VEHICLE SCALE GUIDE

Cardinal®
Cardinal Scale Manufacturing Co.

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INTRODUCTION

Like many business decisions, the decision to purchase a vehicle scale must take into consideration a number of factors. Most businesses find the purchase of a vehicle scale to be a significant investment and one that requires substantial research to ensure the scale purchased will provide a satisfactory return on their investment. This guide is provided with the hope that it will prove useful in avoiding the pitfalls common to a project of this type.

BACKGROUND INFORMATION

Regulations For Scale Use

In your selection and purchase of a vehicle scale, you will find that they fall under a variety of regulations including state and local regulations as well as federal. You must be cognizant of these regulations and take them into consideration when determining the total cost of the scale.

Local regulations may include construction permits, zoning, setbacks, and others. Some cities and counties have their own legal metrology laws regulating the use of scales used in trade. Almost every state has a department of weights and measures that oversees the use of scales, including vehicle scales, used in commerce while several agencies of the federal government have their own set of rules for regulating the use of vehicle scales in special applications. While your local scale service company should be familiar with these regulations, it is a good idea for you to become familiar with them as well simply to provide you with the assurance that you will not be faced with an unpleasant surprise at some future date after your scale is installed.

A good place to start is with a call to your local weights and measures office. If you are unable to find a local telephone number for a local department of weights and measures, you should check with listings in your capital city. Another source of information is the Internet where most state departments of weights and measures maintain a Web site. A listing of state weights and measures departments can be found on the National Conference on Weights and Measures' Web site at **www.ncwm.net**.

State weights and measures personnel will be happy to provide you with any requirements that are unique to your state. For example, some states have different requirements for the length, width, and slope of approaches to a scale while others may also have requirements concerning the minimum clearance beneath the scale structure. Most states will also tell you that the scale must have a NTEP Certificate of Conformance in order to be used in commerce. We will discuss that in greater detail later in this booklet.

The next step is to call your city's building code office to learn what requirements they have. Often, a building permit will be required for construction of the concrete foundation and approaches and for the wiring needed to power the scale. You may find that these services must be performed by contractors licensed by the city.

You should also determine whether there are local laws that regulate the use of the vehicle scale. These laws would typically be enforced by a local weights and measures department that you should be able to find in your phone directory. Remember that many cities do not have local weights and measures departments. To make sure, ask the people in your state office of weights and measures.

Regulatory Bodies

The previous section described in general those regulatory bodies that may have jurisdiction over your scale. One regulatory body that you should be familiar with is the National Type Evaluation Program, or NTEP for short. This program is managed by the National Conference on Weights and Measures and has the responsibility of evaluating weighing equipment to make certain that it meets the current requirements for performance, operation, and markings. Once a device has successfully passed the evaluation, a NTEP Certificate of Conformance is issued for it. This NTEP Certificate is required by almost every state for scales that are to be used in commerce. The existence of a NTEP Certificate for the scale you purchase gives you assurance that this scale type has been evaluated and found to perform as required. The National Conference on Weights and Measures maintains a list of all active NTEP Certificates of Conformance on their Web site, which can be accessed at **www.ncwm.net**. This site allows you to search the various manufacturers' certificates by model number, manufacturer name, scale type, or certificate number. Remember that if you use the weights from your scale to buy or sell by, it must have a NTEP Certificate of Conformance.

There are other regulatory bodies, both state and local, that may have jurisdiction over all or a portion of your scale installation. Your city's Building Department can tell you if you need a building permit for the installation of your scale as well as any electrical requirements for running power to the scale and data cables from the scale to your office. They may normally be found in your phone directory under city offices. If you are not in an incorporated city, check with your local county offices for the same department.

As previously mentioned, your state office of weights and measures is an excellent source of information about installation and use of vehicle scales. We recommend that you contact their office as early as possible in the process to ensure that you meet all of their requirements for installation and certification for use of your new scale.

Support Team

One good way for managing the successful acquisition, installation, and startup of your new vehicle scale is to establish a support team. This support team consists of a number of team members each of whom bring their expertise to the group to help ensure a complete and satisfactory end to the project. Although you may choose to add a number of members to your support team, the following members represent the minimum:

Scale Service Company Representative – This team member represents the company who will sell and normally service the scale. If they do not service the scale, you should make certain that you select a service company early and have them represented on the team.

Weights and Measures Representative – This team member represents either the state or local weights and measures regulatory body. Including them in your support team will ensure that you are kept advised of the legal metrology requirements affecting your scale.

General Contractor Representative – This team member represents the contractor who will be responsible for the concrete work necessary for the installation of your scale. In some instances this responsibility will fall on the scale service company but, if not, you should ensure that you maintain contact with the person responsible for this work.

Scale Manufacturer Representative – This team member represents the scale manufacturer and can provide you with valuable information about the scale construction, options, and features available for it and can help ensure that the scale model you choose will be the right one for your application.

Cost Justification

Purchasing a vehicle scale is a major investment for most companies. To ensure that you are making a correct purchasing decision, you must determine if investing in the scale makes economic sense. In some applications, you have no choice and must purchase a scale, while in others it is viewed as a means of controlling costs or quality. Regardless of the reason for purchasing a scale, you should evaluate the economic return on your scale investment.

Begin by determining the savings you expect to reap by having accurate weight data. If you are using the scale to purchase raw material, you need to make an estimate of the costs associated with paying for material you did not receive. On the other hand, if you are using the scale to weigh material being sold, what is the cost of the excess material you have been shipping before buying the scale. You should also estimate the average net load of material you will be weighing and how many loads will be weighed in one month. With this information you can calculate the potential savings provided by the scale:

A = error in % without scale (can range from 0.5% to as much as 10%)
B = error in % with scale (0.1% average for Class IIIL vehicle scales)
X = cost of material per pound
Y = average net load in pounds
Z = average number of loads per month

For example, if you had an estimated error rate of 0.5% (one half percent) prior to installing the scale and your commodity had a cost of $0.11 per pound and your average net load is 24,000 pounds and you have 100 loads per 30 days, your savings are:

(X)(Y)(Z)(A – B)/100 = (0.11)(24000)(100)(0.5-0.1)/100 = $1056 every 30 days

Of course, it may not be this simple. It may be that you will have to determine the savings based on a number of different materials of different quantity and cost but the basic procedure remains unchanged. Once you have determined the amount of savings that can be achieved when you have an accurate weight, your next step is to determine the cost of the scale.

Begin by adding up all of the costs associated with the installation of the scale. These include but are not limited to:

Purchase Price of Scale and associated Instrumentation	_____
Cost of Concrete and Finish (if concrete deck)	_____
Cost of Installation	_____
Cost of Permits	_____
Cost of Testing and Scale Permits	_____
Miscellaneous Costs	_____
TOTAL COSTS	_____

Most of these costs will be available from your scale service company and from your local weights and measures department. For our example, we'll assume that the total price of the installed scale is $42,000.

Next, you'll need to check with your accountant to determine the depreciation rate, tax rate, and interest rate for the remaining calculations. Assuming a ten year life of the scale and a $2000 salvage value and using straight-line depreciation, the annual depreciation on the scale is

(42000 – 2000) / 10 = $4000 per year

Assuming that interest is 6%, the cost of the payback for the scale is $5,595.43 per year. If your income tax rate is 20% and you anticipate $1500 of annual maintenance charges, the following analysis would apply:

Annual Cost (purchase and maintenance)	$7,095.43
Less Depreciation Savings	(800.00)
Less Operation Savings ($1056 x 12 months)	($12,672.00)
Net (Savings) Cost per year	**($6,376.57)**

In this simplified example, purchasing the scale would increase your income by over six thousand dollars per year. Of course, this was a simple example and yours could differ significantly depending upon your application. It does, nevertheless, show that an analysis of your costs and savings is a good idea before making the investment in a vehicle scale.

