
Modbus Protocol Guide

TotalSense Series

Senva Sensors
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TotalSense™ Series

154-0044-0C

Rev.	Release Date	By	Description of Change	ECR
0A		NAK	Initial Release	---
0B	9/23/2021	NJS	Adding system config points	---
0C	6/7/2022	NJS	Updates for engineering CI release	---

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See Also:

152-0401 [TotalSense Installation Instructions](#)



154-0042 [TotalSense Display Navigation Guide](#)



154-0043 [TotalSense BACnet Protocol Guide](#)



Configuration

Congratulations on installing your new Senva Modbus TotalSense Series indoor air quality monitor! The *Modbus Protocol Guide* assumes the first stage of installation is complete, with the TotalSense connected to your local RS485 network and powered.

See "TotalSense Installation Manual" for setup.



The TotalSense supports the following functions of the Modbus Application Protocol Specification, v1.1b3.:
The TotalSense supports the following Modbus functions:

- 0x03 *Read Input Register*
- 0x04 *Read Holding Registers*
- 0x06 *Write Single Register*
- 0x10 *Write Multiple Registers*

Protocol

TotalSense device supports Modbus RTU encoding only (not ASCII).

Scale:

Values must be divided by this scale factor to be read correctly.

Store:

All registers 100 or greater will be stored in non-volatile memory.

R/W:

R = Read Only

R/W = Read and Write

Type, Min, Max:

INT8 8-bit integer; -128 to 128, unless otherwise noted

INT16 16-bit integer; -32768 to 32767, unless otherwise noted

Float Number that contains a decimal point

ENUM = UINT16 16-bit unsigned integer that maps to a defined list of values

Readings

Register	Description	Min/Max	Units	Read	Modbus Scale	Type	Functionality
1	Temperature	-400 / 1220	°F/C	R	10	Float	Read current temperature. Units depend on setting in 102.
2	Relative humidity	00 / 1000	%RH	R	10	Int16	Read current relative humidity in %.
3	CO2	0 / 10000	PPM	R	1	Int16	Read current CO ₂ concentration in PPM.
4	TVOC ug/m3	0 / 10000	µg/m ³	R	1	Int16	Read current TVOC reading in µg/m ³ . This value is compensated for ambient temperature and barometric pressure.
5	TVOC PPB	0 / 10000	PPB	R	1	Int16	Read current TVOC reading in PPB. This value is compensated for ambient temperature and barometric pressure and assumes an average molecular weight of 46.069 g/mol for conversion, which is based on Ethanol. To adjust this value, see register 108 to adjust scaling factor.
6	PM 1.0 ug/m3	0 / 1000.0	µg/m ³	R	10	Int16	Read current concentration of particles sized 0.3-1.0 µg/m ³ .
7	PM 2.5 ug/m3	0 / 1000.0	µg/m ³	R	10	Int16	Read current concentration of particles sized 0.3-2.5 µg/m ³ .
8	PM 4.0 ug/m3	0 / 1000.0	µg/m ³	R	10	Int16	Read current concentration of particles sized 0.3-4.0 µg/m ³ .
9	PM 10.0 ug/m3	0 / 1000.0	µg/m ³	R	10	Int16	Read current concentration of particles sized 0.3-10.0 µg/m ³ .
10	Air quality	0 = Good 1 = Fair 2 = Poor	no units	R	1	Enum	Read current air quality status. See "Air Quality Thresholds" section for more information.
11	Slider display	-400 / 1220	°F/C	R	10	Float	Read current setpoint slider position. Minimum and maximum values for scaling can be set in 109 and 110 respectively. Units depend on setting in 102.

