Smart Note

What are automated discrete analyzers? How do automated discrete analyzers work?

Automated discrete analyzers utilize colorimetric and enzymatic measurements—of several analytes simultaneously—from a single sample through photometric analysis. The discrete analyzer imitates the lab chemists' operation sequence of dispensing samples, mixing reagents, incubation, and photometric measurement; however, the discrete analyzer provides fast and reproducible results. Discrete analyzers consist of four components: a photometer with a specific number of filter positions; dispensing probes; an incubator to control the reaction temperature; and a mixer. In discrete analysis, each individual reaction cell is isolated and the temperature is stabilized, enabling highly controlled reaction conditions.

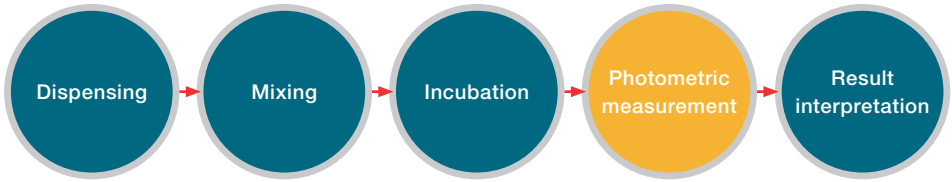


Figure 1. Discrete analyzer workflow.

After the reagents and samples are prepared, they are loaded onto the instrument. Next, the individual cuvettes are loaded into the incubation chamber and the samples and reagents are dispensed to the individual cuvettes and then mixed. Finally, the combined samples and reagents undergo photometric detection, depending on the absorbance of specific wavelengths of light. Each measurement is done using single discrete cuvettes and this data is then interpreted through integrated software platforms.

Automated discrete analyzer selection

Integrated discrete analyzers offer flexibility and ease-of-use, as well as, a unique opportunity to automate time consuming and labor intensive wet chemical analysis. When conducting multiparameter analysis for wine, malt, beer, environmental water, industrial water, and water utilities, the discrete analyzer technology ensures high product quality and throughput, while reducing cost, waste, and hands-on sample time. Typically, the selection is done just based on the number of tests per hour or throughput. However, taking a closer look at the benefits of each discrete analyzer is important before making the investment decision.

What are top ten factors to consider before making a purchase decision?

1 Measurement technology: true discrete/direct read system vs. fusion/hybrid system

Depending on how the final photometric measurements is done, discrete analyzers can be classified into two categories: true discrete/direct read system; or fusion/hybrid system that are similar to flow injection analyzers.

In true discrete analyzers (Figure 2), the sample addition, reagent addition and the final measurement is made in the same cuvette. True discrete analyzers are highly flexible with the direct read measurement of the reaction occurring within the cuvette providing important information about the measurement and makes the overall method development or optimization easier. True/direct read discrete analyzers also allow the easy blank, spiking, and sample dilution with real-time kinetic or activity measurements. All measurement is done in a single cuvette, eliminating the rinsing step and carry-over effect and improves the throughput considerably.

