Explanatory notes to the ATO-certification of reefer containers (version 4.0) [1]

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Report number 1354

[1] *downloadable from www.climatecontrol.wur.nl and www.reefertransport.nl*

Colophon

Document history

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0.0	1996	Explanation and motivation of existing ATO-norms	Dr. Jos Sillekens
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Content

Summary

Intercontinental transport of flowerbulbs in general takes place in climate controlled seagoing reefer containers. A shipment may take two up to six weeks. To maintain quality during this time span proper climate inside the container is important. ATO certification yields a quality assurance on aspects not covered in other standards or certification schemes, and primarily of interest to flowerbulb shipments. The ATO approval of containers for the transportation of flowerbulbs is solely based on characteristics influencing the gas conditions (fresh air exchange), temperature spread (air circulation and T-bar height), and moisture inside the container box (drain holes).

Climate aspects important to flowerbulbs are temperature, relative humidity (RH) and gas concentration, especially ethylene, inside the container. It depends on the species, cultivar and stage of life which aspect is most important in a specific shipment. The two large-volume flowerbulb species, tulip and lilium (lily), make up for about 50% of the total flowerbulb shipments. Lily bulbs are generally transported in peat at temperatures just below 0 °C. They are more temperature-critical than most other commodities. Tulip bulbs may be shipped at a any temperature between +5 °C and +22 °C (Table 1), depending on the bulbs' stage of life (= ± season), variety, and receiver's purpose of use. Tulip bulbs are sensitive to too high relative humidity and to elevated concentrations of the plant hormone ethylene. The remedy for removal of ethylene is abundant air exchange of the container, requiring fresh air exchange folds not seen in any other commodity.

To make sure that a container is suitable for flowerbulb transportation, Wageningen UR issues internationally accepted ATO-certificates when its requirements on air circulation, air exchange, T-bar height and number of drain holes are met.

The requirements for ATO certification are:

1. Fresh air exchange of empty container (at 400V/50Hz) at least 2.6 m^3/h per m^3 internal container volume.
2. Air circulation inside empty container (at 400V/50Hz) at least 40 m^3/h per m^3 internal container volume.
3. Height of T-bars in 40 ft. containers at least 60 mm, in 20 ft. containers at least 30 mm.
4. Four drain holes in the corners.

ATO certificate can also be allowed to container equipped to only 2 drain holes. In this case, the reefer containers are only suitable under the following conditions:

- To shipment of non-frozen flower bulbs staying within moderate climate zones during the whole trip. Moderate climate zones are by definition located above the Tropic of Cancer in the north hemisphere or under the Tropic of Capricorn in the south hemisphere.
- To any destinations for the transport of frozen lily bulbs.

Basically only two measurement devices are needed for ATO testing: a tape measure and an anemometer. After measurement of air velocities and dimensions some basic formulas are used to calculate the measured air exchange – and circulation fold. An ATO test report is divided in 4 parts: general information, information about the unit, information about the box and information on air circulation and air exchange. Besides measured T-bar height and observed number of drain holes the information on air circulation and air exchange is decisive for ATO certification: do fresh air exchange and air circulation capacity suffice to meet the ATO-standards?

1 Introduction

Overseas transport of flowerbulbs in general takes place in climate controlled seagoing reefer containers. Three types of containers are employed for this purpose: the 20 *ft* container, with an internal volume of 30 m^3, the 40 *ft* container, with an internal volume of about 60 m^3, and the 40 *ft* high cube container, with an internal volume of about 65 m^3. Intercontinental transport takes some two up to six weeks. To maintain quality during this time span proper climate inside the container is important.

1.1 The ATO certification program at a glance

ATO certification yields a quality assurance on aspects not covered in other standards or certification schemes, and primarily of interest to flowerbulb shipments. As can be seen from the requirements in chapter 3, the approval of containers for the transportation of flowerbulbs is solely based on characteristics influencing the gas conditions (fresh air exchange), temperature spread (air circulation and T-bar height), and moisture inside the container box (drain holes). The ATO-certificate is additional to other certificates which cover issues like mechanical strength of containers, hazards at sea, and biological and toxicological risks connected with the transportation of foodstuffs.