Register	Description	Min/Max	Units	Read	Modbus Scale	Type	Functionality
12	<i>Occupancy</i>	0 = Unoccupied 1 = Occupied	no units	R	1	Enum	Read current status of PIR occupancy sensor. This value will stay in the occupied state after a motion event for the period specified in 112.
13	<i>Ambient light</i>	0 / 100	foot candles	R	1	Int16	Read current ambient light value in foot candles.
14	<i>Relay contacts state</i>	0 = OPEN 1 = CLOSED	no units	R	1	Enum	Read current state of setpoint relay. Relay settings can be adjusted in 115-120.
15	<i>Dewpoint</i>	-400 / 1220	°F/C	R	10	Float	Read current dew point temperature. Units depend on setting in 102.
16	<i>Pressure</i>	000 / 3544	inHg	R	100	Int16	Read current barometric pressure in inHg. This reading is only available on units that include either CO ₂ or VOC sensors.
27	<i>PM0.5 Particle Count</i>	0/10000	#/cm ³	R	10	Int16	Read Current counts for particles size 0.3 to 0.5.
28	<i>PM1.0 Particle Count</i>	0/10000	#/cm ³	R	10	Int16	Read Current counts for particles size 0.3 to 1.0.
29	<i>PM2.5 Particle Count</i>	0/10000	#/cm ³	R	10	Int16	Read Current counts for particles size 0.3 to 2.5.
30	<i>PM4.0 Particle Count</i>	0/10000	#/cm ³	R	10	Int16	Read Current counts for particles size 0.3 to 4.0.
31	<i>PM10.0 Particle Count</i>	0/10000	#/cm ³	R	10	Int16	Read Current counts for particles size 0.3 to 10.0.
32	<i>PM Avg Particle Size</i>	0/1000	um	R	100	Int16	Read Current average size of particle that the device has measured.

Diagnostics


Register	Description	Min/Max	Read	Modbus Scale	Type	Functionality
17	<i>System status</i>	0 / 255	R	1	Int8	0x01 = EEPROM hardware fault (Consult factory) 0x02 = EEPROM data corruption (Consult factory) 0x04 = EEPROM write error (Consult factory) 0x08 = Device is currently using factory defaults (Consult factory) 0x10 = Sensor error (see individual sensor status to more info). Bolded statuses will trigger this error.
18	<i>Temp sensor status</i>	0 / 255	R	1	Int8	0x01 = Sensor hardware fault (Consult factory) 0x02 = Sensor Data error (Consult factory)
19	<i>RH sensor status</i>	0 / 255	R	1	Int8	0x01 = Sensor hardware fault (Consult factory) 0x02 = Sensor Data error (Consult factory)
20	<i>CO2 sensor status</i>	0 / 255	R	1	Int8	0x01 = Sensor hardware fault (Consult factory) 0x02 = Sensor Data error (Consult factory) 0x04 = Sensor not ready (Consult factory) 0x40 = Temperature compensation not applied (No action necessary. Default value 25°C is used for temp compensation). 0x80 = Pressure compensation not applied (No action necessary. Default value 25°C is used for pressure compensation).
21	<i>TVOC sensor status</i>	0 / 255	R	1	Int8	0x01 = Sensor hardware (I2C) fault (Consult factory) 0x02 = Sensor error (bad init range) (Consult factory) 0x04 = Sensor error (Gas timeout) (Consult factory) 0x08 = Sensor error (other) error (Consult factory) 0x10 = Sensor not ready (training, 3 min stabilization after training) 0x20 = Sensor training (48 hours after power on)
22	<i>PM sensor status</i>	0 / 255	R	1	Int8	0x01 = Sensor communication error (Consult factory) 0x02 = Sensor Data Error (Consult factory) 0x04 = Sensor not ready (Consult factory) 0x08 = Sensor fan speed warning (Consult factory) 0x10 = Sensor fan failure (Consult factory) 0x20 = Sensor laser failure (Consult factory)
23	<i>Pressure sensor status</i>	0 / 255	R	1	Int8	0x01 = Sensor hardware fault (Consult factory) 0x02 = Sensor Data error (Consult factory) 0x04 = Sensor not ready (Consult factory)
24	<i>PID Output Power</i>	0.0/100.0%	R	10	Int16	Read current output percentage of the PID output.

