ME-Trackweigh®
In-motion Train Weighing Systems

& Proposals for Amendments to NIST Handbook 44

About Us

- Established in 1987 as a consulting company
- Industrial weighing systems division established 1998
- Primary business focus is train weighing and train loading
- Major clients include BHP Billiton, Rio Tinto, Fortescue Metals Group Ltd, Glencore, ALCOA, and Aurizon Ltd

Train weighing historical development

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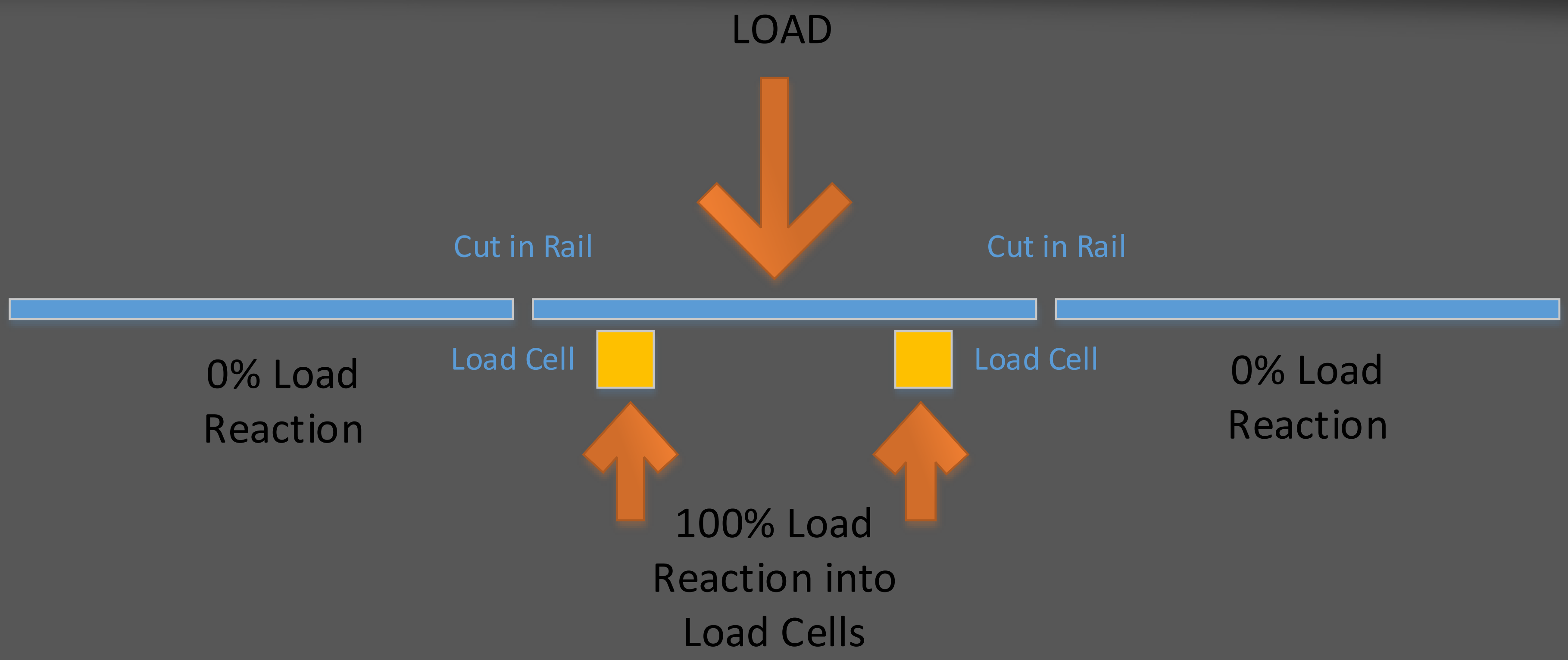
Platform Scale with Cut Rail:

- Significantly limits train speed;
- Expensive to install;
- Requires more maintenance;
- Can be more accurate (depending on uncoupling);
- When used for coupled in motion train weighing, the high accuracy of the load cells is effectively lost

Platform Systems with Cut Rail



NIST Handbook 44 contains comprehensive procedures to test this type of system.

