

Engineering White Paper

**AUTOMATIC AND NON AUTOMATIC
WEIGHERS FOR MARITIME APPLICATIONS.
PENKO ENGINEERING B.V.**



INTRODUCTION

This White Paper discusses the challenges, options and solutions for weighing equipment, used in maritime applications, especially used on board of fishing ships.

PURPOSE OF WHITE PAPER

...is to explain why it is important to control the correct amount of catch. Whether an on board weighing system is of industrial proportion or simply a small system on shop level, similar challenges regarding accurate mass control apply which have a direct effect on cost and profit margins for the fisherman. Incorrect grading, overweight as well as underweight directly influences the action in process. As a result a wrong decision can be taken. So inaccurate weighing results in spillage of the catch, delayed shipments, unhappy customers what means profit loss, and may even cause a legislative fallacy.

In addition to such losses, there is the added argumentation of operating inside a quality management system and of international standards and legislations on trade such as for the European Economic Region that warrants a scrutinizing view on accurate, fair and proper filling of prepackages of any size. The advantages of fast weighing (PENKO instruments weigh at 1.600 samples per second) is faster throughput and less spillage, leading to fast ROI.

BACKGROUND OF ON BOARD WEIGHING

The definition of weighing equipment is: “a measuring instrument that serves to determine the mass of a body by using the action of gravity on this body.” Weighing on board of fishing ships on the high sea creates an amount of challenges. The first issue is the variation in the acceleration of the gravity, in the European coastal seas from 9,819289 m/s² in the north to 9,799248 m/s² in the very south, so with a 0,2 % difference.



Photo 1. Fish processing ship „Navigator“ – of shipping company Uftaskip.



Photo 2. On board processing for the composition of batches of fish, build and installed by AFAK.

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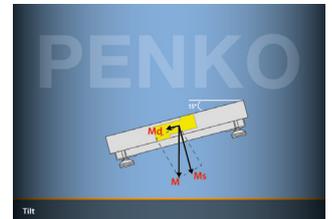


- ▶ More serious influences are created by the waves on open sea. As showed in the picture below a ship turns around three axes, the X- or longitudinal axis, the Y- or transverse axis and the Z- or top axis causing the ship to roll, pitch respectively yaw, see picture 1.



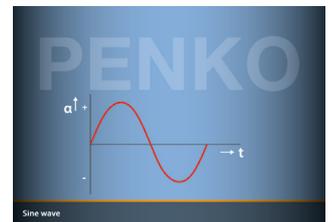
Picture 1. The movements of a ship, caused by the waves, around the three axis.

These movements will take place simultaneously. Movements around the X- and Y-axis cause a heeling of the ship, under “normal” circumstances up to 15°, however 45° during severe storms. A heeling of 15° causes, see picture 2, without a correction a misreading, M_s instead of M , of up to $1 \times \cos 15^\circ$ or 3,4 %, see picture 2



Picture 2. A heeling of the weighing platform causes a misreading.

More frustrating under normal operation is the effect of the side force M_d , up to $1 \times \sin 15^\circ$ or almost 26 % of the load, on the weighing system. This effect cannot be defined, the heeling takes place over 90° around both axis, X and Y, in the horizontal plain simultaneously.



Picture 3. How the vertical movements influence the weighing signal.

The major influence however is caused by the movements of the ship itself. When not exactly located in the crossing point of the three axis, the weighing system goes up and down in a circular arc shape. This effect is estimated by heeling's of $\leq 15^\circ$ to cause a sine wave shaped acceleration or de-acceleration of the weigher between 0 and + or - 3 m/s^2 with a 0,03 up to 0,3 Hz frequency, see picture 3. So the measuring equipment notices apparently an acceleration of the gravity, varying between 9,8 + or - 3 m/s^2 or from 6,8 up to 12,8 m/s^2 . This means misreading's up to ± 44 %!

A complicating factor is, the movements caused by the waves are variable, take place simultaneously and influence each other. What makes the utilization of a “pre-set” compensation useless. Moreover a ship on the high seas is more or less “alive”. The engine, winches and windlasses, see photo 3, cause vibrations, transported via the steel structure all over the ship. Vibrations cause another movement of the weigher, so influence the measuring result.

