# Data Standards for Temperature Monitoring and Cold Chain Equipment Inventories

Briefing document for Wednesday afternoon breakout 6: Data Standards for Temperature Monitoring and Cold Chain Equipment Inventories: Developing Frameworks for Interoperability.

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A central challenge for information systems is interoperability, or more directly, allowing systems to work together. The breakout session on Wednesday afternoon - *Data Standards for Temperature Monitoring and Cold Chain Equipment Inventories: Developing Frameworks for Interoperability* will look at this problem for information systems supporting the vaccine cold chain. The session will address two closely related cold chain domains: managing cold chain equipment and tracking equipment performance by temperature monitoring. Data standards are a necessary first step to achieve interoperability, by specifying the information that needs to be collected, and describing the structure and the representation of information. Interfaces can be developed based on a standard to allow different systems to exchange information and work together. Data standards are central to digital technology, ranging from the HTML standards supporting the world wide web, the IP standards supporting internet communication, and the USB standard allowing exchange of information between devices.

There are technical aspects in developing a data standard, including agreeing on data elements and their representation. However, it is also critical to keep the broad picture in mind of allowing a range of information systems to work together to enable people to achieve their goals. For cold chain information systems, we want countries to have multiple options on systems to use, including having the ability to compose different systems to meet their needs. For Cold Chain Equipment Inventories, we envision a range of tools in use for the inventories, including spreadsheet tools, CCEM, DHIS2, and custom built data, with the ability to exchange data between the systems and also submit the data to analysis tools that can perform multi-country analyses. On temperature monitoring we would like to see countries able to simultaneously use a range of approaches and products to monitor their vaccine cold chain, including having real time monitoring devices from multiple manufactures reporting to a common data base. The data from manually recorded forms, 30 day temperature recorders, and real time devices should align, so that comparisons can be made across sites that use different approaches to data collection. There are also significant advantages on the vender side from standards for interoperability. For temperature monitoring, standards that allow countries to collect temperature information across multiple different devices is likely to increase the market as a whole for such devices. Developers of software to support aspects of cold chain management benefit if their tools can directly interact with complementary tools: to give a specific example, it would be highly beneficial if logistics modelling tools could directly utilize data from cold chain equipment inventories, such as having Hermes import data directly from CCEM.

Data standards promote systems *working together*. There are different ways that systems can work together, and this is reflected in the representation and the precision of the standard. We identify three separate cases to illustrate this:

* **Sharing of information across systems.** Different systems may represent the same underlying data. An example of this is a Cold Chain Equipment Inventory. Standardization in this case allows for the same data elements to be collected for inventories, and identifies a minimal common core of necessary data.
* **Utilizing data from different sources**. Systems may receive data from different sources. Even if this data does not necessarily agree (for example, in temperature monitoring, some sites may report continuous data, while others may report daily data), it is important for the data sources to align, so that comparisons can be made in a meaningful way.
* **Interfaces for direct connection between systems.** Modern information systems rely on the interfaces to allow multiple devices to communicate. The interfaces can either be realized as hardware protocols, such as could be used for different temperature sensing devices to communicate to a common backend systems, or agreed upon file formats, so that applications can share information through file import and export.

It is often helpful to view a data standard consisting of two levels. The top level consists of data definitions and structure that needs to come from domain experts, and can provide the framework for the standard. The lower level is more technical, and needs the involvement of software experts to ensure that it is rigorously defined, and can support the formal implementation of interfaces. It is natural to begin by developing the framework first, before all implementation details are worked out. Our efforts are focusing on developing the frameworks which can later be refined to include the technical standards.

There is currently a lot of discussion about *Open Data Standards*, and we want these efforts to be considered open. There are many different definitions of what Open Data Standards are, but there is general agreement on a set of properties that an open process should have. A leading example of open data standards is the World Wide Web Consortium (W3C) which has managed standards such as HTML. Key properties of an open standard include transparency, impartiality, availability, and a mechanism for evolution.

