1.6.1 STATIC VEHICLE WEIGHING

Weighbridges are the work horses of modern weighing, providing valuable weight data from a diverse range of vehicle activities and having a major impact on overall efficiency, safety and profitability. The increased use of modern instrumentation, user-friendly software and communication technology is rapidly increasing the scope of weighbridges, thereby expanding their operational and data collection capabilities.

Certification
Weighbridges are classed as non-automatic weighing instruments (NAWIs) and if the weight data is used as part of any commercial or legislative transaction* they require approval to European weights and measures standards in accordance with directive 2009/23/EC. This Directive is implemented in the UK through the Non-automatic Weighing Instruments Regulations 2000 (SI 2000 No. 3236). Some users insist their weighbridges are weights and measures approved, even if they are not used for commercial transactions. This ensures that the weighbridges are maintained and certified for optimum precision.

**This includes checking vehicles for overloading. Weighbridges are also widely used at ports and terminals to ensure ships and ferries are correctly loaded.*

Statistics show that the average value of transactions conducted over weighbridges typically ranges from £200 for general waste and aggregate, up to £20,000 for chemicals and metals. Errors in weighbridge equipment can therefore have important financial implications for businesses. For example, based on 50 weighings per day, an error of just one 20 kg weight increment per transaction can cost between £10 and £300 per day.

Most weighbridges in the UK are approved to either 1 part in 2,500 (e.g. 50,000 kg with a minimum verification interval of 20 kg) or 1 part in 3,000 (60,000 kg with minimum verification interval of 20 kg). Higher resolution weighbridges are produced (e.g. 20,000 kg x 5 kg or 60,000 kg x 10 kg) but these are usually limited to indoor use because of the adverse affects of influence factors such as wind. For outdoor NAWIs, the OIML (R76) give a strong recommendation that *'a value of n = 3 000 should not be exceeded' with further recommendations that for 'road or rail weighbridges the verification scale interval should not be less than 10 kg'.*

This limit should also apply to each weighing range of combinations of instruments or of multiple range instruments or to each partial weighing range of multi-interval instruments.

Multi-range instruments are useful where weighbridges are used to weigh a range of vehicle types from cars or small vans up to trucks. A typical example would be where a 60,000 kg weighbridge provides a minimum verification interval of 10 kg for the first 30,000 kg after which the instrument automatically switches to an interval of 20 kg for the remainder of the range. This allows both smaller and larger vehicles to be weighed with the same proportional accuracy.

Once a weighbridge has been installed and verified, there is no legal requirement for the weighbridge to be reverified unless any repairs involve critical components such as load cells or weigh indicators. However, weighbridges are subject to inspection by Local Trading Standards Officers. These inspections involve full weight testing for linearity, hysteresis and eccentric loading. Checks are also made to ensure the weighbridge has not been replaced and that critical parts of the measuring chain are still 'as they were' at the last inspection. The frequency of the inspections is determined from a risk analysis study, which takes into account how and where a particular weighbridge is operated. Typically inspections will take place every two to three years. Those installations designated as public weighbridges are inspected more frequently - usually at 6-8 month intervals. (Public weighbridges are those

where the owner makes the weighbridge available for use by the general public and other businesses, usually on payment of a fee. In these circumstances, the weighbridge operator needs a certificate of competence which is issued by the local Trading Standards Office following an examination and test of the operators' competence. There are also specific requirements about record keeping.)

Calibration
Refer to section 3.3 of the Technical Articles.

Choice
Weighbridges come in a wide range of sizes and designs, manufactured from steel, steel-concrete composite and pre-stressed concrete. Designs include pit mounted, surface mounted, modular and portable. Typical capacities range from 30 to 100 tonnes, in lengths of 9, 15 and 18 metres. Widths typically vary from 3 to 4.5 metres. The common factor for all these variants is that they need to be robust, accurate and reliable. The majority of weighbridges are verified for trade use. Whether this is to check the weight of goods purchased or despatched, for onsite check for overloading or law enforcement. The choice for a particular application will depend on factors including maximum vehicle sizes and weights, available space, usage and, of course, budget. Most weighbridges are operated in a drive-through manner. In other words, the vehicles drive on at one end and off at the other. However, in applications where space is at a premium, vehicles may go on and off from the same end. For plants where vehicles are weighed in and out, the obvious choice is to operate two separate weighbridges. Not only does this streamline traffic flow, but it also gives the opportunity to service one bridge whilst keeping the other operational. However, this is clearly a more expensive option and in many applications one weighbridge is sufficient.

