Casting Emission Reduction Program

www.cerp-us.org

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First Verification of SIVL Instrument

Technikon # 1411-231

November 2004

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United States Environmental Protection Agency

UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH

DaimlerChrysler Ford Motor Company General Motors

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November 2004

This report has been reviewed for completeness and accuracy and approved for release by the following:

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Executive Summary

The 2003 CERP report, "Systems Integration and Validation Laboratory Test Site,"[1] detailing the establishment of a laboratory for measuring foundry emissions included the validation of a California Analytical Instruments Total Hydrocarbon (THC) analyzer. The report established acceptable criteria for emissions measurement with total hydrocarbon analyzers using a flame ionization detector. The acceptance criteria established in that study was that results from the E-Bench THC analyzer would not vary by more than +-5% from the reference THC analyzer used in that study.

This report provides details on the selection, procurement, testing, and validation of a low cost THC analyzer for measuring emissions from foundry pouring-cooling-shakeout processes. The objective was to compare a low-cost THC analyzer with the validated E-Bench THC analyzer (higher cost and less versatile) by testing it in parallel during the pouring-cooling-shakeout tests performed at the Technikon Research Foundry. The instrument under test successfully met all test criteria for use in foundry emissions monitoring.

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1.0 Introduction

1.1 TECHNIKON OBJECTIVES

One of the primary objectives of Technikon is to evaluate materials, equipment, and processes used in the production of metal castings. Technikon's facility is designed to evaluate alternate materials and production processes designed to achieve significant air emission reductions, especially for the 1990 Clean Air Act Amendment. The facility's principal testing arena is designed to measure airborne emissions from individually poured molds. This testing arena has been specially designed to facilitate the repeatable collection and evaluation of airborne emissions and associated process data.

1.2 OBJECTIVES OF THIS STUDY

The establishment of a standard laboratory for emissions measurement from foundry pouring-cooling-shakeout process has been provided in the Systems Integration and Validation Laboratory (SIVL) Test Site Report from 2003 [1]. The report detailed the procurement, installation, and validation of a reference THC analyzer at the Technikon Environmental Development Center. The objective of the work for this report was the selection, installation and validation of a commercially available low-cost but accurate THC analyzer to monitor VOC emissions from foundry pouring, cooling and shakeout operations.

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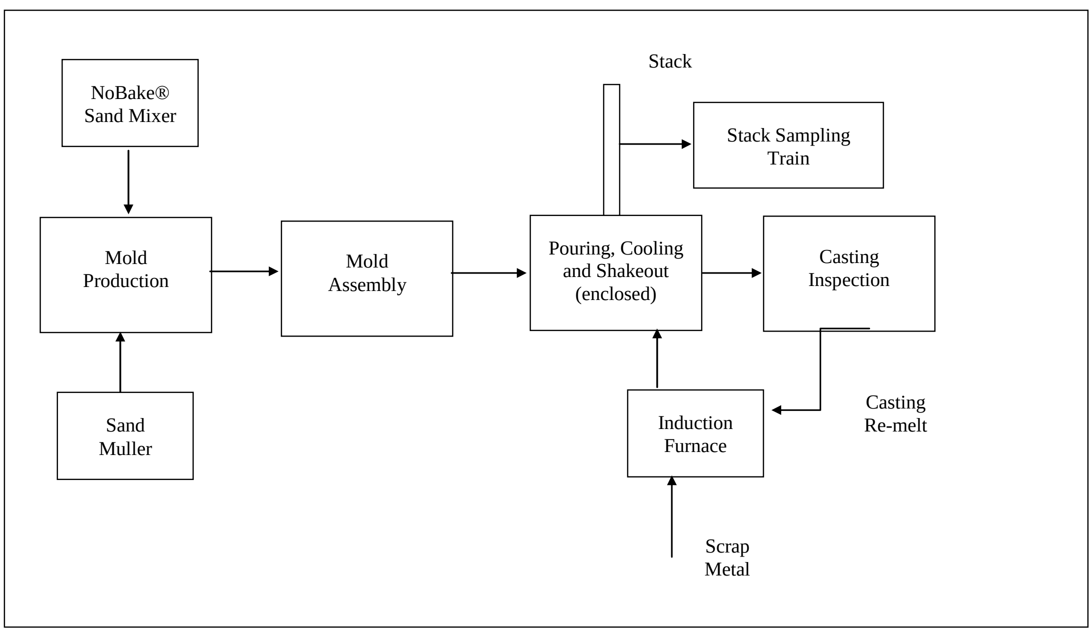
2.0 Technikon Environmental Research and Development Center