Train weighing historical development

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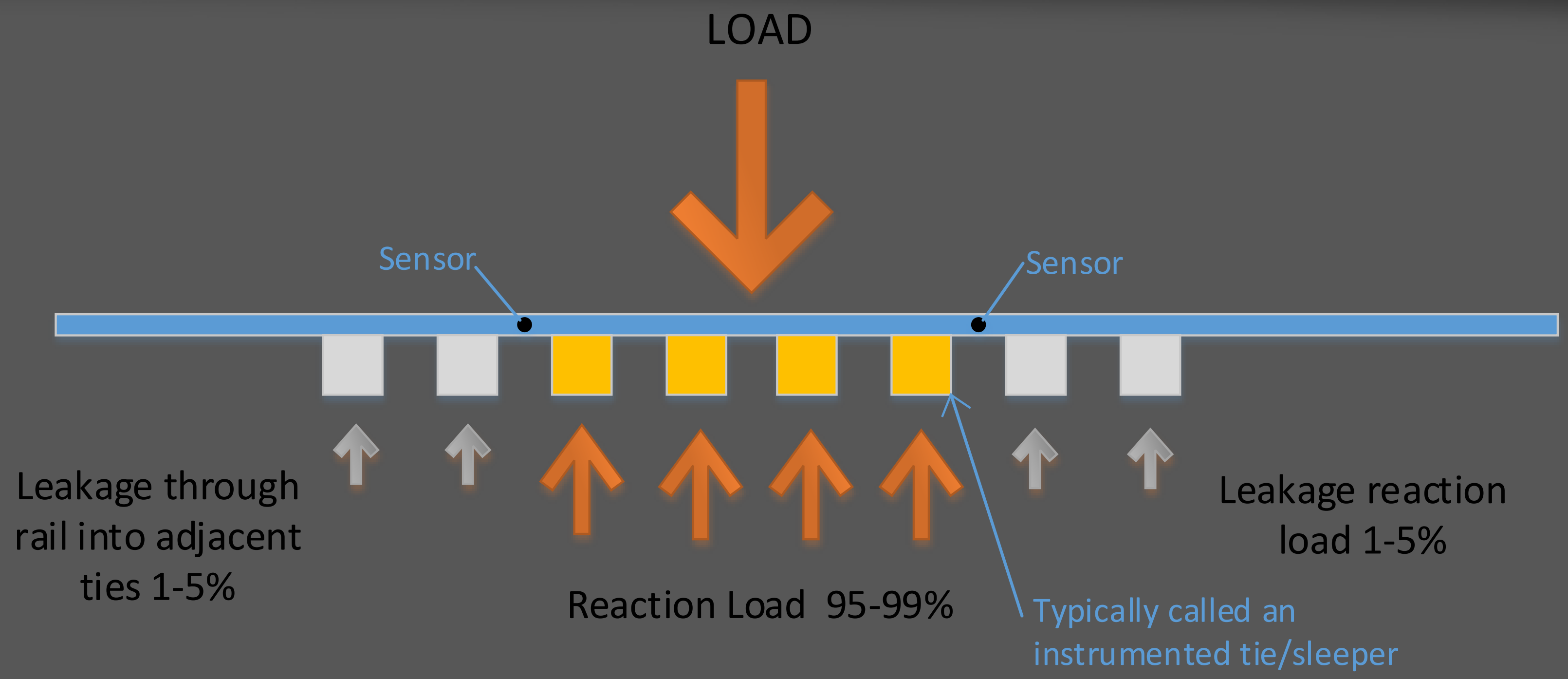
Platform Scale with Continuous Rail:

- Expensive to install;
- When used for coupled, continuous rail train weighing, the high accuracy of the load cells is effectively lost.

Platform Systems on Continuous Rail



- Sensor has to compensate for leakage i.e. is marketed as a "virtual cut";
- The entire accuracy of the system is dependant on the sensor, however NIST Handbook 44 does not assess this component on an individual basis.

Train weighing historical development

Instrumented transducer bolted to rail:

- “New” technology not considered in Handbook 44;
- Inexpensive to install.

Instrumented Rail Systems
(shear stress variant, continuous rail)

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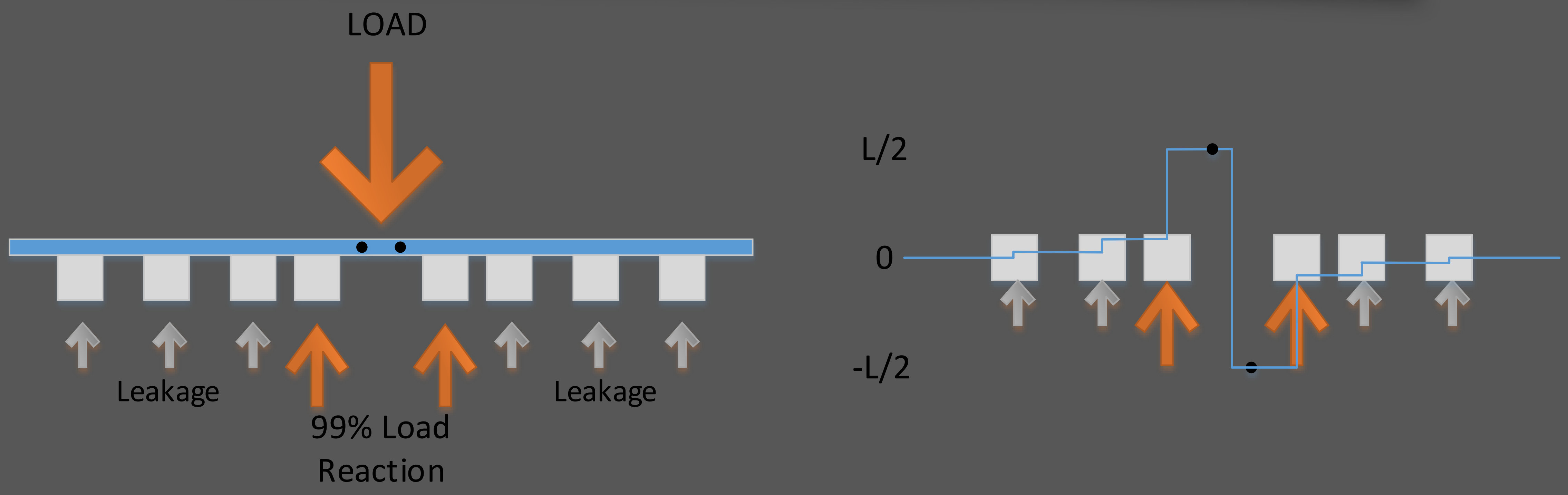

Sensor measures L/2 shear regardless of leakage.

