INTERNATIONAL ROAD DYNAMICS INC.

QUALITY IN MOTION

WIM TECHNOLOGIES COMPARISON

Revision A
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For further information or assistance, please call IRD at tel: 306-653-6600.

Corporate Office
702 43rd Street
Saskatoon, Sask.
Canada S7K 3T9
Tel: (306) 653-6600
Fax: (306) 242-5599

U.S. Corporate Office
2402 Spring Ridge Drive, Suite E
Spring Grove, IL
USA 60081
Ph: 1 (877) 444-4473
Fax: (815) 675-1530

VARIOUS WEIGH-IN-MOTION TECHNOLOGIES

Single Load Cell Scale

The Single Load Cell Scale consists of two (2) weighing platforms with a surface size of 6' by 3'2", placed adjacent to each other to fully cover a normal 12' traffic lane. A single hydraulic load cell is installed at the center of each platform to measure the force applied to the scales. The load measurements are recorded and analyzed by the system electronics to determine the axle loads.

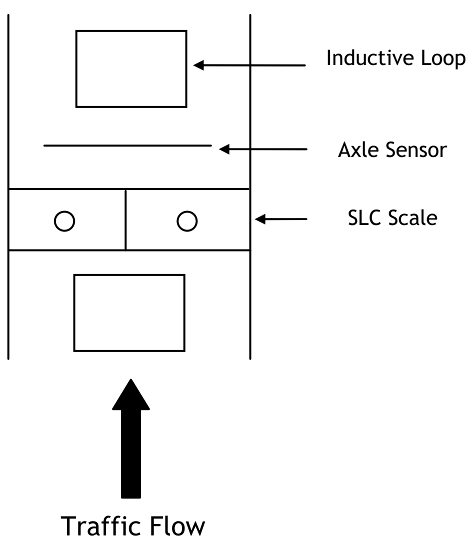
The installation of a single load cell scale requires the use of a concrete vault. The roadway is cut and excavated to form a pit. The frame is positioned in place and then is cast into the concrete to form a secure and durable foundation for the scale. The size of the vault required is slightly large, measuring 165" by 58" by 38".

The Single Load Cell scale is typically installed in a lane with two inductive loops and an axle sensor to provide vehicle length and axle spacing information. Installing a complete lane of scales, loops and axle sensor can be accomplished in 3 days.

When properly installed and calibrated, the Single Load Cell WIM system should be expected to provide gross vehicle weights that are within 4-6% of the actual vehicle weight for 95% of the trucks measured.

Common Configuration

Single Load Cell Scale:



Equipment List:

Inductive Loop (x2)
Single Load Cell Scale (1 Lane)
Axle Sensor (x1)

Scheduled Maintenance - Single Load Cell Scale

At six (6) month intervals the following scheduled maintenance should be performed to ensure continued scale operation.

- Visually inspect the scale installation.
- Maintain installation of the concrete vault.
- Maintain the slot between the concrete vault and the existing roadway with loop sealant.
- Remove the load cell from the load cell cavity, retorque the four (4) mounting bolts in the load cell cavity, check the splice, replace the antifreeze in the load cell cavity, replace the load cell, load cell hatch, secure and reseal load cell hatch.
- Retorque and/or replace the eight (8) mounting bolts as required.
- Replace all frost plugs as required.
- Maintain the installation of the silicon sealant between the scale and frame.
- Maintain all splices in junction boxes as required.
- Measure the signal cable resistance of the scale.
- Recalibrate the scale.

Bending Plate Scale

The Bending Plate scale consists of two steel platforms, which are each 2' by 6', placed adjacent to each other to cover a 12' lane. The steel plate is instrumented with strain gages at critical points to measure the strain in the plate as a tire or axle passes over. The measured strain is analyzed to determine the axle load. The Bending Plate scale is typically installed in a lane with two inductive loops and an axle sensor to provide vehicle length and axle spacing information.

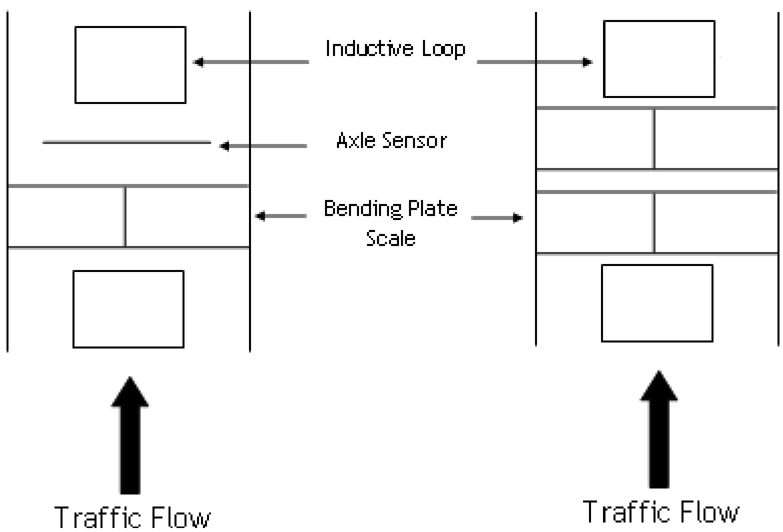
There are two basic installation methods for a Bending Plate scale. In concrete roadways of sufficient depth, a shallow excavation is made in the surface of the road (Quick Installation). The scale frame is anchored into place using anchoring bars and epoxy. In asphalt roads or thin concrete roads, it is necessary to install a concrete foundation for support of the frame (Vault Installation). The roadway is cut and excavated to form a pit of 30" deep by 4'10" wide by 13'10"long. The frame is positioned in place and then is cast into concrete to form a secure and durable foundation for the scale.

