A PORTABLE WEATHER MONITORING SYSTEM FOR MOBILE EMERGENCY RESPONSE APPLICATIONS

David I. Katz

Climatronics Corporation
2865 South Eagle Road, STE 369
Newtown, PA 18940

Abstract

This paper describes a portable weather monitoring system which can be used for gathering data to predict the transport of radionuclides and other hazardous materials downwind of an accident site. The design of the sensor and interface are discussed. An example of the output of a hazardous materials spill model, using the weather system's data for input, is demonstrated.

1. Introduction

Since its inception in the 1960's, Climatronics Corporation has been dedicated to producing the highest quality, state-of-the-art instrumentation and systems for meteorological measurements and research. Through continued excellence and performance, Climatronics has established itself as one of the leading companies within its field. Climatronics has conceived, engineered, and manufactured a broad spectrum of sensors and systems designed to meet various applications and measurement criteria, which include airport meteorological measuring systems and low level wind shear detection.

2. Sensor Background

The United States Air Force determined in the mid 1980's that they needed an improved tactical meteorological sensing capability. In response to this requirement, the Air Force commenced a sensor system development program which resulted in the Tactical Meteorological Sensing System, or TACMET, which has the military nomenclature TMQ-34.

Climatronics designed the TACMET weather sensor as part of the TMQ-34 program (see Fig. 1). The sensor measures wind speed and direction, air temperature, and relative humidity. The TACMET includes a magnetic compass allowing it to automatically orient the wind direction signal to magnetic North. It is designed for rapid deployment and use by one person under adverse conditions. The TACMET can be hand-held or mounted on a tripod with a 1/4-20 screw.

The original TACMET design included a rotor to measure the wind speed and a short-tailed vane to measure the wind direction. The size constraints of this design were required to minimize the chance of damage to the sensor when used by military forces in a tactical situation. The performance of these sensing elements was adequate for this application.

A second version of the TACMET is also available which includes a three-cup anemometer and conventional, counterbalanced lightweight wind vane. The performance characteristics of these two sensors meet the requirements of the EPA's, "Ambient Monitoring Guidelines for Prevention of Significant Deterioration" and "On-Site Meteorological Program Guidance for Regulatory Modeling Applications".

3. Sensor Description

The internal construction of the TACMET sensor is shown in Fig. 2. The wind speed is sensed with either the rotor or cup assembly which is connected to a 30-slot chopper wheel assembly (shutter). The rotating shutter interrupts a beam of infrared light between a solid-state light emitting diode and a phototransistor detector assembly. This low-power detector produces a frequency which is proportional to the wind speed. The solid-state electronics in the sensor convert the number of pulses into an analog voltage signal which proportional to the wind speed.

The wind vane and magnetic compass are each connected to an electronic transducer which creates sine wave signals. Two signals represent the position of the wind vane and the pointer of the compass. The resultant of these two signals is the direction of the wind vane relative to magnetic North. The signal conditioning board in the TACMET scales the resultant to a linear analog voltage.

A four-wire thermistor is used to measure the air temperature. The sensor is housed in the space below the vane and rotor assembly which is designed to provide shielding from direct and reflected solar radiation, and precipitation. The sensor signal is linearized and scaled to an analog output over the full range of the sensor.

The relative humidity is sensed with an inert hygroscopic cellulose element connected to piezoresistive, thermally-matched strain gage. The sensor is shielded from solar radiation in the shield below the wind sensors and includes a filter to minimize particulate contamination.

The sensor output consists of four analog voltage signals as required by the original TMQ-34 program. These are linear in the range of 0.1 to 2.5 VDC for the four parameters measured by the TACMET. These signals can be displayed by a portable display or recorded with a low-power data logger. Both systems can be used in emergency response applications.

4. Portable Display Description

The TACMET Portable Display (see Fig. 3) displays all four parameters measured by the TACMET sensor. An internal barometric pressure transducer is available as an option. The TACMET Portable Display includes both integral LCD display panel and a keyboard for information entry. The information to be displayed can be the five observed parameters or several calculated parameters. The selection of information to be displayed is made using the integral keyboard. The display includes a timer to turn off the display to conserve battery power, and a backlighting capability for visibility at night.

