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POOR ANALYTICAL SYSTEMS CAUSES, CONSEQUENCES AND COSTS

BACKGROUND

In the past five years every Wysowl manufacturing and processing plant client has identified significant weaknesses in their analytical processes. Not some of them; all of them. Clients as varied as metallurgical, cement and petrochemical plants as well as pharmaceutical operations are included. In several cases analytical error has been halved or better.

WHY BOTHER?

The operations are the customer of the laboratory. The lower the analytical error, the better people in operations are able to understand and control operations. Nevertheless, in recent years every laboratory studied has had significant problems with higher analytical error than was necessary. All too often, this leads to problems in the production areas and an attendant increase in costs.

This is a principal reason we should be concerned about analytical error. Unnecessary variation in assay results lead to poorer process control and higher costs. Another reason for concern is that metallurgists, biologists, chemists, engineers and other technical people cannot do good science if their data are poor. When technical people can't do good science, we can expect process control to be suboptimal and for costs to rise.

PRINCIPAL ISSUES

Four common issues have been found. Nearly every analytical system studied had at least two of these issues present. Many had three or all of them. They are not rare; they are the norm.

Unstable assays. The first issue is unstable assays, as demonstrated in the laboratory controls. There is no basis for prediction without reasonable stability. This means the operations folk can never know the degree of confidence they pay place in the assay results.

High between analyst and between shift variation. This problem is almost universal. It has been the single biggest and most common cause of instability in the assays investigated, as well as the single biggest cause of unnecessary analytical error.

Corrupted or falsified data. This problem, whilst not as common as between analyst variation, destroys any confidence one can have in the data.

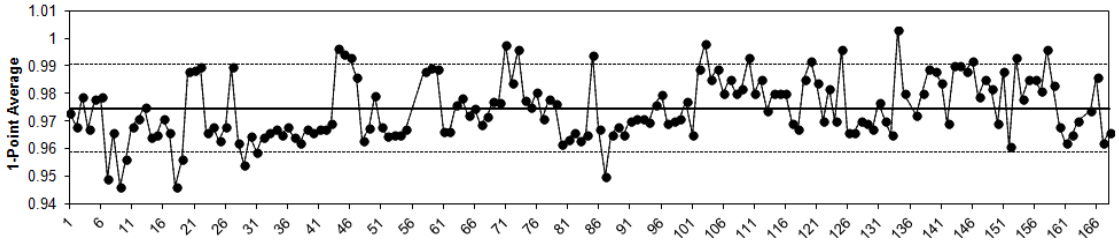
High sampling error. This is another very common issue. Although sampling is not part of laboratory work, it is included here because it is an integral part of the analytical process.

UNSTABLE ASSAYS

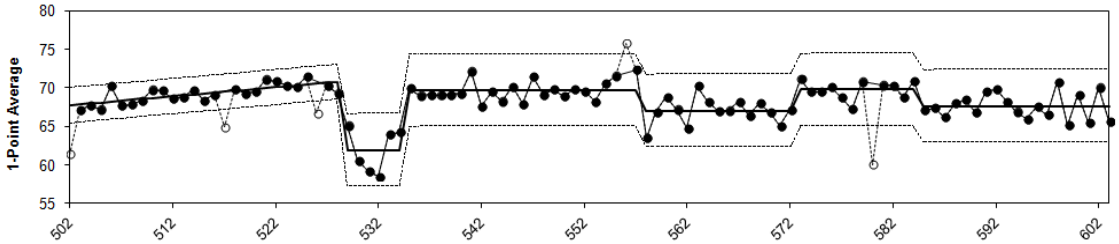
Figure 1 shows the laboratory controls (reference material) from two operations, a metallurgical and a petrochemical laboratory. Both show poor control. This is the norm; it is what one expects when first examining laboratory data.

Figure 1
TWO EXAMPLES OF LABORATORY CONTROLS

Petrochemical laboratory (plastics).



Metallurgical laboratory (gold).



The degree of instability and unnecessary analytical error is high in both the above cases. This leads us to ask why the assay is suffering from such high error. Usually, there are several contributing factors, but in most cases the most significant problem is between analyst (or between shift) variation.

