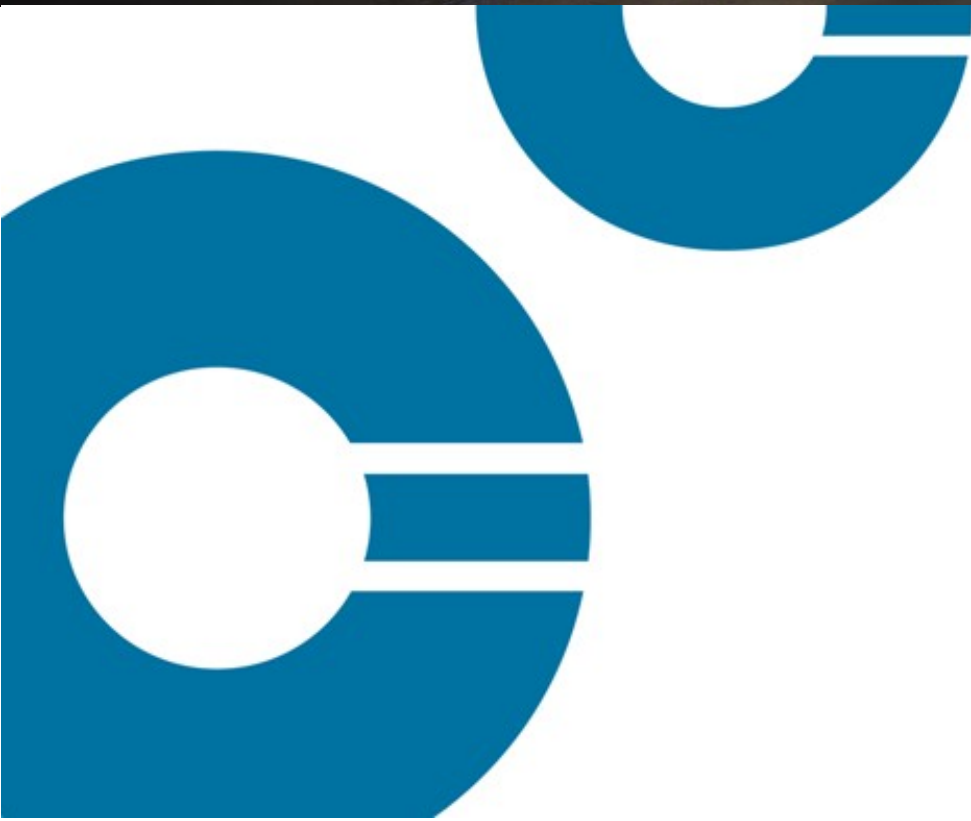


WEIGHBRIDGE LOAD CELLS WHITE PAPER



Don't judge a load cell by its cover – its the heart of your weighing system

Introduction

Strain gauge load cells are at the center of all modern, high performance industrial weighing systems, playing a particularly important role in weighbridge and heavy capacity weighing solutions. Despite the harsh operational environment's weighbridges encounter (extreme temperatures, ice, snow, wash-down, flooding, excessive braking and minimum maintenance), the load cells are expected to provide exceptional **reliability, accuracy, and durability**.

When Arthur Lincoln Thurston patented the first compact compression strain gauge load cell in 1949, little did he know that this humble invention would continue to be at the heart of industrial weighing over 70 years later. Modern loadcells have come a long way since then, but the basic technology and over-riding sound mechanical design-build principles established by Thurston are still vitally important.

One fact remains to this day. There are no quick and easy ways to produce high quality weighbridge load cells that embrace the fundamental requirements of **Reliability, Accuracy and Durability**. Unfortunately, there are always companies who will try to make a product cheaper by cutting corners of the three fundamental requirements- even though quality will suffer with the ultimate loser being the end-user. Short circuiting any of the fundamental principles or processes will result in inferior quality load cells. As a result, low-cost weighbridge load cells are unlikely to meet all performance criteria and will almost certainly turn out to have a higher cost of ownership in the long term.

Unfortunately, low cost - low quality load cells have entered the market from low-cost center based manufacturers and some weighbridge companies are happy to try to capitalize on this. At first glance these inferior load cells may look the same as their high-quality counterparts from the outside, but there the similarity ends. Often the problem stems from the fact that some low-cost load cell manufacturers produce a 'Golden load cell' for weights and measures evaluation, which is not typical of the quality of normal production run load cells. In fact, this evaluation load cell may not have been manufactured at the same site as normal production load cells. The US market established production surveillance named VCAP to try to bring greater control to load cell manufacture- (see details at the end of this document), whilst the European market relies heavily on localized market surveillance, that often does not exist.

