

DataMaster DMT Explanation of Status Codes and Their Limits

Based on Vermont Software as of 3/30/2009

“PUMP ERROR”

If at anytime during the purge cycle or the running of a wet bath external standard, the flow rate drops below approximately 3 liters per minute (derived from a flow voltage limit of 1.35 Vdc), the message “PUMP ERROR” will be generated.

This voltage and the corresponding flow rate of approximately 3 l/m is also used as the MINIMUM FLOW RATE required when determining subject sample acceptance.

“FILTER (1, 2 or 3) WON'T ZERO”

In the event the DMT's D to A converter is unable to adjust the output detector signal prior to an analysis at any of the three wavelengths (3.44 μ , 3.37 μ and 3.50 μ) to within 30 mV of 0.000 V, the message “FILTER (1, 2 or 3) WON'T ZERO” will be generated identifying which specific filter was unable to zero.

“AMBIENT FAIL”

During the initial purge cycle of a given test, the output signal of the detector is measured and quantified. The initial measurement is made 10 seconds after the pump comes on. A second measurement is made at the completion of the purge, 25 seconds from the start. When these 2 measurements are compared, if the difference is $> .040$ Vdc, the message “AMBIENT FAIL” will be generated.

“BLANK ERROR”

A Blank Test is performed subsequent to zeroing and prior to analysis when the primary, or 3.44 μ filter is in the optical path. If this measurement produces a measurement ≥ 0.004 g/210 liters or equivalent, the message “BLANK ERROR” will be generated.

Additionally, if, after the allotted purge time after a sample has been delivered the displayed value ≥ 0.008 g/210 liters or equivalent, the message “BLANK ERROR” will be generated.

“STANDARD OUT OF RANGE”

If the simulator tolerance check is enabled, the value of an external standard must be within ± 0.005 g/210 liters (THIS SHOULD BE $\pm 5\%$), or equivalent, of the target ethanol concentration for values of 0.080 g/210 liters or equivalent and above. For target

concentrations below 0.080 g/210 liters, the limit is ± 0.004 g/210 liters. If the result produce is outside the above allotted tolerances, the message “STANDARD OUT OF RANGE” is generated.

“SIMULATOR NOT TO TEMPERATURE”

When connected to a digital wet bath simulator, if the monitored temperature falls outside the limit of 33.5 to 34.5 degrees C inclusive when a test is conducted, the message “SIMULATOR NOT TO TEMPERATURE” will be generated.

“SIMULATOR TIMEOUT”

When running an external standard, if the sample acceptance parameters are not met within the allotted 30 second window, the message “SIMULATOR TIMEOUT” will be generated.

“INTERNAL STANDARD ERROR” (I BELIEVE OUR WORDING IS ‘CALIBRATION CHECK FAILED’)

When performing a measurement of the internal quartz standard during the testing sequence, if the measured value equals or exceeds the Xq value stored in the calibration factors by $\pm 4\%$, the message “INTERNAL STANDARD ERROR” will be generated.

“INVALID SAMPLE”

Reference NPAS document DMT Invalid.doc dated 12/14/07 (attached).

“DETECTOR OVERFLOW”

When a voltage corresponding to the alcohol concentration (Detector Voltage) during any time the DMT is taking any type of measurement exceeds the limit of -2 Vdc to +2 Vdc, the message “DETECTOR OVERFLOW” will be generated. This voltage corresponds to an alcohol concentration outside the limits of detection of the DMT (approximately 0.83 (or -0.83 g/210 liters) as a reference).

SAMPLE CHAMBER TEMPERATURE CHECK

The temperature range for the sample chamber is 44 to 52 degrees C exclusive. The DMT will only allow a test to be conducted if the sample chamber temperature is above 44 and below 52 degrees C. If the temperature is outside this limit, a message stating so (WHAT

IS THE EXACT WORDING OF THE ERROR?) will be displayed when a test is attempted.

When the DMT is powered-up, the 20 minute wait period (SOMETIMES IT'S ONLY 10 MINUTES??) to the time that a test can be conducted is 20 minutes after the sample chamber temperature reaches 45 degrees C.