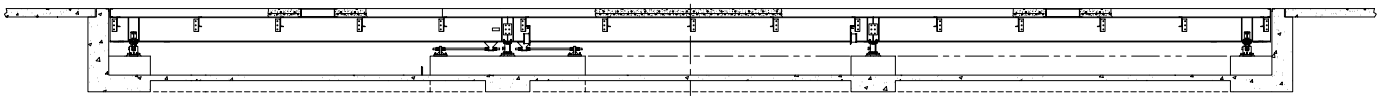
Low-profile, steel deck vehicle scale with concrete approaches.

FUNDAMENTAL CONSIDERATIONS

Type of Scale

Vehicle scales are available two basic types with variations on each type. Vehicle scales can be installed over a pit (similar to the basement of a house) or they can be installed above grade on a concrete slab. Pit type scales are often found in colder climates and offer several advantages. Although generally more expensive than a similar model installed above grade, a pit type scale provides easy access to the components beneath the scale and does not require ramps for the truck to pull onto the platform. Approaches to a pit type scale are much easier since the weighing platform is flush with the surface of the ground. On the other hand, a pit type scale normally requires some means of dealing with the accumulation of water within the pit whether it be a gravity drain or sump pump and are significantly more expensive to construct requiring excavation, forming, and pouring of pit walls and floor. One other thing to consider is that with a pit type scale, the truck cannot fall off the scale should the driver cut his wheels too sharp.

Engineering drawing example of a low-profile vehicle scale



Engineering drawing example of a pit type vehicle scale

Vehicle scales designed for above grade mounting, sometimes called low-profile models, can be installed either in a shallow pit or on a slab at grade level. Placing them at or near grade level requires ramps and level approaches at each end of the scale. This type of scale is often equipped with guard rails to keep the operator from driving off the scale platform. A low-profile scale also adds to maintenance costs since the area beneath the scale platform needs to be kept free of rubbish and debris that can affect the operation of the scale. This cleaning procedure needs to be performed on a regular basis.

Generally, low-profile scales seem to be more popular probably because of the lesser cost of installation but, before deciding, you should consider the advantages and disadvantages of both types.

Platform Size

Platform size is an important consideration because, once purchased, it is almost impossible to change the size of the platform. You must identify not only the vehicles you currently use that will be weighed but also those you may use in the future. Since a typical vehicle scale will have a life of ten years or significantly more, consideration should be given to what vehicles you will be weighing five, or seven, or ten years from now.

Vehicle scales typically come in widths of 10, 11, 12, and 14 feet or even wider. Lengths range from 20 feet or so to over 200 feet. Of course, as the size increases, so does the cost so it is best to select the smallest

size that will accommodate the vehicles you currently weigh yet is large enough to allow you to weigh those larger vehicles that may be in your future. A typical size might be 11 feet wide x 70 feet long but your application may require a longer and / or wider platform.

Vehicle scales typically come in widths of 10, 11, 12, and 14 feet or even wider.

When choosing a platform size, you also need to keep in mind the area in which the scale will be located. Most states require a straight and level approach to the scale on both ends. Normally the length of this approach is 10 feet but it could be more. Add to this the room necessary for the truck to maneuver onto the scale and you could find that 70 foot long scale requiring over 150 feet of real estate.

Weighing Capacity

Unfortunately, there has been much confusion when it comes to describing the weighing capacity of a vehicle scale. Actually, when you start to examine competitive models of vehicle scales you'll find that there are two basic capacity figures, the CLC or concentrated load capacity and the nominal capacity. There may even be other names for capacity used by some manufacturers like section capacity or maximum capacity or so on. Keep in mind that there are only two capacity ratings recognized by the National Conference on Weights and Measures and those are the concentrated load capacity or CLC and the nominal capacity.

What's the difference between these two capacities? The CLC is just what it says, the concentrated load capacity or, in other words, the scale's ability to weigh a load concentrated in a relatively small area on the scale platform. As you know, a typical truck is supported by multiple axles each with two or four or even more wheels on a single axle. Each one of these axles places a portion of the truck's weight on the scale platform. Tandem axles are placed close together and place a larger load in a smaller area on the platform. The CLC rating is based on the maximum load that can be applied in an area approximating that used by a tandem axle. NIST Handbook 44 defines Concentrated Load Capacity as *a capacity rating of a vehicle or axle-load scale, specified by the manufacturer, defining the maximum load applied by a group of two axles with a centerline spaced 4 feet apart and an axle width of 8 feet for which the weighbridge is designed. The concentrated load capacity rating is for both test and use.*

CLC
(Concentrated Load Capacity)
The scale's ability to weigh a load concentrated in a relatively small area on the scale platform.

Nominal Capacity
The total load that can be weighed on the scale when uniformly distributed over the scale platform.

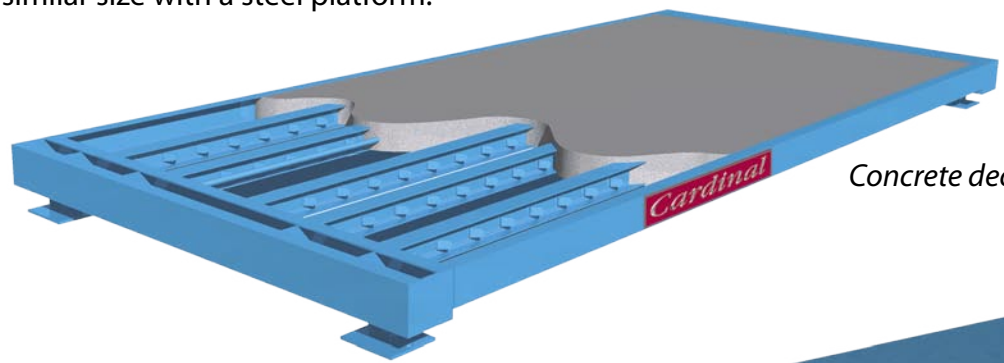
Nominal capacity differs from CLC in that it is the total load that can be weighed on the scale when uniformly distributed over the scale platform. Both the nominal capacity, sometimes referred to as simply "capacity" and the CLC are marked on the vehicle scale nameplate and on the weight indicator nameplate.

Now that you know the definition for the two types of capacity rating, how much capacity do you need? That is a question that typically is a hot topic among scale manufacturers and there is no simple answer. Begin by taking a look at the trucks that are going to be weighed on the scale. Are they trucks that are going to be weighed within the legal highway load limits (34,000 pounds for tandem axles and 24,000 pounds for a single axle)? If so, you may find that you do not require a larger CLC. On the other hand, will the scale be used to weigh highly concentrated loads common to mining trucks and some dump trucks? If so, a higher CLC rating may be required for your application. One easy way to find out is to refer to Table UR.3.2.1. shown in NIST Handbook 44. By knowing the number of axles in your vehicle and the distance between them, you can use this table to arrive at an "r" factor which, when multiplied by the scale's CLC, gives you the maximum load that scale can weigh for this configuration of vehicle. Following this procedure will allow you to calculate the CLC needed to weigh your current and planned vehicles.

