

Reporting Specifications for Electronic Real Time Gas and Vapor Detection Equipment

Fact Sheet

Sponsored by the AIHA® Real Time Detection Systems Committee

Approved by AIHA Board: October 17, 2016



CONTENTS

1.0 Scope	3
2.0 Equipment Specification Sheet	3
3.1 Specifications	3
3.2 Information Specifications	3
3.3 Performance Definitions	4
3.4 Operating Conditions Definitions	5
3.5 Error-State Notification Definitions	6
3.6 Readings Definitions	6
3.7 Interference Definitions	7
3.8 Maintenance Definitions	7
3.9 Data Management Definitions	8
4.0 Safety Definitions	8
References	8
Instrument Sheet	10
Sensor Sheet	10

Preface

This manual was developed to provide a standardized approach to the definitions and methods used to develop an equipment specification sheet. When this manual was developed, real-time detection equipment specification sheets differed between manufacturers in their content, definition of terms, and methods used to develop specifications. This manual is intended to encourage manufacturers to provide key instrument performance characteristics. These inconsistencies can lead to end users' misinterpreting information provided by manufacturers, which may ultimately increase risk to life and health. It is our hope that the adoption of the AIHA Standardized Equipment Specification Sheet Program will provide a common language through which the manufacturer and end user can effectively communicate, thereby enabling the end user to better understand the capabilities and limitations of the instruments.

This manual describes the programmatic approach to developing an AIHA Standardized Equipment Specification Sheet. It describes the definitions for the specifications to be included, the methods for determining the specification parameters, and a template for the specification sheet.

The information provided in this manual was developed by a consensus-based subcommittee of the AIHA's Real-Time Detection Systems Committee. The subcommittee included stakeholders representing equipment manufacturers as well as military, government, academic, emergency response, and commercial end users.



1.0 Scope

This guide provides important criteria when considering specifications for real-time gas and vapor detection equipment. An instrument may be obtained for a variety of uses: personal exposure monitoring, response to a hazardous material incident, or continuous or intermittent area monitoring. Users may have specific requirements for their instruments. These include the capability to provide a warning of a hazardous condition, specific accuracy and calibration requirements, and long-term storage requirements. For the purposes of this document, real-time gas and vapor detection equipment includes single- and multi-gas instruments capable of detecting oxygen, toxic gases, vapors, and combustibles.

2.0 Equipment Specification Sheet

Users should review the specification sheet provided by the manufacturer with the instrument. If this sheet has not been supplied, the user should request it from the manufacturer. Manufacturers shall provide the specifications for each sensor type available for the instrument. Manufacturers may use one or multiple specification sheets for each instrument or sensor, and their specification sheets should be available on the manufacturers' websites. If a third-party has evaluated an instrument, the manufacturer should provide this reference if publicly available.

3.1 Specifications

The specifications are divided into subsections found on the Standardized Equipment Specification Sheet. For some specifications, a definition is given where appropriate. If a standardized method for determining the specification parameters is recommended, it is listed as well. There are a few definitions included in this manual for reference only.

Specifications key: *I* represents a box on the instrument sheet.

S represents a box on the sensor sheet.

B represents a box on both sheets.

3.2 Information Specifications

3.2.1 Hazard Type (B)

The hazard type may be oxygen deficiency, oxygen enrichment, toxic levels of gases or vapors, or the presence of combustible gases.

3.2.2 Instrument Type (I)

The instrument type will be classified as single-gas, multi-gas, PID, FID, multi-gas + PID, Fourier transform infrared spectroscopy (FTIR), or other type.

3.2.3 Sensor Type (B)

The following are some common examples of sensors: metal oxide semiconductor (MOS), catalytic, electrochemical, photoacoustic infrared spectroscopy, photoionization detector (PID), Fourier transform infrared spectroscopy (FTIR), infrared spectroscopy (IR), Raman spectroscopy, ion mobility spectrometry (IMS), and flame ionization detector (FID).

3.2.4 Instrument Manufacturer (I)

Include contact information.

3.2.5 Instrument Name, Model Number(s) and Firmware (permanent software programmed into an internal memory) version (I)

3.2.6 Display (I)

The manufacturer describes this. Characteristics to mention: backlight, screen size, graphical, numerical, characters, color or black and white, etc.