The required testing procedure has been specified in a way that it can be done in the field. This means that the required measurements to determine the air circulation rate and the air exchange rate in container boxes are performed on empty containers at container depots or workshops for the maintenance of container equipment. Testing of containers under laboratory conditions for this purpose would have made the certification scheme more accurate, but also more complicated and expensive. For the same purpose of enabling testing in as many locations as possible the requirements for flowerbulbs in reefer containers on board of vessels (60 Hz power supply) have been translated to requirements for empty containers running at either 60 Hz or 50 Hz electrical power supply (like supplied in on-land situations around the world).

The requirements (see chapter 3) mention optimal conditions and acceptable conditions. With these requirements for ideally and acceptably equipped reefers, the containers are labelled as very good, good, just acceptable, acceptable and not acceptable.

1.2 History

The ATO-certification of containers for the carriage of flowerbulbs has been introduced in the 1970's in order to keep the quality of the flowerbulbs optimal during transit. A second motivation was the reduction of risk for insurance companies involved in insuring flowerbulbs during transit, by excluding the use of inferior containers. As a result there is quite a difference in fee to insure a load of flowerbulbs during a carriage over sea by means of an ATO-certified or a not ATO-certified container.

The requirements for the certification were agreed upon in The Netherlands by the Laboratory for Flowerbulb Research (currently PPO, part of Wageningen UR), the Sprenger Institute (later integrated in ATO and since 2003 part of Wageningen UR) and the Transport Advisory Bureau of the Flowerbulb Shippers Association at Rotterdam (later represented by Anthos, The Royal Dutch Wholesalers Association for Flowerbulbs and Nursery Stock). Initially Sprenger Institute was charged with the inspection of the containers and the issuance of the certificates of approval. Nowadays that duty of Sprenger Institute is fulfilled by Wageningen UR.

In order to facilitate the certification of containers for companies which own large series of similar containers and have building programmes running at factories for the construction of those containers a change of procedure has been introduced in the year 1992. Instead of approval afterwards the test procedure and certification can be performed at the moment the container leaves the factory. For that situation ATO accepts data according to the test report in the appendix (page 17). The data can be collected by anyone, on precedent that surveyors from classification societies like ABS or Bureau Veritas witness and endorse that the test procedure is ran according to our prescription. Data must then be submitted by the classification society through www.reefertransport.nl, after which Wageningen UR checks the data and issues the ATO-certificates if the data meet the standard.

First the Royal Dutch Wholesalers Association for Flowerbulbs and Nursery Stocks kept hardcopy records of the certified reefer containers in the world and was equipped to inform shippers and insurance companies directly on request. Nowadays this is fully automated by a link from their website www.anthos.org to the public part of the database maintained by Wageningen UR at www.reefertransport.nl.

2 Climate aspects important to flowerbulbs

Climate aspects important to flowerbulbs are temperature, relative humidity (RH) and gas concentration, especially ethylene, inside the container. It depends on the species, cultivar and stage of life which aspect is most important in a specific shipment. Some broad categories are indicated in Table 1.

Table 1, bulb categories, typical temperatures and important aspects.

bulb species	temperature	important aspects
lily	-2 ~ +2 °C	temperature
tulip	+5 ~ +22 °C	temperature, ethylene, RH (60 ~ 75%)
others	+1.5 ~ +30 °C	often temperature and RH (60 ~ 75%)

Tulips make up for 32% of the volume, followed by lily (19%), gladiolus (12%), daffodil (7%), and quite a lot of other species with smaller volumes. The two large-volume flowerbulb species, tulip and lilium (lily), make up for about 50% of the total shipments. Lily bulbs are generally transported in peat at temperatures just below 0 °C. They are more temperature-critical than most other commodities. The temperature should be maintained in a very narrow band: too high temperature causes sprouting (Fig. 1), too low temperature causes freezing injury (Fig. 2). Freezing injury is only visible after cutting the bulb and inspecting its interior. Therefore samples of lily bulb shipments are routinely cut and analyzed after shipment. Sprouting is pretty often observed upon arrival, especially near the container doors. Both freezing injury and sprouting are visible immediately after arrival. Abundant air circulation and sufficiently high T-bars to allow supply air to flow all the way to the container doors are essential for lily bulbs.

