Avery Weigh-Tronix

The Weigh Bar®: Designed for Durability

Time-tested strength pairs with cutting-edge design in the Avery Weigh-Tronix Weigh Bar—leading the industry in accurate, repeatable weighing technology

HISTORY

The scale was one of the first tools of civilization; ancient Egyptian tomb art from as early as 2500 BC depicts the use of balance scales, which continued to be used until the industrial age. The first incarnation of the modern strain gauge scale was introduced in 1938. This scale determined the weight of the applied load based upon the amount of force—or strain—that was placed on the gauge, which was attached to the most stressed section of the scale platform. In the past half-century, this technology joined the computer age, yielding higher-accuracy readings within a more convenient-to-use design. The electronic transducer, also known as a load cell, operates utilizing four or more strain gauges wired together, which establishes a "Wheatstone bridge" electrical circuit. The load cell became a popular selection for commercial weighing applications in the mid-20th century, but this new weighing method was not without its own shortcomings.

Electronic scales use load cells to convert mechanical movement, or applied force, into an electrical signal. The load cell deforms while bearing a load, and the compression or tension force that has been applied yields a corresponding electrical signal that is read by the weight indication system. While different designs are available, load cells based on the cantilever principle are most common; one end of the load cell is fixed and the other suspended to absorb the force of the applied load. The suspended end then reverts to its initial position once the load is removed.

As this mechanical movement must be precise in order to deliver highest accuracy readings, the early load cells were particularly susceptible to environmental forces that could influence this movement—such as shock and vibration. This made the load cell more challenging to apply in outdoor conditions, as well as in busy industrial environments. Additional mechanical devices such as expensive check rods and check plates were often required within these scale arrangements to help protect the load cell from damage. They also helped prevent extraneous loading from affecting the load cell's operation. However, as with all mechanical scale parts, these devices are subject to wear, weather and other deteriorating factors that reduce their overall operational life. Continual—and often costly—maintenance programs were required to ensure proper scale operation, making the technology more expensive to apply.

THE FIRST WEIGH BAR

A better method was developed as a result of an innovative weighing solution designed for livestock farms in the 1960s. Art's-Way Manufacturing, Inc. of Armstrong, Iowa enlisted the help of New Jersey engineer Dick Bradley to create an on-farm feed mixing solution that included an integrated scale, which would weigh each ingredient individually with far higher accuracy than the previous volume-based method. This scale would also need to withstand a broad range of environmental effects—including shock and vibration—and weather conditions, as Art's-Way would market this system to farmers throughout the US. Existing systems employing mechanical components could wear easily in outdoor conditions, and undesirable loading effects influenced the load cell's readings. Side loading, end loading and torsion effects would all impact the measurement of the applied load, reducing the accuracy and repeatability of the scale system.

The Avery Weigh-Tronix Weigh Bar weight sensor improved upon the initial electronic load cell design to make weighing easy to apply in harsh industrial areas. Today, the Weigh Bar still offers one of the lowest failure rates in the industry.

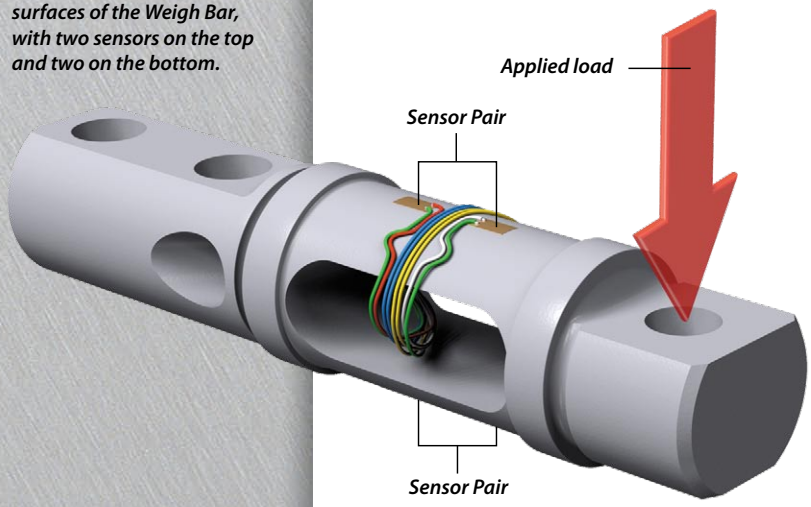
Bradley's solution was the Weigh Bar, an all-electronic strain gauge weight sensor designed to measure the applied load accurately without experiencing problematic loading effects. The Weigh Bar reliably delivered precise, repeatable readings, while its weatherproof and shockproof design allowed it to withstand environmental challenges. Its electronic design meant the Weigh Bar needed only minimal maintenance and provided a long usable life, allowing users to save significant expense both in the initial investment and in overall upkeep.

