Qualification of temperature-controlled road vehicles

Technical supplement to

Annex 9: Model guidance for the storage and transport of time and temperature–sensitive pharmaceutical products

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### Technical Supplement: Qualification of temperature-controlled vehicles

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Abbreviations

±K Difference in absolute temperature
ATP Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage: - UNECE
cGMP current Good Manufacturing Practice
EDLM Electronic Data Logging Monitor
EN XXXX European Norm (standard)
IQ Installation Qualification
OQ Operational Qualification
PQ Performance Qualification
SOP Standard Operating Procedure
TTSPP Time and Temperature-Sensitive Pharmaceutical Product
Glossary

**Electronic Data Logging Monitor (EDLM):** A small portable device that measures and stores temperature at pre-determined time intervals by means of an electronic sensor. They have programmable alarm capabilities, integrated displays, and can create reports and graphs which may be permanently stored, shared and analysed via proprietary hardware, software, desktop application or through hosted databases.

**Coefficient of heat transfer:** (The "U" value, also referred to as the "K" coefficient in the ATP Agreement): The overall heat transfer of the equipment, defined as the heating power or cooling capacity, $W$, per degree temperature difference, $T$, between the internal and external surfaces over the surface of the body, $S$.

The units are $W/(m^2K)$ and its formula is below.

$$K = \frac{W}{S \cdot \Delta T}$$

**Installation Qualification (IQ):** The process of obtaining and documenting evidence that equipment has been provided and installed in accordance with its specifications and that it functions within predetermined limits when operated in accordance with the operational instructions.

**Operational Qualification (OQ):** Documented verification under controlled conditions that the equipment or systems, as installed or modified, perform as intended throughout the anticipated operating ranges.

**Performance Qualification (PQ):** Documented verification that that the equipment and ancillary systems, as connected together, can perform effectively and reproducibly based on the approved process method and specifications.

**Pharmaceutical product:** Any product intended for human use or veterinary product intended for administration to food producing animals, presented in its finished dosage form, that is subject to control by pharmaceutical legislation in either the exporting or the importing state and includes products for which a prescription is required, products which may be sold to patients without a prescription, biologicals and vaccines. It does not, however, include medical devices.

**Standard Operating Procedure (SOP):** A set of instructions having the force of a directive, covering those features of operations that lend themselves to a definite or standardized procedure without loss of effectiveness. Standard operating policies and procedures can be effective catalysts to drive performance improvement and improve organizational results.

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2. ibid
**Time and temperature sensitive pharmaceutical product (TTSPP):** Any pharmaceutical good or product which, when not stored or transported within pre-defined environmental conditions and/or within pre-defined time limits, is degraded to the extent that it no longer performs as originally intended.

**Validation:** Documented testing performed under highly controlled conditions, demonstrating that processes, methods, and systems consistently produce results meeting pre-determined acceptance criteria.⁴

1. Introduction

This technical supplement has been written to amplify the recommendations given in WHO Technical Report Series No. 961, 2011, Annex 9: Model guidance for the storage and transport of time- and temperature-sensitive pharmaceutical products. It outlines the actions that need to be taken to qualify vehicles equipped with active temperature-control systems which are used to transport TTSPs.

What is ‘qualification’?

In the context of this series of Technical Supplements, qualification is an inspection and testing process used to establish that a piece of equipment or a physical installation is fit for purpose in the operational context within which it will be used. There are typically three stages in the process. Each stage must be fully completed before the next one begins.

Stage 1 (for equipment): Establish by laboratory testing under tightly controlled conditions that a specific item of equipment performs in accordance with the user requirements specification (URS). This is design qualification. Whilst design qualification demonstrates compliance with the URS and associated test protocols; it does not prove that the equipment will be suitable in a specific operating environment because the URS and the test procedures are unlikely to reflect the full range of operating conditions.

Stage 1 (for installations): Establish by documented inspection and testing that an installation that has been assembled in a specific location is fully in accordance with the user requirements specification and installation drawings. This is installation qualification.

Stage 2: Establish by further documented testing under controlled conditions that this equipment or installation is likely to perform as intended in the operating environment in which it will be used. This is operational qualification.

Stage 3: Carry out a final stage of documented testing to establish with a high degree of assurance that the equipment or installation, together with all associated systems, does indeed perform as intended under routine operating conditions. This is performance qualification.

