The Unknown Sources of Error in the Weighing Process

Why Read This White Paper?

What can go wrong when weighting a sample in a typical GxP regulated or a food and beverage laboratory? This white paper looks at potential sources of error that could occur when weighing a sample and how to avoid them by improving the business process. In taking these approaches a laboratory can eliminate sources of error to improve data integrity and quality whilst at the same time gaining business efficiency. In addition, elimination of errors means that out-of-specification (OOS) results are reduced meaning that fewer laboratory investigations are necessary.
Intended Audience

This white paper is addressed to analytical scientists and quality assurance professionals working in laboratories
in either the regulated healthcare or food and beverage industries.

Why is this White Paper Important?

Analytical balances are at the heart of virtually all quantitative analysis that occurs in regulated and unregulated
laboratories. Accurate weighing and data integrity are essential in the preparation of analytical reference solu-
tions, as well as in taking aliquots of samples for analysis and preparation of solutions, buffers, and HPLC mobile
phases. Errors in this process can have profound impacts on data integrity and product quality. The aim of this
white paper is to highlight ways to avoid some of the more common errors and save time when carrying out
weighing operations.

The Way We Are Now

In this section we will look at how an analytical balance is used for common weighing operations and highlight
where potential errors and problems might occur.

Let us look at the instruments, tools, and the process that we will discuss.

The process described here is the preparation of an analytical reference standard solution by weighing an amount
of a reference standard, transferring it to a volumetric flask, dissolving it and making up to volume. This is a typi-
cal use of an analytical balance in all laboratories involved in quantitative analysis.

This will be achieved, depending on the way the process is performed, by using some of the following items:

- Analytical balance with or without a thermic printer attached
- Laboratory notebook for recording the work and summarizing the results
- Calculator or spreadsheet for calculating the concentration of reference standard after adjustment for factors
  such as purity or conversion from salt form to base weight.
- LabX Laboratory software used to automate the process and record the results directly in the application’s data-
  base. The software will be operated using the screen on the balance and work will be tracked by the audit trail
  in the software. Finally, reports will be signed electronically with an option to print the report if required.

Process Flow Figures Explained

Figures 1-3 in this white paper are cross-functional process maps or “swimming lanes.” Each of the lanes repre-
sents the work carried out by an item in the list above, for example the analytical balance, spreadsheet, LabX, or
a laboratory notebook. Activities occur in the lane for that item, e.g. weigh an external mass or tare the weighing
vessel for the balance. Where the process crosses from one lane to another it represents an interaction between
two parts of the process, e.g. weigh a sample on the balance and record the observed balance weight in a labo-
ratory notebook. The overall time for the process starts at the top of the figure and ends at the bottom.

Overview of the Weighing Processes

The three processes described in this white paper refer to the preparation of an analytical reference standard.
The processes all assume that there is a standard operating procedure or work instruction for the preparation of
a nominal concentration of reference standard and therefore the amount of reference material to be weighed is known. The instructions will typically describe that an amount to be weighed must be within a range of acceptable values. Once the weight of the standard is known an analyst will then calculate the actual concentration as opposed to the nominal concentration of the solution.

If there are no instructions available, then an analytical scientist is required to prepare a reference solution from first principles. In this case an additional calculation step is required to determine the amount of standard to be weighed and the volume that the substance must be dissolved in. This is not included in the three process flows but it would take more time than presented in Table 1.

The processes also describe a vessel in which the reference standard is weighed. This can be a weighing boat or directly into a volumetric flask depending on the working practices of an individual laboratory.

**Process 1: Weighing and Recording by Observation**

Shown in Figure 1, below, is the process flow for weighing the reference standard where the values are recorded by observation from the balance screen and written into a laboratory notebook by an analyst. The subsequent calculations are performed using a hand-held calculator with the results also written directly into the analyst’s laboratory notebook. The volumetric flask is labeled by hand to identify the solution, preparation information, and the expiry date of the solution.

The process begins by writing up the work to be done in the laboratory notebook and checking that the correct reference standard to be prepared has been selected. Next the balance is checked with an external calibration mass. The balance and calibration standards used are recorded in the lab notebook by the analyst. Then the weighing vessel is weighed and the balance tared.

The reference material is weighed on the analytical balance and the reading on the screen is observed and recorded in the lab notebook by the analyst.

When completed, the vessel is removed and the balance is cleaned and tidied ready for the next user. The reference material is transferred to the appropriate size volumetric flask and liquid added to prepare the reference solution. Then the flask is inverted to dissolve the analyte and then made up to volume.

