Weighing Containers in Ports and Terminals

A PEMA Information Paper



This Information Paper is intended to provide an overview of the technologies available today for the weighing of containers in terminals. The paper covers both weighbridges and weighing systems for use on ship-to-shore container cranes, mobile harbour cranes, RTGs, RMGs, straddle carriers, reach stackers and container handling fork lift trucks.

The goal is to provide ports, terminals and other interested parties with a clear understanding of the various technologies available today and their relative capabilities.

The document concludes with a table summarising the various technologies and their weighing accuracy.



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INTRODUCTION

DOCUMENT PURPOSE

The following Information Paper discusses alternatives available to measure container weights in container terminals, with specific focus on the aspect of container weight verification. The document covers the commonly available weighbridges and various alternative weighing systems for use on ship to shore cranes, mobile harbour cranes, RTGs, RMGs, straddle carriers, reach stackers and fork lift trucks.

Some of these weighing systems are primarily designed as overload protection systems for container handling equipment, while some provide actual real time container weight information. All systems known to the authors have been included in this paper.

It is not the intention of this paper to review, recommend or promote particular brands or concepts of weighing systems. PEMA cannot advocate or decide which solution, or combination of solutions, is the right choice for any particular facility.

The intent here is to contribute to industry awareness of the possibilities now available, and the issues that ports and terminals should consider when making their selection.

ABOUT THIS DOCUMENT

This document is one of a series of Information Papers developed by the Safety Committee (SC) of the Port Equipment Manufacturers Association (PEMA). The series is intended to inform readers about the design, application and use of equipment and technology to improve the safety of people, equipment and cargo in port and terminal operations.

This document does not constitute professional advice, nor is it an exhaustive summary of the information available on the subject matter to which it refers.

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1 | CERTIFICATION, CALIBRATION & ACCURACY

1.1 CERTIFICATION & CALIBRATION

Container weighing systems must be certified if the information generated from the system (i.e., weight data) will be used as the basis for commercial transactions. Weighing system certification is performed through national regulatory authorities or companies accredited by those authorities.

Of the weighing system alternatives described in this paper, the only types known to be presently certified are the weighbridges. In theory, all weighing systems can be certified. Weighing systems are normally type certified, but most of them need to be periodically recalibrated to ensure their continued accuracy.

1.2 ACCURACY

When discussing the precision of weighing systems, the practice in this document is to refer to the system's inaccuracy, rather than its accuracy.

The weighing measurement inaccuracy as referenced in this paper always refers to a percentage of full scale. This means that if the maximum weight range of the weighing device is 40 tonnes and its inaccuracy is 1% as a percentage of full scale, then the inaccuracy expressed as an absolute weight will be +/- 400kg. It should be noted that the absolute inaccuracy will also depend upon the position of the measuring device. 5

For instance, if the measuring device is positioned in a quay crane trolley, its measuring range must be specified to cover not only the maximum weight of the container, but also the weight of the spreader and headblock, as well as the crane cables and ropes.

The weight of these additional items can easily be deducted from the total weight. However, the potential deviation resulting from the higher measuring range will affect the absolute inaccuracy of the device when used as a container weighing system.

As this aspect is highly dependent both on the type and manufacturer of the equipment in question, and on the specification of its component parts, it is not included in the indicated inaccuracies given in the next chapter for the various weighing alternatives.

However, ports and terminals must be aware of this requirement when planning to implement handling equipment-based container weighing systems.



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2 | WEIGHING SYSTEM ALTERNATIVES

2.1 WEIGHBRIDGES

Weighbridges offer a vehicle weighing solution, often positioned at site entrances/exits. The incoming truck passes over the weighbridge and the total weight is registered. In order to determine the container weight, the tare weight of the truck is deducted from the total weight. The tare weight of the truck can be measured if the truck leaves the terminal empty or the weight of the truck can be declared when entering the terminal. Weighbridges should be recalibrated periodically by an accredited technician to ensure accurate weighing.

Weighbridges can be paired with driver operated consoles, which enable fuller automation of the weighing process. They have a very high accuracy, very often up to +/- 20kg, but to achieve this the truck needs to come to a standstill on the bridge. Axle weighbridges are also available, allowing vehicles to be weighed 'in motion' at speeds of up to 15 km/h, at a lower accuracy than a standard weighbridge.

Weighbridges can be surface-mounted, with a ramp leading up a short distance and the weighing equipment underneath, or pit-mounted, with the weighing equipment and platform in a pit so that the weighing surface is level with the road.

Access to a surface-mounted weighbridge requires the addition of ramps which, when added to the vehicle turning circle required, means that aboveground weighbridges take up a significant amount of space on site. Pit-mounted weighbridges will take up less surface area. The civil and foundation work required can make them the more expensive option, but pit mounting the weighbridge negates the need for ramps or guide rails.

