

APPROVAL REPORT

MODIFICATIONS TO APPROVED COMBUSTIBLE GAS SENSOR/TRANSMITTERS MODEL 5100-02 USED IN SENTRY 5000 SERIES GAS DETECTION SYSTEM AND MODEL 4101-02 STAND ALONE SENSOR/TRANSMITTER

Prepared For:

Sierra Monitor Corporation
1991 Tarob Court
Milpitas, CA 95035

J.I. 1B4A2.AX
(6320, 3615)
January 3, 1997



Factory Mutual Research

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from

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I INTRODUCTION

1.1 Sierra Monitor Corporation requested Approval of the apparatus listed in Section 1.2. to be in compliance with the applicable requirements of the following standards.

<u>Title</u>	<u>Number</u>	<u>Issue Date</u>
Combustible Gas Detectors	FMRC Class No. 3610, 3620	December 1989
Explosionproof Electrical Equipment General Requirements	FMRC Class No. 3615	March 1989
Electrical and Electronic Test, Measuring, and Process Control Equipment	FMRC Class No. 3810	March 1989

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Job Identifier 1B4A2.AX

1.2 Listing and Equipment Identification - The subject apparatus will appear in the Factory Mutual Research Corporation Approval Guide as follows:

COMBUSTIBLE GAS DETECTORS, Fixed

Stationary Gas Detection System. SENTRY system consists of 2, 4 and 8 channel controller Models 5000-02, 5000-04 and 5000-08 for connection to remote digital combustible gas sensor/transmitter Model 5100-02. The system monitors 0-99% LFL of combustible gas-in-air atmospheres. The controller is for use in indoor or optional outdoor (NEMA 4X) nonhazardous locations, the combustible gas sensor/transmitter is for use in Class I, Division 1, Groups C and D hazardous (classified) indoor locations. The controller is panel mounted and can be operated from 120 Vrms, 220 Vrms 50/60 Hz or 12 Vdc. The controller provides the following standard functions; 2, 4 or 8 channel measurement, displays, keypad and common High/Low/Trouble alarm contacts. The following are Approved controller options; Model 5380-00 Controller 19" rack mounting accessory, Model 5383-00 Controller NEMA 4X enclosure, Model 5392-00 Individual 8 channel high and low alarm contacts, and Model 5387-00 Serial RS-232 printer port software. Included in the Approval are; conventional and multiplexed sensor/transmitter installation configurations, normal and global calibration modes, user editable channel tag function, combustible gas calibration delivery system Model 1200-26 with methane gas cylinder Model 1290-02 and delivery fitting Model 5360-00, calibration adaptors Models 5358-00 and 5358-01. Operating temperatures are 0°C to +50°C (32°F to +122°F) for the controller, -40°C to +80°C (-40°F to +176°F) for the combustible gas sensor/transmitter. Approval covers use of the instrument when the instrument calibration is performed using the gas to be monitored and when the higher of the two alarm set points is preset within 10% LFL of the monitored calibration gas concentration.

Stationary Combustible Gas 4-20 mA Sensor/Transmitter. Model 4101-02 stand alone sensor/transmitter monitors 0-99% LFL of combustible gas-in-air atmospheres. The Approved apparatus is explosionproof for use in Class I, Division 1, Groups C and D hazardous (classified) indoor locations. Included in the Approval are combustible gas calibration delivery system Model 1200-26 with methane gas cylinder Model 1290-02 and delivery fitting Model 5360-00, calibration adaptors Models 5358-00 and 5358-01. Operating temperatures for the sensor/transmitter are -40°C to +80°C (-40°F to +176°F). Approval covers use of the instrument when the instrument calibration is performed using the gas to be monitored.

II DESCRIPTION

2.1 General - Product descriptions in Approval report J.I. 2V4A4.AX for Model 5000 Series Sentry Combustible Gas Detection System with Model 5100-02 Sensor/Transmitter and in Approval report J.I. 1V9A6.AX for Model 4101-02 Stand Alone Combustible Gas Sensor/Transmitter remain applicable for this examination.