The Technikon Environmental Research and Development Center has developed the capability to reproducibly generate emissions from mold production, core making, metal melting, and mold pouring, cooling and shakeout processes under controlled conditions. This center has a general purpose, non-automated metal casting plant, which has been adapted to generate, collect and measure emissions, using methodologies based on EPA protocols for pouring, casting cooling, and shakeout processes on discrete mold and core packages under tightly controlled conditions not feasible in a commercial foundry.

2.1 TEST METHODOLOGY AND RESULTS

This research foundry utilizes cored and un-cored greensand and No-Bake® molds. In order to obtain reproducible emission samples, a number of process parameters are carefully controlled. Process and stack parameters include the weights of the casting, mold, seacoal additions, core and binder; loss-on-ignition (LOI) values for the mold prior to the test and at shakeout; LOI for the core; percent clays and metallurgical data. Stack parameters measured include temperature, pressure, volumetric flow rate and moisture content. The process parameters are maintained within prescribed ranges in order to ensure the reproducibility of the tests. A layout of the Research Foundry is provided in Figure 1.

Figure 1 Research Foundry Layout Diagram



The most widespread chemical binder systems are organic in nature. These systems are chemically and/or thermally cured to harden the sand mold. The pouring of molten metal, in the range from 1200 ^{o}F to nearly 3000 ^{o}F, causes the organic polymer to undergo pyrolysis. During this metal pouring process, the mold is heated non-uniformly, which causes incomplete combustion of the organic polymer to produce a multitude of pyrolysis products. It also produces significant amounts of carbon monoxide and carbon dioxide as by-products of this process.

The mold is placed under a hood for pouring, cooling and shake-out so that all emissions are collected for analysis. This general purpose casting plant has been adapted and instrumented to allow the real-time and batch collection and measurement of organic emissions (Figures 2a-2b).

Figure 2a Technikon Research Foundry Emission Collection Hood

Figure 2b Metal Pouring into Test Casting Molds

3.0 Testing Details

The 2003 CERP Report, "Systems Integration and Validation Laboratory Test Site," [1] provided details on the development of a suite of instruments and associated sampling equipment for the measurement of emissions from pouring-cooling-shakeout processes in a foundry. The THC analyzer (E-Bench) used in that study was from California Analytical Instruments (CAI). Instrument calibration was performed using an Environics™ gas mixing unit with NIST traceable mass flow meters to provide for accurate flow rates of calibration gas mixtures. Calibration was performed using the system calibration procedure. Gas mixtures, generated using the Environics unit, were introduced into the Teflon line that traversed the 47 ft. distance from the E-Bench to the stack filter. The analyzer was calibrated and validated per EPA Method 25 A [2].

The bias, calibration drift and associated parameters were kept within ±5% of span for all measurements. The instrument was calibrated before each test run; in-between test runs and at the end of each day after completing the test runs for that day. Total sampling time for a run was typically 75 minutes and the average for the hydrocarbon analyzer was calculated upon completion of each run.

The E-Bench pump was not capable of delivering additional sample (flow rate) to a new analyzer. This required the incorporation of a new sample transfer line to transport stack samples from the stack to the measuring device. Therefore, a new probe (with appropriate in-line particulate filter) was installed in the stack, its location appropriate with EPA guidelines for placement of sampling equipment. One end of the new sample transfer line was attached to the stack probe and the other end to a measuring device.