Load cells
Most mechanical weighbridges have now given way to fully electronic versions where the weighbridge deck or deck sections are supported on a number of strain gauge load cells, connected to weight instrumentation. Load cell types include traditional analogue and digital versions of column cells, double ended shear beams and cantilever beams. Digital load cells are growing in popularity, offering a number of installation and operational advantages. Load cell capacities must be selected so that they can support not just the deck and maximum weighing capacity, but also cope with overloaded vehicles, shock loads and excess loads when vehicles come onto or leave the weighbridge (including braking and acceleration forces). Load cell approvals (R60) specify a minimum verification interval v_{min} for particular models. The value of v_{min} divided by the square root of the number of load cells in the weighbridge, must be less than the minimum scale interval 'd'.
The mounting of load cells is crucial to ensure correct load introduction under all operating conditions and to prevent damage to the cells.

Weighbridge Types
Pit mounted weighbridges have weigh decks that are flush with the ground. As a result, they pose no restrictions to vehicle movement on site. Mechanical weighbridges were installed in pits so when these are upgraded or replaced, the new pit mounted weighbridges provide a very cost effective answer.

Surface weighbridges offer one of the strongest designs and the side frames ensure vehicles always drive centrally through the bridge. Approach and departure ramps can either be of steel construction or pre-cast in concrete on-site. Removable steel ramps have the advantage of being able to be moved with the bridge if relocation is required, leaving the site level.

Portable weighbridges have special load cell assemblies and feet, allowing temporary installation with minimum foundation preparation. Steel ramps provide vehicle access. Careful consideration must be given to the integrity and flatness of the mounting surface.

Concrete weighbridges can offer advantages for certain applications, for instance where corrosive liquids may be present or to avoid problems from spillages of oil based substances. Pour-on-site composite versions provide a cost effective solution for medium use operations. These consist of a steel outer frame, inner strengthening beams and reinforcing mesh. Once the unit is assembled on site, the ready mixed concrete is poured in and when the deck has cured, the load cells are fitted. Alternatively, the complete weighbridge can be constructed at the factory and delivered to site.

Weighbridges with modular or multiple decks are growing in popularity, especially as steel prices continue to increase. Although they incorporate more load cells than single piece bridges, this cost is more than offset by the reduction in steel costs. Furthermore, because the modules are constructed in lighter steel they are easier to handle, transport and install.

Environmental Considerations

Weighbridges are expected to operate in the harshest of environments, fully open to the elements. Therefore, a well structured finishing procedure is essential to provide optimum longevity. In a typical coating process, all steel is shot-blasted to remove mill scale and surface imperfections prior to painting. This ensures maximum adhesion of the surface coating applications. In parallel, sound design principles ensure a well drained deck and no hidden traps underneath where corrosion can occur. For maximum protection, the underside of the weighbridges should be coated in a proprietary self-sealing water repellent coating. Hot dip galvanised steel work offers the best protection for applications in particularly harsh environments.

Load cells should be weld sealed with glass to metal cable entry to provide sealing to IP67 minimum. Cables should be protected against abrasion, heat and rodent damage.

Lightning can cause serious damage to weighbridge components, with the deck acting as an ideal receptor for the huge voltages generated during electric storms. Damage can be limited by using load cells with built-in lightning protection and implementing a good earthing regime in and around the weighbridge.

If weighbridges are installed in designated hazardous areas they must meet ATEX requirements. Refer to section 1.8 on hazardous environment applications.

Construction

Weighbridge decks should be constructed to ensure minimum deflection under all loading conditions. Excessive deflection can affect weighing accuracy and introduce premature fatigue failure.

The foundations of any weighbridge are crucial to their performance. It is of little use having the most accurate load cells and well designed weighbridge structure if the foundations are unlevel or unstable. For pit weighbridges, adequate drainage is also important to prevent flooding. Where applicable, it is possible to install weighbridges on sloping terrain using special steel wedges in the load cell mounting assemblies, or adapted mounting kit assemblies for certain types of load cells.

Significant end to end forces can be generated when vehicles drive on and off the weighbridge, especially if heavy braking occurs. Such forces can damage critical components such as load cells and can also cause serious damage to the surrounding structure. Built-in restraints restricting end-to-end and side-to-side movement are therefore an important part of any weighbridge design.

Instrumentation

In the simplest standalone layout, the weighbridge is typically linked to a basic weight indicator. This will allow rudimentary weighing processes to be carried out and allow

operators to initiate zero, tare and print functions (if a suitable ticket or tally roll printer is connected).

For more complex applications the weight indicator may have pre-programmed function keys, memory recall and a key pad for data entry. Interface cards may offer further integration with modern communication protocols including Ethernet. The indicator may provide the capability to operate with more than one weighbridge.