There are two separate data standards efforts underway which are in different stages. For both of these efforts we want expand the stakeholder buy in. Specific goals for TechNet include promoting and broadening the technical discussions on the standards, and getting agreement on the next steps to move the process forward.

### Cold chain equipment inventory standards.

A cold chain equipment inventory is a record of a countries vaccine storage equipment, along with information about health facilities that store vaccines. The inventory not only tracks equipment, but has basic information to allow an evaluation of the quality of the cold chain and an assessment of the adequacy of the storage capacity.

There are multiple options available for storing cold chain equipment inventories. The most common method is to store the information in spread sheets, either as lists of equipment, or as part of excel tools for managing immunization logistics. Another option is storage of the information in a Microsoft Access database on a PC. The CCEM tool was built on top of Microsoft Access to provide a database along with a set of Cold Chain analysis tools and reports. A final option, which aligns with current health information systems is to store the inventory in a web accessible database, so that it can be kept up to date by distributed updates.

An effort to develop a common standard for Cold Chain Equipment Inventories was initiated in 2012. The goal was to provide a standard that would facilitate the movement of data between different inventory tools, and also to allow inventory tools to provide data that could be used for modeling or logistics tools. Another objective of the work was to make it easier to compare inventory data from different countries to help understand the global status of cold chain equipment and needs.

The Cold Chain Equipment Inventory (CCEI) data standard was initiated by the Unicef Cold Chain Logistics (CCL) working group. The first draft of the standard was a cleaned up version of the data elements used in CCEM, which in turn came from earlier WHO tools. A substantial amount of feedback was received from individuals and in group calls, and the standard was refined over the period of about a year. We consider the current version to in good shape (although there is continual discussion around some data elements). Next steps for the CCEI Data standard include:

1. Determining if there is need for changes in specific data elements.
2. Identification of a process of making this an open data standard and determining an organization that can manage the standard.
3. Development of on interchange format for the standard to allow software to import and export CCEI data according to the standard.

### Temperature Monitoring

Discussions of a cold chain temperature monitoring standard were initiated with the dual objectives of promoting real time reporting of temperature data, and making it easier to evaluate multiple sources of temperature data reported by different mechanisms. If was felt that it would be easier for companies to develop products for temperature reporting if there were common standards of data being collected and reported. Since there are many current approaches to monitoring, including both manual reading of refrigerators, and the use of logging devices to record temperatures for a period, we would like to have these methods collect data that is compatible remote temperature devices.

The work on the temperature monitoring standard is at a much earlier stage than the cold chain inventories work. There was an initial convening on temperature monitoring data standards at University of Washington in 2013, which led to initial documents which were then iterated on by a small group. The work was revisited at the Zanzibar RTM Workshop in October 2014. The current document was revised in January 2015.

We emphasize that this work is preliminary, and the next step is to get a broader range of stakeholders to weigh in and participate. We hope to generate a reporting framework that will cover both automatically collected temperature data, as well as data from manual reading and logging devices. A first goal of the work is to get a high level consensus on what temperature information should be collected and stored. As there are multiple use cases for temperature data, this needs to be done with recognition that temperature data will be collected and used in different ways, and that there is need for compatibility of the different approaches.

# Appendix 1: Cold Chain Inventory Equipment Data Standards

Version 1.8, May 1, 2015

## Cold Chain Equipment Inventory data model

The basic data model is structured around facilities (which can be either health facilities or vaccine storage facilities), with equipment associated with specific health facilities. The model includes both Cold Chain Equipment Inventory as well as addition information that would be used across applications

* Health/ Vaccine storage facilities – information on each of the country’s health and vaccine storage facilities. The basic model for the inventory is to associate assets with facilities
* Core Assets – cold rooms, refrigerator/freezers, coldboxes and vaccine carriers.
* Asset catalogs – information associated with particular models of assets. (The issue of non-cataloged assets needs to be addressed).