Table 1 Comparison Between E-Bench THC and the Intermediate THC Analytes

Sample Number	E-Bench THC	Intermediate THC	Difference	Variance
1	6.0	5.7	0.3	4.2%
2	6.2	6.2	0.0	-0.6%
3	6.5	6.5	0.0	0.7%
4	8.5	7.9	0.6	7.0%
5	8.0	7.7	0.3	4.3%
6	7.1	7.1	0.0	0.0%
7	6.6	6.5	0.1	1.4%
8	7.5	7.3	0.2	3.2%
9	8.6	8.4	0.2	2.1%
10	6.5	6.5	0.0	0.0%
11	6.7	7.1	-0.4	-5.5%
12	7.8	7.9	-0.1	-1.4%
13	7.0	6.8	0.2	3.0%
14	8.4	8.0	0.4	5.2%
15	14.4	14.6	-0.2	-1.0 %
16	15.9	16.4	-0.5	-3.2 %
17	13.5	14.1	-0.6	-4.3 %
18	14.6	15.1	-0.5	-3.7 %

This additional sample transfer line had to be validated for its effectiveness in transporting sample without attendant compromise of sample characteristics (due to condensation, out gassing, etc.). To demonstrate this, an identical THC analyzer from the same manufacturer as used in the E-Bench was attached to one end of this sample transfer line with the other end being attached to the probe in the stack. This second THC analyzer has been labeled "Intermediate THC" analyzer in future references to it in this document to distinguish it from the E-Bench THC analyzer, though both of them were identical analyzers. The new sample transfer line was also maintained at the same temperature (130°C) as that of the E-Bench sample line. The data acquisition hardware and software used was the same as that for the E-Bench system. For the validation tests, both the analyzers simultaneously analyzed stack samples during pouring-cooling-shakeout processes at the Technikon Research Foundry. Table 1 compares results for the two THC analyzers.

Figure 3 VIG Industries THC Analyzer

A comprehensive survey of available analyzers in North America was conducted and a Table was constructed that listed specifications by manufacturer (see Appendix B). Based on a comparison of the various instruments using
parameters relevant to emissions measurement (accuracy, drift, resolution, etc.), the VIG Model 20 was chosen for the validation tests. Figure 3 provides a graphic image of this analyzer. Appendix C provides a detailed listing of specifications for this instrument.

This analyzer was labeled VIG THC analyzer in all tests conducted with this device. The Intermediate THC analyzer was replaced by the VIG THC analyzer for the low-cost instrument validation tests in this study. Stack samples were analyzed simul-

Table 2 Comparison Between the E-Bench and VIG THC Analyzers

E-Bench THC	VIG THC	% Difference
15.06	14.2	5.71%
15.37	15.9	-3.45%
16.96	16.69	1.59%
15.1	14.84	1.72%
16.23	16.2	0.18%
19.88	19.44	2.21%
22.8	22.34	2.02%
22.26	22.58	-1.44%
20.56	20.21	1.70%
21.67	21.41	1.20%
18.25	18.15	0.55%
22.91	22.41	2.18%
14.42	14.19	1.60%
15.89	16.06	-1.07%
13.51	13.42	0.67%
14.57	14.89	-2.20%
15.44	16.3	-5.57%
10.32	10.3	0.19%
16.75	16.7	0.30%
13.53	13.55	-0.15%
13.56	13.31	1.84%
21.7	20.84	3.96%
29.71	28.29	4.78%

taneously by both the E-Bench THC and the VIG THC analyzers. Table 2 provides results from comparative studies with these two analyzers.

The same procedure was repeated with the VIG THC analyzer now calibrated for hexane. Table 4 shows the results of the first trials and Table 5 shows the results of the second trials following tuning of the VIG instruments.

