

Dual Sensor Infrared Sensor Technology For Use in CO2 Incubators

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Constant thinking.



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SHELDON MFG. INC.

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INTRODUCTION

Incubation of live cells requires precise control of environmental parameters such as temperature, humidity and pH. Carbon dioxide lowers the pH in the chamber of an incubator to levels similar to that of the natural mammalian body environment and is a critical element in incubation. Infrared technology is the most accurate method of sensing, and therefore controlling CO₂. There are two methods of employing the Infrared Sensor Technology: single and dual-sensor implementation.

PROBLEM STATEMENT

When single-sensor Infrared Technology was introduced, it was much more accurate than the Thermal Conductivity method but some users found it to be costly to purchase and maintain. While the technology dramatically increased accuracy and decreased recovery time, since it is impervious to changes in humidity or temperature, the gradual decay in light intensity from the IR source necessitated continual calibration and expensive repairs.

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PREVIOUS OPTIONS

Single-sensor Infrared Sensor Technology replaced the Thermal Conductivity method. Previous methods introduced gas using a number of direct methods in calculated amounts without sensor feedback or control.

THE SOLUTION

Dual-sensor Infrared Technology addresses the reliability and functionality issues present in single-sensor IR devices.

- **Benefit 1;** Dual-sensor technology automatically compensates for the natural intensity decay of the IR source over time.
- **Benefit 2;** Dual-sensor technology reduces the constant need to enter calibration offsets to compensate for aging components.
- **Benefit 3;** IR sensor technology is now competitively priced and more reliable.

CO₂ INCUBATOR FUNCTIONALITY

Thermal Conductivity Sensors

The Thermal Conductivity sensor feedback control system was a monumental advance from these unsophisticated methods of CO₂ introduction. For the first time, CO₂ concentration actually was being measured and injected based on a user-defined set point.

Thermal Conductivity sensors measure CO₂ indirectly. Each sensor is comprised of two, matched thermistors in a brass housing and a small electronic board that translates the analog output to a digital signal. Thermistors measure the air's thermal conductivity. The two, matched thermistors are calibrated to a very precise voltage output. One of the Thermistors is encased in a hermetically sealed chamber in the sensor head. The other thermistor is exposed to the chamber condition.

The thermistors deliver analog signals which, after being converted to digital output, are compared by the controller. The controller uses an algorithm to extrapolate a CO₂ reading based on the difference between the two thermal values. Because the thermistors cannot actually read CO₂ concentration, all other parameters that affect the conductivity of air must remain constant for the CO₂ control to calculate an accurate value, these being temperature, humidity and CO₂ gas concentration. While temperature remains stable in a water-jacketed incubator even after the door is opened, humidity takes time to build-up in the chamber. While the humidity is recovering, the CO₂ sensor cannot deliver an accurate reading.

Application values for CO₂ incubators in Tissue Culture applications are typically 37°C, 95+% relative humidity and 5% CO₂. The controller calculates the CO₂ concentration based on the parameters at baseline calibration which is typically done with these application values. When there is a change in chamber atmosphere, for example when the door is opened, the drop in rH will cause the controller to calculate a CO₂ value that is much higher than the actual value. The air density will equate in terms of high rather than low humidity. Low CO₂, although not ideal for cell growth, is not fatal to the colonies. This very slow recovery has therefore been considered an acceptable weakness of CO₂ incubators using Thermal Conductivity sensors.

If the door of the chamber is opened once every three hours, it is likely that the CO₂ will never have a chance to fully recover. In a busy lab, it is very likely that a TC sensor CO₂ incubator will spend a majority of the time in a low CO₂ condition.

If a fyrite reading is taken when the temperature or humidity is not at the exact value present during baseline calibration, the reading will be different than the calculated value on the display. This false reading could prompt a user to recalibrate the controller. This calibration will do more harm than good. Once the humidity and temperature have recovered to application values, the calculations of the controller will be flawed because it will be referring to the values used at the time of calibration. The cause of these false readings will be invisible to the customer who will likely continue to calibrate and further compromise the functionality of the unit.

Thermal Conductivity Sensor
Diagram with Cut-away

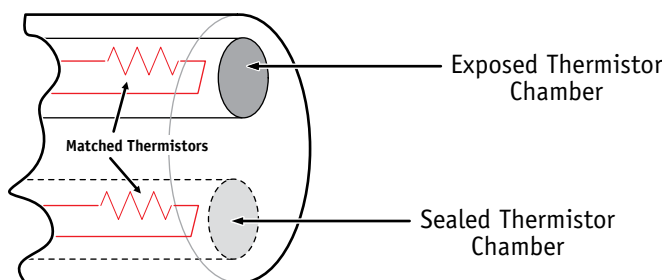


Figure 1

Infrared Sensor Technology

Unlike TC technology Infrared Sensor Technology directly measures CO₂ concentration. Temperature, humidity and chamber size have no bearing on the accuracy of the CO₂ control. This direct measurement technique provided users with exceptionally fast recovery and very accurate readings.

Infrared Sensors work by employing a broad spectrum IR source and a specialized sensor (fig. 2). The chamber atmosphere passes through a channel between an IR emitter and an infrared sensor. Some IR light is absorbed by the CO₂ in the chamber atmosphere. The light emitted from the bulb is a known quantity. The exact concentration of CO₂ gas is determined by subtracting the light that reaches the sensor from the light emitted by the bulb.