The losers in all this are the end users, but they are often oblivious to the consequences, believing the 'false' performance claims of the weighbridge supplier and offers of "lifetime" guarantees. More often than not, the user may not be aware that inaccurate weighing is costing them money as well as risking their reputation with their customers and have significant additional recalibration and certification costs that isn't covered by any guarantee.

The following key factors are vital to ensure manufacturers produce high-capacity load cells that consistently meet the required performance and reliability criteria:

- Sound mechanical design principles including optimized environmental sealing to IP69K
- Repeatable, high specification material properties and heat treatment for the critical load cell structural components, sourced from certified steel producers.
- Hi grade Stainless Steel for both the body of the loadcell and the enclosure
- High quality strain gauges designed specifically for the load cell measuring element
- Well-disciplined manufacturing and testing procedures
- 100% product production testing
- Integral lightening protection

The following Questions should be asked about loadcells in any weighbridge system

- **Q:** *What IP rating are the loadcells?* - **A:** Anything below IP68/9K will have issues with water ingress over time
- **Q:** *Are tool steel loadcells suitable for weighbridges?* - **A:** Low-cost manufacturers prefer to utilize tool steel in their production as the machining of the body shape is cheaper than machining stainless steel. They will then often Zinc coat the loadcell in an attempt to extend the life span by providing basic protection from corrosion.
- **Q:** *Are tool steel loadcells suitable for weighbridges?* - **A:** Weighbridge loadcells are outside in all environments, tool steel bodies will corrode, leading to premature failure of the body increasing the risk of inaccuracies of weighing and expensive repetitive repair costs.
- **Q:** *Are my loadcells temperature compensated?* - **A:** Weighbridge loadcells should be approved to operate between -10c and +40c, the only way to ensure this is for the manufacturer to temperature test 100% of their production and not to sample test a small percentage.

- **Q:** *What if the loadcells aren't temperature compensated?* - **A:** During the normal daily operation of a weighbridge the effect of a temperature change throughout a day will influence the weighing result provided from the loadcell.

Example of errors:

- 6 a.m. -3°C Test Weight value 38000 kg
 - 12 noon +20°C Test Weight value 38060 kg
 - 6 p.m. +10°C Test Weight value 38020 kg
- **Q:** *How many strain gauges should a loadcell have?* - **A:** Typically, a weighbridge loadcell will have a minimum of 8 strain gauges - 4 in a vertical axis and 4 in a horizontal axis. Having 8 strain gauges ensures that the weight value is accurately determined where-ever the load is applied from. Sometimes the load applied may not always be in a central vertical manner through the loadcell body, this is called "Side loading". Side loading may occur if the loadcell is not installed correctly or due to movement in the foundation, this Side loading cannot be accurately compensated in loadcells with fewer strain gauges and weight inaccuracies will occur, even though the system may seem to be working perfectly.

- **Q:** *Does the loadcell cable passed directly inside the loadcell body?* - **A:** Most low cost manufactures allow the cable to enter the loadcell body, higher grade loadcells have a watertight interface where the cable connects from outside of the body, ensuring the critical electronic circuits are protected from water ingress that may occurs via the cable.
- **Q:** *How does water enter inside the loadcell body?* - **A:** If the loadcell cable passes directly inside the loadcell body then water can "Creep" along the inside of cable sheaf into the loadcell. This could happen should there be any small cut in the cable sheafing. This effect may happen over a length of time but will cause significant damage and eventual failure.
- **Q:** *Is my loadcell protected against lightening?* - **A:** 99% of weighbridge loadcells do not have any form of lightening protection, some companies install add-on protection that is mainly for show. Weightron Bilanciai is one of the few manufacturers to have a fully integrated lightening protection as standard, the system is a combination of the loadcell, junction box and weight indicator all having active layers of protection.
- **Q:** *What could happen to loadcells without lightning protection?* - **A:** Lightning strikes close by to a weighbridge can have devastating effects. Ground current or "step potential" – Earth surface charges race towards the flash channel during discharge. Because the ground has high impedance, the current "chooses" a better conductor, often a metal structure, such as a weighbridge deck. The near-instantaneous rate of discharge causes a potential (difference) over distance, which may amount to several thousand volts per linear foot and a high transient power spike is created.