Weighbridges weigh the complete vehicle and cannot

Weighbridges: key points

Pros	Cons	Inaccuracy
Weighing accuracy	Can be disruptive to the terminal workflow	0.2-0.5% of full scale
Overweight containers turned away before entering terminal	Cannot separately measure individual containers loaded on the same vehicle	

identify the individual weights of two containers loaded on the same truck. In these cases the two containers have to be reloaded and weighed independently. Containers arriving by train, or by sea for transhipment, will have to be sent to a weighing station, a step which is uncommon in terminal logistics today.

2.2 LOAD CELLS ON STS CRANES

Load cells on ship-to-shore (STS) cranes are installed at the rope ends on the crane trolleys or booms, in the sheave pins, or elsewhere in the rope system. They are often intended to perform principally as an overload protection, rather than a weighing, system. Load cells have a weighing inaccuracy of about 3-5% of the maximum STS crane lift weight and need to be regularly re-calibrated.

Nowadays, all new STS cranes have such an overload protection system installed as standard. There are also several suppliers that provide such systems for retrofit installation on existing STS cranes.

Load cells are not always easy to install, however, especially if they are fitted into the rope sheave shafts. Cranes will need to be taken out of service and the refitting of the rope sheave shafts can be challenging, especially if the dimensions of the shafts are not known in advance. In these cases, shafts have to be measured while the cranes are out of service and new shafts may also have to be manufactured to accommodate the load cell system.

Crane-mounted load cell weighing systems cannot weigh each container individually, nor can they easily determine container load eccentricities. However, rope end-mounted load cells can be used to measure and adjust rope tension, which is an additional advantage to ensure equal wear of all ropes.

Load cells on STS cranes: key points

Pros	Cons	Inaccuracy
Non-disruptive to terminal flow (may not always measure during standard lift cycle)	Less accurate Cannot separately measure individual containers handled with twinlift spreaders	3-5% of full scale

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Attention needs to be given to adjust the weight readouts depending on whether the spreader is at ground level or hoisted. The weight of the ropes can make a considerable difference to the total weight, depending on the height of the spreaders. In addition, if overhead frames or cargo hooks are used, the tare weight change has to be taken into account.

2.3 LOAD CELLS ON RTGS

Load cell systems are also available for use on rubbertyred gantry cranes (RTGs). In this application, the load cells are installed in the shafts of rope sheaves on the trolley or in the rope anchors. These systems have an inaccuracy of about 3-5% and need to be re-calibrated regularly. Again, installation on existing cranes can be complicated if there are no drawings available of the sheaves and shafts. If the cranes are equipped with twinlift spreaders, the load cells cannot measure each container individually.

For 4-high or 5-high stacking RTGs, the rope weight can make a considerable difference if the system is calibrated with the spreader at ground level or hoisted, unless the lift height is taken into account in the weighing system.

2.4 WEIGHING SYSTEMS ON MHCS

A mobile harbour crane (MHC) needs a weighing

Load cells on RTG cranes: key points

Pros	Cons	Inaccuracy
Non-disruptive to terminal flow - measure during standard lift cycle	Less accurate Cannot separately measure individual containers handled with twinlift spreaders	3-5% of full scale

MHC weighing systems: key points

Pros	Cons	Inaccuracy
Non-disruptive to terminal flow - measure during standard lift cycle	Less accurate Cannot separately measure multiple containers handled with twinlift spreaders	>5% of full scale

system to control the stability of the crane, as the load weight is strictly limited depending on the boom outreach. These systems are therefore normally integrated by the crane manufacturers during the production process. MHC weighing systems often measure the hydraulic pressure in the boom lift cylinders or may be built into the rope system.

2.5 LOAD CELLS ON STRADDLE CARRIERS

Load cell weighing systems have also been installed on straddle carrier hoist systems. However, the degree of inaccuracy is quite large. Similar to container crane load cell systems, these systems cannot weigh containers individually if the straddle carrier is fitted with a twinlift spreader, nor can they determine container loading eccentricities. Accidents are common with straddle carriers during twinlift operations, when one container is loaded and one is empty or very lightly loaded.

2.6 WEIGHING SYSTEMS ON REACH STACKERS

Most reach stacker manufacturers provide builtin systems which use the hydraulic oil pressure in the boom lift cylinders to measure load weight. The systems are rather limited in accuracy and performance may vary depending on whether the reading is taken after a hoist movement or after the lowering of a load.

Load cells on straddle carriers: key points

Pros	Cons	Inaccuracy
Non-disruptive to terminal flow - measure during standard lift cycle	Less accurate Cannot separately measure individual containers handled with twinlift spreaders	5% of full scale

Reach stacker weighing systems: key points

Pros	Cons	Inaccuracy
Non-disruptive to terminal flow - measure during standard lift cycle	Less accurate Cannot separately measure multiple containers handled with twinlift spreaders	>5% of full scale



The friction in the cylinders can make quite a large difference in reading. The telescopic boom extension is however normally taken into account as it has an effect on the weight readings. Reach stacker load cell systems are also available, which are built into the rotator-boom head mounting shafts.

In any case, the spreader needs to be hanging freely without the tilt being activated in order to have the centre of gravity of the spreader and container lined up and ensure the best accuracy.

