

History of INFICON HAPSITE



1996



2002



2005



2008



2008

From Classic to ER: A Brief Report on the Differences between HAPSITE® Iterations

By Craig Crume

Welcome to the first of several articles about high end Commercial Off The Shelf (COTS) equipment. There are a wide variety of choices in field analytical equipment, and it is not always obvious which piece of equipment is best for which application. The focus of these articles will be to shed some light on what is currently available and what may be coming in the near future.

This time the focus is the INFICON HAPSITE® GC/MS. The HAPSITE® was introduced in 1996 and was the first truly portable, downrange Gas Chromatograph/Mass Spectrometer (GC/MS). Before the HAPSITE®, the closest field GC/MS weighed in at a mere 70lbs and required a marine battery on a cart for power. The HAPSITE® raised the bar that has yet to be bested by coming in at less than 40lbs with the battery. It even has a shoulder strap and an optional backpack.

For some background, I have been using, training and supporting users of the HAPSITE® since the beginning in 1996. I have used this instrument on many environmental projects and have analyzed thousands of samples. Prior to seeing the light and moving to the field, I managed a fixed laboratory and have used most brands of GC/MS systems. KD Analytical has trained hundreds of people and been a primary supplier of Technical Support for the military for over 6 years.

INFICON achieved this breakthrough portability through the use of an innovative GC column heating approach and a chemical (rather than mechanical) pumping system for its vacuum source. Perhaps the most interesting aspect of this instrument is that for the first time, high end chemical analyses could be performed at the incident by First Responders. Before the HAPSITE®, First Responders used simple direct read equipment. First Responders then had to collect samples to send to a laboratory for high end confirmation.

Author's note: To keep this to the length of an article instead of a dissertation, I am avoiding a detailed discussion of the merits of hand-held direct read equipment compared to high end COTS. This will most likely be its own article in the future. For now, suffice it to say that most equipment has a useful function used correctly for the right situation. There will always need to be more than one tool in the toolbox.



HAPSITE Classic

Introduced 1996

This is the original that started it all.

Some of the innovative features that set this instrument apart were:

- Chemical pump (NEG) weighing about 5lbs used to maintain vacuum instead of the mechanical turbo/roughing pump combination weighing in over 30lbs all by themselves.
- GC column oven less than a tenth the size of a benchtop GC.
- Onboard gases.
- An onboard swappable battery.
- Front panel startup, method selection, and reporting.
- Operation downrange (even in light rain).
- Wipe down decontaminatable.
- Survey mode that bypasses the GC for direct MS screening.
- Integrated Internal Standard gases for tuning and Quality Control.

A few years after introduction of the classic, INFICON added a headspace module to increase capabilities to include water and soil analysis.

With this impressive list of innovations, the HAPSITE® became the only way to perform air, water and soil analyses – right? Yeah, not so much. GC/MS instruments were (are) complicated and required a chemist with years of experience to master. It turned out that these chemists were perfectly happy working in the lab. They weren't rushing to get in the field. Geologists, Engineers and Field Techs weren't able to invest the time required to get good at the instrument. Mobile labs already in the business typically bought used laboratory instruments that were a third the cost of a new HAPSITE®. They also didn't have to convince a regulator that a 40lb GC/MS with a shoulder strap was the same as a laboratory.

That was unfortunate. I enjoy the flexibility of the HAPSITE®. It gave me the capability of responding to any need the customer had. I could do projects that were one day or 10 months. I could run out of a trailer or on top of a roof. I covered sites all over the world. I routinely performed projects that were fully validated as laboratory quality results using EPA's strictest criteria. In every way the HAPSITE® performed as billed.

So it turned out that the HAPSITE® was a great instrument, but for a specialized market segment. The instrument was created for the EPA's Clean Air Act. This legislation targeted a list of chemicals called the

Hazardous Air Pollutants (HAP) list. In fact, that is where the HAPSITE® got its name – Hazardous Air Pollutants on SITE. It was thought that emissions from factory sources would have to be analyzed as individual chemicals. It turned out that emissions could also be counted as a total value which source testing firms could do with existing equipment.