ME-Trackweigh® System Overview

ME-Trackweigh® Overview

- Meridian’s flagship product;
- Has been in production and development for 15 years;
- Weighs coupled trains on continuous rail;
- Has trade approval in Australia (National Measurement Institute) and the EU (OIML R106);
- Utilized by BHP Billiton Iron Ore exclusively for all their Train Loading sites. Considered a critical control device by BHPBIO;
- Not currently utilised for static reference weighing.

ME-Trackweigh® Transducers

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- A number of sets of transducers are bolted on to a length of rail, resulting in the rail itself becoming a ‘rail load cell’;
- Transducer provides accurate measurement of point force load on the rail, but not as accurate as a conventional C3 compression load cell.
- Transducer detects relative change in axial load in the rail;
- Transducer measures rail temperature;
- The transducers are encapsulated to provide protection from the environment;

ME-Trackweigh® Transducers

ME-Trackweigh® 'Rail Load Cells'

The 'rail load cells' are designed to be welded or bolted (using fish plates) into the rail line into which the system is installed, and rest on sleepers (ties) or other supports.

Alternatively, the transducers can be bolted onto the rail in-situ.

Weighing points / Weighbridge

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- 8 transducers and a track switch form a single **weighing point;**
- A **weighbridge** can consist of multiple weighing points;
- Multiple weighing points increase accuracy and/or speed range.

ME-Trackweigh® Trackside System Box

A Meridian ME-TSB trackside system box receives input signals from the weighing transducers, temperature sensors, track switches, and automatic equipment identification systems (RFID tag readers) if used.

An ME-TSB typically contains:

- The master controller;
- ME-CANAMP-1 or ME-CANAMP-4 module(s) to acquire data from the weighing transducers;
- Load cell protection devices and other equipment as necessary (e.g. for communications and interfacing to track-switch sensors).

ME-Trackweigh® Output

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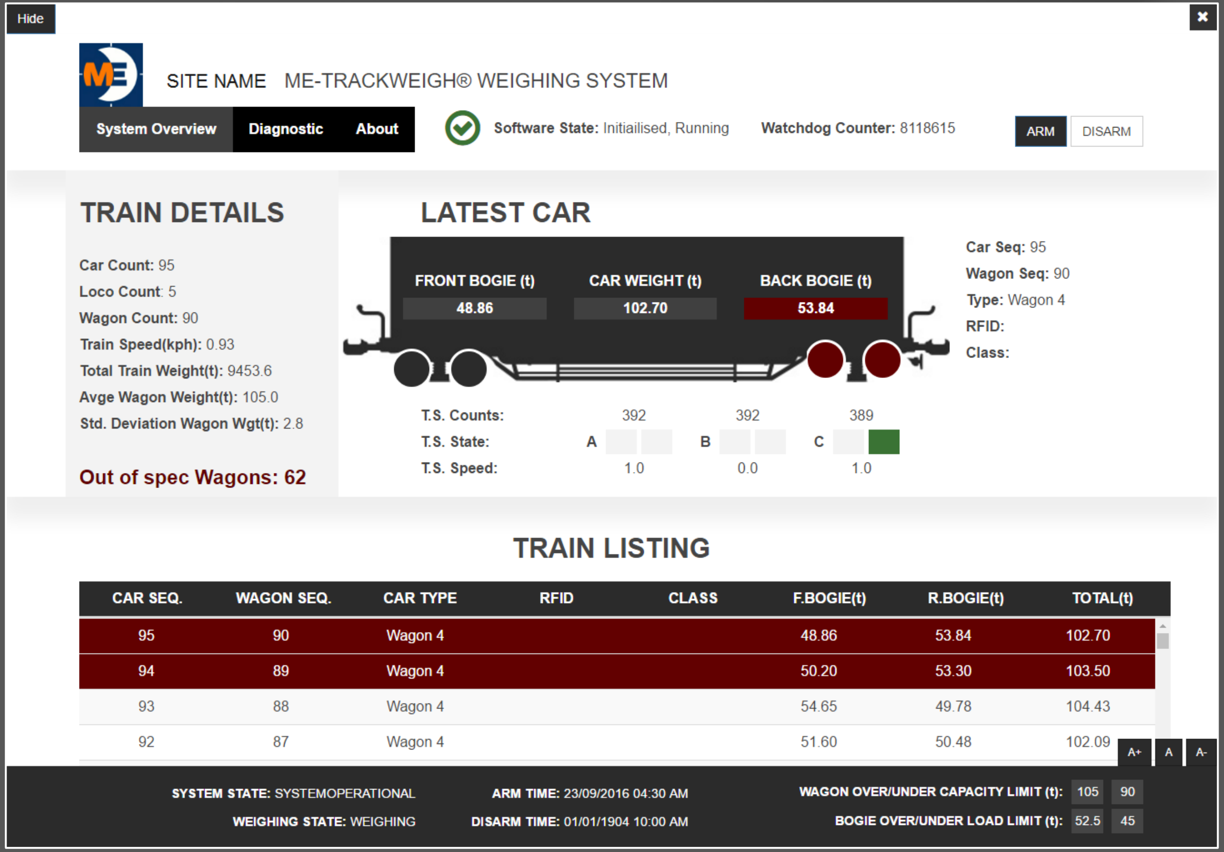
The master controller can be deployed with a web server so that a graphical user interface of the weighing system may be viewed and/or controlled on any PC connected to the same network as the trackside system junction box via a standard internet browser.