BREATH TUBE TEMPERATURE CHECK

The temperature range for the breath tube is 40 ± 10 degrees C inclusive. If the temperature is outside this limit, a message stating so (WHAT IS THE EXACT WORDING OF THE ERROR?) will be displayed when a test is attempted.

“RFI DETECTED”

An antenna wire in the breath tube monitors the environment around the DMT for elevated levels of radio frequency interference. If the set threshold for detection is exceeded due to elevated levels of RFI the message “RFI DETECTED” will be generated.

“INCOMPLETE SAMPLE” (THE MESSAGE IS SIMPLY ‘INCOMPLETE’)

If the breath sample parameters are not met during the allotted 2 minute window for accepting a breath sample the message “INCOMPLETE SAMPLE” will be generated if it is determined that it is not a refusal.

“FILTER WHEEL ERROR”

2 optical sensors are used to validate proper positioning of the filters and quartz standard in the optical path. A stepper motor is used to move the filters and quartz standard into the proper position and a locking pin is actuated via a solenoid to secure in place. The software monitors the movement of these wheels and if there is misalignment during any of the movement sequences, the message “FILTER WHEEL ERROR” will be generated.

“SUCK BACK ERROR”

In addition to being able to determine the rate of airflow through the pathway, the mass airflow sensor can determine the direction of airflow. If the sensor detects airflow in the reverse direction during a breath test (sucking), the message “SUCK BACK ERROR” will be generated.

“INTERFERENCE DETECTED”

Each sample measured by the DMT is done so to determine the ethanol concentration. In addition, by measuring the sample at 3 wavelengths, we determine whether or not the sample is specific to ethanol. If a discrepancy is found compared to what is expected at the three separate filters, the sample is said to be non-specific to ethanol and the message “INTERFERENCE DETECTED” is generated. The limits for determining this are outlined in NPAS document DMT interference threshold.doc dated 1/18/2008 (attached).

Note: Status messages are in some instances software specific based upon customer requests. This list may not cover all scenarios and possible status messages. Additionally, allowable limits for certain checks may also differ among software / hardware configurations at the customers’ request.

WHAT ABOUT THE MESSAGES ‘CHOPPER OUT OF REGULATION’ AND ‘PURGE ERROR’, ARE YOU SURE THIS IS A COMPLETE LIST OF THE ERROR CODES?

Preliminary

National Patent Analytical Systems, Inc.

Explanation of the INVALID SAMPLE message and the DataMaster DMT

12/14/07

Measurements of the alcohol concentration during breath sample delivery are taken every 250 milliseconds (4x per second).

A “positive slope” is defined as a comparison of a 2 consecutive point average to the previous where the trend is not in the negative direction. Both conditions of a positive change and no change are considered a positive slope.

The message “INVALID SAMPLE” will be produced while the instrument detects at least the minimum rate of airflow during sample delivery if:

There are three consecutive comparisons of two point averages where the trend is in the negative direction (values are decreasing) after seeing first a minimum of six positive comparisons of two point averages.

Or

Any final result ≥ 0.060 g/210 l is less than 95% of any previous high reading during that successfully delivered sample.

Or

Any final result ≥ 0.003 g/210 l but < 0.060 g/210 l is lower than any previous high reading during that successfully delivered sample by at least 0.003 g/210 l.

The “Filter Agreement” concept as it pertains to analytical principles incorporated in the DataMaster DMT breath test instruments. (Interference Detection)

Calibrating a DMT involves introducing known standards of water vapor and either wet or dry ethanol vapor. The purpose is twofold. First, the error in quantifying the ethanol, pre-calibration, as evidenced in the discrepancy between the known ethanol concentration (Ca) and that analyzed and displayed by the instrument upon introduction of that standard, is normalized to the known (Ca) by dividing the known value (Ca) into the reported (resulting in CAL). Second, by knowing that a true ethanol standard, free of any potential interfering substances, is introduced during the calibration procedure, the instrument determines the relative measurement of the ethanol sample when analyzing the vapor at each of the three narrow bandpass filter wavelengths (ref: a21, a31), thereby allowing subsequent analyses to be qualified as either containing or being free of interfering substance(s).