## Facility data model

Required indicates if this is essential for the inventory. Other fields could be made required by specific tools or deployments.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | Facility ID | String | Primary key for the application. This ID must be unique. | Y |
| 2. | National Facility ID[[1]](#endnote-1) | String | Official ID of the facility, from a master facility list. | N |
| 3. | Facility Name | String (UTF-8) | The name of the facility. Standard capitalization should be used. The UTF-8 representation allows multiple scripts to be used. | Y |
| 4. | ASCII Name[[2]](#endnote-2) | String (ASCII) | The name of the facility in ASCII (e.g., basic Latin characters, without accents). | N |
| 5. | Administrative Region[[3]](#endnote-3) | Admin NodeID | Location in the administrative (geographic) hierarchy. The information is extracted from the Admin Table | Y |
| 6. | GIS Coordinates[[4]](#endnote-4) | String | Use the ISO 6709 standard for representing latitude and longitude (and possibly altitude). Decimal degrees is the preferred format. | N |
| 7. | Facility Type[[5]](#endnote-5) | Enumeration | Type of facility from a fixed list of possibilities: StorageX, HospitalX, HealthCenterX, HealthPostX, OtherX. X is an integer that allows different levels of the same type. [List TBD] | Y |
| 8. | Facility Ownership | Enumeration | Ownership of facility from a fixed list of possibilities: Public, Private, NGO, FaithBased, Other. [List TBD] | Y |
| 9. | Facility Population[[6]](#endnote-6) | Numeric | Total catchment population for the facility. | Y |
| 10. | Facility Coverage[[7]](#endnote-7) | Numeric (Percent) | Percentage of Population receiving routine immunization services from the facility | Y |
| 11. | Storage Type | Enumeration | Storage for transfer to another facility, or storage for use at the facility. {Depot, Delivery, DepotAndDelivery, NoStorage} | Y |
| 12. | Vaccine delivery type[[8]](#endnote-8) | Enumeration | Static, Outreach, StaticAndOutreach, None | Y |
| 13. | Power Infrastructure | Composite | See below | Y |
| 14. | Cold Chain Logistics | Composite | See below | N |
| 15. | Contact Information[[9]](#endnote-9) | String | Phone number and contact official | N |

## Power Infrastructure

Four power sources are generally considered for the cold chain: electricity, kerosene, gas, and solar. Countries may restrict their number of power types, so NotApplicable should be an option (even if not available at the user level)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | Electricity Source[[10]](#endnote-10) | Enumeration | Grid, Generator, GridAndGenerator, None | Y |
| 2. | Grid Power Availability[[11]](#endnote-11) | Enumeration | MoreThan16, 8To16, 4To8, LessThan4, None | Y |
| 3. | Gas Availability[[12]](#endnote-12) | Enumeration | Available, Irregular, NotAvailable, Unknown, NotApplicable | Y |
| 4. | Kerosene Availability | Enumeration | Available, Irregular, NotAvailable, Unknown, NotApplicable | Y |
| 5. | Climate suitable for solar[[13]](#endnote-13) | Enumeration | Yes if area gets a sufficient number of hours of sunshine throughout year  Yes, No, Unknown, NotApplicable | N |
| 6. | Site suitable for solar | Enumeration | Yes if there are possible unshaded locations for solar panels  Yes, No, Unknown, NotApplicable | N |
| 7. | Climate zone | Enumeration | WHO zones: Hot, Moderate, Temperate | N |

## Cold Chain Logistics

Cold chain logistics information is technically not part of the equipment inventory, so it has been put into a separate component.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | Vaccine Supply Interval[[14]](#endnote-14) | Numeric | Interval of delivery or collection (in weeks). This is needed if it overrides national policy | N |
| 2. | Vaccine Reserve Stock Requirement | Numeric | Required reserve stock (in weeks). This is needed if it overrides national policy | N |
| 3. | Mode of Vaccine Supply | Enumeration | Delivered, Collected, DeliveredAndCollected, None | N |
| 4. | Distance to supply point | Numeric | One way distance in KM to closest supply point. | N |
| 5. | MainSupplyPoint[[15]](#endnote-15) | String | FacilityId of main supply point | N |
| 6. | SecondarySupplyPoint | String | FacilityId of secondary supply point | N |