ME-Trackweigh® Zeroing Functionality

- Our transducers are not manufactured with conventional, in-built zero-shift compensation;
- The ME-Trackweigh® system constantly digitally zeroes transducer output, typically after every 4th axle that is weighed;
- Zero weights are published between bogies (trucks) and between trains;
- NIST Handbook 44 does not take this design philosophy into account. It calls for use of conventional load cells only that have zero shift compensation incorporated into the load cell circuitry

ME-Trackweigh® Advantages

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- Installation is far simpler and cheaper than any other trade-approved weighbridge currently on the market;
- The bolt-on nature of the system means maintenance or repair activities are simple and do not require large windows of rail access;
- The system has few parts and is extremely reliable in all environmental conditions including permanent submersion.

Proposals to Amend NIST Handbook 44

Section S.5. Table 3, Note 3

& Section T.N.3.6.

Objective of Proposed Amendments

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- Align Handbook 44 with OIML R106 when dealing with coupled in-motion train weighing systems
- Additional requirements may be added to define which accuracy classes can be used in trade application
- Relax tolerance required for laboratory testing phase of load cells in line with the end accuracy requirements of the actual system
- Allow more practicable cost effective systems to be used in trade applications
- Long term goal is to allow systems certified by either organization to be accepted for trade in either jurisdiction

OIML R 106-1 vs NIST Handbook 44

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Important differences are:

OIML R 106-1	NIST Handbook 44
For Field Testing:	
Multiple accuracy classes provided for.	Only a single pass fail accuracy provided for.
No static testing required if the weighing system is not being used for reference weighing.	Must pass static reference weighing tests even if system is only used for dynamic weighing
For Lab Testing:	
Transducers with no zero shift compensation permitted.	Full load cell testing required with no consideration given to the application that the transducers are designed for. (This means only transducers with zero shift compensation are permitted)

Change to Section S.5. Table 3, Note 3

Table 3. Parameters for Accuracy Classes			
Class	***Value of the Verification Scale Division (d or e[1])***	***Number of Scale[4] Divisions (n)***	
		Minimum	***Maximum***
III L[3]	equal to or greater than 2 kg equal to or greater than 5 lb	2 000	10 000

[3] The value of a scale division for crane and hopper (other than grain hopper) **and coupled-in-motion railroad weighing systems (not used for static reference weighing)** shall be not less than 0.2 kg (0.5 lb). The minimum number of scale divisions shall be not less than 1000.

(Note OIML R106 allows minimum number of divisions to be 500 for coupled in-motion rail weighing applications)

Section S.5. Table 3, Note 3

Justification:

- The Class IIIL accuracy requirements on load cells would be an excessive requirement if the tolerances on dynamic Coupled-in-Motion train weighing were relaxed (next proposed amendment);
- Not all CIM weighing systems are required to weigh statically or to provide reference weighing for dynamic calibration purposes. In these cases class IIIL is an excessive requirement.
- Errors from rolling stock quality, track foundation condition, as well as how smoothly a locomotive traverses the weighing system, are significantly higher than the individual Class IIIL permissible errors;
- The Handbook is effectively dictating the design of these products in such a way that is detrimental to innovation and the interests of our clients. Focus should be on the end system accuracy and not the subsystem components.

Section T.N.3.6. Coupled-In-Motion Railroad Weighing Systems.

Replace section in its entirety with the following:

T.N.3.6.1. Accuracy Classes - Systems are divided into four accuracy classes as follows:

0.2 0.5 1 2

A system may be in a different accuracy class for individual car weighing than that for train weighing.

Section T.N.3.6. Coupled-In-Motion Railroad Weighing Systems.

T.N.3.6.2. Tolerance Values – The acceptance and maintenance tolerance values shall be as specified in Table T.N.3.6 below:

Accuracy Class	Table T.N.3.6. Percentage of mass of single car or train as appropriate	
	Acceptance Tolerance	Maintenance Tolerance
0.2	0.10%	0.20%
0.5	0.25%	0.50%
1	0.50%	1.00%
2	1.00%	2.00%

Section T.N.3.6. Coupled-In-Motion Railroad Weighing Systems.