The flask is labeled by hand with the standard identification number, substance information, calculated concentration, analyst who prepared the solution, storage conditions, and the dates of preparation and expiry.

The analyst uses any factors such as purity or water content to calculate the actual concentration of the reference standard solution. The calculations and conversion factors used are recorded in the lab notebook. The calculation...
is performed using a hand-held calculator; the analyst reads the final value from the calculator display and transcribes it into their lab notebook.

The analyst checks the data and results, including repeating the hand-held calculation, and if correct signs the relevant pages of the lab notebook.

If there any deviations from the procedure or instructions, the analyst must record them in their laboratory notebook.

A second person reviews the data and procedure to confirm that all data are correct and then signs to approve the work. If there are any corrections, the first analyst will do this and return for approval.

**Manual Process and Multiple Transcription Error Checks**

Looking at Figure 1 it is apparent that the whole process is manual:

- Manual recording of data;
- Manual calculation of data using the handheld calculator;
- Manual checking of the data.

Owing to the manual nature of the process it will be tedious to operate and error-prone. Let us examine in more detail some of the key areas where errors could occur.

**Transcribing Data and Transcription Error Checking are Error-prone:** Quality standards (e.g. ISO 17025) and pharmaceutical industry regulations use the four eyes principle when performing work: one person performs the work and a second independent person reviews it. This principle is based on the idea that four eyes are better than two. However, as the process is performed by humans it is error-prone in its own right. So this manual process is not perfect and typographical errors could be missed in the second person review, especially if the individual is under pressure with other tasks to perform.

**Lack of a Data Audit Trail:** In essence there is no paper audit trail; this process relies on the ability of the analyst performing the work to accurately record the values displayed on the balance and calculator, and transcribe these results into the laboratory notebook without error. Only the calculator result can be replicated by keying in the data and performing the calculation again. Unfortunately, as the process is operated by humans, even highly trained humans, it is subject to errors. What the brain thinks it has seen and recorded may not be the actual value on the balance or calculator. The second person cannot check the actual balance reading, which is the major failure point of this process.

**Failure to Meet GxP Regulatory Requirements:** For laboratories that must comply with GxP regulations it is important to have records or documented evidence that can be checked by a second person and is also available for inspection. The method of working described in Figure 1 is unacceptable to FDA inspectors, as noted by this warning letter citation:

> Your firm failed to ensure that laboratory records included complete data derived from all tests necessary to assure compliance with established specifications and standards (21 CFR 211.194(a)). For example, your firm did not retain any raw data related to sample weights and sample solution preparations for the HPLC assays of <redacted> tablet batches <redacted> and <redacted> that you conducted on July 18, 2012.


The major issue is that the balance result cannot be verified – in fact the analyst could just write down anything and say the work was performed. Over 20 years ago the FDA advised their inspectors when looking at weighing results from analytical balances and preparation of standard solutions:
Carefully examine and evaluate laboratory logs, worksheets and other records containing the raw data such as weighings, dilutions, the condition of instruments, and calculations. Note whether raw data are missing, if records have been rewritten, or if correction fluid has been used to conceal errors. Results should not be changed without explanation. Cross reference the data that has been corrected to authenticate it. [Ref 1]

Review records of standard solution preparation to assure complete and accurate documentation. It is highly unlikely that a firm can “accurately and consistently weigh” to the same microgram. Therefore data showing this level of standardization or pattern is suspect and should be carefully investigated. [Ref 2]

Therefore, to comply with GxP regulations and avoid intimidating questions from an inspector, a regulated laboratory needs to have a printer attached to the balance to record the weights of reference standards and samples in the course of analysis. The advantages of this approach from regulatory compliance and laboratory efficiency perspectives will be reviewed in the next section.

The Way We Could Be

To help eliminate sources of error the process needs to be automated. Here there are two alternatives that we will discuss in this white paper:

1. Using a thermic technology printer attached to the analytical balance. The remaining items used are the same as in the previous section. Although the process is still manual there are records available that can be independently checked by a second person. Thermic technology can print both thermic and normal paper labels. The major advantage of thermic paper is that it is very stable and has high resistance to plasticizers, oil, fat, and water. This makes it more robust than paper and allows for an archive time of 25 years. In addition the printer is very fast, very quiet and, if required, can also be used in a clean environment as it does not produce any airborne dust, unlike paper printers.

