Improving Return on Innovation in Gas Chromatography

Incremental Economic Value of the Agilent Intuvo 9000 GC System

White Paper

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Introduction

For quite some time, the field of gas chromatography had been considered relatively mature. That is, until recently. Innovations embodied in the Agilent Intuvo 9000 GC system represent a paradigm shift in how much easier gas chromatography can now be done[1], and how much the productivity and the economics of the GC lab can be improved.

The Intuvo innovations include a direct heating system, which is faster, uses half the power, and takes half the bench space of a conventional air-bath oven. Ferrule-free direct connections with a plug-and-play flow path eliminate a major source of complexity and leaks. A unique disposable Guard Chip eliminates the need for column trimming. When considering an Intuvo investment, it is helpful to estimate what economic value the Intuvo innovations unlock.

In this paper, we illustrate how Intuvo can present well over US $50,000 of incremental economic value compared to a conventional air-bath oven GC system, even in the first year. This can result in an improved ROI, or return on innovation, for the GC lab manager. It can be an important criterion for justifying asset management decisions as lab managers strive to optimize and refresh their instrument asset base.

The Value of Leak-Free Connections

Challenge

Many GC lab managers complain that unplanned downtime, due to leaks resulting from faulty GC connections, is a major source of productivity loss for their labs. They also express frustration at how difficult it can be to properly train an operator to make cumbersome ferrule-based connections correctly. The old rule *finger tight and quarter turn* helps, but the uninitiated often think if a quarter turn is good, a whole turn must be that much better. Not so.

Insidious leaks are often not detected until a major portion of a batch of samples are run, only to find that QC checks are not passing. Disrupting workflow to troubleshoot leaks in the flow path, to repair, verify, and then rerun the batch, are productivity losses that threaten on-time delivery of results. Losing precious samples that are difficult, if not impossible, to replace can be worse than the productivity loss itself.

Innovation

The use of nuts and ferrules to make flow path connections is eliminated with Intuvo. Instead, direct, face-to-face Click-and-Run connections are made simply with one click of a torque driver. The audible and tactile click tells operators they have successfully made a leak-free connection. Automatic leak detection, unique to Intuvo, also provides continuous assurance that the connection was made correctly as the batch proceeds.

Economic value

Ensuring lab managers that they can deliver results with confidence day to day, and plan their workflow without disruption, are enormous benefits of eliminating unplanned downtime resulting from faulty flow path leaks. This reduction of business uncertainty has tangible value to a busy lab (Table 1).

Expressing this value in economic terms depends on the structure of the enterprise the lab serves, but it is fair to say that significant time is wasted annually by many GC labs to resolve connection leaks. Many lab managers lament that they can easily spend 6–8 hours or more per quarter troubleshooting and remediating flow path leaks. Six hours per quarter represents the time that could have been used to run an additional 72 samples per year. Most managers can relate to the productivity improvement and the economic value of running 72 additional samples.

If a lab were a service lab that could charge $125/sample, which is not uncommon in the environmental market, 72 samples represents $9,000 incremental revenue annually. Many environmental labs have largely fixed human resource and infrastructure costs, so a significant portion of that incremental revenue can fall to the bottom line. Even if the revenue derived a 20 % profit margin, the lab would gain $1,800 of incremental profit annually.

Table 1. Economic value of avoiding leaks with an Agilent Intuvo 9000 GC.

Parameter	Value
Number of times troubleshooting leaks	2 per quarter 8 per year
Hours to troubleshoot, remediate, verify, and repeat runs	3 hours per incident 24 hours per year
Cycle time for EPA 8270D method run	20 minutes per sample
Incremental samples that could be run by Intuvo	72 samples per year
Revenue	$125 per sample
Incremental revenue, Intuvo	$9,000 per year
Profit margin	20 %
Incremental profit, Intuvo	$1,800 per year

The Value of Fast Direct Heating and Cooling

Challenge

Minutes matter to many GC labs. Police labs say they need fast results to support either detective or prosecutory cases. Service labs know they can charge premium rates if they turn samples around faster. The more billable samples they can run per day, the higher the profit they can turn. QA labs do not want to threaten production flow. They want to be sure their ability to report QA results is not a rate-limiting step in revenue generation. R&D labs are often under pressure to support a failed process or quality problem where product shipment and revenue are at stake, and are often put into a position of needing results fast. To many enterprises, time-to-result can mean tens to hundreds of thousands of dollars an hour – so getting answers fast can mean big money.

Innovation

Increasing the heating and cooling rates for the GC sample flow path decreases the cycle time between injecting one sample and reaching ready status to run the next sample. Intuvo achieves this throughput improvement by means of an innovative, fast direct heating and cooling system. Unlike conventional air bath oven GC systems, an Intuvo column can be heated at rates as high as 250 °/min, and cooled 1–2 minutes faster, while using half the power consumption, half the space, and placing half the demand on the lab HVAC system.

Economic value

Lab managers globally recognize the importance of valuable lab bench space. Many operations do not have the funding or resources to expand, or might not be able to secure the necessary permits and licenses to expand chemistry lab space. However, many are expected to increase productivity nonetheless. Allowing enterprises to increase their productivity without having to expand lab space is a great value (Table 2).

