What makes a good ATP hygiene monitoring system?

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No one in the food industry doubts the value of effective cleaning or the role that Adenosine Triphosphate (ATP) bioluminescence can play in monitoring and verifying cleaning protocols. Clean food contact and environmental surfaces are increasingly recognised to be important in limiting pathogen spread, preventing cross contamination and in the manufacture of food and beverage products that are safe and of a quality to meet shelf life needs or claims. The problem is how to decide what makes a good ATP bioluminescence detection system.

Choosing a system

Marketing and advertising materials should help – but there is a famous quote "there are lies, damn lies and statistics". One definition of quality includes 'the totality of characteristics of a product or system' and this applies to everything from cars to ATP test systems. However, busy food production or hygiene managers may not have the time or even the expertise to judge some of the claims made by manufacturers or their relative importance in relation to their needs, especially when there is often a big difference in system performance and price.

The goal when choosing a test system (instrument, swab and reagents) should be good value for money – one that delivers optimum performance in relation to price, although as with most things in life a quality product is rarely the cheapest.

Cheap systems may initially sound attractive financially but if they fail to deliver reliable results they can present a false impression of cleaning efficacy, leading to unsafe food being produced in an unclean environment or product that will spoil before the labelled expiry date.

Longer term they can prove to be much more expensive if they fail to detect inadequate cleaning leading to product quality or safety being compromised.

Each ATP test system manufacturer tries to establish unique selling features for their own system. They may highlight individual aspects or advantages of their test or instrument without presenting an overall picture or in relation to industry needs and this can be misleading.

There is relatively little reliable information on what industry actually wants from an ATP hygiene monitoring test system although research reporting on this has subsequently been found to be still valid today (see Table 1).

This published research sets out the role of ATP hygiene monitoring as part of a strategic approach to managing cleaning, as well as comparing eight different test systems, in relation to what industry said they required and wanted.

Attributes/ characteristics	Industry ranking
Speed of results	1
Accuracy of results	2
Reproducibility of results	3
Simplicity and ease of use	4
Cost per test	5
Reliability of equipment	6

Table 1. Industry's perceptions of what is important in ATP hygiene monitoring (adapted from Griffith et al, 1997).

Although most test systems have advanced in instrumentation and reagent chemistry more recent unpublished data confirm the previous quantitative and qualitative findings concerning industry requirements and it is interesting to evaluate the technological developments in relation to what is important to industry.

Speed of results is of course a crucial factor and is one of the key advantages of ATP compared to microbiological testing which may only provide results 24-48 hours later. However, conventional microbiological testing and cultivation still have a vital role to play as part of an integrated cleaning management strategy. Within limits all ATP test systems provide a rapid result although some test protocols take longer than others. This can be important if a large number of tests need to be undertaken or, as is often the case, there is only a short window of opportunity for testing cleaning efficacy before production resumes.

A difference of even 10 seconds per test can add up if several hundred tests need to be performed. To an extent the time taken for a result is going to be dependent upon the time the manufacturer has set for the instrument to read the test and the number of steps or stages required to activate the test.

Collectively this is known as the 'time to result' (TTR) which varies by over 60% between some leading instruments. Having a single step in swab activation, apart from being quicker, also helps to reduce variability in results and improve repeatability and reproducibility as well as ease of use.

Ranked 2 and 3 in importance by industry are accuracy and reproducibility and it is perhaps in this area that there is most confusion, claims and counter claims. In hygiene monitoring an accurate result is one where the result correctly reflects whether a surface has been cleaned or not to the standard required, based on values and limits that have been set by the user from baseline data and how well the magnitude of the result reflects the degree of contamination.

Repeatability essential

The repeatability from instrument to instrument and test device to test device from the manufacturer and the linearity of the response are important factors. As is the repeatability and reproducibility that can be achieved by the routine users of the system. What users obtain is highly dependent on the design of the product, how intuitive it is to use, how easily operatives can be trained in its use and the likelihood of errors being made.

Repeatability concerns how consistent (little variation) there is when one operator repeatedly samples a standardised contaminated test surface. Reproducibility describes the consistency of the results between two or more operatives. Clearly both are important, especially when sampling is undertaken by more than one person and results are being used correctly and proactively as part of trend analysis, which is vital to the effective management of cleaning.