Unlike other load cells of this period, the Weigh Bar used an electronic signal to convey force measurements, rather than mechanical components. With this design, the Weigh Bar demonstrated exceptional accuracy, with no external mechanical apparatus re-

quired for dependable operation. The strain gauges, or electronic sensors, were positioned on the outside surfaces of the Weigh Bar, with two sensors on the top and two on the bottom—a design that ensured optimal performance.

The result was a new type of load cell that experienced reduced fatigue, with a low failure rate and exceptional overload protection. It also did not require complex vacuum-type hermetic seals that existing load cells used. Combining a simple potted seal with the device's already-rugged design, the Weigh Bar provided the most robust and reliable weighing solution the industry had seen—all at a competitive cost.

As of 1969, Art's-Way began selling industry's first grinder/mixer with an incorporated Weigh Bar-based scale system. In 1971, Weigh-Tronix (now Avery Weigh-Tronix) incorporated as a subsidiary of Art's-Way and sold the scale system itself to farm equipment manufacturers. Two years later, the company's deck scale featuring Weigh Bar weight sensors became industry's first all-electronic scale to earn legal-for-trade approval from the National Bureau of Standards (now the National Institute of Standards and Technology). Plus, the system's reliability made it the only industrial scale to carry a two-year warranty; competitive model warranties rarely exceeded 12 months.



Two sensor pairs are positioned on the outside surfaces of the Weigh Bar, with two sensors on the top and two on the bottom.

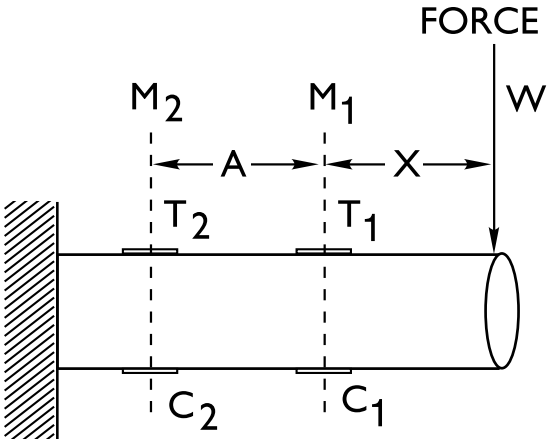
HOW THE WEIGH BAR WORKS

The Weigh Bar is a steel structure with two pairs of electronic sensors: one pair placed on top and the other on the bottom. As with most load cells, the Weigh Bar structure acts as a cantilever, unsupported on one end and fixed on the other. When a load is applied on the unsupported end, the sensors detect strain in the structure and provide an analog mV/V output. This output is interpreted by indicator electronics, and the weight indicator digitally displays the strain as the load's weight.

How the Weigh Bar eliminates undesirable loading effects is exhibited in its principles of operation, expressed here as equations.