Water vapor is introduced so as to allow the amount evident at each of the filter wavelengths to be subtracted from all analyses thereafter. This water vapor concentration will be constant regardless of the ethanol concentration of the sample so a straight subtraction will suffice (ref: b1, b2, b3).

For discussion of the basic concept, we will show an example using 2 of the three filters (3.44 [filter 1] and 3.37 [filter 2] microns) and calibrating with water and ethanol. As stated above, water is introduced to determine the amount to be subtracted at 3.44 μ and 3.37 μ . These will not be the same value as water absorbs IR energy to a greater degree at 3.37 μ than at 3.44 μ . With the water content accounted for, the relative absorption by ethanol between 3.37 μ and 3.44 μ is determined. Since ethanol absorbs approximately 20% more IR energy at 3.37 μ than that at 3.44 μ , we would expect a21 to be in the neighborhood of 1.2 as a21 is defined as the value of ethanol measured at 3.37 μ with respect to that at 3.44 μ . As each IR filter has slightly different transmittance characteristics (center wavelength and half peak bandwidth), albeit within the published filter specifications, each instrument must be calibrated to determine the specific calibration factors for the use of those filters in a specific instrument. Those calibration factors are the characteristic values for that particular instrument. The a21 value is used on subsequent analyses to determine the presence (or absence) of an interfering substance.

This is done by first determining the concentration of the sample as analyzed at the 3.44 μ filter. The 3.37 μ filter is then inserted into the optical path and the sample is analyzed at that wavelength. The result analyzed at 3.44 μ is multiplied by a21. The result at 3.37 μ is subtracted from this product of the value at 3.44 μ x a21. If the difference is $\leq$ the filter agreement threshold (default 0.005) then the sample is said to be free from an interfering

substance. This is because the relative absorption seen between 3.37μ and 3.44μ for this sample is the same as that for the ethanol standard used to calibrate the instrument. When a substance other than ethanol, but still absorbing IR energy in the 3.4μ region, is added to the sample, a disagreement becomes evident in the value at 3.37μ with the result from $3.44\mu \times a_{21}$. The greater the concentration of the interference, or the less like ethanol (a_{21}), the greater the discrepancy becomes.

As some allowance for variation between the values ($3.44\mu \times a_{21}$ and 3.37μ) is necessary due to expected variability in any measurement (± 0.002 for each measurement) the question arises as to at what level the discrepancy becomes significant and scientifically and legally of importance. The limit for the filter agreement threshold is 0.005. What this means is that once the discrepancy between the value at 3.37μ and the value at $3.44\mu \times a_{21} \geq 0.005$, the sample is said to contain an interfering substance. This threshold can, however, be adjusted.

The following is an explanation of what might happen if the sample were to contain acetone in addition to ethanol. Lets assume the ethanol concentration of the sample as measured at 3.44μ was 0.160. Knowing that ethanol absorbs approximately 20% more energy at 3.37μ , we would anticipate the result at 3.37μ to be $0.160 \times 1.2 = 0.192$. If acetone is also a component of the sample, it would be useful to know the characteristics of acetone at 3.44μ and 3.37μ . Test data has shown that acetone absorbs 2 to 3 times the amount of IR energy at 3.37μ than it does at 3.44μ (again, independent of the concentration). For this discussion we will use a 2:1 ratio. Assume a contribution of 0.010 at 3.44μ . Since we expect in this example 2X that concentration at 3.37μ , the value would be 0.020. If we add these concentrations of acetone to the ethanol portion we would see:

Reading at $3.44\mu = 0.160$ (etoh) + 0.010 (ace) = 0.170 total concentration

Reading at $3.37\mu = 0.192$ (etoh) + 0.020 (ace) = 0.212 total concentration

When multiplying the result at 3.44μ by a_{21} we see:

$$0.170 \times 1.2 = 0.204$$

Comparing this to the result at 3.37μ we see:

$$0.204 - 0.212 = -0.008$$

This exceeds the “filter agreement threshold”, (preset at 0.005) by 0.03. This test would result in the message of “interference detected” if the software were designed to handle the discrepancy in this manner.

