



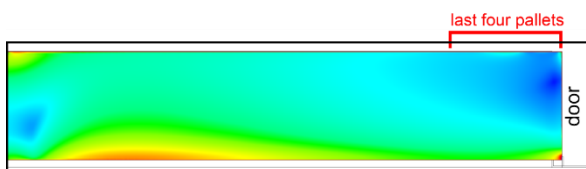
## Container cooling – Best practice guidelines

Tarl Berry and Paul Cronje,  
Citrus Research International (CRI)

The use of refrigerated containers to reach and maintain a target temperature is a critical factor in most South African citrus export protocols. Containers have more than sufficient refrigeration capacity to apply different cold disinfestation treatments during shipping. However, various factors and practices in the industry can drastically reduce cooling performance, resulting in “hot spots” that can invalidate the cold disinfestation treatment. There is also the need to avoid excessive cooling to protect fruit quality. The sections below provide some best practice guidelines towards achieving optimal cooling performance in refrigerated containers.

### THE CHALLENGES

Figure 1 illustrates the air velocity profiles within pallet stacks during shipping. Of note, is the low air velocity region in the last four pallets of the container at the door. Velocities can be further reduced when the container is loaded improperly or if poorly ventilated packaging is used.



**Figure 1:** Simulation (side view) of air velocity within the pallets during shipping inside a refrigerated container. (red and blue colours indicate high and low air velocities, respectively).

### 1. PACKAGE VENTILATION

A high amount of ventilation through packaging is critical to the successful application of cold disinfestation treatments in a container. The following points are applicable to shipping conditions under FMS, and are strongly recommended for all other cold treatment markets.

- All packaging must follow the specifications set out in: “Packaging Material Specifications and Palletization Protocols for Citrus Export”.
- For phytosanitary sensitive markets, at least 5% of the top and bottom faces of cartons should be

open/ventilated. With vent holes positioned so that they align after stacking.

- A15C – Supervent design must be used, as it has better vent-hole alignment in stack.
- Trays within cartons obstruct the flow of air. Only trays with ventilation holes may thus be used (under C codes shipping).
- Fruit wrapping obstructs the gaps between fruit, which encourages air to bypass the stack. Avoid wrapping at all costs. If used, fruit may only be wrapped on top layer in alternating rows.
- Carton vent holes must align with the gaps of the pallet base.
- Bulk bins - ventilation openings must be present between the pallet base slats and the bulk bins (leave openings for airflow).

*NOTE: In due time and flowing from detailed experimental work in the commercial cold chain, specific requirements of the packaging i.t.o. carton ventilation, securing sheets, pallet caps as well as pallet base will be included in the protocols and the “Packaging Material Specifications and Palletization Protocols for Export”.*

### 2. SECURING SHEETS

A survey in 2019, showed that almost all Opentop carton designs resulted in effectively zero vertical ventilation within the pallet. As a result, Opentop pallets have more than twice the resistance to airflow, when compared to A15C pallets. This is due to many packhouses unknowingly using incompatible securing sheets with vent holes that do not align with the holes in the bottom of the Opentop cartons (see Figure 2 for example).

- Misalignment of vent holes occurs when the securing sheet has not been correctly designed or is incompatible with the specific carton design used.
- Packhouses need to ensure that they only make use of compatible securing sheets. Manufacturers can be contacted for further details.
- In general, more than 90% alignment of the carton bottom vent holes with openings in the securing sheet is required to allow adequate ventilation.

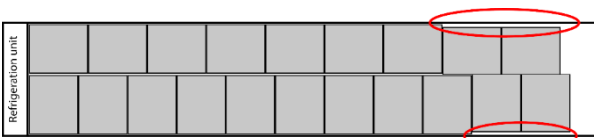


**Figure 2:** Illustrates how the vent holes at the bottom of the Opentop cartons must align with the holes in the securing sheet.

