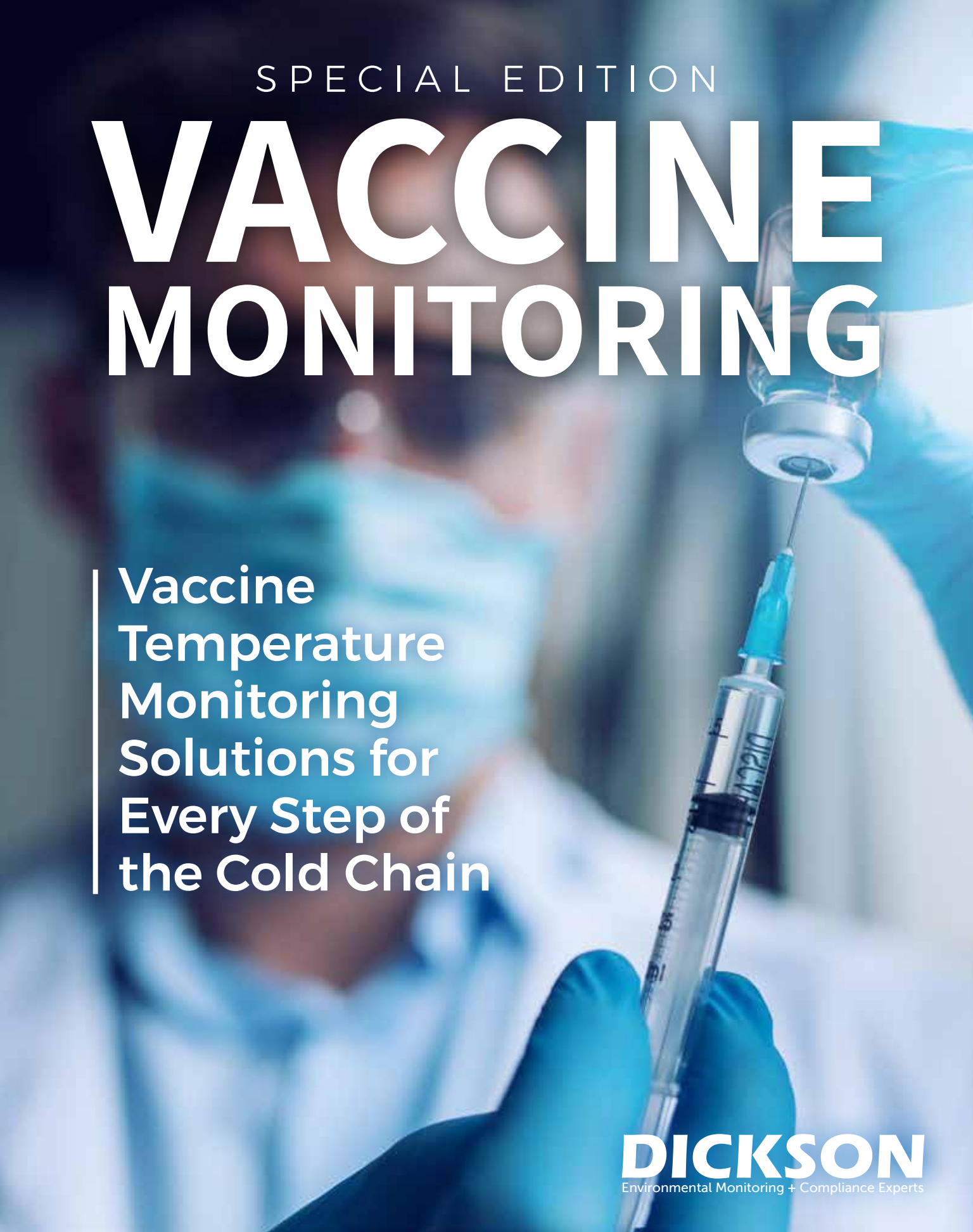


SPECIAL EDITION

VACCINE MONITORING

Vaccine Temperature Monitoring Solutions for Every Step of the Cold Chain

DICKSON

Environmental Monitoring + Compliance Experts

DICKSON
Environmental Monitoring + Compliance Experts

ABOUT DICKSON

Dickson is our customers' expert compliance partner for environmental monitoring.

