Measuring Cleanliness by R.W. Powitz

When we make changes in cleaning products, cleaning equipment or even cleaning systems, our decisions should be defensible. Just because something is "new and improved", doesn't necessarily mean that it is better. A questionable housekeeping-related purchasing decision can have far reaching consequences through lowered customer satisfaction and poorer cleaning outcomes; not to mention the potential of increased cost and decreased manpower efficiency. In this day and age, when we have to watch every penny, and when a professional error can result in serious litigation, we need to do everything possible to justify our actions. For these reasons, we need to compare what we have and already do to what we intend to change. In other words, we need to ask the questions: "Are we doing a reasonable job with what we have?", and, "Is there a real benefit in what we propose?" Part of the answers lies in comparing some of the not-so-obvious cleaning outcomes through inspection and a simple series of experiments using measurements.

The concept of using measurement tools to validate our decisions really took off with the introduction of Integrated Cleaning and Measurement (ICM). ICM put measurement in the forefront to give us unbiased comparisons between one product and system to another. Basically, the measurement portion of ICM provides us with objectivity rather than a subjective opinion. It lets us compare new to old, before and after, and most importantly, good measurement can justify our decisions. As a bonus, measuring housekeeping outcomes can answer the question: "How clean is clean?" for customer satisfaction and economy.

Basics of measurement

When we begin to consider measuring anything, we need to determine several basic issues including: Why we are measuring? What are we measuring? How do we eliminate bias when we measure? And, what will we do with the measurements once we have them?

Why we measure

We start by defining the problem. Namely, what do we hope to accomplish by measuring? Quite simply, we measure to make comparisons. A good measurement strategy helps us make an informed judgment in choosing the better of two alternatives. For example, we can use measurements to compare the performance of one cleaning chemical to another; measurements can contrast cleaning methods such as wet-mopping to touch-less cleaning or measure the effectiveness of using microfiber versus cotton cloths. The possibilities are endless.

Keep in mind, when we use measurements for comparative analysis, we need to clearly establish a single objective. We cannot compare apples to oranges. For instance, no measuring tool can compare biological cleanliness to slip resistance or appearance (aesthetic cleanliness). The biological cleanliness outcome of one system or product can only be compared to the biological cleanliness outcome of another. Slip resistance of one can only be compared to slip resistance of another … and so on.

Sampling and Interpretation

Now that we've defined a single measurement objective, we have to consider how to set up our sampling plan, select and use the measuring tools, and, interpret the outcomes.

Good measurement begins with sampling. The objective of sampling is to get a set of measurements that are representative of the source under investigation. To do this, we need to develop a sampling plan that accomplishes three very important goals. The first is to match the sampling methods and tools to the questions we want answered. While this may seem intuitive, all too often we sample for one thing or at a given site, when we want something completely different. For instance, we sample for mold when we actually should be looking for the source of wetness. We need to target our actions. Sampling for sampling sake, really makes no sense. Secondly, we need to eliminate bias. Sampling should ensure neutrality. We should never predict the outcome before we actually take the measurements. Finally, we need to develop a sampling scheme and sampling strategy that is repeatable, so that we can go back and verify our findings if needed. If we plan it well, we can use the same sampling scheme in a similar situation or even expand on what we do without redoing everything. Repeatability is also credibility.

Before we leave this topic, there are two important things to remember: First, encourage data sharing. The more information we share with one another, the better is the feedback. In fact, by sharing your findings, you may get some excellent suggestions and recommendations. Secondly, never use sampling or monitoring data punitively. Always use these data constructively to change methods, materials and behaviors for the better.

Measuring Tools, Devices and Systems to Measure Cleanliness

So, with that as a brief introduction to sampling, here are some practical tips on measuring tools; how to apply them and how to interpret what you measure. Let us begin by introducing five types of measurements that we routinely use in the field of environmental health and safety; which are also quite appropriate for housekeeping. While the selection of equipment can get a bit extensive, there are however inspection and measurement tools that we can use all the time. These items make up a basic housekeeping inspection and measurement tool kit. These few measuring tools provide us with the data to make informed decisions in assessing cleanliness and selecting the best cleaning products and processes.