2. Using LabX to convert a manual process to an electronic one. The application is configured once to prepare reference standards and perform the requisite calculations. To aid compliance, all user actions are recorded in the audit trail and electronic signatures are used by the analyst and a second individual to review and approve the results. This makes the process fully electronic and has all data in a single location.

Process 2: Weighing with a Printer attached to the Balance

In this process, shown in Figure 2, the main changes are the addition of a thermic printer to record results contemporaneously from the printer, and the substitution of a validated spreadsheet for the handheld calculator. This allows the process to be more efficient but, more importantly, less error-prone than process 1 with the added bonus of a regulatory or quality paper trail.

In the same way as the first process started, the lab notebook is written up for the work to be performed and the correct reference standard is selected.

Next, the balance is checked and the weighing vessel is weighed and tared. The values are printed out on the printer together with the date and time of the activity.

Then the reference standard is weighed on the analytical balance and the reading is recorded on the printout. Adding the printer avoids the need for the analyst to record this information in the lab notebook.
When completed, the vessel is removed and the balance is cleaned and tidied ready for the next user. The reference material is transferred to the appropriate size volumetric flask and the standard solution prepared. The balance can print a label for the reference solution containing all quality and regulatory information to save the analyst performing this task manually.

The balance printout is removed and the analyst inputs the actual weight of the reference substance into the spreadsheet together with any correction factors such as purity or salt to base conversion to calculate the concentration of the reference standard solution automatically. The spreadsheet is then printed out and the analyst pastes the balance and the spreadsheet printouts into the lab notebook.

The analyst checks the data and results. This check is more complete than process 1 as all the data are available on the two printouts. The calculation need not be repeated or verified as the spreadsheet is validated. Once the data checks show the data are correct, the analyst signs the relevant pages of the lab notebook.

The second person review becomes more relevant as there is now a complete data trail to follow and demonstrate that the procedure was followed and that all data are correct. The reviewer signs the lab notebook. This second person check is faster than the previous process as there are no hand-held calculations to be performed.

Process Improvements

As seen in Figure 2, there are a number of improvements that are apparent in the new process over that shown in the manual process of Figure 1:

**Data Integrity:** The integrity of the data generated in this process has improved: the original weighing results are available on the balance printout together with the date/time and the name of the analyst.

**Paper Audit Trail:** As a consequence of improved data integrity the audit trail is complete, as the original results can be traced from the balance printout to the spreadsheet for calculation of the standard concentration.

**Error Reduction:** Transcription errors from the balance and calculator readings have been eliminated by the use of the balance printer.

**Improved Speed of Process:** Manual calculations by the analyst and the reviewer have been eliminated, with the spreadsheet speeding up this part of the process. Second person review of the data is quicker and more meaningful as there is a complete audit trail of data.

**Process Meets Regulatory Expectations:** Use of the balance printer enables improved data quality and permits an audit trail of data from the weighing of the reference standard to the calculation of solution concentration. This allows a regulated laboratory to meet GxP expectations [Ref 1, 2] and avoids the warning letter citation shown in the last section.
Disadvantages of the Process

Despite the improvements there are still parts of the process where errors can occur and further optimization of the process is possible.

Manual Data Entry to the Spreadsheet: Transcription error checking is not eliminated as the balance result and any conversion factors have to be entered into the spreadsheet. These figures must be checked by the analyst and the reviewer to ensure that they are correct.

Paper Based Process: As Figure 2 makes apparent, the process is paper based. There are two printouts that are produced and pasted into the laboratory notebook to form the analytical record. This, together with the preparation and summary of the work that needs to be written by the analyst, results in a slow process.

To improve the process further and to eliminate the transcription check we need to consider working electronically, as we shall see when we look at Process 3 in the next section.

Process 3: Weighing Using LabX Server Software

In this process the lab notebook, the spreadsheet and the associated printouts have all been replaced by METTLER TOLEDO’s LabX software. The LabX software has the technical controls for ensuring data integrity to comply with GxP regulations for electronic records and electronic signatures [Refs 3, 4]. However, the function of more importance to regulated and non-regulated laboratories alike is the ability to sign records electronically. Whilst a non-regulated laboratory is not concerned about compliance with pharmaceutical industry regulations, cost-consciousness and improvements to analytical laboratory processes are still relevant topics, and this is where LabX software can help.

Implementing LabX allows the process to be made fully electronic. It eliminates the last source of transcription error, improves data integrity and quality, speeds up the overall process, and reduces time needed to perform a task.