2.2 Modifications Covered in This Examination - Sierra Monitor submitted for Approval enhanced catalytic sensors for use in Model 5100-02 and 4101-02 Combustible Sensor/Transmitters. The enhancement consists of manufacturing process refinements to improve the long term stability of the catalytic sensing beads. Sierra Monitor's goal was to achieve FMRC Approval to increase the recommended calibration interval specified in the instruction manuals from 30 days to 90 days. The enhanced catalytic devices are for use in currently Approved combustible gas sensor assembly P/N 22043-001 and in a new sensor assembly

FACTORY MUTUAL RESEARCH CORPORATION

Job Identifier 1B4A2.AX

P/N 22072, both for use in the above sensor/transmitter assemblies. New sensor assembly P/N 22072 consists of a tubular body with two separate sintered metal flame arrestors recessed into the tubular body. This differs from the original sensor design which consisted of a single larger sintered metal cup flame arrestor protruding from the sensor body. Sierra Monitor requested performance verification of the new catalytic sensing process for use in both the current and new sensor assemblies and for use in either Models 5100-02 and 4101-02 Combustible Sensor/Transmitter assemblies. In addition, Sierra Monitor requested the combustible gas sensor be verified for operation to a maximum ambient temperature of 80°C (176°F). Tests for sensor assembly P/N 22072 consisted of gas detection performance tests as well as explosionproof tests to verify the sensor's suitability for use in Class I, Division 1, Groups C & D hazardous locations.

2.3 Specifications - The manufacturer's specifications for the subject combustible gas detection apparatus remain as stated in Approval reports J.I. 2V4A4.AX for Sentry 5000 Series Gas Detection System and J.I. 1V9A6.AX for Model 4101-02 stand alone Sensor/Transmitter with the exception of the operating temperature and recommended calibration frequency, as follows:

MODEL 5100-02 AND 4101-02 COMB. GAS SENSOR/TRANSMITTERS

Operating Temperature: -40 to 80°C (-40 to 176°F)

Recommended Calibration Frequency: 90 days

2.4 Additional Information - For additional information, reference the attached manufacturer's operation instructions "Model 5000 SENTRY GAS MONITORING SYSTEM" Version 6, T12001 Rev. A1 and "MODEL 4101-02 COMBUSTIBLE GAS MODULE 4-20 mA" T13002 Rev. A1.

III EXAMINATION AND TESTS - PERFORMANCE

3.1 General - Representative samples of Model 5000 controller with Model 5100-02 Combustible Gas Sensor/Transmitters fitted with enhanced catalytic sensing elements in sensor assemblies P/N 22043-001 and P/N 22072 were examined and tested by Factory Mutual Research Corporation (FMRC) to determine acceptability for gas detection performance, electrical utilization as well as a review of the manufacturers documentation and the equipments physical construction. All were satisfactory and are summarized in the following sections. All data is on file at FMRC along with other documents and correspondence applicable to this program. All tests were conducted at FMRC facilities in Norwood, MA.

3.2 Conditions for Performance Tests - All tests were conducted at ambient temperature of 20 to 30°C (64 to 86°F), having a relative humidity in the range of 30-70% unless otherwise specified. Room air circulation was relatively still, not more than 1 m/s (3.3 ft/sec). The Sentry 5000 test system consisted of a Model 5000-08 controller powered by 115 Vrms ±10%, with two Model 5100-02 combustible gas sensor/transmitter. One sensor/transmitter was fitted with new sensor assembly P/N 22072 and the other with sensor assembly P/N 22043-001, both included enhanced catalytic sensing elements. Both sensor/transmitter assemblies were connected to the controller with 15 ohm resistors in series with each wire to simulate the maximum wire resistance specified by the manufacturer. A third device connected to the controller was a sensor/transmitter modified by the manufacturer to functionally simulate the remaining 6 possible sensor/transmitters on the system. Controller software version 6.04f was installed and functional during all tests conducted as part of this examination. The controller's display indications were recorded during tests requiring measurement verification.