In a first scenario the high current passes from the weight indicator to the loadcells that are connected to the ground, as the weighbridge provides a very comprehensive "ground" for electrical circuits. The high current destroys the unprotected delicate circuitry of the loadcell as there is no way to suppress the incoming current arriving down the loadcell cabling.
- **Q:** *What could happen to loadcells without lightning protection?* – In a second scenario the ground near to the weighbridge is struck by lightning, the current passes from the ground through the loadcells and to the weight indicator that is connected to the electrical ground circuit of the building it is housed in. Having no lightening protection between the loadcells to the weight indicator allows the high current to freely pass to the weight indicator and then back to ground via the building electrical earthing protection, often a loop of current is created as the spike returns through the loadcells (grounded), to weight indicator and to ground several times before becoming fully discharged.

Mechanical design

The mechanical design criteria for a load cell are of paramount importance. Testing and compensation procedures can only fine trim performance characteristics so therefore the original design must consider real working environments. The design should ensure the load cell has good tolerance to off-axis, side, and angular loading. Good environmental sealing is vitally important to prevent premature failure especially regarding cable entry to the loadcell body.

Material Specification

Load cells are very low deflection springs that must behave in a highly repeatable manner as they are loaded and unloaded. As a result optimized material selection and heat treatment for the measuring element and other key components play a critical role in this, material must be sourced from certified steel mills with all the material composition closely followed.

Strain Gauges

The matching of strain gauge characteristics to those of the load measuring element is crucial, especially where creep and linearity characteristics are concerned. The performance of the finished load cell is also directly dependent on the repeatable nature of the strain gauge bonding process. Strain gauges and other electronic components must not be changed for low-cost equivalents, this is an area low cost manufacturers often attempt to save money and diverge from the original approved design.

Testing

Load cells have individual characteristics and therefore each and every load cell should be tested and compensated during the manufacturing process. It is often in this area that lower quality manufacturers cut corners to reduce cost. Testing must include load cycling from Zero to Full load, shock loading and 12-hour temperature testing from -10°C to +40°C.

Design concept

There are three fundamental load cell designs used in modern weighbridges:

- **Single Ended Beam Cells**



- **Double Ended Beam Cells**



- **Compression Canister**



Single Ended Beams

Cumbersome high-capacity single ended bending beam load cells represent outdated technology and are far from ideal for weighbridges. Typically, they only have four strain gauges and are susceptible to torsional, off axis and side loading effects. Mounting assemblies and fasteners are subjected to high forces as load is applied to the cantilever beam. Design performance limitations usually restrict construction to alloy steel rather than stainless steel and ensuring effective environmental sealing can also present a problem.

Double Ended Beams

Double ended shear beams provide a better mechanical solution than single ended beams and the shear technology provides a product less susceptible to non-axial forces. However, there are a number of questionable and misguided claims relating to their reliability, especially when mounting assemblies incorporate large ball bearings, the ball bearing design is mainly used in Asia where low-cost products are prevalent and are now adopted by low quality suppliers across Europe. Contrary to belief, such assemblies do not absorb shock and require high maintenance. In practice this is often not carried out, leading to poor performance and premature mechanical failure, especially in harsh environments.

Compression Canister Load Cells

Canister load cells have a long history in weighbridge applications and are considered to offer the best solution - provided they are well designed and built. The Bilanciai Group have dedicated years of research and field testing in order to develop the ultimate patented canister load cell family.

The analogue CPR-M and *TRU Digital* CPD-M models have an unrivalled track record for reliability and performance. Both are based on the same mechanical envelope and key design features set these load cells apart from competitive units (see diagram below). Their engineers have not just focused on the design of the load cells themselves, but also on the functionality of the mounting assembly. Key features are:

- The central column has a dedicated shape that incorporates top and bottom spherical surfaces
- Proprietary heat treatment provides a robust yet highly repeatable central column
- The design incorporates eight strain gauges, strategically placed to provide optimum performance even under adverse loading conditions
- A compact special seal is incorporated in the bottom assembly to prevent dust/debris/water causing problems. This removes the need for more onerous rubber sleeves and covers to protect mounting assemblies, which can do more harm than good.
- The inside of the load cell is protected from the environment via a fully welded sealed two-part stainless steel outer housing. The bottom section is noticeably thicker than the top in order to provide mechanical protection to the load cell, the 45-degree shape prevents build up a debris from accumulating around the lower mounting assembly