Some studies report on factors that actually make no difference to the reliability of the result for real tests on surfaces and are misleading. For example comparing the signal from ATP added to the sampling swab and the signal from ATP that is added to the test reagent which can only be done by dismantling the device, then measuring the difference and reporting this as a measure of 'precision' or 'accuracy'.

In reality, what is important in repeatability and accuracy is the sum of all the components in the test system (see Table 2) and how these factors all interact to achieve the overall final result.

Swab reagents

Performing an ATP assessment of surface cleanliness starts with the swab type and the reagent chemistry. Organic residues need to be lifted off the test surface so that they can be detected. This can be problematic with the presence of biofilms and the varying ability of different systems' swab reagents to remove surface residues.

Test systems that do not effectively remove surface residues will give a false impression of cleanliness and thus accuracy as the ATP in those residues will not be subsequently detected.

When the swab provided by the manufacturer is dry and is to be moistened with clean water this not only adds another step but may also be less productive.

Where the swabs are provided pre-moistened with an agent that lifts soil and microbial cells the extraction will largely occur as the user swabs.

With those where clean water is used then extraction is after swab-

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bing and on activation of the test.

Wherever the extraction occurs there can be differences between products. It is relatively easy to extract ATP from eukaryotic cells but is usually much more difficult to extract it from some types of prokaryotic (bacterial) cells.

The extractants used by some manufacturers fail to do this effectively – thereby underestimating the microbial ATP present.

The ratio of microbial to non-microbial ATP varies with circumstances and product type, but for example the former could be 33% or more of the total ATP present.

A good extractant liberates the ATP from all types of cells and simplicity of swab use with the minimum number of steps involved in the extraction helps to minimise variability. Reagents are then needed to convert the removed and extracted ATP into a light signal measured in relative light units (RLUs).

Tests done with pure ATP, or even model soils, in the laboratory may or may not correlate well with those undertaken in a manufacturing environment. This can be due to the presence of residual inhibitory substances left on the surface or can be related to differences in extraction.

Most tests on the market today give a light output profile that is largely independent of small timing differences between activation and reading the test. The light output is already at the maximum in a time faster than the user can get the test into the instrument and take a measurement and the signal does not decay quickly, a glow rather than a flash.

However, there are some tests where this is not true, where the time to reach maximum is slow and/or the decay is very fast. With these tests the variation may be much larger than reported in laboratory studies, especially with inexperienced operators. This emphasises the need to conduct in house trials within the production environment.

Additionally, in real life conditions in food plants swab reagents can be affected by inhibitory substances in soil or from cleaning chemicals.

The repeatability of the tests is also dependent upon good quality manufacturing process control.

However, the design of some tests is such that even with good controls it is not possible to produce a test with low variability device to device and batch to batch.

Table 2. Interacting factors that contribute to accuracy and repeatability.

Instrumentation
- Capturing light emitted
- Detecting light emitted
- Measuring and recording light emitted
- Consistency of calibration

Swab type and reagent chemistry
- Ability to:
  - Remove surface organic debris
  - Extract ATP from cells
  - Convert extracted ATP into light
- Design and consistency of production.

Human/operator
- Ease of use
- Simplicity of use
- Convenience of use
- Consistency of use

Failure rates

Swab failure rates are much higher with some makes than with others and can lead to a waste of time and effort as well as leaving gaps in results making trend analysis incomplete and more difficult with some swabs by design being more susceptible to failure/breakage.

The length and format of the sampling portion of the product can be important as it can affect the ability to sample difficult to reach/access sampling points. It has been said 'easy to clean places are usually well cleaned but difficult to clean places are often poorly cleaned'. Soil can accumulate in 'nooks and crannies' and difficult to clean places present the most risk. Although industry wants as cheap as swab as possible, ensuring swab consistency, a key component of reproducibility and repeatability does not come cheaply. Again the concept of value for money is important rather than just a cheap swab price.

Importance of design

Instrumentation design, construction and manufacture are other important factors in how the light is captured, detected and recorded.