- Visible cleanliness – This is aesthetic cleanliness or simply stated: “Clean to sight and touch”. The tools we use to measure visible cleanliness do not necessarily provide us with numbers, but they definitely provide us with “before and after” comparisons. The most important is our eye sight; the tools we use to judge visible cleanliness greatly enhance what we are able to see, as well as the soiling we cannot see.
- Biological cleanliness – The ultimate goal of biological soil removal is the control of microbes in our environment. We want to prevent their spread and ensure that the immediate environment is not a risk of disease transmission. While most of the tools we use to measure biological cleanliness do not actually give us numbers of microbes, they provide us with numbers that include the bio-burden. These tools are excellent for making before and after cleaning comparisons and planning quality improvements. Other tools used in this category measure the concentration of disinfectants and sanitizers.
- Process cleanliness – This is not so much measuring the end result of cleaning as with visible and microbiological cleanliness. Process cleanliness focuses on measuring the act of cleaning. The measuring tools tell us if we create a risk of disease or injury as a direct result of the cleaning process. These tools measure aerosols resulting from mechanical agitation resulting from using such equipment as vacuums, buffers and power washers, to name but a few.
- Safety cleanliness - The tools we use to measure safety measure slip resistance to prevent slips and falls. These tools are ideally used to evaluate the resiliency of a flooring system before it’s installed. However more often than not, tools that measure slip resistance are routinely used to compare floor finishes and evaluate any number of floor cleaning systems as well as determining the cause of slip and fall injuries.

Determining visible cleanliness

The best tool in evaluating the effectiveness of housekeeping outcomes is through the eyes of a customer. Most of what we do is remove visible soiling. However, to really see how well we clean, we need to see the soil that is left behind. A camera is an essential tool to capture what we see. The pictures serve as excellent documentation and training aids.

Flashlight - We cannot clean what we don’t see. Dust, dirt, streaking, film deposits or any residual soiling is best observed using a pure white light. To do this, consider using an LED flashlight with a focused beam. These flashlights are inexpensive and readily available in any big box store. The LED flashlight should have at a light output of at least 60 lumens (the light output information is indicated on the package). When the light is held at an acute angle to the surface (almost parallel with the surface being inspected), it gives the best contrast … you can really see the dirt.

To eliminate bias in your observations, consider delineating several smaller areas that you are evaluating by placing an 8-inch by 10-inch (8"x10") picture frame, without its glass. Place the frame on the surface to be inspected and examine the area inside the frame area. By repeating this process several times in randomly selected sites, you should be able to evaluate the effectiveness of your cleaning efforts. The small inspection areas, allow for easier identification of the type of soiling and gauging the effectiveness of the cleaning efforts. By plotting the number of observations or patterns you selected when placing the frame on the surface, the observations can be easily repeated if you need to make comparisons. This allows for easier documentation and evaluation.

UV Light - To see bodily fluids such as urine, semen or vaginal discharge, or soiling from toothpaste, soap scum as well as mold growth, use an LED Ultra Violet (UV) flashlight in the 365 to 400 nm (nanometer) range. A UV flashlight is particularly effective when ensuring the cleanliness of restrooms. To best expose blood spills and spatter, use the UV light with orange-tinted goggles or dark shooting glasses. The blood spatter will stand out from any of the other contaminants. Orange-tinted goggles and shooting glasses are available in most sports stores and gun shops, or on-line from businesses selling forensic supplies.

Most UV flashlights do not have the light intensity of the white light LED flashlights. Therefore, when using the UV flashlight as an inspection tool, it is best to have the room or area as dark as possible. While the target contaminants fluoresce, they are easier to see with the UV flashlight under low light conditions. LED UV flashlights are relatively inexpensive and available in many specialty and home improvement stores.

Inspection Mirror - Another essential tool for inspecting visual cleanliness is an inspection mirror with an extension handle. These are sold in all hardware stores. The inspection mirror lets us see where the dirt is without getting on our hands and knees or upon a ladder.

Other essential tools - A piece of clear cellophane tape and a magnifying glass or access to a binocular microscope is ideal for looking at soil on carpets or fabric surfaces. Simply press the tape on a carpet or fabric surface and count the contaminants such as hair, dander, dirt and dust particles on the tape when viewed under magnification. This is probably the easiest way to compare the effectiveness of cleaning methods or determine cleaning frequency when gross soiling is not obvious.