If the contribution by acetone were 0.005 at 3.44μ in the above example, the amount at 3.37μ would be expected to be 2X or 0.010. This, added to our base ethanol concentration would yield:

Reading at 3.44 = 0.160 (etoh) + 0.005 (ace) = 0.165 total concentration

Reading at 3.37 = 0.192 (etoh) + 0.010 (ace) = 0.202 total concentration

When multiplying the result at 3.44 μ by a21 we see:

$$0.165 \times 1.2 = 0.198$$

Comparing this to the result at 3.37 μ we see:

$$0.198 - 0.202 = -0.004$$

This would be below the set filter agreement threshold (0.005) and in this instance, the final result would be a reported ethanol concentration of 0.165.

The explanation above is repeated except filter 2 (3.37 μ) is replaced with filter 3 (3.50 μ) and a21 is replaced with a31.

This example is when acetone absorbs only 2x as much at 3.37 μ wrt 3.44 μ . As you approach a 3x relationship, the allowable contribution by acetone at 3.44 μ is reduced.

The filter agreement threshold will be adjustable. This settable level (2-10) implying, when referring to g/210L units of measurement, an adjustable threshold of between 0.002 g/210L and 0.010 g/210L will pertain to the difference in the calculated concentration at filter 1 (3.44 μ) and filter 2 (3.37 μ) or the difference in the calculated concentration at filter 1 and filter 3 (3.50 μ). The selected filter agreement threshold will be the absolute value for sample concentrations measured at filter 1 of up to 0.100 g/210L. For values at or greater than 0.100 g/210L the threshold will be a percentage of the analyzed concentration at 3.44 μ :

Filter Agreement if $3.44\mu \geq 0.100 \text{ g/210L} = (\text{Int} \times 0.001) \times (\text{value at filter 1} / 0.100)$

Where Int is the set filter agreement threshold value from 2 to 10

If the difference when comparing the results of 3.44 μ and 3.37 μ OR when comparing the results of 3.44 μ and 3.50 μ exceeds the threshold, a non-specific to ethanol sample is said to have occurred.

An additional filter agreement threshold calculation will also be employed where the threshold outlined above is not exceeded but the difference in the 2 calculated differences (filter 1-2 and filter 1-3) when combined reaches a level defined as:

For filter 1 measured concentrations of up to 0.100 g/210L interference detected will be the result if:

$$\text{Diff filter 1-2 plus Diff filter 1-3} \geq (\text{Int} \times 0.001) \times (7/5) = 0.007$$

For concentrations measured at filter 1 of 0.100 g/210L or greater interference detected will be the result if:

$$\text{Diff filter 1-2 plus Diff filter 1-3} \geq (\text{Int} \times 0.001) \times (\text{value at filter 1} / 0.100) \times (7/5)$$

See table below for example of thresholds with INT set to 5

Value @ Filt 1	Filter I1-2I Diff	Filter I1-3I Diff	Combined Diff I1-2I + I1-3I
0.025	0.0050	0.0050	0.0070
0.050	0.0050	0.0050	0.0070
0.075	0.0050	0.0050	0.0070
0.100	0.0050	0.0050	0.0070
0.150	0.0075	0.0075	0.0105
0.200	0.0100	0.0100	0.0140
0.250	0.0125	0.0125	0.0175
0.300	0.0150	0.0150	0.0210
0.350	0.0175	0.0175	0.0245
0.400	0.0200	0.0200	0.0280
0.450	0.0225	0.0225	0.0315
0.500	0.0250	0.0250	0.0350
0.550	0.0275	0.0275	0.0385
0.600	0.0300	0.0300	0.0420

Enter Int Thrshld
(2-10)
5

Separate worksheet allows changing Threshold setting to see limits.