# Testing & Evaluation Report Form

Report Date: 11/28/2007

## Project Information

Title: Griffin 450 GC/MS Evaluation
Evaluation Type: Instrumentation
Stakeholder(s): Griffin Analytical Technologies, NFSTC Mobile Laboratory Project
Start Date: 8/8/2007  End Date : 10/4/2007

## Manufacturer Information

Manufacturer: Griffin Analytical Technologies, a business unit of ICx Technologies
Address: 3000 Kent Avenue, West Lafayette, IN 47906
Contact Person: John Grossenbacher, Ph.D.
Phone Number: 765-775-1701 Ext. 113

## Evaluation Overview

The National Forensic Science Technology Center (NFSTC) conducted a six week in-depth assessment of the Griffin 450 all-in-one field portable gas chromatograph mass spectrometer (GC/MS). The purpose of this performance evaluation was to determine and establish the suitability of this chemical analyzer for use in the analysis and identification of forensically relevant chemical compounds. The samples used during this assessment were selected to be a representative subset from each of the following forensic classification groups: drugs of abuse, ignitable liquids, and explosives.

While performing over 150 manual injections of these types of compounds, the following observations were noted:

- The instrument exhibited an external as well as an internal appearance of ruggedized engineering dynamics
- The Griffin 450 GC/MS possessed a small bench top foot print, which allows for its usage in areas of limited work space
- Unit power up to sample injection time was noted to be approximately 30 minutes. Typical GC-MS systems require lengthier pump down times to remove residual air and water before sample injection can occur
- The graphical user interface (GUI) of the Griffin System Software (GSS) was quite intuitive; it was also configurable, which provides for the restriction of access to users of different levels of expertise
- The instrument is capable of performing real time snap shot analysis of unknown spectra, allowing the identification of the unknown compound through direct library spectral comparison. The Griffin system software incorporates the AMDIS, NIST, and/or a user defined compound library to create an

extensive searchable spectral database of compounds
- The instrument performed adequately for the analysis and identification of drugs, ignitable liquids, and explosives. Strengths, opportunities for improvement, and instrument limitations are documented below

## Evaluation Team

Joan Ring
NFSTC Laboratory Manager

Kirk M. Grates
NFSTC Physical Analytical Scientist

Carrie Sutherland
NFSTC Senior Physical Scientist-DNA Specialist

## Product Specifications

Photos


Product Name: Griffin 450
Model No.: 450
Serial/Lot No.: 450-00103

Brief Description

The Griffin 450 is a small bench top chemical analyzer that has been manufactured with a hardened aluminum outer casing and ruggedized internal components. These enhanced engineering specifications allow for the safe transportation and dependable utilization of the instrument in either a traditional or mobile laboratory environment.
By directly coupling a gas chromatograph (GC) to a mass spectrometer (MS) detector, this all-in-one GC-MS instrument can separate and identify individual compounds from complex sample mixtures originating from gas, liquid, and solid matrices.
The GC portion of the Griffin 450, utilizing differences in affinity of each component for the fused silica of the capillary column, is responsible for the separation of each of the individual sample components. As each component exits the column into the MS detector, the compound is ionized and fragmented. The Griffin 450 mass spectrometer is based on an innovative ion trap technology design known as Cylindrical Ion Trap (CIT), which is capable of scanning ion fragments within the mass range of 40 to 425 m/z. Final compound spectra,

composed of ion fragments, can be searched against a spectral database(s).

Product Uses

The Griffin 450 GC/MS can be used to identify chemical warfare agents (CWA), industrial chemicals, explosives, or other organic compounds.

Dimensions: 19.2 in x 19.2 in x 21.1 in
Weight: 85 pounds
Storage Conditions: Not applicable
Operational Conditions: 5 to 40 degrees Celsius, Less than 85% relative humidity
Power Requirements: 100-120/220-240 volts
Cost: $80,000 - $85,000

## Evaluation

Objectives

- To assess the Griffin 450 GC-MS for forensic applications in the analysis and identification of:
  - Drugs of abuse and common diluents
  - Ignitable liquids
  - Explosives
- To build a drug library
- To provide user feedback from operators of different levels of expertise

Instrument setup performed by:
☐ Manufacturer ☑ Manufacturer & NFSTC Laboratory Staff ☐ NFSTC Laboratory Staff Only

Instrument Setup Comment(s)
The instrument arrived packaged in a lockable hard-plastic foam lined case housed in a wooden crate.