No cleanliness inspection tool kit is complete without wood-stick cotton swabs and small prep pad alcohol wipes. These are ideal for finding dirt in inaccessible areas and particularly for evaluating the cleanliness of high- or common-touch surfaces. The wood-stick cotton swabs are rigid and therefore easier to use when looking for soiling around toilets, faucets, drinking fountain bubblers, wall-floor junctions, sill plates or any hard-to-access area that is subject to occasional wetness. The prep pad alcohol wipes or swabs that are routinely used in clinics are ideal for wiping common touch surfaces such as flush handles, faucets, push plates, public telephones, elevator buttons, banisters and hand rails or any surface that is repeatedly touched. When using these tools, try to maintain a constant pressure on the surface being monitored and keep the number of wipes across the surface consistent. The alcohol in the pad easily removes oils and impregnated soils that are deposited by hands. Because both the cotton and alcohol swabs are white, soiling is easily seen. The amount of soiling can be estimated by the varying shades of white to grey to black.

Measuring Biological (Organic) Cleanliness

We use two different strategies to measure biological cleanliness of surfaces. The first and least expensive of the two systems detects ATP (adenosine triphosphate), which is a constituent in all cells, both of both plant and animal origin. The ATP measuring system will count all cells including microbes (both living and dead), mold and fungal spores, skin cells, hair, dander, food particles, plant debris, insect parts … the list goes on and on. There is a grave misunderstanding in our industry that the ATP monitoring system is a “bug test” when it really is a “dirt test”. It does not distinguish between the different types of biological soiling.

This is also true measuring particles in the air. Airborne particle counters are broader in scope than the ATP systems. They do not distinguish between viable (microbes) and non-viable particles, but count all particles that pass their sensors; wet or dry. Airborne particle counters precisely measure the quantity of airborne particles and provide particle size distribution. The main use for handheld particle counters is checking contamination levels of different housekeeping activities, particularly those cleaning systems that can send surface soiling airborne. They are also used to locate sources of particle emissions.

However, if we want to specifically measure microbiological cleanliness, we have to use a laboratory. Measuring microbiological cleanliness involves actually recovering living microbes from the environment. There are different measuring devices required in order to monitor microbes in the air, water and on surfaces. And as you will see, these microbial recovery systems are designed to measure the number of microbes under various conditions and for specific reasons. This is particularly so when monitoring microbes on surfaces and in the air.

For surfaces there are two microbial measuring systems that are relatively easy to use: The first is direct contact agar plates; the second system uses swabs to recover microbes from a surface and transferring the microbes to a medium that encourages their growth. For the most part, measuring microbes in the air requires rather sophisticated equipment. However, there are situations where these assays are absolutely invaluable in our industry. The equipment needed is available through several scientific instrument rental services.

As stated earlier, all microbiological measuring tools require laboratory support. At a minimum, an incubator and perhaps a colony counter and binocular microscope is required. Also essential is some means to decontaminate the used growth medium before it is discarded. Depending on the degree of sophistication needed, any microbiological assay can become quite expensive and time-consuming. Microbiological measuring tools are best used for determining the possible source or sources of disease outbreaks such as MRSA (Methicillin Resistant *Staphylococcus aureus*), *Clostridium difficile* (C.diff), *E. coli*, or any disease causing organism linked to environmental transmission or believed to exist in the institutional environment.

Whether using total biological measuring devices or looking for viable microbes, the equipment manufacturers of the measuring tools have done an exceptional job in preparing the instructional manuals. The instructional manuals not only contain information on the operation of the equipment, but also practical information on sampling and interpretation of results.

To begin, here is an introduction to the ATP measuring system. The purpose of ATP testing is to document effective cleaning by following the principle that if there is no biomass on critical surfaces after cleanup, there is not enough medium for microbiological growth. The main advantage of ATP as a biological indicator is the speed of the analysis. Unlike quantitative microbiological monitoring that requires at least several hours, quantitative biological monitoring takes only minutes from collecting the samples to obtaining the results. Results are in real time.