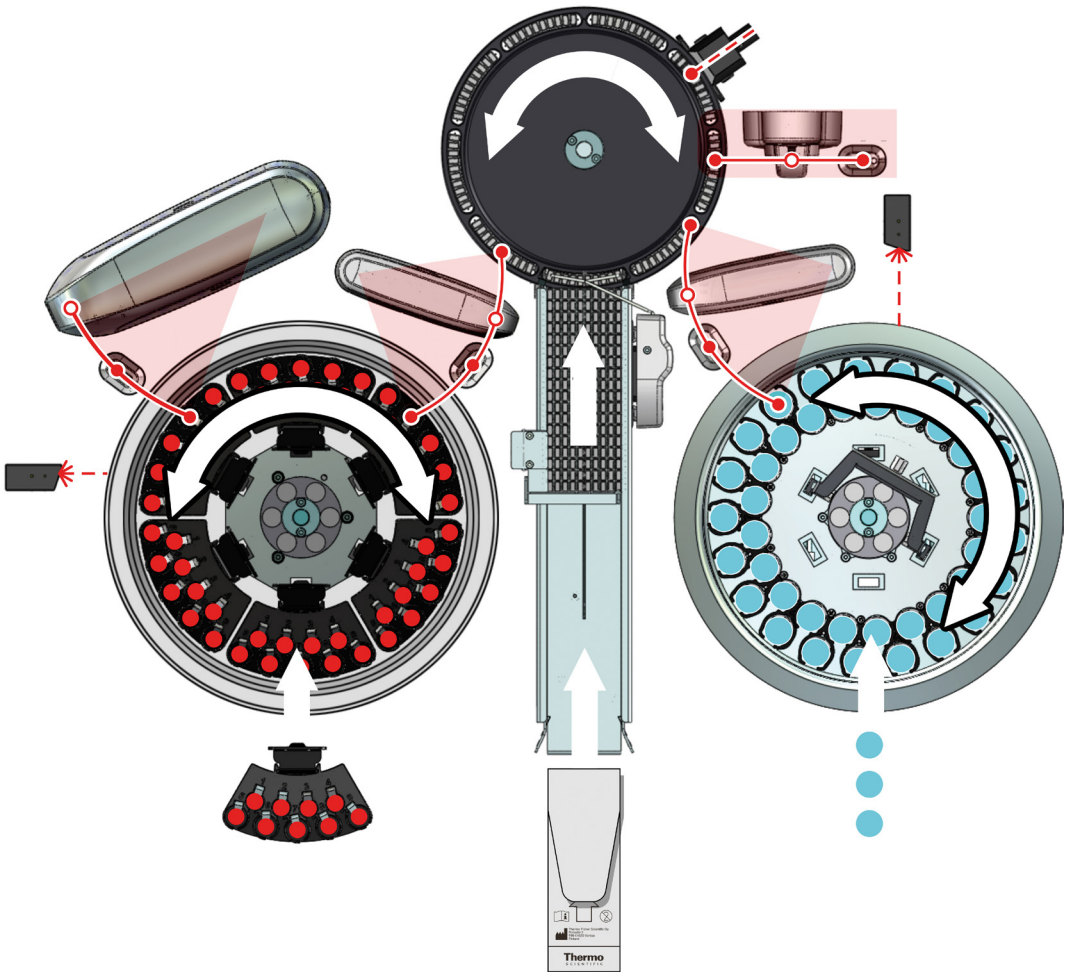


Figure 2. Direct read discrete analyzer.

In the fusion/hybrid discrete analyzers (Figure 3), the sample, reagent addition, and color development are done in the disposable reaction wells. Final sample solutions from disposable reaction wells are subsequently transferred to a static flow-through cell using a peristaltic pump or a dispenser. The photometric measurement is done in the static flow-through cell. The function is somewhat similar to the flow injection analyzer or segmented flow analyzer, except the color development is done in a disposable reaction well. Because the final photometric measurements are done using the same flow-through cell, it must be rinsed thoroughly between the samples with deionized water or buffers before the next measurement. This substantially reduces the throughput. The fusion discrete analyzer system compromises on throughput, as well as, the cost of the disposable reaction wells, and the cuvettes. The fusion/hybrid systems have the possibility to change the path length of the flow-through cell to achieve lower detection limits, if necessary.

The Thermo Scientific™ Gallery™ discrete analyzer and the Thermo Scientific™ Gallery™ Plus discrete analyzer are true discrete or direct read discrete analyzers where in the sample, reagent additions, and final photometric measurements are done with the same disposable Thermo Scientific™ Decacell™ cuvettes. The workflow is easy to learn, train and maintain.