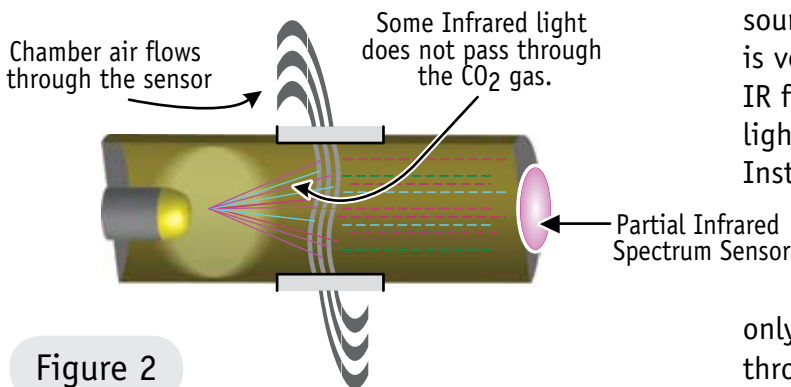


Figure 2

This method is extremely accurate and reliable. The single-sensor systems can give accurate readings for a number of years.

As with all light sources, intensity gradually diminishes over time. As the source ages, the sensor reads a weaker signal and interprets this as an increase in CO₂. The condition is remedied by the end user with an offset calibration based on a pyrite reading.

The continual need to calibrate the unit to compensate for the fading source resulted in costly sensor replacement after only a few years of service. Initially, this short life span and costly maintenance has discouraged adoption of this superior technology.

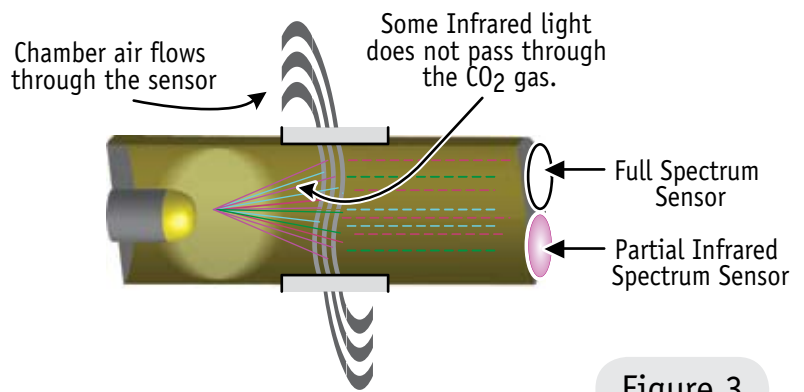


Figure 3

THE SHELDON MANUFACTURING SOLUTION

Dual-Sensor Infrared Technology

The CO₂ Infrared sensors used in all brands of CO₂ incubators built by Sheldon Manufacturing employ a dual-beam sensor which addresses the issue of source dimming. The dual-sensor Infrared CO₂ Sensor is very similar in principle but superior to the classic IR found in all competitive units. An IR source emits light which passes through the chamber atmosphere. Instead of one sensor, there are two that receive the light that has passed through the gas. One sensor detects a wavelength that is not affected by the presence of CO₂. The other sensor detects only the portion of the infrared spectrum that passes through CO₂ (fig.3).

The sensor compares the full-spectrum sensor reading to the known intensity of the bulb. As the bulb fades, the sensor calculates the reduction in total light and compares this to the amount of infrared light that is detected by the second sensor. Rather than equate every reduction in infrared light as a drop in CO₂, the control can now factor in reduction in total light emission and realize the actual CO₂ concentration in the chamber.

As with most new technology, the IR incubators were more expensive than TC incubators when they were first released. However, the technology has matured over the last decade and the cost of materials has dropped to nearly the level of TC sensors. To encourage adoption of the Dual-Sensor IR technology, Sheldon Manufacturing, Inc. has reduced the price of their complete line of IR CO₂ incubators

Dual-Sensor Infrared Technology, *continued*

to the TC price. Now that they are reaching their entire customer base with this exceptional value on the highest technology incubators, the decision to discontinue manufacture of TC sensor incubators was an easy one. As with all of their products, they plan on supporting TC units in the field for years to come.

SIGNS OF LIGHT INTENSITY DECAY

Since all CO₂ incubators currently on the market which are not manufactured by Sheldon Manufacturing, Inc. have a single sensor, they will inherently exhibit signs of source intensity decay. It is important to educate lab personnel about the symptoms of this condition so that decisions to replace the sensor from the original manufacturer or replace the unit with a Sheldon Manufacturing, Inc. Dual-Sensor IR Technology incubator can be made quickly.

SUMMARY

IR sensors addressed all of the weaknesses previously associated with TC sensors. Dual-Sensor IR Technology addressed all of the weaknesses previously associated with IR sensors. By accommodating the natural decay in light intensity emitted by the broad-spectrum bulb, Sheldon Manufacturing, Inc. has reduced the need for IR

Low CO₂

If the CO₂ concentration in the chamber is frequently lower than expected when checked with the fyrite, it may be a sign of light intensity decay. The reduction in the light detected by the sensor is read as high CO₂ concentration so CO₂ is not injected when it should be.

Discoloration of Media

Purple or bright pink media is a characteristic sign of a very low CO₂ and a high pH condition.

Frequent CO₂ Offset Entry Required

CO₂ incubators, whether TC or IR, should only require calibration offset entry every 4-8 months. While regular Fyrite readings should be taken, the need to calibrate should be rare. If a unit needs to be calibrated more than once every 3 months, call the manufacturer.

sensor replacement from every 2-3 years to every 7-10 years. That savings in parts and labor represents nearly the cost of a new chamber every 8 years. Most importantly, it eliminates lab down time and provides a level of reliability not previously available in CO₂ incubators. Sheldon Manufacturing, Inc offers an unparalleled 7 year warranty for any necessary replacement of the sensor.

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