Installing a complete lane of scales, loops and axle sensor can be accomplished in a day using the shallow excavation method and in 3 days using the concrete vault.

When properly installed and calibrated, the Bending Plate WIM system should be expected to provide gross vehicle weights that are within 8-10% of the actual vehicle weight for 95% of the trucks measured for Configuration 1 and within 6-8% for Configuration 2.

Common Configuration

Bending Plate Scale:



Configuration 1: Single Threshold **Configuration 2: Double Threshold**

Equipment List:

Inductive Loop (x2)
Bending Plate Scale (1 lane)
Axle Sensor (x1)

Scheduled Maintenance – Bending Plate

Quick Installation (No concrete vault)

At six (6) month intervals the following scheduled maintenance should be performed to ensure continued scale operation.

- Visually inspect the scale installation.
- Maintain installation of the epoxy material
- Re-torque and/or replace stainless steel cap screws.
- Replace frost plugs as required.
- Maintain installation of the silicon seal.
- Maintain all splices in the junction boxes as required.
- Measure signal cable resistance of scale.
- Recalibrate the scales.

Vault Installation

At six (6) month intervals the following scheduled maintenance should be performed to ensure continued scale operation.

- Visually inspect the scale installation.
- Maintain installation of the concrete vault.
- Maintain the slot between the concrete vault and the existing roadway with loop sealant.
- Re-Torque and/or replace stainless steel cap screws.
- Replace frost plugs as required.
- Maintain installation of the silicon seal.
- Maintain all splices in the junction boxes as required.
- Measure signal cable resistance of scale.
- Recalibrate the scales.

Kistler Lineas Quartz

The Kistler Lineas Quartz WIM Sensor consists of a light metal profile in the middle of which quartz disks are fitted under preload. When force is applied to the sensor surface the quartz disks yield an electric charge proportional to the applied force through piezoelectric effect. This electric charge is converted by a charge amplifier into a proportional voltage, which can be then further processed as required.

The sensors can be installed in combination with other traffic detectors like induction loops, switching cables, etc. Kistler WIM sensors are easy to install both individually and in groups for comprehensive recording over a wide roadway. Typically, two 1.75 meter (68.9”) long sensors are required to cover one typical lane width of approximately 12 feet.

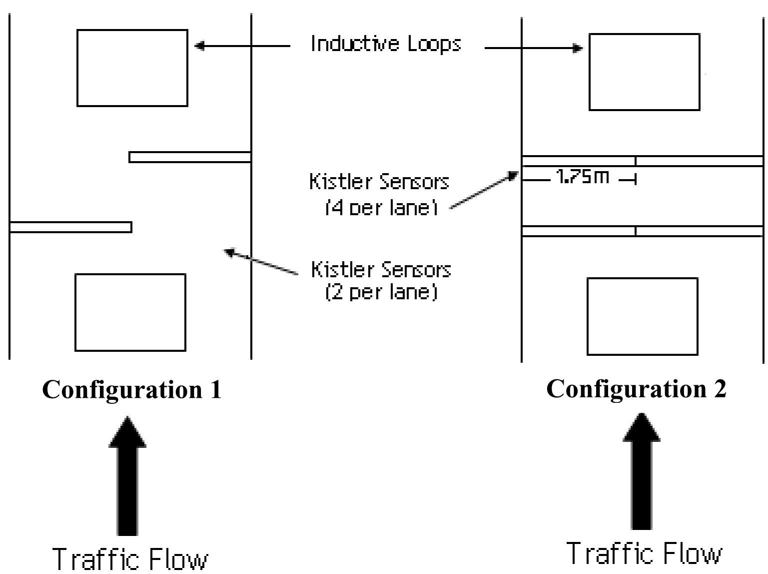
Installation begins by making a relatively small cut in the road into which the sensor will be installed. The size of the cut varies depending on the sensor being installed, but is generally 2.25” deep and 3” wide. The sensor is placed in the sawcut and secured in place by a fast curing grout.

A complete lane installation consisting of four sensors and two loops can be accomplished in less than a day, including curing time.

When properly installed and calibrated, the Kistler WIM system should be expected to provide gross vehicle weights that are within 10% of the actual vehicle weight for 95% of the trucks measured for Configuration 1 and within 8-10% for Configuration 2.

Common Configuration

Kistler:



Equipment List:

Inductive Loop (x2)
Kistler WIM Sensor (x2)

Equipment List:

Inductive Loop (x2)
Kistler WIM Sensor (x4)

Scheduled Maintenance – Kistler Sensors

At six (6) Month intervals the following Scheduled Maintenance should be performed to ensure continual sensor operation.