There is also a cost saving on electrical power consumption using Intuvo. Using a typical 20-minute method for measuring pesticide residues in food as an example[1], the energy needed to run one chromatographic cycle with Intuvo was measured at 0.105 kWH, while that measured for a conventional air bath oven running the same method was 0.228 kWH – over twice as much.

At US $0.12/kWH, the conventional system would cost an estimated US $492, while the cost for Intuvo would be US $227, an annual savings of US $265. If the application were a fast-GC method such as total petroleum hydrocarbon analysis (TPH) of environmental samples, or simulated distillation analysis of petroleum products, these savings could be as much as 2–3 times more. This may not seem like a lot until you consider the total savings over the lifetime of the instrument, which can be 10–15 years.

Although these cost savings are certainly tangible, many consider how the energy and space savings of Intuvo can help them achieve rigorous corporate carbon footprint, and more important, sustainability goals (Table 3).

Economically speaking, reducing cycle time, sample to sample, by even a few minutes, can have enormous value to many GC labs. For example, for a lab that is running US EPA 8270, determination of semivolatile organic compounds (SVOC) in soil and sediments[2], with a chromatographic cycle time of approximately 20–25 minutes, speeding up cycle time by only 90 seconds can easily allow 3–5 more samples to be run per day.

Even if the lab were only to run one more single sample a day, 5 days a week, 50 weeks per year, it would mean that 250 additional samples could be run per year. This is a productivity gain anyone can relate to in the context of their own lab.

If the lab charged $125/sample, an additional 250 samples would represent an incremental revenue of $31,250 annually. Although much of this incremental revenue might flow to the bottom line, if operating at a 20 % profit margin, the lab would recognize as much as a $6,250 incremental profit potential.

Table 2. Energy savings with an Agilent Intuvo 9000 GC.

Parameter	Value
Power per pesticide run, Intuvo	0.105 kWH
Power per pesticide run, Conventional	0.228 kWH
Pesticide run time	20 minutes
Number of runs	72 per day
Instrument usage	50 weeks per year 5 days per week
Energy used, Intuvo	1,890 kWH
Energy used, Conventional	4,104 kWH
Energy cost	0.12 per kWH
Energy cost, Intuvo	$227 per year
Energy cost, Conventional	$492 per year
Energy Intuvo/Energy Conventional	46 %
Energy cost savings, Intuvo	$266 per year

The Value of Eliminating the Need for Column Trimming

Challenge

Trimming a capillary column to remove contamination by sample matrix material is a common time-consuming maintenance task for a GC lab. Unfortunately, column trimming is a process that requires considerable skill and time to do correctly. Many labs assign the task to only a select few individuals who have proven to have sufficient skill, lest the job be done wrong. Often, an improperly performed column trim is only detected well into a sample batch when QA-checked samples fail to meet their criteria. This not only results in unplanned downtime, and having to rerun the sample batches, but it also can result in losing precious samples. These are productivity losses that lab managers want to avoid.

An unfortunate result of trimming the analytical column is that its length is reduced each time it is trimmed. Reducing the length causes two problems. First, the chromatographic performance of the column degrades as its length decreases. Secondly, when the length of the column changes it causes shifts in analyte retention time. This in turn requires an adjustment of operating conditions to realign retention times. This can take quite some time to perform – time that could otherwise be used to run samples.

Innovation

Intuvo eliminates the need to trim the analytical column by using a disposable Guard Chip between the inlet and the column. This Guard Chip acts as a retention gap to trap unwanted high molecular-weight material, keeping it from depositing on the column. This unwanted material would otherwise contaminate the column, degrading its performance and ultimately its useful life.

Table 3. Economic value of an additional environmental sample per day.

Parameter	Value
Additional samples run	1 per day
Time period	5 days a week 50 weeks per year
Incremental samples run by Intuvo	250 samples per year
Revenue	$125 per sample
Incremental revenue, Intuvo	$31,250
assumed profit margin	20 %
Incremental profit, Intuvo	$6,250

The Guard Chip can be changed in just approximately 3–5 minutes, compared to 20–30 minutes to trim and reinstall a conventional column. Changing the Guard Chip also avoids the troubleshooting and remediation downtime often associated with leaks that can result from removing, trimming, and reinstalling the column improperly. Equally as important, retention times shift after trimming a column, requiring at least 20–30 minutes to readjust retention times and confirm the operation. In contrast, retention times do not shift when replacing the Guard Chip, saving considerable time.

An additional benefit of the Guard Chip is that it can extend the lifetime of the analytical column by avoiding deposition of damaging matrix material on the column. Imagine a 30 m column the day it is installed, remaining a 30 m column to the day it is retired.

Economic value

To estimate economic value for Intuvo, let us assume an environmental lab runs an SVOC analysis of soil extracts using EPA Method 8270, and takes 20 minutes to run the chromatogram. Compare running this analysis on Intuvo to running with a conventional air bath oven GC (Table 4).