Fig. 1, sprouting of lily bulbs.

In some case, lily bulbs can also be shipped at set points just above 0°C, usually between 0 and + 2°C. Non-frozen lily bulbs are not fully dormant and not always packed in moist peat. Non-frozen lily bulbs mays till produce quite some moisture. The excess moisture is removed via the 4 opened drain-holes.

Fig. 2, freezing injury lily bulbs.

Tulip bulbs may be shipped at any temperature between +5 °C and +22 °C (Table 1), depending on the bulbs' stage of life (= ± season), variety, and receiver's purpose of use. Tulip bulbs are sensitive to too high relative humidity and to elevated concentrations of the plant hormone ethylene. At the same time Fusarium-infected tulip bulbs produce ethylene and some degree of Fusarium infection is inevitable (Fig. 3). Ethylene levels higher than 0.1 parts per million may negatively influence the bulbs. The damage only comes to light later on in the flowering stage: small and partly developed flowers (Fig. 4).

Fig. 3, fusarium-infected tulip bulbs.

Fig. 4, poor flowering due to ethylene damage during transport.

The remedy for removal of ethylene is abundant fresh air exchange of the container, requiring air exchange folds not seen in any other commodity. In principle also ethylene removal by scrubbers or reducing the bulbs' ethylene sensitivity by using ethylene blockers could be a possibility, but at present no reliable and cost-effective system is available to perform that task.

Another common source of cargo damages is the growth of moulds (Penicillium) on flowerbulbs (Fig. 5). This is related to too high relative humidity in the container, and especially happens to tulip and iris bulbs. Though Penicillium is harmless to the bulb it is an aesthetical problem, especially when the bulbs are meant to be sold to consumers, instead of flower growers. Moreover it may come together with root growth (Fig. 6), especially in case of bulbs shipped at lower temperatures, which does much more harm to the bulb quality.

Fig. 5, Penicillium on tulip bulbs due to moist environment.

Fig. 6, root growth (arrow) of tulip bulb, together with Penicillium.

Reduction of relative humidity to 60 – 75% is important to many flowerbulbs, but not to lily bulbs, therefore dehumidification is requested for most flowerbulb shipments. Bad experience has learned that four drain holes (in each corner) are a necessity in order to drain off liquid water in case it enters the container from whatever origin.

From the description above it will be clear that the transport of flowerbulbs imposes several strict demands on the reefer container in which they are shipped. To make sure that a container is suitable for flowerbulb transportation, Wageningen UR issues internationally accepted ATO-certificates when its requirements on air circulation, air exchange, T-bar height and number of drain holes are met. Besides, the certificates also state the optimal settings for fresh air exchange. An ATO-certified container is suitable for transporting flowerbulbs to overseas areas, but the specifications are also relevant to other sensitive cargoes. The importance of the certification system is widely recognized by container companies, shippers, growers, insurance companies, container manufacturers, and others.

3 Requirements for ATO approval of refrigerated containers

The requirements for ATO certification are:

1. Fresh air exchange of empty container (at 400V/50Hz) at least 2.6 m^3/h per m^3 internal container volume.
2. Air circulation inside empty container (at 400V/50Hz) at least 40 m^3/h per m^3 internal container volume.
3. Height of T-bars in 40 ft. containers at least 60 mm, in 20 ft. containers at least 30 mm.
4. Four drain holes in the corners.

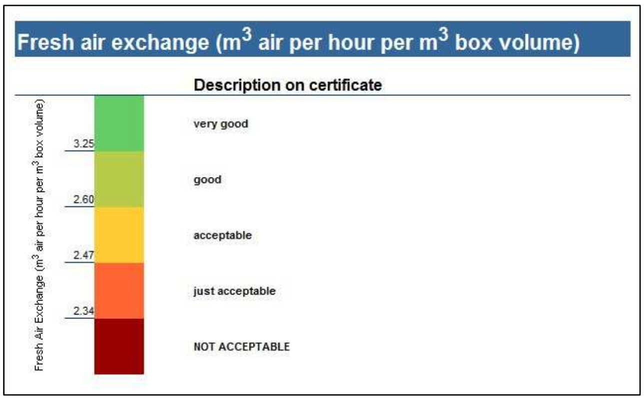

Fig. 7, classification of fresh air exchange capacity.