Dickson was incorporated in the United States in 1923. By incorporating the best and newest innovations, Dickson enables our customers to manage compliance, asset protection, data analysis, and product quality with confidence.

Today, Dickson provides validated solutions and services for over 80% of Fortune 100 companies in highly-regulated industries including healthcare, medical device, pharmaceutical, food, aerospace and more. With the trust of over 80,000 customers worldwide, Dickson helps to protect billions of dollars' worth of assets and remains an industry innovator and leader.

CUSTOMER SUPPORT

Our product experts are available via phone and email to provide assistance with your environmental monitoring needs. Call 630.563.4217 to speak with someone directly or you may email support@dicksondata.com.

TECHNICAL SUPPORT

Our technical support experts are available via phone and email to provide assistance with your Dickson product(s). Call 630.563.4217 to speak with someone directly or you may email support@dicksondata.com.



TABLE OF CONTENTS

04 R&D

- Set Your R&D Up for Success
- Why Your R&D Needs The Right Monitoring Solution
- R&D Monitoring Solutions

06 MANUFACTURING

- The Key to Good Manufacturing Practices
- How Dickson Safeguards Your Manufacturing Process
- Manufacturing Monitoring Solutions

08 TRANSPORTATION

- Transportation: A Critical Link in the Cold Chain
- Protect Your Valuable Assets in Transit
- Transportation Monitoring Solutions

10 DISTRIBUTION

- Distribution: Keeping the Cold Chain Moving
- Protect Your Valuable Assets in Transit
- Distribution Monitoring Solutions

12 PATIENT SITE

- Protecting the Final Step in the Cold Chain
- A Monitoring Solution that Adapts to Your Needs
- Distribution Monitoring Solutions



R&D

SET YOUR R&D UP FOR SUCCESS

The first step in deploying a new vaccine is a multi-stage R&D program. In R&D, the effectiveness and safety of candidate vaccines are tested, using cell or tissue-based experiments, in animals, and eventually in human trials. The stepwise approach for vaccine development is also followed in the development of other drugs and biologics. However, since vaccines are given to healthy people, a higher standard for safety is used.

In modern R&D, scientists first conduct basic research to find out how a virus works on a molecular level. This information is used to develop candidate vaccines, which are then tested for safety and effectiveness in animals in pre-clinical trials.

The results of pre-clinical trials are evaluated by the FDA during the Investigational New Drug (IND) application process. Successful candidates are given approval for human (clinical) trials. Human trials take place in a three-phase process, where the vaccine is tested on progressively larger groups of human subjects, who are closely monitored for immune response and adverse side effects.

At the conclusion of clinical trials, vaccines can be licensed for sale through the Biologics License Application (BLA) process, which is conducted by the Center for Biologics Evaluation and Research, or CBER, a center within the FDA. The approval decision is made by a cross-functional group of doctors, statisticians, and other health professionals. In addition to examining the results

RELIABLE AND COMPLETE RECORD

PRECISE MEASUREMENTS

AUTOMATED DATA COLLECTION

of clinical trials and storage/stability data, this group conducts inspections of the R&D sites, and reviews the process that will be used to manufacture the vaccine, including environmental monitoring. During a public health crisis, vaccine manufacturers and the CBER can work together to accelerate approval in a number of ways, including through an emergency use authorization, which allows public release of the drug before clinical trials are complete.

WHY YOUR R&D NEEDS THE RIGHT MONITORING SOLUTION

Thorough, precise environmental monitoring is integral to successful R&D. This stage is not as highly regulated as later steps we will discuss, but monitoring environmental conditions, and maintaining precise control over those conditions is still important.