The following components were provided with the Griffin 450:

- Dell Latitude D820 laptop computer equipped with Windows XP
- Griffin System Software Professional (Version 3.2 beta 4)
- A hardware and software user manual
- Accessories and spare parts

The instrument was placed on a laboratory bench and connected to power, BIP helium carrier gas, and the laptop computer. Once communication was established between the instrument and the PC, the 'power up' sequence was executed. It took approximately 30 minutes for the instrument to reach operational readiness. Setup of the Griffin 450 was very intuitive and quick, requiring minimal assistance from the manufacturer.

Minimum Skill Level of Operator as Set By Manufacturer
☑ Non-Scientist ☐ Technician ☐ Scientist

## Standards, Controls and Samples Used In Evaluation

| Controlled & Non-Controlled Substances | |
|---|---|
| Alprazolam | Hydromorphone |
| Amitriptyline | Ketamine |
| Amphetamine | Lidocaine |
| Benzocaine | MDA |
| Benzphetamine | MDEA |
| Caffeine | MDMA |
| Carisoprodol | Meperidine |
| Chlordiazepoxide | Methadone |
| Clonazepam | Morphine |
| Codeine | NFSTC Drug Test Mix (Methamphetamine, Benzocaine, Cocaine, Diazepam, Testosterone proprionate) |
| Ephedrine | Niacinamide |
| Fentanyl | Oxycodone |
| Flunitrazepam | Delta 9 Tetrahydrocannabinol |
| Herion | Triazolam |
| Hydrocodone | |

| Ignitable Liquids | |
|---|---|
| C11 | Kleanstrip Liquid Sand Paper |
| Carbon Disulfide | Lamplight Farms Lamp Oil |
| CondeaVista LPA | NFSTC Fire Debris Test Mix (C6-C28 n-alkanes, toluene, p-xylene, o-ethyltoluene, m-ethyltoluene, 1,2,4-trimethylbenzene and C6-C20 even alkanes in MeCl2) |
| Gasoline | |
| Kingsford odorless Charcoal Starter Fluid | |
| Kleanstrip Lacquer Thinner | n-Hexane |
| Kleanstrip Mineral Spirits | Ronsonol Lighter Fluid |
| Kleanstrip Concrete Cleaner | Sunnyside Kerosene |

| Explosives & Other Organic Compounds | |
|---|---|
| **Method 8330 Calibration Mix A** | **Method 8330 Calibration Mix B** |
| 2-Amino-4,6-dinitrotoluene A | 4-Amino-2,6-dinitrotoluene B |
| 1,3-Dinitrobenzene A | 2,6-Dinitrotoluene B |
| 2,4-Dinitrotoluene A | 2-Nitrotoluene B |
| HMX A | 3-Nitrotoluene B |
| Nitrobenzene A | 4-Nitrotoluene B |
| RDX A | Tetryl B |
| 1,3,5-Trinitrobenzene A | ACN |
| 2,4,6-Trinitrotoluene A | Methanol |
| A Run individually and as component of Cal Mix A | B Run individually and as component of Cal Mix B |

## Equipment and Consumables

- Fisherbrand 10x75mm Borosilicate Glass disposable culture tubes
- Fisher Scientific Optima Acetonitrile
- Fisher Scientific Certified ACS Methanol