The readout of an ATP monitoring device is in relative light units (RLUs), which mean that the measurements are in luminescent units (light), not cells. It is generally accepted that clean surfaces have low levels of total ATP. On the low end of sensitivity, most ATP monitoring units will detect less than 0.5 picograms (0.5 pg) of ATP from all cells on a surface; this includes microbes. For comparison only, this number is equivalent to about 1,000 bacterial cells. It is safe to assume that measurements greater than 2 to 3 times the background number you established for a clean surface, may indicate that the area tested is contaminated with biological material. Therefore, in using an ATP measuring system, some preliminary work is required to establish the relevant Pass/Fail limits for the test. This is best accomplished by collecting reference data in accordance with a consistent sampling plan; following normal cleaning procedures. The levels set will depend on the type and condition of the surface and the cleaning methods used.

There is absolutely no regulatory limit on RLUs. Neither the industry nor government has ever established absolute numbers in defining biological cleanliness. In addition, nowhere are any standard numbers given or even suggested in the scientific literature to define cleanliness. The few numbers that made it into print were at best, unique to that individual study. All surfaces, their degree of soiling and the cleaning operations use on those surfaces vary greatly and are quite different. Each area and surface is unique and should be evaluated by establishing separate base line values (for clean surfaces) and then comparing the results of cleaning activities against those values.

The companies that sell the ATP monitoring systems suggest limits to make some sense in interpreting the test results, but they may not apply to every situation. The numbers suggested are inferred for that specific system when used under "standard" conditions. Although several companies manufacture and sell ATP measuring systems, each is one is unique. There are no uniform standards for detection limits or sensitivity. Therefore, if you begin working with a particular system, stay with it. If you are planning to change ATP measuring systems, you will need to reestablish an entirely new set of baseline numbers in defining cleanliness for your facility. Regardless of the system you use, it is strongly recommended that you first familiarize yourself with the manufacturer's instruction or operator's manual before starting any inspection or quality control program, or, ICM experiments. It is best to use the equipment in several "dry-runs" to become comfortable with it.

Because ATP measuring systems are ideal for ICM and provide dramatic "before and after" comparisons as well as providing numbers in monitoring routine cleaning processes, consistency is essential. Sampling should be repeatable. The techniques you use need to be the same whether taking the first or the hundred and first test. To do this, consider using a template that is laid on the surface to be sampled. The sample size is determined by the framed opening of the template. The template opening outlines the area that is sampled with the swab that comes with the test kit. Teflon® sampling templates are readily available through most laboratory supply houses. However, for our purpose, simple templates can be fashioned from file folders or any rigid materials. They do not have to be sterile. Two different configurations seem to work in most situations: a 2-inch by 2-inch (2"x2") square opening and a 1-inch by 4-inch (1"x4") rectangular opening cut in the cardboard. The rectangular template is more convenient for sampling common touch surfaces such as light switches, buttons, levers, door handles or any irregular shape. Decide on a sampling protocol for each surface to be measured at the beginning, and use that protocol consistently throughout the experiment.

It is also important to establishing controls before sampling. For instance, water used in cleaning may come from a surface source or is passed through some on-site water treatment system. Both surface waters and water treatment systems may contain large numbers of harmless bacteria and other cellular materials. The same holds true when mops and other cleaning equipment is reused without processing. Defining these background levels is essential to the results you get and their interpretation. It is also advisable to test any liquid chemical cleaners as they are not manufactured under sterile conditions. If any bio-contamination is suspected in or on anything related to the experiment, it is always prudent to run suitable controls in order to eliminate false data when working with ATP monitoring systems.

Microbiological Assays

Microbiological Air Monitoring

Each microbiological air monitoring system is used for a different purpose. Individually they answer questions such as: What is the total number of viable microbes in the air? What is the airborne microbial particle size distribution? What activities liberate the most microbes into the air? and, if the source is not known, Where do the airborne microbes come from? All of these collectors are generally used in active and dynamic environments such as determining the number of microbes liberated from vacuuming, buffing, changing and sorting linens; dusting, sweeping or any other vigorous housekeeping function that can send soil into the air. One of the systems is particularly useful in determining the effect of housekeeping activities and pedestrian traffic in critical areas in health-care facilities.

