Meeting the Revised Requirements of the ASTM 1318-02 Standard Specification for Highway Weigh-in-Motion (WIM) Systems

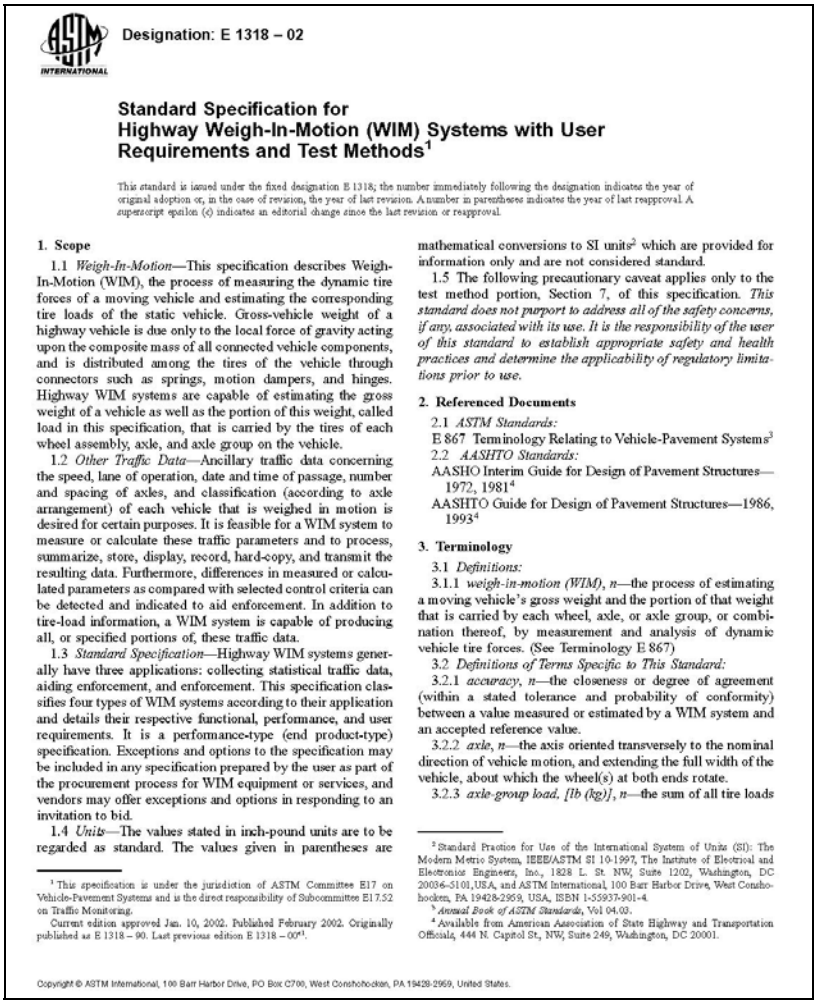
Felix Klebe, METTLER TOLEDO
August, 2002

Introduction

Weigh-in-Motion (WIM) systems for vehicle weighing consist of a weighing sensor and the associated electronics for interpreting, recording, and communicating weight data. The primary purposes of WIM systems are to:

1. Record weight data for road use analysis and pavement research projects.
2. Pre-screen trucks as part of commercial vehicle weight enforcement operation.
3. Use weight information to calculate tolls on toll roads, bridges, or tunnels.

Many papers have been written comparing the various WIM technologies, installation criteria, and life cycle costs. The purpose of this paper is to review the recently issued revision (February, 2002) to the industry standard for WIM systems, ASTM 1318, Standard Specification for Highway Weigh-in-Motion (WIM) Systems. The paper also includes a brief overview of METTLER TOLEDO's compliance with these specifications prior to their official release.



Designation: E 1318 – 02

Standard Specification for Highway Weigh-In-Motion (WIM) Systems with User Requirements and Test Methods[1]

This standard is issued under the fixed designation E 1318; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 *Weigh-In-Motion*—This specification describes Weigh-In-Motion (WIM), the process of measuring the dynamic tire forces of a moving vehicle and estimating the corresponding tire loads of the static vehicle. Gross-vehicle weight of a highway vehicle is due only to the local force of gravity acting upon the composite mass of all connected vehicle components, and is distributed among the tires of the vehicle through connectors such as springs, motion dampers, and hinges. Highway WIM systems are capable of estimating the gross weight of a vehicle as well as the portion of this weight, called load in this specification, that is carried by the tires of each wheel assembly, axle, and axle group on the vehicle.

