyor Belt

04 · WOOD CHIP MOISTURE GATE

Technical parameters & characteristics

TECHNICAL PARAMETERS

24 V
low-voltage system — shock protection

2.4 GHz
ISM frequency band

< 10 mW
output RF power, EIRP (GSM phone max. 2 W)

80 scans/s
≈ 3 m/s belt speed × 1/25 s ≈ 12 cm

MAIN CHARACTERISTICS

20–80 %
moisture content range

< ± 1.0 %
repeatability at the same spot, absolute

- Calibration by comparison with laboratory results — required for each wood species (e.g. spruce, beech, eucalyptus)
- Integrated bulk-density compensation
- Frozen wood chips cannot be measured — only “free water” is detectable

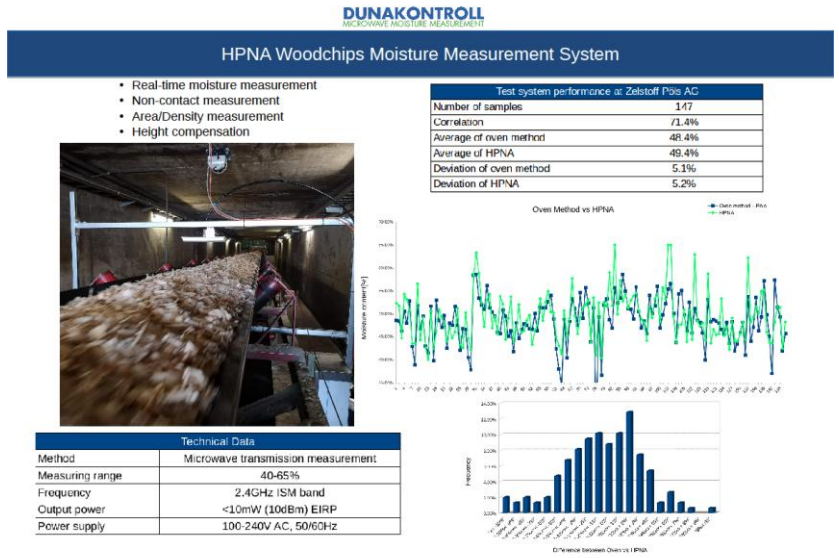
Wood Chip Moisture Gate on Conveyor Belt

04 · WOOD CHIP MOISTURE GATE

User interface



Live dashboard — mass flow, temperature, volume flow, belt velocity, dry density and moisture trend.



HPNA woodchips moisture report.

Wood Chip Moisture Gate on Conveyor Belt

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04 · WOOD CHIP MOISTURE GATE

Advantages

- Easy to install
- Operates in real time
- Operates contact-free
- No special safety protection necessary
- Radiates through the wood chip layer
- Microwave power emitted below 10 mW
- A scan every 0.04 seconds
- Not influenced by the colour of the chips

Wood Chip Moisture Gate on Conveyor Belt

DUNAKONTROLL
MOISTURE INTELLIGENCE

Know the moisture and density of every load.

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IMG INDUSTRIAL MOISTURE GATE