Settings

Register	Description	Min/Max	Units	Default Value	R/W	Modbus Scale	Type	Functionality
101	<i>Temp Offset</i>	-90/90	°F	0	R/W	10	Float	Adjust T reading by up to 9°F (or 5°C).
102	<i>Temp Unit</i>	0=F 1=C	No units	0	R/W	1	Enum	Select whether display shows degrees Fahrenheit or Celsius. This will also determine the scale of the reading in Register 1.
103	<i>RH Offset</i>	-50/50	%RH	0	R/W	10	Int8	Adjust RH reading by up to 5%.
104	<i>CO2 Offset</i>	-250/250	PPM	0	R/W	1	Int16	Offset CO ₂ reading by ±250 PPM.
105	<i>CO2 autocal enable</i>	0=disabled 1=enabled	None	1	R/W	1	Enum	Enable or disable ABC function for CO ₂ sensor calibration. It is not recommended to disable this unless you are using a dual channel CO ₂ element.
106	<i>CO2 Autocal Baseline</i>	400 / 1499	PPM	400	R/W	1	Int16	This sets the baseline value for the automatic baseline calibration. This should correspond to expected “unoccupied” levels of CO ₂ .
107	<i>CO2 Autocal Period</i>	1 / 15	Days	14	R/W	1	Int8	This sets the period for which ABC will calculate its unoccupied level and calibrate.
108	<i>TVOC scale</i>	0000 / 10000	No units	1000	R/W	1000	Int16	This value can be used to adjust the TVOC reading. The standard readings are based on an Ethanol equivalent. See “TVOC Molecular Weights” section for more information.
109	<i>Slider display min</i>	-400 / 1220	°F/C	50	R/W	1	Float	Value shown when slider is at lowest position for display purposes only. This will not affect the slider resistive output. This will also set the minimum value for the Register 11 reading.
110	<i>Slider display max</i>	-40.0 / 122.0	°F/C	95	R/W	1	Float	Value shown when slider is at highest position for display purposes only. This will not affect the slider resistive output. This will also set the minimum value for the Register 11 reading.

Register	Description	Min/Max	Units	Default Value	R/W	Modbus Scale	Type	Functionality
111	<i>PIR Motion event sensitivity</i>	10 / 100	No units	80	R/W	1	Int16	Sensor sensitivity can be adjusted from 0-100. The default of 80 achieves the specified distance and degree. If nuisance triggers occur or a further sensing distance is required, this value can be decreased and increased accordingly. See TotalSense Installation Manual for a visual representation of this sensitivity value.
112	<i>PIR Occupied delay</i>	1 / 120	Minutes	10	R/W	1	Int8	This is the number of minutes the occupancy state will remain active after each motion event is detected. This applies to the "occupancy" BACnet and Modbus point as well as the output relay state, if set to PIR in 115.
113	<i>PM clean interval</i>	0 / 8760	hours	168	R/W	1	Int16	Timed automatic clean cycle of PM element. To disable auto-clean, set to 0.
114	<i>PM command</i>	0 / 2	no units	0	R/W	1	Int8	Write 1 to execute fan manual clean operation Write 2 to execute PM sensor reset
115	<i>Relay source</i>	0=None 1=CO2 2=Humidity 3=Temp 4=TVOC µg/m ³ 5=PM 6=Occupancy 7=Air Quality	no units	0	R/W	1	Enum	Which measurement will activate setpoint relay
116	<i>Relay polarity</i>	0 = N.O. 1 = N.C.	no units	0	R/W	1	Enum	A N.O. (normally open) relay will be in the open state until it is activated, i.e., turn-on threshold is met, at which time it will close. A N.C. (normally closed) relay will be in the closed state until it is activated, at which time it will open.