The TACMET Portable Display includes a digital interface to allow the data to be relayed to a computer. The interface uses the RS-232C format and will communicate at rates compatible with most personal computers. The output of the display provides the input information to hazardous materials spill models or dose assessment calculation models.

5. Emergency Response Applications

The ease of setting up the TACMET is shown in Fig. 4, which shows the TACMET sensor and portable display on a lightweight, portable tripod. The sensor's threaded base fits easily and quickly on this or other standard tripod. The time required to set up the TACMET is typically 5-10 minutes.

Fig. 5 shows an earlier generation of TACMET display used in a portable air traffic control system developed for the FAA. This "Fly Away Kit" gives the FAA the capability to control an airspace where conventional air traffic control is unavailable.

The utilization of the TACMET weather data in an emergency response model is shown in Fig. 6. This is the output from the EPA/NOAA model called ALOHA. ALOHA is used to estimate the movement and dispersion of gases. The model estimates pollutant concentrations from the source of a spill, taking into consideration the toxicological and physical characteristics of the spilled material. ALOHA uses a Gaussian dispersion model and assumes that the gas is neutrally buoyant. Fig. 6 shows the output of the model, overlaying a map of the spill location, and highlighting both the estimated area of ground level concentrations greater than a predetermined level of concern, and the possible cloud movement based on atmospheric stability.

This ALOHA run used the TACMET system data as the input for winds, sigma theta, and temperature. The model requires manual input of the relative humidity. The model requires manual input of the type and amount of material spilled based on each incident. The spill shown was for a hypothetical ammonia spill.

6. Conclusion

A portable weather monitoring system which can be used for gathering data to predict the transport of radionuclides and other hazardous materials downwind of an accident site has been described. The design of the sensor and interface and an example of the output of a hazardous materials spill model, using the weather system's data for input, were demonstrated.

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TACMET WEATHER SENSOR

FEATURES:

- Portable/Hand Held
- Self-Orienting Sensor
- Rugged
- Low Power

The TACMET① weather sensor is designed for maximum portability and utility, making it uniquely applicable for rapid deployment and use by one person under adverse conditions. The TACMET sensor may be hand-held or mounted on a tripod.

The TACMET weather sensor was designed for the US Air Force as part of the AN/TMQ-34 program. The sensor measures wind speed and direction, air temperature, and relative humidity. An optional pressure measurement is available (see TACMET Portable Display data sheet). The TACMET includes a magnetic compass. This ensures a wind direction output which is referenced to magnetic North, regardless of sensor orientation.

Two versions are available. The first includes a rotor to measure the wind speed and a short vane to sense wind direction, optimizing size and ruggedness. The second version offers a 3-cup anemometer and a longer vane which allows this version to be used for air quality monitoring and emergency response modeling applications.

The sensor's analog output signals can be handled by any data acquisition device which has an analog to digital conversion capability. Climatronics' TACMET Portable Displays and IMP-850/860 data loggers are devices which can be used for this purpose.

Wind speed is sensed by either a rotor or cup set connected to a photo chopper detector assembly, producing a frequency directly proportional to the wind speed. The wind vane and magnetic compass transducers produce signals representing the position of the wind vane and the pointer of the compass. The resultant is the direction of the wind relative to magnetic North. A wide range thermistor is used to measure the air temperature. The relative humidity is sensed with an inert hygroscopic element connected to a strain gage, supplied with a filter to minimize particulate contamination. Both sensors are located below the wind sensor shielded from solar radiation and precipitation. The signal conditioning boards in the TACMET convert the various transducer signals into linear analog voltage outputs.

The TACMET Weather Sensor is supported by a number of accessories, including: carrying cases; hand-held displays (including the optional pressure measurement); compact, lightweight tripods and depot repair fixtures.

① Available as a commercial or military unit.