### 3. PALLET POSITIONING

Heat energy from outside the container is constantly being conducted into the container via the walls/doors. This is especially relevant to the last four pallets in the container when poorly ventilated packaging is used and the airflow rate can be inadequate to remove excess incoming heat energy, resulting in hot spots.

Cooling can be considerably improved in this region if the pallets (particularly the last four) are shifted towards the middle line of the container and away from leaning against the container wall (Figure 3). This allows the cold air flowing between the packaging and wall to remove excess heat build-up.



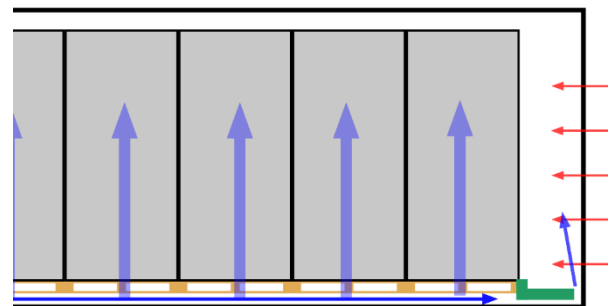
**Figure 3:** Side shift the pallets away from the container walls, especially the last 4 pallets.

### 4. VOID PLUGS

Void plugs eliminate airflow short-circuiting at the exposed floor near the door-end of the container (Figure 3). More cold airflow is thus available to penetrate the pallets.

The void plug boards should not exceed beyond the T-bar floor, so that a small gap remains open along the edge of the door (Figure 4). This allows cold air to flow across the door and remove heat being conducted via the less insulated door.

Additionally, no part of the void plug should ever be placed under the pallets. This obstructs air movement between the T-bar floor and the fruit, which reduces overall cooling.



**Figure 4:** Door-end of container, showing airflow distribution in container and the position of the void plug. Void plug indicated in green. Red arrows indicate heat conduction through the container door. Blue arrows indicate cold airflow.

### 5. ALTERNATIVE CONTAINER LOADING APPROACHES

Several loading kits are currently sold by service providers. These kits attempt to redirect airflow in the container to improved cooling during shipping. The industry has requested the testing of two of the kits designs:

The **Swift Horizontal Airflow system** was evaluated in the commercial cold chain to the EU (ambient loading). The kit, however, more than doubled the cooling times. This was attributed to the airflow having to flow horizontally through the packaging, which is considerably less efficient than normal vertical airflow.

The **Otflow floor cover** was evaluated for shipments to the EU and other special markets. The following findings were made:

- Otflow obstructs much of the container floor, reducing overall airflow rates.
- Considerably increased loading times.
- Reduced cooling performance at refrigeration unit and near the door (*USDA 3 position*).

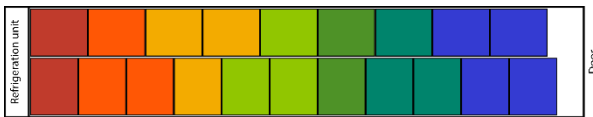


- One of the containers tested with Oflow failed to comply with the China export protocol.

The reports for these studies are available on request (tarl@sun.ac.za). Currently, the FMS does not allow for the use of any loading kits which could influence airflow. It is strongly recommended that loading kits are not used for export to any market without adequate prior testing.

## 6. LOADING TEMPERATURE FOR THE FMS

In the case of warm loading (EWC-export codes), the temperature of the last four pallets at the door-end of the container should always be carefully considered during loading. Every effort should be made to load the coldest pallets at the door-end and concentrate warm pallets towards the refrigeration unit (Figure 5).