1.2 *Other Traffic Data*—Ancillary traffic data concerning the speed, lane of operation, date and time of passage, number and spacing of axles, and classification (according to axle arrangement) of each vehicle that is weighed in motion is desired for certain purposes. It is feasible for a WIM system to measure or calculate these traffic parameters and to process, summarize, store, display, record, hard-copy, and transmit the resulting data. Furthermore, differences in measured or calculated parameters as compared with selected control criteria can be detected and indicated to aid enforcement. In addition to tire-load information, a WIM system is capable of producing all, or specified portions of, these traffic data.

1.3 *Standard Specification*—Highway WIM systems generally have three applications: collecting statistical traffic data, aiding enforcement, and enforcement. This specification classifies four types of WIM systems according to their application and details their respective functional, performance, and user requirements. It is a performance-type (end product-type) specification. Exceptions and options to the specification may be included in any specification prepared by the user as part of the procurement process for WIM equipment or services, and vendors may offer exceptions and options in responding to an invitation to bid.

1.4 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units[2] which are provided for information only and are not considered standard.

1.5 The following precautionary caveat applies only to the test method portion, Section 7, of this specification. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*
E 867 Terminology Relating to Vehicle-Pavement Systems[3]
2.2 *AASHTO Standards:*
AASHO Interim Guide for Design of Pavement Structures—1972, 1981[4]
AASHTO Guide for Design of Pavement Structures—1986, 1993[4]

3. Terminology

3.1 *Definitions:*
3.1.1 *weigh-in-motion (WIM), n*—the process of estimating a moving vehicle's gross weight and the portion of that weight that is carried by each wheel, axle, or axle group, or combination thereof, by measurement and analysis of dynamic vehicle tire forces. (See Terminology E 867)
3.2 *Definitions of Terms Specific to This Standard:*
3.2.1 *accuracy, n*—the closeness or degree of agreement (within a stated tolerance and probability of conformity) between a value measured or estimated by a WIM system and an accepted reference value.
3.2.2 *axle, n*—the axis oriented transversely to the nominal direction of vehicle motion, and extending the full width of the vehicle, about which the wheel(s) at both ends rotate.
3.2.3 *axle-group load, [lb (kg)], n*—the sum of all tire loads

[1] This specification is under the jurisdiction of ASTM Committee E17 on Vehicle-Pavement Systems and is the direct responsibility of Subcommittee E17.52 on Traffic Monitoring.
Current edition approved Jan. 10, 2002. Published February 2002. Originally published as E 1318 – 90. Last previous edition E 1318 – 00[ε1].

[2] Standard Practice for Use of the International System of Units (SI): The Modern Metric System, IEEE/ASTM SI 10-1997, The Institute of Electrical and Electronics Engineers, Inc., 1828 L. St. NW, Suite 1202, Washington, DC 20036-5101,USA, and ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA, ISBN 1-55937-901-4.
[3] *Annual Book of ASTM Standards*, Vol 04.03.
[4] Available from American Association of State Highway and Transportation Officials, 444 N. Capitol St., NW, Suite 249, Washington, DC 20001.

Figure 1: ASTM 1318-02

Background and Evolution of Weigh-in-Motion Systems for Highway Use

1951: The U.S. Bureau of Public Roads worked with the Virginia State Department of Highways and the Williams Construction Company to complete construction of a pit and slab for the load cells and electrical equipment to test weigh-in-motion equipment on the Henry G. Shirley Memorial Highway. The experiment, near the intersection with U.S. 1, led to the conclusion that a good possibility exists for improving accuracy to the point that weighing trucks in-motion will provide data that is as accurate as weighing trucks statically. Other significant events related to WIM evolution are as follows:

1960s: The California Department of Transportation becomes actively involved with weigh-in-motion research.

1983: The first National Weigh-in-Motion Conference held.

1987: Long-term Testing of Pavement Program initiated in 1987 as part of the Strategic Highway Research Program.

1990: The first version of ASTM 1318 Standard Specification for Highway Weigh-In-Motion (WIM) Systems is published.

1994: Minor revisions are made to ASTM 1318.

1996: The first mainline electronic weight and credential screening system is installed in California.

1997: The U.S. DOT FHA published "Best Practices Weigh-in-Motion Handbook," written by the Center for Transportation Research and Education at Iowa State University.

2002: A second revision to the ASTM 1318 Standard Specification for Highway Weigh-In-Motion (WIM) Systems is released.

The original edition of ASTM 1318 was published in 1990 in response to the need for a definition of performance standards for various types of WIM systems. Revisions to the standard were made in 1994. Extensive additional research and field experience identified the need for additional revisions, which were released this past February.