SPECIFICATIONS:

PERFORMANCE:	Cup/Vane	Rotor/Vane
WIND SPEED:		
Type:	3-cup polycarbonate plastic	thermoplastic
Range:	1-100 mph (0-45 m/s)	1-100 mph (0-45 m/s)
Accuracy:*	±1 mph or 1.5% of true air speed, which ever is greater	±1.75 mph (0.8 m/s)
Starting Threshold:	<1 mph (<0.45 m/s)	<2 mph (<0.9 m/s)
Distance Constant:	<8 feet	N/A
WIND DIRECTION:		
Type:	counter-balanced aluminum magnesium	thermoplastic
Range:	0°-360°	0°-360°
Accuracy:*		
Vane:	±3 degrees	±3 degrees
Magnetic Compass:	±2 degrees	±2 degrees
Starting Threshold:	<1 mph (<0.45 m/s)	<2 mph (<0.9 m/s)
Distance Constant:	<8 feet	N/A
Damping Ratio:	0.3	N/A
TEMPERATURE:		
Range:	-58 to 131°F (-50 to 55°C)	
Accuracy:	±0.5°F (±0.3°C)	
RELATIVE HUMIDITY:		
Range:	0-100%	
Accuracy:	±4%	
ELECTRICAL:		
Power Requirement:	+12 ±2.5VDC @ 10 mA	
Voltage Output:	+0.1 to 2.5VDC for the specified ranges (.1 to 5 volts P/N 101688)	

ENVIRONMENT:

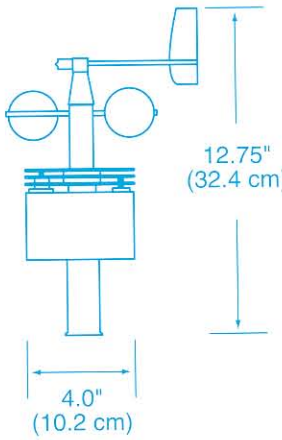
Accuracies are maintained over a wind speed, humidity, and altitude range of:

Wind Speed Range:	1 to 100 mph
Temperature Range:	-50 to 55°C
Humidity Range:	5% RH to 99% RH non-condensing
Altitude Range:	-100 ft. to 10,000 ft. Mean Sea Level (MSL)

* This accuracy is maintained when the sensor is within ±10 degrees (cone) of the vertical.

Specifications subject to change without notice.

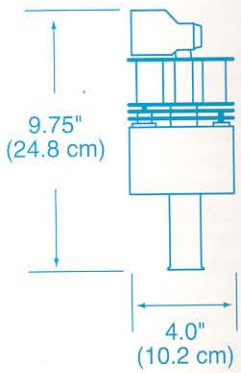
P/N 101990
G1 OR G2 VERSION



Vane Radius 5" (12.7 cm)
Cup Radius 3.66" (9.8 cm)
Mounting 1/4-20 Screw

WEIGHT:
1.7 LBS (0.77 Kg)

P/N 101990
G0 VERSION
(P/N 101688 MILSPEC)



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140 Wilbur Place, Airport International Plaza
Bohemia, NY 11716 USA **(516) 567-7300**
Fax: (516) 567-7585

LEGEND

1. SCREW
2. VANE ASSEMBLY
3. SETSCREW
4. SLEEVE
5. SIDE COVER
6. HANDLE
7. SPACER
8. O-RING
9. SPACER
10. SHUTTER ASSEMBLY
11. ROTOR
12. BEARING
13. PLATE
14. PLATE
15. GROMMET
16. CAP ASSEMBLY
17. SEAL WASHER
18. MOUNTING NUT
19. SEAL WASHER
20. TEMPERATURE SENSOR
21. HUMIDITY SENSOR
22. TOP COVER
23. RETAINER RING
24. BEARING
25. PRINTED CIRCUIT CARD ASSEMBLY
26. STRAIN RELIEF NUT
27. TRANSDUCER ASSEMBLY
28. PRINTED CIRCUIT CARD ASSEMBLY
29. PRINTED CIRCUIT CARD ASSEMBLY