## Storage Assets

### Refrigerator/Freezers

Refrigerators and Freezers are the most important asset for the inventory. There should also be a distinction between vaccine and icepack freezers. Since most of the equipment in use is from the PQS/PIS list, the way to handle asset information is to only store the model number, and then use a secondary table to represent the catalog information. We will assume that the catalog is augmented to include additional models. Generic entries can cover unidentified types of domestic refrigerators.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | Unique ID[[16]](#endnote-16) | String | Unique ID for the application. (This ID should be unique across all asset types) | Y |
| 2. | Model ID | String | Key into an official catalog. Information about the model is derived from this. | Y |
| 3. | Equipment tracking ID | String | Ideally, the real serial number. However, this is not always available or maintained at the facility. | N |
| 4. | Bar Code | String | If a barcode is used, the information can be stored here | N |
| 5. | Year[[17]](#endnote-17) | Numeric | Year of acquisition (manufacture). Often not accurate (but may not need to be.) | N |
| 6. | Source | String | Where the equipment came from | N |
| 7. | Working status | Enumeration | Functioning, AwaitingRepair, Unservicable | Y |
| 8. | Reason not working or not in use[[18]](#endnote-18) | Enumeration | NeedsSpareParts, NoFinance, NoFuel, Surplus, Dead, NotApplicable | N |
| 9. | Utilization | Enumeration | InUse, NotInUse, InStoreForAllocation | Y |
| 10. | Voltage regulator | Enumeration | For electric equipment, is it connected to a voltage regulator. Yes, No, Unknown, or NotApplicable. NA for non-electric | N |
| 11. | Power source[[19]](#endnote-19) | Enumeration | Electricity, Gas, Kerosene, Solar, Unknown | N |

### Coldrooms

This is a first cut on the cold room data.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | Unique ID[[20]](#endnote-20) | String | Unique ID for the application. (This ID should be unique across all asset types) | Y |
| 2. | Identifier | String | Model and type | Y |
| 3. | Manufacturer | String | Name of manufacturer | N |
| 4. | Storage Temperature | Enumeration | {Plus4, Minus20} | Y |
| 5. | Equipment tracking ID | String | Ideally, the real serial number. However, this is not always available or maintained at the facility. | N |
| 6. | Bar Code | String | If a barcode is used, the information can be stored here | N |
| 7. | Year[[21]](#endnote-21) | Numeric | Year of installation | Y |
| 8. | Source | String | Where the equipment came from | N |
| 9. | Working status | Enumeration | Functioning, AwaitingRepair, Unservicable | Y |
| 10. | Reason not working or not in use[[22]](#endnote-22) | Enumeration | NeedsSpareParts, NoFinance, NoFuel, Surplus, Dead, NotApplicable | N |
| 11. | Utilization | Enumeration | InUse, NotInUse, InStoreForAllocation | Y |
| 12. | Backup Generator | Enumeration | Yes, No, Unknown, or NotApplicable. | Y |
| 13. | Voltage regulator | Enumeration | For electric equipment, is it connected to a voltage regulator. Yes, No, Unknown, or NotApplicable. NA for non-electric | Y |
| 14. | Gross Volume | Numeric | Volume in m3 | N |
| 15. | Net Volume | Numeric | Volume in m3 | Y |
| 16. | Dimensions | Numeric triple | (Width, Depth, Height) in meters | N |

## Refrigerator Catalog

This information is associated with the PIS/PQS catalog. We don’t need all of the information from the PQS/PIS sheets. (Is there additional information that is of interest?) This will be augmented to handle other equipment types