Register	Description	Min/Max	Units	Default Value	Read/ Type	Modbus Scale	Functionality																														
117	<i>Relay on threshold</i>	000 / 10000	percent	varies	R/W Int8	10	<p>Based on full scale range of the selected sensor, set the value above which the relay will activate. For example, if CO₂ is selected, its full available range is 0-10,000 PPM, so a setpoint of 800 PPM would correspond to an 8.00% threshold setting. For temperature, the full range is -40 to 122°F, so a setpoint of 70°F would correspond to a threshold value of 68%. Use this equation to determine threshold setting for temp in °F: $(T+40)/162*100$. This setting is ignored for PIR and G/F source selections. Display will show the calculated value as you adjust this setting. The below shows the values that are set by default when each source is selected as well as the calculated value for each.</p> <table border="1"> <thead> <tr> <th>Source Selection</th> <th>Range</th> <th>Default Turn-on Threshold</th> <th>Calculated Turn-on value</th> <th>Default Turn-off Threshold</th> <th>Calculated Turn-off value</th> </tr> </thead> <tbody> <tr> <td>CO2</td> <td>0-10,000 PPM</td> <td>8.0%</td> <td>800 PPM</td> <td>7.0%</td> <td>700 PPM</td> </tr> <tr> <td>RH</td> <td>0-100% RH</td> <td>60%</td> <td>60% RH</td> <td>55%</td> <td>55% RH</td> </tr> <tr> <td>Temp*</td> <td>-40 - 122 °F</td> <td>74%</td> <td>80°F</td> <td>73%</td> <td>78°F</td> </tr> <tr> <td>TVOC</td> <td>0-10000 µg/m³</td> <td>4.0%</td> <td>400 µg/m³</td> <td>3.5%</td> <td>350 µg/m³</td> </tr> </tbody> </table>	Source Selection	Range	Default Turn-on Threshold	Calculated Turn-on value	Default Turn-off Threshold	Calculated Turn-off value	CO2	0-10,000 PPM	8.0%	800 PPM	7.0%	700 PPM	RH	0-100% RH	60%	60% RH	55%	55% RH	Temp*	-40 - 122 °F	74%	80°F	73%	78°F	TVOC	0-10000 µg/m ³	4.0%	400 µg/m ³	3.5%	350 µg/m ³
Source Selection	Range	Default Turn-on Threshold	Calculated Turn-on value	Default Turn-off Threshold	Calculated Turn-off value																																
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118	<i>Relay off threshold</i>	000 / 10000	percent	Varies	R/W Int8	10	<p>Based on full scale range of the selected sensor, set the value below which the relay will de-activate. For example, to deactivate relay when CO₂ setting reaches 790, set this threshold value to 7.90%. This value must be set lower than the relay on threshold.</p>																														
119	<i>Relay min on time</i>	1 / 240	seconds	60	R/W Int16	1	<p>When relay activates, it will not deactivate until this time has lapsed, regardless of the turn-off setting. The relay will deactivate only when this time has expired AND the turn-off threshold is met.</p>																														

Register	Description	Min/Max	Units	Default Value	Read/Type	Modbus Scale	Functionality
120	Relay min off time	1 / 240	seconds	60	R/W Int16	1	When relay de-activates, it will not activate again until this time has lapsed, regardless of the turn-on setting. The relay will re-activate only when this time has expired AND the turn-on threshold is met.
121	Display PM size	0 = 0.3-1.0 1 = 0.3-2.5 2 = 0.3-4.0 3 = 0.3-10.0	Micro-meters	1	R/W Enum	1	Select which particulate size to show on display units.
122	Display center	0 = None 1 = Temperature 2 = Humidity 3 = CO2 4 = Air Quality 5 = TVOC $\mu\text{g}/\text{m}^3$ 6 = TVOC ppb 7 = PM 8 = Temp Setpoint	None	4	R/W Enum	1	Choose the value to show in the center of the OLED display (Display models only). The below is an example of the "Air Quality" setting. If PM is selected, the particle size displayed will depend on the setting in 121. 
123	Display upper left	0 = None 1 = Relay Icon	None	0	R/W Enum	1	Choose whether to show the relay state icon on the top left of the OLED display (Display models only).
124	Display upper right	0 = None 1 = Temperature 2 = Humidity 3 = CO2 5 = TVOC $\mu\text{g}/\text{m}^3$ 6 = TVOC ppb 7 = PM 8 = Temp Setpoint	None	1 or 0	R/W Enum	1	Choose the value to show in the upper right of the OLED display (Display models only). Default depends on whether temperature element is included.
125	Display lower left	0 = None 1 = Temperature 2 = Humidity 3 = CO2 5 = TVOC $\mu\text{g}/\text{m}^3$ 6 = TVOC ppb 7 = PM 8 = Temp Setpoint	None	2 or 0	R/W Enum	1	Choose the value to show in the lower left of the OLED display (Display models only). Default depends on whether humidity element is included.