3.2.7 Battery Type (I)

Examples include lead acid, NiCad, NiMH, Li-ion, alkaline, and dry cell (AAA, AA, C, D, and 9 volt). This may include operating on external power (wall, solar).

3.2.8 Dimensions (I)

Dimension units are given in metric and U.S. standard. Length, width, and height are based on the maximum point-to-point distance in each dimension. Other modules may be listed, such as remote sensor attachments.

3.2.9 Weight (I)

Units in grams and ounces (pounds), includes batteries. A minimum and maximum weight can be specified for instruments that offer optional configurations.

3.2.10 Warranty (B)

List the specific components covered by the warranty and the length of the warranty coverage for instruments and sensors.

3.2.11 Approved to Safety Standard(s) (I)

List the applicable published safety standards to which the instrument complies (e.g., UL, cULus, CSA, MSHA, or CENELEC).

3.2.12 Additional Information (I)

List the recommended trainings or special limitations.

3.3 Performance Definitions

3.3.1 Measuring Range (S)

This refers to the concentration range (minimum and maximum value) that the sensor is designed to measure with a specified accuracy criterion.

3.3.2 Minimum Detection Limit (S)

This refers to the lowest nonzero detectable concentration within the specified measurement range.

3.3.3 Resolution (S)

This refers to the degree to which a change in the reading is displayed on the instrument. For example, low-concentration H₂S sensors may have a range of 0-100 ppm with a resolution of 0.1 ppm. The readout on the display will show readings in increments of 0.1 ppm that begin with the stated detection limit. If the minimum detection limit is 1.0 ppm, the lowest possible reading is 1.0 ppm, the next at 1.1 ppm, and so on to 100.0 ppm.

3.3.4 Uncertainty / Accuracy (I)

Uncertainty or accuracy is the difference between measured values and accepted reference values over repeated measurements.

Uncertainty or accuracy, calculated based upon bias and precision, is best assessed through testing to a standard test protocol. The protocol used should be referenced alongside the value(s) quoted. Unless an equivalent method is used, manufacturers should use the method provided in Appendix A of the National Institute for Occupational Safety and Health: *Components for Evaluation of Direct- Reading Monitors for Gases and Vapors*. Uncertainty/accuracy should be provided for each sensor mode.

3.3.5 Linearity (B)

Linearity is the closeness of an instrument or sensor's calibration curve to a mathematically defined straight line.

3.3.6 Recovery Time (S)

Recovery time is the time required to return from a challenge at the upper calibration concentration to zero or background. *Note:* EPA defines Fall Time as the time interval between initial measurement response and 95% of final response after a step decrease in input concentration.

3.3.7 Continuous Operating Time (I)

This time is the shortest duration that an instrument will operate until any consumables are depleted under ideal conditions (e.g., carrier gas or data logging memory).

3.3.8 Battery Operating Time (I)

This time is the typical duration that an instrument will operate on a fully charged battery at 68°F (20°C).

3.3.9 Sampling Rate (I)

Sampling rate is the volumetric (or equivalent) rate that the air containing the substance is introduced into the instrument, that is, the pump flow rate (for an active sampling device) or the diffusive uptake rate (for passive sampling devices).

3.3.10 Response Time (B)

Response time, also rise or lag time, is the time required for a sensor to reach a certain percentage of the final value. This lag time depends on the sensor/instrument type and measurement conditions. Response time is typically described by the manufacturer as a T_{90} or T_{50} time. *Note:* NIOSH defines response time as the time required for an instrument's response to a measurement (gas, temperature, pressure) to reach a specified fraction of its final response. EPA defines lag time as the time interval between a step change in input concentration and the first observable corresponding change in measurement response. EPA defines rise time as the time interval between initial measurement response and 95% of final response after a step increase in input concentration (T_{95}).

3.3.11 Response Time (T_{50}) (S)

This refers to the time for a sensor to reach 50% of its final value while under a constant challenge. The final value should be stated.

3.3.12 Response Time (T_{90}) (S)

This refers to the time for a sensor to reach 90% of its final value while under a constant challenge. The final value should be stated.

3.3.13 Start-up to T_{90} after 24-hour Storage (B)

This refers to the time for a sensor to reach 90% of its final value after it has been shut down for 24 consecutive hours and then restarted. The final value should be stated.