To be conservative, assume 5 minutes to change an Intuvo Guard Chip, 20 minutes to trim a conventional column, and 20 minutes to relock retention times on the conventional GC. Typically, the column is trimmed twice a week. Many labs find that they actually have to re-adjust retention times every time they trim, but this depends upon the length trimmed, which varies from lab to lab. Conservatively, assume that retention times are only adjusted after every other column trim on the conventional GC.

Even by this conservative estimate, over the course of a year, Intuvo requires about 6 times less maintenance. This translates into an additional 125 samples that could be run on an Intuvo per year. At $125/sample, this translates to a net $7,625 revenue after including the cost of the Guard Chips, or $1,525 in incremental profit at a 20 % margin.

Now consider the value of column life extension. Extended column lifetime is typically observed when using retention gap technology. In our applications lab running the EPA 8270D application, as well as running methods to determine pesticide residues in foods, we found that the Intuvo Guard Chip could extend the life of the analytical column by as much as 2 weeks. So, if a conventional column lasted typically 4 weeks, an Intuvo column could last up to 6 weeks. This method specifies that the GC needs to be recalibrated after significant maintenance is performed, such as changing the analytical column. Therefore, an important outcome of extended column life is a reduction in the frequency at which the GC needs to be recalibrated, which can be very time-consuming – up to 6–8 hours each time.

The lifetime of the analytical column will vary from lab to lab depending on the specific analytical method, and especially on the type of samples injected into the GC. However, in the environmental and food applications mentioned above, if the Intuvo column lasts 6 weeks versus 4 weeks for a conventional column, recalibration would only have to be done 8.3 times per year with Intuvo, versus 12.5 times with a conventional GC.

To estimate economic value, let's assume a typical recalibration cycle for these methods could take 6 hours to complete every time a new column is replaced. This means that Intuvo saves 25 hours of recalibration time, which translates to an incremental 75 samples (with a 20-minute cycle time) that could be run. This translates into an incremental $9,375 revenue, or $1,875 profit for Intuvo (Table 5).

Table 4. Economic value of eliminating column trimming.

Parameter	Value
Time to change a Guard Chip	5 minutes
Time to trim conventional column	20 minutes
Time to re-adjust retention times	20 minutes
Chromatographic run time	20 minutes
No. column trims, or Guard Chip changes	2 per week
Retention time relock every	2 trims
Retention time relock frequency	1 per week
Guard Chip maintenance time, Intuvo	10 minutes per week
Column trim maintenance time, Conventional	60 minutes per week
Maintenance time saved for Intuvo	50 minutes per week 50 weeks per year
Time saved by Intuvo	2,500 minutes per year
No. additional samples that can be run by Intuvo	125 per year
Revenue per sample	$125
Incremental gross revenue opportunity for Intuvo	$15,625
Number of Guard Chips used	100 per year
Guard Chip price	$80 US List price per chip
Total cost of Guard Chips	$8,000 per year
Net incremental revenue opportunity for Intuvo	$7,625 per year
Lab profit margin	20 %
Net profit margin opportunity for Intuvo	$1,525 per year

Table 5. Economic value of reduced recalibration due to extended column life.

Parameter	Value
Recalibration time	6 hours per column change
Example GC method	US EPA 8270D
Intuvo column lifetime observed in this example	6 weeks
Conventional column lifetime observed in this example	4 weeks
Intuvo recalibrations	8.3 per year
Conventional column recalibrations	12.5 per year
Recalibration time per year, Intuvo	50 hours per year
Recalibration time per year, Conventional	75 hours per year
Recalibration time saved, Intuvo	25 hours per year
Incremental number of samples, Intuvo	75 per year
Incremental revenue, Intuvo	$9,375 per year
Profit margin	20 %
Incremental profit	$1,875 per year

Incremental Economic Value of Agilent Intuvo

These few examples illustrate how the transformational innovations of Intuvo could provide over US $50,000 in annual incremental economic value – a much better ROI, or return on innovation, compared to conventional GC systems.

It is especially important to note that the cost of labor, especially for maintenance procedures not required by Intuvo but required by conventional GC systems, are not considered in these examples, because of the high variability in labor rates. However, this savings can easily be calculated using the times presented above, and are likely to fall in the range of tens of thousands of dollars per year. Additionally, the total incremental value illustrated is achieved each year the system is put into use. The lifetime of an Agilent GC is typically 10 or more years. So, it is easy to see how significant the total return on investment can be – several hundreds of thousands of dollars over the lifetime of the instrument.

It is also worth considering that one of the biggest values of Intuvo is the reduction in business uncertainty resulting from unplanned downtime. Providing more consistent and predictable business results, day to day, especially between operators, or between operational sites across the globe, can help ensure business continuity and productivity. This can be one of the most important returns on an Intuvo investment.

Table 6. Estimated economic value of using an Agilent Intuvo 9000 GC.

Innovation	Attribute	Estimated economic value
Guard Chip	Elimination of trimming maintenance	$7,625
	Reduction of recalibration time	$9,375
Click-and-Run connections	Avoiding connection leaks	$9,000
Direct heating	Lower power consumption	$266
	Improved cycle time	$31,250
	Total incremental economic value per year	$57,516

References

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