



# Comet Analytics, Inc

## Introducing PPT analysis



Simplifying TOC PPB Applications  
Pharmaceuticals  
Microelectronics  
Power, Other

Methods

Specifications

Simple To Operate

**Operate** RX Lamp < 180 Days Run - OnLine

Range 1 Range Select

**TOC** 74 ppb  
Proc. Resistivity (Mohm): (Disabled)

Analyzer Online

Conductivity  $\mu\text{S/cm}$ : 2.25  
Resistivity (Mohm): 0.44  
Temp degC: 31.89

Sample Pressure (PSI): 0.69

Menu 03/06/12 11:58 Analyzer ID: 1251

**Setup** RX Lamp < 180 Days Run - OnLine

System Control: Pumps, Reactor, Analyzer Online

Range 1 Range Select

**TOC** 70 ppb  
Proc. Resistivity (Mohm): (Disabled)

Sample Pressure (PSI): 1.57

User Alarm Configuration: TOC Temp Range, TOC Limit 666.00

Go to Advanced Settings

Menu 03/06/12 12:00 Analyzer ID: 1251

Simple To Validate

**Cal. Verify (Rs)** RX Lamp < 180 Days Run - OnLine

Number of Replicates: 9  
Sample ID: 1116  
Sucrose Standard (ppbC): 500.000

Range 1 Range Select

**TOC** 82 ppb  
Proc. Resistivity (Mohm): (Disabled)

Replicate Results:

Rep. 1	514.981
Rep. 2	516.750
Rep. 3	515.186
Rep. 4	513.090
Rep. 5	510.593
Rep. 6	509.234
Rep. 7	507.878
Rep. 8	507.626
Rep. 9	508.072

Current Blank: 74.979  
Validation Value (ppbC): 511.490  
Limit Response (Rs-Rw): 436.510  
Verification Result (%): 87.302  
MDL

Go To Blank Screen

Start Validation Abort Validation

Menu 03/06/12 12:01 Analyzer ID: 1251

**System Suitability (Rss)** RX Lamp < 180 Days Run - OnLine

Number of Replicates: 9  
Sample ID: 125  
Benzoquinone Standard (ppbC): 500.000

Range 1 Range Select

**TOC** 70 ppb  
Proc. Resistivity (Mohm): (Disabled)

Replicate Results:

Rep. 1	460.362
Rep. 2	463.632
Rep. 3	466.360
Rep. 4	467.490
Rep. 5	465.555
Rep. 6	465.513
Rep. 7	464.732
Rep. 8	467.171
Rep. 9	466.297

Benzoquinone Value (ppbC): 465.235  
Limit Response (Rs-Rw): 436.510  
Rss Corrected (Rss-Rw): 390.255  
Response Efficiency (%): 78.051

FAIL (Limit Criteria = 85% to 115%)

Start Validation Abort Validation

Menu 03/06/12 11:59 Analyzer ID: 1251

Simple To Trouble-Shoot

**Alarms** RX Lamp < 180 Days Run - OnLine

Start	Message	End
03/06 11:49:39	Inlet High Temp	03/06 11:52:31
03/06 11:52:46	Inlet High Temp	03/06 11:56:49
03/06 11:58:23	Loss of Sample	03/06 11:54:30
03/06 11:57:45	Loss of Sample	03/06 11:58:30

REVERSE Fcs.Up Fcs.Dwn Ref.