FACTORY MUTUAL RESEARCH CORPORATION

Job Identifier 1B4A2.AX

3.3 Unpowered Preconditioning Storage - Model 5100-02 Sensor/Transmitter assemblies fitted with sensor assemblies P/N 22072 and P/N 22043-001, while unpowered, were pre-conditioned at the following temperatures:

- a. -40°C (-40°F) for 24 hours
- b. ambient temperature for at least 24 hours
- c. +55°C (131°F) for 24 hours
- d. ambient temperature for at least 24 hours

3.4 Vibration Tests - The sensor/transmitter assemblies only were vibrated vertically with a frequency range of 10 to 30 Hz at a total excursion of 1.0 mm (0.04 in.) for one hour in each of three mutually perpendicular axes. During and after the test, there was no loss of function, no false alarms and no false indications of malfunctions. There was no visible damage to the sensor/transmitters or any hidden damage which could manifest itself in loss of function and no loose components which could cause electrical hazard. The instruments' measurement indications at the conclusion of the tests were within $\pm 5\%$ of Full Scale concentration.

3.5 Initial Calibration - The Sentry 5000 Gas Detection system with Model 5100-02 Combustible Gas Sensor/Transmitters were calibrated at 50% LFL methane using specified calibration apparatus per the procedure in the manufacturer's instruction manuals.

3.6 Accuracy Tests - After initial calibration, the sensor/transmitters were exposed to concentration of methane in air at 10%, 25%, 50%, 75% and 100% LFL. The gas was applied in a manner to simulate the instrument's actual diffusion method of monitoring. In all cases, the instruments' measurements were within $\pm 3\%$ of Full Scale or $\pm 10\%$ of applied concentration, whichever was greater. The test results were satisfactory.

3.7 Step Change Response and Recovery Tests - The following tests verified the step change response and recovery of the instruments were satisfactory.

3.7.1 Step Change Response - The instruments were subjected to a step change by suddenly exposing the gas sensor to a gas concentration of 100% LFL methane in air. The instruments' measurements increased to 50% LFL within 10 seconds and to 90% LFL within 30 seconds.

3.7.2 Recovery Test - After stabilization to exposure at 100% LFL, the test gas was removed. The instruments' measurements decreased to 50% LFL within 20 seconds and to 10% LFL within 45 seconds.

3.8 Supply Voltage Variation Tests - Model 5000 gas detection system with Model 5100-02 Sensor/Transmitters were subjected to the following supply voltage variations. With the controller powered from 115 Vrms, 60 Hz line power and with the sensor/transmitters exposed to clean ambient air, the AC power voltage to the controller was decreased to 85% then increased to 110% of nominal line voltage. This test was repeated with the sensor/transmitter exposed to 50% LFL. The results were satisfactory since the system's indications did not vary more than $\pm 2\%$ LFL and there were no instrument malfunctions or false actuation of alarms.

3.9 Temperature/Humidity Variation Tests - With the sensor/transmitter assemblies in an environmental chamber and after calibration at ambient temperature, the chamber temperature was varied from -40°C (-40°F) at ambient relative humidity (RH) to 80°C (176°F) at 90% $\pm 5\%$ RH. After stabilization at each temperature and humidity, the sensors were exposed to the calibration concentration. The results

FACTORY MUTUAL RESEARCH CORPORATION

Job Identifier 1B4A2.AX

were satisfactory since the instruments' measurement did not vary by more than $\pm 10\%$ LFL from those observed at ambient conditions.

3.10 Gas Humidity Variation Tests - With the sensor/transmitter assemblies at ambient temperature and after calibration at 50% LFL at $50\% \pm 5\%$ RH, the sensors were exposed to same concentration and relative humidity for two hours. The sensors were then exposed to 50% LFL at $90\% \pm 5\%$ RH for two hours and then sensors were then exposed to 50% LFL at $10\% \pm 5\%$ RH for two hours. The results were satisfactory since the instruments' measurement did not vary from those observed while exposed to 50% LFL at $50\% \pm 5\%$ RH by more than $\pm 10\%$ of Full Scale concentration.