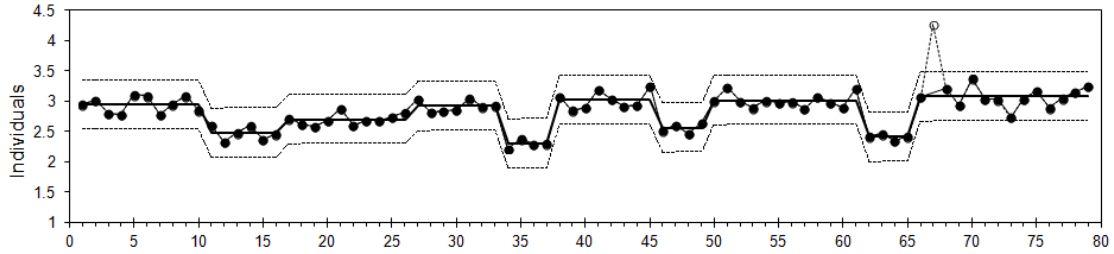
Between analyst variation is not a technical issue, it is an operational problem that can be solved only with good leadership. Many laboratories have demonstrated a good ability to deal with technical issues, but a poor capability when it comes to dealing with human issues.

BETWEEN ANALYST VARIATION

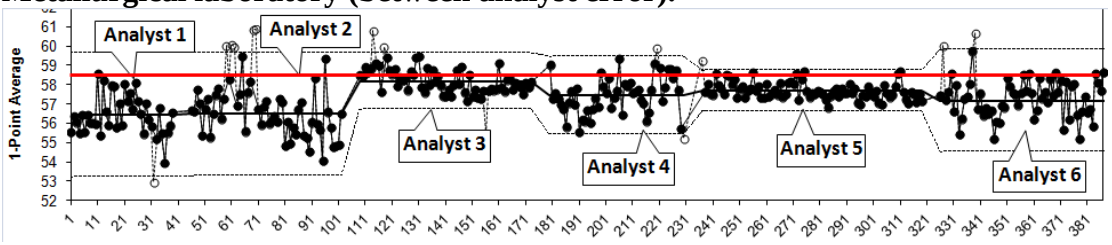
Figure 2 shows the laboratory controls (reference material) data for two laboratories. The first comes from a pharmaceuticals laboratory and illustrates shift-to-shift variation. The second is a metallurgical example which demonstrates analyst-to-analyst variation.

Figure 2
BETWEEN SHIFT AND BETWEEN ANALYST VARIATION

Pharmaceuticals laboratory (between shift error).



Metallurgical laboratory (between analyst error).

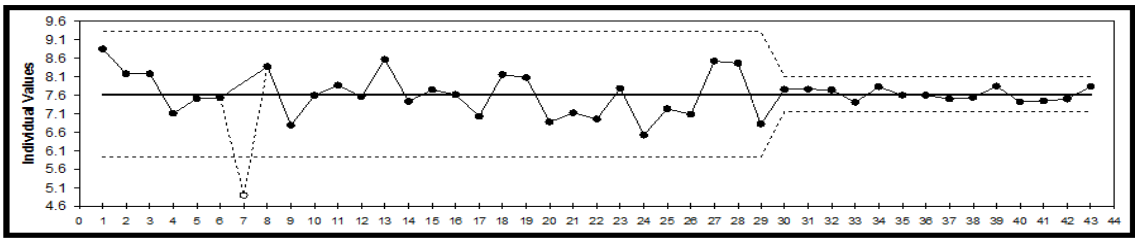


If the laboratory managers were able to eliminate between shift and between analyst variation in the examples at Figure 2, analytical error would be at least halved. In the metallurgical example, the potential exists to reduce analytical error to a third or perhaps even a quarter of the original level.

In both cases, nothing was done as a consequence of these initial investigations. Requests for additional data and for trials to conquer the problem were ignored.

To contrast this situation Figure 3 is an example from a pharmaceuticals (biological – vaccines) laboratory. In this case the assistant director of the unit and the unit statistician set to work with the analysts to improve the precision of the assay. The results were immediate and spectacular.

Figure 3
IMPROVED PHARMACEUTICALS LABORATORY CONTROLS



CORRUPTED OR FALSIFIED DATA

Although less common, the existence of corrupted or falsified data destroys any confidence one can have in the data. The data at Figure 4 are petrochemical laboratory controls that were sent to me along with a request that I assist by conducting an initial analysis of the data. The colour coding is used to illustrate where data has been cut and pasted. Similar colours indicate identical data.