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T.N.3.6.3. Car Weighing – The tolerance value for uncoupled or coupled car weighing shall be one of the following values, whichever is greater:

a) the value calculated according to the appropriate accuracy class in Table T.N.3.6., rounded to the nearest scale interval;

b) the value calculated according to the appropriate accuracy class in Table T.N.3.6., rounded to the nearest scale interval for the mass of a single car equal to 35 % of the maximum car weight (as inscribed on the descriptive markings); or

c) 1 *d*.

Section T.N.3.6. Coupled-In-Motion Railroad Weighing Systems.

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T.N.3.6.4. Train Weighing – The tolerance value for train weighing shall be one of the following values, whichever is greater:

a) the value calculated according to the appropriate accuracy class in Table T.N.3.6., rounded to the nearest scale interval;

b) the value calculated according to the appropriate accuracy class in Table T.N.3.6., for the mass of a single car equal to 35 % of the maximum car mass (as inscribed on the descriptive markings) multiplied by the number of reference cars in the train (not exceeding 10 cars) and rounded to the nearest scale interval, or

c) 1 d for each car in the train but not exceeding 10 d.

Test Train Case Studies

- Three test train certification results are presented
- Example 1 is for an unusual ballasted rail result where force transfer between car couplers occurred. Failed individual car weighing but still very accurate on total train weighing.
- Example 2 is a typical resulted for ballasted rail systems
- Example 3 is result for concrete slab rail system
- All examples used identical Meridian train weighing hardware
- Examples 1 and 3 were the exact same test train separated by only a few days.

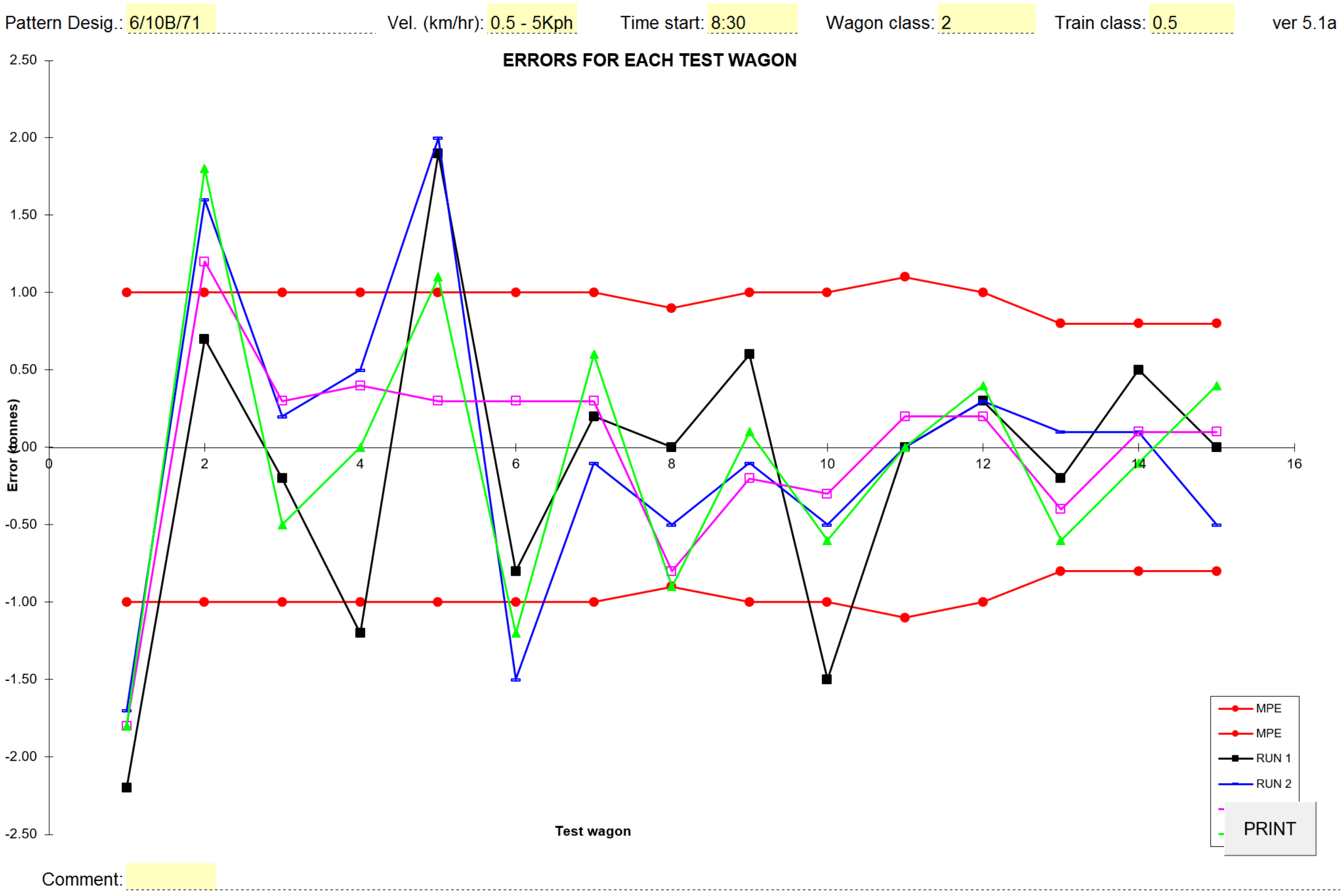
			RUN 1			RUN 2			RUN 3			RUN 4		
TEST WAGON No.	**TEST WAGON KNOWN MASS (t)**	**MPE (t)**	**RUN 1 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 2 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 3 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 4 (t)**	**ERROR (t)**	**PASS or FAIL or BET**
1	100.00	1.00	97.80	-2.20	FAIL	98.30	-1.70	BET	98.20	-1.80	BET	98.20	-1.80	BET
2	99.00	1.00	99.70	0.70	PASS	100.60	1.60	BET	100.20	1.20	BET	100.80	1.80	BET
3	100.20	1.00	100.00	-0.20	PASS	100.40	0.20	PASS	100.50	0.30	PASS	99.70	-0.50	PASS
4	100.60	1.00	99.40	-1.20	BET	101.10	0.50	PASS	101.00	0.40	PASS	100.60	0.00	PASS
5	99.50	1.00	101.40	1.90	BET	101.50	2.00	BET	99.80	0.30	PASS	100.60	1.10	BET
6	100.40	1.00	99.60	-0.80	PASS	98.90	-1.50	BET	100.70	0.30	PASS	99.20	-1.20	BET
7	98.60	1.00	98.80	0.20	PASS	98.50	-0.10	PASS	98.90	0.30	PASS	99.20	0.60	PASS
8	90.50	0.90	90.50	0.00	PASS	90.00	-0.50	PASS	89.70	-0.80	PASS	89.60	-0.90	PASS
9	97.60	1.00	98.20	0.60	PASS	97.50	-0.10	PASS	97.40	-0.20	PASS	97.70	0.10	PASS
10	96.50	1.00	95.00	-1.50	BET	96.00	-0.50	PASS	96.20	-0.30	PASS	95.90	-0.60	PASS
11	107.00	1.10	107.00	0.00	PASS	107.00	0.00	PASS	107.20	0.20	PASS	107.00	0.00	PASS
12	98.40	1.00	98.70	0.30	PASS	98.70	0.30	PASS	98.60	0.20	PASS	98.80	0.40	PASS
13	79.80	0.80	79.60	-0.20	PASS	79.90	0.10	PASS	79.40	-0.40	PASS	79.20	-0.60	PASS
14	80.00	0.80	80.50	0.50	PASS	80.10	0.10	PASS	80.10	0.10	PASS	79.90	-0.10	PASS
15	77.80	0.80	77.80	0.00	PASS	77.30	-0.50	PASS	77.90	0.10	PASS	78.20	0.40	PASS
TOTAL	1425.90	5.70	1424.00	-1.90		1425.80	-0.10		1425.80	-0.10		1424.60	-1.30	
% Error				-0.133			-0.007			-0.007			-0.091	
Tot. Train			5182.20			5207.10			5200.30			5196.80		
											Total Train (sum of 60 ref. wagons)=	5700.2		