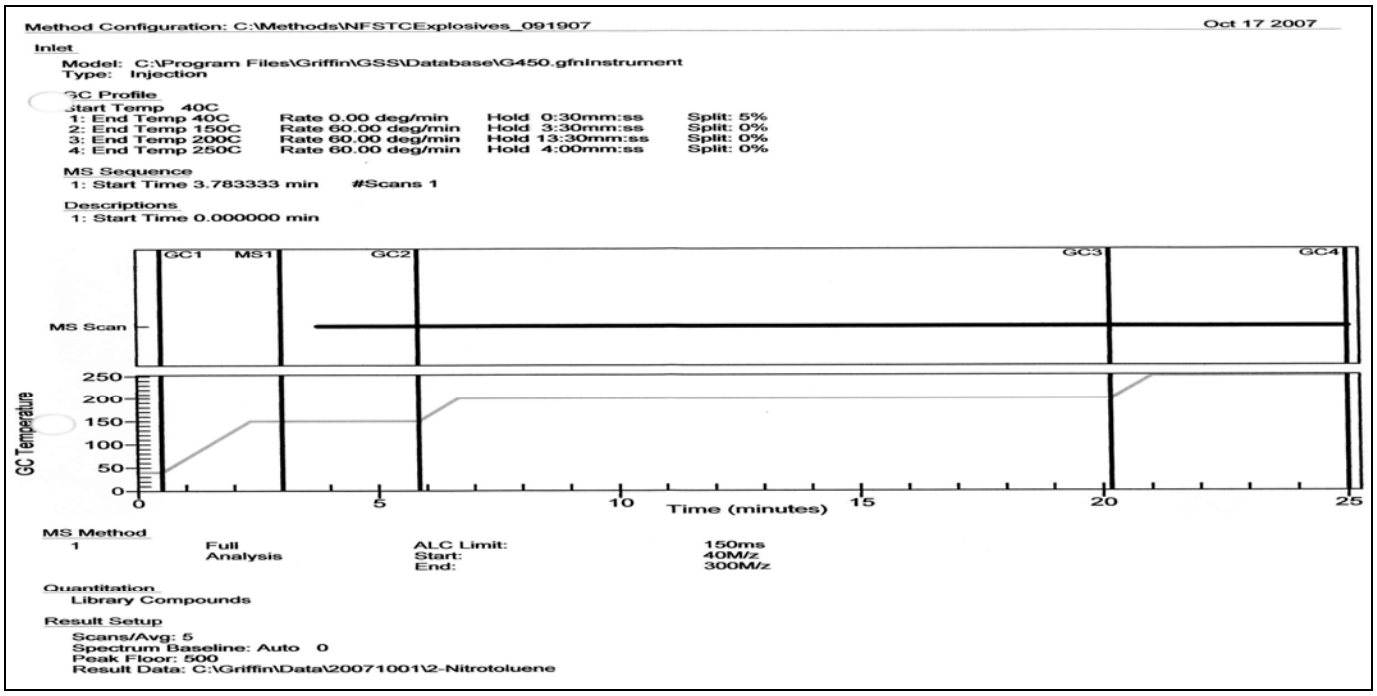
- National Scientific Company 2.0mL 12x32mm Amber Vials with PTFE/Silicone Septa
- Eppendorff epTIPS 10uL - 1000uL PCR clean disposable pipette tips
- Eppendorff Research Pro 100/1000 uL
- Acros Pentane, 98%
- Fisher Scientific ACS Grade Methylene Chloride
- 0.5 M NaOH
- Analytical Balance
- Hamilton 1uL syringe

Synopsis of Experiment(s)

Experiments were designed to assess the ability of the Griffin 450 to separate and produce quality ion spectra for the identification of forensically relevant compounds. The samples used during this assessment were selected to be a representative subset from each of the following forensic classification groups: drugs of abuse, ignitable liquids and explosives. GC/MS methods provided by Griffin Analytical Technologies were modified to optimize detection and identification of these specific compounds of interest. To prevent the saturation of the ion trap, methods were also adjusted to utilize split injection and the scans per average value was decreased from 10 to 5 in order to collect more data points across chromatographic peaks.

Below is a list of the method names used during the testing process:

1. NFSTCDrug75split
2. NFSTCDrug50split
3. NFSTCBenzo
4. NFSTCDrug90split
5. NFSTCDrug_75Split_Multistep_5scan
6. NFSTCDrug_90Split_Multistep_5scan
7. NFSTCFire
8. NFSTCExplosives



The evaluation was divided into three separate parts based on the different classifications of substances and each sample was manually injected at a volume of 1 uL using a Hamilton 1 uL syringe.

Part I: Drugs of Abuse

- 1 mg/mL solutions of each of the twenty-nine different drug standards were made up in A.C.S. grade methanol.
- Each relevant drug spectra was added to the NFSTC library.

Part II: Ignitable Liquids

- Ignitable liquids samples were prepared by pipetting 20 uL of neat accelerant reference standard into 1.5 mL of pentane.

Part III: Explosives

- Explosive samples were prepared by pipetting 15 uL of neat explosive reference standard into 15 uL of acetonitrile, creating a concentration of 500 ug/mL.

Sample TIC and Spectral Data

Figure 1: NFSTC Testmix

Figure 2: Fire Debris Testmix

Figure 3 & 4: Method 8330 of Calibration Mix B (Explosives)