If container meets the previous requirements, the ATO certificate allows the transport of any flower bulbs to any destinations all around the world.

What will happen if a container has less than 4 drain holes? For some reasons, few reefer containers have been built the last few years with only 2 drain holes. Although these containers fulfil the air exchange, air circulation and the height of T-bars requirements, they are ATO-certified for transport of flowers bulbs under specific restrictions. Under these conditions, reefer container is classified as “only suitable for frozen lily bulbs or for moderate climate”. This rule properly covers flower bulb shipments respecting the following conditions:

- To any destination for frozen lily bulbs when and only when the reefer unit setting are:
  - Temperature setpoint below 0˚C, and
  - Fresh air exchange closed, and
  - Dehumidification OFF
- To shipment through moderate climate zones for any non-frozen (Setpoint ≥0°C) flowerbulb shipment. The shipment has to stay within the moderate climate zone during the whole trip. The moderate climate zones are located or above the Tropic of Cancer in the North hemisphere or under the Tropic of Capricorn in the South hemisphere. In the Dutch flowerbulb export practice that actually boils down to ‘only suited for exports to the US East coast’.

How is air velocity data collected at 60 Hz power supply handled? The measured air velocities are divided by 1.2, the values thus obtained must meet requirement 1 and 2 mentioned above.

Some fine-tuning is applied to norm 1 through 3 according to Fig. 7 through Fig. 9 below. For container owners, unit - and box manufacturers the far most important concern should be to avoid ending up in the class ‘not acceptable’.

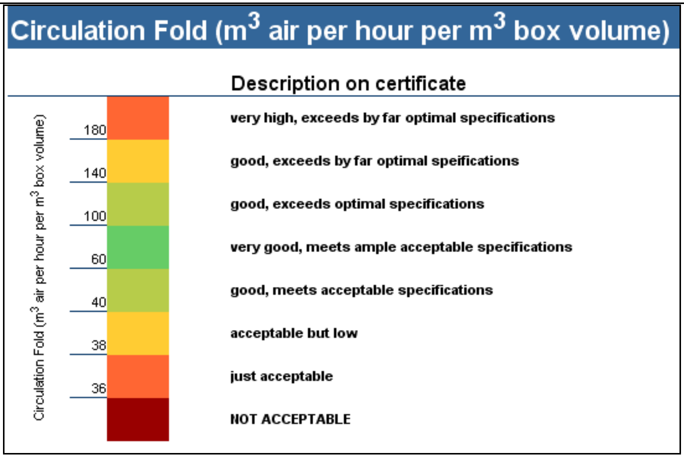

Fig. 8, classification of air circulation capacity.

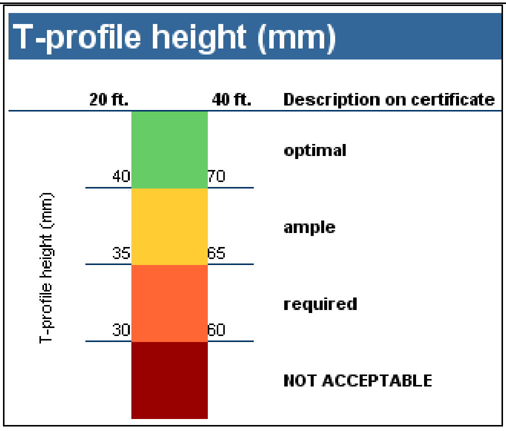

Fig. 9, classification of T-bar height.

3.1 Additional recommendations for reefer purchasers and unit manufacturers

Below some additional issues are listed which are relevant to flowerbulb shipment, while they are not (yet) covered by criteria in ATO-certification:

- Accurate control of supply air temperature in a bandwidth of ± 0.25 °C around setpoint.
- The relevant range of temperature settings ranges from -3 °C to +30 °C.
- A possibility for dehumidification of supply air. The optimal relative humidity for most flowerbulbs is 60 – 75% (lily bulbs are shipped without dehumidification).
- Avoid short-circuiting from fresh air outlet to – inlet by proper design of fresh air vents.
- Minimize differences in supply air velocity upon entry into the T-bars.