In the basic research stage, targeted experiments are used to determine the effect of multiple variables on vaccine performance. In this stage, monitoring and control of temperature and humidity in the lab environment, and in freezers, refrigerators, and temperature-controlled test chambers eliminates these environmental conditions as variables, improving experimental sensitivity and accuracy.

In the pre-clinical and clinical phases, environmental and storage monitoring ensures that the vaccine is administered under controlled conditions. This is essential to maintain the fidelity of the trial data that will be used by the FDA to determine whether a vaccine should be approved to move between R&D stages, and ultimately to be licensed.

In addition to effectiveness and safety, tests are performed to determine the proper storage conditions, the shelf life, and stability of the candidate vaccine. Since this will affect the infrastructure needed to manufacture, ship, and store the vaccine, highly precise and accurate environmental data is needed for these tests.

Another reason that a centrally controlled network of environmental sensors works well in R&D is that the collection and organization of environmental data can be automated. This reduces the amount of intervention needed by research staff, allowing them to focus on the complex tasks in vaccine development.

The FDA enforces thorough environmental monitoring and control to ensure the accuracy of pre-clinical and clinical testing, through Good Laboratory Practices (GLP) regulations. During R&D, labs are audited to confirm they are following GLP, which, similar to GMP for manufacturing, includes well-documented and thorough environmental monitoring.

R&D MONITORING SOLUTIONS



TWE
-20˚C OR -80˚C VACCINE DATA LOGGER BUNDLE



DWE
-20˚C OR -80˚C VACCINE DATA LOGGER BUNDLE



EMERALD
DRY ICE VACCINE DATA LOGGER BUNDLE



ATLAS
TRANSPORTATION DATA LOGGER



MANUFACTURING

THE KEY TO GOOD MANUFACTURING PRACTICES

Vaccines, along with drugs and other biological products, are manufactured following GMP (Good Manufacturing Practices). A central theme of GMP is thorough, complete record-keeping using validated systems. This includes environmental monitoring of the manufacturing facility, and inside storage and processing units in the manufacturing line. Following these practices is the best known method for safe, consistent manufacturing of products intended for human consumption. For this reason, using GMP to make biological products and drugs is enforced by the FDA.

In general, regulation is more prevalent in manufacturing compared to R&D. As part of the BLA process before a vaccine is licensed for sale, regulators review plans for manufacturing and perform audits of the manufacturing site. After approval, audits are performed regularly to ensure GMP compliance, and can also be performed when changes are made to the production line. The FDA has the authority to change inspection requirements depending on outside factors, like public health emergencies or the discovery of new areas of risk, so it is important to have a robust, compliant environmental monitoring scheme that easily adapts to changing regulatory requirements.

Another important aspect of manufacturing is that its later stages represent the first part of the cold chain. The cold chain is the refrigerated distribution and storage network where the temperature of the vaccine is maintained from the point of manufacture to the patient site where the vaccine is administered.

CLEAN START TO THE COLD CHAIN DATA TRAIL

CUSTOM ALARMS TO PREVENT EXCURSIONS

MEET REGULATORY REQUIREMENTS

HOW DICKSON SAFEGUARDS YOUR MANUFACTURING PROCESS

Three key pillars of GMP are traceability, accountability, and data integrity. Any system used in vaccine manufacturing must integrate these three concepts. To ensure data integrity, data collection should follow the ALCOA rule: attributable, legible, contemporaneously recorded, original copy, and accurate.

A system of remotely monitored, distributed digital data loggers (DDLs) is ideally suited to meet these requirements consistently in a modern vaccine manufacturing line. First, this type of system is designed to scale in response to increasing demand. For example, a new piece of manufacturing equipment, or an entire manufacturing line can be easily added to a network of existing monitors in a single software tool.

Second, the right system can provide real-time monitoring with an intuitive user interface. This is useful in a manufacturing environment, where several processes are being monitored simultaneously. When real-time data is available, alerts can be customized so production staff can respond to potential excursions quickly and efficiently.