Register	Description	Min/Max	Units	Default Value	Read/Type	Modbus Scale	Functionality
126	<i>Display lower right</i>	0 = None 1 = Temperature 2 = Humidity 3 = CO2 5 = TVOC µg/m ³ 6 = TVOC ppb 7 = PM 8 = Temp Setpoint	None	3 or 0	R/W Enum	1	Choose the value to show in the lower right of the OLED display (Display models only). Default depends on whether CO2 element is included.
127	<i>AQ Ring brightness</i>	0 / 100	no units	100	R/W Int8	1	Adjust value to increase or decrease brightness of AQ Ring (on AQ Ring devices only).
128	<i>Good-Fair</i>	0 / 100	no units	70	R/W Int8	1	Adjust this value to change the threshold below which the display or AQ Ring will show a "fair" rating.
129	<i>Fair-Poor</i>	0 / 100	no units	40	R/W Int8	1	Adjust this value to change the threshold at or below which the display or AQ Ring will show a "Poor" rating.
130	<i>VOC Mode</i>	0/2	No units	0	R/W Int8	1	0 = Normal operation mode 1 = Stabilization mode (3 minutes) 2 = Training mode (48 hours)
131	<i>Factory reset</i>	1234 *	no units	0	Enum	1	Write value 1234 to this register to set all customer accessible values to factory defaults. Device will reboot after factory restore has completed.
132	<i>Protocol</i>	0 = Modbus 1 = BACnet	no units		R Enum	1	Read from device DIP switches. See installation Manual for details.
133	<i>MAC address</i>	0 / 127	no units		R Int8	1	Read from device DIP switches. See installation Manual for details.
134	<i>Baud rate</i>	0 = 9600 1 = 19200 2 = 38400 3 = 57600 4 = 76800 5 = 115200	no units		R Enum	1	Read from device DIP switches. See installation Manual for details.
135	<i>Data/Parity/Stop</i>	0 = 8N1 1 = 8N2 2 = 8O1 3 = 8E1	no units		R Enum	1	Read from device DIP switches. See installation Manual for details.

Register	Description	Min/Max	Units	Default Value	Read/Type	Modbus Scale	Functionality
155	<i>Display Lock</i>	0 = Disabled 1 = Enabled	No units	0	R/W Enum	1	Choose to lock the settings Menu. This will override the menu lock setting in the device GUI display settings and the device will remain locked until this setting is changed through comms.
156	<i>PIR Display Wake-Up</i>	0 = Disabled 1 = Enabled	No Units	0	R/W Enum	1	Will use the PIR motion sensor to wake up the device display when a motion event is detected
157	<i>Screensaver Timeout</i>	1/120	Min	1	R/W Int8	1	Sets the time in minutes the screen will stay active until the screensaver turns on.

Analog Output

Register	Description	Min/Max	Units	Read/Type	Modbus Scale	Functionality
136	Analog Source	0 = None 1 = CO2 2 = Humidity 3 = Temperature 4=VOC 5 = PM 6 = Slider Temp 7 = PID-Temp 8 = PID-CO2 9 = PID-Slider Temp	None	R/W Enum	1	Sets the source of the analog output channel.
137	Analog V min	0/100	Volts	R/W Int8	10	This value corresponds to the lowest point on an analog scale. For a 0-10V signal, set to 0V. For a 2-10V signal, set to 2V.
138	Analog V max	0/100	Volts	R/W Int8	10	This value corresponds to the highest point on an analog scale. For a 0-10V signal, set to 10V. For a 0-5V signal, set to 5V.
139	Analog mA min	0/200	mA	R/W Int16	10	This value corresponds to the lowest point on an analog scale. For a 4-20mA signal, set to 4mA. For a 0-20mA signal, set to 0mA.
140	Analog mA max	0/200	mA	R/W Int16	10	This value corresponds to the highest point on an analog scale. For a 0-20mA or 4-20mA signal, set to 20mA.

PID Settings

Register	Description	Min/Max	Units	Read/ Type	Modbus Scale	Functionality
141	PID CO2 setpoint	0/10000	ppm	R/W Int16	1	Sets the CO2 setpoint for the PID controlled analog output.
142	PID Temp Setpoint	-400/1220	F/C	R/W Float	10	Sets the Temperature set point for the PID controlled analog output.
143	PID Kp	-1000000 /1000000	None	R/W Float	1000	Sets the Proportional gain PID coefficient.
144	PID Ki	0/100000	None	R/W Float	1000	Sets the Integral gain PID coefficient.
145	PID Kd	0/100000	None	R/W Int16	1000	Sets the Derivative gain PID coefficient.
146	PID Invert	0 = Not Inverted 1 = Inverted	None	R/W	1	This setting will invert the overall error signal (R - SP instead of (SP - R).