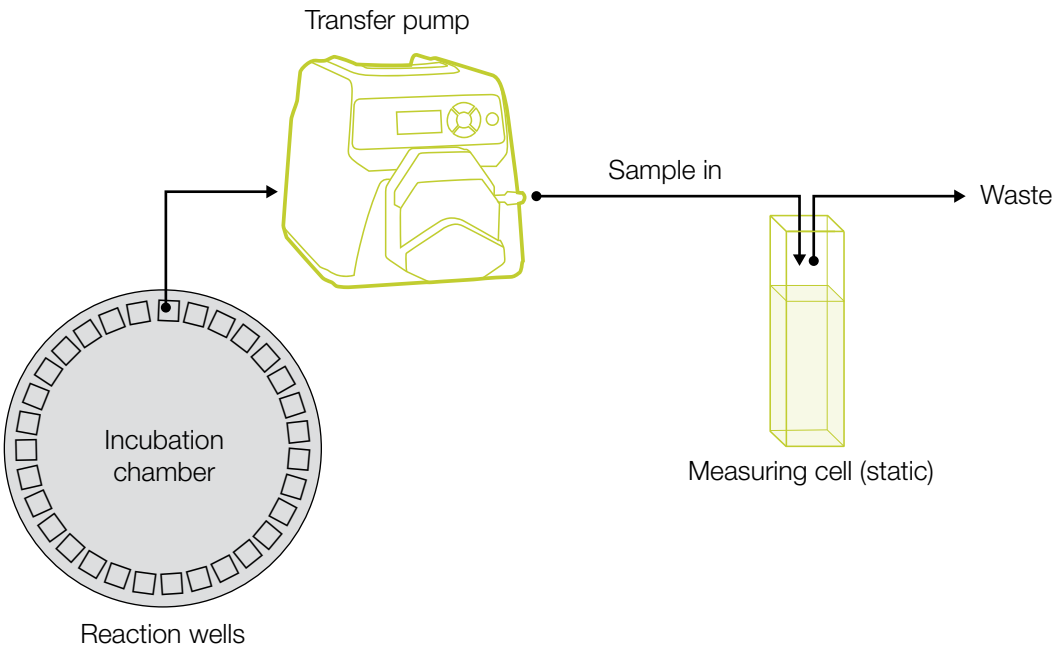


Figure 3. Hybrid discrete analyzer.

Table 1. Summary of discrete analyzers type and benefits.

	True discrete/direct read discrete analyzers		Fusion/hybrid discrete analyzers	
Advantages	• High throughput • No carry-over	• Blank, spiking, or dilution • Real time kinetic or activity measurement	• Static cell • Path length can be changed	• Improved sensitivity
Limitations	• Fixed path length • Cost of disposable cuvettes		• Cleaning between measurement • Carry-over effect	• Reduced throughput • Cost of disposal wells

2 Number of filters in a discrete analyzer and number of chemistries per sample

Every discrete analyzer has a photometric measurement setup with finite numbers of filters of specific wavelengths. The number of filters and wavelength of filters are an important technical feature to evaluate during the purchase phase as it can directly affect the lab's current and future application capability.

Few questions to gain insight are:

- How many filter positions does the instrument have?
- How many on-board filters does the instrument have?
- What are the wavelengths of these filters?
- How many chemistries can be performed simultaneously?
- Is there expandability with other filters?

The number and the type of chemical parameters that a discrete analyzer can perform simultaneously are directly dependent on the number of filters and their wavelengths. The wider the wavelength coverage, the greater number of on-board filters can increase the discrete analyzers throughput and application capability.

Discrete analyzers typically have 5 to 12 filters—equivalent to channels in flow analyzers—and are suitable for multiparameter analysis. Many of the entry level discrete analyzers have 5 to 6 on-board filters with limited wavelength coverage. Typically, these instruments are fit for few parameter analyses in a specific sample matrix, like wine or beer, and cannot be expanded for other feed water or waste water related applications. Once purchased, these instruments cannot be upgraded with additional filters.

Advanced discrete analyzers like the Gallery and the Gallery Plus discrete analyzers have 12 filter positions. And, depending on the configuration, have 9 to 11 on-board filters. The high number of on-board filters allows the Gallery discrete analyzers to perform up to 20 different chemistries simultaneously, depending on the applications. Based on the application needs, special filters can be ordered and upgraded in the field. This unique possibility makes the Gallery discrete analyzers future-proof as the lab can expand with new applications.