Menu 03/06/12 12:01 Analyzer ID: 1251

**Diagnostics** Total Reactor Runtime 4 Days RX Lamp < 180 Days Run - OnLine

Proc. Resist. (Disabled) Concentrate

Reference VDC: 8.496  
Conductivity VDC: 9.886  
Conductivity  $\mu\text{S/cm}$ : 2.374  
Resistivity (Mohm): 0.420  
Temp VDC: 2.692  
Temp degC: 31.83

Sample Pressure (PSI): 0.80

Flow: P1 2.00, P2 0.20

Range 1 Range Select

**TOC** 82 ppb  
Proc. Resistivity (Mohm): (Disabled)

Menu 03/06/12 11:59 Analyzer ID: 1251

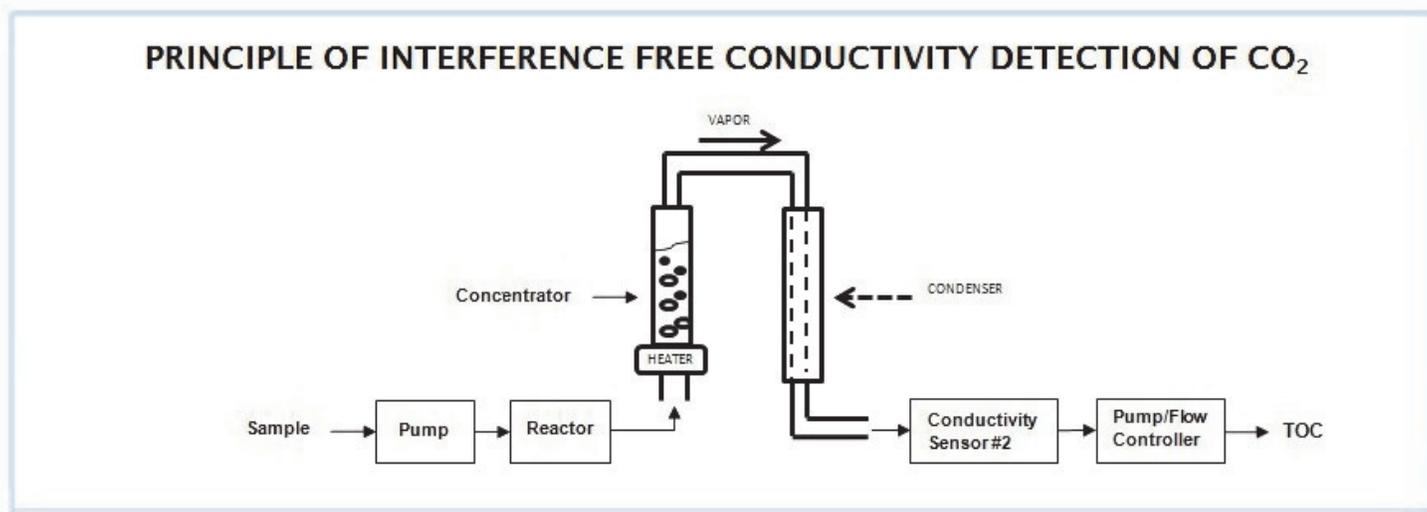
## The Comet Method

Comet uses a revolutionary PPT TOC Concentration Method\* which eliminates interferences in conductivity detection of the CO<sub>2</sub> gas formed in the Photo-Oxidation of organic carbon to CO<sub>2</sub>.



Sample is initially fed to the Total Inorganic Carbon removal stage to eliminate the TIC interference and allow a direct analysis of TOC. The sample with the remaining total organic carbon then continuously flows to the UV Reactor where the TOC is oxidized to CO<sub>2</sub>. The Concentrator vaporizes a portion of the liquid sample containing all of the CO<sub>2</sub> gas generated in the UV Reactor but leaves behind all the interfering ions in the Concentrator's liquid phase to be drained. The vapor containing the CO<sub>2</sub> flows through the Condenser where the ion-free vapor is condensed to liquid and the dissolved CO<sub>2</sub> measured by a conductivity sensor and converted by the PLC to ppb/ppt units of TOC.

Photo-Oxidation is achieved when UV energy at 185 nm and 254 nm create highly reactive Hydroxyl Radicals, a very aggressive oxidizer. Carbon compounds in water are converted to carbonic acid which is further decomposed to water and carbon dioxide (CO<sub>2</sub>). The measurement of CO<sub>2</sub> is a direct correlation to the carbon content in water. Conductivity is the most sensitive and reliable method for low level TOC analysis.