Air Quality Thresholds

If Air Quality is selected Settings, the device will monitor each CO₂, TVOC, PM, RH, and Temp sensor present and will display accordingly. The device will calculate an average air quality based on up to 5 sensors and display good, fair, or poor accordingly.

Sensor	Good	Fair	Poor
PM2.5	<35 µg/m ³	35-55 µg/m ³	>55 µg/m ³
TVOC	<1000 µg/m ³	1000-3000 µg/m ³	>3000 µg/m ³
CO ₂	<1200 PPM	1200-2000 PPM	>2000 PPM
Temp	64-79F	<64F, >79F	
RH	30-60%	<30%, >60%	<10%, >90%

The average air quality is calculated as follows for the sensors that have been enabled (see table below to enable and disable each sensor):

1. Each reading is rated according to the above thresholds and given an air quality rating. For each sensor, a good rating is given 90%, fair is given 60% and poor is given 0% air quality.
2. The average of all sensors' air quality is calculated.
3. The average air quality is assigned based on the following thresholds. These thresholds can be adjusted in 128 Good-fair and 129 fair-poor.
 - a. Good ≥ 75
 - b. 55 < Fair < 75
 - c. Poor ≤ 55

Register	Description	Min/Max	Units	Read/ Type	Modbus Scale	Functionality
150	AQ Enable Temp	0 = Disabled 1 = Enabled	None	R/W Int16	1	<p>These settings are used to enable or disable a sensor being used for the Air Quality calculation. For a sensor to be enabled it must be installed on the device.</p> <p>All sensors will be shipped with present elements enabled in the Air Quality calculation.</p>
151	AQ Enable Humidity	0 = Disabled 1 = Enabled	None	R/W Float	1	
152	AQ Enable CO2	0 = Disabled 1 = Enabled	None	R/W Float	1	
153	AQ Enable PM	0 = Disabled 1 = Enabled	None	R/W Float	1	
154	AQ Enable VOC	0 = Disabled 1 = Enabled	None	R/W Int16	1	

TVOC Molecular Weights

Senva's TVOC sensor uses an Ethanol reading to determine a raw TVOC value. Additionally, conversion from $\mu\text{g}/\text{m}^3$ uses the molecular weight of Ethanol. To scale based on a different gas baseline, choose the appropriate gas from the list below and enter the scale factor in 108.

Please note that the sensor is measuring TOTAL VOCs, so adjusting the scale factor will not necessarily result in a gas-specific reading unless, in special cases, that is the only expected VOC present in the area. It is recommended to use the 1.0 scale factor in most cases. The RESET standard suggests calculating TVOC based on the molecular weight of Isobutylene (scale factor: 1.218).

Data Source: <http://aqt-vru.com/emissions/complete-list-of-vocs/>

Contamination	Name	Molecular Weight	Scale factor
ACETYLENE	ACETYLEN	26.04	0.565
FORMALDEHYDE	FORMALD	30.03	0.652
METHANOL	MEOH	32.04	0.695
PROPANE	PROPANE	44.1	0.957
ETHANOL	ETOH	46.07	1.000
DIMETHYL ETHER	ME-O-ME	46.07	1.000
METHYL CHLORIDE	CH3-CL	50.49	1.096
1,3-BUTADIENE	13-BUTDE	54.09	1.174
ISOBUTENE	ISOBUTEN	56.11	1.218
N-BUTANE	N-C4	58.12	1.262
ISOBUTANE	2-ME-C3	58.12	1.262
ACETIC ACID	ACETACID	60.05	1.303
ISOPROPYL ALCOHOL	I-C3-OH	60.1	1.305
ETHYLENE GLYCOL	ET-GLYCL	62.07	1.347
ISOPRENE	ISOPRENE	68.12	1.479
BUTANAL	1C4RCHO	72.11	1.565
N-PENTANE	N-C5	72.15	1.566
ISOPENTANE	2-ME-C4	72.15	1.566
HYDROXY ACETONE	HOACET	74.08	1.608
ISOBUTYL ALCOHOL	I-C4-OH	74.12	1.609
BENZENE	BENZENE	78.11	1.695
TOLUENE	TOLUENE	92.14	2.000
M-XYLENE	M-XYLENE	106.17	2.305
O-XYLENE	O-XYLENE	106.17	2.305
P-XYLENE	P-XYLENE	106.17	2.305
TERPENE	TERPENE	136.24	2.957