TACMET II
TRV WEATHER STATION, EMI
OPERATION MANUAL

Met One Instruments, Inc
Corporate Sales & Service: 1600 NW Washington Blvd. Grants Pass, OR 97526
Tel (541) 471-7111 Fax (541) 471-7116
www.metone.com - www.service@metone.com

Technical Support

Should you require support, please consult your printed documentation or our website www.metone.com to resolve your problem. If you are still experiencing difficulty, you may contact a Technical Service representative during normal business hours;

Monday – Friday 7:00 a.m. to 4:00 p.m. Pacific Time.

Voice: (541) 471-7111

Fax: (541) 471-7116

E-Mail: service@metone.com

Mail: Technical Services Department
Met One Instruments, Inc.
1600 NW Washington Blvd
Grants Pass, OR 97526

Safety Notice

The contents of this manual have been checked against the hardware and software described herein. Since deviations cannot be prevented entirely, we cannot guarantee full agreement. However, the data in this manual are reviewed regularly and any necessary corrections are included in subsequent editions.

Faultless and safe operation of the product presupposes proper transportation, storage, and installation as well as careful operation and maintenance. The seller of this equipment cannot foresee all possible modes of operation in which the user may attempt to utilize this instrumentation. The user assumes all liability associated with the use of this instrumentation. The seller further disclaims any responsibility for consequential damages.

Electrical & Safety Conformity

The manufacturer certifies that this product operates in compliance with the following standards and regulations:

FDA/CDRH This product is tested and complies with 21 CFR, Subchapter J, of the Health and Safety Act of 1968

US 21 CFR 1040.10

Warranty

All instruments are warranted against defects in parts or workmanship for a period of one (1) year from the date of shipment. Should any instrument or part prove to be defective within the warranty period, upon written notice and return of the unit (freight prepaid), Met One Instruments, Inc. will, at its option, repair or replace the defective unit, and return it, transportation prepaid via surface transportation.

Equipment abused, modified, or altered may cause cancellation of this warranty.

The above warranty applies only to items manufactured by Met One Instruments, Inc. Items not manufactured by Met One Instruments, Inc. are warranted only to the extent and in the manner warranted by the manufacturer of such items. Should emergency warranty repair be required at a customer's facility, Met One will provide such repairs and charge only the portal-to-portal Field Service rates and actual expenses in accordance with our published rates then in effect. Expendable supplies and wear items, such as bearings and lightning- related damages, are not covered under this warranty.

Table of Contents

1.0 Safety

1.1 Safety

This manual may include a **CAUTION** and a **WARNING** indication. Familiarize yourself with the following definitions for the meanings of these indicators.

A **CAUTION** indicates a hazard and calls attention to a procedure that if not correctly followed could result in damage to the instrument. Do not proceed beyond a caution indicator without understanding the hazard.

A **WARNING** indicates a hazard to you and calls attention to a procedure that if not correctly followed could result in injury or even death. Do not proceed beyond a warning without understanding the hazard.

2.0 Introduction & Overview – TACMET II Weather Station

2.1 Overview

Met One's sonic weather station (P/N 102602) is designed as a stand-alone weather station to provide accurate measurements of wind speed, wind direction, temperature and relative humidity, an internal flux-gate compass is standard. The unit has no moving parts and is ideally suited for use wherever reliable, maintenance free operation over a wide operating range under adverse operating conditions is required. The unit is built with a metal housing and filtering on all input and output lines to offer some protection from electromagnetic interference. Additional EMI gasketing has been supplied.

2.2 Specifications

PERFORMANCE

Wind Speed:		
	Range:	0-100 mph (0-44.7 m/sec)
	Accuracy:	1.1 mph ± 5% (0.1 m/sec)
	Resolution:	0.1
Wind Direction:		
	Range:	0-360 deg
	Accuracy:	± 5^0 @ wind speeds > 5 mph (2.2 m/sec)
	Resolution:	0.1
Temperature:		
	Range:	-30 to +55°C (-22°F to 131°F)
	Accuracy:	± 0.5°C (± 0.9°F) (sensor element)
	Resolution:	0.1
Relative Humidity:		
	Range:	0 to 100%
	Accuracy:	± 4%
	Resolution:	0.1
MTBF:		80,000 hours