Around 2000 to 2001, the National Guard Bureau (NGB) stood up Civil Support Teams – Weapons of Mass Destruction (CST-WMD) in each of the 10 primary FEMA regions across the country. These teams were specifically designated to respond to terrorism threats. Their analytical capability was largely based on COTs equipment instead of “green gear”. The HAPSITE® was chosen as a primary response instrument for both the Survey and Science sides of the teams. NGB has expanded this program to have 57 CST-WMD Teams with 1 to 2 in each state and every US territory. While other DoD entities were also getting the HAPSITE®, the NGB was most likely the start of the major shift from the instrument being used for mainly for environmental projects to focusing on Emergency Response. Part of this shift included INFICON responding to requests to improve the detection limit capabilities of the HAPSITE®.

HAPSITE® Legacy (Gen2)

Introduced 2002



INFICON improved the sensitivity and response time of the instrument by making a few very important modifications. The first was a new GC column oven. The new oven involved directly heating the column itself by incorporating a heating wire with the column before it was coiled, so that heat is directly transferred to the column itself rather than just to the surrounding oven. This allowed the temperature of the column to be ramped during the analysis. This shortened run times, increased the range of volatile chemicals that could be analyzed and improved

chromatography and peak shape.

The second innovation was to incorporate a concentrator into the system. The new concentrator allowed the user to improve detection limits to well below requirements for chemical agent analysis. In some cases, detection limits were well over an order of magnitude more sensitive than any direct read equipment.

Other DoD branches including the Air Force, Navy and Marines found that the HAPSITE’s low detection capabilities for chemical agents were well below direct read devices and added the HAPSITE® as part of their response capabilities. Most notably, the Air Force placed HAPSITES on most bases around the world.

The military took advantage of these lower limits to improve the overall usability of the instrument by developing a series of methods, known as the JPMSEG methods, designed to provide qualitative and quantitative results specifically based on their needs.

After 9/11, Homeland Security provided grant money to many state and local agencies to purchase equipment like the HAPSITE®. The HAPSITE® quickly became part of any well equipped Responder's equipment fleet. This was a little too big of a step for most Responders that were used to direct read equipment than a full GC/MS. As a result, the instrument was quickly relegated to "door stop" status in the First Responder community for anyone who did not have the time, sustainment money or training to properly use the equipment. Those who did learn, upkeep, and utilize their instruments correctly found them to be very much primary analysis instrument on most responses. The DoD groups like the Air Force, NGB and Navy also found that their success was directly linked to how much attention they paid to the equipment.

Author's note: While I have been around during the entire evolution of the instrument, I am not the official historian for the HAPSITE®. I may be slightly off on who got what when. The key element is that this began the shift from an environmental instrument to a first response instrument.

With new DoD methods and increased sensitivity, the HAPSITE® had become the gold standard of downrange analysis. The bulk of the users were not analytical laboratory spectroscopists, so while decision makers saw the benefits of the instrument, the user community was still frustrated by the difficult user interface and software. After several years in development, INFICON attempted to address user concerns by introducing the HAPSITE® Smart.

HAPSITE® Smart

Introduced 2005



The Smart upgrade improved usability of the instrument in a number of ways and has significantly improved user satisfaction. The Smart had very few hardware changes. It was primarily focused on the software and user interface. The front panel was modified to be a larger display and added a real time chromatogram with real time library searching and reporting. Prior to this, the user would have to wait until the end of the run to see if anything was present and what the substance might be, unless they were connected to the computer. Another big change

was that the Autotune program was fixed so that it worked properly and was incorporated into the normal startup.