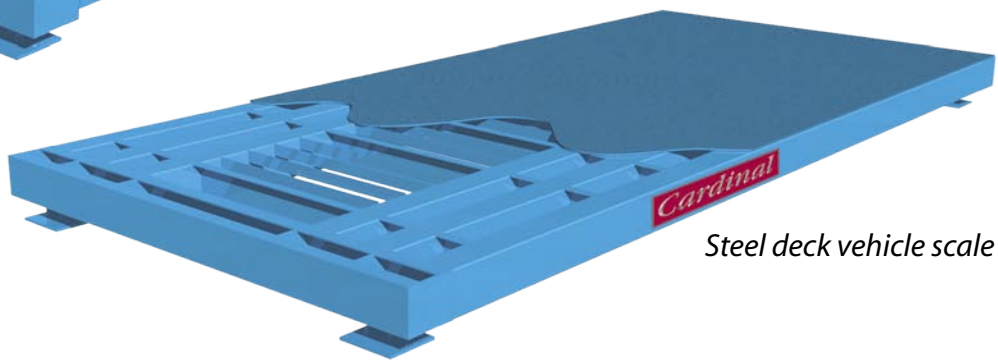
Most vehicle scales have capacities ranging from 120,000 pounds to 200,000 pounds. The 200,000 pound level is the maximum nominal capacity for a vehicle scale when using 20 pound divisions because NIST Handbook 44 limits a vehicle scale to a maximum of 10,000 divisions. It is possible to achieve a nominal capacity greater than 200,000 pounds by either using a scale with a 50 pound division or a dual-ranging scale where weights are displayed in increments of 20 pounds up to say 100,000 pounds then in 50 pound increments up to the scale capacity. Generally speaking, however, the 200,000 pound value is more than sufficient for the vast majority of vehicle scale applications.

Platform Material

Normally, vehicle scales are available with one of two platform materials; steel or concrete. As with most things, each has its advantages and disadvantages. Although the total cost of a scale with a steel platform is less than one with a concrete platform of the same size, the steel can be slippery when wet and is subject to corrosion. The concrete platform is more expensive and requires finishing labor and curing time, but is not subject to corrosion. Concrete can, however, deteriorate with age and weather. Generally speaking, a concrete deck is a better choice for high traffic applications. Another consideration is that a weighbridge with a concrete deck is much more difficult to move at a later date than a weighbridge of similar size with a steel platform.



Concrete deck vehicle scale



Steel deck vehicle scale

Weighing Technologies

Vehicle scales can be viewed as a platform that is supported by one or more weight-sensing elements which produce an output proportional to the load placed on the scale. The previous sections have looked at the variations in the construction and size of the platform while this section takes a look at the different weight sensing technologies that can be employed. In general, the technologies can be divided into two broad categories; mechanical and full electronic where the mechanical versions employ a series of levers to reduce the load to a value compatible with either a mechanical beam indicator or a load cell while the full electronic version uses multiple load sensing elements to support the scale platform. These sensing elements differ in type and include both analog and digital load cells employing strain gauges and hydraulic load cells. Each of these technologies will be explored in greater detail.

Mechanical

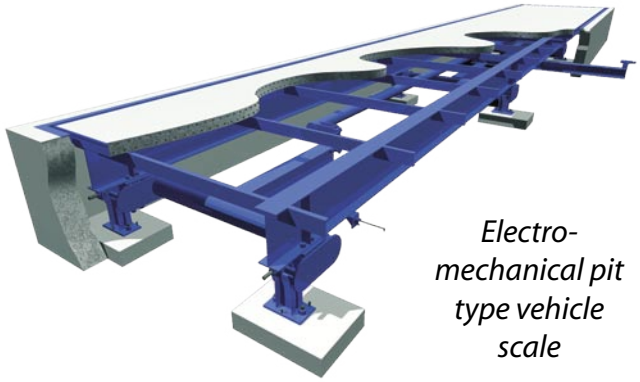
Mechanical vehicle scales have been around for a long time but are becoming the exception rather than the rule. This is because a mechanical vehicle scale, while an excellent weighing device, is normally more expensive than a model using multiple load cells. The mechanical vehicle scale consists of a series of force reducing levers where the load on the scale platform is reduced through a series of mechanical levers to a smaller value that is compatible with a mechanical beam indicator. The output of a mechanical vehicle scale is connected through a rod (called a steelyard rod) to one end of a balance beam. Calibrated weights on the opposite side of the fulcrum (pivot point) are moved away from the fulcrum until a balance condition is achieved. The distance the weights are moved is proportional to the load on the scale platform. It requires a minimal level of skill to properly operate a mechanical vehicle scale but the scale is capable of high-precision weighing.

Self-contained mechanical vehicle scale

This type of scale is immune to lightning damage since there are no electrical components used and therefore requires no power. Of course, it is not possible to connect such a scale directly to modern computing peripherals but it can be done (see the next section). Fewer and fewer scale manufacturers offer a fully mechanical vehicle scale, although there is a market for used scales of this type.

Electromechanical

Electromechanical vehicle scales are identical to the previously described mechanical scales with one important addition. Electromechanical scales include a strain gauge load cell mounted within the steelyard rod (the rod connecting the output of the scale lever system to the mechanical beam indicator) to produce an electrical signal proportional to the load on the scale platform. This addition allows the scale to be connected to a digital

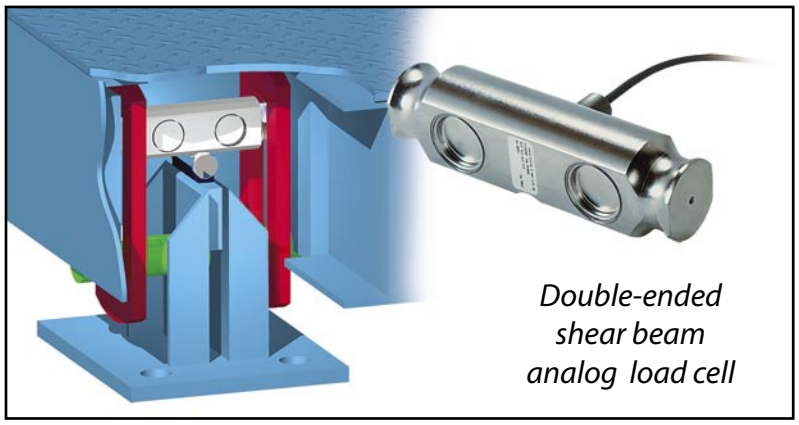


Electro-mechanical pit type vehicle scale

weight indicator and, from there, to any number of devices. This type of scale is available from a several scale manufacturers. The drawback with this type of scale is that it uses moving parts. Moving parts are affected by friction and wear eventually requiring service or replacement. Refurbishment of a mechanical or electromechanical scale can be expensive and time consuming, but durability and simplicity of such a scale sometimes overshadow these drawbacks. Normally a mechanical or electromechanical scale will be mounted in a pit.

Analog Load Cell

Probably the most common vehicle scale today is one where the scale platform is supported by multiple analog strain gauge load cells. In this type of scale, a portion of the load placed on the scale platform is applied to each load cell where an electrical signal proportional to the load applied to the cell is generated. These individual load cell signals are summed in a junction box and the combined signal fed to a digital weight indicator where it is converted to a digital value and displayed for the operator. Analog load cells used in vehicle scales can come in a number of configurations, but the most common are the compression load cell and the double-ended shear beam load cell. Both types of load cells perform the same function, but sense the load applied to the load cell in two different ways. Vehicle scales employing compression load cells typically have rigid restraint systems to keep the platform from moving while scales using double-ended shear beam load cells use restraint systems that allow the scale platform to move. When considering a vehicle scale that uses multiple analog load cells, there are a number of legal metrology requirements that must be met. These are more fully described at the end of this section.