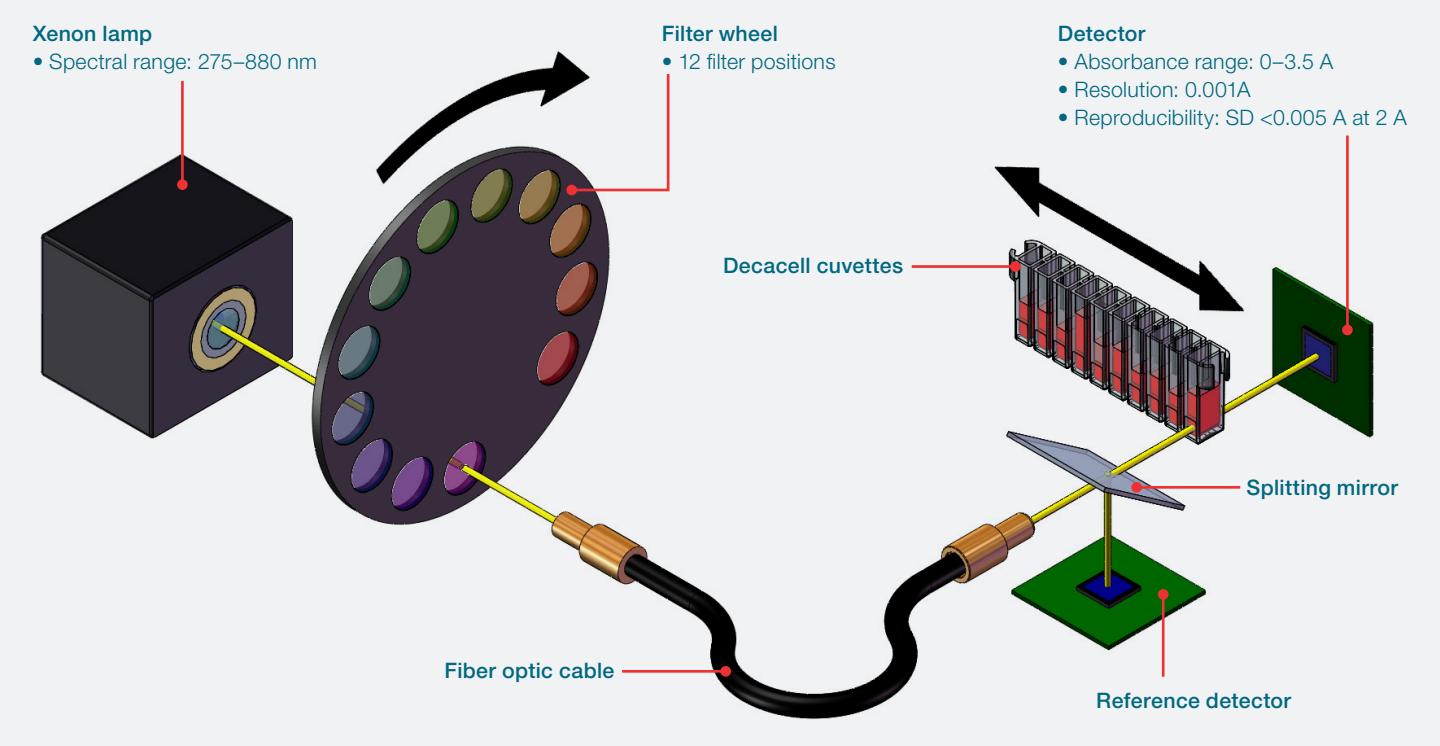


Figure 4. Gallery Discrete Analyzer—photometric measurement.

Table 2. Recommended filters for specific sample matrix.

Water	Wine	Juice	Enzymes/Food	Beer	Beermaster
—	—	—	—	—	275
340	340	340	340	340	340
—	—	—	405	405	405
420	420	420	420	—	—
—	—	—	—	430	430
480	—	480	—	—	—
—	—	492	—	—	—
510	510	510	510	—	—
—	520	520	520	520	520
540	540	540	540	540	540
575	575	575	575	575	575
600	600	600	600	600	600
620	620	620	—	—	—
660	660	660	660	660	660
700	700	—	700	700	700
—	750	—	—	—	—
880	—	—	—	—	—

3 Cuvette type: single-use disposable or reusable cuvettes

A conventional UV-VIS spectrophotometer utilizes reusable cuvettes made of quartz and are very expensive. High demand from the clinical industry has facilitated the development of disposable cuvettes. This revolutionary development is key for high-throughput wet chemical analysis and has increased result reliability. Being produced in bulk, the cost of single-use disposable cuvettes are negligible (6 to 7 cents), compared to the reusable quartz cuvettes and the productivity loss due to washing and cleaning the cuvettes between the measurements.

