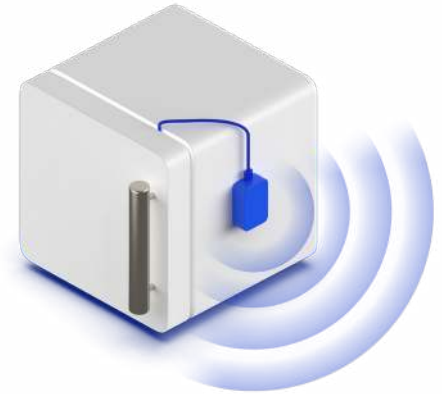


# CO<sub>2</sub> Incubator Monitoring E-Guide

## Introduction

The potential behind new biological therapies and stem cell research is fueling an uptick in biological research. Many of these studies require growing specialized cells, such as immortalized and stem cells. Growing these high value cells requires special care, from the raw materials to the process equipment, such as CO<sub>2</sub> incubators. There are several incubator parameters that scientists assign and monitor to ensure proper cell growth and proliferation:



Parameter	Common settings and usage
Temperature	Most incubators are set to a temperature of 37 degrees C
Humidity	Most incubators are set to about 95% relative humidity
CO <sub>2</sub> concentration	Most incubators are set to about 5% CO <sub>2</sub> concentration
O <sub>2</sub> concentration	Most incubators are set to about 20% O <sub>2</sub> concentration
Shaker speeds	The function of a shaker is to distribute nutrients to the cells within the incubator. Shaker speeds may vary based on incubator model and application.

Note: These conditions are general guidelines and may vary depending on the types of cells and your specific application.

## Current Incubator Monitoring

Many CO<sub>2</sub> incubators already have built-in monitoring functions that measure temperature, humidity, CO<sub>2</sub> and O<sub>2</sub> concentrations, and shakers speeds. When incubator conditions deviate from user set points, audible alarms are triggered to alert laboratory staff that incubator conditions must be checked. Some incubators also have built-in data loggers capable of recording environmental parameters for approximately 72 hours.

While current incubator models offer some utility in monitoring environmental parameters, these solutions still fall short of monitoring and alerting staff of out-of-spec conditions. For example, while audible alarms are useful when staff is on-site, this solution fails to solicit corrective action if an alarm is triggered overnight or during weekend hours when staff is less likely to be around. In this case, staff may only become aware of an out-of-spec incubator hours or possibly days after the issue occurred. Another shortcoming of built-in monitoring functions is that

they fail to capture out-of-spec incubator conditions caused by power outages. After all, inclement weather, such as snow storms or hurricanes, can lead to power outages that interrupt cellular incubation cycles and thus impede research studies. Lastly, a third major shortcoming of built-in monitoring systems is that they may not allow for data export of the environmental conditions during a cellular incubation cycle. These data records can be quite useful for troubleshooting as well as record keeping for compliance with GXP guidelines.



- Many incubator models have some built-in monitoring features



- Alarming features not effective when lab staff is not around
- Alarming features cannot provide alerts caused by power outages
- Environmental logs of incubators cannot be exported for record keeping

## Incubator Monitoring Through IoT

New technologies, such as the Internet of Things (IoT), offer more robust incubator monitoring solutions compared to traditional techniques.

There are two different options available for data collection and incubator monitoring. The first option is to use Primary Sensors to capture the most important variables which are known to impact research. Cloud-connected IoT sensors can be placed inside an incubator to monitor variables such as; temperature, humidity, light, CO<sub>2</sub>, and O<sub>2</sub>. The Element-T will capture Temperature, while the Element-A can be used to gather information about Temperature, Light, Humidity and Pressure. Customers interested in capturing CO<sub>2</sub>, Humidity and O<sub>2</sub> can use the Element-D or Element-C to gather information from individual sensors. Critical data collected from

Elements are continuously streamed onto the Elemental Machines Cloud for secure storage. Choosing the correct sensors will be determined by the importance of each variable.

The second option available is to capture data already being measured and generated by the incubator from its own internal sensors. Element-D (digital) and Element-C (analog) data collection devices connect directly to an incubator's data port to gather operational set points and actual operational conditions being measured. Parameters that can be monitored via Element-D and Element-C are: temperature, humidity, CO<sub>2</sub> concentration, O<sub>2</sub> concentration, and shaker speeds. (Note: Not all parameters may be available on all incubator models.) Similar to Element-A and Element-T, the data collected by Element-D and Element-C are continuously streamed to the Elemental Machines Cloud for secure storage. Users of the Elemental Machines platform can configure customized alerts for each asset in their dashboard. These alerts are triggered when incubator conditions are out of specified range. Users can also choose to receive alerts via email and/or SMS.

Incubator monitoring through IoT offers many advantages over traditional built-in incubator monitoring functions. The primary advantage is that data is no longer localized to a specific incubator. Data is available remotely to users for real-time monitoring. Thus, users can respond promptly to alerts even when off-site. Next, IoT offers a broader coverage of failure modes. For example, traditional built-in incubator monitoring functions will fail to alarm in the event of an power outage. However, with connection and power alerts built into IoT devices, users are quickly notified about power outages at the site. Furthermore, battery powered Element-A sensors, coupled with a battery-powered gateway tablet, can still send environmental data from incubators even when the incubator is powered off. This allows users to track environmental drift within the incubator, which can be used to assess whether the samples in the incubator may be compromised. Setting up an IoT monitoring for your incubators is a simple, straightforward process. The Elemental Machines platform is designed to be a plug and play product. Just connect

the Element-D or Element-C to your incubator data output or place the Element-A inside the incubator. Data automatically streams to the Elemental Insights Dashboard.

### Primary Data Collection-Independent Monitor - ET, EA, ED/EC



- Get independent data
- Backup in case of incubator sensor malfunction
- Automated data collection
- Real-time alerts



- More hardware – more plug points, more calibrated equipment to maintain
- More expensive – need to procure more hardware

### Direct Incubator Connection via Data Port/Comm Board - ED/EC



- Utilize built-in functionality and increased ability to capture more variables
- Less hardware to maintain
- Cheaper because you don't need extra sensors
- Automated data-collection
- Real-time alerts



- Calibration and accuracy must be maintained per SOP
- No secondary reading

*"We are excited about and have deployed numerous EM devices on our incubators to track and record CO2 levels. Deployment was straightforward and all of the information is readily available to us on their cloud-based network. We are able to use this data to help simplify asset management, data collection and improve scientific best practices."*

**Lyndsey Rissin**

*Sr. Manager, Lab Operations*

If you would like to learn more about your incubator monitoring options please contact us at:

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