Example 1: Unusual Ballasted Rail Result

15 Car Distributed Test Train - Total of 60 Cars - 4 verification test runs 0.5,1, 3 and 5kph

R 160 - Individual Car Weights Class 2 Fail but still passed Total Train Class 0.5

Handbook 44 – All runs fail for individual cars but pass for total train within 0.2 %



Example 1: Unusual Ballasted Rail Result
Individual Car Error Plot
(vertical force transfer between couplers significant)

			RUN 1			RUN 2			RUN 3			RUN 4		
TEST WAGON No.	**TEST WAGON KNOWN MASS (t)**	**MPE (t)**	**RUN 1 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 2 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 3 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 4 (t)**	**ERROR (t)**	**PASS or FAIL or BET**
1	69.75	0.35	70.20	0.45	BET	70.25	0.50	BET	70.15	0.40	BET	69.95	0.20	PASS
2	68.95	0.35	68.50	-0.45	BET	69.20	0.25	PASS	69.00	0.05	PASS	68.85	-0.10	PASS
3	68.40	0.35	68.70	0.30	PASS	68.65	0.25	PASS	68.35	-0.05	PASS	68.30	-0.10	PASS
4	68.15	0.35	68.40	0.25	PASS	68.65	0.50	BET	68.25	0.10	PASS	68.15	0.00	PASS
5	68.15	0.35	68.20	0.05	PASS	68.40	0.25	PASS	68.05	-0.10	PASS	68.00	-0.15	PASS
6	67.70	0.35	67.65	-0.05	PASS	67.70	0.00	PASS	67.65	-0.05	PASS	67.65	-0.05	PASS
7	67.50	0.35	67.45	-0.05	PASS	67.55	0.05	PASS	67.50	0.00	PASS	67.50	0.00	PASS
8	67.45	0.35	67.55	0.10	PASS	67.45	0.00	PASS	67.25	-0.20	PASS	67.25	-0.20	PASS
9	67.20	0.35	67.25	0.05	PASS	67.15	-0.05	PASS	67.15	-0.05	PASS	67.10	-0.10	PASS
10	66.95	0.35	67.05	0.10	PASS	67.30	0.35	PASS	67.00	0.05	PASS	67.05	0.10	PASS
11	66.85	0.35	66.90	0.05	PASS	67.05	0.20	PASS	67.05	0.20	PASS	66.90	0.05	PASS
12	66.95	0.35	66.75	-0.20	PASS	66.55	-0.40	BET	66.55	-0.40	BET	66.60	-0.35	PASS
13	66.70	0.35	66.80	0.10	PASS	66.85	0.15	PASS	66.70	0.00	PASS	66.85	0.15	PASS
14	66.70	0.35	66.60	-0.10	PASS	66.90	0.20	PASS	66.65	-0.05	PASS	66.80	0.10	PASS
15	66.55	0.35	66.70	0.15	PASS	66.80	0.25	PASS	66.75	0.20	PASS	66.65	0.10	PASS
TOTAL	1013.95	10.15	1014.70	0.75		1016.45	2.50		1014.05	0.10		1013.60	-0.35	
% Error				0.074			0.247			0.010			-0.035	
Tot. Train			1310.60			1312.00			1311.90			1313.00		