- A glass to metal seal ensures IP68/69K sealing for the cable entry. The digital CPD-M has an external plug/socket to allow the cable to be removed, making servicing of the loadcell easier. Braided stainless steel Anti-rodent proof cable is available.
- The Patented anti-rotation pin prevents the load cell rotating in its mount thereby eliminating possible cable damage that occurs to other products without such anti-rotation devices
- Lightning Protection: Each load cell kit includes an insulation disk (D) that interrupts the electrical continuity between the load cell and the rest of the structure, a by-pass copper cable (F) drives the lightning voltage to ground without affecting the load cell body.
- Lightning Protection: A second "active "protection layer is provided by thermistors and Zener over voltage suppressors, mounted within the load cell on the main PCB, and gas discharger placed on the junction board card. This arrangement combines the fast-switching time of Zener suppressors with the high-power capacity of gas dischargers in order to provide complete protection.
- Lightning Protection: Finally, the communication lines between weight indicator and load cells are optically isolated thereby preventing coupling occurring during any electrical discharge by either lightning or other sources.



A - 8 STRAIN GAUGES
 High precision - Repeatability - Reproducibility
B - HEAVY-DUTY PROTECTION AT 45° CONE
C - MECHANICAL PROTECTION COVER
D - INSULATION DISC FOR LIGHTNING PROTECTION
E - OVERVOLTAGE AND INTERFERENCES PROTECTION
F - COPPER BRAIDED EARTHING CABLE
G - WATERTIGHT IP68/IP69K STAINLES STEEL CONNECTOR

Digital Load Cells

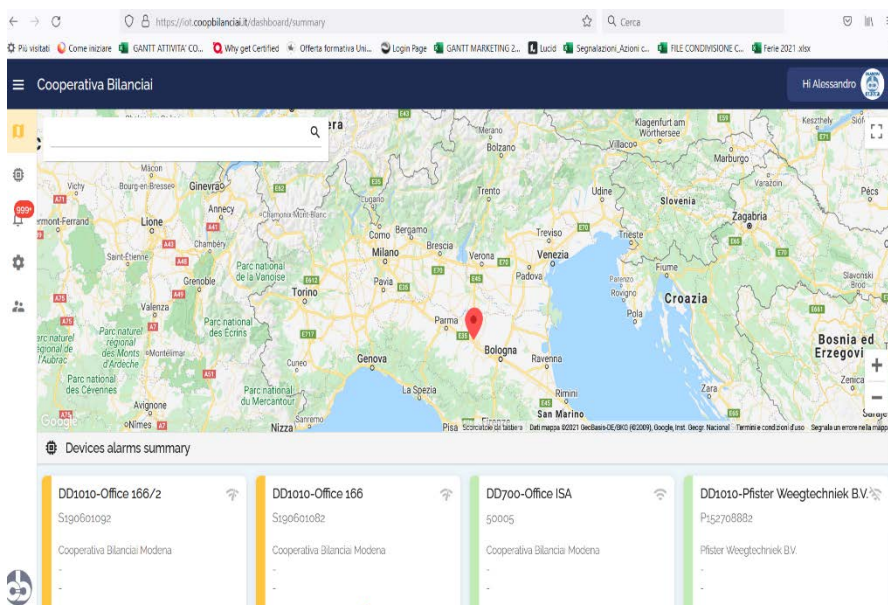
Digital load cells were first developed in the 1980s initially to make low cost, low-capacity load cells in high volumes. The concept was based on the presumption that emerging low-cost electronics could be used to provide output compensation corrections for less than perfect load cell designs.

It is only really over the past decade that their advantages have been fully utilized for high-capacity weighbridge load cells, providing important and tangible benefits for both the manufacturer and the end user. Bilanciali Group have been granted two patents relating to the design and use of Digital Loadcells (US 7,151,230 B2 and US 7,361,851 B2) Each Digital Loadcells has on-board electronics, which carry out a number of functions and supply a digital representation of the load on each load cell. The load cells at the heart of a weighbridge system form a communication network allowing direct access to the parameters of individual load cells. The individual calibration data for each load cell is stored in the electronic memory, facilitating calibration, trouble shooting and interfacing with the **NEXIA** remote diagnostic software for real time monitoring.



The future for Weighbridge Predictive Maintenance

If you've previously had issues with your weighbridge and are left wondering when or if it might encounter a fault, then you'll be pleased to know that at Weightron Bilanciali, we have new NEXIA™ technology to help. Our Remote Diagnostics are developed through NEXIA™ and use cloud technology. We're offering this web based new tool to help enhance our support packages for all scale owners and operators. Through this revolutionary new technology, our support team can get real-time notifications for any issues with your weighbridge, as well as a live status update function to monitor essential components of a scale or weighbridge. This information is available remotely and can be configured so that larger operators can have a level of controlled access to their own equipment on site



This new NEXIA™ technology will help to minimize any downtime by reporting any hardware faults or by isolating them. This system will also deliver suggestions for remedying any issues, allowing you to keep your equipment in operation for longer and reducing your repair costs. Technicians can visit with all the information, prepared to tackle the outage as they will have visibility into your scale remotely.

