



INTERNATIONAL ROAD DYNAMICS, INC.

*WEIGH-IN-MOTION TECHNOLOGY COMPARISONS*

**JANUARY 2001**

**Technical Brief**

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**VARIOUS WEIGH-IN-MOTION TECHNOLOGIES**

**Kistler**

The Kistler WIM 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, four one meter (39.4") long sensors are required to cover one typical lane width of approximately 12 feet.

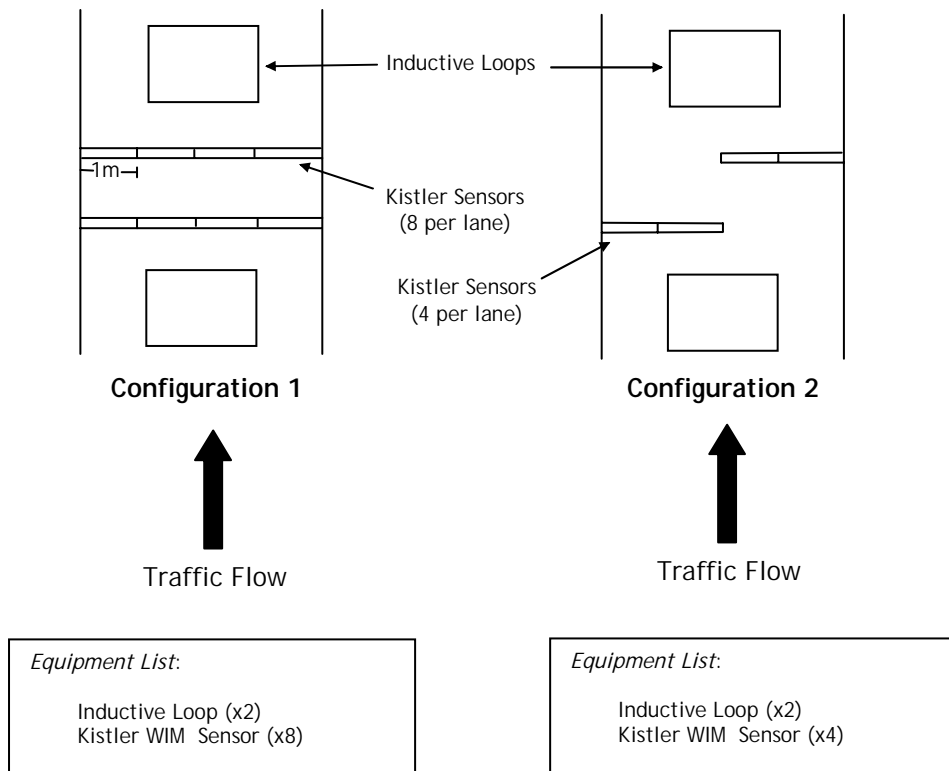
Installation begins by making a relatively small cut in the road into which the sensor will be installed. The size of the cut varies depending on the sensor being installed, but is generally 2.25" deep and 3" wide. The sensor is placed in the sawcut and secured in place by a fast curing grout.

A complete lane installation consisting of eight 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.

*Common Configuration*

Kistler:



*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.

## 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.

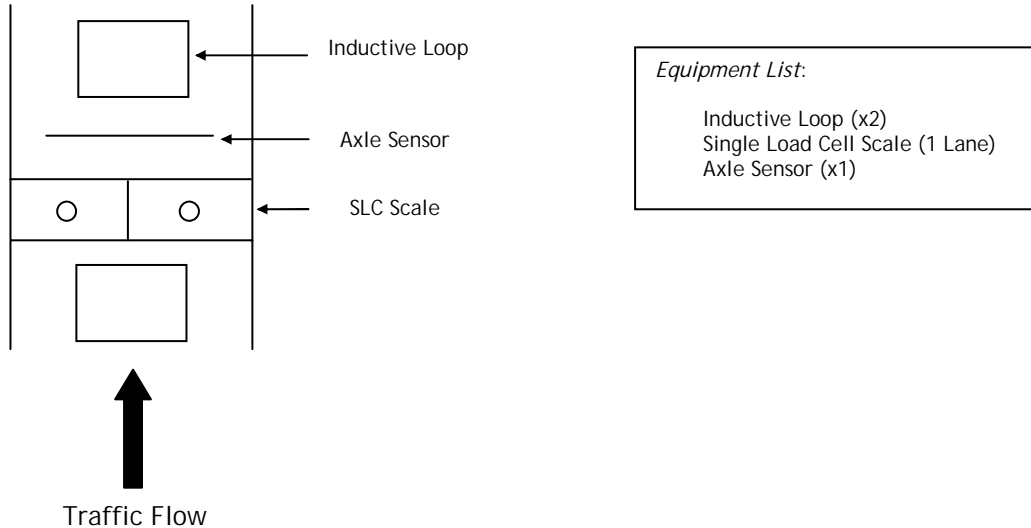
The installation of a single load cell scale requires the use of a concrete vault. The roadway is cut and excavated to form a pit. The frame is positioned in place and then is cast into the concrete to form a secure and durable foundation for the scale. The size of the vault required is slightly large, 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 6% of the actual vehicle weight for 95% of the trucks measured.