Total Train (sum of 60 ref. wag.s)= 4058.8

Example 2: Typical Ballasted Rail Result

15 Car Distributed Test Train - Total of 60 Cars - 4 verification test runs 0.5,1, 3 and 5kph

R 160 - Individual Car Weights Class 2 Passed for Total Train Class 0.5

Handbook 44 - Runs 1 & 2 fail for individual cars – Run 2 failed for total train within 0.2 %

Example 2: Typical Ballasted Rail Result
Individual Car Error Plot

			RUN 1			RUN 2			RUN 3			RUN 4		
TEST WAGON No.	**TEST WAGON KNOWN MASS (t)**	**MPE (t)**	**RUN 1 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 2 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 3 (t)**	**ERROR (t)**	**PASS or FAIL or BET**	**RUN 4 (t)**	**ERROR (t)**	**PASS or FAIL or BET**
1	100.00	0.50	100.10	0.10	PASS	100.20	0.20	PASS	100.00	0.00	PASS	100.60	0.60	BET
2	99.00	0.50	99.10	0.10	PASS	99.10	0.10	PASS	99.40	0.40	PASS	98.60	-0.40	PASS
3	100.20	0.50	100.40	0.20	PASS	100.40	0.20	PASS	100.60	0.40	PASS	100.10	-0.10	PASS
4	100.60	0.50	100.30	-0.30	PASS	100.50	-0.10	PASS	100.40	-0.20	PASS	100.60	0.00	PASS
5	99.50	0.50	99.50	0.00	PASS	99.30	-0.20	PASS	99.40	-0.10	PASS	99.40	-0.10	PASS
6	100.40	0.50	100.70	0.30	PASS	100.60	0.20	PASS	100.60	0.20	PASS	100.50	0.10	PASS
7	98.60	0.50	98.40	-0.20	PASS	98.10	-0.50	PASS	98.50	-0.10	PASS	98.40	-0.20	PASS
8	90.50	0.50	90.30	-0.20	PASS	89.80	-0.70	BET	90.50	0.00	PASS	90.30	-0.20	PASS
9	97.60	0.50	97.30	-0.30	PASS	97.20	-0.40	PASS	97.60	0.00	PASS	97.60	0.00	PASS
10	96.50	0.50	96.50	0.00	PASS	96.40	-0.10	PASS	96.60	0.10	PASS	96.40	-0.10	PASS
11	107.00	0.50	107.10	0.10	PASS	107.00	0.00	PASS	107.10	0.10	PASS	107.20	0.20	PASS
12	98.40	0.50	98.60	0.20	PASS	98.40	0.00	PASS	98.60	0.20	PASS	98.70	0.30	PASS
13	79.80	0.40	79.80	0.00	PASS	79.70	-0.10	PASS	79.80	0.00	PASS	79.70	-0.10	PASS
14	80.00	0.40	79.80	-0.20	PASS	79.80	-0.20	PASS	79.80	-0.20	PASS	79.80	-0.20	PASS
15	77.80	0.40	77.70	-0.10	PASS	77.80	0.00	PASS	77.80	0.00	PASS	77.90	0.10	PASS
TOTAL	1425.90	5.70	1425.60	-0.30		1424.30	-1.60		1426.70	0.80		1425.80	-0.10	
% Error				-0.021			-0.112			0.056			-0.007	
Tot. Train			5228.00			5228.00			5228.00			5228.00		