This Technology is :

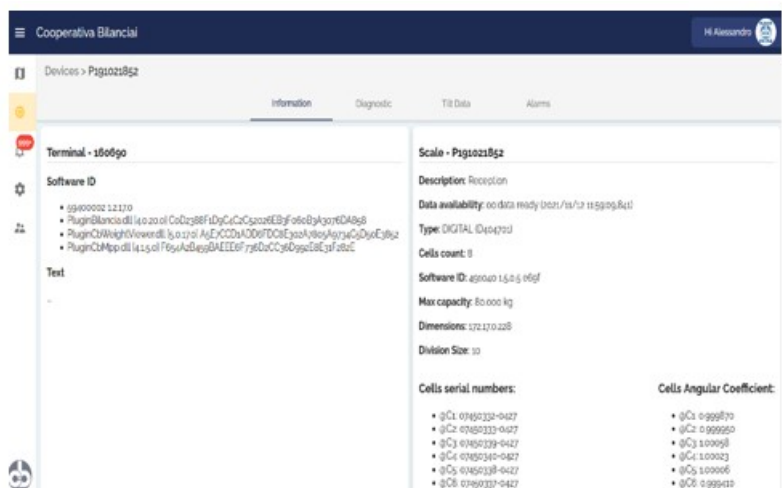
- Ideal for both single and multi-site installations
- Suitable for any weighbridge with CPD-M digital load cells and ethernet or GSM connection
- Suitable for any Weightron Bilanciai scales with ethernet or GSM connection
- Suitable for upgrading existing analogue weighbridges when fitted with our Emula "SMART" junction box

From anywhere in the UK, our engineers can log in and view how your scales and weighbridge are operating. It's a 24/7 capability delivering comprehensive data via a secure connection. This system allows for the following:

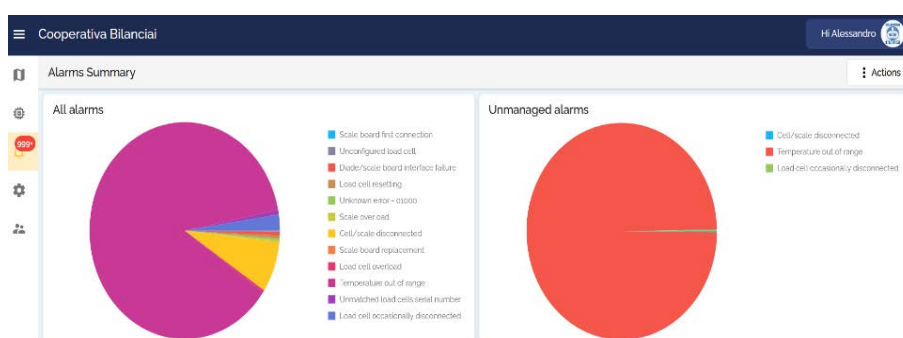
Data Analytics

• 54 points of data transferred and converted to usable scale information

- Loadcell data
- Temperature
- Calibration data
- Serial number
- Supply Voltages
- Internal Voltages
- Live weight readings • Inclination
- Software release

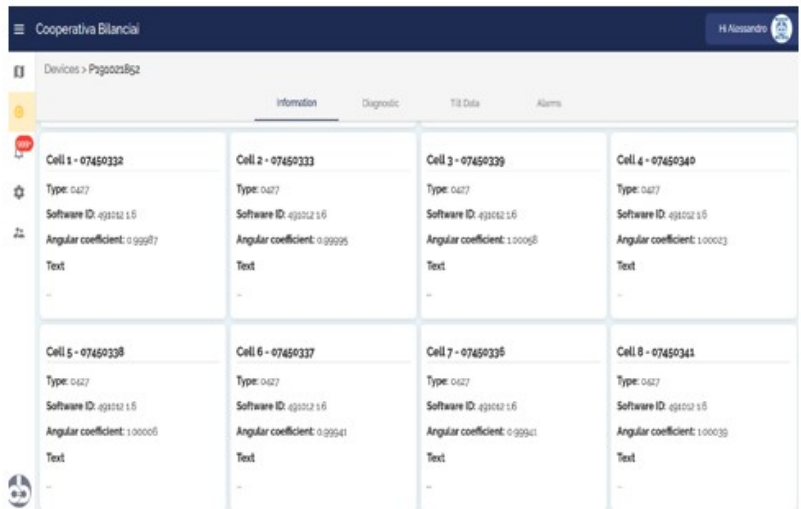


• Terminal Data – All errors messages generated (temporary or permanent) CPU and scale card performance – Software release – Metrological data Components changed and registration of changes