1.1 Requirements

Where temperature-controlled vehicles are directly owned and/or operated it is important, wherever possible, to qualify each vehicle before it becomes operational. The qualification procedure should:

- **Demonstrate** that the temperature distribution within the payload area of the temperature-controlled compartment is maintained within the range specified for the products being transported (e.g. +2°C to +8°C). The qualification procedure must be able to assess actual product temperatures for commonly used load layouts. Qualification should be carried out at the ambient temperature extremes anticipated during normal operation, over known distribution routes.

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6 The installation will typically incorporate components that have a design qualification.
• **Define** zones within the vehicle's payload area which should not be packed with TTSPP's (for example areas in close proximity to cooling coils or cold air streams).

• **Demonstrate** the time taken for temperatures to exceed the designated maximum or minimum in the event that the temperature-controlling unit fails. Similar tests should be used to validate the anticipated door opening times that will occur during deliveries.

• **Document** the qualification exercise for internal quality assurance and external regulatory purposes.

This procedure constitutes a temperature-mapping exercise similar to that employed for fixed temperature-controlled storage facilities.

An alternative approach is to perform an initial full qualification on each trailer/temperature-control unit type, combined with an installation qualification (IQ) for each example when a new vehicle becomes operational.

Carry out additional qualification exercises whenever significant modifications are made to the vehicle. Consider the need for re-qualification whenever temperature monitoring shows unexplained variability that is greater than normal.

These requirements are to ensure that TTSPP's can be safely transported within the transport temperature profile defined for each product and that compliance can be demonstrated to the regulatory authorities and other interested parties.

### 1.2 Objectives

The objective of the Technical Supplement is to provide guidance on how to qualify temperature-controlled vehicles used for transporting TTSPP's in a way which meets the above requirements.

#### 1.2.1 Verification

When a temperature-controlled vehicle is procured, the purchaser must exercise due diligence to ensure that the required performance and detailed characteristics are clearly specified so that the vehicle supplier can provide equipment that matches the needs of the operating environment. Only equipment which has been properly verified against industry standards and norms should be considered. If procurement is done correctly there is a high probability that the vehicle will perform well in the operating environment.

#### 1.2.2 Validation

Once the vehicle has been delivered it is essential that its actual performance is validated. Validation is used to demonstrate that the specified performance standards are met in the actual operating environment. This process should take place before the vehicle is used to transport valuable TTSPPs.

Validation procedures are increasingly being seen as a requirement of cGMP (current Good Manufacturing Practice). The validation process applies a set of clearly defined criteria and provides documented evidence that the equipment is fit for its intended purpose. Typically this is a three stage exercise:
Installation Qualification (IQ) - verifies that the equipment is installed correctly as per the original requirements and that any documentation needed for its use is in place.

Operational Qualification (OQ) - verifies that of the equipment concerned with maintaining and ensuring product quality operate correctly over all expected ambient conditions.

Performance Qualification (PQ) - verifies that those parts of the equipment concerned with maintaining and ensuring product quality can perform as intended in an effective and repeatable manner over time.

1.3 Target readership

Principally the owners and operators of temperature-controlled vehicles used to transport TTSP’s; the aim being to provide sufficient information to enable them to produce an SOP relevant to their own specific transport operations.
2. Guidance

The importance and regulatory significance of verification, validation and qualification has been outlined above. This section describes the principal steps that need to be taken in order to achieve these objectives.

2.1 Associated materials and equipment

The following are required:

- A sufficient quantity of electronic data logging monitors (EDLMs), qualified to EN 12830:1999, together with the necessary download software. WHO PQS pre-qualified EDLMs may be used for this purpose.[7]
- Temperature monitor with remote sensor.
- Where possible, an ATP-approved temperature-controlled chamber should be used. The specific requirements of the cold chain for pharmaceutical products have not been ratified, but recommended guidelines have been produced[8].
- Real, expired or dummy product.

2.2 Preliminary construction validation

The following checks should be carried out to satisfy the Installation Qualification stage. Essentially this is an inspection procedure designed to ensure that the vehicle meets required standards; these requirements should have been stated clearly in the procurement specification.