3.3.14 Start-up to T_{90} after 7-day Storage (B)

This refers to the time for a sensor to reach 90% of its final value after it has been shut down for 7 consecutive days and then restarted. The final value should be stated.

3.3.15 Start-up to T_{90} after 30-day Storage (B)

This refers to the time for a sensor to reach 90% of its final value after it has been shut down for 30 consecutive days and then restarted.

3.4 Operating Conditions Definitions

3.4.1 Temperature Range (I)

This refers to the range of temperature where the sensor and its readings are within the stated accuracy.

3.4.2 Effect of Temperature (I)

Effect of temperature describes how the instrument responds outside the stated temperature range and the means of compensation or correction. *Note:* If the temperature can affect the sensor or the sensed characteristics of the air significantly, the extent of the effect should be noted and a correction should be made. Temperature sensing and compensating circuits may be incorporated in the instrument to enable it to give corrected readings as the temperature varies.

3.4.3 Humidity Range (I)

This refers to the range of relative humidity for given temperatures where the sensor and its readings are within the stated accuracy. If a specific humidity range leads to instrument or sensor failure or damage, include that information.

3.4.4 *Effect of Humidity (I)*

Effect of humidity describes how the instrument responds outside the stated humidity range and the means of compensation or correction. If the amount of water vapor in the air can affect the sensor or the sensing properties of the instrument, an error could be noted in the response of the target contaminant. If the effect is great enough to change the readings at a certain concentration by more than the normal variability of the sensor, the extent of the effect should be noted. If there is a range of humidity where the sensor and its readings are not affected significantly, this could be noted and reported as the range of humidity for normal operation. If the water vapor can mimic a signal equivalent to a response of the contaminant or interfere with the response of the sensor to the contaminant, the amount of interference should be determined and a correction factor for different humidity should be reported.

3.4.5 *Pressure Range (I)*

Pressure range refers to the range of atmospheric pressure and/or elevation where the sensor and the readings are within the stated accuracy. *Note:* If the pressure can affect the sensor or the sensed characteristics of the air significantly, the extent of the effect should be noted and a correction should be made. Pressure sensing and compensating circuits may be incorporated in the instrument to enable it to give corrected readings as the pressure varies.

3.5 **Error State Notification Definitions**

3.5.1 *High/Low Temperature (I)*

This refers to whether and how the instrument notifies the user, in real time, that the ambient temperature conditions may be adversely affecting the contaminant concentration displayed.

3.5.2 *High/Low Humidity (I)*

This refers to whether and how the instrument notifies the user, in real time, that the ambient humidity conditions

may be adversely affecting the contaminant concentration displayed.

3.5.3 *Over-Range (I)*

This refers to whether and how the instrument notifies the user, in real time, that the ambient contaminant concentrations may be adversely affecting the contaminant concentration displayed.

3.5.4 *Pump Flow Restriction (I)*

Pump flow restriction refers to the means by which the instrument notifies the user, in real time, that the flow to the instrument sensor may be restricted.

3.5.5 *Low Battery (I)*

This refers to the means by which the instrument notifies the user, in real time, that the remaining power in the battery has reached a critical level and that the battery should be recharged or replaced.

3.6 **Readings Definitions**

3.6.1 *Instantaneous Reading Frequency (I)*

This refers to how frequently a new, distinct reading is displayed and the method for how it is calculated (e.g., ten 0.10-second readings are averaged every second).

3.6.2 *TWA (Time-Weighted Average Concentration) (B)*

TWA is the cumulative measured average concentration over the course of the period sampled. Alarms may be set at excursions over specific TWA values, which are defined as concentration limits for an 8-hour work shift (and for a 40-hour work-week), even where the instrument is not used to measure the entire period.

3.6.3 STEL (*Short-Term Exposure Limit Concentration*) (B)

STEL is the time-weighted average concentration measured over a limited sampling period (usually 15 minutes unless otherwise noted).

3.6.4 Peak (B)

Peak is the highest measured value for any given substance since the instrument started its current run or has been manually cleared. If there is a specified time period over which a value has to be maintained for it to be reported as a peak value, the time period should be noted.

