LEVELING SILOS

The intent of this technical note is to help in making good leveling of silos. This is a very important part of the silo's instalation for obtaining a homogenious distribution of the load and to prevent an overload of the load cells and consecuently make a good weighing system.

In three–loadcell silo, the load is ussually distributed homogenously without problems, being so stable as a three –legged- chair. However in four or more –loadcell silo it is necessary make a good leveling.

The main problem of having an unleveled silo is that the weight use to be concentrated on the main diagonal and, if so, it can exceed the nominal capacity of the chosen loadcells. For this reason it is very important to choose an adecuate loadcell capacity, oversizing, as it is explained in detail in the technical note *"Loadcell selection guide for tanks".*

This is a common problem. Silos are big mechanical structures and the ground is normally irregular. It is difficult to obtain precisions of tenths of millimeters between the supporting loadcells. Loadcells have small deflection of 0,5mm aproximately. A 0,1mm deviation can mean the 20% of the weight. Fortunately big structures are flexible and they will adapt the shape, but there are some cases as in a silo with rim or ring in the base where they are very rigid.

Let's start with an example of a silo not leveled, with the problems and the solutions, finishing in detailing the silo leveling procedure.

Practical example of a silo not leveled

We start with an example of a four–legged silo of 100t with four load cells. Note in the Figure 1, that the overload always appears in a diagonal. Additionally there is a bad choice of loadcell's nominal capacity of 30t each, so the total capacity of the load cells is 120t, thinking of the extra 20t will be enough, but it is not enough because there are load cells loaded up to 40t.

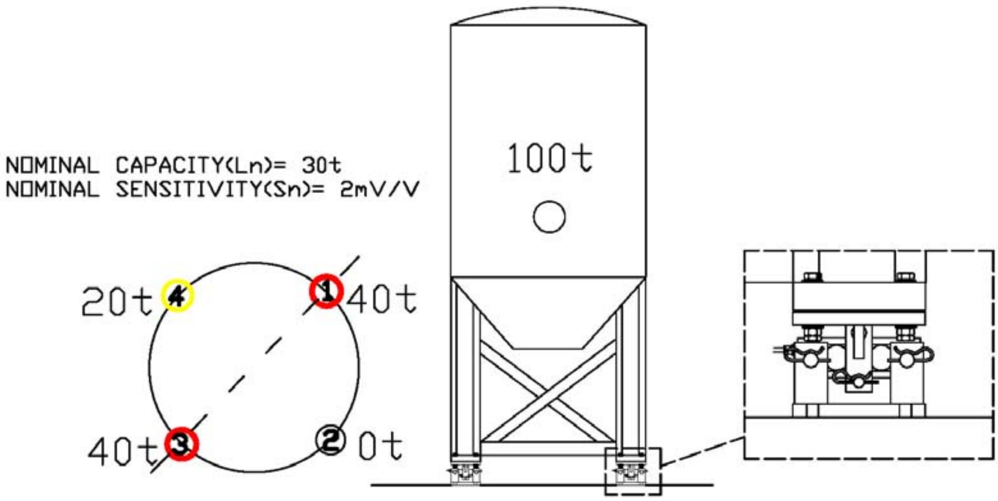


Fig. 1- Plant and front view of an uneven Silo

In this silo, if we do a measurement of each individual output signal (mV) of the load cells we will easily detect these load differences due to a lack of leveling.

LoadCell Num.	*Load*	*Signal*	*% of load*
Loadcell 1	**40t**	► **2,66mV/V**	**is the 133,33% of its nominal capacity**
Loadcell 2	0t	► 0mV/V,	is the 0% of its nominal capacity
Loadcell 3	**40t**	► **2,66mV/V**	**is the 133,33% of its nominal capacity**
Loadcell 4	20t	► 1,33mV/V	is the 66,66% of its nominal capacity

As we can see, loadcell 1 and 3 exceeds of their nominal capacity, but on the other hand loadcell 2 does not work.

When we are faced in a four –legged silo, we have to oversize the loadcells with a security factor of K≥ 1,5; so in this way, we will have chosen at least 40t load cell capacity (1,5 x 100t/4 legs=37,5t) and we would not exceed its nominal capacity for this application.

We have to level the silo, using metal shims of 0,5mm, 1mm and 2mm, interposed between the silo's structure and the loadcell accessory, as shown on Figure 2, until to reach same analog output signal (mV) for all load cells. In practice, the maximum difference of the analog output signal (mV) between each loadcell should be less than 30%.

In this example, we will start levelling with the load cell number 2, no load in it, and then we will measure again all individual signal load cells (mV) and check the differences. The process continues iteratively by levelling the lowest loaded and measuring again up to equalize the loads on each leg.