When force is applied on the Weigh Bar's unsupported end, the weight sensor measures the strain at the T_1 position—which is associated with the bending moment M_1, a measurement that is equal to WX. When the strain at the position closest to the fixed end, T_2, is measured, it results in the second bending moment (M_2), which in this equation is equal to W (A + X), or WX + WA. The Weigh Bar is then designed to electronically subtract the first bending moment from the second to reach the final equation: $M_1 - M_2 = WA$. The distance A is a fixed, known amount that is factory-set and serves as an amplification factor while allowing users to determine W, which is the force measurement.

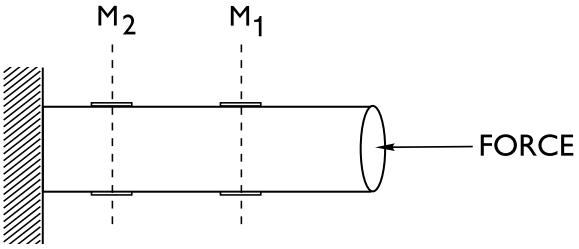
This design ensures the Weigh Bar is unaffected by moment arm variations (X in the above equation)—providing consistent readings even when load placement differs. It also eliminates several types of loading errors that plagued traditional load cells.



HOW THE WEIGH BAR WORKS *continued*

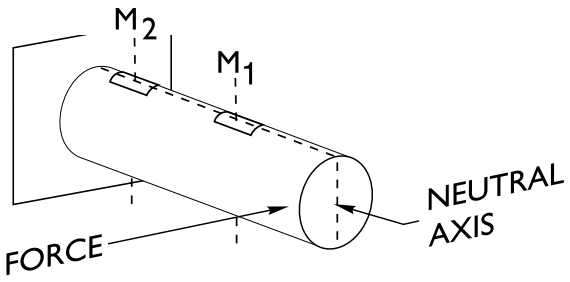
END LOADING:

The Weigh Bar experiences a uniform compressive strain throughout its full length when an end load is applied. Because the sensor is wired to subtract the strain experienced at M_1 from the strain experienced at M_2, which are equal in this instance, the electronic result is zero. With no additional force measurement to affect the applied load, the Weigh Bar ensures high accuracy and repeatability.



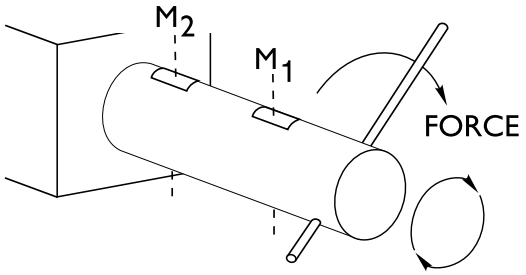
SIDE LOADING:

A neutral axis runs the length of the beam at a 90-degree angle to the applied force during side loading, causing no tension or compression at the top of the Weigh Bar. The sensors, therefore, do not measure the force from side loading—preventing this undesirable loading effect.



TORSION EFFECT:

As with the end loading example, any torque applied to the Weigh Bar results in a strain—in this case, a 360-degree torsional shear strain—that is uniform throughout the length of the Weigh Bar. Once again, when the strain experienced at M_1 is subtracted from the strain experienced at M_2 the result is zero, eliminating any torsion effect that could influence measurement of the applied load.



Unlike a traditional load cell, the Weigh Bar deflects an appreciable amount—usually a fraction of an inch—under maximum load. This deflection of the structure absorbs the energy of the impact. This benefit, combined with the aforementioned features inherent in the Weigh Bar's design—including its electronics and its ability to ignore unwanted forces— results in a linear weighing device that provides accurate, repeatable measurements.