LabX is a configurable software application and the SOP for preparing a standard solution can be incorporated in an electronic process and validated, thus enforcing compliance with the written procedure.

The LabX electronic process starts by the analyst selecting the reference standard to weigh and then logging onto LabX at the terminal of the analytical balance. There is no need to log onto a separate workstation to access LabX.

Balance checks must be performed if prompted by LabX. Otherwise the analyst takes the weighing vessel and tares the boat, then weighs the reference material.
No results are recorded by the analyst as LabX does all the work: actions and weights are recorded in the database against the user’s identity, together with a time and date stamp.

Dissolving of the reference material in the volumetric flask and making up to volume is carried out by the analyst. A printer attached to LabX can produce a label for the volumetric flask containing the requisite quality or regulatory information such as identity, concentration, expiry date, etc.

When complete, the validated process simply needs the analyst to electronically sign what has been done.

The reviewer’s tasks in an electronic system are greatly simplified as the process is enforced by the software. No checks for transcription or calculation errors are required, as the whole process and records are held within a single system. Once the data are checked they can be electronically signed.

There is an option to print out the record, although this is not strictly necessary unless required by local procedures or practices.

Advantages of the Electronic Process

There are a number of advantages to the electronic process shown in Figure 3:

**Elimination of Manual Data Entry:** There is no manual data entry in the process; all data are captured via LabX server.

**Elimination of Transcription Errors:** All transcription errors have been eliminated, which improves on the situation with the other two processes shown in Figure 1 and Figure 2. Now there is a single process controlled by LabX with automatic data capture that eliminates any human recording of data. The analyst can focus on scientific work rather than clerical tasks.

**Single System Log-On:** Interfacing an analytical balance to LabX turns its display screen into a terminal for interaction with the software. A user logs on to the system via the balance screen rather than at a separate workstation; no separate terminal is necessary for operating LabX.

**Fast, Efficient Process:** The electronic process is faster than the paper based ones and therefore saves laboratory time and effort.

Barcoding to Eliminate More Manual Data Entry

METTLER TOLEDO’s new P-58 printer is capable of printing various symbology (e.g. code 128, QR, 2D, etc.) barcoded labels that can be affixed to the containers of analytical reference substances to identify them uniquely. Balances with a barcode reader can scan the label and input the identity of the compound automatically, thus avoiding manual data entry as well as accelerating the process. Other commonly used samples for weighing can be labeled likewise to avoid manual entry of data. Using bar codes in this way eliminates another source or error in the process.

Comparison and Summary of the Three Ways of Working

Table 1 shows a comparison of activities performed in the three processes and the time taken to perform each one. This illustrates the benefits of process optimization through using either a balance printer or LabX to reduce errors and ensure data integrity. As can also be seen in Table 1 there are substantial time savings to be achieved as well. Moving from a purely manual process to one where a thermic printer records the activities results in a 25% gain in productivity. However, moving from a manual to an electronic process increases productivity by
194% for each weighing. Even if a laboratory already has a printer, converting to an electronic process with LabX still brings a productivity gain of 135%.

What do these figures mean in practice? As weighing on an analytical balance is a very common activity, let us examine their implications for a relatively small laboratory with a staff of 10 analysts. If each analyst makes 1,000 weighings per year (reference standards, samples, control samples and preparation of buffers and mobile phases) or between 4 and 5 per working day, then there will be 10,000 weighings per annum throughout the laboratory. Using the timing figures from Table 1, we can calculate the total time spent on weighing operations in this laboratory as shown in Table 2. The first row of Table 2 outlines the total time spent on weighing in the laboratory; it is calculated by multiplying the time for the operation from Table 1, converting this to days and dividing by 220 days available per year for working in the laboratory. The result of the calculation is expressed as FTE or Full Time Equivalent. The reason for choosing FTE to present the saving is that any laboratory in any country can read and understand the time taken and also the potential savings to be gained from improving the process.