3.6.5 Alarm Set Point(s) (B)

Instrument manufacturers typically have an alarm set point or low- and high- alarm set points that are factory preset. These set points give the user early warning of elevated gas concentrations. Toxic gas exposure limits established by the ACGIH, OSHA, and NIOSH are often the levels used to establish alarm set points. In some cases the alarm set points can be adjusted through a password protected menu on the instrument or by using software and configuration equipment provided by the manufacturer.

3.6.6 Alarms/Indicators (B)

This refers to a signal that can be acoustical, visual, or tactile (e.g., loud noise, flashing light, or vibration) and that may alert the user that some action is required. Alarming events include a fault with the instrument, a low battery status, the exceeding of a preset concentration limit, or other such useful information for the user.

3.7 Interference Definitions

3.7.1 Cross-Sensitivities (S)

Cross-sensitivities are the known additive or subtractive effect of other gases or vapors on the instrument reading for a gas or vapor being measured. Cross-sensitivity is

often presented as the anticipated change in reading of a calibration standard. If applicable, the manufacturer should report potential sensitivity to classes of compounds or types of molecules, even when interference is only anticipated and not tested.

3.7.2 Interferences (S)

This refers to the effect produced by any chemical or physical interaction with the instrument sensor that reduces the instrument's accuracy or precision. If applicable, the manufacturer should report interferences for classes of compounds or types of molecules, even when interference is only anticipated and not tested.

3.8 Maintenance Definitions

Refer to the ISEA Statement: *Validation of Operation for Direct Reading Portable Gas Monitors* for recommendations on bump tests and calibration.

3.8.1 Recommended Factory Service Interval (I)

This interval is the time specified by the instrument manufacturer for returning the instrument to the manufacturer for service, e.g. hours, months, or years of operation time. The specific components needing factory service should be identified along with their interval.

3.8.2 Detector (Sensor) Life Expectancy (S)

This refers to the time a sensor is expected to properly function when following the manufacturers' guidelines for calibration and use.

3.8.3 Instrument Life Expectancy (I)

This refers to the amount of time the instrument is expected to properly function when following the manufacturer's guidelines for use.

3.8.4 Recommended Bump Test (Function Check) Interval (I)

Use the ISEA recommendation (prior to each day's use) unless a more stringent recommendation is specified by the manufacturer.

3.8.5 Recommended Full Calibration Interval (I)

Use the ISEA recommendation unless a more stringent recommendation is specified by the manufacturer. This may vary considerably by sensor type.

3.9 Data Management Definitions

3.9.1 Data Logging Memory (I)

Data logging memory describes the storage of measurement concentrations and events with date and time, in increments adjustable by the user. The typical factory default is 1-minute increments.

3.9.2 Computer Interface (I)

Computer interface refers to the system by which the instrument communicates with a computer (e.g., USB, IR, or wireless). For wireless interfaces, manufacturers should report computer compatibility (PC or Apple™).

3.9.3 Software Required to Access Data (I)

This refers to the software necessary to operate the instrument, obtain data from memory, or perform any other instrument function. The software version should be included.

3.10 Safety Definitions

3.10.1 Hazardous Area Ratings and Classifications (I)

These identify the intrinsic safety certifications and approvals this instrument has obtained, as well as the issuing organization(s).

3.10.2 Ingress Protection (I)

Ingress protection refers to the instrument resistance rating of the potential for dust and water to enter.