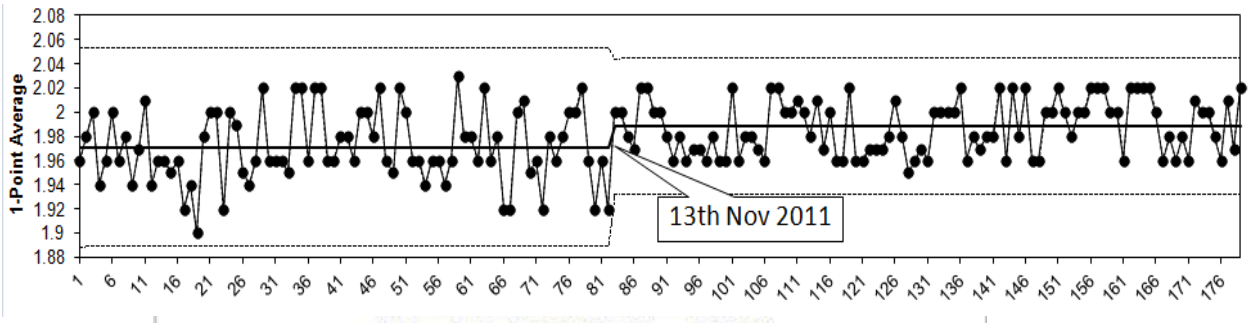
These laboratory controls are meaningless. We know nothing about the degree of analytical error in this laboratory. The data give us no opportunity to conduct any analysis whatsoever.

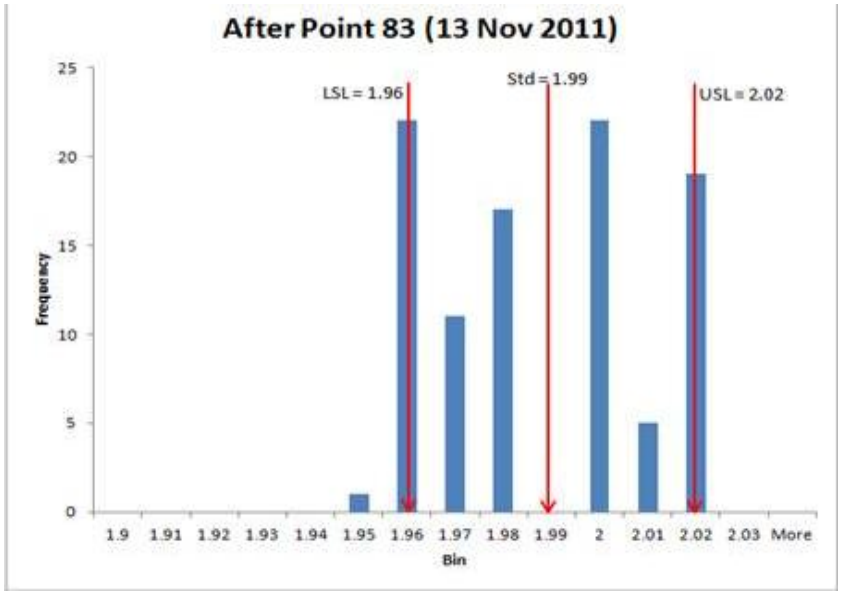
Figure 4
FALSIFIED LABORATORY CONTROLS

	Equipment 1					Equipment 2			
ANALYST	Viscometer1	Viscomete	Viscometer3	Viscometer4	ANALYST	Viscometer1	Viscometer2	Viscometer3	Viscometer4
AH	0.787	0.843	0.858	0.843	MS	0.794	0.821	0.821	0.794
	0.858	0.847	0.772	0.847		0.83	0.793	0.793	0.83
	0.772	0.824	0.819	0.824		0.798	0.813	0.813	0.798
	0.819	0.800	0.809	0.800		0.815	0.825	0.825	0.815
	0.809	0.858	0.857	0.858		0.816	0.797	0.797	0.816
	0.857	0.822	0.832	0.822		0.823	0.814	0.814	0.823
	0.832	0.838	0.795	0.838		0.826	0.831	0.831	0.826
	0.795	0.822	0.822	0.822		0.807	0.801	0.801	0.807
	0.822	0.835	0.822	0.835		0.805	0.818	0.818	0.805
	0.822	0.828	0.72	0.828	AG	0.816	0.839	0.839	0.816
MG	0.843	0.858	0.843	0.789		0.821	0.794	0.794	0.821
	0.847	0.772	0.847	0.819		0.793	0.83	0.83	0.793
	0.824	0.819	0.824	0.809		0.813	0.798	0.798	0.813
	0.800	0.809	0.800	0.857		0.825	0.815	0.815	0.825
	0.858	0.857	0.858	0.832		0.797	0.816	0.816	0.797
	0.822	0.832	0.822	0.795		0.814	0.823	0.823	0.814
	0.838	0.795	0.838	0.822		0.831	0.826	0.826	0.831
	0.822	0.822	0.822	0.822		0.801	0.807	0.807	0.801
	0.835	0.822	0.835	0.870		0.818	0.805	0.805	0.818
	0.828	0.752	0.828	0.840		0.839	0.816	0.816	0.839

The next example shows corrupted laboratory control data from a metallurgical laboratory (grade controls from an open cut mine). At figure 5 we see two charts. The first is a control chart of the laboratory controls. Note the truncated appearance in the second system (after 13 November). The second chart is a frequency distribution of that second system.