- Liquid-impinger samplers such as the AG30, is an all-glass collecting device that separates microbes from the air that is drawn through it. The air goes through a solution that scrubs the microbial particles out of the airstream. The solution can subsequently be plated on, or mixed in a microbiological growth medium for counting number of microbes per unit volume air and identifying microbes of interest. The AG30 is used to determine the wide range of airborne species that exist in an area.
- The Reuters or centrifugal sampler basically does the same thing as the AG30, except it deposits all microbes captured on an agar strip. It too is widely used to determine the total airborne bio-burden of an area.
- Sieve samplers, better known as “Andersen Samplers” consist of a series of perforated plates, through which air is drawn. The perforations in the stacked stages of this sampler are of ever smaller sizes; starting with large holes and ending with holes that are very small in the final stage. The air drawn through these holes causes microbes wafting on different sized particles to impact onto agar plates. The plates arranged below the perforated plates in a stack, separate particle sizes from the size of dust to very small droplet nuclei. These devices are used to measure the microbiological bio-burden in air that may be deposited in the lung. These samplers also come with a single perforated plate that samples everything below a certain size. The Andersen Samplers are primarily used by industrial hygienist and quality control technicians in clean-environment applications.
- Slit to agar samplers consist of placing an agar plate on a clock mechanism that turns at a predetermined rate. As the plate turns, it exposes agar to contaminants drawn through a single critically sized slot. The deposition of the microbial contaminants on the agar clock face shows levels of activity and the subsequent generation of microbial aerosols as a function of time. These samplers are ideally suited for determining the effect of human activity on the environment.
- Settling plates are the simplest of the microbiological air screening devices. They are used to describe the origin of biological contaminants in our immediate environment, particularly when the particles are large such as droplets and dust. While the settling plate is not as exacting as the samplers mentioned above, they have their use as an inexpensive screening tool.

Microbiological Surface Sampling

Among the many techniques to detect microbes on surfaces, only two are relatively easy to perform and as stated earlier, require only basic micro-lab equipment such as an incubator and a way to count microbial colonies … if identification of the microbes is not required.

The easiest of the surface sampling tools are RODAC® (Replicate Organism Detection and Counting) plates. These are agar media filled plates that have a raised meniscus. They are used by directly touching the agar to the surface being sampled. Microbes adhere to the agar and once incubated, their numbers are readily counted. If further identification of the organisms is needed, the colonies are easily transferred to specialty media.

The second method uses a sterile swab to wipe the surface. The swab is then rolled on the media in a Petri plate where organisms that were picked up on the swab, are transferred to the agar. The swab technique allows for sampling where the RODAC plates cannot be used such as with surfaces whose shapes are round, cylindrical, uneven and even hard-to-reach.

Measuring Cleaning Processes

Essential to any product comparison is determining the strength of the solution as listed on the product label. The chemical’s use-dilution, its corrosive potential and the amount left on the surface after cleaning are all important factors in comparing one to another. These tools yield good objective results in making comparative measurements.

pH – The measurement of acidity and alkalinity using pH measuring devices will provide an indication of chemical changes to the cleaning solution and the surfaces before and after cleaning. It is an excellent monitor to determine if an appropriate cleaning solution was used. The pH measuring devices come as

Paper Test Strips and as electronic pH pens. The pens require periodic recalibration, but are more accurate.

Sanitizer and Disinfectant Indicator Papers - Sanitizer and disinfectant indicator papers are mostly used to measure the dilution of Quaternary Ammonium Chloride (QAC) and Chlorine-based disinfectants and sanitizer solutions. They are particularly useful to determine the accuracy of proportioning devices and chemical pump systems and are also used to detect when a solution is no longer effective during routine cleaning.

The QAC papers come in several detection ranges. For most of our applications, a level of detection up to 400 ppm is adequate. Chlorine test papers or test strips should have a detection level up to 200 ppm.

Spot test such as Urine and Organic Residue detectors are chemically impregnated papers that change color in the presence of the target contaminant. They only measure the presence (or absence) of a contaminant; not the quantity of that contaminant. They are a rapid test and a relatively inexpensive way to monitor adequacy of surface hygiene efforts when ATP monitors are not readily available.