Double-ended shear beam analog load cell

Analog load cells offer a number of advantages, but also have some disadvantages as well. Analog load cells are relatively inexpensive and are a proven technology. They are available from multiple sources and can even be rebuilt or refurbished under the proper circumstances.

Analog load cells used in vehicle scales range in cell capacity from 50,000 to 100,000 pounds with each pair of load cells comprising a section of the scale. This type of load cell uses several strain gauges that consist of a series of thin electrical conductors bonded on a nonconductive backing and cemented to the load- bearing element. Strain gauges, because of their electrical characteristics, are sensitive to lightning damage and manufacturers of load cells and scale manufacturers both take steps to minimize this risk by including surge suppression components to shunt the excessive current from lightning strikes around the strain gauges. In spite of their manufacturers' best efforts, many analog load cells are damaged or destroyed by lightning each year. If the scale you select uses analog load cells, make certain that you follow the recommendations of the scale manufacturer to minimize the risk of damage to the load cells.

Another enemy of analog load cells is moisture. When comparing scales, look for those that use load cells manufactured from corrosion-proof materials like stainless steel and feature hermetic seals and integral cables with moisture barriers. Entry of moisture into the load cell circuit can cause problems ranging from unstable readings to a completely inoperative weighing system.

Digital Load Cell

Digital load cells are load cells that produce a digital output rather than an analog output. Although this can be accomplished in a number of ways, digital load cells used in vehicle scales are typically analog load cells containing signal processing and analog to digital conversion circuitry within the load cell enclosure. Digital load cells offer several advantages over analog load cells. The fact that the output is digital rather than analog means that there is no degradation of the signal as it travels from the load cell at the scale to the weight indicator. Further, the output from a digital load cell is normally optically coupled which provides the digital load cell with a much greater level of immunity to lightning damage. Errors common to analog load cells (nonlinearity, hysteresis, and creep) can often be reduced through compensation algorithms contained within the load cell itself.

A cross-section and exterior photo of a digital compression load cell

Unlike analog load cells, there are no standards regarding the output of digital load cells hence the format of the data output differs from digital load cell to digital load cell. This means that it can be difficult to impossible to replace a digital load cell without buying it from the original manufacturer or their representative. Analog load cell replacements are available from a number of sources.

Because the output format from digital load cells differ from manufacturer to manufacturer, you normally must use instrumentation that comes from the manufacturer of the digital load cell. While normally that is not a problem, special applications may require features not available with digital load cell instrumentation.

Yet another consideration is with the effective sample rate of digital load cells. Although getting better, digital load cell systems may not always be a good choice when you are doing any automatic filling on your vehicle scale. The time needed to read the weight data from all of the digital load cells in a scale is greater than the time needed to perform a single analog to digital conversion in a multiple analog load cell scale of the same type. With an analog load cell scale you get your weight data quicker and therefore can make decisions regarding the flow of material sooner resulting in more accurate material control.

iCAN Junction Box Systems

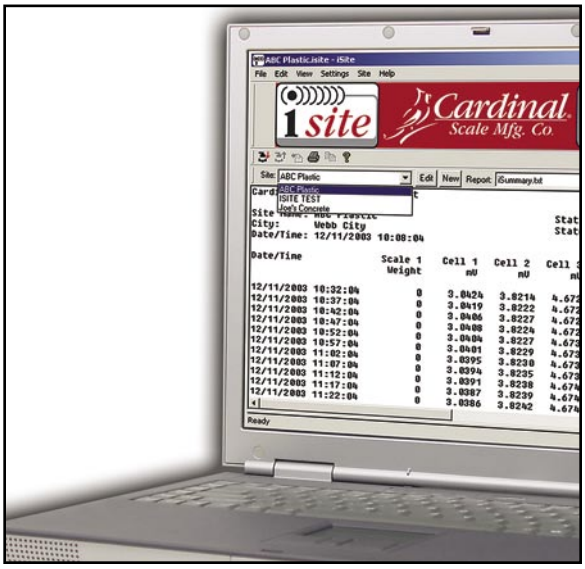
iCAN Junction Box

The iCAN Junction Box System is relatively new and adds many of the advantages offered by digital load cells to analog load cell systems. This junction box, sometimes called by other names by different manufacturers, takes the analog to digital conversion to the load cell rather than perform the function within the weight indicator. Normally this type of junction box has an analog to digital converter for each load cell thus digitizing

each load cell signal then calibrating and combining them into a single value using special software algorithms. This type of system offers the lightning immunity of a digital load cell while working with standard off-the-shelf analog load cells.

Perhaps the greatest advantage of this type of system is its ability to constantly monitor the condition of the load cells and alert the operator when a change indicative of a problem is detected. This proactive type of system catches and identifies problems before they become large enough to shut your weighing operation down.

Another advantage of the iCAN Junction Box System and systems like it is in its ability to minimize the time required for calibration of the scale. In normal analog load cell based systems, the scale technician must place a known load at various positions on the scale platform and make a number of corresponding adjustments such that the load produces the same weight reading regardless of where it is placed on the scale platform. This often lengthy procedure is replaced by a special software algorithm within the junction box requiring that the technician only place the load on in the various positions one time. The special software then calculates the required compensation automatically for each load cell to ensure a uniform output regardless of load position. This feature can save hours or even days of testing for the scale technician.



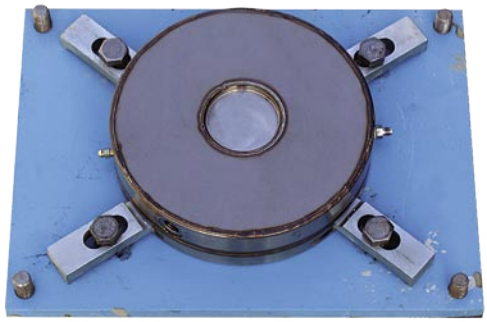
Remote scale monitoring software allows a technician to view the scale operation over the Internet.

Some models of junction boxes offer other features that increase the utility of your scale. For example, it is possible to view the scale operation from an Internet connection or transmit the weight data entirely by optical fiber. On-board diagnostic features allow the technician to view the output of each load cell from the junction box itself. That too can be a real time saver when the indicator is located several hundred feet or further from the scale platform.

Most of these junction boxes are modular in design allowing a quick change out of a defective board. Should you decide this type of system is for you, be sure to make certain that the model you look at has a current NTEP Certificate of Conformance and that it has a good track record. Like most things, some models are better than others.

Hydraulic Load Cell

Another type of load cell is the hydraulic load cell. This load cell uses a hydraulic fluid to transmit the force applied to the scale platform to a pressure transducer where it is converted to an electrical signal. The hydraulic load cell operates entirely on hydraulic pressure and uses no electrical components making it a good choice for hazardous areas or areas prone to lightning damage. Hydraulic load cells used in vehicle scales are normally of the compression type and can range in capacity from 25,000 to 100,000 pounds.



Hydraulic load cell

When comparing hydraulic load cells, make certain that the load cell is listed on a current NTEP Certificate of Conformance and is constructed from a corrosion-proof material like stainless steel.