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | Catalog ID[[23]](#endnote-23) | String | Primary Key from PQS/PIS | Y |
| 2. | Model Name | String |  | Y |
| 3. | Manufacturer Name | String |  | Y |
| 4. | Power source[[24]](#endnote-24) | Enumeration | Electric, Gas, GasElectic, Kerosene, KeroseneElectric, Solar, PassiveCooler | Y |
| 5. | Equipment Type | Enumeration | A simplified version from PQS without the power source: ChestFreezer, IcePackFreezer, ChestRefrigerator, IceLinedRefrigerator, UprightRefrigerator, SolarPhotvoltaicRefrigerator, SolarThermalRefrigerator | Y |
| 6. | Climate Zone | Enumeration | PQS Designation: Hot, Moderate, Temperate | Y |
| 7. | Data Source | Enumeration | PQS, PIS, Custom, Generic |  |
| 8. | Storage volume[[25]](#endnote-25):  GrossPlus4, NetLus4, GrossMinus20, NetMinus20 | Numeric | Can we just do Net volume. Although I would prefer just to report a single number, we probably need to give both +4 and -20 numbers | Y |

## Other Assets

The cold room format needs to be completed. The inventory also includes other asset types – there are vaccine carriers, which are often counted. These should be included in the inventory – although likely viewed as “supplies” – we are only interested in how many there are – not information on each individual carrier.

Transportation assets should be defined. These would be an optional component.

## Data Structures for the Cold Chain Equipment Inventory

In order to fully represent the Cold Chain Equipment Inventory, it is necessary to define data structures to link the information. Although these could be considered a property of the implementation, it is necessary to define a format to allow information to be exchanged.

## Facility Equipment Lists

The link between equipment and facilities is no longer represented as part of the asset. In most cases, an asset can be associated with a facility, is it was convenient to represent the information by just recording a facility with an asset. However, there are a few exceptions to this, and logically, the facility is not a property of the asset.

For completeness, we specify a simple scheme of asset, facility pairs.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | FacilityID | String |  | Y |
| 2. | EquipmentID | String |  | Y |
| 3. | AssetType | Enumeration | Refrigerator, ColdRoom, etc | Y |

## Administrative Hierarchy

The administrative hierarchy is represented as a collection of nodes. Each node in the hierarchy has a unique ID, so that facilities can be assigned to an arbitrary position in the hierarchy.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | NodeID | Integer | Unique non-negative integer ID | Y |
| 2. | Name | String | UTF | Y |
| 3. | Ascii Name | String | Ascii | N |
| 4. | Level[[26]](#endnote-26) | Integer | National level (root) is level 1 | Y |
| 5. | Parent | Integer | Node ID of Parent. (-1 for root) | Y |
| 6. | Category[[27]](#endnote-27) | String | UTF – Subdivision category | Y |
| 7. | AsciiCategory | String |  | N |
| 8. | ISOCode | String | Code from ISO 3166 | N |

## Country Name Table

For compatibility across countries, some information is represented generically (names of administrative levels, health facility types). To enable applications to appropriately display this information, a table of names in presented. Names are represented in both UTF-8 and Ascii. Information will be recorded for Adminstrative Levels, Facility Ownership, Facility Types. The level is given for each type to allow an arbitrary number of levels.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Name | Type | Comments | Req. |
| 1. | GenericName | Enumeration | AdminLevel, VaccineStore, Hospital, HealthCenter, HealthPost, OtherHealthFacility, Public, Private, NGO, FaithBased, OtherOwner | Y |
| 2. | Level | Integer | Starting from 1 | Y |
| 3. | Name | String | UTF-8 | Y |
| 4. | AsciiName | String | Ascii | Y |

# Appendix 2: Temperature Monitoring Data Standards

Version 1.0

May 1, 2015

Preliminary draft for comment and revision

The standard consists of Objects[[28]](#endnote-28), Reports, and Summaries

Objects: Concepts that are standardized in the data modely. They are core data building blocks for generating reports and summaries.

Reports: Aggregated temperature data for storage in a database.

Summary: Higher level aggregation of temperature data.