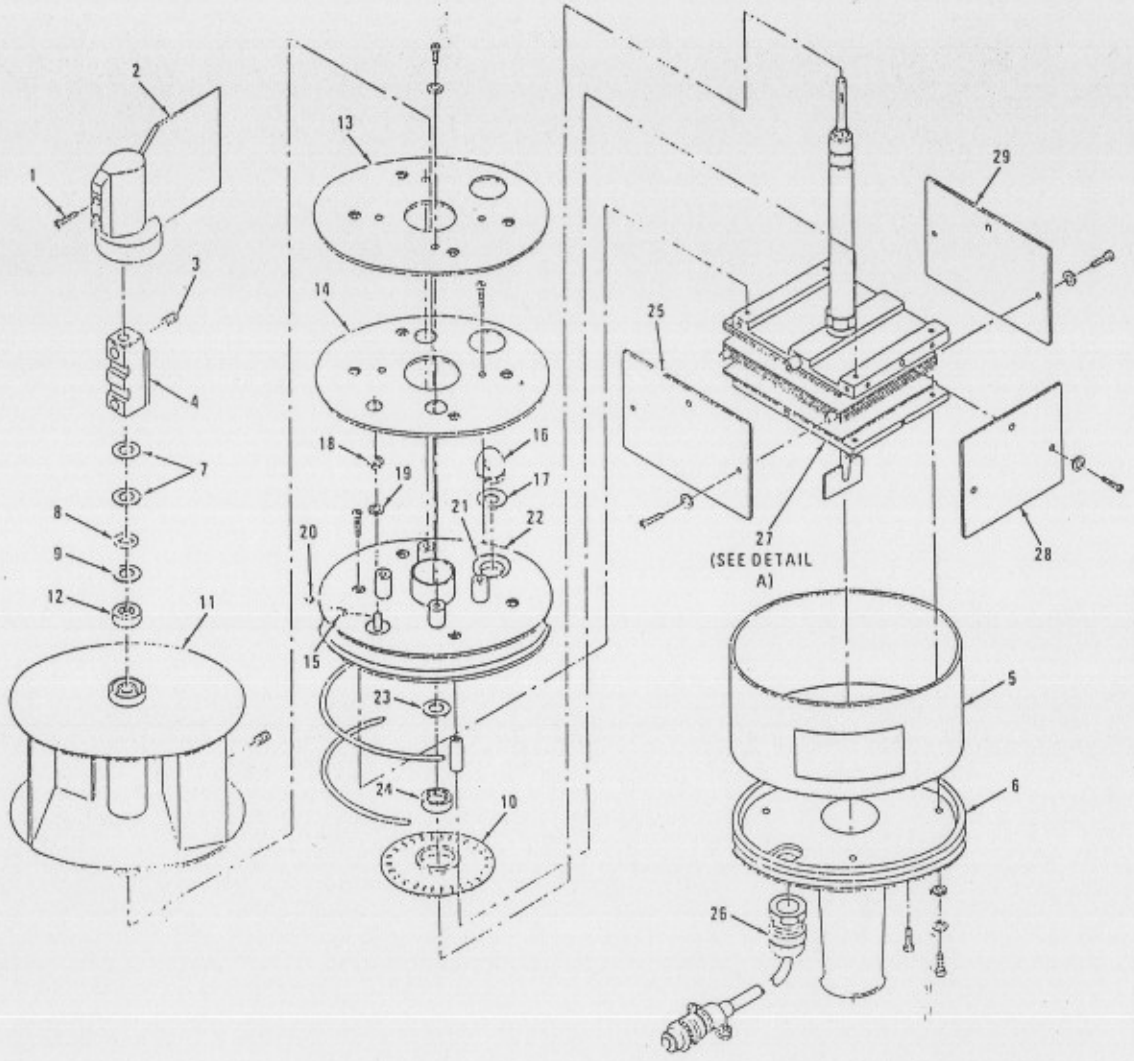

Figure 2 - TACMET Sensor Assembly

TACMET PORTABLE DISPLAY

FEATURES:

- Hand-Held or Tripod Mountable
- Tactile Feedback Membrane Keypad
- Rugged, Weatherproof
- Backlit, Supertwist LCD
- Selectable Measurement Units
- ALOHA Compatible
- PC Interface (RS-232)

Climatronics' TACMET Portable Display (P/N 102174) combines the latest display technology with lightweight design for a unique display package. The display works with the TACMET Weather Sensor[1] to form a self-orienting, rugged but accurate portable weather station. This ultra-lightweight weather station is ideal for site surveys, audits, emergency response situations, and a host of agricultural, aviation, and military applications. The display may be hand-held or mounted on the optional TACMET tripod.