Advantages of single-use disposable cuvettes are:

- Precision and accuracy
- Improves throughput—no need for cleaning
- Improves result reliability—no carry-over
- Wide range of chemical parameters
- Reliable results across a wide concentration range
- High and low detection
- Peace of mind

Fusion/hybrid discrete analyzer systems use disposable chemical wells. However, the measurements are done using a static quartz cuvette and these hybrid systems have two limitations: **cost of the disposable wells and the carry-over effec**t. A detailed rinsing step between the measurement is mandatory, but it reduces the throughput substantially and the carry-over effect cannot be guaranteed.

Some of the direct read discrete analyzers use the washable and reusable cuvettes with dedicated washing stations. The dedicated washing stations wash the cuvettes after each measurement and the cleanliness of the cuvettes are tested optically, which does not guarantee the chemical cleanliness. The risk of carry-over cannot be ignored and adds additional system complications. The overall gain from the washing stations for reusing the cuvettes is negligible, due to productivity loss and carry-over effect. On the other hand, the disposable cuvettes, which eliminates the carry-over effect, improves the result reliability and provides peace of mind.

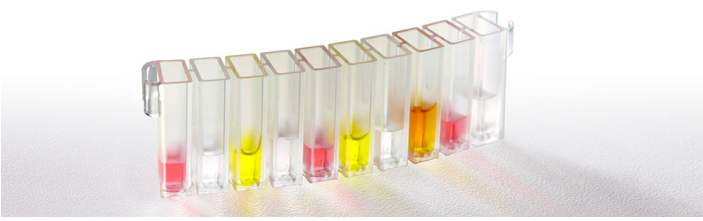


Figure 5. Unique disposable Decacell.

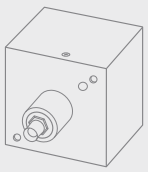
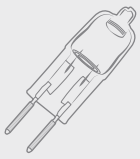
4 Source lamp type and lifespan

A source lamp is an important part of the discrete analyzer's photometric hardware setup. Spectrophotometer design, in particular the type of lamp and internal optical configuration used, contributes to varying performance characteristics which can influence the efficiency of a discrete analyzer. The source lamp ideally should cover a wide wavelength range, long service life, and low cost. Most of the discrete analyzers are equipped with Tungsten lamps as the source lamp and can cover only the visible range. Any measurement below 340 nm is not possible with a discrete analyzer that uses tungsten as the source lamp. To cover the ultraviolet (UV) range, a deuterium lamp is needed and are not used in discrete analyzers, meaning an application like bitterness in beer, which is done at 275 nm, is not possible with this type of discrete analyzer.

Discrete analyzers that use a Tungsten source lamp as the source lamp are considerably less efficient as it covers only the visible range. Furthermore, they must continue to operate during the entire instrument up-time. This contributes to shorter lifetimes and higher instrument maintenance costs. Depending on the usage, the Tungsten source lamp requires replacement in every six months, which can cost hundreds of dollars. Over the instrument's lifetime, which is typically 10 years, cumulative replacement expenses can me very expensive, assuming they are user replaceable and no associated service cost is involved.

Xenon source lamps cover an ultraviolet-visible (UV-VIS) spectral range. In this case, a Xenon flash lamp operates only for the duration of the actual measurement and it boasts the lifetime of the lamp and improves the total cost of ownership.

Table 3. Xenon and Tungsten lamp comparison.

Xenon source lamp	Tungsten source lamp
	
Long life ~ ten years • Saving over instrument lifetime • Less maintenance • Lifetime saving • Low cost of ownership	Short life ~ six months • Recurring expense • Increased maintenance • Stabilization time
Extended wavelength range • 275 to 880 nm • Expandable applications	Limited wavelength range • 340 to 880 nm • Limited applications

5 Additional modules: simultaneous and parallel analysis

Automated discrete analysis is a technique that utilizes colorimetric and enzymatic measurements of several analytes simultaneously from a single sample through photometric analysis. Optional modules for some discrete analyzers can also conduct electrochemical analysis for pH and conductivity, or bitterness in finished beer, through fully automated sample preparation and photometric detection. The option to perform simultaneous and parallel measurements of pH, conductivity, or bitterness of beer considerably improves the lab's throughput.