The startup was also updated to take the instrument through the entire process up to being ready to run a sample. Prior to this, the user had to perform multiple steps to get the instrument ready. The computer software was the biggest change and was completely redesigned from the ground up. Individual programs were integrated into one interface and sample review was greatly simplified. One of the other significant changes was more behind the scenes. An extended standby was added to significantly improve the life of the consumables including the NEG pump and carrier gas. These are two of the more expensive operating costs and are often the most frequent causes for instrument failure. This change alone resulted in significantly improved up time and time between NEG pump changes.

INFICON has announced that the SMART has been obsoleted as of Spring of 2008. They will continue to support it as long as they can get parts which will likely be several years. Users will need to upgrade their Smarts to a Smart Plus or purchase the new HAPSITE® ER.



HAPSITE® Smart Plus

Introduced 2008

To update the Smart, INFICON introduced the Smart Plus upgrade. This included some hardware changes and completely revamped the front panel user interface. The hardware changes include reducing the number of boards and improving the connection of those boards.

INFICON also added a USB port to replace the floppy drive and added wireless capability. The front panel was changed to a color touch screen, and the functionality was significantly improved. New front panel features includes a direct link to the NIOSH safety database and a Probe distance indicator with a “Survey to Analyze” capability. This capability allows the user to use the direct read Survey mode to determine how far to keep the probe from the sample to get the best representative analysis. Once this is determined, the user can press the analyze button to perform a full GC/MS analysis of the sample without saturating the instrument. Another improvement is that the system automatically determines if a concentrator is present and runs a concentrator cleanup run as part of the startup.

Several Program Managers have expressed that when it comes to the HAPSITE®, they are starting to suffer from “upgrade fatigue”. It seems like every few years a key upgrade came out that required more money, time and training. There are some instruments still in active use (including one of ours) that are more than 10 years old but kept running by getting upgrades as available. INFICON’s latest improvements are the first that can’t be upgraded but instead will require the purchase of a new instrument. It should be noted that INFICON has not announced a date or plans to obsolete the HAPSITE® Smart Plus.



HAPSITE® ER

Introduced 2008

The latest incarnation of the HAPSITE® is the ER. Besides changing the color from the familiar yellow to a military green, the big focus on this platform was to increase the range of chemicals the instrument could detect. According to INFICON, the ER can detect chemicals with boiling points as high as 300°C where the Smart Plus topped out at about 250°C. They achieved this primarily by removing the precolumn,

shortening the analytical column and getting rid of some inherent cold spots in the system. The ER is also supposed to allow for some additional inlet options coming in the future. Another behind the scenes feature is better management of the NEG pump that may at least double the life of the pump.

INFICON plans to include quantitative methods as part of the default package. The DoD have been using their own JPMSEG methods on the HAPSITE® built for identification and quantitation of chemical agents and Toxic Industrial Chemicals (TICs) all the way back to the Gen2. If the military wants to upgrade to the ER, they will not be able to use the JPMSEG methods that went through a rigorous interagency validation process. I am not sure what plans INFICON has to validate their own methods to a similar level as the JPMSEG methods, but it won't be a straight across replacement until the validated methods are in place. To be fair, any manufacturer with a potential replacement for the current system faces the same challenge.

First Responders, however, should benefit from INFICON's included methods. They did not have access to the military methods. Anyone using any quantitation method should remember to put the appropriate caveats on any results provided.

We have had a little bit of time on the ER and so far the results are good. The ER seems more reproducible and sensitive than before and carryover has been reduced. We look forward to putting the instrument through its full paces in the future.

Summary

I was a fan the first time this instrument was demonstrated to me, and I am still a fan. This instrument has amazing capabilities in a relatively small package (compared to a benchtop GC/MS). It has become a key part of the country's response capabilities. The portability, front panel and Smart software are putting instrumentation that was previously only for laboratory chemists with at the incident where the results can have an impact. Portable GC/MS won't replace the need for fixed laboratories, but they can provide more and better information to make better decisions quicker.