The TACMET Portable Display presents not only the four parameters measured by the TACMET sensor (see the TACMET sensor data sheet), but also the barometric pressure as sensed by a transducer in the display. The display pressure transducer includes a piezoresistive silicon strain gauge characterized over its pressure and temperature range. The resulting data, representing the ideal transfer curve of that sensor, is stored in microprocessor memory. During normal operation, the microprocessor measures temperature and pressure for each reading and looks up the compensated data stored in memory.

The display includes both an integral LCD panel and a tactile feedback membrane keypad for information entry. The 4-line supertwist LCD provides excellent contrast combined with wide viewing angle, while the membrane pad ensures trouble-free operation even under the most adverse environmental conditions. The displayed information can be the five observed

[1]P/N 101990 Commercial: P/N 101688 Military

parameters or several calculated parameters including peak wind speed (gust), dew point calculated from the relative humidity and temperature, altimeter setting (QNH and QFE), density altitude (based on QFE and temperature), and the time. The selection of information to be displayed is made through the integral keypad. The display is activated by the "POWER" key and remains active for three minutes after which it automatically shuts down to conserve battery power. The display includes switch activated backlighting for nighttime viewing and is powered from two alkaline C-cell batteries. A separate AC adapter, P/N 100520, is also available.

The unit features a digital interface to allow the data to be transferred to a computer. The interface uses the RS-232C format and will communicate at rates compatible with most PCs. An ALOHA compatible format is available for use with either Apple or DOS compatible CAMEO/ALOHA software. Details of the digital interface are shown in the specification section.

The optional TACMET carrying case (P/N 501389) is used to transport the TACMET sensor and Portable Display. The case has a rugged outer shell made of thermoplastic polyethylene and foam inserts to cushion the sensor and display while in transit. And optional tripod (P/N 501394) can be used to mount the TACMET sensor while in operation. It is lightweight, compact, and easily transported with the sensor. Once on site, the tripod is deployed in a minimum amount of time. The 1/4-20 captive screw at the top of the tripod matches the thread in the base of the TACMET sensor. The optional Pole Mount Fixture (P/N 100675) is also available to mount the display on the tripod.

SPECIFICATIONS:

DISPLAY:	Liquid crystal display with switchable backlighting.Four lines of 20 characters each. English or Metric units may be selected from the display keypad.
KEYPAD:	The display includes a 20-digit membrane keypad. The keypad is used to enter information and select the scaling units.
ALGORITHMS:	Algorithms based on FAA Advisory Circular AC-150/5220-16 (latest edition) are used to determine the meteorological parameters.
ACCURACY:	Display accuracy is greater than the accuracy of the TACMET sensor.
BAROMETRIC PRESSURE ACCURACY:	+/-0.03 in Hg or +/-1.0 mb
RESOLUTION:	Wind Speed and Peak Gust: 1 knot, 1 mph, or 1 m/s Wind Direction: 1° Temperature: 0.1° C or F Relative Humidity: 1 % Barometric Pressure: 0.01 in Hg or 0.1 mb Altimeter Setting (QNH or QFE): 0.01 in Hg or 0.1 mb Density Altitude: 100 feet or 10 meters Time: hours, minutes, seconds
DATA OUTPUT:	RS-232C, 9600 baud, no parity
POWER REQUIREMENTS:	180 mA max. The display will operate for a minimum of 35 hours using 2 alkaline C-cell batteries. The display will accept 9.5 - 13.5 VDC external power.
DIMENSIONS:	4.625 x 7.875 x 2.625 inches (W x L x H) (11.8 x 20 x 6.7 cm)
WEIGHT:	<2 lbs (.9 kg); 4 lbs (1.81 kg) shipping
ENVIRONMENTAL:	Temperature: 0° to 50° C Humidity: 10-100%, non-condensing
OPTIONS:	
TRANSIT CASE, P/N 501389	Dimensions: 10.5 x 13.5 x 8.5 inches (W x L x H) (26.7 x 34.3 x 21.6 cm) Weight: 2.5 lbs (1.1 kg) empty; 5 lbs (2.3 kg) shipping
TRIPOD, P/N 501394	Dimensions: 4.5 inches diameter x 31 inches length (11.4 x 78.7 cm) Maximum Height: 9 feet (274.3 cm) Weight: 3 lbs (1.4 kg); 5 lbs (2.3 kg) shipping