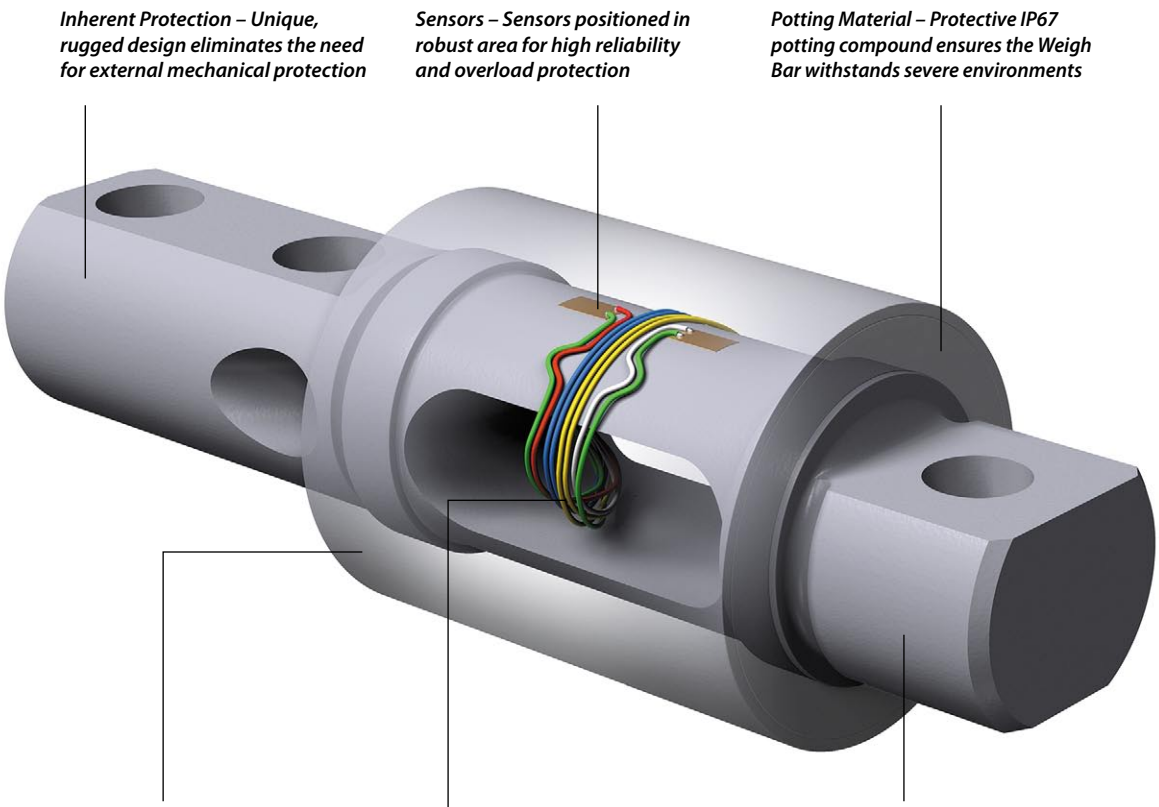
For additional overload protection, this design allows the incorporation of a simple, adjustable stop, such as a threaded bolt. The stop prevents the Weigh Bar from deflecting beyond its ability to recover due to excessive overloading or shock, thus protecting it from damage.

TODAY'S ADVANCEMENTS

In the decades since the Weigh Bar's invention, Avery Weigh-Tronix has continued to enhance its design. Today's Weigh Bar features a multi-layer sealing process that further protects it from harsh environments. During manufacturing, the Weigh Bar also undergoes a three-step treatment process to further ensure strength, repeatability and low hysteresis. This combination empowers the Weigh Bar to withstand everyday jolts and moisture penetration—delivering long operational life.

Since the 1980s, the Weigh Bar's construction has been strengthened through the use of aircraft-quality alloy steel, made up of a fine grain structure that further improves performance. Other Weigh Bar components such as the strain gauges and adhesive have undergone continuous improvement throughout the decades since its inception. With these enhancements, today's Weigh Bar provides exceptional impact loading absorption and withstands in excess of one million cycles.

Several Weigh Bar models are available, including those designed with stainless steel construction featuring fully welded NEMA 4X (IP68) cans for sanitary applications, such as in food and beverage manufacturing. Models are also available specifically for use in hazardous areas. The same rugged Weigh Bar design can be implemented in weight sensors that vary in capacity from 100 to 250,000 pounds. The wide array of Weigh Bar configurations promotes its use in agricultural, petrochemical, pharmaceutical, food processing, material handling and transportation industry applications.