A thorough data record can also help to troubleshoot problems with the manufacturing line.

Since the end of manufacturing represents the beginning of the cold chain, standardized temperature monitoring becomes even more critical. Any temperature excursion between now and when the vaccine is administered risks damaging its effectiveness. This part of the cold chain is also particularly sensitive because it involves the hand-off of the vaccine between two steps, which can be affected by additional variables like outside temperature, or delays in loading and unloading. For these reasons, it is critical to maintain a complete, accurate record of vaccine temperature to make sure the record is unbroken from manufacturing to the subsequent transportation and distribution steps.

MANUFACTURING MONITORING SOLUTIONS



TWE
-20˚C OR -80˚C VACCINE DATA LOGGER BUNDLE



DWE
-20˚C OR -80˚C VACCINE DATA LOGGER BUNDLE



RFL
RADIO FREQUENCY DATA LOGGER



EMERALD
DRY ICE VACCINE DATA LOGGER BUNDLE



TRANSPORTATION

TRANSPORTATION: A CRITICAL LINK IN THE COLD CHAIN

Advances in communications and transportation technology since the 1970s have allowed a dramatic increase in the geographical scale of pharmaceutical manufacturing and distribution. As a result, modern vaccines can be transported using long, complex supply chains involving transport by a combination of road, rail, air, or sea (intermodal or multimodal transport).

For vaccines, this introduces a number of concerns, because the cold chain must be maintained and unbroken across all of these steps. One concern is the potential for temperature excursions during transport through areas with unpredictable fluctuations in outside temperature.

Another is possible loss of refrigeration due to equipment malfunction, in an area with relatively undeveloped infrastructure, limited access to backup equipment.

Logistical delays, like traffic or vehicle breakdowns, can also slow down shipments and cut into the shelf life of the vaccine. This is especially problematic for vaccines with a short shelf life, like COVID-19 vaccines that are shipped in dry ice.

These issues can be addressed using a number of approaches. One is the use of refrigerated intermodal shipping containers or “reefers”. The other is to use integrated electronic monitoring, including RFID tags, GPS tracking, and temperature sensors that can be embedded in the shipment, with data read out remotely in real time. This approach provides a complete picture of the location and conditions of a shipment, down to the package level if needed.

BLUETOOTH CAPABILITY FOR SMARTPHONE ACCESS

COMPACT DESIGN TO MEET LOGISTICAL REQUIREMENTS

PEACE OF MIND THROUGH RELIABLE MONITORING

As the vaccine progresses through transportation channels, risk of a temperature excursion actually increases over time. The first legs of a shipment are usually palletized, in bulk quantities with reliable large scale refrigeration equipment. As the shipments get closer to the patient site, shipments can be broken down into smaller parts, with environments maintained with less reliable refrigeration equipment. In particular, the ‘last mile’ of the shipment, or delivery to the patient site, must be correctly planned so the receiver is ready to handle the shipment and refrigerate it when it arrives.

PROTECT YOUR VALUABLE ASSETS IN TRANSIT

Temperature monitors used in vaccine transport should be compact and battery powered, so that they can be embedded directly at the package level. They should also have the ability to transmit data to a remote reader, for example via Bluetooth. This allows access to temperature data in real time, which ensures that temperature excursions can be detected and resolved quickly.

It is also advantageous for transport temperature sensors to be inexpensive, so that many of them can be placed throughout a large shipment. Using disposable sensors also avoids having to return the sensors to the point of origin.

Having a temperature sensor embedded in the packaged shipment allows an unbroken, accurate record of the actual shipping box temperature throughout its entire journey. For this reason, digital data loggers are recommended by the CDC and WHO. During transport, digital monitoring data can be an important complement to vaccine vial monitors, which detect when an individual vial experiences a temperature excursion. If an excursion takes place, vial monitors indicate which vials were affected, while the monitoring data collected by sensors provides detailed information on the length and severity of the excursion.