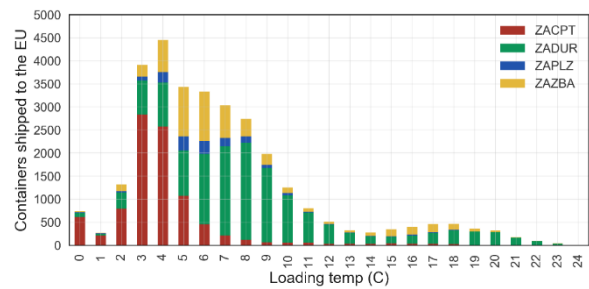


**Figure 5:** Concentrate the coldest pallets to the door-end of the container.

Phytopsanitary cold disinfestation treatments are time and temperature dependent, in that the fruit must first cool to a specific temperature and then remain below this temperature for a set period.

Ambient loading thus decreases the active period of a phytopsanitary cold disinfestation treatment. Fruit should preferably be loaded at set-point, so that the protocol can start as soon as possible. When ambient loading is unavoidable, it is strongly recommended to load fruit < 10°C, as warmer temperatures require undesirably longer cool-down periods.

Figure 6 shows that FMS load-out temperatures vary widely and are largely dependent on the production region and port used. A critical industry priority in the short term is to shift this distribution to the left (load at < 10°C).



**Figure 6:** Loadout temperature of FMS containers in recent seasons.

## 7. CONTAINER LOADING AND USAGE IN THE FMS

The following protocol should be prioritised for FMS containers:

- Pre-chill containers (Genset) to < 5°C before doors are opened. If no Genset is used, keep the container in the shade/cool area.
- Never leave container in sun after loading without refrigeration (container put on power).
- Stuff cold containers as quickly as possible to minimize condensation in the container (< 40 min).
- In the eventuality of port delays, plan logistics so that the container remains plugged in. This will ensure adequate temperature exposure and is particularly important where shipping durations are short.
- Make every effort to not break the cold chain i.e. fruit temperatures should not fluctuate after being induced into the cold chain.

## 8. CONTAINER TEMPERATURE STEP-UP FOR THE FMS

In the 2018 and 2019 seasons, 8% of FMS containers spent > 30 days under shipping. These extended shipping periods at low temperatures can cause chilling injury related quality loss.

- FMS allows containers to be stepped-up permanently to 4°C after 30 days of shipping.
- Step-up should be applied wherever possible to minimise chilling injury.

*The authors would like to thanks Dr Elma Carstens for assistance.*



For any further queries contact Tarl Berry  
([tarl@sun.ac.za](mailto:tarl@sun.ac.za), 082 419 7218) or Paul Cronje  
([paulcronje@sun.ac.za](mailto:paulcronje@sun.ac.za), 084 447 1047)



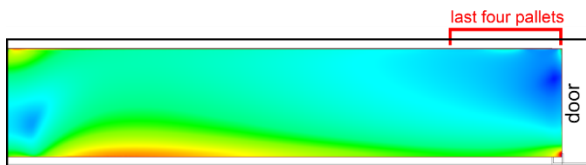
## Houerverkoeling – Riglyne vir beste praktyke

Tarl Berry en Paul Cronje,  
Citrus Research International (CRI)

Die gebruik van verkoelingshouers om 'n teiken temperatuur te bereik en te handhaaf is 'n kritieke faktor in meeste van die Suid-Afrikaanse sitrus uitvoer protokolle. Die houers het meer as voldoende verkoelingskapasiteit om verskillende koue disinfesteringsbehandelings gedurende verskeping toe te pas. Verskeie faktore en praktyke in die bedryf kan egter die effektiwiteit van verkoeling drasties verminder, wat aanleiding kan gee tot “hot spots” en gevolglik die koue disinfesterings behandeling ongeldig kan maak. Daar is ook 'n belangrike behoefte om vrugkwaliteit te beskerm teen oordadige verkoeling. Die onderstaande afdelings bespreek riglyne wat kan dien as beste praktyke om optimale verkoeling in houers te bewerkstellig.

### UITDAGINGS

Figuur 1 illustreer die lugspoedprofiel binne-in palette tydens verskeping. 'n Lae lugspoed area is in die laaste vier palette van die houer by die deur teenwoordig. Dit sal verder verlaag word indien die houer nie behoorlik gelaai word nie of as swak geventileerde verpakking gebruik word.