Table 3 Comparison of E-Bench THC Analyzer (Propane) and Intermediate THC Analyzer (Hexane)

E-Bench (Propane)	Intermediate THC (Hexane)	Ratio
19.06	9.89	1.93
21.26	10.17	2.09
22.48	10.96	2.05
19.53	9.92	1.97
20.98	10.89	1.93

Table 4 Comparison of VIG and E-Bench THC Analyzers for Hexane and Propane

VIG (Hexane)	E-Bench (Propane)	Ratio
10.36	24.89	2.40
11.99	28.29	2.36
10.82	24.40	2.25
9.88	23.34	2.36
12.23	27.87	2.28
9.63	22.51	2.34
10.86	26.62	2.45
9.96	22.75	2.29
9.67	22.42	2.32

Table 5 Comparison of VIG and E-Bench THC Analyzers for Hexane and Propane after Modification of the VIG Analyzer

VIG (Hexane)	E-Bench (Propane)	Ratio
3.90	8.08	2.07
3.77	7.46	1.98
3.73	7.65	2.05
3.88	7.21	1.86
3.33	6.76	2.03
3.56	7.03	1.97

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4.0 Discussion

In the first part of this study, the effectiveness of a new sample transfer line was evaluated. Table 1 shows the data from experimental runs where stack sample was analyzed simultaneously by both the E-Bench THC analyzer and the Intermediate THC analyzer (this one had the new sample transfer line). Most of the comparative results indicated that the results were within +- 5%, deemed acceptable during the establishment of the Systems Integration and Validation Laboratory [1]. This served to validate the effectiveness of the new sample transfer line used in this study.

The Intermediate THC was replaced by the VIG THC analyzer for subsequent tests. Table 2 provides results from the tests conducted simultaneously with the VIG THC and E-Bench THC analyzers. The variation here was also mostly +-5%, within acceptable limits for emissions measurements in the SIVL laboratory. This together with the excellent stability (acceptable drift of no more than +- 5% of span), would make it a suitable device for use in stack VOC measurements in foundries.

Another objective of Technikon is to adapt to changing emissions reporting requirements for foundries. Traditionally, Total Gaseous Organic Concentration (TGOC) by EPA Method 25A has been expressed as ppmv as propane. At Technikon, the ppmv is used to calculate lb. TGOC per lb. of metal poured. Future requirements call for the emissions to be reported on a ppmv as hexane basis. To address this issue, a few tests were conducted to compare results from the E-Bench THC analyzer calibrated with propane with the Intermediate THC analyzer calibrated with hexane. Theoretically, the ratio of VOC emissions expressed on a hexane to propane basis is expected to be nominally ~ 2.0. Table 3 provides the results from these tests. The results indicate conformance to theoretically expected values.

When the VIG THC analyzer was used in similar comparative tests with the E-Bench THC analyzer, a moderate deviation (see Table 4) of ~ 20% from expected values was observed for most of the tests. When the manufacturer was informed about these deviations, appropriate corrective action was initiated. Following this, additional tests were conducted again with the VIG THC analyzer. Table 5 shows the results after the modifications. The values were closer to theoretical expectations for the modified analyzer. During the course of the testing and validation process for the VIG THC analyzer, attention was devoted to instrument characteristics such as zero and span calibration drift, linearity, accuracy, ease of calibration and use, noise, gas consumption, etc. The VIG THC analyzer compared with the E-Bench THC analyzer provided good performance and would be a suitable device for use in foundry stacks to measure VOC emissions.

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APPENDIX A TEST PLAN

TECHNIKON TEST PLAN

- > **CONTRACT NUMBER:** 1411 **TASK NUMBER:** 2.3.0 **Series:** NA
- > **SITE:** Technikon Research Foundry
- > **TEST TYPE:** Validation of commercially available Total Hydrocarbon Analyzer by comparison with previously validated Total Hydrocarbon Analyzer installed on the E-Bench.
- > **METAL:** Class-30 gray iron
- > **MOLD TYPE:** Greensand and No-Bake molds depending on given test
- >
- > **SAMPLE EVENTS:** Sample transported through heated sampling line to E-Bench THC. Another heated line transports stack sample to instrument under validation.
- > **ANALYTES:** TGOC
- > **TEST DATE:** **START:** Aug 2004
  FINISHED: Oct 2004

TEST OBJECTIVES:

1. Compare commercially available total hydrocarbon analyzers. Select one for validation in research foundry.
2. Use the E-Bench system that serves as the gold standard as the reference system for validating the new analyzer.
3. Draw sample from the same stack and compare results from new analyzer to the E-Bench analyzer.