References

1. **Anna, D.H. (ed.):** *The Occupational Environment: Its Evaluation, Control, and Management*, 3rd ed. (AIHA White Book). Fairfax, VA.: AIHA, 2011.
2. Table Z-1, Limits for Air Contaminants, *Code of Federal Regulations* Title 29, Part 1910.1000.1976.
3. "Exposure Limits for Airborne Contaminants," *Code of Federal Regulations* Title 30, Part 56.5001.1976.
4. NIOSH *Manual of Analytical Methods*, 5th ed. <http://www.cdc.gov/niosh/docs/2003-154/new.html>.
5. **Anderson, C. Clarine, E., C. Gunderson, and D. M. Coulson:** Sampling and analytical methodology for workplace chemical hazards. Ch. 1 in *Chemical Hazards in the Workplace: Measurement and Control*, Vol. 149, G. Choudhary (ed.). Washington, D.C.: American Chemical Society, 1981. pp. 3–19.
6. **Bush, Kenneth A., and David G. Taylor.** Statistical protocol for the NIOSH validation tests. Ch. 31 in *Chemical Hazards in the Workplace: Measurement and Control*, Vol. 149, Gangadhar Choudhary (ed.). Washington, D.C.: American Chemical Society, 1981. pp. 503–517.
7. **NIOSH:** *Development and Validation of Methods for Sampling and Analysis of Workplace Toxic Substances* by E.C. Gunderson and C.C. Anderson (DHHS NIOSH 80-133). Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health 1980. <http://www.cdc.gov/niosh/docs/95-117/>
8. **NIOSH:** *Components for Evaluation of Direct-Reading Monitors for Gases and Vapors* (DHHS NIOSH 2012-162). 2012. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. <http://www.cdc.gov/niosh/docs/2012-162/>

9. **ISEA Statement:** *Validation of Operation for Direct Reading Portable Gas Monitors*. Arlington, Va.: International Safety Equipment Association, 2010.
10. **National Electrical Manufacturers Association:** *Degrees of Protection Provided by Enclosures (IP code) (ANSI/IEC 60529–2004)*. Rosslyn, Va.: NEMA, 2004.
11. **US Environmental Protection Agency:** *Air Sensor Guidebook* doc id: 277996, 6/9/2014, accessed 7/31/2016 from website: https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=277996

Acknowledgments

This document represents a compilation of information from the valuable input of the members of the AIHA Real Time Detection Committee. Major contributors were:

- Edward G. Ligus, Jr. Martin Harper, PhD, CIH Jack T. Hill
- Lee E. Monteith, CIH Patricia D. Moser
- Patrick D. Owens, CIH, CSP Terri A. Pearce, PhD
- Jodi G. Quam, CIH Michael Nolan Marc Roe



Instrument Sheet

Manufacturer: _____

Instrument Name / Model No.: _____

General Information	
Hazard Type	
Instrument Life Expectancy	
Instrument Type	
Manufacturer	
Sensor Types	
Display	
Battery Type	
Dimensions-Stripped	
Dimensions with Accessories	
Low Battery Indication	
Weight (with/without Accessories)	
Warranty	
Approval Standard(s)	

Safety	
Hazardous Area Rating & Classification	
Ingress Protection Rating	

Maintenance	
Bump Test Interval	
Calibration Interval	
Factory service Interval	
Instrument Life Expectancy	

**Refer to SESS Manual, 3.2.8

Revision # (Date): _____

Template Revision: (25 August 2015) Standardized Equipment
Specification Sheet

Date Management	
Data Logging Memory	
Computer Interface	
Software Required to Access Data (Version)	

Instrument Performance	
Continuous Operating Time **	
Battery Operating Time	
Sampling Rate	
Response Time T_{90}	
Response Time T_{50}	
Start-up to T90 after 24-hour Storage	
Start-up to T90 after 7-day Storage	
Start-up to T90 after 30-day Storage	

Error-State Notification	
High/Low Temperature	
High/Low Humidity	
Over Range	
Pump Flow Restriction	

Instrument Readings	
Instantaneous Reading Frequency	
STEL	Yes / No
TWA	Yes / No
Peak	Yes / No
Alarms/Indicators	
Alarm Set Points	



Sensor Sheet

Manufacturer: _____
 Instrument Name / Model No.: _____

General Information	
Hazard Type	
Sensor Type	
Warranty	

Sensor Performance	
Measuring Range	
Minimum Detection Limit	
Resolution/Sensitivity	
Accuracy/Uncertainty	
Linearity	
Recovery Time	
Response Time T ₉₀	
Response Time T ₅₀	
Start-up to T90 after 24-hour Storage	
Start-up to T90 after 7-day Storage	
Start-up to T90 after 30-day Storage	
Life Expectancy of Sensors	

Sensor Readings	
STEL	
TWA	
PEAK	
Alarms/Indications	
Alarm Set Points	

Maintenance	
Bump Test Interval	
Calibration Interval	
Factory service Interval	
Life Expectancy of Sensor	

Interferences	
Contaminant:	Effect:

Additional Information:

Revision # (Date): _____