IN THE FIELD

The Weigh Bar has been successfully implemented in applications ranging from floor scales and batching operations to forklift and truck scales in the field. These recent examples demonstrate how the Weigh Bar has proven its durability and high accuracy.

M-I SWACO

M-I SWACO distributes two important materials for the drilling industry: Barite, a cement-like casting material that keeps soft, sandy earth from caving in during the drilling process; and a gel material, mixed to customer specifications, which allows a bit to drill more efficiently. To weigh tanks filled with Barite, M-I SWACO needed a scale system that could handle regular loads of up to a million pounds. For their gel product, M-I SWACO faced the additional challenge of weighing anywhere from three to five chemicals used to make up the customer-specified material—all of which must be weighed and pumped into a single tank.

M-I SWACO weighs tanks filled with imperative substances for the drilling industry using Avery Weigh-Tronix Weigh Bars and Model 1310 indicators. The tanks can weigh up to a million pounds each.

The solution included 35 separate systems, each requiring four 250K batching Weigh Bars and the Model 1310 Indicator—capable of handling tanks of up to a million pounds and able to track the weights of individual ingredients used to create each batch. With this scale design, a boat can simply go in and out of the weighing area without returning for multiple product batches, saving M-I SWACO time and money. The system provides accurate weighments despite challenging weather conditions, including rain, salt water and humidity.

LAKEVILLE MOTOR EXPRESS

Accurate weighing is particularly important in shipping and distribution applications, allowing carriers to optimize revenue by precisely determining the weight of delivered freight. Forklift scales that incorporate Weigh Bar technology deliver the high-accuracy measurements required while allowing forklift drivers to obtain weigh data en route.

Lakeville Motor Express weighs and bills freight using the FLSC forklift scale. Its scale carriage contains two metal plates paired with Weigh Bar weight sensors.

LTL carrier Lakeville Motor Express maximizes profits and protects shippers by using Avery Weigh-Tronix forklift scales to weigh and bill freight, which the company picks up from myriad facilities and transfers to customers. The forklift scales are used to verify that the customer pays for exactly the amount of freight transported instead of estimating the weight of each load. After keeping running totals of the differences in actual costs versus estimations over the course of a year, Lakeville Motor Express determined that Avery Weigh-Tronix's weighing system saved the company in excess of a million dollars.

Lakeville Motor Express now employs Avery Weigh-Tronix's FLSC forklift scale system, which allows users to lift, then move and weigh loads at once to expedite operations. The forklift scale carriage contains two metal plates combined with Weigh Bar electronic weight sensors. This arrangement has no flexures, hydraulics or springs, allowing it to deliver highly accurate, legal-for-trade weighments of up to 5,000 pounds even while the forklift mast is tilted. Its rugged design ensures responsive, repeatable performance while withstanding the jolts and heavy, frequent loads common in fast-paced warehouse environments.

UTAH DEPARTMENT OF TRANSPORTATION

Another important advantage of the Weigh Bar is demonstrated in truck scale applications, where scales are used not only to determine the weight of loads, but also to confirm vehicles meet stringent state and federal weight regulations. Accurate measurements are critical in these applications to prevent excessive wear on vehicles, as well as roads.

The port is located directly off a wetland area, causing the water table to be very high. In this environment, a scale must not only withstand challenging conditions but also be easy to maintain. As Avery Weigh-Tronix offers a galvanizing option and corrosion-resistant steel construction on their truck scales, their weighing equipment proved well suited for this application's harsh conditions. The scale is self-checking, which also proved advantageous, as UDOT MC needed no extraneous equipment to ensure the scale was centered correctly in this difficult environment.

The replacement port of entry truck scales, operated by the Utah Department of Transportation Motor Carriers Division, are designed for simple maintenance—with Weigh Bars and additional components easily accessed.