3.11 Air Velocity Variation - The sensor/transmitters were calibrated while exposed to a static mixture of the calibration concentration. The instruments were then exposed to the same mixture in motion so as to impinge on the gas detection sensors a velocity of 5 ± 0.5 m/sec (1000 ± 100 ft/min). The instruments' measurements while subjected to the mixture in motion were satisfactory since they did not vary from that observed during exposure to the static mixture by more than $+10\%$ or -5% of the Full Scale concentration in any orientation of the sensor with respect to the motion.

3.12 Long Term Stability Tests - After calibration, long term stability testing was conducted over a period of 30 days. During this time, the sensors were repeatedly exposed to consecutive 6 day periods of clean air at ambient temperature, humidity and the initial calibration gas mixture. While exposed to the initial calibration mixture for 24 hour periods every 7th day, the instruments' measurements did not vary from the actual applied concentration by more than 10% LFL. Subsequently, the accuracy tests in Section 3.6 were repeated. The instruments' measurement were satisfactory since they did not vary from the applied concentration by more than $\pm 4\%$ of Full Scale concentration or $\pm 12\%$ of applied gas concentration, whichever was greater. The instruments were calibrated only at the start of the long term stability tests and did not require re-calibration at the end of the 14th day or prior to the final accuracy test. As a result, the recommended 90 day calibration frequency specified in Sierra Monitor's instruction manuals is satisfactory.

3.13 Flooding - The sensor/transmitters were subjected to a step change in gas concentration from 0% LFL to 100% gas by volume. The results were satisfactory since the instruments' measurements indicated concentrations of 60% LFL within 10 seconds after sudden exposure to the 100% gas by volume.

3.14 Radio Frequency Interference (RFI) - RFI tests conducted as part of examinations J.I. 2V4A4.AX and J.I. 1V9A6.AX satisfactorily verified the instruments' ability to withstand exposure to specified radio frequencies of 150 to 179 MHz and 450 to 470 MHz at 5 Watts from a distance of 1.0 m (3.25 ft) at any orientation. Additional testing was not required.

3.15 Constructional Requirements - Constructional requirements examined as part of projects J.I. 2V4A4.AX and 1V9A6.AX remain satisfactory.

3.16 Instruction Manual - Instruction manual "Model 5000 SENTRY GAS MONITORING SYSTEM" Version 6, T12001 - Rev. A1 and Model 4101-02 COMBUSTIBLE GAS MODULE 4-20 mA, T13002 - Rev. A1 were examined and found satisfactory.

FACTORY MUTUAL RESEARCH CORPORATION
Job Identifier 1B4A2.AX

IV EXAMINATION AND TESTS - HAZARDOUS LOCATION

4.1 General - The following examination and tests verified the suitability of combustible gas sensor assembly P/N 22072 as explosionproof for Class I, Division 1, Groups C and D hazardous (classified) locations.

4.2 Flame Propagation Tests - A specially constructed test sample (Sample 1) of combustible sensor assembly P/N 22072 in which a spark gap had been added in the location where one of the sensor electrodes is normally positioned was utilized for the flame propagation tests. This sensor was placed in a chamber heated to 100°C (80°C rated + 20°C Safety Factor) where mixtures of hydrogen, ranging in concentration from 22.6% to 38.9% by volume, in air, were allowed to permeate into the sensor cavity containing the spark gap. Thirty tests were conducted over this range where each gas mixture was allowed to permeate into the sensor cavity for a period of three minutes prior to ignition by the internal spark gap. In no case did the resulting internal explosion propagate to an identical external mixture surrounding the sensor or did permanent deformation of the sensor enclosure body occur. This is satisfactory.

4.3 Hydrostatic Test - Sensor - As it was not practical to measure the ignition pressure resulting from the explosion in the sensor cavity, a maximum theoretical ignition pressure of 75 psi (515 kPa) was used to determine the hydrostatic test pressure. A hydrostatic test was then conducted on a second test sample (Sample 2) at a pressure equal to 400% of this pressure. The pressure was increased at a rate of 100 psi (690 kPa) per minute and then held at the test pressure of 300 psi (2060 kPa) for one minute. At the conclusion of the test, the sensor assembly showed no visible signs of permanent deformation or movement of the potting compound. This is satisfactory.