The reacted sample is continuously vaporized, leaving the interfering species in the liquid sample while carrying over CO<sub>2</sub> in the vapor phase. Vapor is condensed and the condensation is analyzed by a conductivity sensor as TOC.

CO<sub>2</sub> gas generated in the oxidation of carbon in the Reactor is proportionate to the volume of the reacted liquid containing the CO<sub>2</sub>. Thus, when the condensed sample from the vapor is pumped to the conductivity sensor at a lower flow rate containing all the reacted CO<sub>2</sub> in the smaller sample volume, the CO<sub>2</sub> concentration is increased as the ratio of the concentrated sample to the original reacted sample volume. For example a concentration factor of 20 actually provides 1,900% gain in sensitivity.

## HOW DOES IT WORK?

Sample is introduced to the analyzer either ON-LINE from the facility or a TEST position as selected by valve V1. Sample is drawn to the TIC Removal assembly by pump P4 where acid is added to the sample by pump P3. The TIC is then converted to dissolved CO<sub>2</sub> and swept out by sparge gas of oxygen or CO<sub>2</sub> free air. The remaining sample containing organic carbon is then pumped by P1 to the UV Reactor where the TOC is oxidized to CO<sub>2</sub>. The reacted sample continuously flows to the Concentrator where a portion of the sample is vaporized and all the CO<sub>2</sub> gas is separated from the liquid sample containing all the interfering ions which then flows to drain. Pump P2 draws the CO<sub>2</sub> laden vapor through the Condenser where CO<sub>2</sub> is reabsorbed in the condensate which is measured by the Conductivity Sensor and converted by the PLC to ppb/ppt units of TOC without interference. For example the concentration factors of 20 to 30 actually provide 1,900% to 2,900% gain sensitivities, allowing the most reliable PPT (parts-per-trillion) TOC analysis.

## WHY CHOOSE COMET?

### Maximum Interference Rejection

1. Comet avoids the common error of a differential conductivity measurement to arrive mathematically at the “TOC” value. That alternate method measures the incoming sample conductivity assigning a “TIC” value to it, then exposes the raw sample to UV in a Reactor and measures the “CO<sub>2</sub>” of the reacted sample by another conductivity sensor assigning a TC value to that separate measurement. Accuracy of the TIC concentration determination therefore becomes crucial to an accurate mathematical determination of true TOC concentration. This method suffers the following errors:  
*Raw source water normally contains not only CO<sub>2</sub> from the natural environment and other TIC as carbonates which convert to CO<sub>2</sub> in an acidic liquid medium but also contains many other ions that interfere with the desired TIC/CO<sub>2</sub> only analysis. Thus to classify the conductivity of the raw sample as “TIC” presents uncorrected error that will be cumulative in the mathematical derivation of “TOC.” This often results in false negatives and false positives and has been rendered unsuitable for controlled low ppb product waters.*
2. Disregarding the limitation of 1, above, when multiple analyses are required to derive a controlled mathematical result, in this case TOC, cumulative error of the individual measurements add resultant error to TOC analyses.

### What does Comet do to provide more accurate TOC results?

Comet conforms to long established EPA approved methods of acidifying the sample to a pH of 2 whereby the TIC as carbonates are all converted to dissolved CO<sub>2</sub> and eliminated by sparging. TOC is then directly analyzed more accurately without interference from TIC. Only a single analysis for the CO<sub>2</sub> generated by oxidizing organic carbon represents the most accurate analysis of TOC directly and without interferences and multiple analyses with questionable TOC results.

### Most Sensitive TOC Analytical Method

Comet’s patented method of CO<sub>2</sub> concentration provides up to 1,900% realized gain in TOC analysis sensitivity.