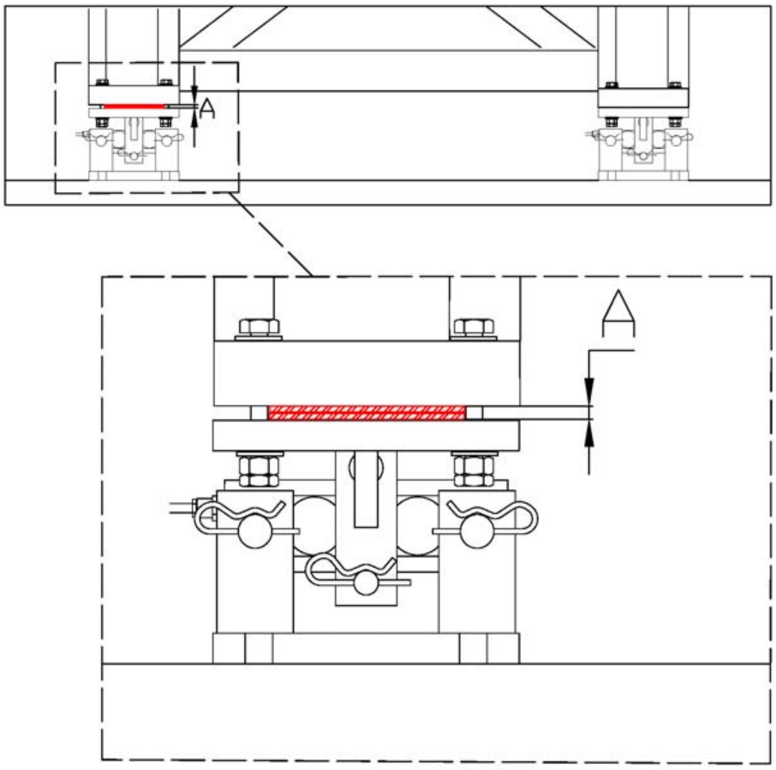


Fig. 2- Silo leveled with shims
A- Leveling Shims (0,5 to 2 mm as appropriate)

How to verify the maximum difference of the output signals between the loadcells is kept bellow 30%, so calculating the ratio the ratio between the major and the minor signal loadcell and it must be less than 1,3.

Maximum Signal difference between Loadcells = Major Loadcell signal / Minor Loadcell signal
The result should be ≤ 1,3.

After making the leveling of this silo it will be acceptable to obtain a load distribution as shown in Figure 3.

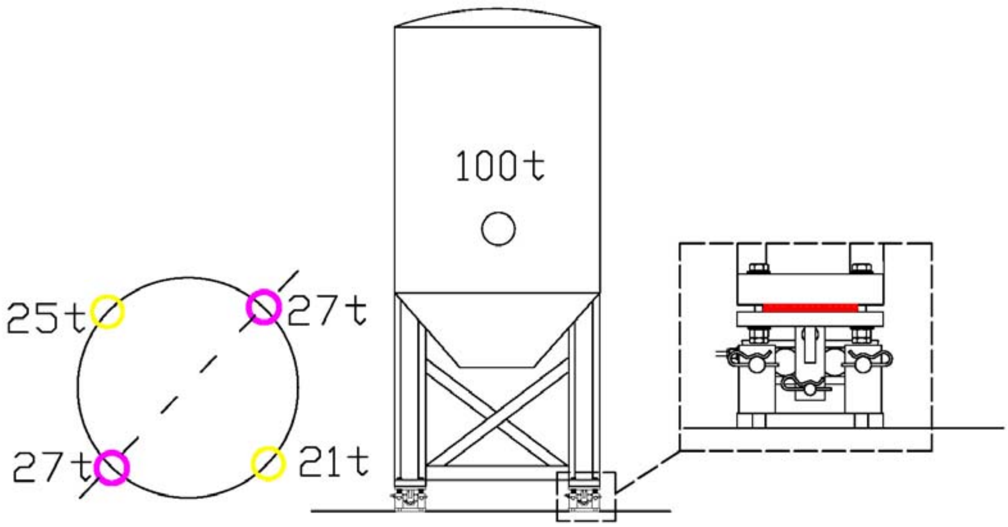


Fig. 3- Plant and front view of an leveled Silo

We have seen with a practical example: the silo was uneven; the output signal between major and minor loadcell were bigger than 1,3, more than 30%; originally the load cells of 30t were overloaded and the importance of oversizing the load cell capacity in the moment of choosing them. After an accurate leveling, the load cells of 30t were enough, but it had been safely to originally select load cells of nominal capacity of 40t.

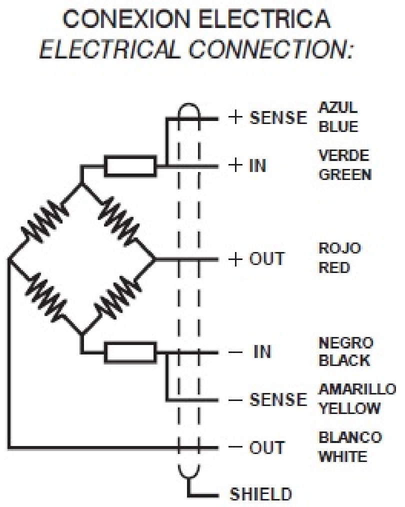
The Leveling Silos Procedure

Once we have done a visual level of the silo, we can start with the leveling procedure. This procedure consists on three steps:

1- Power Supply all the loadcells
2- Measure the output signal of each loadcell
3- Level the silo with metal shims

1- Power Supply all the loadcells

It is necessary sypply all the loadcells to obtain the output signal in mV. We can use the own power supply of the electronic weighing indicator. Then we should connect the load ell excitation wires to the junction box (Green +IN to +V and Black –IN to -V). If it is a 6 wire load cell with senses, they will be connected in parallel to excitation wires (Blue +SENSE to +V and Yellow –SENSE to –V).