Transportation of the vaccine also involves leaving the clean environment of the manufacturing site. For this reason, temperature sensors should be rugged and resilient against impact, dirt, and water. The resistance of an electronics housing is quantified in the IP (Ingress Protection) code, which should be part of the specification for a transportation sensor. Part of the selection criteria for a sensor should be matching the specified IP code with the environments where the sensor is expected to be used.

TRANSPORTATION MONITORING SOLUTIONS



ATLAS
TRANSPORTATION
DATA LOGGER



EMERALD
DRY ICE VACCINE
DATA LOGGER BUNDLE



EMERALD
BLUETOOTH
DATA LOGGER



DISTRIBUTION

DISTRIBUTION: KEEPING THE COLD CHAIN MOVING

Vaccine distribution networks tend to be complex and dynamic. This is partly due to stringent storage temperature requirements, which can change over time as vaccine technology and our understanding of the fragility of individual vaccines improves, and partly due to expansion in the geography of vaccine distribution. Modern supply chains involve movement over long distances, with distribution sites placed in regions with unpredictable weather and infrastructure. Globalization of distribution networks also introduces potential delays at customs and other trans-border logistics issues.

Let's use COVID-19 vaccines as an example. The international courier DHL envisions three different distribution scenarios, depending on the temperature sensitivity and shelf life of a vaccine, and the distance over which it is shipped. The three scenarios are:

- Direct shipping from production facility to the point of administration
- Cross-docking at local sites, where vaccine shipments are loaded directly from one shipping mode to another, with little or no intermediate storage
- More traditional distribution schemes involving local warehousing

Looking more closely at these three schemes, they all involve an emphasis on storage at different locations, for example at warehouses near the manufacturing facility,

SIMULTANEOUSLY MONITOR MULTIPLE FREEZERS, IN REAL-TIME

EASILY SCALE UP DISTRIBUTION NETWORKS

CUSTOMIZE ALARMS TO MITIGATE AND PREVENT EXCURSIONS

storage in a freezer farm at an intermediate location, or temporary storage before 'last mile' transit to a patient facility. The specific configuration of this part of the cold chain will depend on the nature of the vaccine and the storage and handling capabilities of various steps.

PROTECT YOUR VALUABLE ASSETS IN TRANSIT

In the context of temperature monitoring, this means that an effective scheme needs to be able to adapt to changes in the configuration of the cold chain. This could involve adding new freezers or freezer farms, retrofitting existing warehouses, or building new ones. Using a centrally monitored, distributed network of temperature data loggers is an effective strategy in these situations because it can be easily reconfigured or scaled up.

Storage and monitoring equipment may also need to adapt to specific storage temperature requirements. Most vaccines require storage at between 2-8 °C ("refrigerated"), or -50 to -15 °C ("frozen"), while some candidate COVID-19 vaccines require lower temperature storage, as low as -70 °C. These storage requirements can change as more data is collected, and vaccines evolve.

At distribution sites, risk is increased by the high amount of traffic, frequent door opening, and handling of vaccine packages, like breaking down a pallet of vaccine into smaller shipments. These situations could all cause a temporary loss in temperature control. In general, any hand-off from one transport mode to another involves this type of risk. For example, it was found that the effectiveness of the H1N1 vaccine in the 2013-2014 flu season was reduced by high outside temperature, indicating short temperature excursions took place during loading and unloading.

To address these issues, an environmental monitoring system needs to provide real-time temperature data at a sufficient number of monitoring points to ensure the vaccine is tracked at all times during distribution, particularly during these high risk operations.

This is another situation where configuring custom alerts is a proactive and effective way to prevent excursions. For example, staff can be given warnings when the temperature of a particular storage unit at a distribution center is trending up over time. In the event of an equipment malfunction, targeted alerts can be sent to the appropriate support staff to ensure fast, reliable responses that can prevent excursions or mitigate their effect. Effectively configuring real time monitoring and alerts can provide peace of mind that the valuable vaccine stock is thoroughly monitored and protected as it moves through the distribution network.