Determining Effects from Cleaning:

To properly assess the effects of the actual act of cleaning, an airborne particulate monitor is the best measuring instrument. Probably the worst consequence of cleaning in a school building or hospital is re-aerosolizing dirt that initially found its way to the floor or shaken loose from soiled linen. Apart from allergens and asthma-causing particles, pathogenic organisms carried on skin cells, dander and hair can be redistributed into the breathing zones of health-compromised individuals. This dispersion is mostly caused by handling soiled linen; dry-buffing, sweeping and conventional vacuuming where HEPA filters is not used on the vacuum’s exhaust. To monitor the effect of these operations, airborne particle counters provide excellent quantitative analyses. These airborne particulate counters measure both physical and biological particles of respirable size [generally between 1 and 10 microns (µ)]. These measuring devices are also helpful in comparing similar pieces of equipment such as vacuums, floor scrubbers and carpet cleaners for suitability in critical environments.

Moisture meters can measure the moisture left behind from carpet and furniture cleaning activities. They are an excellent quality control tool for this application. The less moisture left in a carpet or furniture, the lower is the risk of mold growth and malodors. Moisture meters are non-destructive and rely on impedance to provide a measurement of residual wetness. They are handy devices for identifying chronically damp areas that promote musty odors.

Measuring Safety

Measuring safety largely involves the prevention of slips and falls. Not all floor finishes and floor types are the same. As we all know, a shine on the floor can compromise the slip resistance; so can the resilience of the flooring materials. In areas where unintentional injury is a risk to the residents or users of the facility, determining the relative slip coefficient under wet and dry conditions can greatly enhance safety and help us determine the best floor care products and cleaning methods to use in our facility. To do this, there are several types of measuring devices commercially available.

- Horizontal Drag Slip Meter. This unit performs static coefficient of friction (COF) testing. This is used to assess the flooring material and can help determine the best floor finishes and cleaning methods for optimal safety.
- Portable Articulated Strut Machine and Variable Incidence Tribometer (“English Slip Meter”) is used where dynamic COF testing is needed such as in heavily trafficked areas. These measuring devices mimic our natural gait on the surface being evaluated. Their use is essential in determining probable causes of slip and fall injuries.

Both types of measuring devices are fairly expensive, but definitely worth it we need to evaluate slip resistance in heavily trafficked area under all types of conditions. However, if we only need to make a simple comparison of floor resilience or slip resistance between two floor types or floor finishes, it is easy to fashion a “horizontal drag slip meter” for under $5. Begin with an approximate 8-inch square block of scrap wooden building frame timber. On the bottom, attach three heel protectors: they come in a four-pack. Mount a large one in the center of the front of the block and two smaller ones at the rear of the block. Pieces of leather word equally as well. The heal protectors or leather simulates the sole and heel of a shoe. On the front end of the wood block, anchor a screw hook about 1 inch up from the bottom. When the completed wood block is placed on the flooring surface, a force gauge is then attached to the eye hook. To activate the wood-block meter, gently pull on the force gauge until the block starts to move. The indicator on the gauge shows the force needed to move it. Force gauges are readily available. Most maintenance shops already have force gauges to measure the pressure needed to activate panic bars on emergency exit doors.

Different floors and floor finishes have different slip resistances. By using this home-made “horizontal drag slip meter”, comparisons are easy and fast to obtain. If you need to “standardize” the device, try using it on clean quarry tile which has a slip resistance of about 0.6. This is the resistance recommended by the Americans with Disability Act (ADA) Guidelines for resilient floors.

There is one more tool that may be a valuable adjunct to our inspections: a Cosign compensated Light Meter with an effective illumination detection level greater than 10 foot-candles. Because we cannot clean what we cannot see, a light meter is absolutely essential to measure illumination for cleaning activities. Industry standards suggest a level of illumination of at least 20 foot-candles for optimal visual acuity when measured at approximately knee-height above a surface.

Bottom Line

A housekeeping tool kit with select inspection and measuring instruments is essential in conducting the experiments for ICM. Moreover, these tools are important in documenting safety, economy and customer satisfaction.

Inspecting and measuring our immediate environment, along with good documentation of our findings, help us see and interpret the often not-so-obvious. The data we generate help us in our Quality Assurance, Quality Control and Quality Improvement efforts. These data provide a solid basis to determine economy and efficiency for needed change in our housekeeping practices. Using the right tools constructively, demonstrates professionalism and pride in what we do … by doing it in the best way possible.