### Objects

**Temperature Monitoring Device**

* One time (upon installation), basic data about the monitoring device.
* This model designed for monitoring devices with multiple sensors.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Temperature Monitoring Device ID | String | KEY. Unique ID of the temperature monitoring device | Y |
| Temperature Monitor Type | String | RTM, data logger, 30 day logger, paper, etc | Y |
| Number of Sensors | Numeric | No. of sensors/probes connected to the device. | Y |
| Temperature Monitoring Device Name | String | Human readable ID. | N |
| Temperature Monitoring Device Manufacturer | String |  | N |
| Power Source | String | e.g. Solar, electricity, battery only. | Y |
| Temperature Device Plugged into Same Power as Fridge | Boolean | Used to determine if power outages detected by the device are also experienced by the fridge. | N |

**Sensor**

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Sensor Index | Numeric | The index of the sensor/probe. | Y |
| Sensor Location | String | Where the sensor is located (including ambient) | Y |
| Sensor Type | String | e.g., TEMPERATURE, DOOR\_OPEN, HUMIDITY | Y |
| Temperature Monitoring Device ID | String | FOREIGN KEY: Reference Device table. | Y |

**Temperature Reading**

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Sensor ID | String | Foreign key | Y |
| Temperature Monitoring Device ID[[29]](#endnote-29) | String | Foreign key | Y |
| Sample date/time | Date/time |  | Y |
| Temperature Reading | Numeric |  | Y |
|  |  |  |  |
| Other | Numeric/String | Possibly multiple fields representing additional data collected by the sensor at the time at the temperature reading. E.g power availability, battery level, location, door open, etc… | N |

**Alarm Configuration**

|  |  |  |  |
| --- | --- | --- | --- |
| Temperature Threshold | Numeric | Degrees Celsius | Y |
| Threshold Duration | Numeric | Minutes outside of temperature threshold to trigger alarm. | Y |
| Excursion type | String | Above or below | Y |

**Temperature Alarm:** The temperature alarm data model is used to record temperature alarm events. This data can be generated/recorded when the alarm first happens, continually updated as more information is available, or stored as a final record.

Recording long-term alarms: In scenarios where there is a long multiday alarm/event each new day should instantiate a new alarm report.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Temperature Monitoring Device ID | See above | Foreign Key | Y |
| Sensor Index | See above | Foreign Key | Y |
| Start time | Datetime |  | Y |
| Alarm Type | String | ‘COLD’, ‘HOT’, ??? |  |
| Alarm resolved | Boolean |  | Y |
| Alarm Configuration | String | Foreign Key | Y |
| Time outside of threshold | Numeric | Minutes | Y |
| Extreme temperature | Numeric | The max or min reached during this alarm | Y |
| Alarm Cause | String |  | N |
| Alarm Resolution | String | Actions taken to rectify alarm: e.g. supervisor contacted, maintenance, repairs, device replacement, backup or alternative power used, diagnosed problem to power outage and no further action possible | N |

**Event alarm:** The event alarm data model is used to record optional events/indicators generated by temperature monitoring devices or implements. This data can be generated/recorded when the alarm first happens, continually updated as more information is available, or stored as a final record.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Temperature Monitoring Device ID | See above | Foreign Key | Y |
| Sensor Index | See above | Foreign Key | Y |
| Start time | Datetime |  | Y |
| Alarm resolved | Boolean |  | Y |
| Alarm Type | String | Power outage, battery, fuel outage, door open, device replacement, etc. | Y |
| Duration of Alarm | Numeric | Minutes | Y |
| Alarm Cause | String |  | N |
| Alarm Resolution | String |  | N |

**Device Status:** The device status data model is used to record miscellaneous data reported by temperature monitoring devices. This can range from additional non temperature data about the equipment being monitored to data about the monitoring device performance.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Status date/time | Datetime |  | Y |
| Status Type | String | Examples: battery level, connectivity metric/indicator, door open, storage space, etc. | Y |
| Status | String/Numeric/Other |  | Y |

## Reports

Reports are the rudimentary aggregation of data to be stored in a database to handle the majority of use cases.