2.2.1 Temperature-controlling equipment

The sizing of refrigeration equipment relative to the heat load has a significant effect on the vehicle’s ability to maintain the required temperature and its carbon dioxide emissions. If the equipment is too small, the temperature cannot be maintained; if it is too large it will consume excessive amounts of fuel. In cold climates, heating capacity will also be required to provide low temperature protection if the temperature-controlled compartment needs to be maintained above 0°C. The ATP agreement stipulates that refrigeration equipment should have an over-capacity of a least 1.75 times the overall heat ingress into the insulated body under operating conditions at +30°C ambient. If the predicted ambient temperature is above +30°C, it would be prudent to increase the over-capacity to 2.25.

[8] Practical Guidelines – Cold Chain for Medicines
2.2.2 Insulation equipment

ATP regulations state that for frozen transport the insulation should have a K-coefficient of heat transfer of ≤0.4W/m²K, and for chilled transport a value of ≤0.7W/m²K. It is recommended that all new vehicles be selected with an insulation coefficient <0.4W/m²K.

2.2.3 Performance checks

Before qualification, the performance of the temperature-control and insulation equipment should be checked according to the maintenance procedure; see the companion WHO Technical Supplement: Refrigeration equipment maintenance.

2.3 Field shipment test

The field shipment test is designed to satisfy parts of the Operational Qualification and Performance Qualification stages.

2.3.1 Purpose

The purpose of this test is to demonstrate whether the product temperature distribution, within the temperature-controlled compartment, is maintained within the specified limits. Testing should be designed to cover commonly used load layouts at the ambient temperature extremes anticipated during normal operation over known routes.

Ideally a temperature-controlled chamber would be used for the test because this provides a consistent, monitored environment. A downside of this approach is the validity of the simulated conditions; it may be difficult accurately to predict the real world conditions of a delivery.

In many cases a large test chamber will not be available. In these circumstances a test procedure carried out under real operating conditions is an acceptable compromise.

2.3.2 Loading

When conducting a field shipment test under real operating conditions, there are two options:

- **Use real products**: In the case of a simultaneous transport and validation exercise, use actual products.

- **Use expired or dummy products**: If validation is being carried out before live operations commence, use real products that have reached their expiry date whenever possible. Otherwise use substitutes having similar thermal properties, mass and packaging to the actual products to be transported.

The vehicle should be packed according to the manufacturer’s instructions and should reflect the load layout commonly used. Although the precise equipment and layout will depend on the vehicle and products transported, general guidance can be found in the WHO EVM SOP E7-05: Loading and operating refrigerated vehicles.

2.3.3 Temperature probe placement

Temperature probes should be fixed within the packaging of the transported products. Ideally the temperature probes should be spread throughout the load; however, as a minimum requirement, they should be placed in the locations most vulnerable to
temperature excursions. It is also informative to include less vulnerable positions. See Annex 1.

If there are multiple drop-off points along the delivery route, this should be considered when locating the temperature probes. At least one probe must remain attached to the payload up to the final drop-off.

2.3.4 Test procedure
As a minimum, a series of four tests should be conducted to reflect the full range of the vehicle’s use.

a. Test performance with maximum payload during the warmest season;
b. Test performance with minimum payload during the warmest season;
c. Test performance with maximum payload during the coldest season;
d. Test performance with minimum payload during the coldest season.

The operator may wish to repeat these tests for statistical confirmation. See the companion Technical Supplement: Transport route profiling qualification.

During the tests, the vehicle should be operated as intended and the route should be chosen to reflect a typical worst-case scenario. Preferably the tests should be conducted during an actual delivery in order to collect accurate data. If this is not possible, a representative route should be chosen. A worst-case scenario would usually include multiple drop-offs with associated door openings, with the least journey time between drop-offs and overnight stops on electric standby.

Following the completion of each test, the data from the loggers can be downloaded to determine the overall performance.

2.3.5 Acceptance criteria
In order to pass the OQ and PQ qualification, the product temperatures should remain within the required temperature range during the entire route and across all four tests. For example if the requirement is for +2°C to +8°C, the minimum temperature recorded should not be below +2°C -0.5°C and the maximum should not exceed +8°C +0.5°C.

2.4 Temperature-control failure test
A temperature-control failure test is required to complete the OQ and PQ. This test determines the time in which a breakdown becomes critical.

2.4.1 Purpose
The purpose of the test is to demonstrate the time taken for temperatures to exceed the designated maximum or minimum in the event that the temperature-controlling unit fails. Note that this test cannot be carried out using real products during a simultaneous transport and validation test because the product would be damaged.

2.4.2 Loading
Do NOT use actual products for this test as it will be irrevocably damaged during the test. Instead use expired product if this is available. Alternatively, use a substitute with similar
thermal properties, mass and packaging to the actual products. Minimal payload should be used.