**Figuur 1:** Simulasie (sy-aansig) van lugspoedtempo binne-in palette gedurende verskeping in 'n verkoelingshouer. Die kleure dui areas van hoë (rooi) en lae (blou) lugspoed aan.

### 1. GEVENTILEERDE VERPAKKING

'n Hoë volume ventilasie deur die verpakking is krities vir die suksesvolle toepassing van koue disinfesteringsbehandelings in 'n houer. Die volgende punte is van toepassing op FMS-markte (Europese Unie), maar word ook sterk aanbeveel vir alle koue behandelingsmarkte:

- Alle verpakking moet voldoen aan die spesifikasies soos uiteengesit in: “Packaging

Material Specifications and Palletization Protocols for Citrus Export”.

- Vir fitosanitêre sensitiewe markte moet kartonne se bo en onderkante ten minste 5% ventilasie gatte bevat. Die gatte moet so geïmplementeer wees dat hulle belyne in die palet na pak.
- A15C kartonne – SuperVent ontwerp moet gebruik word, omrede beter oplyn na palettisering.
- “Trays” binne kartonne verhoed lugvloei. Slegs “trays” met ventilasiegatte mag dus gebruik word (onder C-verskepingkodes).
- Toedraai van vrugte versper die openinge tussen vrugte, wat lug dwing om verby die palet te gaan. Vermy die toedraai van vrugte ten alle koste. As dit gebruik moet word, mag slegs vrugte in die bolaag, in alternatiewe rye toegedraai word.
- Kartonne se ventilasiegatte moet ooreenstem met die openinge van die paletbasis.
- “Bulk bins” – daar moet ventilasie openinge tussen die paletbasis se bolaagplanke en die “bulk bins” wees (los openinge vir lugvloei).

*Nota: In die afsienbare toekoms, en as 'n uitvloeisel van navorsingswerk in die kommersiële koueketting, sal spesifieke vereistes van verpakking tov karton-ventilasie, palet hegvelle en paletdeksels, sowel as paletbasisse in die “Packaging Material Specifications and Palletization Protocols for Citrus Export” ingesluit word.*

### 2. PALET HEGVELLE

'n Opname in 2019 het bevind dat bykans alle oopvertoon karton ontwerpe effektiewelik geen vertikale ventilasie in die palette toelaat nie. As gevolg hiervan, het oopvertoon “Opentop” palette meer as dubbeld die weerstand teen lugvloei in vergelyking met A15C-palette. Grotendeels kan dit toegeskryf word aan pakhuisse wat onwetend hegvelle gebruik waarvan die openinge nie enigsins belyne is met die openinge van die oopvertoon kartonne nie (Sien Figuur 2).

- Swak belyning van die ventilasiegatte kom voor as die velle nie reg ontwerp is nie, of nie pas op die spesifieke karton ontwerp wat gebruik word nie.



- Pakhuise moet seker maak dat hulle die korrekte hegvelle wat verenigbaar is met die karton gebruik. Kartonverskaffers kan gekontak word vir verdere informasie.
- Oor die algemeen moet daar meer as 90% belyning wees tussen die karton se onderste ventilasiegate met die openinge in die hegvelle om genoegsame lugvloei toe te laat.

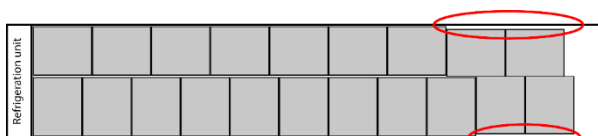


**Figuur 2:** Illustrasie van die ventilasiegate in die onderkant van 'n oopvertoon karton wat moet oplyn met gate in die hegvelle.