4 A guideline on how to perform the ATO-test

4.1 Instrumentation

Only two measuring instruments are necessary to perform the ATO test:

1: Tape measure – to measure internal length, width and height of the box and T-bar height, pitch and opening.

2: Anemometer – to measure air velocities from which air circulation and – fresh air exchange can be calculated. For example a testo400 data logger (Fig. 10) in combination with a hot wire probe (Fig. 11) is perfectly suited. The air velocities measured in reefer containers range from about 1 till 15 *m/s*.

The anemometer needs a yearly recalibration. Anyone could generate a table of measurements and call it a calibration certificate. To avoid being misled check whether the certificate is issued under ISO17025 and reads 'The results are traceable to international standards'.

By default, air velocity sensors are calibrated at +20 °C and 1 atm pressure, which is referred to as the standard temperature and pressure (STP), or Normal temperature and pressure (NTP). However if one knows in advance that measurements will always take place at +15 °C then better request calibration at +15 °C.

Fig. 10, testo400 handheld datalogger.

Fig. 11, hot wire probe.

4.2 Advised test procedure

Advised chronological steps in ATO-testing:

1. Start the reefer unit at 400V / 50Hz, set temperature +15 °C and fans running in high speed with container doors closed and vents fully opened.
2. Wait sufficiently long for the internal box temperatures (and fresh air exchange rates) to stabilize at +15°C.
3. Take a tube with tube length 70 cm, diameter 12 cm, and smooth inner surface. Drill a small hole 10 cm from the tube's end, just big enough to allow your anemometer sensor to be inserted.

4. Connect correctly the tube to the fresh air outlet with the small hole in the tube wall about 60 cm from the outlet vent (Fig. 12). Make sure that no leakage occurs between the fresh air exchange panel and the opening of the tube. Subsequently measure air velocity through the small hole at at least 3, but preferably 5, locations in the tube's cross section, e.g. ± 1, 3 and 5 cm from the tube wall. Hints:
   a. Allow the probe sufficient time to reach the temperature of the air flow in which it is measuring the velocity (check read temperature on display, usually 30 seconds suffices).
   b. Mind how you hold the probe in your warm hand: don't heat the probe with your body warmth.
   c. Modern instruments like the Testo400 can give mean results over a predefined time interval. Use that function to take time-averaged measurements over e.g. 30 seconds in case the airflow fluctuates.
5. Repeat step 4 at the fresh air inlet. One difference from the measurement at the outlet vent: For the inlet take the same tube but turn it around, the hole for the anemometer 10 cm from the inlet vent. Hint:
   a. If a serious difference, say more than 20%, occurs between in- and outlet measurements then allow the internal box temperatures some more time to stabilize and go back to step 3.
6. Close the vents, open the container doors and cover the first 50 cm of the T-bars at the reefer unit side with e.g. aluminium plating.
7. Measure air velocity in the centre of each air duct between two T-bars at the end of the plating covering the T-bar (Fig. 13).
8. Measure air velocity at 5 locations evenly distributed over the return air opening. Remark:
   a. These data may be used to check the supply air velocities measured in the T-bars.
9. Measure length and width of return air opening above bulkhead.
10. Measure internal length, width and height of the box.
11. Measure height, pitch and opening of T-bars (Fig. 14).
12. Fill out the remaining fields in the test report (section 0, p. 17).
13. Submit data to www.reefertransport.nl.