How much of the ATP on a swab becomes recognised as light is a function of the swab design in relation to the reading instrument's ability to detect it.

Two basic types of instruments exist, those containing a photomultiplier tube (PMT) and those with a photodiode.

Each has advantages and disadvantages. There is no doubt that PMTs are more sensitive and can detect lower levels of light but they are more expensive. Use of photodiode detectors allows lower production costs but in turn require the use of reagents that gives a higher light output to get the same overall sensitivity. Different manufacturers of photodiode systems have used different strategies to obtain the higher level of light.

To date those on the market may have some disadvantages such as reagents with poor repeatability, poor kinetics (time to maximum and/or rapid decay) or requiring the use of dry swabs that the user must moisten with water.

One of the extolled advantages of photodiode technology is that regular calibration and maintenance is not necessary.

However, some suppliers of PMT based instruments maintain their products are very stable with little or no need for recalibration, even after years of use. In any case for quality assurance and audit purposes, calibration checks and updated test certificates (just like for probe thermometers) will be required for all instruments. In turn, this requires good instrument and technical support, whatever the type of light detection system. The detection system must also show good linearity (relationship between ATP and RLUs) across a wide range but especially at the lower levels.

Some systems drop to zero below a certain level of ATP or use a logarithmic scale. This can make it difficult to discern small differences in results. It is easy to detect very dirty surfaces but key to determining cleaning efficacy and identifying areas for cumulative improvements and hence the production of safe food is the ability to detect 'marginally' unclean surfaces.

The scales used to measure the detected light vary between instruments, even though they all measure in relative light units, this is an arbitrary standard set by the manufacturers for their instrument. Those with logarithmic based scales can be very misleading with small differences in measured RLUs representing very large differences in ATP.

Operators and cleaners may have poor technical knowledge and the scale used must allow for incremental improvements and benchmark setting within the production plant. As with the swabs good quality assurance with instrument manufacture is important.

The build quality and reliability of some instruments are not as good as others. Instrument failure can be disruptive and lead to gaps in hygiene monitoring until a replacement instrument arrives or the original is repaired. It is important that users have faith in and trust the instrument they are using and that it will give trouble free service.

Directly linked to instrumentation is the software that goes with it. The ability to easily store and analyse the results collected can be a very powerful help in problem prevention as well as root cause analysis in failure investigation.

The performance of the software available with the different instruments vary in their ability to both store and analyse data.

The third component of the accuracy and precision triad is the operator. In the hands of food industry personnel (not laboratory technicians conducting trials) a good instrument/test combination should have good repeatability and have a low variation.

This is only possible if the test is convenient, simple to use with as few steps in swab activation as possible. Swabs should be preferably activated with one hand to both reduce operator error as well as making it practical for ease of use in a food production environment.

The more steps there are the greater the time required, the more potential sources of error, and the lower the human repeatability, irrespective of any reagent or instrument factors.

When buying or replacing an instrument/test system, just like choosing a car or any other product or service, there are a selection to choose from and it pays to investigate all the factors considered in this article.

Independent recommendations have been published on how to choose a luminometer and probably the best approach to adopt is to look at what the manufacturers have to say, read one of the articles on choosing a luminometer and then conduct your own 'in house' trials.

One manufacturer offers a test challenge inviting companies to compare their test system against competitor products in their own real food plant environment.

In addition to the factors so far discussed, and also considered important by industry, is consideration of the company selling the system.

Technical service

Factors to think about include the technical support they provide, both in terms of instrument/test information; knowledge of their food sector, the nature of any specific problems they could encounter and aspects of cleaning in relation to product risk; 'hand holding' during implementation including advice on where and when to sample; assistance with setting limits coupled with incremental improvements and trend analysis; equipment replacement should that prove necessary; what other users of the system have to say along with the reputation and track record of the company are just some of the factors for consideration.

Comprehensive technical support is important to all purchasers but can be especially valuable for multinational companies with factories all over the world who have a need to compare results on a global basis.

To return to the title question – what makes a good ATP hygiene monitoring test system? – the answer is a complex amalgam of many factors, but hopefully this article has provided some advice on the questions to ask and what to look for. ■

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