Entry level discrete analyzers provide only photometric measurements and some of the advanced integrated discrete analyzers offer modules for either pH, conductivity, cadmium reduction coil, or bitterness measurement.

Advanced integrated discrete analyzers like the Gallery and the Gallery Plus systems provide the option to expand with electrochemistry unit (ECM) for parallel pH and conductivity measurements. pH is a critical parameter for wine, beer, and other beverages, as well as, drinking water and sewage water. The ECM unit is capable of measuring 67 samples per hour for pH and conductivity, in parallel and simultaneously with other photometric measurements. Simultaneous and parallel pH and conductivity measurements help to consolidate the overall wet chemical analytical needs and enhances the lab's productivity.

6 Incubation temperature range and precision

Most of the wine, beer, food and beverage samples are tested using ready-to-use enzymatic reagents. Precise temperature control is critical in achieving reproducible results. Furthermore, if your applications involve measuring enzyme activity, enzyme kinetics, and enzyme assays that are commonly determined using a UV-VIS spectrophotometer, then a wide range of incubation temperature is critical. Wider incubation temperature allows the users to cover many different enzyme-related measurements with precise temperature control, incubation time, and reagent addition at specific intervals that are critical for these tests. Measuring enzyme activity is a precise job and can be influenced by many variables such as pH, temperature, buffer type, and ionic strength. Results accuracy is highly dependent on temperature stability. Just one degree temperature change can lead to a 4 to 8% variation in enzyme activity. For consistent and reproducible results, an enzyme assay should be carried out in well-defined conditions that can be duplicated in other laboratories.

Most of the discrete analyzers can perform measurement at a fixed incubation temperature at 37 or 40 °C. This posts a huge application limitation and suitability for enzyme related applications. With the Gallery discrete analyzer platform, the incubation temperature can be defined based on the chemistry needs from 25 to 60 °C. Precision temperature control prevents samples from overheating and the smart incubation feature automatically starts with low temperature samples, progressing to high temperature samples.

7 Software that supports workflow

Analytical labs need a reliable analytical instrument for multiparameter analysis that enables lab personal without technical or chemistry knowledge to carry out the routine wet chemical analysis. The software and instrument workflow, as well as, ease-of-use and walkaway freedom play an important role in the discrete analyzer selection.

It is important that the software meets regulatory requirements:

- Advanced user administration
- Audit trail
- Traceability
- Date and time stamped raw data

Other features to consider are:

- Automated calibration using single stock standard
- Automated startup and shutdown
- LIMS connectivity
- Barcode readers for reagents and samples
- Auto dilution of over-range samples
- Automated spike and recovery
- Automated standard addition for complex sample matrices
- Client-server version for easy method and data transfer

Many entry level discrete analyzers do not have barcode readers for reagents and samples or have LIMS connectivity, or they may be offered as optional component. It is a best practice to check these features as it helps to improve the labs productivity and traceability.

The premier benefits of the Gallery and Gallery Plus discrete analyzers are the built-in barcode readers for samples and reagents and bi-directional LIMS connectivity, which are standard features. The analyzer's easy-to-use, automated workflow allows laboratories to simplify their testing with the dual benefits of time and cost savings. All necessary analysis steps are automated, providing true walk-away time for the operator. The Gallery discrete analyzer consolidates and simultaneously tests up to 20 parameters—using a single instrument by a single operator. As a fully integrated walk-away solution, the testing workflow is easy to learn, can be left unattended, improves throughput, system uptime, and staff productivity. In addition, users have the method development freedom to use their own reagents that are defined in their standard operating procedure. An automated method development series helps the users to optimize the right measuring parameter that provides highest sensitivity and reproducibility.