The individual pressure lines from the hydraulic load cells must be combined into a single output in order for it to be displayed by the weight indicator. Sometimes the combined signal is achieved by stacking pressure actuators, one for each load cell, thereby mechanically summing the forces. The combined force is then applied to a single pressure transducer. Another method employs a pressure transducer for each hydraulic load cell then combining the outputs electrically. This method allows use of a iCAN type of junction box system bringing the expanded diagnostics to the scale.

A vehicle scale using hydraulic load cells is usually significantly more expensive than one using analog load cells. This is because of the added manufacturing costs associated with the hydraulic load cells and associated pressure totalizing system. This increased cost can sometimes be offset because of the inherent reliability of this type of system and because of its immunity to damage from lighting and voltage surges.

	MECHANICAL	ELECTRO-MECHANICAL	ANALOG LOAD CELL	DIGITAL LOAD CELL	iCAN JUNCTION BOX	HYDRAULIC
Lightning Immunity	Excellent	Very Good	Fair to Good	Good to Very Good	Good to Very Good	Excellent
Hazardous Environments	Excellent	Consult Factory				Excellent
Service Life	Excellent	Excellent	Good	Good	Good	Excellent
Spare Part Availability	Good to Limited	Good to Limited	Excellent	Limited	Limited	Limited
Number of Manufacturers	Few <5	Few <5	Many >5	Few <5	Few <5	Few <5

Table No. 1 Vehicle Scale Technology Comparison

Peripheral Devices

Once you and your scale manufacturer representative have determined which scale technology and platform size and type best fit your application, it is time to decide what, if any, peripheral equipment will be required. There are all types of equipment to transmit, display, store, and process the weight data from your scale and identifying what is required can sometimes be difficult. The following is a brief overview of the most common types of peripheral equipment.

Power Conditioning Equipment:

Depending on your location and the quality of the power your electrical utility provides, you may wish to add power conditioning equipment. The most common power problems include low voltage levels, electrical noise, and line transients caused by lightning or switching of inductive loads. Weight indicators operated from the power line are required to operate correctly down to 85% of the nominal line voltage so low line voltage is not normally a problem. If it is, an inexpensive voltage regulating transformer will take care of the problem.

If your scale is in a remote location and you experience power outages on a regular basis or if the continual operation of your scale is extremely important, you may wish to consider adding an uninterruptible

power supply. An uninterruptible power supply, or UPS for short, supplies power to the scale for a limited time should there be a disruption in the utility power. Some of these devices power the scale continually from batteries recharging the batteries when utility power is present while others automatically switch the scale from the utility power to battery power when a power outage is detected. For most applications, the former type of UPS is a better solution. The size and number of batteries is determined by the length of time you want the UPS to be able to power the scale and by the total load attached to the UPS. In many cases, the UPS is a good investment and even adds a layer of protection against power line surges.

There are a variety of devices on the market used to protect electrical equipment against damage from power transients. Some are quite effective while others leave much to be desired. Just make certain to review the specifications on the device and, if in doubt, check with your scale manufacturer representative or local utility company for their recommendation.

Digital weight indicators

<u>Weight Indicating Instrument</u>:

There are many models of weight indicating instruments available that can be used with vehicle scales. The best place to start is again with your scale manufacturer's representative who can explain the different features offered by each model. Make certain that the indicator that you choose has an NTEP Certificate of Conformance and is compatible with the scale you have selected. Not every indicator may be capable of powering the ten load cells in your analog load cell-based vehicle scale. It is usually a good idea to use a weight indicator manufactured by the same company that will manufacture your vehicle scale. Doing this will ensure that there are no compatibility problems and provide you with a single point of responsibility.

Make sure that the type of display used by the weight indicator is legible under the lighting conditions where it will be installed. Vacuum fluorescent types of display can be hard to read in direct sunlight while reflective type LCD displays can't be read when the lighting level is low.

Try to choose a weight indicator that has at least two serial interfaces that will enable it to interface with a printer or computer or remote display. The most common interfaces include RS232, RS485, and USB types. The indicator should also come with a keyboard tare feature to allow you to weigh net loads.

NEMA 4X rated indicators are protected from water.

Pick a weight indicator that has a type of enclosure appropriate for the location in which it will be installed. An office type or NEMA 12 enclosure is not a good choice if the indicator is going to be used outside or where it will be exposed to water. If you plan on installing your indicator outside, be sure that the enclosure has a rating of NEMA 4 or NEMA 4X or equivalent so that it is protected from dust and water.

Including your scale manufacturer representative in the decision on a weight indicator is a good idea. They can show you a number of models with special features that will make the operation and use of your new scale quick and easy.

Printers:

Most every vehicle scale should have a printer to record the weight from the scale. There are three basic types of printer commonly used with vehicle scales: the ticket printer, the tape printer, and the full sheet or report printer. In most instances it is a good idea to buy the printer with the weight indicator and scale. This way you can be assured that the indicator and printer are compatible and that you have the correct interface cable. You might be able to save some money by buying a printer at a local discount store and connecting it to the indicator yourself, but you run the risk of having a printer that is not compatible with the indicator.

Weight printers

Some indicators are equipped with a feature that will allow you to format the printed information as you wish. This is a good feature and will allow your equipment to handle future print layouts as your needs change.

Remote Displays:

A remote display is good to have when you need to show the weight at more than one location. For example, depending on your application, you may be required to provide a weight display for the vehicle driver. In these instances, a remote display can be connected to your weight indicator and provide a visual display of the scale weight.

Remote displays

Remote displays can range in character size from a half-inch high to over six inches high and can be read in all lighting conditions. Look for displays that are housed in weather-proof enclosures that can be directly interfaced with your weight indicator. Interfaces can range from RS232 or current loop types to wireless interfaces. Again, your scale manufacturer representative is a good source for information concerning the use of remote displays.

Vehicle Management Software Programs:


Vehicle weight management software

Vehicle management software programs are available to accept weight from the weight indicator and keep track of the weight of commodities either shipped and/or received. These software programs are a great management tool that allows you to keep track of production and costs. They can even be interfaced with your accounting system. Your local scale manufacturer representative can tell you about available packages and their features. Make certain, however, to ask if the system you are considering has an NTEP Certificate of Conformance. If you're using the system to generate invoices or receipts or to charge by weight, an NTEP Certificate is an absolute must.

Legal Metrology Issues

Most vehicle scales are used in commerce and therefore are required to meet certain minimum requirements to ensure that the weight readings they produce are accurate. As previously mentioned, the National Type Evaluation Program or NTEP is used to evaluate weighing instruments and their components and, when found to be in compliance, issuing a Certificate of Conformance attesting to that fact. Your complete vehicle scale requires three different NTEP Certificates of Conformance: one for the scale structure or "load-receiving element", one for the load cells used in the scale (if it is not a mechanical scale), and one for the weight indicator. You can view all existing NTEP Certificates of Conformance on the NCWM website at **www.ncwm.net**. The certificate number will also appear on the nameplate of each device.

A few states also require that the scale have a state-issued certificate of conformance for these same components. Your local weights and measures representative can tell you whether your state is one of those that require this certification and, if so, where it can be obtained. Your scale manufacturer representative can provide this information as well.

Most state or local jurisdictions also require that you purchase a permit or license for your new scale. This step ensures that the weights and measures officials have a record of your scale and that, after initial inspection, it can be placed into commercial use. This is usually indicated by placement of an official state sticker on the scale or weight indicator showing that it is authorized for commercial use.