SPECIAL CONDITIONS:

All tests will be conducted in a total emission enclosure conforming to US EPA method 204 maintained at a standard temperature. Balance air flows to make enclosure conform to US EPA Method 204 for total enclosures. The emission enclosure air temperature and incoming sand temperature will be maintained to standardize the test for repeatability of both the emission process and the emission sampling technique.

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APPENDIX B COMPARISON OF COMMERCIALLY AVAILABLE HYDROCARBON ANALYZERS

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Parameters	VIG Model 20 (2 detector model also available)	VIG Model 200 Methane and Non-methane	Signal 300 HM
Price	$ 9950 with heated sample pump(OEM price 15% discount of above) autocalibration adds $2400	$ 19990 with GC and FID—2 separate detectors--	
Contact Info	VIG Industries 4051 E. La Palma #C, Anahiem, CA 92807 800-862-7844 www.vigindustries.com	VIG Industries 4051 E. La Palma #C, Anahiem, CA 92807 800-862-7844 www.vigindustries.com	K2BW Environmental Equipment Co. 355 North York Road, Suite B Willow Grove, Pennsylvania 19090 USA Phone: (215) 830-8882, Fax: (215) 830-8922 email:Sales@K2BW.com
Measurement range	0-10000 in 4 steps, lower detection limit 0.01 ppm, 0-100000 ppm in 4 steps, detection limit 0.1 ppm autoranging	4 ranges per amplifier, one amp for total THC and one for methane and non-methane	0-10000 in 8 ranges, auto ranging available
Zero and span noise	< 0.2% of full scale	< 0.2% of full scale	
Zero and span drift	+- 1% full scale per 24h	+- 1% full scale per 24h	Less than 0.1 ppm zero drift in 8 h
Linearity	Within 1% of full scale through all ranges	Within 1% of full scale through all ranges	
Accuracy			
Repeatability	Within 1% of full scale through all ranges	Within 1% of full scale through all ranges	
Stability	Within 1% of full scale through all ranges	Within 1% of full scale through all ranges	
O2 synergism	Within 1% of full scale within selected range	Within 1% of full scale within selected range	
Response time	Within 5 seconds, 90% of final reading	Within 5 seconds, 90% of final reading For methane, 40 s, updated every 3 minutes, for nmethane, 70 s, updated every 3 min	
Operating ambient Temp	50- 120 F	50- 120 F	
Flow rate	Typically 4 L/min	Typically 4 L/min	
Weight	35-45 lb	55-65 lb	
Dimensions	Rack mountable	Rack mountable	
Oven temp	From 200-400 F	From 200-300	
Voltage Output	0-10 V standard	0-10 V standard	
Current output	4-20 mA	4-20 mA	
Ignition	automatic	automatic	
Detection limit	100 ppb with lower range analyzer		
Precision			
Warm-up time	Usable in 45 min, stable in 2h	Usable in 45 min, stable in 2h	
Safety	Flame out indicator, fuel shut-off, optional sample shut-off	Flame out indicator, fuel shut-off, optional sample shut-off	
Fuel requirements	UHP hydrogen at 18 psi (also available in H2/He mixture option)	UHP hydrogen at 18 psi (also available in H2/He mixture option)	
Air	Zero air at 18 psi	Zero air at 18 psi	
Warranty	Standard 1 year	Standard 1 year	
Power requirements	115 VAC at 60 Hz, 600 W Automatic fuel shut off and flame out indicator	115 VAC at 60 Hz, 600 W Automatic fuel shut off and flame out indicator	
Options	RS-232 interface, automatic calibration, internal air supply,		