Table 1: Comparison of Timings for the Three Processes

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<tr>
<td>Prepare lab notebook for work</td>
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<tr>
<td>Log on via balance screen</td>
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<tr>
<td>Check balance function and tare vessel</td>
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<tr>
<td>Document check in lab notebook</td>
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<tr>
<td>Weigh reference standard</td>
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<tr>
<td>Record value in lab notebook</td>
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<td>•</td>
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<tr>
<td>Remove vessel and tidy balance</td>
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<td>•</td>
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<tr>
<td>Paste printout into lab notebook</td>
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<tr>
<td>Calculate concentration manually</td>
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<tr>
<td>Enter values to spreadsheet</td>
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<tr>
<td>Calculate results in spreadsheet and print</td>
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<tr>
<td>Paste spreadsheet printout into lab notebook</td>
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<tr>
<td>Check work and analyst signs lab notebook</td>
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<tr>
<td>Second person check of work</td>
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<tr>
<td>Correction of any mistakes</td>
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<tr>
<td>Second person signs the lab notebook</td>
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<tr>
<td>Automatic calculation of results</td>
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<tr>
<td>Analyst electronically signs the report</td>
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<tr>
<td>Second person checks the work</td>
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<tr>
<td>Second person electronically signs the report</td>
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*Overall Time for the Process* 25 min. 20 min. 8.5 min.

Note: *Verified in internal lab tests.

Table 2: Calculated Time Spent on Weighing Operations in a Laboratory

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<tbody>
<tr>
<td>Total Time Spent on Laboratory Weighing</td>
<td>0.79 FTE</td>
<td>0.63 FTE</td>
<td>0.27 FTE</td>
</tr>
<tr>
<td>Saving with changed process (per annum)</td>
<td>0</td>
<td>0.16 FTE</td>
<td>0.52 FTE</td>
</tr>
<tr>
<td>Percentage process improvement over baseline process</td>
<td>Baseline</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Baseline</td>
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Baseline 194% Baseline 134%
As can be seen from Table 2, whilst small productivity improvements can be made with the addition of a printer, the most productivity gain is achieved when moving to an electronic process. In our example, the electronic process can save half a person per year continually, compared to the manual process without a printer. These gains are in addition to the benefit of error reduction that we discussed earlier.

This white paper has deliberately chosen to base productivity and time improvements using a relatively small laboratory as an example. For larger laboratories with more personnel or where more weighings per analyst are performed, then the time and productivity savings will be much bigger.

For GxP regulated laboratories, there is always the need to validate the software before use. The cost of computer validation on the overall cost savings is discussed later.

Table 3 compares the error reduction and quality improvement from the manual process to the electronic process using LabX. One of the key points expressed by the table is a reduction of errors made in the laboratory. However, this is a subjective statement. What we need to do is compare studies that have looked at error rates in laboratories. Papers on how often we make mistakes in an analytical laboratory are hard to find. Help is at hand from clinical chemists working in hospitals who have published many studies on this subject. Clinical chemistry is involved in the analysis of human blood, urine and tissues to assist diagnosis and management of diseases. Mistakes in this area can critically impact the health of a patient, so reducing errors is essential.

One paper, entitled The Blunder Rate in Clinical Chemistry, measured the rate of detected analytical errors before and after the introduction of a Laboratory Information Management System (LIMS). This was reduced from about 5% to less than 0.3% after implementation of the computer system [Ref 7].

Manual transcription errors in patient blood results recorded in a critical care setting by comparing the handwritten and printed laboratory results in 100 consecutive patients in the intensive care unit of a UK hospital. Out of 4664 individual values, 67.6% were complete and accurate, 23.6% were not transcribed at all, and 8.8% were inaccurate transcriptions of the results. Interestingly, this study found that the most accurate work was performed in the morning [Ref 8].

The first study shows that the overall impact of automating a process results in a 10-fold reduction in input errors to a LIMS. The second shows that when personnel are under pressure, as in an intensive care facility, then
the error rate increases. Therefore, in a laboratory with a manual process the checking needs to be performed
diligently to ensure that as many errors as possible are caught and corrected.

Therefore taking the principles described above, LabX, an instrument control software application, can be used
to automate weighing process as described earlier and eliminate many data input errors.

Validation of an Electronic Process

Software used in GxP regulated laboratories must be validated for its intended use. To help, there are guidance
documents available such as the Good Automated Manufacturing Practice (GAMP) version 5 guidelines [Ref 5] and the GAMP Good Practice Guide entitled “A Risk-based Approach to Compliant Laboratory Computerized Sys-
tems” [Ref 6]. However, in regulated laboratories there is often a fear that computer validation is a slow, labori-
ous, burdensome, paper process.

If a risk-based approach is taken for validation, then these fears should not occur. Validation of LabX can use a
simpler life cycle for configurable software, and most of the testing effort should be focused on the configured
process rather than the basic application. If this is true, then the effort of validating software needs to be put in
context with the daily savings gained by use of the software throughout the laboratory. The principle of “validate
once and use multiple times” holds here.