After you purchase and begin to use your new vehicle scale, there are a few things to keep in mind to make certain that will ensure continued compliance with legal metrology regulations:

1. Be sure to maintain your scale in good condition and to renew the scale license when it becomes due. The expiration date is located on the official sticker.
2. Should it become necessary to replace one of the load cells, remember that the replacement cell must be of the same type (compression, double-ended shear beam), have a equal or lesser load cell verification interval (Vmin marked on the cell and on accompanying documentation), and have a current NTEP Certificate of Conformance. Be wary of rebuilt or refurbished load cells. While less expensive, they often are not acceptable for use and do not have an NTEP certificate.
3. Should you replace the weight indicator, make certain that the new indicator has a current NTEP certificate and is compatible with your vehicle scale.

SCALE SITE CONSIDERATIONS

Location of the Scale

Although sometimes you have little choice about where you will place your vehicle scale, there are some things to keep in mind. The selected site should have easy access both onto and off of the scale. The truck should be able to pull on and off in a straight line. No maneuvering should be necessary until the truck is completely off the scale platform.

The scale should be positioned such that the scale operator can view the truck on the scale. This is necessary so that the operator can ensure that the truck is fully on the scale platform and not have a wheel partially off the scale. The scale should also be located such that the scale operator can communicate with the truck driver, exemplified in the picture above. Some installations are such that a electronic intercom must be installed between the scale and the weight indicator to allow driver-to-operator communications to take place.

If possible, you should take weather conditions into consideration as well when selecting a site for the scale. A location where the effects of wind on the vehicle and scale and where the accumulation of snow and rain is less is preferable to one where the wind can blow on the platform and wind-driven snow collects on the scale.

Site Requirements

There are certain requirements for the selected scale site. The soil must be of sufficient load-bearing capacity to hold the scale foundation and scale structure plus the loads being weighed. Your scale manufacturer representative will provide you with the minimum soil bearing capacity for your scale. It may then be necessary to have the soil tested to ensure that it meets this minimum capacity.

Foundation

The scale's foundation is critical to the successful operation of the scale. Assuming that there is sufficient soil-bearing capacity, the scale foundation must be of sufficient strength to hold the scale and the maximum load that is weighed on it. The scale manufacturer will provide you with a set of foundation drawings that detail the construction of the foundation for your scale. It is crucial that the foundation be constructed in conformance with these drawings. An improperly positioned pier or insufficient reinforcing

steel can ruin the installation and cause operational problems for what would be an otherwise excellent scale. Most local scale service companies either handle their own foundation work or have contacts with contractors who are experienced with scale foundations. Generally, it is best to have your local scale service company handle the scale foundation for you. As with any type of foundation, care should be taken to ensure that proper drainage techniques are employed to prevent the collection of water in or around the foundation.


Concrete foundation for a vehicle scale

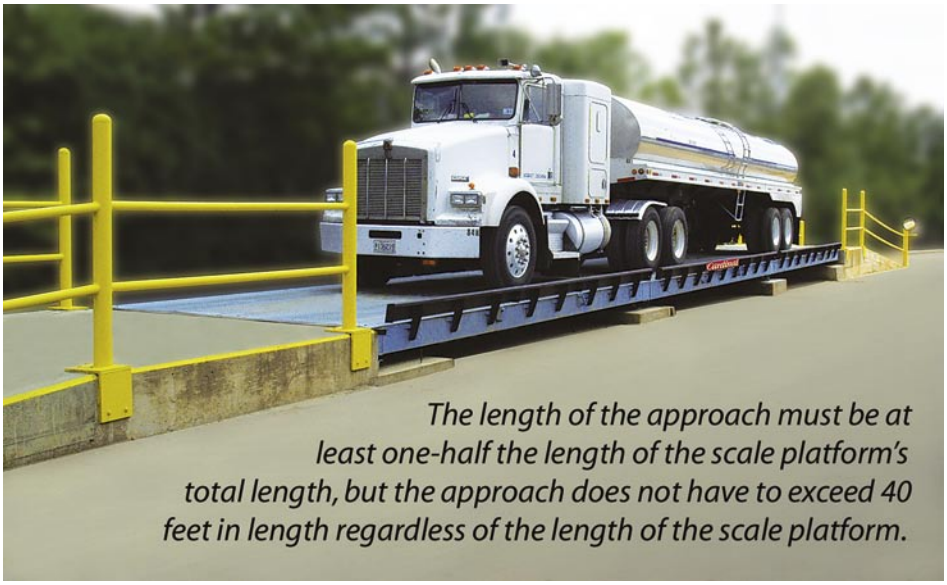
Instrumentation Location

As previously mentioned, the location for installation of the weight indicator should be carefully evaluated. Of course, there are the obvious considerations including available space and scale operator access but there are others to consider. Most manufacturers recommend that your scale instrumentation be on a separate circuit from your electrical distribution panel. In many cases, it will be necessary to install a new circuit for the scale. Make certain to include sufficient outlets for the indicator and for each peripheral connected to it like a printer, intercom system, and/or computer. When adding this circuit make sure to follow all of the applicable local electrical codes.

Another consideration is that the location must be such that the scale operator can have visual sight of the vehicle on the scale. The scale operator must be able to see the vehicle on the scale to not only properly identify it but to verify that it is fully on the scale platform and not positioned with a wheel off or partially off the scale. Further, there needs to be a means of communication between the scale operator and the driver of the vehicle being weighed. The scale operator must be able to tell the vehicle driver if they need to reposition the vehicle and when they may pull off the scale. In many instances communications is provided by an intercom system or a traffic light may be used to signal the driver when to exit the scale.

Approaches to Scale

NIST Handbook 44 specifies certain minimum requirements for the approaches to the scale. These requirements pertain to any scale that will be installed in one location for at least six months or longer. In general, the requirements state that the approaches are to be straight and at least as wide as the scale platform. The length of the approach must be at least one-half the length of the scale platform's total length, but the approach does not have to exceed 40 feet in length regardless of the length of the scale platform. At least the last 10 feet of the approach must be constructed of concrete or similar durable material to make certain that this portion of the approach remains smooth and level and in the same plane as the

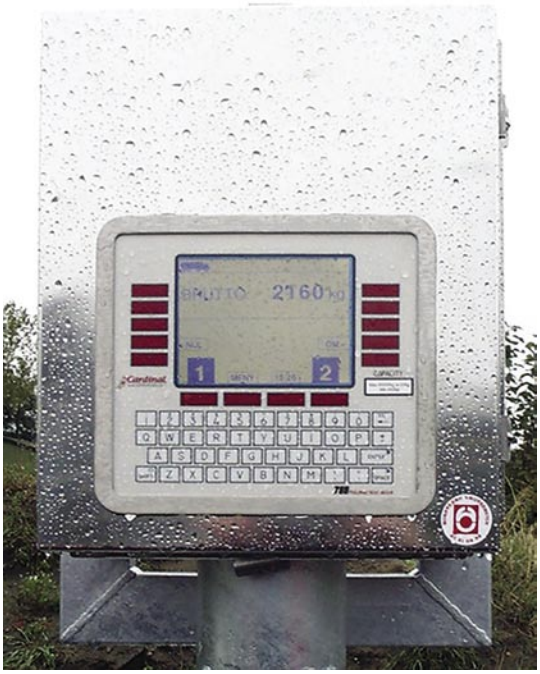

The length of the approach must be at least one-half the length of the scale platform's total length, but the approach does not have to exceed 40 feet in length regardless of the length of the scale platform.

scale platform. A slope in the remaining portion of the approach is allowed provided the slope does not affect vehicle access and access for testing purposes. Any slope should be away from the scale platform to keep water away from it.