Parameters	Baseline Model 8800H	Siemens FIDAMAT	402 REU
Price	$ 13000 (discount possible) remote calib and span possible. Autoignition will shut off after 5 tries	$16000 not flexible on price.	
Contact Info	Baseline Industries 19661 highway 36 P. O. Box 649 Lyons,CO 80540 970-203-0880 www.baseleinindustries.com	Framatome ANP Environmental Systems 1007C Mansell Road Roswell GA 30076 Sales: Sales@epd-usa.com (770) 5214500	Teledyne 16830 Chestnut St. City of Industry, CA 91748 1-888-789-8168 www.teledyne-ai.com
Measurement range	0-1000 auto ranging,lower detection limit at 0.01 ppm propane auto ranging standard	4 ranges autoranging	0-1000
Zero and span noise		< 0.5% of 10 ppm	
Zero and span drift	Zero < 0.1 ppm/24h Span +-1% of F. S/24h	< 2% of span/week	
Linearity	!% F. S.	Better than 1% F. S.	
Accuracy			+-2% F. S.
Repeatability	+-1% F. S.	0.1 to 1% F. S rande dependent	
Stability			
O2 synergism			
Response time	< 30s for 90% F.S.	2-3 s	< 15s for 90% F. S.
Operating ambient Temp	0-40 C	5 to 45 C	41-110 F
Flow rate		1l/min	
Weight	30 lbs	28 kgs	
Dimensions			
Oven temp		110-200 C	
Voltage Output	0-10V	0-2,4V	0-1V
Current output	4-20 mA	4-20 mA	20-Apr
Ignition			Auto ignition and auto sampling with sample pump
Detection limit	0.01 ppm propane at 0-10 ppm	0.1 ppm	1% of F. S.
Precision			
Warm-up time		2-3h	1 h
Safety	Auto ignition Auto shutoff		Fuel shut off
Fuel requirements	40 cc/min pure H2 100 cc/min H2/He mixture	20 cc/min 110 cc/min H2/He	
Air	200 cc/min	350 cc/min	
Warranty			
Power requirements			
Options	Remore operation, sample pumps, automatic calibration standard—solenoids insertion will cost extra $1000	Cal gas at 2l/min	

Parameters	300 HFID	Enda-HF503	FIA-510THC
Price	$ 14000		
Contact Info	California Analytical 1238 W. Grove Ave Orange, CA 92865 714-974-5560	HORIBA 17671 Armstrong Ave. Irvine, California 92614 Tel: 949-250-4811 FAX: 949-250-0924 email: nsa.environsupport@horiba.com	HORIBA 17671 Armstrong Ave. Irvine, California 92614 Tel: 949-250-4811 FAX: 949-250-0924 email: nsa.environsupport@horiba.com
Measurement range	0-30,000 8 ranges no autoranging yet will be available	0-30000	0-30000
Zero and span noise	< 0.5% F. S.	< 1% of FS/24h	Zero at +-1% of FS/24h Span at +-2% F. S./24h
Zero and span drift	< 1% F. S./24h		
Linearity	Better than 1% F. S.		
Accuracy			
Repeatability	0.5% F. S.	+-1% of F. S.	
Stability			
O2 synergism	Less than 2% F. S.		
Response time	1.5s for 90% F. S.		< 60s
Operating ambient Temp	5-45 C		
Flow rate	3 l/min		
Weight			
Dimensions			
Oven temp	60-200 C		
Voltage Output	0-10 V		
Current output	4-20 mA	4-20 mA	
Ignition			
Detection limit	0.01 ppm at 0-10 ppm		1.0 ppm
Precision			
Warm-up time			
Safety			
Fuel requirements	30 cc/min H2 100 cc/min H2/He		
Air	200 cc/min at 25 psig		
Warranty			
Power requirements	115 V, 60 Hz, 750 W		
Options			