In legal for trade approved installations, regulations relating to the compatibility of modules must be complied with. (See section 3.1)

Modern technology

Traditionally the weighing process in many weighbridge applications has been relatively slow and data collection has been confined to local printouts of tickets and daily tally rolls. Now more emphasis is being placed on developing key peripheral areas. This is aimed at speeding up throughput of vehicles, improving security and extending weighbridge operational periods, together with improving and simplifying data collection and distribution. Technologies employed include Ethernet communication for remote access, automatic vehicle recognition systems, smart card or key readers, wireless interfacing, the world wide web and GSM. Bespoke, yet configurable, software packages can now be tailored for specific applications and are designed for the seamless integration with existing management systems such as ERP.

Driver operated systems

Driver operated systems (often referred to as unmanned weighbridge systems) have been one of the most effective developments for weighbridge operational efficiency. Such systems offer a number of advantages and remove the need to have permanently manned weighbridges. Operation is usually via a designated swipe card or key and the unit provides a complete material handling management system which is easy to use by both vehicle and site operators. Not only does the system speed up weighing operations, but it also extends the available working period for weighbridges. Terminals are located alongside the weighbridge for easy driver access. Operational conditions will dictate if there are terminals at both ends of the weighbridge. Where applicable, the terminal may have two identical displays at different levels to accommodate different vehicles. The terminals must be given suitable (and substantial) mechanical protection to avoid physical damage from the vehicles driving across the weighbridge.

There are essentially two modi operandi, colloquially known as double weighing and single weighing.

Double weighing is carried out on vehicles not registered in the database for a particular site. In this case, the driver stops the vehicle on the weighbridge and either swipes the card or presents the key to the terminal. The terminal then stores the weight and issues a ticket with the inbound weight data. After loading or unloading has taken place, the driver returns to the weighbridge and, having presented the card or key again, receives a ticket automatically calculating the weight of material delivered or collected.

In the single weighing mode, when a card or key for a known vehicle is presented, the terminal retrieves previously stored data relating to that vehicle's registration number and tare weight. Using this information, the terminal then issues a ticket showing the calculated net weight of material being delivered or collected, thereby removing the need for a second weighing.

Data from such systems can be distributed as required within the site or to a central location off site via land line, mobile phone or email to designated recipients. Rapid and effective data collection allows rapid invoicing without the problems associated with manual transcription to spread sheets.

Vehicle recognition
Vehicle recognition systems are effective in increasing vehicle throughput at weighbridges whilst introducing an effective security system. They are particularly effective at remote sites and at those where 'out-of-hours' weighing is required, where they are used in conjunction with driver-operated terminals. Recognition technologies employed include automatic number plate recognition systems using cameras and those which rely on the vehicles being fitted with transponders containing key vehicle details.

For automatic or remote weighing in a typical system, the weighbridges usually have entry and exit barriers. Vehicles approaching the entrance are picked up by the camera and the number plate is checked against the database. If the vehicle is registered it is allowed through the first barrier onto the bridge to be weighed. At this point the driver presents his card or key at the control terminal positioned outside the window and this initiates the weighing.

Simple 'command prompts' guide the driver through the weighing process and as soon as the weighing has been successfully carried out, the vehicle is allowed off the weighbridge. Such systems can also maintain a current and historical record of vehicles on site, allowing a comprehensive vehicle movement log to be maintained at both single and multiple sites.

Service and support
Service and support is a critical issue for weighbridge operators especially for equipment working in harsh environments. New developments are bringing important changes to the way in which servicing can be optimised and this is particularly useful at remote unmanned sites. Any weighbridge breakdowns have a rapid and major impact on daily operations and therefore, effective servicing and trouble shooting is very important. However, traditional methods of servicing do not necessarily cater for the changes in the working pattern of a particular weighbridge. Typically, estimates are made to establish the frequency of servicing, often with the emphasis on minimising costs.

Most of us are familiar with the built-in service monitors on modern cars, which assess servicing requirements based on a combination of factors including time, mileage and how the car is driven. This technology is now available for weighbridges advising, for instance, when the next service is due based on time, number of weighments or a combination of both. The system can also record a history of peak loads, which may be above normal operating capacity and detrimental to the working of the bridge. This information can be useful in determining why, for instance, a particular weighbridge is going out of calibration or suffering from excessive component failure.

Although regular servicing and maintenance can help to minimize problems, predicting what and when things will go wrong is very difficult with traditional analogue weighbridges. Digital load cell technology offers remote maintenance service support capability, which can save considerable time and effort especially for equipment operating in harsh, remote areas.

With such a system installed, any problems with the weighing equipment are automatically flagged up at the supplier's offices. Details are immediately forwarded to the local engineer who can then dial into the weighing system remotely and make a risk assessment of the situation. In many cases, the engineer can carry out a range of checks and, where possible, rectify the problem without having to visit the site. If not, then if appropriate, plans can be made to carry out any remedial work during the next scheduled visit, thereby minimising the disruption to the site operation.

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. However, the quality of the data they provide is still totally dependent on sound mechanical design principles and well defined installation procedures.