Figure 5
CORRUPTED LABORATORY CONTROLS





Please note that in the distribution only one data point fell out of the specification limits (in red). Note also that the "tails" of the distribution are missing, and that many data are parked exactly on a specification limit. This is good evidence of corrupted data. Further investigation soon revealed that data that tested as outside specification were being adjusted onto the specification, because the senior analytical people were happy provided standards were met. This fact might go a long way towards explaining why grade control at this mine was so problematic, and why the assessments of the mine and the mill of the gold content in the ore differed significantly. In practical terms one is inclined to wonder how much ore was sent to the waste dump, and how much waste material reported to the mill.

SAMPLING ERROR

The data at Table 1 hail from a metallurgical operation that has two processing lines. Metal accounting had been experiencing problems for years, and a hierarchical study was conducted to separate sampling error from analytical error and the process related variation. In this instance we are concerned with the sampling and analytical error only.

Table 1
RESULTS OF METALLURGICAL HIERARCHICAL STUDY

LINE 1			LINE 2		
	Variance	Sigma		Variance	Sigma
Test	15.875	3.984	Test	13.227	3.637
Sample	67.127	8.193	Sample	22.578	4.752

In this case we note that the test or assay error is very similar for both lines. Given that the same laboratory services both lines, this is to be expected. However, Line 1 has nearly double the sampling error (measured in terms of standard deviation) noted in Line 2.

In fact, the data reveal that in both cases the sampling error is greater than the assay error. Even after sampling at Line 1 is improved to make it comparable with Line 2, sampling error will remain greater than assay error in both cases. This is a common situation. As an experienced laboratory manager once said, "Sampling is the mother lode of all errors".

CONCLUSION

Analytical precision in many companies varies from barely satisfactory to abysmal. This is a harsh statement, but the data speak for themselves and make any other conclusion difficult. To further illustrate how significant and widespread the problem is, Annex "A" contains a series of charts for laboratory controls from one laboratory. Annex "B" shows between analyst variation from several laboratories, one chart per laboratory.

This condition is not the most significant problem. Inactivity is. To the best of my knowledge, of all the examples given above, only two sites decided to do something about the degree of analytical error present. Only one successfully reduced between analyst variation, although it was present in all cases.

At the time of the initial investigations the remainder did nothing, except perhaps to create very technical sounding excuses for the error present. One can only hope that this changed with time.

Of all the problems we face in manufacturing and processing, conquering analytical error is one of the simplest. In most cases finding the analytical error and tracing it to causation is very simple. Usually this takes a day or so. Calibrating the analysts (for example) to conquer between analyst variation seldom takes more than a month, and in some cases has been achieved in a week, but a willingness and a capability to deal with human rather than technical issues is a necessary and often missing ingredient.

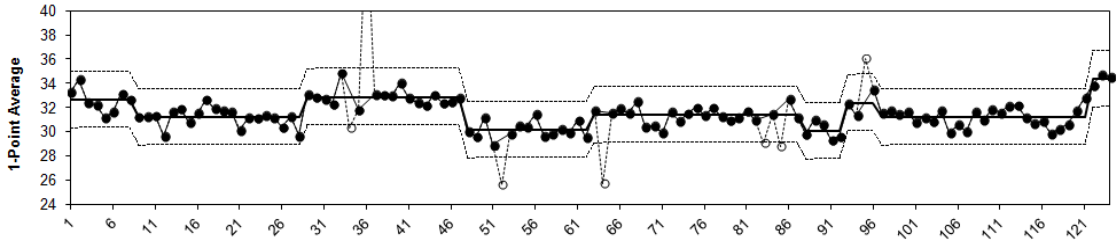
The cost of analytical error varies significantly. In some cases it is modest. In others, such as those examples where grade control and process control is being negatively impacted, it can be millions of dollars per year.