Parameters	3-300A, 5-100, 3-200 and 3-300MC, VE-7	55c	51 C
Price	$ 13000 19950 for one with methane, NMHC and total		
Contact Info	J.U.M., Lone Star Group, Inc. 12900 FM 3436 P.O.Box 878 Dickinson, TX 775309-0878 Phone: (281) 559-3366; VM (281) 559 8139 Fax (281) 559-3369 e-mail: lonestar@jum.com	Thermo Environmental 8 West Forge Parkway Franklin, MA 02038 (508) 520-0430 don bayer 909-944-3615	Antek Instruments 300 Bammel Westfield Rd. Houston, TX 77090 www.antekhou.com 1-800-365-2143
Measurement range	Many ranges, auto ranging	0-2000	0-100000 autoranging
Zero and span noise			
Zero and span drift	< 1% F. S. /24h	3% of current range/24h	< 1% /24h
Linearity	Within 1% F. S.		
Accuracy		2% of span	2% of measured value from 10% to 110% of span
Repeatability			
Stability			
O2 synergism	< 1-2%		
Response time	2 s	< 5 s for 90% F. S.	< 5 s for 90% of F. S.
Operating ambient Temp	5-43 C		
Flow rate	2.5l/min	1.0 l/min	
Weight	28 lbs	63 lbs	30 lbs
Dimensions			
Oven temp	~ 190 C	125-200C	
Voltage Output	0-10V	4 programmable outputs	0-10 V
Current output	4-20 mA	2 outputs standard	4-20
Ignition			
Detection limit	0.1 ppm methane	0.05 ppm	0.01 ppm propane
Precision			
Warm-up time			
Safety	Fuel shutoff	Flame out sensor	
Fuel requirements	20 cc/mim H2 90cc/min H2/He		25 cc/min H2, 75 cc/min H2/He
Air	300 cc/min with one model having air generator within (VE-7)		200-300 cc/min
Warranty			
Power requirements			
Options		autocalibration	

Parameters	Model 1040	Liston Model 20
Price	$11000	$10,000 auto calibration $2400 VIG unit
Contact Info	Liston 18900 Teller Ave Irvine, CA 949-756-1632 www.enviromax.com	Liston 18900 Teller Ave Irvine, CA 949-756-1632 www.enviromax.com
Measurement range	0-10000 ppm autoranging	Auto ranging 0-10000 auto calibnratrion available internal combustion air, external zero air generator
Zero and span noise		
Zero and span drift	< 0.5% F. S/24h	+1 % of F. S./24h
Linearity	Within 1%	Within 1%
Accuracy		
Repeatability		
Stability		
O2 synergism	Less than 1% of selected range	Within 1% of selected range
Response time	< 60 s for 90% of F. S.	Witin 1 s to 90 % F. S.
Operating ambient Temp	40-110C	
Flow rate		6 or 14 l/min
Weight	25 lb	
Dimensions		
Oven temp	70 C	200-400 F
Voltage Output	0-10	0-1, 5 or 10
Current output	4-20	4-20
Ignition		
Detection limit	10 ppb in 0-1 ppm range	
Precision		+- 1% F. S.
Warm-up time		
Safety		Flame out with gas shutoff
Fuel requirements	30 cc/mim H2 80 cc/min H2/He	
Air	300 cc/min	
Warranty		
Power requirements		110V
Options		Requires fuel, combustion air and operation air

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APPENDIX C SPECIFICATIONS OF THE VIG HYDROCARBON ANALYZER

Heated Total Hydrocarbon Analyzer Model-20

The VIG Industries, Inc. Model-20 is a microprocessor-based, heated total hydrocarbon gas analyzer designed for high accuracy, sensitivity and stability. The Model-20 is designed to continuously measure a variety of hydrocarbon concentrations from one sampling point.

The Model-20 uses a flame ionization detector (FID). The FID, sample filter, all sample lines, solenoid valves, pump head, capillaries and all other components that come in contact with the sample are maintained in a temperature-controlled heated oven to prevent condensation, and to provide repeatable, reliable performance in the analysis of a wide variety of hydrocarbon concentrations in gaseous mixtures or in ambient air.