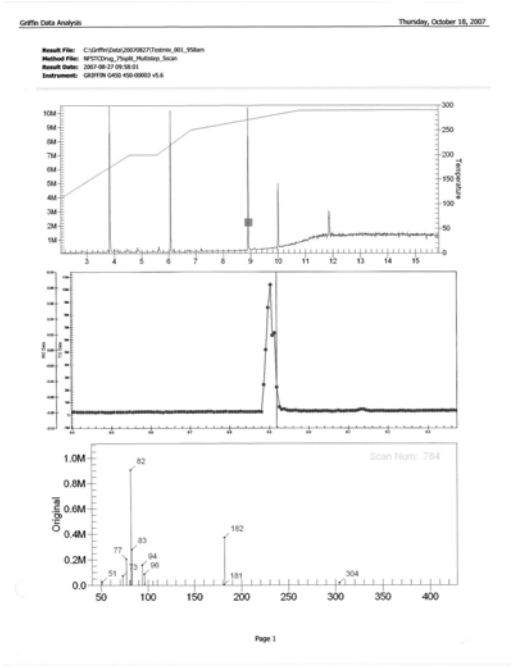



Figure 1

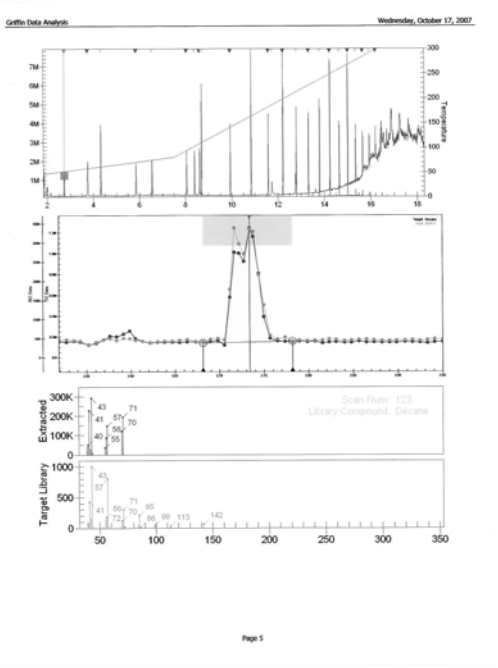



Figure 2

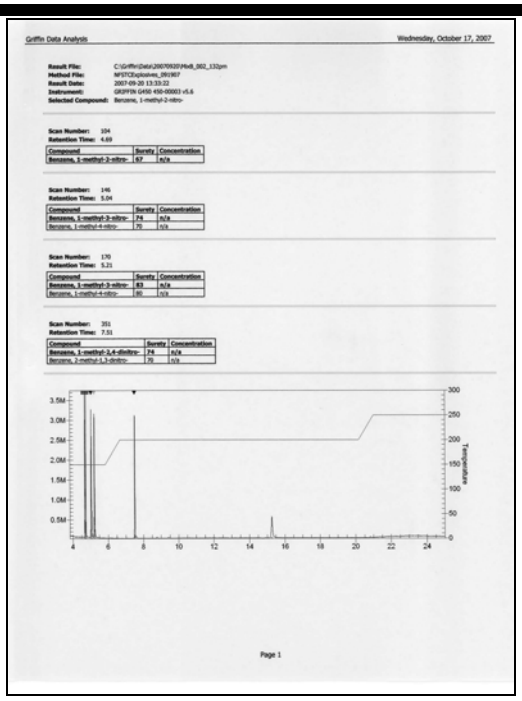



Figure 3

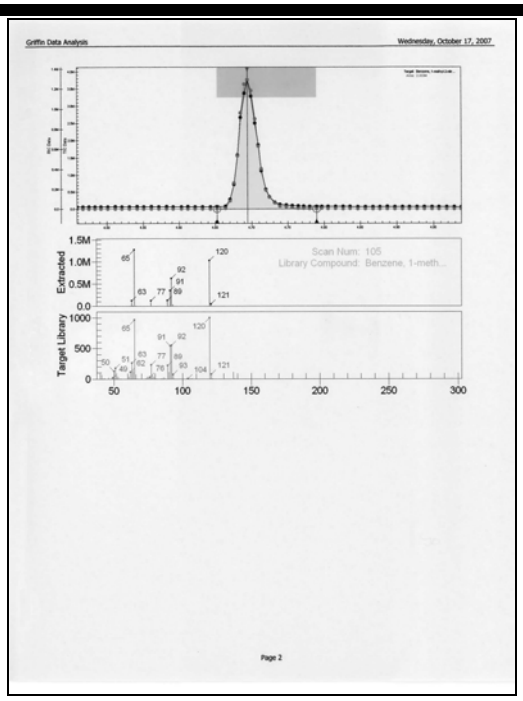



Figure 4

## Findings

Strengths

- The instrument is engineered to be utilized in field environments making it capable of operating under conditions that most ordinary bench top GC-MS instrumentation would be unable to handle.
- Unit power up to sample injection time was noted to be approximately 30 minutes. Typical GC-MS systems require lengthier pump down times to remove residual air and water before sample injection can occur.
- The instrument is capable of performing real time snap shot analysis of unknown spectra, allowing for the identification of the unknown compound through direct spectral library comparison. The Griffin System Software incorporates the AMDIS, NIST, and/or user defined compound libraries to create a searchable spectral database consisting of numerous compounds.
- The instrument uses a miniature dual diaphragm rough pump that is housed within the instrument, thus eliminating the need for a heavy external vacuum pump.
- The amount of time required to cool the column between an end-of-run temperature of 290 $^{o}$C to a start temperature of 40$^{o}$C for the injection of the next sample was noted to be approximately 4.2 minutes. This brief column cooling period between samples will not have a substantial effect on the overall analysis time or throughput of each sample.
- The Griffin 450 GC-MS is quite compact and possesses a small foot print; therefore, requiring only a small manageable workspace.
- The Griffin System Software is quite easy to use and is configurable to restrict access to users of different levels of expertise.
- The analyzer possesses a filament assembly that has a redundancy system consisting of dual filaments.
- The GSS allows for a restricted access three tiered system that designates the user as an operator (lowest level), a developer, or an administrator (highest level).
- Although the Griffin X-Sorber and Air Dock system was not evaluated, this instrument is capable of analyzing air samples for a variety of organic compounds.

Opportunities for Improvement

- Corruption to a result data file occurred when the result data file was viewed simultaneously to the analysis of another sample and the methods of the two open data files differed.
- Replacement columns can be obtained only through the instrument manufacturer and are four to eight times the price of ordinary GC columns. According to the instrument manufacturer, the increased costs have been attributed to the modification of common capillary columns to fit the interior space dedicated to housing the column in the instrument.
- The inter day variability for the PFTBA on the Griffin 450 GC/MS was noted to have a mean abundance of 4.6 million with a S.D. of ± 4.16 million. This variability in calibration gas baseline could have a potential effect on correct mass assignment.
- Manual injection of samples was required on the Griffin 450. A small removable or integrated autosampler would be beneficial to laboratory efficiency in sample analyses.
- The Hardware and Software User Manual is well written and reasonably comprehensive. However, both the manual and the software do not define the limits of the global parameter settings (trap temperature, injector temperature, and transfer line temperature).