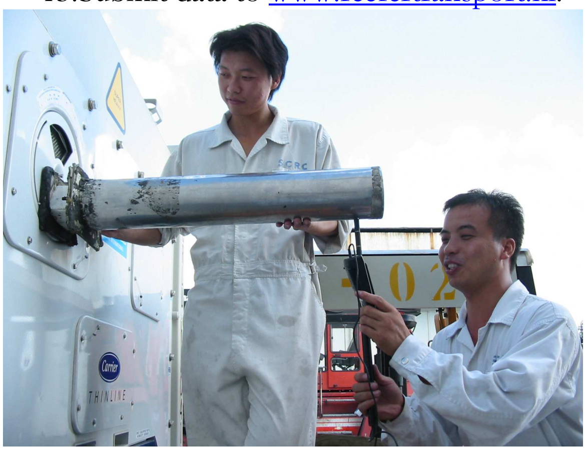

Fig. 12, air speed measurement of fresh air outlet vent (step 4).

Fig. 13, plating covering first 50 cm of T-bar for air circulation measurement (step 7 above).

4.3 Calculation of fresh air exchange and – circulation fold from the collected data

After collection of the data and submission of the test report according to the procedure described in chapter 4.2 the air exchange fold and circulation fold are computed according to:

$$\text{Air exchange fold} = \frac{0.96 * \frac{\pi}{4} * (\text{tube diameter})^2 * 3600 * \frac{1}{n} * \sum_{i=1}^{n} v^i_{\text{inlet/outlet}}}{L_{internal} * W_{internal} * H_{internal}} \quad [h^{-1}] \qquad (1)$$

and

$$\text{circulation fold} = \frac{0.757 * H_{T-bar} * W_{internal} * 3600 * \frac{1}{m} * \sum_{i=1}^{m} v^i_{\text{T-bar}}}{L_{internal} * W_{internal} * H_{internal}} \quad [h^{-1}] \qquad (2)$$

where

$v^i_{inlet/outlet}$ = the i-th air velocity measurement in fresh air inlet and outlet

n = number of air velocity measurements in fresh air inlet and outlet ($n \geq 6$)

v^i_{T-bar} = the i-th air velocity measurement in the T-bars

m = number of air velocity measurements in T-bars, usually m = 36

5 Remarks on the items indicated in the test report

The blank ATO test report is shown in Annex 1, p.17. This section gives some extra information on the items requested in the test report. The test report is divided in 4 parts: general information, information about the unit, information about the box and information on air circulation and air exchange. Section 5.1 till 5.4 each discuss one such part of the test report.

5.1 General Information

It is the intention to test one container out of 100 during the production of a series of more than 100 containers. For series of less than 100 containers one container will be regarded as representative for the series. The test container can be chosen at random. The fleet-number or the owners-number (XXXU – yyyyyy[y], X being letters, y being numbers) of the inspected container has to be filled in on the form together with the range of (maximally 100) owners-numbers the container is chosen from.

5.2 Information about the reefer unit

Some general information is required, like the name of the unit manufacturer and the unit model. That information is used to assess amongst others the refrigeration capacity, heating capacity and the temperature control range. Especially that last feature proved important in recent years, as iris bulbs were sometimes shipped at +30 °C while for many reefer units that was beyond the range of possible temperature setting. Nowadays nearly all newly manufactured units seem to allow a set temperature up till +30 °C.

Another item required to fill out is the manufacturing date of the unit. It becomes important after 5 years as flowerbulb exporters strongly prefer units and boxes younger than 5 years.

The last issue requested about the conditioning units, is the presence of extra facilities. At the moment the extra facilities registered are dehumidification, humidifier, CA and MA. Nowadays only dehumidification really matters to flowerbulb exporters. Below a short explanation of each of the four extra facilities is given:

Dehumidification. It is often indicated as humidity control. It means the refrigerating unit is capable of controlled reduction of relative humidity. It requires at least a relative humidity (RH) sensor and the possibility to introduce an RH setpoint.

Humidifier. It means the refrigerating unit is capable of increasing the relative humidity by injecting water in the circulating air, using an atomizer for example. Not used for flowerbulb shipment.

CA is an abbreviation of Controlled Atmosphere. This means that an auxiliary apparatus is present to control the CO_2 level and the O_2-level of the air inside the container. The container box has to be almost airtight. It requires at least O2 and CO2 sensors and the possibility to introduce setpoints for O2 and CO2. Examples: Everfresh, Nitec.