- Visually inspect the Kistler sensor installation.
- Ensure no cracks are forming in grout or surrounding pavement.
- Ensure seal between grout and pavement.
- Maintain the installation of the grout.
- Maintain all Kistler sensor cable splices as required.
- Visually inspect the BNC connector and replace if required.
- Measure the resistance and voltage output of the sensor.

Piezoelectric Sensors

The basic construction of the typical sensor consists of a copper strand, surrounded by a piezoelectric material, which is covered by a copper sheath. When pressure is applied to the piezoelectric material an electrical charge is produced. The sensor is actually embedded in the pavement and the load is transferred through the pavement. The characteristics of the pavement will therefore affect the output signal. By measuring and analyzing the charge produced, the sensor can be used to measure the weight of a passing tire or axle group.

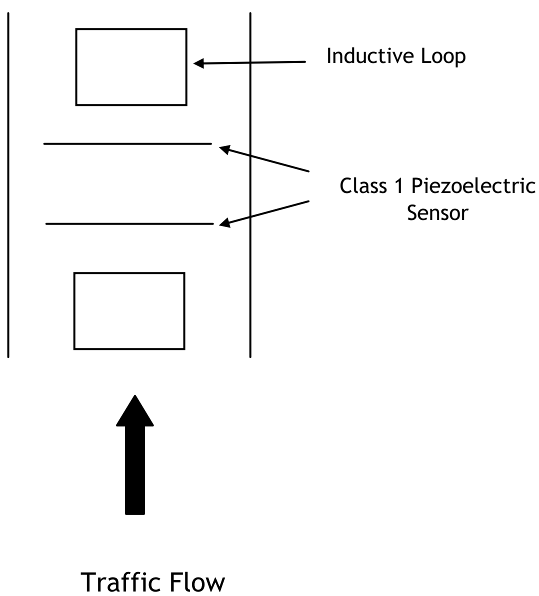
For a complete data collection system, it is common to install two inductive loops and two piezoelectric sensors in each lane, which is being monitored. Installation begins by making a relatively small cut in the road into which the sensor will be installed. The size of the cut varies depending on the sensor being installed, but is generally 1” to 2” deep and 1” to 2” wide. The sensor is placed in the sawcut and secured in place by a fast curing grout.

A complete lane installation consisting of two sensors and two loops can be accomplished in less than a full day, including curing time.

When properly installed and calibrated, a piezoelectric WIM system should be expected to provide gross vehicle weights that are within 15% of the actual vehicle weight for 95% of the trucks measured.

Common Configuration

Piezoelectric Sensor:



Equipment List:

Inductive Loop (x2)
Class 1 Piezoelectric Sensor- 12 ft (x2)

Scheduled Maintenance – Piezoelectric Sensors

At six (6) Month intervals the following Scheduled Maintenance should be performed to ensure continual sensor operation.

- Visually inspect the piezo installation.
- Maintain the installation of the grout.
- Maintain all piezo cable splices as required.
- Visually inspect the BNC connector and replace if required.
- Measure the resistance and voltage output of the sensor.

COMPARISON OF WIM TECHNOLOGY ACCURACIES AND COSTS

In order to evaluate which technology is most appropriate, the cost of each technology must also be considered. However, there are many factors to include in the cost of a WIM technology beyond equipment cost or the installation cost. Other factors to consider include the expected life, maintenance cost, and replacement costs.

The life cycle costing below is over a twelve-year period. For comparison, the equipment and installation costs are for the in-road equipment only. The cost of the electronics, cabinet, power supply, telephone connection, and road preparation are assumed to be relatively constant, regardless of technology used and are not included in these estimates. The initial installation includes the equipment supply, installation by a local contractor, installation supervision and calibration by a vendor representative and traffic control during installation and curing. Installation costs are dependent on site conditions and local market rates and may vary.

The equipment included for each type of WIM technology is displayed in the individual configurations shown previously.

Table 1 – WIM Technology Comparison

	Single Load Cell (/lane)	Bending Plate (/lane)		Kistler (/lane)		Piezoelectric (/lane)
		Single Threshold	Double Threshold	Single Threshold	Double Threshold	
Accuracy (GVW) (95% confidence level)	2σ=4-6%	2σ=8-10%	2σ=6-8%	2σ=10%	2σ=8-10%	2σ=15-20%
Service Life	12	7	7	4	4	3
Budgetary Equipment Cost	$55,239	$21,548	$37,548	$19,780	$39,560	$2,324
Budgetary Installation Cost	$24,310	$17,238	$34,476	$14,669	$29,338	$5,962
Annual Maintenance Cost	$1,867	$1,867	$3,734	$3,304	$6,608	$4,750
Cost per year (over 12 year period)	$8,496	$8,331	$15,738	$11,916	$23,833	$7,512

Note:

- Prices shown are *ESTIMATED* only.
- All monetary values in USD.
- Life cycle costing carried out over a twelve year period.
- All accuracies stated at a 95% confidence level.
- Initial Budgetary installation costs include materials to install and physical installation.