### 3. POSISIE VAN PALETTE IN DIE HOUER

Hitte-energie van die buitekant van die houer penetreer die houer konstant via die houerwande/deur. Hierdie is veral relevant vir die laaste vier palette in die houer wanneer swak geventileerde verpakking gebruik word en die tempo van lugvloei nie genoegsaam is om die addisionele inkomende hitte-energie te verwyder nie en wat dan lei tot warm kolle of "hot spots".

Verkoeling kan aansienlike verbeter word as die palette na die middellyn van die houer geskuif word en nie meer teen die houerwand leun nie (Figuur 3). Dit laat koue lugvloei toe tussen die verpakking en die wand om addisionele opbou van hitte te verwyder.



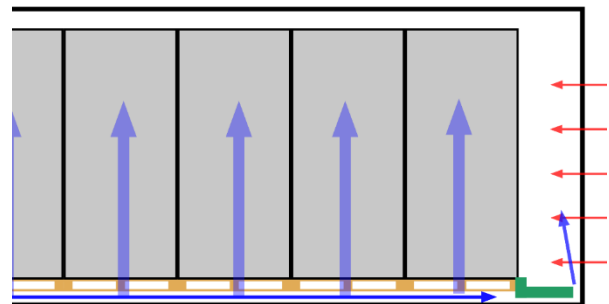
**Figuur 3:** Plaas die palette weg van die houerwand, veral die laaste 4 palette.

### 4. VOID PLUGS

Void plugs verhoed dat die koue lug by die oop vloer naby die deur van die houer verby vloei (Figuur 4). Meer koue lug is dus beskikbaar om deur die palette te vloei.

Die "void plug" moet nooit verby die T-balk vloer strek nie, maar 'n klein gaping moet langs die deur oop bly (Figuur 4). Dit laat toe dat koue-lug oor die deur vloei en verwyder die opbou van hitte weens die swakker geïsoleerde deur.

Addisioneel moet geen gedeelte van die "void plug" ooit onder palette geplaas word nie. Dit verhoed lugbeweging tussen die T-balk vloer en die vrugte, wat die verkoeling in totaal verminder.



**Figuur 4:** Syaansig van die houer: let op die plasing van "void plug" om die lugvloei in die palette te verbeter, asook lugvloei toe te laat teen die deur. Rooi pyle dui op hittegeleiding deur die houer deur. Blou pyle dui op koue lugvloei.

### 5. ALTERNATIEWE BENADERINGS TOT DIE LAAI VAN HOUERS

Verskeie "loading kits" word tans deur diensverskaffers verkoop. Hierdie "kits" poeg om lugvloei in die houer te verander om verkoeling gedurende verskeping te verbeter. Op versoek van die bedryf is twee van die kits getoets:

Die "Swift Horizontal Airflow system" is in die kommersiële koueketting na die EU geëvalueer (warm laai). Die kit het egter 'n verdubbeling in verkoelingstyd tot gevolg gehad. Dit kan toegeskryf word aan die horisontale lugvloei deur die verpakking, wat aansienlik minder effektief as normale vertikale lugvloei is.

Die **Outflow-vloerbedekking** is vir verskeping na die EU en ander spesiale markte geëvalueer. Die volgende resultate is gevind:



- Otflow belemmer meeste van die houer se vloer, en verminder die algemene lugvloeiempo's.
- Verleng aansienlik die laaitye.
- 'n Verlaagde verkoeling by die verkoelingsseenheid en naby die deur (*USDA 3 posisie*).
- Een van die houters waarin Otflow getoets is, het gefaal om aan die China protokol te voldoen.

Die verslae van hierdie studies is op versoek beskikbaar ([tari@sun.ac.za](mailto:tari@sun.ac.za)). Tans maak die FMS nie voorsiening vir die gebruik van enige "loading kits" wat lugvloei kan beïnvloed nie. Dit word sterk aanbeveel dat die toestelle nie vir uitvoer na enige mark gebruik word alvorens dit nie eers genoegsaam getoets is nie.