Standard Specifications

Measuring Method - Oven Heated, Flame Ionization Detector (FID)

Measurement Range -

Standard Ranges (4 Ranges per amplifier, one choice per analyzer) + Auto Range

- 0-10, 0-100, 0-1000, 0-10000ppm (lower detection limit 0.01ppm)
- 0-100, 0-1000, 0-10000, 0-100000ppm (lower detection limit 0.1ppm)

Other ranges available upon request

- Zero & Span Noise - Less than 0.2% of full scale
- Zero & Span Drift - +/- 1% full scale per 24 hours
- Linearity - Within 1% of full scale through all ranges
- Repeatability - Within 1% of full scale through all ranges
- Stability - Within 1% of full scale through all ranges
- Oxygen Synergism - Within 1% of full scale within selected range
- Response Time - Within 5 seconds to 90% of final reading
- Ambient Temperature - From 50°F to 110°F
- Flow Rate - 4 Liters/Minute (standard), Others Available Upon Request
- Physical Dimensions - 19” Front Panel, 16.75” Wide Chassis, 18” Deep Chassis, 21” Deep with fittings and handles, 9” High
- Weight – 35 lbs to 45 lbs depending on options
- Oven operating temperature - 300°F (Adjustable from 200°F to 400°F)

Safety -

- Flame-Out indicator lamp, flame out alarm contact on back panel, fuel shut-off, calibration and zero solenoid shut-off
- Optional sample shut-off

Outputs -

One of the following voltage outputs

- 0-10VDC (Standard)
- 0-1VDC (Optional – no extra charge)
- 0-5VDC (Optional – no extra charge)

Current output

- 4-20mA
- Sourcing

Flame-out alarm

- Normally open, low current relay contact (Closes on alarm, latching)

Concentration 1 alarm

- Normally open, low current relay contact (Closes on alarm, latching)

Ignition - Automatic (can be set to manual by operator from front panel)

Glow Plug - Main and spare glow plugs installed (Selectable by switch on back panel)

Warm-up Time -

- Useable in approximately 45 minutes
- Stable in approximately 2 hours

Display - Graphic, backlit, 240W x 64H pixels, high contrast, wide viewing angle

Operation Requirements

Fuel

- UHP Hydrogen @ 18psi incoming pressure (standard)
- UPH Hydrogen/Helium Mixture @ 18psi incoming pressure (optional)

Combustion Air

- Oil/Water/Hydrocarbon free instrument air @ 10psi incoming pressure

Zero Calibration Gas

- Zero grade air or nitrogen @ 9psi incoming pressure

Span Calibration Gas

- Known concentration of operator selected hydrocarbons balanced in either air or nitrogen @ 9psi incoming pressure

Optional Gasses

- UHP nitrogen for units with dilution option @ 10psi incoming pressure
- Oil/Water/Hydrocarbon free instrument air for internal cleaning option @ 50psi incoming pressure

Power Requirements - 115VAC @ 60 Hz @ 600 Watts or optional 220VAC @ 50 Hz @ 600 Watts

APPENDIX D NOMENCLATURE

CAI	California Analytical Instruments
E-Bench	Emissions Bench
EPA	Environmental Protection Agency
lb	Pound (weight)
LOI	Loss on Ignition
MACT	Maximum Achievable Control Technology
MFCs	Mass Flow Controller
NIST	National Institute of Standards and Technology
ppmv	Parts per million volume
SIVL	Systems Integration and Validation Laboratory
TGOC	Total Gaseous Organic Concentration
THC	Total Hydrocarbon
VOC	Volatile Organic Compound
Zero Air	Hydrocarbon & Moisture Free Air

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APPENDIX E REFERENCES

[1] Systems Integration and Validation Laboratory Test Site, Report to Army under Contract # 1410-230, August 2004.

[2] http://www.epa.gov/ttn/emc/promgate/m-25a.pdf