DISTRIBUTION MONITORING SOLUTIONS



-2(
DATA LOGGER BUNDLE



EMERALD
DRY ICE VACCINE
DATA LOGGER BUNDLE



EMERALD
BLUETOOTH
DATA LOGGER



ATLAS
TRANSPORTATION
DATA LOGGER



PATIENT SITE

PROTECTING THE FINAL STEP IN THE COLD CHAIN

Safely handling vaccines at the final step of deployment, clinical sites, presents unique challenges which are mostly related to an expansion in the number of storage locations and the number of people handling the vaccine. The situation is made more complex by the variety of different vaccines stored at a single site, which require different storage conditions (2-8 °C, -50-15 °C, or lower). Addressing these challenges requires a monitoring network that can effectively adapt to these conditions.

For example, one hospital network could be managing many different vaccination sites, each of which require storage monitoring. The storage environment itself is also somewhat different to what would be used for transportation and distribution. For one, refrigerators and freezers at clinical sites are frequently opened, with each door opening presenting an opportunity for a temperature excursion.

The various storage sites could also use different refrigeration equipment, requiring the monitoring system and alarm conditions to be set up differently at each site. For these reasons, digital data logging is recommended by the CDC, and is even required for sites that participate in the Vaccines for Children (VFC) program.

At clinical sites, a consistent, thorough staff training protocol, including standard operating procedures and emergency procedures, would also be required system-wide for any personnel handling vaccines. (Federal law actually states that staff handling vaccines should have a “thorough understanding” of the operations they perform.)

COST-EFFECTIVE SCALING TO MULTIPLE MONITORING LOCATIONS

SIMPLE TO USE, EASY ONBOARDING FOR PERSONNEL

POWERFUL TOOL FOR SITE VACCINE COORDINATORS

A MONITORING SOLUTION THAT ADAPTS TO YOUR NEEDS

Given the increased number of variables, and the unique aspects of vaccine handling at clinical sites, a remote monitoring system like DicksonOne provides the necessary ability to adapt to any type of clinical site configuration, and simplifies expansion to multiple sites. The combination of real-time data monitoring, with the ability to customize when alarms are sent, and who they are sent to, effectively mitigates the potential and impact of the most common types of excursions at clinical sites.

The use of automated data storage across the network of storage sites also simplifies compliance with recommendations by the CDC that storage temperature data is reviewed and analyzed weekly, and stored for three years, to help identify any trends. Automatic, time-resolved data storage is also useful in a temperature excursion, where this data can be used to determine the severity of the excursion when deciding on a response.

The other aspect that must be considered here is the personnel that come into contact with the vaccine. The health care personnel involved in vaccine handling and storage are simultaneously managing a diverse number of



other issues related to patient care. Automating as much of the safe handling and storage of vaccines as possible through a central, remotely monitored system frees them to focus on these tasks, and reduces the chances of an excursion at the final stage of vaccine deployment. The easy to use interface of a remote temperature monitoring scheme also speeds up and simplifies staff training. The importance of training is reflected in the thorough vaccine and storage toolkit published by the CDC.

Sensor calibrations using NIST-traceable standards, which should be conducted at 1-2 year intervals, can also be tracked by central monitoring software.

Remote monitoring software is an especially useful tool for clinical site vaccine coordinators, who are responsible for, among other things, setting up and reviewing temperature data, responding to temperature excursions, and overseeing vaccine transport if necessary.

PATIENT SITE MONITORING SOLUTIONS



TWE
-20˚C OR -80˚C VACCINE DATA LOGGER BUNDLE



DWE
-20˚C OR -80˚C VACCINE DATA LOGGER BUNDLE



DSB
-20˚C OR -80˚C VACCINE DATA LOGGER BUNDLE



EMERALD
DRY ICE VACCINE DATA LOGGER BUNDLE

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