4.4 Hydrostatic Test - Sensor Conduit Seal - A hydrostatic test was then conducted on the sealed conduit entry of a third test sample (Sample 4) at a test pressure of 1200 psi (8275 kPa). The pressure was increased gradually and then held at the test pressure for one minute. At the conclusion of the test, the sensor assembly showed no visible signs of permanent deformation or movement of the sealing/potting compound. This is satisfactory.

4.5 Flammability - Sensor Sealing Compound - Flammability testing was waived as the sealing compound, Sauereisen DW-30, has been previously tested with satisfactory results as reported in J.I. 1V9A6.AX.

4.6 Chemical Compatibility - Sensor Sealing Compound - Chemical compatibility testing was waived as the sealing compound, Sauereisen DW-30, has been previously tested with satisfactory results as reported in J.I. 1V9A6.AX.

4.7 Artificial Aging - Sensor Sealing Compound - Artificial aging tests were waived as the sealing compound, Sauereisen DW-30, has been previously tested with satisfactory results as reported in J.I. 1V9A6.AX.

V PROTECTION AGAINST SHOCK, FIRE, AND INJURY

5.1 General - Examination and tests of Model 5100-02 and Model 4101-02 Combustible Gas Sensor/Transmitter assemblies for protection against shock, fire and injury were satisfactorily conducted as part of examinations J.I. 2V4A4.AX and J.I. 1V9A6.AX, respectively. Additional testing for these assemblies was not required with the exception of a dielectric withstand tests with new sensor assembly P/N 22072 installed to a sensor/transmitter assembly.

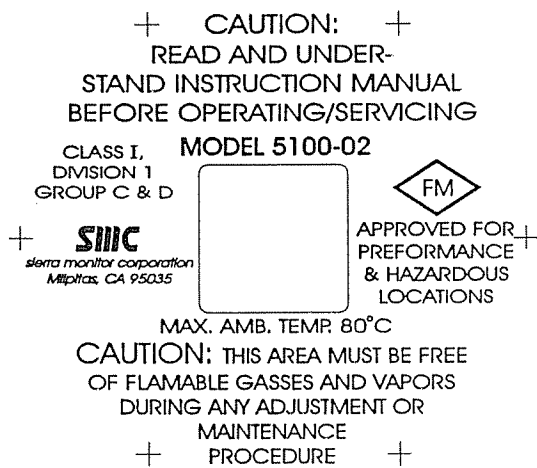
FACTORY MUTUAL RESEARCH CORPORATION

Job Identifier 1B4A2.AX

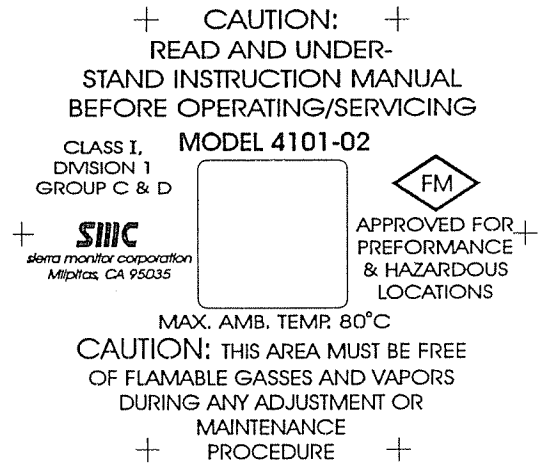
5.2 Dielectric Voltage Withstand Tests Sensor/Transmitter - Dielectric tests were conducted on Model 5100-02 sensor/transmitter assembly fitted with sensor assembly P/N 22072 at 500 Vrms between the field wire terminals tied together and the protective ground terminal. The results were satisfactory since there was no breakdown when the voltage was applied for one minute.

VI MARKING

Markings for Model 5100-02 and 4102-01 Combustible Gas Sensor/Transmitter assemblies satisfactorily meet Standard requirements as illustrated below.