- A small removable side and/or rear gas cylinder harness would increase the instrument's ease of portability, while decreasing the safety hazards associated with unsecured compressed gas cylinders. A small built-in readily accessible two stage gas regulator with easily readable inlet and outlet pressure gauges would also be required to effectively monitor the carrier gas supply.
- The Griffin 450 currently has a small removable front panel which allows limited access to the column area for maintenance. This front panel is held on by four screws, which require the use of a screw driver for removal. After removal, these screws can be easily misplaced or even lost during simple maintenance in the field. Also, screws can become stripped from over tightening, which did occur during this evaluation. *A large removable access panel, mounted on a hinged door system with two recessed spring loaded quick release tabs, would better suit access to this system for mobile laboratory applications.*

Limitations

- The Griffin 450 GC/MS does have a limited mass scan range of 40 to 425 m/z for small organic molecule identification. For forensic applications, the instrument should be capable of reaching an upper mass range of at least 650 m/z
- The column heating mechanism was unable to reach temperatures above 290 $^{o}$C, which may effect the elution of some compounds of interest.
- The injector temperature does not go above 250 $^{o}$C. This temperature limitation does have an effect on the ability of being able to vaporize compounds of higher molecular weight and/or lower volatility.
- Peak shape is grossly effected when the detector becomes saturated, resulting in a Total Ion Chromatograph (TIC) displaying the peak with data points of which have intermittently dropped back to baseline.
- Although the manufacturer characterizes the ease of mobility of this system, safe relocation of the 85 pound instrument still requires a two member team.
- High concentrations can overload the Cylindrical Ion Trap producing a space charge effect (spectral distortion) resulting in values being recorded for mass to charge ratios where there are no ions. *This is a limitation common to all ion trap technology.*

Training Requirements

- The depth and length of training will depend on the desired level of the end user.

- An operator with limited to no chemistry background can quickly be trained to a level that would allow the competent performance of simple sample preparation, sample introduction, data collection and basic data interpretation. However, instrument maintenance, troubleshooting, method development, and advanced data interpretation would require more extensive scientific knowledge.

Health and Safety Issues

- The Griffin 450, like any other GC-MS, does have potential safety and health risks associated with usage. The operator, no matter what their skill level may be, should be provided the appropriate training to prevent any unnecessary injuries due to chemical, extreme temperature, or high voltage exposures.
- The introduction section of the Hardware and Software User Manual immediately establishes the necessary warnings and cautions of which the operator should be made aware. The manual continues to reiterate these safety concerns in the chapters covering installation and maintenance, where injuries are most likely to occur.