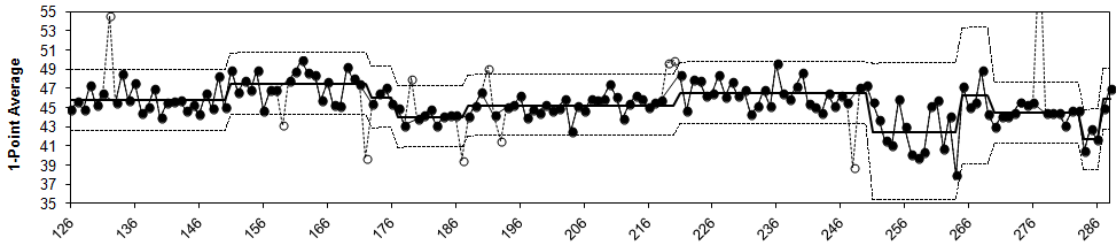
Finally, there is one more good reason to reduce the analytical error where possible; because it is the right thing to do; it is what we expect of professionals.

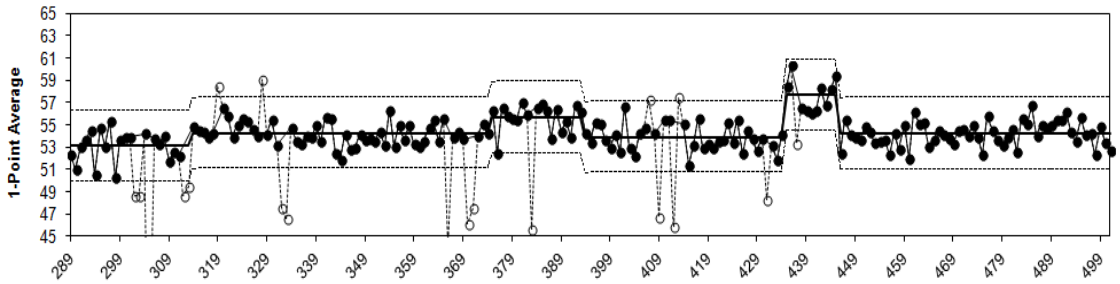
The choice is ours. We can ignore analytical error or we can reduce it significantly, along with the associated costs.

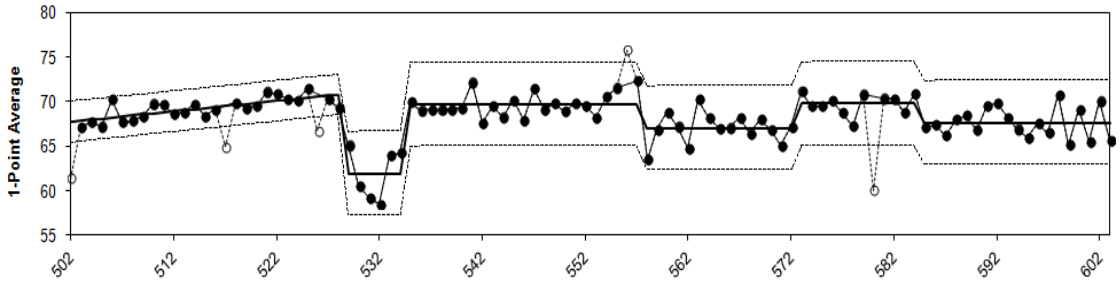
Annex "A" to
Wysowl Newsletter
Dated 3 May 2013

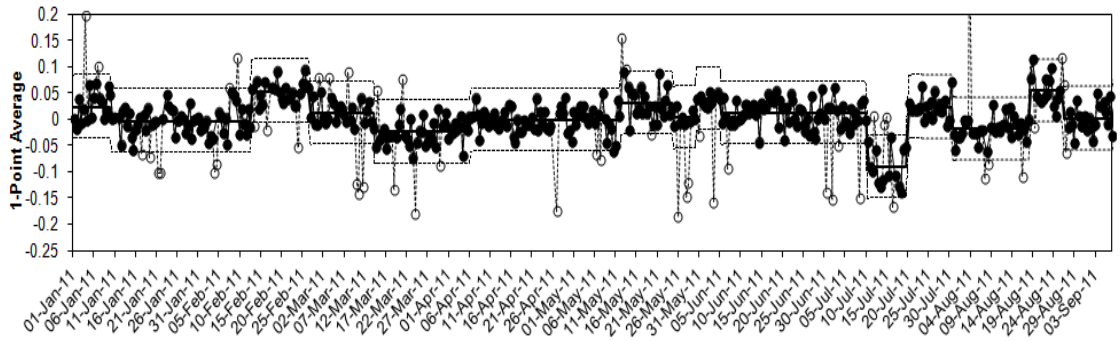
VARIOUS LABORATORY CONTROLS FOR A SINGLE LABORATORY











Annex "B" to
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BETWEEN ANALYST VARIATION
Laboratory controls - one chart per laboratory