**Daily Temperature Status Report:** Sent anytime.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Report date | Datetime |  | Y |
| Data source | String | Manual or Automatic (indicate if reported manually or from a device) | Y |
| AM reading | Numeric |  | Y |
| PM reading | Numeric |  | Y |
| Min temperature | Numeric |  | N |
| Max temperature | Numeric |  | N |
| Grid power availability, Fuel Status | Boolean | True if sufficient power/fuel to keep cold storage unit operating properly | N |
| High Alarm | Boolean | True if a high alarm was recorded for the day | Y (if there is alarm) |
| Max Temperature during High Alarm | Numeric |  | Y (if there is high alarm) |
| Low Alarm | Boolean | True if a low alarm was recorded for the day | Y (if there is alarm) |
| Min Temperature During Low Alarm | Numeric |  | Y (if there is freeze alarm) |
| Time above threshold | Numeric | Minutes | Y (if there is alarm) |
| Time below threshold | Numeric | Minutes | Y (if there is alarm) |
| Data missing | Numeric | Minutes of data missing | N |

Multiday temperature reports can be created by repeating the daily temperature reports, thus, a monthly report would be just a list of 30 daily reports.

**Continuous Temperature Report (verbose)**

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Start time | Datetime |  | Y |
| End time[[30]](#endnote-30) | Datetime | Optional | N |
| Sampling interval | Numeric | Total time between samples | Y |
| Sampling duration | Numeric | Total time covered by this report | Y |
| Temperature readings[[31]](#endnote-31) | Numeric List | List implemented as required by DB. | Y |
| Other | Numeric List/String List | Possibly multiple lists representing additional data collected by the sensor at the time at the temperature reading. E.g power availability, battery level, location, door open, etc… | N |

## Summaries

Summaries are intended as a further aggregation of the report data to fit alternate uses. In some cases monitoring devices and data recorded in the field (such as on paper)

**30DTR**

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req |
| Start date/time[[32]](#endnote-32) | Datetime |  | N |
| End date/time | Datetime |  | Y |
| High days | Numeric | Number of high days | Y |
| Low days | Numeric | Number of low days | Y |

**Multiday Summary:** A superset of the 30DTR.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Type | Comments | Req. |
| Start date/time | Datetime |  | Y |
| End date/time | Datetime |  | Y |
| High days | Datetime List | List of days where high temperature excursion was present. | Y |
| Low days | Datetime List | List of days where low temperature excursion was present. | Y |
| Time above threshold | Numeric | Minutes | N |
| Time below threshold | Numeric | Minutes | N |
| Data missing | Datetime List | List of days with insufficient data | Y |
| Grid power availability, Fuel Status | Numeric | List of days with insufficient power/fuel to keep cold storage unit operating properly | N |