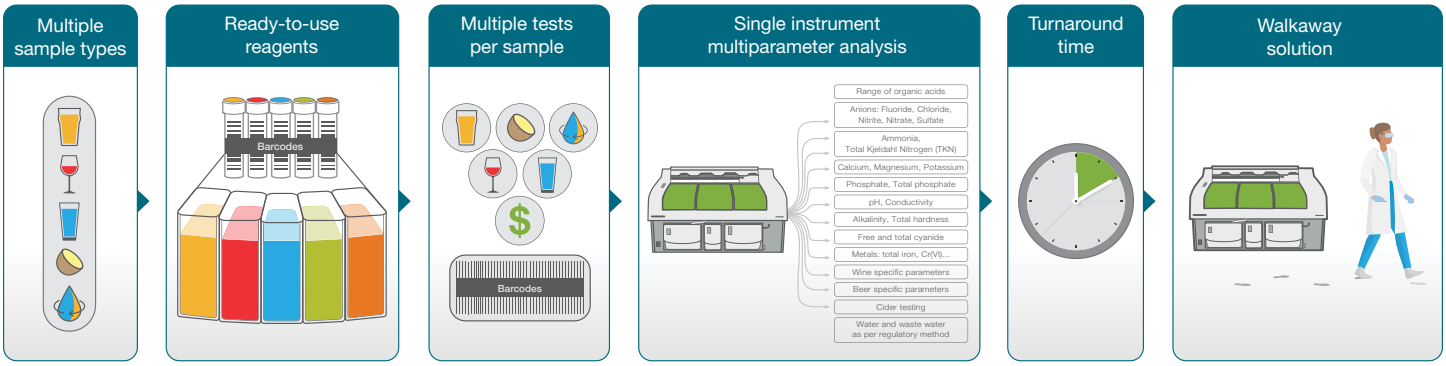


Figure 6. Multiparameter analysis—optimized workflow with the Gallery discrete analyzer.

8 Cost per analysis: smaller reagent consumption

Ready-to-use reagents and enzymatic assay kits are designed to be accessible for any user, including those without a specialized scientific background. Ready-to-use system reagents take away guess work out of analytical chemists and provides walk-away efficiency. From a small lab to a larger commercial testing lab that turns tens to hundreds of samples, the overall cost per analyte/analysis is an important consideration. There are many variables to be considered in the overall cost per analysis calculation; however, below are the variables directly related to the reagents.

- Cost of ready-to-use reagents and enzymatic assay kits
- Number of tests per kit
- Reagent consumption (mL) per test
- Disposal cost
- Cuvette cost (if it is disposable)
- Operator time (washing cuvettes if it is reusable)

The reagent consumption per test and the associated waste disposal cost are the two important instrument specific parameters. Reagent consumption is decided by the cell volume, which in turn is related to the sensitivity of the photometer.

The initial cost to purchase the entry level discrete analyzer or semi-automated spectrophotometer are less expensive than the integrated automated discrete analyzer. However, the cost per analysis for the entry level discrete analyzer or semi-automated spectrophotometer are 10 to 20 times higher than the integrated automated discrete analyzer. The entry level discrete analyzer uses 12 mm sample tubes or standard 1 cm cuvettes and consumes 10 to 20 times higher reagents volume, therefore the cost per analysis is higher.

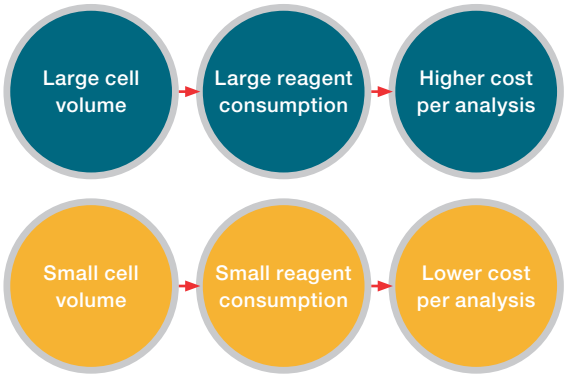


Figure 7. Cost per analysis comparison.

The Gallery discrete analyzers use the unique Thermo Scientific Decacell cuvettes technology, which allows laboratories to measure multiple analytes simultaneously while reducing total analysis and operator time. The unique low volume design of a 7 mm pathlength cuvette accommodates small sample and reagent volumes, minimizes reagent waste, and therefore reduces costs per analysis. The Gallery discrete analyzer consumes 2 to 240 µL of reagents and 2 to 120 µL of sample per test and, as a result, the cost per analysis is 10 to 20 times less than the traditional wet chemical methods. The cost of disposable Decacell cuvettes is insignificant when compared to confident results and improved lab productivity. The barcode reader improves the traceability and continuously monitors the reagent consumptions while providing real-time reagent information. Optimized kit sizes and on-board stability further minimize the amount of waste produced and increases cost efficiency.