MA is an abbreviation of Modified Atmosphere. It means that the regular atmosphere of 21% O_2 and 0.03% CO_2 is modified, but automatic full control of O2 and CO2 is not possible. Examples: Transfresh, AFAM+, eAutofresh. MA usually means that the container is provided with a CO2 sensor activating a control device if CO2 rises above requested/acceptable levels. Moreover a valve may be present enabling the manual injection of a (high nitrogen) gas-mixture into the container before start of a shipment. Examples of control devices to reduce CO2 are the opening of fresh air vents (AFAM+, eAutofresh) or circulating the container air over a CO2 absorber, like activated carbon or lime (Transfresh). In transit O2 typically evolves uncontrolled as a result of initial flushing and CO2 control.

5.3 Information about the boxes

Past experience has learned that containers, even belonging to the same series, can differ in nett interior dimensions. The result is that incidentally a container offered to a shipper is just too small for the planned loading pattern. Differences in nett interior dimensions can result from the use of different batches of metal sheets with distinct profiles for the lining of the inner walls of the containers during the production of one series.

For the ATO certification, the nett internal length is defined as the length of the container from the flat bulkhead till the end of the footing of the floor T-bars near the door. The nett internal width is defined as the smallest distance between the protruding parts of the profiles of the linings of the long side inner walls of the containers. The nett internal height is the distance from the top of the floor T-bars till the ceiling of the container box.

For the height, pitch and opening of the T-bars see Fig. 14. Especially T-bar height is important for temperature homogeneity in the loaded container, as it should facilitate the distribution of supply air through the box, also to the part of the cargo near the doors! T-bar height together with the container width defines the area for the supply of the conditioned air into the container box.

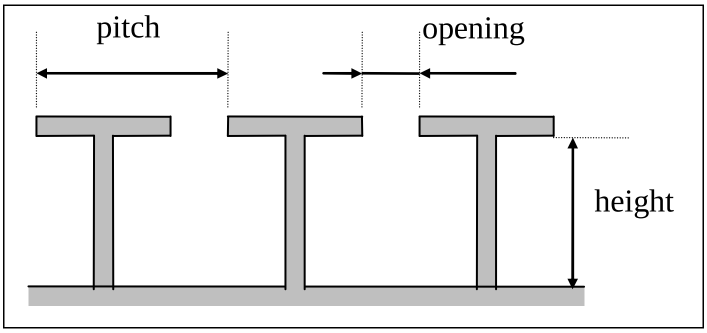

Fig. 14, T-bar floors.

Number and place of drain holes concerns a requirement, which was added to the original requirements in 1984. This took place after the occurrence of several cases, where excess water was found inside container boxes, wetting the load. This phenomenon occurred mainly when containers passed through hot humid regions. The required high fresh air exchange rate in the case of flowerbulbs can easily cause this type of problem while excess water vapour is sucked in under those conditions. As long as a facility to lower the air exchange rate temporarily under those circumstances is lacking, the problem is not solved definitively. Over the drain openings in front of the containers a high airspeed is maintained while the circulating air passes there through narrow channels. This phenomenon hampers the discharge of water at that point and facilitates the penetration of excess water from the unit compartment into the box. Therefore four drains are required for a world wide ATO certificate: two at the front of the container and a second pair at the back of the container.

In 2012, containers equipped with only 2 drain holes at the door-end can also be certified for the worldwide transport of frozen lily bulbs or for the shipment of non-frozen flower bulbs staying strictly within moderate climate zones during the whole trip.

The questions about walls, ceiling, bulkhead, door, refer to the material (stainless steel, aluminium, synthetic material etc.) of the inner linings and the presence of a profiled or a flat surface.

5.4 Information on air circulation and fresh air exchange

Frequency: To establish the circulation and air exchange rates it is necessary to know the frequency of the electrical supply during the measurements: 50 or 60 Hz.

Air circulation in the box usually is bottom-to-top. Other circulation patterns, like e.g. the top-to-bottom common in mechanically refrigerated trucks, might occur. For the ATO-certification we request this information to be provided, but it doesnot affect the ATO certificate.

'Dimensions of the return air opening in the bulkhead' for the return air (usual air circulation system) means the dimensions of the opening in the vertical plane. Sometimes there are more open areas than one. In that case we want to know the length and width of the imaginary joint opening in order to be able to calculate the correct joint surface area (m^2).