## 6. LAAI TEMPERATUUR VIR DIE FMS

In die geval van warm laai (ECW-uitvoerkodes) moet die temperatuur van die laaste vier palette by die deur altyd versigtig tydens laai oorweeg word. Alles moontlik moet gedoen word om die koudste palette by die deur te laai en die warm palette naby die verkoelings-eenheid te konsentreer (Figuur 5).

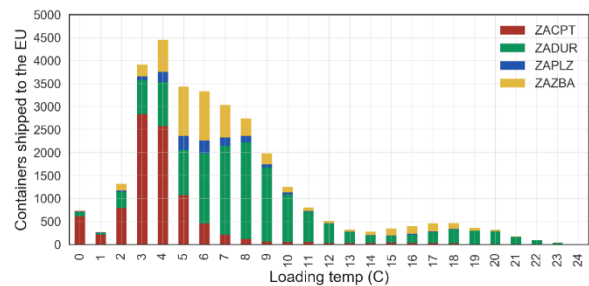


**Figuur 5:** Konsentreer die koudste paletstapels aan die deur-kant van die houer.

Fitosanitiere koue disinfesteringsbehandelings is tyd en temperatuur afhanklik. Vrugte moet eers tot 'n spesifieke temperatuur verkoel word en dan by hierdie temperatuur vir 'n bepaalde tyd bly. Warm laai verminder dus hierdie aktiewe periode van die fitosanitiere koue disinfesteringsbehandeling. Vrugte moet verkieslik teen die teiken temperatuur gelaai word, sodat die protokol so gou as moontlik kan begin. As warm laai die enigste opsie is, word dit ten sterkste aanbeveel om vrugte <math><10^{\circ}\text{C}</math> te laai omdat warmer temperature langer afkoelperiodes vereis.

In figuur 6 kan die variasie in laai temperature van die FMS gesien word en dis grootliks afhanklik van die produksie area en hawe wat gebruik word. 'n Kritieke bedryfsprioriteit in die kort termyn is om

hierdie uitlaai temperature na links te skuif (laai by <math><10^{\circ}\text{C}</math>).



**Figuur 6:** Uitlaai temperature in die FMS in afgelope seisoene.

## 7. LAAI EN GEBRUIK VAN HOUERS IN DIE FMS

Die volgende protokol moet vir FMS-houters geprioritiseer word:

- Voorverkoel houters (Genset) tot <math><5^{\circ}\text{C}</math> voordat deure oopgemaak word. As geen Genset gebruik gaan word nie, hou die houer in 'n skadu/koel area.
- Na laai moet die houer nooit in die son gelaat word sonder verkoeling nie (Houer moet op krag wees).
- Laai houters so gou as moontlik om kondensasie in die houer te verminder (<math><40</math> min).
- In die geval van vertraging in die hawe, beplan die logistiek sodat die houer onder krag bly. Dit sal genoegsame temperatuurblootstelling verseker wat veral belangrik is tydens verskeping vir korter periodes (Figuur 8).
- Doen alles moontlik om nie die koueketting te onderbreek, dws vrugtemperature mag nie wissel na die koueketting begin het nie.

## 8. "STEP-UP" VANTEMPERATUUR IN DIE HOUER VIR DIE FMS

Gedurende 2018 en 2019 seisoene het 8% van die FMS houters se verskeping langer as 30 dae geduur het. Hierdie verlengde verskepingsperiodes teen lae temperature kan lei tot koueskade-gerwante gehalteverliese.

- Die FMS laat toe dat houters na 30 dae van verskeping na <math>4^{\circ}\text{C}</math> verhoog kan word vir die res van verskeping.
- Verhoging van temperatuur moet waar moontlik toegepas word om koueskade te beperk.



*Die outeurs wil graag vir Dr Elma Carstens bedank vir hulp en insette.*

Vir enige verdere navrae kontak Tarl Berry (tarl@sun.ac.za, 0824197218) of Paul Cronje (paulcronje@sun.ac.za, 0844471047)