Specifications for weigh stations and traffic data collection sites are typically written by State Department of Transportation Engineering Divisions. Weigh-in-Motion installation, performance, and acceptance test criteria are included in these specifications (see Table 1 below). ASTM 1318 has allowed state highway engineers to reference performance and installation practices that are now familiar to equipment vendors and contractors. Some state specifications call out ASTM 1318 sections, while others incorporate portions of ASTM 1318 into their specifications. ASTM 1318 has also provided a common performance standard from which equipment vendors and contractors can work, helping to prevent a proliferation of different systems supplied to different states.

Portions of ASTM 1318 are also referenced in other Weigh-in-Motion type guidelines, such as the U.S. DOT Long-Term Pavement Performance *Data Collection Guide for SPS WIM Sites*. The overall objective is to ensure that WIM equipment is installed properly and performs in such a way that accurate data will be reported.

	Tolerance for 95% Probability of Conformity				
Function	Type I	Type II	Type III	Type IV	
				Value (lb)	Tolerance
Speed Range	10 - 80 mph	15 – 80 mph	10 - 80 mph	2 – 10 mph	
Application	Data collection	Data collection	Weight enforcement	Weight enforcement	
Technology	P, BP, LC	P, BP, LC	BP, LC	LC	
Wheel Load	+/- 25%	n.a.	+/- 20%	5000	250
Axle Load	+/- 20%	+/- 30%	+/- 15%	12000	500
Axle Group Load	+/- 15%	+/- 20%	+/- 10%	25000	1200
GWT	+/- 10%	+/- 15%	+/- 6%	60000	2500
Speed	+/- 1 mph				
Axle Spacing	+/- 0.5 ft				

Table 1

Need for Revisions to ASTM 1318 and Significant Changes Made in Latest Revision

The growth of the installed WIM base in a variety of environments has provided insight into the needed revisions to ASTM 1318. The major changes released in February, 2002, in ASTM 1318-02 and their impacts on WIM vendors and users are summarized in Table 2 below. The most significant changes, based on field experience and WIM evolution, have been driven by:

1. The growth of mainline weight sorting systems, which require that weight enforcement-related WIM systems function at higher speeds.
2. Users experiencing inconsistent weight data accuracy stemming from temperature variations, which has compromised the accuracy of collected vehicle weight data.
3. The realization that vehicles are not always centered over the weighing platform, and that weight readings from off-center vehicles can have significantly lower accuracy.
4. Experience and research indicating that pavement smoothness and durability is critical to long-term accuracy of WIM systems, as well as to safe operation.

Revision to ASTM 1318	Reason	WIM Vendor Impact	WIM User Impact
Increase in Type III operational speed to 80 mph	Growth of mainline weight enforcement WIM	Need to ensure accuracy at higher speeds	More options on placement of WIM equipment
Suggestion to user to specify that sensor accuracy is met across – 20°F to 120°F range	Findings that some sensors lose weighing accuracy at the high and low end of the temperature range	Need to ensure accuracy via data conditioning or other methods	Improved quality of weight data
Requirement to certify sensor accuracy across width of weighing platform	Experience that some sensors are less accurate for off-center applied loads	Need to design systems to maintain accuracy across width of weighing platform	Improved quality of weight data
Increase of smooth and level pavement surface to 200′ in advance of WIM sensor (100′ beyond sensor)	Experience that greater distance of smooth pavement increases WIM weighing accuracy	None	No net change to smooth pavement length, only WIM repositioning.
Recommendation that WIM system be installed into Portland Cement concrete pavement only	Experience showed improved accuracy and durability when using PCC vs. asphalt	None	Increase in initial construction cost with increase in system life and accuracy
Increase of minimum road width in advance of and beyond WIM system to 12′ wide		None	Increase in construction cost
Increase in maximum allowable cross slope to 3° for Type I, II, and III		None	Decrease in construction cost
Data communication link between the WIM site and a remote host computer, allowing for remote setting adjustment	Prevalence of sites where operator is not near the WIM system and where users desire to change settings	Hardware and software requirement	Increased WIM functionality
Addition of vendor Type- Approval Test	Cases where WIM system could not meet accuracy requirements	Need to provide Type-Approval Test compliance	Assurance of WIM system capability
Acceptance test includes non-centered platform loading	Experience that some sensors are less accurate for off-center applied loads	Need to design systems to maintain accuracy across width of weighing platform	More accurate data under actual range of use conditions
Acceptance test doesn't require on-site static weights, but rather pre-weighed vehicles		None	Lower testing cost when no on-site static scales exist

Table 2

The benefits for users of having vendors provide WIM systems that meet ASTM 1318-02 are significant, with improved data accuracy under broader operating conditions being the most obvious benefit.