The vents in the reefer unit for inlet and outlet of fresh air can have different shapes. Fig. 15 shows some of the shapes that used to be common in recent years. On the test report only the area (cm^2) is requested, without bothering about the exact shape.

Fig. 15, some of the most common fresh air vents (from left to right Carrier, Thermo King and Daikin).

Supply air velocity is measured according to the procedure described in section 4.2. After submission of the test report these measurements are used to calculate the air circulation fold according to equation 2, p. 13.

Return air: To have a check on the magnitude of the air circulation rate the mean air velocity of the return air has to be known. It was agreed upon to take five air speed measurements along the longest middle line of the rectangular shaped opening for the return air in the bulkhead of the container: One in the middle, the others with equal distances to the neighbouring points and the vertical edges of the opening. The surface for the return air is sometimes divided over more than one opening. In that case and for openings with a relative small area take three air speed measurements per opening. The area referred to is the area of the opening(s) in the vertical plane of the bulkhead, even if the return opening of the unit itself (grill) is not in that vertical plane.

Air exchange: fill out the air velocity measurements collected according to the procedure described in chapter 4.2, p. 11. Without tube the fresh air exchange rate of the container is difficult to measure precisely in the field. One problem is that the accessibility of the inlet and outlet openings is hampered by the slide cover. This slide cover also often complicates the use of a tube. In situations where the use of a tube is not practically feasible the air exchange may be measured by measuring the airspeed at least 5 spots evenly distributed over the inlet and outlet opening and multiplying the mean of these figures by the measured area of the opening. In that case the fresh air exchange rate found for the outlet is the decisive figure. The fresh air exchange rate at the inlet serves as a check on the magnitude of the first derived air exchange.

The calculation of the air circulation rate within the box assumes that no object obstructs the return air between the ceiling of the container and the top of the loading. For this reason we advise to keep at least 15cm of headspace between the loading and the ceiling of the container. The maximum loading height for the transport of flower bulbs is indicated on the ATO certificate.

Disclaimer

Wageningen UR and the authors do not accept any liability for damages or losses of whatever nature, which may result, directly or indirectly, from the use of the information contained in this document.

Annex 1: test report for ATO-certification of reefer containers

<see next two pages>

TEST REPORT
for ATO-certification of reefer containers
for flowerbulb carriage

Please submit the data collected in this test report to ATO via www.reefertransport.nl

General information:

type container (20ft, 40ft, 40ft h.cube)	
name container owner	
commissioning company	owner / box manufacturer
Survey company's registration number for this test report	
identification number test container	
container series ident. numbers	

Information about the unit:

name manufacturer		
model nr. unit		refrigerant:
manufacturing date unit		
dehumidification	yes / no	
humidifier	yes / no	
CA (Controlled Atmosphere)	yes / no	
MA (Modified Atmosphere) (e.g. Transfresh)	yes / no	

Information about the box:

name manufacturer box			
model nr. box			
manufacturing date box			
gross weight (in kg)			
tare weight (in kg)			
nett interior dimensions (in m)	L =	W =	H =
distance ceiling - load mark (in mm)			
height, pitch, opening T-bars (in mm)	h =	p =	o =
number of T-bars			
number and place drain holes			
wall: material, profile (present/not present)			
ceiling: material, profile (pres./not pres.)			
bulkhead: material, profile (pres./not pres.)			
door: material, profile (present/not present)			

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Information on air circulation and fresh air exchange:

frequency mains supply: (50 Hz / 60 Hz)		
air circulation in box (bottom to top / top to bottom / horizontal / different)		
dimensions return air opening bulkhead (length, width)		
dimensions air opening fresh air exchange	Inlet (cm^2)	Outlet (cm^2)

Supply air: airspeed between T-bars in m/s

Return air: minimal 5 air speed measurements evenly distributed over the opening [m/s]

Fresh air exchange: minimal 3 air speed measurements evenly distributed over opening [m/s]

Inlet:									
Outlet:									

Air exchange was measured with a tube of diameter (in cm):	

Place of survey Date of survey Surveyor's name + signature

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