The environment is an issue as well. By nature the humidity will be high and plenty of salty water will be present. So a high protection factor is a requirement and all materials used have to be non-corrosive.

At last the catch, fish and shellfish, is food, so the hygienic requirements are high and intensive cleaning must be possible



Photo 3. Bringing in the nets with the catch.

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SOLUTION

PENKO supplies solutions, equipped with a build in, patented, dynamic compensation for the mentioned uncontrollable influences, present on board of a ship, such as heeling, vibrations, accelerations and decelerations, but also for an automatic adjustment to the local acceleration of gravity. Thanks to a high measurement speed (1 600/s) and high internal resolution (24 bits) out of the rough data a weighing result with a 2 500 d or a $\pm 0,04$ % accuracy is calculated. The system fulfils the legal requirements, it is approved for trade applications.

ACCURACY OF SCALES

The required accuracies and maximum permissible errors are laid down in separate white papers. Available are our white papers for non-automatic weighing equipment, automatic catchweighing instruments (check weighers), automatic gravimetric filling equipment (mono filling) and discontinuous totalizing automatic weighing instruments (totalizing hopper weighers). The legal requirements for weighing on board and on shore are the same. A difference has to be made between weighers for which legal requirements are valid (a) and those not subject to legislation (b). For Europe article 1, sub 2 of the NAWI (non-automatic weighing instruments) directive 2014/31/EU establishes for which types of instruments legal requirements exist:

2. For the purposes of this Directive, the following categories of use of non-automatic weighing instruments shall be distinguished:

- a) i) *determination of mass for commercial transactions;*
 - ii) *determination of mass for the calculation of a toll, tariff, tax, bonus, penalty, remuneration, indemnity or similar type of payment;*
 - iii) *determination of mass for the application of laws or regulations or for an expert opinion given in court proceedings;*
 - iv) *bepaling van de massa in de medische praktijk voor het wegen van patiënten voor observatie, diagnose en medische behandelingen;*
 - v) *determination of mass for making up medicines on prescription in a pharmacy and determination of mass in analyses carried out in medical and pharmaceutical laboratories;*
 - vi) *determination of price on the basis of mass for the purposes of direct sales to the public and the making up of prepackages;*
- b) *all applications other than those listed in point (a).*

This description is copied out of the directive for Non Automatic Weighing Instruments. The Measuring Instruments Directive (MID, 2014/32/EU) contains a similar distribution, however in a different wording.

The difference whether a weighing system is automatic or a non-automatic is the presence of a decision maker. When an operator decides the weighing/dosing is correct or not, the weigher is non-automatic. Decides the weighing controller automatically, it is an automatic instrument.

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TYPES OF ON BOARD WEIGHERS, APPLICATIONS

Filling crates with graded or ungraded fish

Crates are filled both manually and automatically, see photo 4. If this is done in accordance with the regulations, it saves operations ashore so the catch can be marketed faster, and thus fresher. For further information on non-automatic weighing, please refer to the relevant white paper, for automatic filling or automatic check weighing, see the white papers on filling applications and check weighing systems.



Photo 4. A platform weigher on which the catch is packed in buckets.

Weighing of the catch in the net when bringing in

Knowing how much has been caught prevents for surprises. The weight of the net and its contents can be determined as soon as the catch is brought in. This offers advantages not only at sea, but also in fish farms. See photo 5, suitable measures can be taken before emptying the net. In fish farms, this method offers the possibility of removing the correct amount of fish out of the basin, at sea measures can be taken directly for the efficient processing of the catch. Given the application, the use of cables needs to be avoided, so the choice is made for the use of a battery in combination with wireless data transfer.



Photo 5. The weighing of the net with its content during bringing in the catch.

Batch weighers

In many occasions the catch is, directly after grading, frozen. For efficiency reasons the freezing installations are charged with the, required by the customer, amount of fish. So exact batches must be dosed to the freezer. The complete batches are composed out of small so called frosters, each loaded with approximately 20 kg of fish up to the amount sold. The more exactly the weight is dosed, the less overweight or give away is present. Moreover a reduced overweight means less capacity is spend by the freezing installation so energy is saved. Because portioning takes place on board, on the shore no further processing is required. A typical accuracy of $\pm 0,5\%$ of the batch is reached, what offers the possibility to handle a variety of batch sizes. Finally, the legal requirements as laid down in the White Paper for discontinuous totalizing weighers (hopper weighers) apply.