WIM Vendor Technologies to Comply with ASTM 1318-02

Although the changes to ASTM 1318 were only recently enacted, METTLER TOLEDO has long been designing and building WIM systems, which meet these requirements.

METTLER TOLEDO WIM systems have four load cells for each weighing platform to help ensure accurate weight measurement even when vehicle tires are at the edge of a WIM scale platform. The resulting gross weight tolerance of +/- 3% at a 95% confidence level, across the entire width of the scale platform, well exceeds the maximum tolerance specified in ASTM 1318-02. In addition, METTLER TOLEDO's suggested WIM system acceptance test period of 56 consecutive days of operation without downtime or other problems exceeds the on-site acceptance tests recently recommended in ASTM 1318-02.

For weigh stations with both WIM and static scales, METTLER TOLEDO's closed loop calibration technology provides daily WIM scale calibration, which greatly exceeds the minimum annual calibration suggestion made in ASTM 1318-02. Lightning protection technology is also a standard feature in METTLER TOLEDO's WIM systems, helping to assure maximum system reliability and reduced maintenance costs.

Future Use of ASTM 1318-02

As WIM technology continues to improve, its use will continue to broaden into new applications beyond highway planning and weight enforcement. As these new applications emerge, it may become necessary to create new Type Classifications within ASTM 1318 with unique performance requirements. Also, as weigh-in-motion for enforcement purposes becomes more popular, modifications to the Type IV category will likely occur along with the increase in user experience.

Moving forward, METTLER TOLEDO will continue working with highway state departments and others to ensure that the latest WIM technology is employed and that even newer technology will continue to be developed and implemented to ensure the most accurate, reliable in-motion weighing possible – even in advance of additional ASTM 1318 revisions.

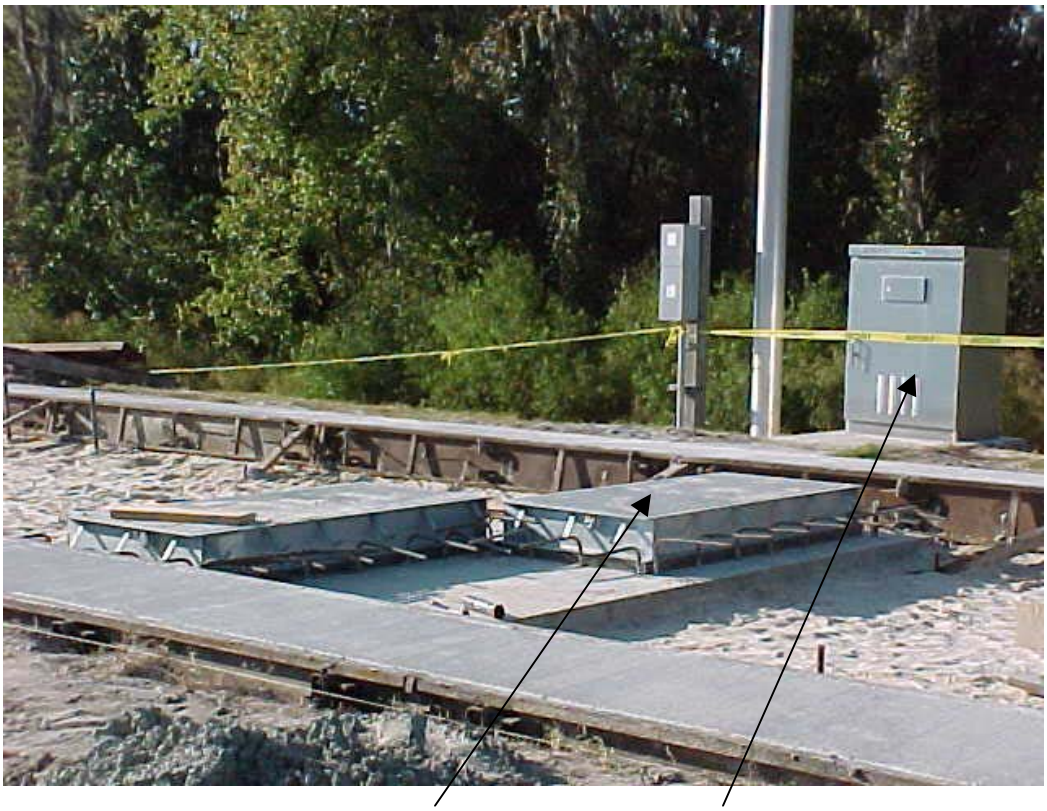


Figure 2: Typical Type III WIM Scale