1. In the ideal case, we would be able to use the National ID as the facility key. However, even when a national facility ID is available, there are likely to be cases where an application diverges from the national ID, so we must keep them separate. [↑](#endnote-ref-1)
2. The ASCII representation is included to facilitate applications which use multiple country data sets. The ASCII representation is also useful for compatibility with other software tools and making it easier to search the data. [↑](#endnote-ref-2)
3. The administrative region is the geographic region that the facility is associated with, which might not be the lowest level in the administrative hierarchy. There are some data sets where the lower levels of the administrative hierarchy are not indicated, which requires associating the facility with a higher level. One issue that is not addressed here is that the health administrative hierarchy might be different from the political administrative hierarchy. [↑](#endnote-ref-3)
4. Multiple formats are used for GIS coordinates. Standardizing on latitude and longitude is a significant simplification. The string representation increases flexibility. [↑](#endnote-ref-4)
5. Standardizing facility types might be controversial. The actual types are still to be determined. Vaccine storage facilities are one obvious type. The proposal that Hospitals, Health Centers, and Health Posts are the other main types. Possibly there are additional ones, and there would be Other for types that were missed. Giving numbers with types allows different levels to be represented. These names will be internal codes for the application. A table can convert them to the country specific name. [↑](#endnote-ref-5)
6. The total population is used, instead of breaking this down to groups such as newborns or pregnant women. These can generally be derived through country specific multipliers. [↑](#endnote-ref-6)
7. The population that receives immunization services from the facility. Some facilities (such as hospitals) may have a large catchment, but few people get their immunization from the facility. I am assuming this is still in terms of the total population (and does not just count under ones.) [↑](#endnote-ref-7)
8. As a minor detail – these could be represented as separate booleans. [↑](#endnote-ref-8)
9. Experience shows that this is a very useful field. To allow flexibility, it will be kept as a string. [↑](#endnote-ref-9)
10. This is referring to the electricity source for vaccine storage – so the generator would be providing power to the vaccine storage equipment. [↑](#endnote-ref-10)
11. The idea is to provide four buckets: GreatThan16 – Regular electricity. 8To16 – Outages occur, so that an ILR is required for adequate hold over. LessThan8 – Long outages, so alternate fuel devices or backup power for an ILR is needed. None – no grid power. It is very difficult to collect more specific information about electricity availability, especially since it is often highly variable throughout the year. [↑](#endnote-ref-11)
12. Gas and Kerosene have the same enumeration type. The Irregular label captures multiple possible problems (irregular supply or poor quality). NotApplicable is available as a type to cover cases where gas or kerosene is not a relevant fuel source. [↑](#endnote-ref-12)
13. Evaluating solar is controversial. The approach here is to record to values – the first is whether the climate is suitable for solar – so this depends on latitude, longitude, and rainfall patterns. This does not require a site visit to determine this. The other variable is whether or not there is an unshaded location so that panels could be installed, which requires some knowledge of the site. Sites would require both values to be yes in order to be suitable for solar. [↑](#endnote-ref-13)
14. Supply intervals if they differ from national guidelines for the facility type. Interval in weeks. Monthly is 4 weeks, Quarterly is 13 weeks. [↑](#endnote-ref-14)
15. The standard becomes simpler if we have just a fixed number of options – so I have just included two. [↑](#endnote-ref-15)
16. Key for equipment used by the application. This must be a unique identifier. This can be used in the table the links equipment to facilities. [↑](#endnote-ref-16)
17. A convention needs to be determined to represent Unknown Age. 1900, 0, -1 or null are all possibilities. I lean towards 0 – as it is less likely to cause problems for applications. [↑](#endnote-ref-17)
18. This is useful, but will not be easy to get. If it use, NotApplicable should be selected [↑](#endnote-ref-18)
19. This is important information for machines which can have multiple power sources (EG or EK equipment). It is not of interest for equipment that has only a single option for power. [↑](#endnote-ref-19)
20. Key for equipment used by the application. This must be a unique identifier. This can be used in the table the links equipment to facilities. [↑](#endnote-ref-20)
21. A convention needs to be determined to represent Unknown Age. 1900, 0, -1 or null are all possibilities. I lean towards 0 – as it is less likely to cause problems for applications. [↑](#endnote-ref-21)
22. This is useful, but will not be easy to get. If it use, NotApplicable should be selected [↑](#endnote-ref-22)
23. A convention needs to be developed for catalog IDs for non PQS/PIS equipment [↑](#endnote-ref-23)
24. Long term passive cooling could also be included to capture devices being developed by Sasnu and IVL. [↑](#endnote-ref-24)
25. All four values are included [↑](#endnote-ref-25)
26. The hierarchy is represented as level, with the national level at level one. The assumption is that each node points to its parent in the tree, which is one level lower. [↑](#endnote-ref-26)
27. There can be multiple subdivision categories at the same level of the hierarchy, e.g, state, federal district, and outlying territory [↑](#endnote-ref-27)
28. Give me a better term than object! [↑](#endnote-ref-28)
29. This could be left off since it could be derived from the sensor. [↑](#endnote-ref-29)
30. This may seem redundant with sampling duration – but I was worrying about how time intervals might not align with storage boundaries. [↑](#endnote-ref-30)
31. I think we should clarify that this can record multiple lists of temperature readings. I want to make sure that our continuous temperature record is robust to the case where a sensor is restarted. [↑](#endnote-ref-31)
32. start date is optional – since almost always this is just for the preceding 30 days (which is then assumed to be a month) [↑](#endnote-ref-32)