



AROMA ATRA171p

Produced Fluid Analyzer Performance

Entanglement Technologies has completed a successful performance-demonstration blind trial of the AROMA model ATRA171p produced fluid chemical analyzer at Entanglement Technologies' facility in Burlingame California. The ATRA171p analyzer—developed to meet Micromem Applied Sensor Technologies' (MAST) need for a sensitive, field-deployable tracer chemical analyzer—provides high sensitivity, robust analysis of partitioning chemical tracers in oilfield production environments. This chemical analyzer system brings analytics into the field, increasing speed, sensitivity, while also reducing the time and cost of labor.



The AROMA chemical analysis platform delivers laboratory-grade performance in a compact, robust, simple-to-operate package. Through a partnership with MAST, this platform has been extensively developed for online analytics of oil-well produced fluid to detect tracer chemicals. These chemicals are deployed for a variety of reservoir intelligence purposes including determination of residual oil saturation, fracture characterization, water tracing, sweep efficiency calculation, and evaluation of EOR performance.

The ATRA171p uses Entanglement Technologies' proprietary chemical vapor analysis (AROMA) engine, which combines a robust chemical analyte separation front end with a high-performance, broad-band cavity ringdown spectrometer (CRDS) to provide multi-species detection and identification

within the complex chemical mixtures encountered in real-world sensing environments. The AROMA tool-set provides the sensitivity, stability, robustness, and fieldability of all-optical methods with the many-analyte capability typically found in gas chromatographs. The AROMA engine is coupled to a high performance liquid/vapor extraction system designed to withstand continuous processing of the high TDS, corrosive chemical mixtures in the oilfield. This makes AROMA ATRA171p a unique tool for reservoir intelligence projects.



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AROMA ATRA171p provides the capability of simultaneous analysis of a broad range of tracer chemicals with detection limits well below 1 ppb. With a broad detection range, the analyzer has performed successfully in a blinded trial against 14 distinct samples prepared in the water-cuts from four different oil fields. Each sample was analyzed in duplicate. Each analysis uses 20mL of sample. The Method Detection Limit (MDL) was determined separately according to EPA method 301, over 40 repeated measurements, with measurement and analysis performed using the fully automated control package. Limit of Detection (LOD) was determined via repeated analysis of blank DI water solutions.

Analyte	MDL [µg/L]	LOD [µg/L]
Isopropanol	2.0	0.2
1-propanol	1.0	0.2
2-butanol	1.3	0.3
Isobutanol	0.3	0.04
1-butanol	0.9	0.1
1-pentanol	0.7	0.02
Fluoro-alcohol 1	0.7	0.06
Fluoro-alcohol 2	0.9	0.3

The broad range of alcohols analyzed provides a number of important capabilities to reservoir managers. Ranging from IPA (nearly conservative) to 1-Pentanol (strongly partitioning into the oil phase), a suite of alcohols can be selected to provide detailed information on residual oil saturation and makeup of that oil. The breadth of alcohols is also important because several alcohols are deployed during normal oil-

field operation. In addition, several alcohols occur naturally due to chemical or biological activity in the reservoir, making pre-analysis important for tracer selection (see below).

Produced Fluid	Salt (g/L)	IPA	1-propanol	2-butanol	IBA	1-butanol	1-pentanol
1	Red	Red	Orange	Yellow	Red	Orange	Yellow
2	Red	Orange	Green	Green	Green	Green	Green
3	Yellow	Green	Green	Green	Green	Green	Green
4	Orange	Green	Green	Green	Green	Green	Green
5	Yellow	Green	Green	Green	Green	Green	Green
6	Green	Green	Green	Green	Green	Green	Green
7	Green	Yellow	Green	Green	Green	Yellow	Green
8	Green	Orange	Green	Yellow	Green	Green	Green
9	Orange	Green	Green	Green	Green	Green	Green
10	Yellow	Green	Green	Green	Green	Yellow	Green
11	Yellow	Red	Green	Orange	Yellow	Orange	Green
12	Yellow	Orange	Green	Green	Green	Green	Green
13	Green	Green	Green	Green	Green	Green	Green
14	Orange	Red	Red	Orange	Yellow	Orange	Yellow
15	Red	Red	Yellow	Green	Green	Yellow	Green
16	Green	Green	Green	Green	Green	Green	Green
17	Yellow	Orange	Green	Yellow	Green	Green	Green