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140 Wilbur Place, Airport International Plaza
Bohemia, NY 11716 USA **(516) 567-7300**
Fax: (516) 567-7585

RECYCLE
9/93

Figure 4 - TACMET Sensor and Portable Display on a Tripod

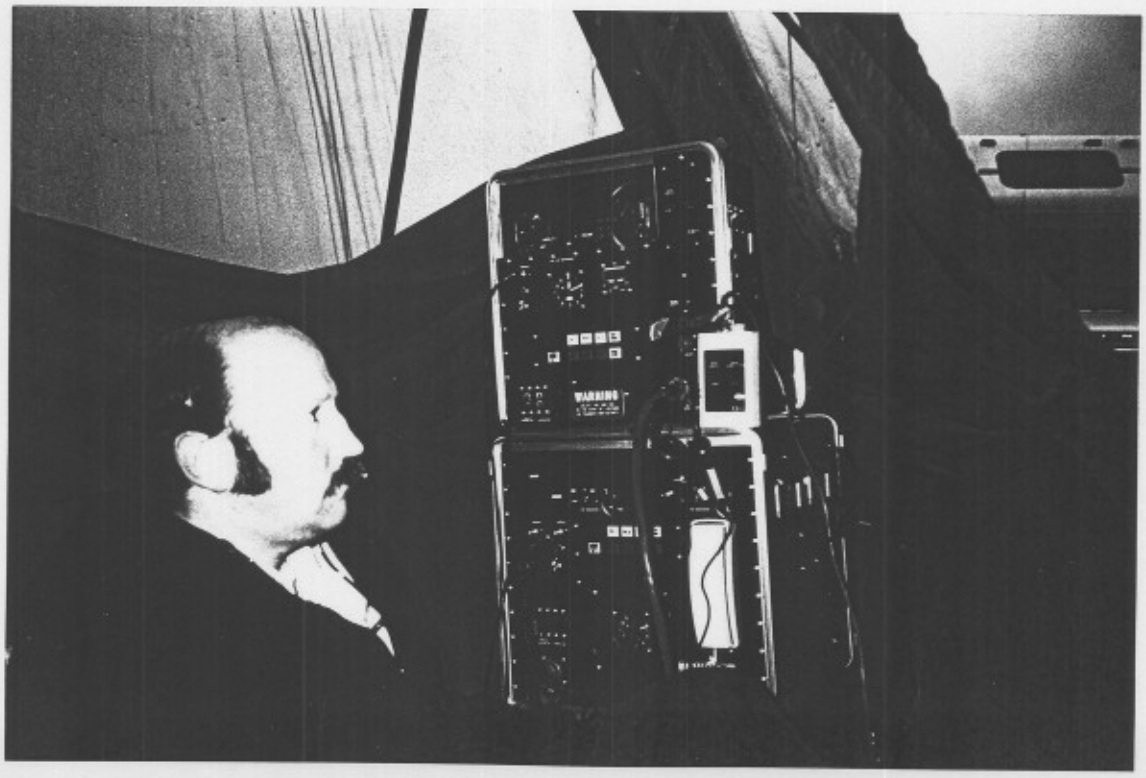

Figure 5 - TACMET Sensor and Portable Display Applications

ALOHA 5.1

File Edit SiteData SetUp Display Sharing SAM Options

Text Summary

SITE DATA INFORMATION:

Locatio

Buildin gle storied)

Date an

CHEMICAL

Chemica

Molecul

TLV-TWA

Footpri

Boiling

Vapor P 1 atm

Ambient 00.0%

ATMOSPHER

Inversi

Cloud C

Relativ country

Wind: 3

Air Tem

Warning

The sys