### Continuous Analysis

Comet does not confuse “continuous sampling” with “continuous analysis” and clearly warrants that Comet’s analytical method is continuous throughout, not continuous sampling with a “batch” analysis as others do. Advantages of continuous analysis include no loss of data between otherwise batch analysis and cleanup cycles, which is a clear advantage in process monitoring and control. While analytical batch methods may attribute response time to individual batch analyses, through-put for the total cycle between samples is the important response factor for process control. Comet’s continuous analysis leaves no similar uncertainties over batch analysis.

### Comet’s PLC Adds Reliability Over Custom Processors

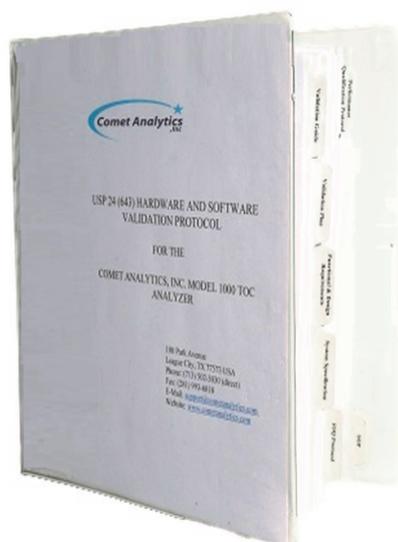
Critical government and industrial plants are increasingly choosing commercial Programmable Logic Controllers for reliability, ease of service and procurement advantages. Comet has selected a worldwide network that distributes and services a well know manufacturer of its PLCs.

## Specifications (may vary with application)

Analysis:	Continuous Analysis: Total Organic Carbon (TOC)
Sensors:	Titanium conductivity sensor implanted with precision platinum RTD temperature sensors
Ranges:	
Conductivity:	Three (3) ranges that adequately support applications from 0.055 uS/cm to 10 uS/cm standard in one analyzer without changing conductivity cells.
Resistivity:	0.1 to 18.2MΩ-cm
Carbon:	0.01 ppb – 10.0 ppm Repeatability: +/- 1% scale Resolution: 0.01 to 0.001 ppb depending on range Limit of Detection: 0.01 ppb Linearity: 1.00+/-0.05
Display:	8.4 inch Color Programmable HMI Ethernet Touch Screen
Data Management:	Paperless Chart Recorder; Print Screen utility containing required test and validation reports. Remote Data Acquisition: Ethernet
Alarms:	Five (5) alarms for TOC levels, over-ranges, temperatures, loss-of-sample, Reactor replacement and Master Fault Alarm.
Outputs:	4-20 ma, RS-232C and RS-485 Modbus
Sample Requirement:	Temperature: 1°C to 90°C; pressure: 0-5 psig (std). Optional pressure-insensitive Sample System
Analyzer Flow rate:	Adjustable from 1 ml/min to 10 ml/min, depending on application
Ambient Temperature:	5-40°C/41-104°F
Humidity:	0-80% non-condensing
Particle size:	50 um, external particle filter
Size:	(HxWxD) 20 in (51 cm) x 20 in (51 cm) x 8 in (20 cm)
Voltage/Power:	100-240 VAC @ 50-60Hz 80 W (max) or 24 VDC, 60W (max) for low voltage applications if 24 VDC available.
Weight:	27.5 lbs / 12.5 kg
Sample Connections:	1/8 inch (3 mm) compression tube fittings
Wetted Parts:	Titanium, 316 Stainless Steel, FDA – Approved tubing

## COMPLETE REGULATORY COMPLIANCE DOCUMENTATION

(Templates available to Customers in WORD Documents)



### Hardware and Software Validation Protocol

#### In Compliance With USP<643> and <645> and EP 2.2.44

- Validation guide
- Validation Plan
- Functional and Design Requirements
- System Specification
- IOQ Protocol
- PQ Protocol

#### Standard Operating Procedures