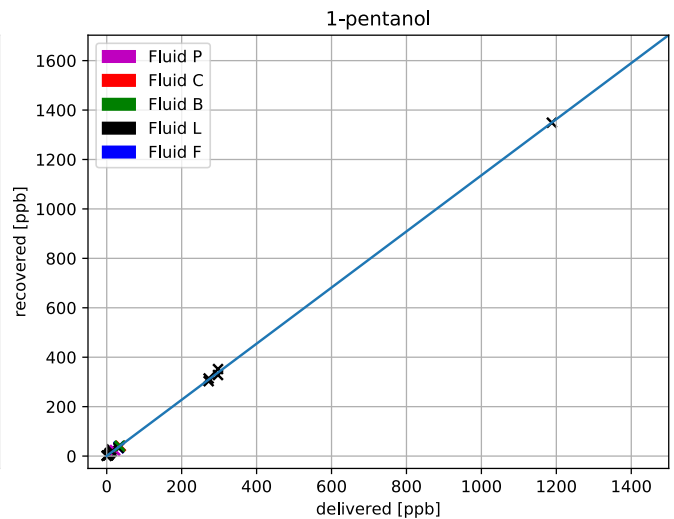
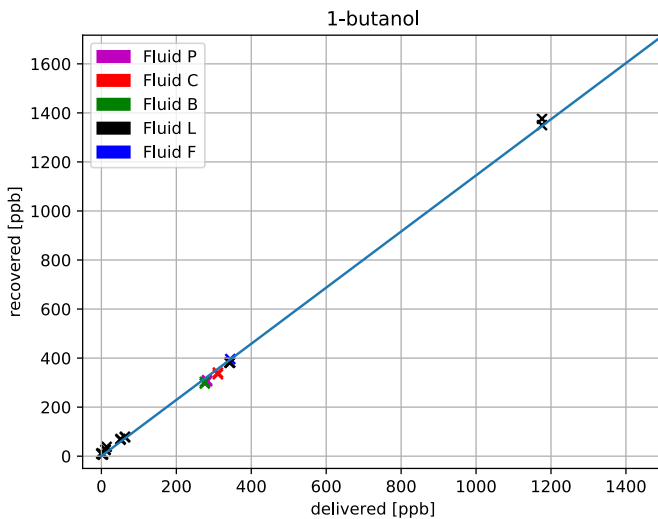
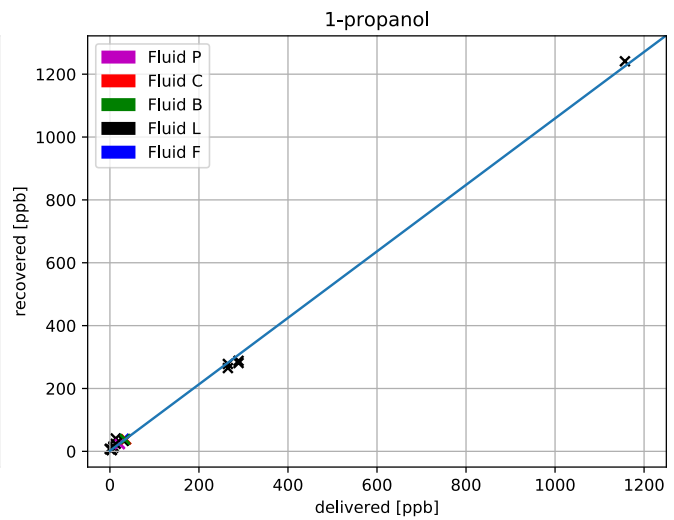
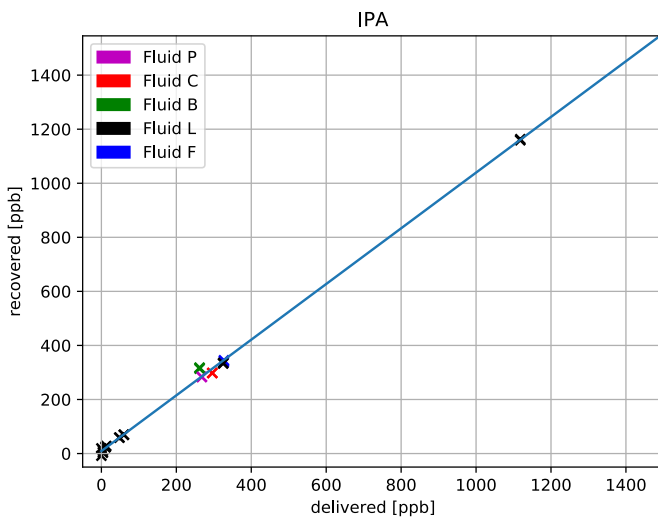
Analysis of pure produced fluid shows the presence of multiple alcohols in several samples. Relative concentration is shown in cell color with the highest concentrations shown in red. The samples are from 17 different fields.



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Blind trial results (shown below for four alcohols) demonstrate excellent linearity, accuracy, and repeatability across the range of concentrations and produced fluids presented for analysis. The AROMA ATRA171p analyzer provides cutting edge performance in real-world conditions and for a broad variety of feed-stocks and tracer chemicals. With unparalleled performance, ease of use, and stability, the AROMA system is quickly establishing itself as a goto tool for real-time, field deployed, chemical tracer analysis.



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