Industry Academia Knowledge Bridge: A case Study

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Abstract

Weighing mechanism is critical in any Industry. Error causing excess material shipped is loss to Industry. Less material shipped is loss to customer, leading to complaints, contract review and legal non compliance. Chemicals in this case are costly& corrosive. Reported complaints are erratic behavior of weighing balance because of mismatch in industry and customer readings, beyond tolerance. Complaints are responded by shipping the difference quantity. Small quantity shipments are risky, because of corrosive chemicals& results in Quality, Environment and Safety -QES risks. Deviation causes considered are Drift, aging, mechanical variations, moisture, wind, temperature, container variations, &human factor. The problem is variance attributes and multivariate analyses are non-conclusive. The relationship between drift, calibration errors and reported mismatch is non-conclusive. SMART incubation center, of Aadishakti Foundation has solved this problem, bytest setup validation and mismatch identification at industry and at customer end defining, mutually acceptable techno-commercial solution, QES guidelines for customer education. The case is based on primary data obtained from observations during the set-up validation &Techno-commercial solution, resulting in Academia-Industry Knowledge Bridge, by an intern. Improvements achieved are development of Standard Operating Procedure, acceptance norms, customer education, eliminating QES risk and complaints.

Key Words

QEMS risks, setup validation, Repeatability & Reproducibility- R & R studies, SMART incubation centre

1. Introduction

The Electronic indicator, reliable load cell with equilibrium correction, compensation for various errors and drift have made weighing easy. The weighing set up in the case, is validated by standard weights. Compensation results in reliable & accurate results. Compensation settings are protected by a password to ensure tamper proofing. Yet, complaints of erratic behaviour of weighing machine are reported as a problem. Since inception, number of successful projects related to problem solving, system development through ISO 9001, ISO 14001, ISO45001, ISO 27001, ISO 22001, SA 8001& ZED certifications; people, products and process improvisation are being executed for Industry, Academia, society and NGO, by Smart incubation centre of Aadishakti Foundation. The problem, although complex is taken up, to mentor the intern and build an Academia Industry Knowledge Bridge; thereby, reducing impact on safety and environment, thus also contributing to society.

2. Literature Review

Mismatch in weight in industry and at customer end is concluded as erratic readings. Not only the chemicals are costly and corrosive but are having high impact on human safety and environment. To minimise this concern, study is conducted. Firstly, study of specification of sensors & the response of the load cells, & various factors and their impact on sensor output is done. Factors identified in DFMEA in, Weighing Scale System are evaluated and test setup design validation, even then the erratic reading and mismatch continued. The weighing system under consideration has temperature and humidity compensation. At some customer end, same is not used, so temperature as well as humidity is recorded with weight. Yet unaware customers cannot interpret it and correction references may not use is one of the attribute for mismatch. Ambient variation is a vital factor and in Indian conditions, the temperature and humidity variation are considerable. The shipment time and geographic location causes temperature and humidity variation. Measurement Systems includes Sensors and Embedded System which is sensitive to voltage fluctuation, so impact of supply voltage and frequency variation &EMI, RFI, dust and water protection is studies. However, the effect of same on weight measurement system is not being shared with customer. Measurement system at customer's end is not having all these protections are also another mismatch attribute as per the researchers.

The data sheet for load cell, information of weights and measures for traders is studied in detail, to identify permissible error as all the measurement systems are not the same. Mismatch due to sensor accuracy difference is also studied. Factors affecting accuracy are reviewed for Weigh Bridge. Specifications and tolerances are reviewed and agreed with customer referring to National institute's standards handbook. Inconsistency caused by automation factors and SCADA system is referred to identify missing points during test setup validation, guidelines for customer education. Analogue to digital conversion errors based on similar studies for sensors and display are studied and added in Knowledge bank. The SCADA system development factors for weighing machines are referred. To identify the mismatch, due to measurement methods from various consumers, industry guidelines are studied for comparative references and shared with customer.

3. Method &Setup observations –

The study is based on primary data. It is related to test setup and measurements being conducted in Industry & customer's end. However Secondary data related to equipment manual, organisation guidelines, SOP – Standard Operating Procedures, check list are referred, as guidelines. The statistical error analysis and drift attributes are also used as reference.