Photo 6. A batch, composed on weight, of deep frozen sea fish.

COMPETITIVE ADVANTAGE

A patented effective compensation of the dynamic effects, caused by the waves at sea, including the utilisation of a high resolution filter system in combination with a measuring system with a high measuring speed and high accuracy, provides useful weighing results in any working environment.

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- ▶ The combination of measuring at high speed (1.600 conversions/s) with a high internal resolution (16.777.216), smart filters and sufficient computing capacity, makes our range of instruments suitable for any weighing application on the high seas with accuracies up to 2 500 d (0,04 %) for trade applications. The sum of these three factors guarantees the best achievable weighing accuracy, and thus prevents for wastage because of give away and saves energy.

PRODUCT SOLUTIONS

Weighing platforms, by example for the filling of crates

For maritime applications, these platforms, see photo 7, are as a standard entirely made out of stainless steel, including stainless steel hermetically sealed load cells with protection class IP68/IP69K. The platforms are provided with a compensation for the dynamic effects. Weighing capacities vary in two ranges up to 300 kg, dimensions up to 800 x 800 mm and the usual accuracy is 2 500 d (0.04%) of the weighing capacity, also for trade applications. The platforms are suitable for use as a non-automatic as well as an automatic weighing system, for example a filling machine or grader on weight.



Photo 7. A weighing scale for maritime use, including an indicator in a special "seawater resistant" enclosure.

Motion Compensated Weighing Crane Hook

This instrument is suitable for all free-hanging mobile applications, see photo 8, both in maritime shipping, for example fishing, but also in fish farms. The scale is made out of a solid stainless steel housing with protection class IP68 and galvanized, partly also painted, lifting eyes and hooks. So it is a unit fit for the applications mentioned. The built-in load cells are made out of stainless steel and hermetically sealed, IP68/IP69K. The scale is provided with an active patented compensation of the dynamic effects, such as swinging, accelerating or deaccelerating. Despite the robust design, the instrument weighs only 25 kg. Vulnerable connection cables are unnecessary. The weighing data is transferred wirelessly to a web browser. The battery power allows 4 hours of continuous weighing. The scale is available in ranges from 0 - 150 kg up to 1 000 kg.



Photo 8. A crane hook weigher with a capacity up to 600 kg.

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► **Batchwegers**

This system is the combination of one or more weighing platforms, see above, with an adapted controlling system, including special software, and reporting of the production. Thanks to the patented dynamic compensation, the weight per froster is precisely determined, facilitating the totalization to take place within a high accuracy, so that the size of the batches approaches the desired value within narrow tolerances.



Photo 9. During the composition of the batches, the information about the ongoing process is directly available.



Photo 10. The reports of the composed batches with the associated weights.

CONCLUSION

Weighing and dosing fresh fish on board a seagoing ship will always be a challenge. At first, there are the associated vibrations of the machines, nature also has a continuous influence on the weighing signal. And then there are the requirements of a quality management system associated with the, on board, filling freezing and storage systems. Third, over- and under-filling must not take place to avoid for waste or to prevent for complaints. The side effects of an efficient and accurate dosing are the savings of energy and the fast and efficient filling of prepackages up to - or as close as possible to – the exact weight.

Fish is by nature a slippery product where no two fishes are of the same shape, size or weight. The onboard swell compensated weighing is not a „one size fits all“ scenario.

Technicians at PENKO work out for you the best and most effective way this can be done. Following White Paper will discuss Load Cells, the Mounting of Load Cells, the selection of Instruments, Supervising Software, Non Automatic Weighing Systems, Check Weighing Systems, Gravimetric Filling Systems, continuous totalizing with Loss-in-Weight and Belt Weighing, discontinuous totalizing with Hopper Weighers, Grading Systems by means of Weighing, Prepackages, Mixing chamber controllers for the processing industry, Mixing control in concrete plants, bakeries, confectionery plants and feed mills.

For more information:: www.penko.com

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