ELECTRICAL

Measurement Format:	Two orthogonal axes, North-South and East-West
Measurement Rate:	Approx. 2 Hz each axis
Operating Frequency:	40 kHz
Signal Output:	RS-232 @19.2 K baud
	Four 0.1 – 2.5 Vdc analog channels (See Section 5.0 for details)
Power Requirements:	6 - 15Vdc: 50 mA draw @ 12 Vdc

PHYSICAL

Size:	30.5 cm (12 inches) by 10.15 cm (4 inches) dia .
Weight:	1.8 kg. (4.0 lb.)
Mounting:	102562-G0 Mount

3.0 Installation

Be sure to mount the sensor in a clear, open area to minimize any turbulent effects caused by local obstructions (e.g., trees, buildings, etc.). The sensor mounts on the prewired sensor mount. The connector key is matched to the keyway on its mate and secured by turning the connector's collar until tight.

4.0 Input/Output Connections

The sensors' pin designations are as follows:

PIN	FUNCTION
A	Power Ground
B	6.0 - 16 Vdc
C	N/C
D	N/C
E	0-100 mph = 0.1-2.5 V
F	0-360 deg = 0.1-2.5V
G	Receive Data RS 232
H	Transmit Data RS 232
I	-50 +55 C = 0.1-2.5 V
J	0-100 % = 0.1-2.5 V

5.0 User Interface

The digital output of the sonic anemometer is a serial data stream at 19.2k baud (N/8/1). The output format is shown below:

01+I0011 02+006.8 03+063.2 04+022.2 05+015.1

The first parameter is the ID number of the sensor (I0011), the second parameter is wind speed (in mph), the third parameter is wind direction (in °), the fourth parameter is temperature (in °C), the fifth parameter is relative humidity (in %). All parameters have fixed decimal points with leading zeroes.

Note: T*he wind direction output will be relative to magnetic north.*

The equations for converting the analog voltage outputs to the desired parameter are as follows:

$WS = (Vout - .1) * 41.67$
$WD = (Vout - .1) * 150$
$T = (Vout - .1) * 43.74 - 50$
$RH = (Vout - .1) * 41.67$

6.0 Theory of Operation

The Met One sonic anemometer operates on the principal that the speed of the wind effects the time it takes for sound to travel from one point to a second point. If the sound is traveling in the direction of the wind then the transit time is decreased. If the sound is traveling in a direction opposite the wind then the transit time is increased. This principal is well known and is the basis of most sonic anemometers. In mathematical terms:

$$t_1 = d / (c + u)$$
$$t_2 = d / (c - u)$$

where t_1= transit time from 1 to 2
t_2= transit time from 2 to 1
d= distance between 1 and 2
c= speed of sound
u= wind speed

If the equations are solved for c+u and c-u and the difference taken:

$$c+u-(c-u)=d/t_1-d/t_2$$
$$u=d/2*(1/t_1-1/t_2)$$

There are many ways to implement a sonic anemometer based on this equation and in fact most, if not all sonic anemometers operate according to this principal. It is important to note that the equation for wind speed is independent of the speed of sound. This is important because the speed of sound is not a constant but is very dependent upon air temperature, changing from 360 m/s at +50 ^{0}C to 300 m/s at -50 ^{0}C. Note that this change of 60 m/s is as great as the range of most sonic anemometers. The speed of sound is also affected by humidity and pressure; however their effect is small compared to the effect of temperature. It is interesting to note in passing that the equations can also be solved for the speed of sound and the air temperature can be determined from the speed of sound.
The relationship between the speed of sound in air and the air temperature can be described by the following equation:

$$c = 20.06\sqrt{T + 273}$$ T=temp °C

The equation for u above does not account for any delays in the electronics nor for any effect temperature might have on these delays. Because of this the path length d is generally made on the order of 10 cm or more. The longer the path length the less significant the other time delays. These design considerations and others lead to the sonic anemometers with which we are all familiar. Transducers are supported on long thin arms in an array to measure the components of the wind. The supports and the transducers are as slender as possible to minimize their effects on the wind field. These traditional sonic anemometers can be designed to measure one, two or three components of the wind.
Sonic anemometers of this type are generally accurate, exhibit high resolution, output temperature as well as wind speed and direction and are very responsive. They also are usually delicate, require extensive software to correct for transducer shadowing, and are expensive. Sonic anemometers of this type are generally used for research.