Table 1: Quick check - calibration results with master

No	Calibration point -	Master readings -Kg	UCC reading
1	100	100.0201	0.1
2	200	199.9358	0.2
3	400	399.8525	0.3
4	500	499.923	0.5
5	1000	1000.3	1
6	2000	1999.8	2
7	3000	3000.1	3
8	5000	4999.93	5
9	10000	9994.999	10
10	15000	14994.499	14.99

UCC- Unit under Calibration

Table 1 shows errors after compensation by standard weight calibration in the industry. The difference is within defined tolerance. However, the same reading when done at customer's end, there is considerable mismatch, apparently having no compensation effect with the compensation. So, the researchers concluded, there are some other factors affecting the readings and leading to mismatch. The delivery time and location specific ambient condition causes difference in temperature and humidity. So, we decided to study the effect of temperature and humidity on weight. Onsite Experiments are conducted in client's presence, to make them aware about variation in weight due to ambient conditions.

Table 2 – Effect of moisture on container.

Container	Readings during Rainy season		Readings during Summer season		Difference in Kg
	Mean Weight - Ton	Number	Mean	Number of Readings	
A	37.35	5	37.02	5	330
B	36.34	10	36.57	10	170
C	16.42	5	16.29	5	130
D	16.37	10	16.29	10	80
E	14.66	5	14.50	5	110
F	14.63	10	14.52	10	110
G	12.20	5	12.14	5	80

Table 2 highlights the effect of moisture. Readings are taken during dry days and wet days at Rajasthan to identify the difference in the weights. The readings are monitored by our student to explain the moisture -humidity effect on the container, to the customer. Defining effect of Rh and temperature on the weights is agreed to help the correction hence on. These effects are compensated by a correction chart and recording the Rh value & temperature value on the weights, to educate the client for correction to be applied based on actual Rh and temperature reading during measurements at their sites. Customers are made aware of ambient effect and correction procedure. Similar to moisture drift, tests for temperature are also conducted, but simulation at site with variable temperature is not feasible. Yet, after training, customer agreed to revise the tolerance. The ambient variation with reference to temperature and humidity are calculated based on simulated condition in laboratory and correction, compensation table with help of simple program is made and given to them. Even after correction of temperature and humidity, the mismatch continued. It is explained to them certain test and simulations are impossible to be done at site like wind effect. Similarly, the wind effect compensation is also explained to them, by a well-accepted formula for wind drag:

Force = $\rho * C_D * A * V^2$
Where: ρ = air density,
C_D = a constant depending on aerodynamic shape of the object,
A = the "frontal" area of the object, and
V = the wind velocity vector.

All ambient variation attributes are defined, to define the permissible variation - tolerance. Also reading of weight are specifically linked to the actual moisture, temperature, &wind drift reading during the measurement. The correction charts are developed from such readings. Developing & sharing the reference tables, for compensation and corrections, with customer, resulted in knowledge bank. It is noticed, even after all above consideration, the mismatch continued. The mismatch with industry and customer end has many attributes. Without resolving this and educating the customer, resulted in the Industry losing some customers, although short supply is compensated by small quantity shipped separately. Site specific action plan for customer education to get minimum mismatch is defined. Action plan to develop the Standard Operating Process - SOP of test set up validation is developed, considering all possible variation, drifts and possible reasons for mismatch, to agree on mutually acceptable solution. The experiments and standardisation has resulted in a knowledge bank, yet not completely solved the problem. To solve the complaint following action plan is defined.

Table 3: Action plan for improvisation and implementation of solution

No.	Activity	By	Date of action	Performance Indicator
1	Identify causes of mismatch, through set up validation &related factors as per check list	CFT	30 April 2017	Check list and setup validation and ambient correction training to client
2	Isolate load fluctuation leading to supply voltage & frequency fluctuations and other ambient effects and drifts & errors.	Swapnil	30-May17	Control transformer installation, where feasible or else allow the correction and review the tolerance
3	Define better layout for small quantity, with distinct location and design of container for different reagents to avoid possible cross-containment.	Swapnil	30-May -17	Layout revision guidelines
4.	Validate the solution and educate the customer and agree the acceptance norms	Marketing team	Ongoing	Contract review, customer satisfaction, records

Small quantity shipments for corrosive liquid are the main environment and safety concern, leading to QES risks arising from mismatched readings. The agreed norm with customer is permissible error up to 500Kg per truck load, which is without considering all ambient conditions and all geographical locations and all test setup. Based on the test setup and measurement facilities, tolerance has to be further redefined. Tolerance is going to be customer specific requirement based on setup validation, repeatability and reproducibility errors, drift and ambient effect specific to site. Such deviation attributes studies are conducted for all categories, and solutions for each is worked out to define optimum feasible tolerance. Any mismatch beyond agreed tolerance has to be considered as due deviation for compensation. It is agreed, the mismatch beyond tolerance has to be compensated commercially and not by material shipment.