Furthermore, computer systems validation should be viewed as a benefit rather than a cost. The time saving with
using a validated electronic process far outweighs the one-time cost to validate the application. Therefore, the
time saved increases the period in which personnel can focus on more productive tasks in the laboratory.

An educated estimate of the time to validate the whole of LabX is between 20 and 40 days. However, this time
embraces the whole system inclusive of other processes configured for different instruments and other balance
processes. However, let us assume that LabX is only to be used for weighing reference substances and prepar-
ing solutions as outlined in process 3. Even in the worst case of 40 days to complete the validation of a single
process, this equates to 0.18 FTE. The time saved by using an electronic process as calculated in Table 2 is
0.27 FTE. This means that in the first year, the laboratory still saves at least 0.09 FTE and 0.27 FTE per year
thereafter. If the computer system validation is quicker and takes less time, then greater savings are obtained.
As noted above, this is a small laboratory; for a larger laboratory the relative savings will be much bigger, with
the same validation costs.

Analytical Balances with Radio Frequency Identification

To help laboratories improve efficiency and eliminate mistakes, the Excellence Plus range of analytical balances
may be fitted with an RFID reader on the side of the balance. This can assist with automating tasks and improv-
ing their efficiency. We will look at two applications of this combination: pipette calibration and titration.

Pipette Calibration with RFID

The last Friday of the month in a regulated laboratory is pipette calibration day! Analysts responsible for pipette
calibration will stop normal work and start their pipette calibration checks. Typically this process involves weighing multiple aliquots of water over the operating range of the pipette, e.g. a 200µL pipette will be checked with between 6 and 10 replicate measurements at 20µL and 200µL (top and bottom of the operating range) or possibly at 20 µL, 100 µL, and 200 µL depending on the procedures in place at a specific laboratory. The mean and RSD of weights at each volume will be calculated and compared with the specification for the individual
pipette to determine if it passes or fails. The printouts and the calculations will be written up in the analyst’s laboratory notebook and the printouts from the balance pasted into the notebook; then the pages will be checked and approved by a second person.

This process is relatively slow, manual, and requires calculations either by a validated spreadsheet where the individual weights are manually input, or using a hand-held calculator. The input values need to be checked by a second person for transcription or calculation errors, again slowing the process.

How can we help automate this process and reduce errors at the same time?

The answer is in two parts.

1. Each pipette must be identified by an RFID chip. This can be achieved either by purchasing a new pipette that contains an embedded RFID chip, or by retrofitting existing pipettes with a label incorporating an RFID chip that transmits a unique identity and other information. Using the RFID reader on the balance, this information can be transferred from the pipette to the balance to connect the identity with the calibration readings. This now eliminates a potential source of error and allows positive, unambiguous identification of each pipette being calibrated.

2. The Excellence Plus range of analytical balances has a pipette check application called QuickCheck. Pipette identities, serial numbers, calibration ranges with tolerances and due dates are entered into the balance memory; when a check is due a user can be prompted to perform a calibration.

**RFID and Titration**

A second area where RFID technology will help with reducing errors is in titration. A beaker used for titration has an RFID chip embedded in its base which can be used to positively identify a sample as well as transfer data between an analytical balance and a titrator. For example, the sample information and weight can be transferred from the balance via the RFID chip and imported into the titrator for incorporation in the analysis record and calculations for the reportable result. This process can save manual recording of the balance weight as it is recorded in the beaker RFID chip.

Using RFID chips in this way automates a wet chemistry analysis that traditionally has been very manual. This has the advantages of error reduction and, at the same time, improving data quality and efficiency.
Conclusion

This white paper has focused on reduction of errors, improving data integrity and quality, and laboratory efficiency when using an analytical balance. Starting with a purely manual process we have seen the problems that can occur and the issue of traceability due to a lack of documented evidence. With the addition of a printer, errors can be reduced, data integrity and compliance raised, and some improvements in laboratory efficiency accomplished. For the greatest productivity improvements and best data integrity, an electronic process with on-line data capture, data processing plus review and approvals using electronic signatures is recommended.

Technology using Radio Frequency Identification (RFID) also enables the new range of Excellence Plus analytical balances to improve traceability and integrity of data whilst increasing productivity for pipette calibration and titration analysis.
References

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9. Current Good Manufacturing Practice for Finished Pharmaceutical Products 21 CFR 211.68(b)