9 Ready-to-use reagents, enzymatic kits, and flexibility to use in-house reagents

Ready-to-use reagents and enzymatic reagent kits are important in food and beverage, wine, beer, fruit juices, and environmental water analysis. As the reagents play an important role in a labs ability to respond to new application needs, it is critical to ask the following questions:

- How many ready-to-use reagents are offered by the discrete analyzer vendor?
- Does it fulfill regulatory methods such as AOAC, DIN, ASTM, USEPA, OIV, and SBC?
- Is the discrete analyzer system compatible with 3rd party reagents or enzymatic kits?
- Is the discrete analyzer an open system? Does it allow in-house reagents use?
- Can an existing flow analyzer or spectrophotometer methods be transferred?

Ready-to-use Thermo Scientific™ Gallery™ system reagents are available for over 50 different tests; however, with the flexibility of the Gallery discrete analyzer, it is also an open-system, which allows laboratories to use 3rd party colorimetric or enzymatic reagent kits. Users can develop new methods or adjust and optimize their existing flow injection analyzer or photometric methods. The smallest sample and reagent consumption aid an adapting Gallery platform when small sample sizes are to be handled, such as new breeding program for new barleys, allowing micro, and picomalting.[1]

10 Validation, training, and on-going support

Automated discrete analyzers involve sophisticated robotic liquid handling systems for reagent and sample transfer. These liquid handling dispensers, the photometric and additional electrochemistry modules need to be validated at the time of installation and periodically to fulfill cGLP and regulatory requirements. Installation qualification (IQ), operational qualification (OQ), and performance qualification (PQ) or instrument performance verification (IPV) services verify and document your instrument's ability to meet manufacturer design specifications for performance.

You are not only choosing a discrete analyzer, but finding a reliable organization to partner with who can support on-going training, application, and service support. It is highly recommended to check how the organization will support you with the following:

- IQ, OQ, and PQ documentation
- Certified installation by factory trained certified service engineer
- User-training during installation and on-demand
- Emergency service and turnaround time
- Preventive maintenance

Instrument qualification services performed by Thermo Fisher Scientific specialists provide you with a comprehensive documentation solution that includes rigorously tested protocols executed by a certified field service engineer. The qualification kit is supplied with the Gallery and Gallery Plus discrete analyzers to ensure your instruments and equipment meet global standards.

Summary

Consulting your current and future application needs with a product specialist is highly recommended when you are selecting a new discrete analyzer for your lab or replacing old flow injection analyzers and other wet chemical instruments. If necessary, requesting a product demonstration and testing a couple of your own samples can help to decide the right instrument and vendor to work with. Our Product Specialists are available to answer your questions. Contact us to schedule a product demonstration.

References

1. How discrete wet chemical analysis is bringing flexible, cost-effective multiparameter testing to the beverage industry executive summary: https://assets.thermofisher.com/TFS-Assets/CMD/Flyers/xx-73267-wet-chemical-beverage-xx73267-en.pdf.

thermo scientific

Top five reasons to consider a Gallery discrete analyzer

Accurate and reproducible results

- Disposable cuvettes (no carry-over)
- Fulfills many regulatory methods for wine, beer, food and beverage, drinking water, and environmental water analysis
- Sensitivity to ppb level

Easy-to-use walk-away solution

- Suitable for all users' levels
- Easy-to-train, use and maintain
- Software that supports workflow

Multiparameter high throughput analysis

- 12 filter positions and up to 20 different chemical parameters
- Parallel pH and conductivity or bitterness measurement
- Barcode reader for samples and reagents
- Disposable cuvettes (eliminates washing cycle)

Low cost-of-ownership

- Long life Xenon source lamp
- Lowest reagents and sample consumption
- Single instrument that covers a wide range of chemical parameters
- Suitable for variety of samples, variable incubation temperature from 25 to 60 °C

Cost per analysis

- 10 to 20 times lower than traditional methods
- Unique small volume cuvettes, reduced sample and reagent consumption (2–240 µL)
- Frees up lab resource

Find out more at **thermofisher.com/discreteanalysis**

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