Physical Environments

Depending on your geographical location, the physical environment in which your scale is installed can have an effect on its performance. The NTEP Certificate of Conformance indicates that the equipment has been tested over a temperature range of 14 to 104 degrees F (-10 to +40 degrees C) and found to comply with the applicable requirements. Unfortunately, most vehicle scales are installed outside and many of them see temperature extremes outside this range. The type of temperature compensation techniques used by most scale manufacturers does not end at the limits of this temperature range used for testing but rather extend beyond it. Normally, you should not have a problem with temperature effects on the accuracy of your scale. Keep in mind, however, that it is best to have your scale calibrated at a temperature that is as close to what is normal as possible in order to minimize these effects. Calibration on the hottest or coldest day of the year cannot always be avoided but, if you have a choice, it is best to perform the calibration at a moderate temperature to ensure the widest temperature range of acceptable performance possible.

Accumulation of snow or mud on the scale platform is normally not a problem since your weight indicator is equipped with a feature designed to compensate for changes in zero. In spite of this, care should be exercised to make certain that snow, mud, or rock do not become lodged between the scale platform and surrounding structure thus affecting the weight display.



This concrete deck low-profile vehicle scale in Denmark operates regularly in icy conditions. The two unattended weight indicators at both ends of the scale allow drivers coming and going to easily check their weight. The unattended weight indicator cabinets are insulated and feature built-in heating to compensate for the extremely cold weather conditions.

CONSTRUCTION AND INSTALLATION

Installation of the Scale

Once the scale foundation has been completed, the scale weighbridge can be installed. Normally, the scale weighbridge structure will arrive at the site on a truck and will require the use of a crane or similar device for unloading.

This service should be provided by your scale service company and should be coordinated with the scale manufacturer so that the crane is on site when the scale arrives.

After the weighbridge(s) are placed on the foundation the load cells are wired to the junction boxes and to the weight indicator. If your scale has a concrete deck, the deck will be poured and finished at this time. It will be necessary to allow sufficient time for the deck to cure before the scale can be used.

Depending on the scale model, the installation can be completed in a couple of days to less than a day. Once the installation has been completed and the wiring checked, the scale can be calibrated.

Calibration of the Scale

Before your scale can be used for accurate weight measurements, it must first be calibrated. Your local scale service company will take care of this by bringing their test truck to the scale test site. The test truck will contain calibrated test weights that are placed on the scale platform for testing and calibration purposes. The test weights, usually in 1000-pound blocks, are moved using either a hoist mounted on the test truck or using a test cart. In many states, the calibration process begins by placing test weights over each load bearing point on the scale platform. These load-bearing points are where the load cells support the scale platform or where the platform is supported by the lever system. A weight reading is taken at each one of these points and adjustments made such that the same reading is obtained within each section (pair of load cells) is the same. Depending on the scale, this process can take some time

since multiple readings may be required for each load cell. Once the individual load cells have been adjusted, the scale sections are adjusted. A section is comprised of a pair of load cells on opposite sides of the platform. The test weights or test cart is placed over the section and a weight reading taken. This process is repeated for all of the scale sections and adjustments are made so that the weight indicator shows the same weight (not necessarily the value of the test load) regardless of where the load is placed on the scale platform.

Once the scale sections have been correctly adjusted, the final step in the calibration process is the span setting. Here the weight display is adjusted to read the exact value of the test load applied to it. Additional testing takes place by checking the weight display with increasing and decreasing loads to make certain the scale is linear. After successful completion of the calibration process, the scale service technician will apply security seals to all of the adjustment access points to prevent further adjustment.

In the US, the scale will be tested to NIST Handbook 44 Class IIIL tolerances which appear below. Note that in Canada these are referred to as Class IIIHD tolerances and are the same as the US Class IIIL tolerances.

LOAD IN DIVISIONS				
0 to 500	501 to 1000	1001 to 1500	1501 to 2000	2001 to 2500
+/- 0.5	+/- 1.0	+/- 1.5	+/- 2.0	+/- 2.5

LOAD IN DIVISIONS				
2501 to 3000	3001 to 3500	3501 to 4000	4001 to 4500	4501 to 5000
+/- 3.0	+/- 3.5	+/- 4.0	+/- 4.5	+/- 5.0

LOAD IN DIVISIONS				
5001 to 5500	5501 to 6000	6001 to 6500	6501 to 7000	7001 to 7500
+/- 5.5	+/- 6.0	+/- 6.5	+/- 7.0	+/- 7.5

LOAD IN DIVISIONS				
7501 to 8000	8001 to 8500	8501 to 9000	9001 to 9500	9501 to 10000
+/- 8.0	+/- 8.5	+/- 9.0	+/- 9.5	+/- 10.0

Figure No. 2 Acceptance Tolerances for Class IIIL and Class IIIHD

To use this table, first determine the number of divisions in the weight of the load. For example, a load of 37,000 pounds is a total of 1850 divisions when using a 20 pound division. Since 1850 divisions is between 1501 and 2000 divisions, the acceptance tolerance is +/- 2 divisions or +/- 40 pounds. This means a 37,000 pound load could indicate anywhere between 37,040 and 36,960 pounds. Note that acceptance tolerances are used only during the first thirty days after the scale is placed in service or returned to service after re-calibration or repair. After that, maintenance tolerances are used which are twice those of acceptance tolerance. In the example given, maintenance tolerance would allow a + / - 80 pound error or an indication between 37,080 and 36,920 pounds.

Certification of the Scale

After the scale has been calibrated, it will normally be tested in the presence of a state or local weights and measures inspector who will verify its proper operation and in-tolerance readings. In some states, the local scale service technician is licensed by the state to perform this function. In either case, once the

scale has been officially tested and a report completed, a sticker will be affixed to the weight indicator attesting to that fact and a copy of the test report sent to the state department of weights and measures for filing. You, as the scale owner, should also receive a copy of this test report for your records.

Scale Use

Once your scale has been calibrated and the certification process completed, you are free to begin using it for your weighing operations. Note that some states have weighmaster laws which require the registration of the scale operator as a weighmaster with the state. Many states do not have this type of law but you should check with your local weights and measures office to make certain that your scale operator need not be licensed. Make sure that you keep all of the manuals so that you can refer to them when operating your scale. Your local scale service technician and scale manufacturers representative should always be available should you have any questions about the operation.

Example of low-profile and pit type vehicle scales installed side by side with a scalehouse in between.

MAINTENANCE

Required Maintenance

To ensure that your scale continues to give you good service year after year, there are certain steps you can take to make certain that it is properly maintained. It is a good idea to establish a maintenance agreement with your local scale service technician to ensure that the scale adjustments and calibration are regularly checked and maintained. You should also make certain that the scale and the area around it are kept clean and free of debris. Drains, if any, should be kept open and clear to prevent the accumulation of water beneath or around the scale.