### *Common Configuration*

Single Load Cell Scale:



*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.

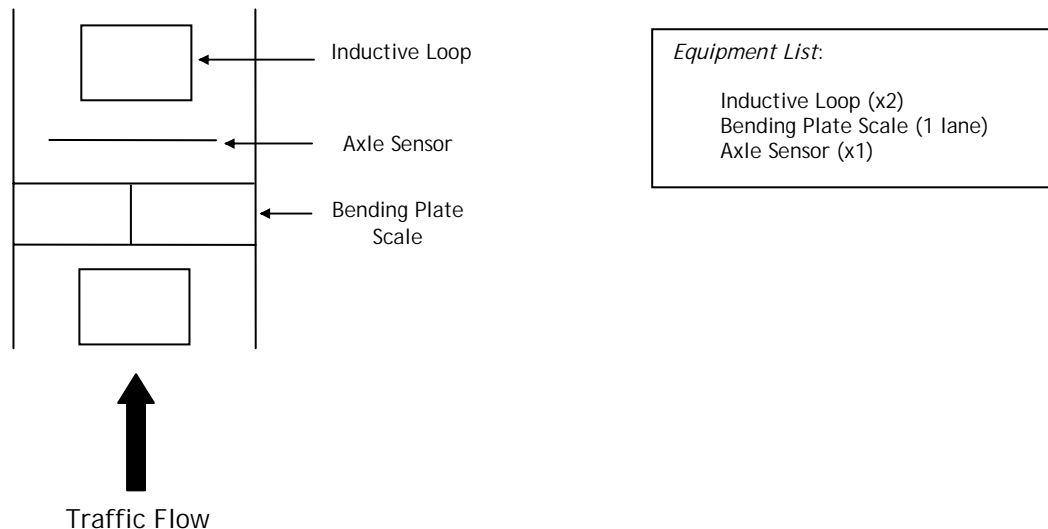
There are two basic installation methods for a Bending Plate scale. In concrete roadways of sufficient depth, a shallow excavation is made in the surface of the road (Quick Installation). The scale frame is anchored into place using anchoring bars and epoxy. In asphalt roads or thin concrete roads, it 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 10% of the actual vehicle weight for 95% of the trucks measured.

### *Common Configuration*

Bending Plate Scale:



*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.

## 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.

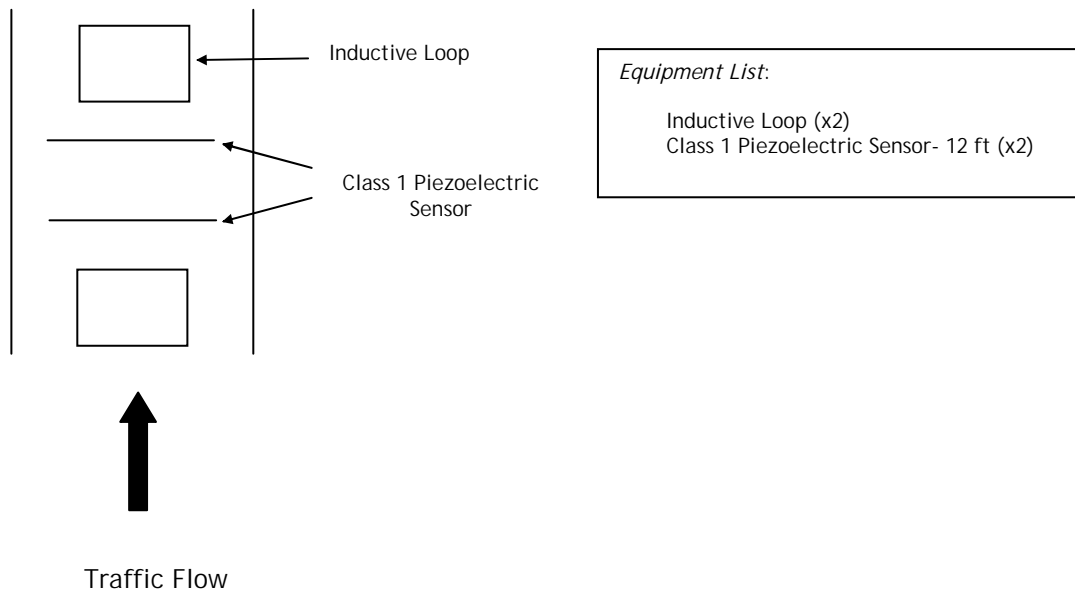
For a complete data collection system, it is common to install two inductive loops and two piezoelectric sensors in each lane, which is being monitored. Installation begins by making a relatively small cut in the road into which the sensor will be installed. The size of the cut varies depending on the 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:



*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 was carried over a twelve-year period. For comparison, the equipment and installation costs will be 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 use 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.

The equipment included for each type of WIM technology is displayed in the individual configurations shown previously. The Quick installation (no vault) has been included for the Bending Plate scale comparison. The Kistler configuration included in the comparison is seen in *Configuration 1*, previously displayed.

Table 1 - WIM Technology Comparison

	Kistler	Single Load Cell	Bending Plate	Piezoelectric
Accuracy (GVW) (95% confidence level)	2σ=10%	2σ=6%	2σ=10%	2σ=15%
Service Life	6 years	20 years	6 years	4 years
Initial Budgetary Equipment Cost	\$ 20,500 /lane	\$39,000 /lane	\$8,000 /lane	\$2,500 /lane
Initial Budgetary Installation Cost	\$12,000 /lane	\$20,800 /lane	\$13,500 /lane	\$6,500 /lane
Life Cycle Cost (over 12 year period)	\$7,500 /year/lane	\$6,200 /year/lane	\$6,400 /year/lane	\$4,750 /year/lane

*Note:*

- \* Prices shown are *ESTIMATED* only.
- \* All monetary values in USD.
- \* Life cycle costing carried out over a twelve year period.
- \* Kistler Accuracy stated for *Configuration 1*.
- \* No Vault installation used in cost comparison of Bending Plate.
- \* All accuracies stated at a 95% confidence level.
- \* Initial Budgetary installation costs include materials to install and physical installation.

**MAINTENANCE/PERFORMANCE MONITORING APPROACH**

The following are a number of suggested maintenance monitoring approaches, depending on the level of service desired.

1. Current Method - Data collection group completes reports every one (1) to three (3) months. At this time they identify any errors, which indicates that maintenance.
2. Scheduled Performance Monitoring by INDOT - INDOT would carry out daily, weekly or monthly maintenance checks and they would prepare summary reports. Within these reports, the client could look for irregularities in % errors, % un-classed vehicles, vehicle volume or % of vehicle types.
3. Scheduled Performance Monitoring by IRD - same as listed in (2.).
4. Self-Diagnostics - Change system software, so software looks for high % errors or vehicle volume irregularities. The system would phone out when problems detected.

## STANDARD IRD MAINTENANCE FORM

### Customer Recommended Maintenance For IRD Weigh-In-Motion (WIM) Systems

#### General

- Preventative Maintenance Service as identified below should be performed at 6 month intervals.

#### In-Road WIM Sensors:

##### All WIM Sensors

- Test response levels, signal level and lead cables
- Verify sensor performance and reliability
- Adjust calibration factors as required

##### Single Load Cell Scales

- Maintain installation of concrete vault
- Maintain silicone seal around perimeter of the weigh pads
- Re-tighten or replace damaged hardware and frost plugs as required
- Remove and replace single load cell hatch and perform visual inspection of single load cell and lightning protection
- Add antifreeze to single load cell scale as required

##### Bending Plates

- Maintain installation of concrete vault or epoxy
- Maintain silicone seal around the perimeter of the weigh pads
- Re-tighten or replace damaged hardware and frost plugs as required

##### Piezo Sensors

- Maintain installation of grout

##### Kistler Sensors

- Maintain installation of grout
- Maintain seal

#### Other In-Road Sensors:

##### All In-Road Sensors

- Test response levels, signal level and lead cables
- Verify sensor performance and reliability

##### Dynax Sensors

- Maintain installation of concrete vault or epoxy
- Re-tighten or replace damaged hardware and frost plugs as required

##### Loops

- Maintain installation of loop sealant

#### Electronics Interface and System Computers:

- Clean interior and exterior of all components
- Remove, clean and inspect all printed circuit boards
- Maintain all electrical connectors, cables and components
- Test and verify control and sequence of operation of interface components

***Note: Please be informed that your system may or may not have all sensors mentioned above. Contact ESS at (306)653-6627 for additional information if required on maintenance or maintenance contracts.***

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