Met One's goal in developing a sonic anemometer was to design a unit that could replace cup and vane and propeller anemometers in terms of cost and accuracy and at the same time be more rugged. We also wanted an anemometer that could be kept ice free at reasonable power levels and without expensive components to transmit heat to the rotating parts such as the cups. Size was determined in part because it was desirable that it have the same overall dimensions as Met One's TACMET sensor for purposes of interchangability. All of these considerations dictate that the transducers will be close together resulting in a short path length. The short path length requires that all system delays be accounted for.

If the equations for the transit time above are rewritten to include the delays in the system then we have:

$$t_1 = d / (c + u) + t_1'$$

$$t_2 = d / (c - u) + t_2'$$

t_1'= delays due to transducers and electronics
t_2'= delays due to transducers and electronics

$$t_1 - t_2 = d/(c+u) + t_1' - d/(c-u) - t_2'$$

if $t_1' = t_2'$

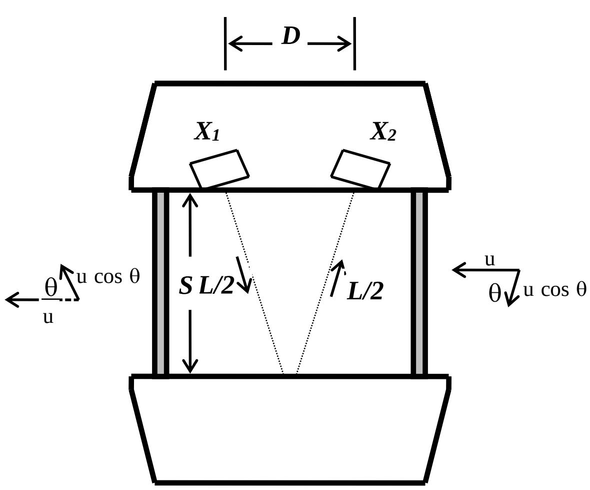
$$t_1 - t_2 = d/(c+u) - d/(c-u)$$

rearranging terms

$$u = -(t_1 - t_2)*(c^2 - u^2)/2d$$

At first this expression looks difficult to evaluate. It is required to measure the temperature to assign a value to c and the expression c^2-u^2 contains the variable we are trying to solve for. The advantage is that it is possible to measure (t_1-t_2) with greater accuracy then it is to measure either t_1 or t_2. The correction required due to the variation of the speed of sound with temperature is also readily accomplished. Note that the term (c^2-u^2) varies by +/- 20% over the range of 0 to 50 m/s and -50 to +50 ^{0}C. Note also that if c is corrected for temperature and u is set equal to zero then the term c^2-u^2 is in error by less than 3% from 0 to 50 m/s. Where the greatest accuracy is required the equation can be solved for u and then this value of u can be substituted back into the equation to solve for a more accurate value of u.

The design that has evolved consists of two tapered cylinders separated from each other by approximately 10 cm. All of the transducers are mounted in the upper cylinder pointing down. Sound is transmitted toward the lower cylinder and reflected back towards the upper cylinder as shown:



The transmission time is affected only by the horizontal component of the wind. Transducers are used as both transmitters and receivers. In this way the close match required for $t_1' = t_2'$ is achieved. Temperature is also measured, but is not corrected for solar radiation errors. This temperature measurement is suitable for speed of sound corrections but not for most meteorological purposes. When more accurate temperature information is required, a multiplate shield is added to the unit.

Wind tunnel tests have shown that the airflow between the upper and lower housing is not greatly affected by the housings themselves through tilt angles in excess of +/- 20 degrees. In this sense, the sensor has an almost cosine response similar to a propeller anemometer's.

7.0 Calibration

The sensor requires a wind tunnel for calibration. Met One can provide NIST traceable calibration in our wind tunnel. Please contact the factory for further details.

8.0 Maintenance

Because the sensor has no moving parts to wear out, the sensor does not require periodic maintenance. In extremely corrosive environments, the condition of the connector used to mount the sensor should be checked. There are no adjustments or user repairable parts located inside the sensor.