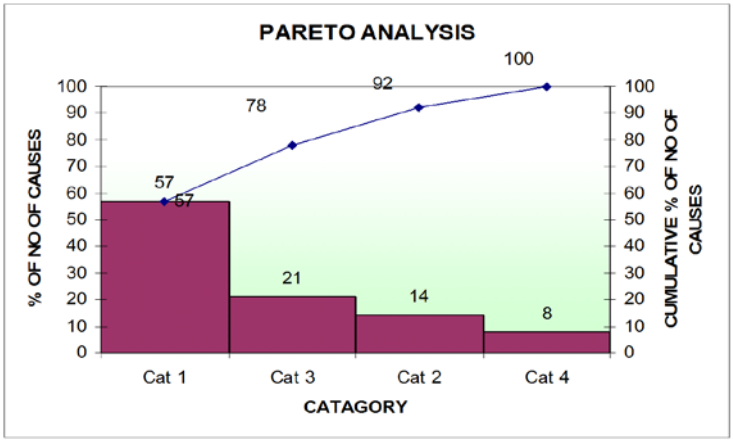

Figure 1: Attribute analysis Pareto showing the Impact

Category 1 shows effect of Position and location of the container on bridge – location of the container affects the weight deviation. Same is demonstrated to customer. Importance of gadget that marks location for the optimal reading is explained to them, minimising variation due to operator, as a part of test setup validation. Operators training and positioning gadget to optimise the performance is the solution for this concern, which is explained to all. Category 3 shows effect of supply fluctuation, due to voltage. Solution for these attribute is to install stabiliser, control transformer, and NEMA enclosure if feasible for minimising power supply. This effect is also simulated and explained to customer. Category 2 shows effect of ambient variation, such as temperature, moisture, wind. Based on correction chart and programs, this variation is minimised. Category 4 shows unknown factors due to measurement uncertainty & handling losses. Measurement uncertainty is considered as unavoidable. Deviations due to handling losses during samples taken, movement, leakage, cross contamination and chemical nature, are avoided by a lab with recommended layout and practice.

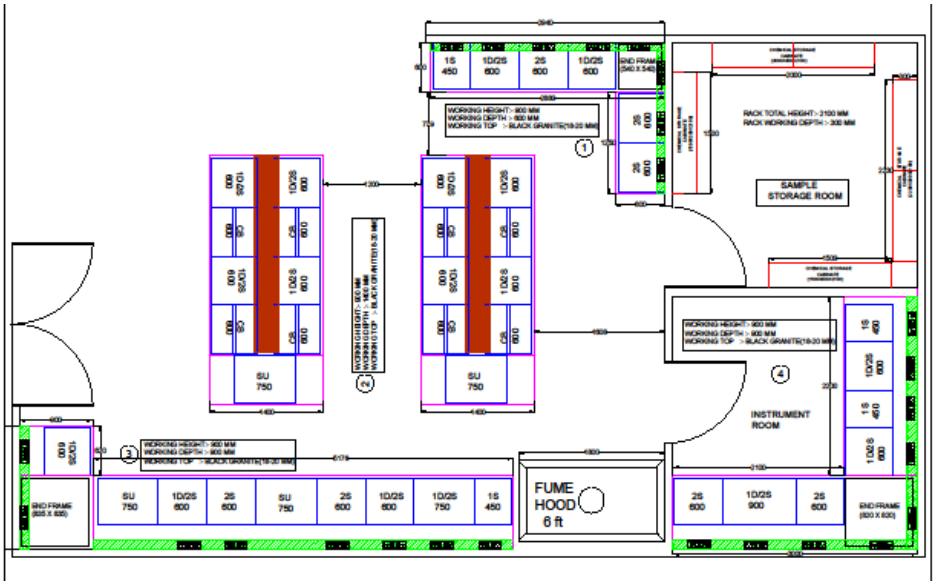

Figure 2: Recommended layout to minimise handling losses & avoid cross contamination

At site, quick check lab, with proper layout should be established, so recommended layout for lab at site is made and shared with site team. The layout for lab setup is important, as the time for which the container is kept open, and sampling quantity and tests taken create losses, if proper layout and handling precautions are not taken.