Again the vehicle should be packed according to the manufacturer’s instructions and should reflect the load layout commonly used. Tests should be undertaken in ambient conditions reflecting both the extremes of heat and cold likely to be encountered during service.

2.4.3 Temperature probe placement
Temperature probes should be fixed within the packaging of the products being transported to ensure that the temperature of the product itself is recorded and not the surrounding air; air temperature within the compartment may fluctuate outside of the designated range for short periods whilst the product temperatures remain unchanged.

Ideally the temperature probes should be spread throughout the load, however, as a minimum requirement they should be placed in the locations most vulnerable to temperature excursion. It is also informative to include less vulnerable positions. See Annex 1.

2.4.4 Test procedure
The temperature-control system should be set to control the product temperatures within the standard operating temperature range. Generally, the mid-point of the temperature range should be chosen to stabilize the products whilst allowing for some variation in the product temperatures. For example if the product demands +2°C to +8°C, then +5°C should be selected. The system should be left to allow the products to stabilize. This time will vary for different types of insulated equipment, though approximately 12 hours should be sufficient. A temperature sensor with remote hand held monitor could be attached to product nearest the doors to allow for temperature readings to be taken during the test, thereby assisting in monitoring the progress of the test.

Once stabilization is achieved, the temperature-control system should be switched off. Temperature readings can be taken periodically to provide a guide to the internal temperature. The test is complete when a single product temperature exceeds the designated maximum or minimum for the designated operating temperature classification.

Following the test, the data from the loggers can be downloaded to determine the overall performance.

2.4.5 Acceptance criteria
The time taken for the product temperatures to exceed the intended maximum or minimum should be recorded in the OQ with reference to the unit being tested. These data can be used to help define contingency procedures and required response times during a transport emergency.

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9See: EVM-SOP-E7-06: Responding to emergencies during vaccine transport operations.
2.5 Documentation

Comprehensive documentation is an essential part of the qualification process because it enables the long-term performance of the vehicle fleet to be monitored and it allows the operator and regulatory bodies to demonstrate compliance with good practice.

2.5.1 Designation of the vehicle

The insulated body and the associated temperature-control unit should both be uniquely identifiable. This is achieved by recording the data on the manufacturer's plate(s), which must clearly and indelibly show at least the following particulars:

- Country of manufacture;
- Name of manufacturer;
- Model;
- Serial number;
- Year and month of manufacture.

2.5.2 Results of the qualification

Appropriate documentation must be kept to ensure that there is an historical record of OQ and PQ qualification for a particular insulated body. All qualification results should be recorded, together with a list of any subsequent modifications. Records of unexplained performance variability should be recorded; these records should be made available for future qualifications, or when there is a change of operator.

2.6 Vehicle qualification failure

In the event that a vehicle fails to meet the standard for qualification, a recommendation should be made, highlighting the reasons for the failure and any improvement that could be made to improve the performance of the vehicle.

Qualification records should be stored as usual along with any recommendations or modifications made.

2.7 Calibration

The dataloggers used for qualification, as well as any on-board temperature monitoring equipment, should be recalibrated according to the procedure and timeframe specified by the manufacturer, e.g. EN 13486:2003.

Where any temperature monitoring devices fail the calibration, they should be clearly marked and removed from service to be repaired or disposed of.
References

- Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage (ATP). UNECE.
- EN 13486: 2002. Temperature recorders and thermometers for the transport, storage and distribution of chilled, frozen, deep-frozen/quick-frozen food and ice cream. Periodic verification
- EVM SOP E7-05 Loading and operating refrigerated vehicles.
- EVM-SOP-E7-06: Responding to emergencies during vaccine transport operations.
- WHO Technical Supplement: Refrigeration equipment maintenance.
Annex 1 - Placing data-loggers or temperature sensors

Data-loggers and/or their sensors should be placed as shown in Figure A1.1. The minimum recording requirements for qualification testing are:

- Outside ambient temperatures around the external surfaces;
- Air delivery of the refrigeration unit;
- Air return of the refrigeration unit;
- Product close to the delivery air of the refrigeration unit;
- Product in any areas likely to be deprived of airflow;
- Product close to the walls;
- Product close to the door.

Figure A1.1 - Example layout for monitoring a part loaded trailer

Source: Cambridge Refrigeration Technologies
### Revision history

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