It is also a good idea to periodically give the scale a good visual inspection. Check for damaged guard rails, if any, and have them repaired as quickly as possible. Look for missing or chipped paint and use touchup paint (available from your local scale service company or scale manufacturer) to keep your scale protected from corrosion. Look also for any obstructions like rock or other debris that may have become lodged between the scale platform and surrounding structure. These should be removed to ensure proper performance of the scale. If you live in snowy country, it's a good idea to remove the salt or other ice-melting chemicals from the scale platform. As with most things, a good maintenance program will help ensure that you receive the maximum return from your scale investment with a long service life and superior performance.

Warranties

Your scale and weight indicator should come with a warranty against defects in material and workmanship issued by the manufacturer or manufacturers. Some scales even come with warranties covering lightning damage to the load cells. As with any warranty, you should take the time to read the fine print to determine what the warranty covers and what your responsibilities are to keep the warranty in effect and to file a warranty claim. Most warranties are for a year but some are longer. All of this information will be contained in the warranty. Make certain that you keep your purchase records in a safe place, so that you can establish the purchase date should a warranty claim ever become necessary.

DEFINITIONS

Acceptance Tolerance – *the tolerance values used when the vehicle scale is first placed in service or returned to service after being repaired or calibrated or after 30 days of being placed in service. Normally acceptance tolerances are half of maintenance tolerances.*

Audit Trail – *an electronic count and / or information record of the changes to the values of the calibration or configuration parameters of a scale.*

Approach – *the pavement at each end of a vehicle scale leading to the scale platform. There are specific requirements for the size and slope of approaches to vehicle scales.*

Bumper Bolt System – *a restraint system employing adjustable bolts located at either end of the weighbridge. These bolts strike adjacent plates mounted to the pit wall or foundation structure preventing excessive horizontal movement of the weighbridge.*

Certificate of Conformance – *see NTEP CC*

Check Rod System – *a restraint system using multiple rods attached between the weighbridge structure and foundation structure to rigidly check the movement of the scale platform.*

Class IIIL Tolerances – *the tolerance class for vehicle scales used in the United States. The tolerance is shown in Handbook 44 and is a step tolerance allowing one half division of error for each 500 divisions or multiple thereof load applied to the scale platform.*

Concentrated Load Capacity (CLC) – *may also be referred to as Dual Tandem Axle Capacity, a capacity rating of a vehicle or axle-load scale, specified by the manufacturer, defining the maximum load applied by a group of two axles with a centerline spaced 4 feet apart and an axle width of 8 feet for which the wegihbridge is designed.*

Corner Adjustment – *calibration adjustments or settings used in multi-load cell vehicle scales to ensure that a given load produces the same weight indication (within tolerance) regardless of where it is placed on the scale platform.*

Dead Load – *that portion of the total load that is permanently applied to the load sensing elements of the scale. Dead load is the sum of the weights of the weighbridge structure, platform material, and any items permanently affixed to the platform like guardrails.*

Division Value (d) – *the value of the scale division, expressed in units of mass, is the smallest subdivision of the scale for analog indication or the difference between two consecutively indicated or printed values for digital indication or printing.*

e_{min} (minimum verification scale division) – *the smallest scale division for which a weighing element complies with the applicable requirements.*

Guardrails – *members running the longitudinal length of the scale platform to warn the vehicle operator when the vehicle's wheels are about to leave the scale platform.*

Handbook 44 – *an annual publication by the National Institute of Standards and Technology of the US Department of Commerce that contains specifications, tolerances, and other technical requirements for weighing and measuring devices including vehicle scales.*

Live Load – *that portion of the total load that is intended to be weighed. The total load is the sum of the fixed or dead load (weighbridge structure, platform, plus the weight of other components permanently affixed to the weighing platform i.e. guardrails) and the live load or load to be weighed.*

Load Cell – *a device, whether electric, hydraulic, or pneumatic, that produces a signal (change in output) proportional to the load applied.*

Maintenance Tolerance – *the tolerance applied to a vehicle scale after it has been in continual service for a period of 30 days. Maintenance tolerance is twice that of acceptance tolerance.*

Maximum Capacity – *the largest load that may be accurately weighed.*

Motion Detector – *electronic circuitry and / or software within the weight indicator used to detect excessive instability in the weight indication. Presence of motion in the weight reading inhibits the pushbutton zero, print, and data transmission functions.*

Multi-Range Scale – *a scale having two or more weighing ranges with different maximum capacities and different scale intervals for the same scale platform, each range extending from zero to its maximum capacity.*

NCWM – *the National Conference on Weights and Measures is an organization made up of both private and public members who develop technical requirements for commercial weighing and measuring equipment. See www.ncwm.net*

Nominal Capacity – *the nominal capacity of a vehicle scale is the capacity marked on the scale by the manufacturer.*

NTEP – *the National Type Evaluation Program is a program administered by the NCWM that conducts evaluations on weighing and measuring equipment and issues certificates of conformance indicating compliance with the appropriate requirements at time of testing.*

NTEP CC – *a Certificate of Conformance issued by the National Type Evaluation Program indicating the successful evaluation of a weighing or measuring device and its compliance with the appropriate requirements. NTEP CCs are required in most states if a device is to be used in the conduct of commerce.*

Pit – *an excavated cavity beneath a vehicle scale containing the concrete foundation for the scale assembly.*

"r" Factor – *a computation for determining the suitability of a vehicle scale for weighing vehicles with varying axle configurations. The factor is derived by dividing the weights in the FHWA Federal Highway Bridge Gross Weight Table B by 34,000 pounds.*

Restraint System – *the means used to restrain the horizontal movement of the vehicle scale weighbridge.*

Scale Division – *The value of the scale division, expressed in units of mass, is the smallest subdivision for analog indicator or the difference between two consecutively indicated or printed values for digital indication or printing.*

Scale Section – *A part of a vehicle scale consisting of two main load supports, usually transverse to the direction in which the load is applied.*

Section Capacity – *the section capacity of a scale is the maximum live load that may be divided equally on the load pivots or load cells of a section.*

Security Seal – *a uniquely identifiable physical seal, such a as a lead-and-wire seal or other type of locking seal, a pressure-sensitive seal sufficiently permanent to reveal its removal, or similar apparatus attached to a weighing or measuring device for protection against or indication of access to adjustment.*

Substitution Test – *a scale testing process used to quantify the weight of material or objects for use as a known test load.*

Substitution Test Load – *the sum of the combination of field standard test weights and any other applied load used in the conduct of a test using substitution test methods.*

Test Cart – *a gasoline or electrically powered cart containing multiple test weights enabling the scale technician to apply a known load to any point on the vehicle scale platform*

Test Report – *sometimes referred to as a Placed-In-Service Report is a report completed by the scale technician or weights and measures inspector summarizing the test results of the scale and indicating that it is fit for commercial use. These reports are normally submitted to and retained by the state or local weights and measures office*

Tolerance – *the acceptable error associated with the load applied to the vehicle scale. Vehicle scales in the US fall under Class IIIL tolerances while those in Canada fall under Class IIIHD tolerances. In the European Union, vehicle scales use Class III tolerances.*

v_{min} (minimum load cell verification interval) – *the smallest load cell verification interval, expressed in units of mass, into which the load cell measuring range can be divided.*

Weighbeam – *a mechanical indicating element used to indicate the weight value by means of a balanced beam where a force proportional to the load to be weighed is balanced against a known force produced by sliding weights*

Weighbridge – *the mechanical structure comprising the scale that holds the vehicle and in turn is supported by the load measuring system (load cells or lever system).*

Weighment – *a single complete weighing operation.*

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REGISTERED ISO 9001:2000

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