Model 5100-02 Sensor/Transmitter



Model 4101-02 Sensor/Transmitter

Note: labels not to scale

VII FACILITIES AND PROCEDURES AUDIT

The manufacturing site at Milpitas, CA was examined with regard to facilities and quality control procedures and results were satisfactory in that the level of performance which produced the item which was tested was maintained.

VIII MANUFACTURER'S RESPONSIBILITIES

8.1 Documentation that is applicable to this approval is on file at FMRC and listed in the Documentation File of this report. No changes of any nature shall be made unless notice of the proposed change has been given and written authorization obtained from FMRC. The Approved Product - Revision Report, FMRC Form 797, shall be forwarded to FMRC as notice of proposed changes.

8.2 A copy of the applicable manufacturer's instruction manual shall be provided to the end user with each instrument.

FACTORY MUTUAL RESEARCH CORPORATION
Job Identifier 1B4A2.AX

8.3 Manufacturer's installation instructions and the National Electrical Code (ANSI/NFPA-70) must be followed when installing this equipment.

8.4 On 100% of production, the manufacturer shall inspect the protective grounding system on the controller and sensor/transmitter enclosures.

8.5 On 100% of production, the sensor/transmitter assemblies shall be subjected to dielectric tests described in Section 10.5 of Approval Report J.I. 2V4A4.AX and Section 9.4 of Approval Report J.I. 1V9A6.AX.

IX DOCUMENTATION FILE

The following documentation is applicable to this Approval and is on file at FMRC.

<u>Document No.</u>	<u>Issue No.</u>	<u>Title</u>
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INSTRUCTION MANUAL

T12001	A1	Model 5000 SENTRY GAS MONITORING SYSTEM Version 6
T13002	A1	Model 4101-02 COMBUSTIBLE GAS MODULE 4-20 mA

SENSOR/TRANSMITTER MARKINGS

H-39120-001	B	Model 5100-02 Silkscreen, Plate Encls. Lid
H-39119-001	B	Model 4101-02 Silkscreen, Plate Encls. Lid <u>COMBUSTIBLE GAS</u>

SENSOR/TRANSMITTER ASSEMBLIES

A13021	F	Model 5100-02 Assy, Uni-Comb. Module
A14001	E	Model 4101-02 Assy, 4-20 Com. Module

MODEL 5200-02E/4202-02E (P/N 22072) COMBUSTIBLE GAS SENSOR ASSY.

A22072	B	Model 5200-02E/4201-02E
F39069	3	Model 5200-02E/4201-02E Spacer
F39157	A1	Model 4101/5100-02 Porous Metal Cup
F39041	A1	Model 4101/5100-02 Comb. Sensor Encl.
F39046	A1	Model 4101/5100-02 Enclosure Seal
89006	11/29/95	Electrical Cement

Other documentation pertinent to this Approval are in files J.I. 2V4A4.AX, 1V9A6.AX and 0Z3A7.AX and remain applicable for the Approval of the subject gas detection apparatus.

FACTORY MUTUAL RESEARCH CORPORATION

Job Identifier 1B4A2.AX

X CONCLUSION

Modifications to the apparatus described in Section 1.2 continues to meet FMRC requirements.

EXAMINATION AND TESTS BY: R. Menot

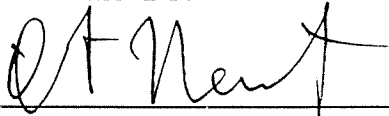
ORIGINAL DATA: PDR 1B4A2.AX

ATTACHMENTS: Manufacturer's Instruction and Service Manuals:

MODEL 5000 SENTRY GAS MONITORING SYSTEM, Version
6, T12001-Rev. A1

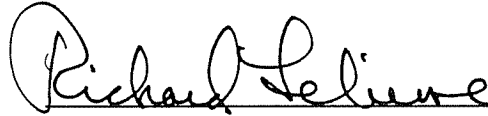
MODEL 4101-02 COMBUSTIBLE GAS MODULE 4-20 mA,
T13002 - Rev. A1

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