+SENSE Positive Sense

+IN Positive Excitation Voltage

+OUT Positive Output Signal

-IN Negative Excitation Voltage

-SENSE Negative Sense

-OUT Negative Output Signal

Fig. 4- Colour coding for a 6 wires UTILCELL loadcell

2- Measure the output signal of each loadcell

To measure the analog signal in mV of each individual load cell we should have "at air", without connection, all output signal wires (Red +OUT and White –OUT), according Figure 5.

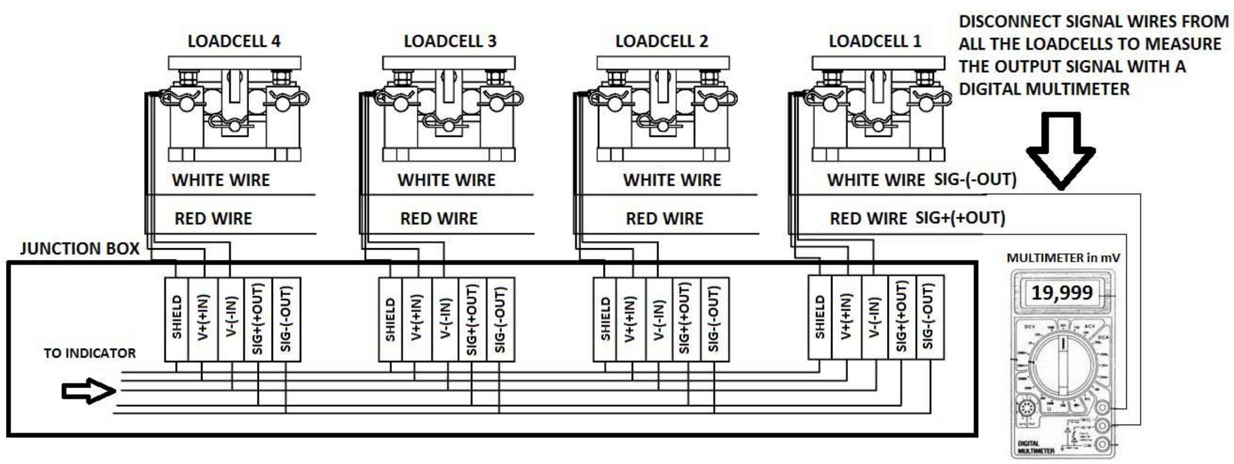


Fig. 5- Loadcell to junction box electrical connection and reading of the output signal in mV with a digital multimeter

We have to **measure the output signal from each loadcell in mV**, keeping in mind that **the silo** must be **loaded of product. Ideally loaded at full load, but in practice should be loaded at least over 30% of its maximum capacity**.

Load cell Number	Iteration 1 Signal in mV	Iteration 2 Signal in mV	Iteration 3 Signal in mV	Iteration 4 Signal in mV
1				
2				
3				
4				
Divide Major/Minor ≤ 1,3 ?				

Table 1- Load cell Output readings and leveling check

Read the output signal for each loadcell and write the results on Table 1.

Then calculate the ratio between major and minor signals and write in the bottom.

Maximum Signal difference between Loadcells = Major Loadcell signal / Minor Loadcell signal
This result should be ≤ 1,3.

3- Level the silo with metal shims

The silo should be leveled if the ratio between major and minor signals is bigger than 1,3.

We have to start leveling the load cell showing the minor output signal by placing metal shims between silo structure and load cell accessory as shown in Figure 2. There is no practical calculation to select the thickness of the shim, you should try starting with the thinnest shim and see its effect on the output signal (mV). Greater is the thickness greater will be signal effect.

Once we placed the shims we should make another output signal measurement iteration and verify the ratio of major and minor signal again. It is an iterative process of mearure, check leveling and compensate with shims, to signal differences lower than 30%, ratio major/minor lower than 1,3.

Before finish the leveling procedure we have to check if the loadcell that recives more load does not exceed to its nominal capacity at the full load of the silo. This is a very important section in checking leveling and so we ensure that the loadcells will *"enjoy good health"*, as will be operating within their normal working conditions (Nominal Capacity).

From Utilcell hope this technical note can be of help in making a leveling of silos, only as a guideline and not serve as a contractual specification. We reserve the right to change the content of this technical note at any time without previous notice.

Remaining at your disposal for any further information.