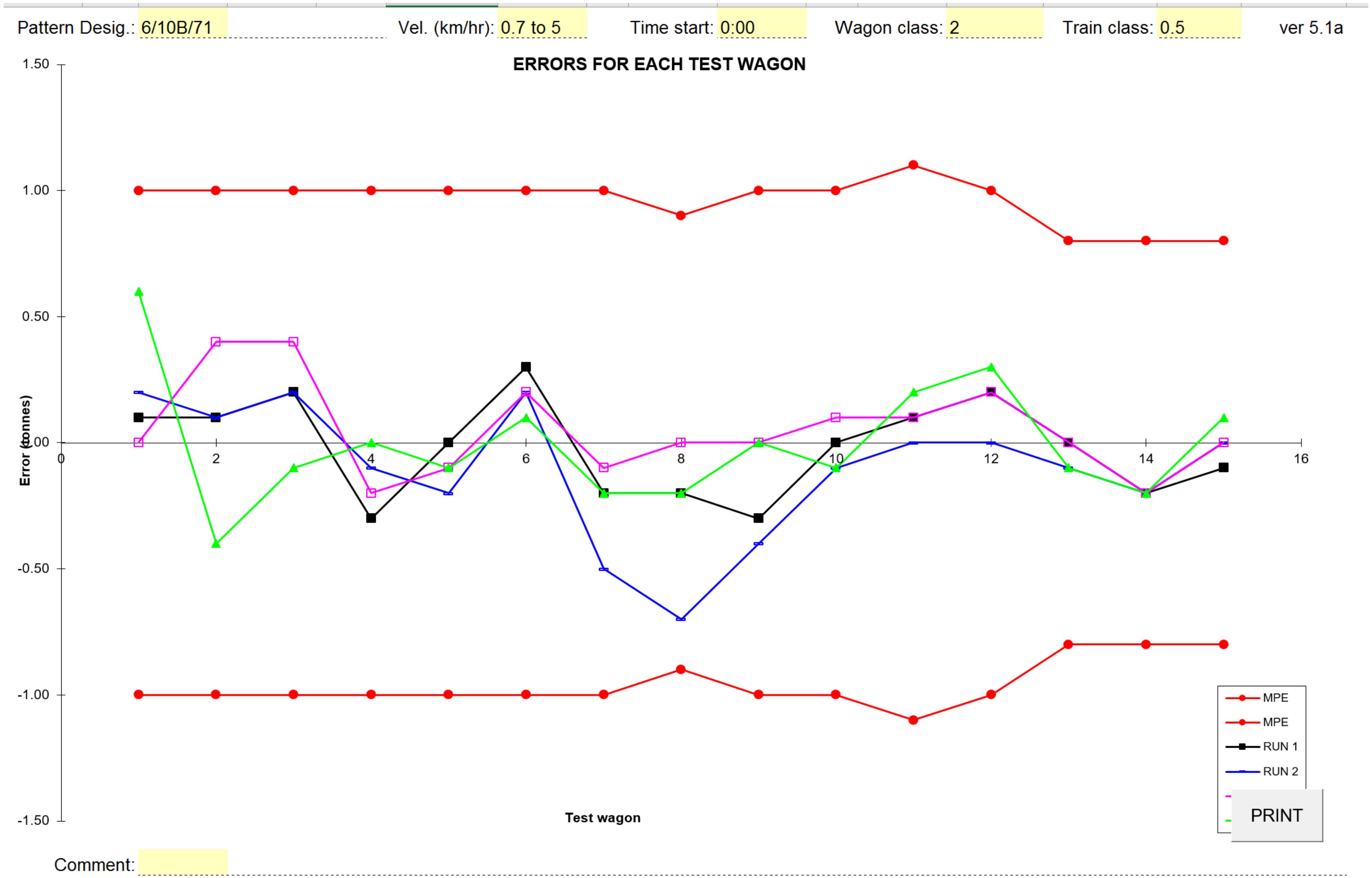
Total Train (sum of 60 ref. wagons)= 5702.4

Example 3: Concrete Slab Rail Result

15 Car Distributed Test Train - Total of 60 Cars - 4 verification test runs 5,3, 0.7 and 0.7kph

R 160 - Individual Car Weights Class 1 Pass and Total Train Class 0.5 (almost 0.2)

Handbook 44 - All runs pass for individual cars and for total train tolerances



Example 3: Concrete Slab Rail Result

Individual Car Error Plot

Section T.N.3.6. Coupled-In-Motion Railroad Weighing Systems.

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Justification:

- The proposed changes are directly from OIML R 106-1 Edition 2011 (E) Automatic rail-weighbridges;
- A range of accuracy classes is more appropriate for these types of weighing systems;
- Paragraph T.N.3.6.2. as it appears currently is not achievable for the vast majority of real life installations as clients are simply not willing to invest the required sums.
- A comparison with Belt-Conveyor Scale Systems in Handbook 44 shows inconsistency in tolerance criteria. 0.2% for Train weighing systems but 0.25% for conveyor weighing systems. Should have consistency. Handbook needs a review to address these inconsistencies.
- NTEP certification for these types of systems is not financially viable for many clients at 0.2%. The cost to achieve a 0.5% system can be 3 or 4 times cheaper.
- Accepting a minimal reduction in weighing accuracy for trade applications will lead to significantly improved weighing efficiencies to the railway industry. It has already happened in the countries that have adopted the OIML standard.

Other Handbook44 Considerations

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The proposed changes if accepted will impact other existing requirements in Handbook 44. These would include:

- Markings
- TBA

- o Some new requirements may need to be added as well. For example requirements could be added to specify which accuracy classes are permitted for trade weighing of unit trains, mixed manifest freight trains etc.