When the port of entry weigh station underwent a renovation, Avery Weigh-Tronix replaced the existing single axle scales with two sets of six multi-deck scales—one northbound and one southbound, each scale 120 feet in length. In order to weigh vehicles more efficiently, each of the decks were configured to accommodate the most common truck axle configurations and arranged in a row, ensuring an entire semi-truck can be weighed in one step. The decks that comprise the scales are placed in a certain order according to size and length. Operators can then select to stop a truck in one of several places on the scale—and most trucks only need to stop once. This arrangement makes the weighing process run smoothly for the port supervisor and crew.

An additional advantage to the scale's design is the simple access it provides for maintenance. Since the Weigh Bars and additional components can be accessed from above the scale, nearly all maintenance necessary can take place without requiring personnel to work beneath the scale—a great benefit when working in an area with a high water table. It is yet one more example of how the Weigh Bar has led to scale systems that provide exceptional accuracy and longevity for challenging transportation applications—and for industry as a whole.

In the Curbside Weighing System, the Weigh Bar is inserted between the hauler's truck and its tipper, allowing recyclables to be weighed dynamically.

RECYCLEBANK, LLC

RecycleBank, LLC, headquartered in New York, encourages community recycling by allowing contributors to accumulate RecycleBank Reward Points according to the amount of materials they recycle. These Points are determined by participation as well as the weight of the contributed materials and can be redeemed for rewards to national and local RecycleBank Reward Partners.

In order to collect recyclables and track them for each household, RecycleBank partner haulers must document how often a household's contributions are made and how much the recyclables weigh. A wheeled tote containing recyclables and a RFID tag, which details the recycler's information, is placed next to the curb at each home and picked up by the tipper on the hauler's truck. The scale on the tipper then needs to generate the weight of the load accurately—

Continued >

IN THE FIELD *continued*

without consuming significant amounts of the hauler's time. The Avery Weigh-Tronix Curbside Weighing System (CWS) does just that—weighing materials in-motion and facilitating easy documentation of all recyclables.

An Avery Weigh-Tronix Weigh Bar is inserted between the truck and the tipper, allowing recyclables to be weighed dynamically and eliminating pauses mid-lift to obtain readings. Avery Weigh-Tronix's rugged Weigh Bar delivers dependable operation and exceptional accuracy, with inherent strength and sophisticated overload protection. Plus, the CWS works in conjunction with a RFID system, which allows simple tracking of recyclables by associating the amount of materials recycled with the contributing household.

PENINSULA TERMINAL COMPANY

When the rugged construction of an Avery Weigh-Tronix truck scale is paired with the time-tested durability of the Weigh Bar, the result is a long lasting and dependable weighing solution to handle even the heaviest of vehicle loads.

At its liquid products transfer site in Portland, Oregon, Peninsula Terminal Company's Transload Services Division receives tanker railcars transporting chemicals for the paper and fuel industries. The company's customers rely upon Peninsula Terminal to help them transfer chemical loads from railcars to the customers' tanker trucks and track the amount of chemicals offloaded. To provide increased accuracy and easy documentation of all weighments, Peninsula Terminal sought a robust truck scale offering multi-faceted operation.

The company selected an Avery Weigh-Tronix aboveground 80 x 11 ft. truck scale, paired with an AVS-5 unattended scale counsel featuring a Model 1310 indicator. The combination provided Peninsula Terminal with a simple yet robust weighing and documentation solution for its customers. The scale features high capacity, rugged construction and guardrails for additional safety in the transfer site's harsh climate. The scale system features Weigh Bar technology for long-lasting, extremely accurate weighing. It is yet one more example of how the Weigh Bar has led to scale systems that provide exceptional accuracy and longevity for challenging chemical handling applications—and for industry as a whole.

At Peninsula Terminal's transfer site, a scale system featuring high capacity, rugged construction and guardrails for additional safety provides high-accuracy weighing in a challenging climate.

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Avery Weigh-Tronix

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