2.7 WEIGHING SYSTEMS ON CONTAINER HANDLING FLTS

Weighing systems for container handling fork lift trucks (FLTs) usually work by measuring the hydraulic oil pressures in the lift cylinders. Alternatively, load cells may be installed under the chain anchors. The inaccuracy of these systems is usually due to friction in the hydraulic cylinders. Currently, it is not very common for weighing systems to be installated on container handling FLTs.

Container FLT weighing systems: key points

Pros	Cons	Inaccuracy
Non-disruptive to terminal flow - measure during standard lift cycle	Less accurate Cannot separately measure individual containers handled with twinlift spreaders	>5% of full scale

2.8 WEIGHING SYSTEMS USING SPREADER TWISTLOCKS

More recently, weighing systems have been developed which measure the load weight and eccentricity on the crane spreader twistlocks. These systems are more accurate than any of the above-mentioned technologies, with the exception of weighbridges. They can also weigh each container individually in twinlift mode, determine container weight eccentricity, and have a variety of safety features to help prevent accidents during handling operations. Twistlockbased systems require no infrastructure changes to the terminal and can be installed on all type of spreaders at point of manufacture or as a retrofit. Use of this weighing technology does however mean that the terminal must install the system on all of the spreaders used together with the crane(s) in question.

Spreader twistlock weighing systems: key points

Pros	Cons	Inaccuracy
Non-disruptive to terminal flow - measure during standard lift cycle Can separately measure individual containers handled with twinlift spreaders	Require installation on all spreaders used on a crane / container handling equipment	0.5-1% of full scale

2.9 WHERE IN THE TERMINAL TO INSTALL A WEIGHING SYSTEM

There is no universal place to install a weighing system in a terminal. The choice depends heavily on the logistics flows of an individual facility, not least its mix of export/import versus transhipment traffic. It also depends on the size of the terminal and the type of container handling equipment in use. In general, though, weighing a container only when it being loaded onto a vessel is too late in the process, as this will not allow the ship stowage plan to be updated in cases where container weight has been mis-declared.

The earliest a container can be weighed when being exported out of the country is with a weighbridge as it enters the terminal. However, transhipped container weights are more efficiently verified when they are in the stacking yard.

An important factor for the terminal to consider is how the strategy to verify container weight affects the logistics flow in the terminal. Many of the alternatives described in this document measure the weight as part of the regular lift cycle, while the weighbridge alternative requires that a transport vehicle takes the container to a weighing station. If weight verification is needed, for instance in a transhipment terminal, this extra activity within the terminal will mean a significant change in terminal logistics.

3 | COMPARATIVE OVERVIEW

Weighing system	Pros	Cons	Inaccuracy*
Weighbridges	High weighing accuracy Allows mis-declared containers to be identified before entering the terminal (assuming weighbridge is located at the gate)	Can be disruptive to the terminal workflow Cannot separately measure individual containers if loaded on the same vehicle	0.2–0.5 %
Load cells on ship to shore cranes	Non-disruptive to the terminal flow - though may not always measure during regular lift cycle	Less accurate Cannot separately measure individual containers handled with twinlift spreaders	3-5 %
Load cells on RTGs	Non-disruptive to the terminal flow – measure during the regular lift cycle	Less accurate Cannot separately measure individual containers handled with twinlift spreaders	3-5 %
Weighing systems on mobile harbour cranes	Non-disruptive to the terminal flow – measure during the regular lift cycle	Less accurate Cannot separately measure individual containers handled with twinlift spreaders	5 %
Load cells on straddle carriers	Non-disruptive to the terminal flow – measure during the regular lift cycle	Less accurate Cannot separately measure individual containers handled with twinlift spreaders	5 %
Weighing systems on reach stackers	Non-disruptive to the terminal flow – measure during the regular lift cycle	Cannot separately measure individual containers handled with twinlift spreaders	>5 %
Weighing systems on container fork lift trucks (FLTs)	Non-disruptive to the terminal flow – measure during the regular lift cycle	Cannot separately measure individual containers handled with twinlift spreaders	>5 %
Load sensing systems using spreader twistlocks	Non-disruptive to the terminal flow – measure during the regular lift cycle Can measure individual containers when handled with a twinlift spreader	Requires installation on all spreaders used on a crane	0.5-1%

* The weighing measurement inaccuracy as referenced throughout this paper always refers to a percentage of full scale. This means that if the maximum weight range of the weighing device is 40 tonnes and its inaccuracy is 1% as a percentage of full scale, then the inaccuracy expressed as an absolute weight will be +/- 400kg



ABOUT THE AUTHORS & PEMA

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ABOUT PEMA

Founded in late 2004, the mission of PEMA is to provide a forum and public voice for the global port equipment and technology sectors, reflecting their critical role in enabling safe, secure, sustainable and productive ports, and thereby supporting world maritime trade.

Chief among the aims of the Association is to provide a forum for the exchange of views on trends in the design, manufacture and operation of port equipment and technology worldwide.

PEMA also aims to promote and support the global role of the equipment and technology industries, by raising awareness with the media, customers and other stakeholders; forging relations with other port industry associations and bodies; and contributing to best practice initiatives.

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