Alert System Benefits

- Preventative alerts prior to scale outage
- Automated scale outage notifications
- Abuse and overload monitoring alerts
- Maintenance reminders
- Analysis of trends to optimize throughput and efficiency
- Identify unusual activity within a fleet of weighbridges and scales



The screenshot shows a web interface for 'Cooperativa Bilanci' with a user profile 'H. Alessandro'. The main content area is titled 'Devices > P99002862' and has tabs for 'Information', 'Diagnostic', 'Till Data', and 'Alarms'. The 'Information' tab is active, displaying a grid of 8 cells. Each cell contains the following data:

Cell ID	Type	Software ID	Angular coefficient	Text
Cell 1 - 07450332	0427	09102 1.6	0.99987	--
Cell 2 - 07450333	0427	09102 1.6	0.99995	--
Cell 3 - 07450339	0427	09102 1.6	1.00068	--
Cell 4 - 07450340	0427	09102 1.6	1.00023	--
Cell 5 - 07450338	0427	09102 1.6	1.00006	--
Cell 6 - 07450337	0427	09102 1.6	0.99941	--
Cell 7 - 07450336	0427	09102 1.6	0.99941	--
Cell 8 - 07450341	0427	09102 1.6	1.00039	--

Although regular servicing and maintenance can help to minimize problems, predicting what and when things will go wrong is very difficult with traditional weighbridges. Therefore, the ability to offer remote maintenance service support can save considerable time and effort especially for equipment operating in harsh, remote areas.

Troubleshooting Benefits

- **Arrive prepared with the proper equipment and reduce critical downtime**
- **Quickly isolate and repair faulty hardware**
- **Recommended break/fix solutions**

This new NEXIA™ technology allows for real-time oversight and swift response to weighbridge and scale issues, giving engineers the information, they need before they arrive. Downtime to your operations is minimized as the right parts can be sourced ahead of a visit and the weight calibration truck can also be made available. With the data available, we can also help to create an optimized service schedule for your weighbridges and scales on an individual basis.

Conclusion

Modern weighbridge systems can offer considerably more than weight information and their integration with other technologies is bringing dramatic changes to a wide range of industries, improving efficiency, streamline operations, automating business back-offices. However, the quality of the data they provide is still totally dependent on sound mechanical design principles, quality and reliable product and well-defined installation procedures.

Having made the decision to invest in a weighing system it is beneficial to know what is at the heart of the equipment. Using low cost loadcells will inevitably mean long term expenses and a higher cost of ownership. Utilizing the latest DIGITAL technology provides not only a faster, more reliable, and accurate loadcell but, opens the equipment to the world of remote diagnostics and support. Ensuring that your investment is working when you need it and is as accurate in year ten as it was on day one.

Foot note: Verified Conformity Assessment Program Procedures

In order to level the playing field with regard to load cell quality, the US authorities have introduced the Verified Conformity Assessment Program, or VCAP. This is a program initiated by the National Conference on Weights and Measures to ensure compliance of certain device types with environmental requirements. These device types are ones for which performance can be affected by changes in their physical environment. The program has started with load cells only. Compliance with the VCAP can be verified by submitting to a VCAP audit of the suppliers manufacturing / testing facility by a VCAP auditor. The auditor will verify that the previously mentioned quality and control elements exist are documented, and that the appropriate procedures are being followed. The auditor also verifies that the proper equipment needed to test and calibrate the devices (load cells) manufactured is present, sufficient for the task, and that they are being properly calibrated and operated. The audit will also include testing of a randomly selected device. The program is intended to prevent manufacturers from producing the 'Golden load cell' for evaluation and then supplying inferior products from uncontrolled sources. The VCAP audit is site specific. If there is more than one site where the testing of the device takes place, then each site must be audited. If the site does not perform any activities that affect the performance of the device and does not perform any device testing, it does not need to be subjected to a VCAP audit. The intent of the VCAP is to provide a level of assurance that these devices perform at a level equal to or better than the device that was evaluated by NTEP.

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