Table 4 – Summary of Variation

Variation from	Magnitude (kg)	Assumption (based on a Bailey Bridge truck) configuration)
Repeatability	40	
Loading point	40	
Mud other	40	
Wind	20	Assuming 28 km/hr (15knots)
Fuel	20	The weight difference between the two weightings.
Removable	80	Tools, chains, spare tire, etc.
Driver	40	Assuming average size driver in the truck during gross weighing and not for the tare weight.
Drift	250	Adrift due to time, temperature, humidity, etc.
Total	550	

Table 4 provides a summary of the different types of variation, if the customer is doing measurements with bridge and loading the truck itself. Mechanical variations, effect of position of the test barrel or loads, effect of mud, are controlled by proper maintenance. A detail check list and clean up and operating process becomes essential for the customer education.

4. Discussions and Solution

It is unlikely that all of the sources of variation affect the reading at one time. In fact, it is likely that some effect even cancels each other. The possible sources of variation that can affect weight readings from weighbridges, at customer's end also results in mismatch. Considering sources of mismatch, the acceptance criteria, is defined, to solve the mismatch complaint. Customer specified permissible tolerances & acceptance norms, minimised customer complaints. Discussions with QES MR and customer representative are organised to develop customer specific norms. Clips for loading, weighing SOP - Standard Operating Procedures, &Gadgets for consistent position of container during weighing are shared. It is agreed; the sources of variation are minimized by designing and maintaining the weighbridge correctly and by following well designed procedures for the operating and checking of a weighbridge, validating the test setup.

Training is organised for educating the customer for right method of weighing, methods for bridge loading and the test setup validation using the Standard Operating Procedures - SOP video clips along with Repeatability & Reproducibility– R&R study. The acceptance criteria and importance of agreeing on tolerances and documenting it, specific to customer, with due consideration to the equipment, ambient conditions is also explained. After the training, customer has agreed to redefine the tolerance. The QES risks of small quantity shipment, are also explained to customer. Customer accepted to waive the difference shipments & short close the order by commercial compensation is better than shipping small quantity at risk of human safety and environment. In brief complying to ISO 9001:2015, 14001:2015 and 45001:2018 by eliminating the risk also led to sustaining the compliance by developing the guidelines.

Table 5: Before and after comparison

Point	Before	After
Time	300 Second per Loading & testing	5 Sec. with gadget
Wastage	23736 rupees per year	Nil
Complaints	More than 12 per year	Nil
Risk – incidence of burning	14	Nil
Environment – spillage incidences	57	Nil

Quality Improvements as per ISO 9001:2015 guidelines for weighing process are developed. The Standard Operating Procedure -SOP and checklist typically the Lean Laboratory Checklist is also reviewed to identify the mismatch attributes for improvisation. The techno-commercial solution of deducting the money &not shipping the short-supplied quantity has eliminated QES risks. The considerable improvement in environment and safety is observed over a month as detailed in table 5. After explaining the results of this pilot project, most of the

customers agreed to follow the SOP and checklists. The customer appreciated it and agreed to review the acceptance norms. The solution is techno-commercial and resulted in knowledge bank and QES system improvements. This eliminated all the risks and non-compliances and converted the complaints to customer delight.

5. Conclusions

In brief this study resulted in a knowledge bank, and knowledge build for the industry and customer. This eliminated quantity mismatch complaints and noncompliance in contract review, & QES risks. Simple technique like setup validation, agreeing on acceptance standards, Repeatability & Reproducibility study, customer education, risk mitigation by SOP development is proven very effective. With help of trained student, a complex problem having negative impact on organisational image, legal, safety and environment concern is solved. Role of the intern is to carryout studies for multiple observations and data collection to identify root causes. The intern has also developed the knowledge bank & shared it during training to convince the customer& educating the customer for the various mismatch attributes to help them in refining the acceptance norms. The solution eliminated the QES risks associated with the complaint resolution by small quantity shipment.

Carrying out experiments at site and various locations is very difficult by the industry staff, due to production pressure. Knowledge built, such as dedicated SOPs - Standard Operating Procedures development and process design and validation are contribution of trained student & academia with mentoring. This is feasible due to better research acumen and lack of production targets. In brief all three student, Industry and Mentors have together contributed to resolve the problem and ensure system compliance. Such Industry Academia knowledge bridge is proven very effective to solve a complex problem.

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