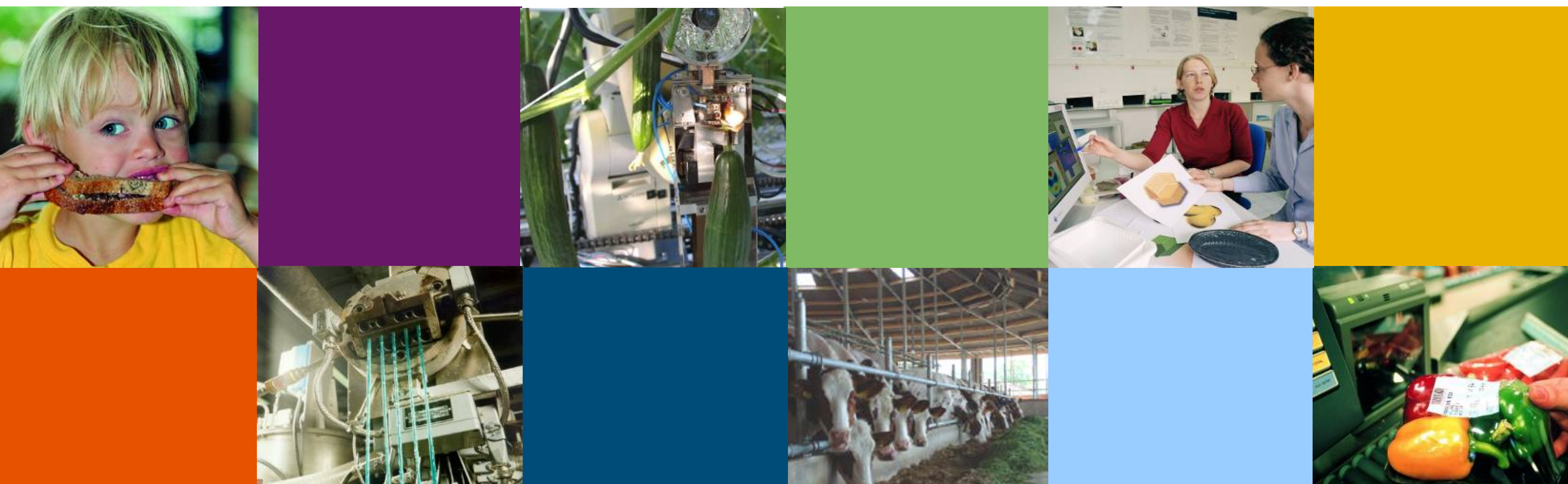
The functioning of extended defrost in Starcool's new design

The (extended) defrosting of Starcool's new designs of return air grid and evap. fans.

Dr. Leo Lukasse
Gerard Leentfaar

Report 1678



Colophon

Title	The functioning of extended defrost in Starcool's new design
Author(s)	Dr. Leo Lukasse, Gerard Leentfaar
Number	1678
ISBN-number	N/A
Date of publication	Sept. 2016
Version	1.0
Confidentiality	yes, till three years after date of publication
project number	6239108200
Approved by	Ir. Janneke de Kramer
Review	Internally peer-reviewed
Name reviewer	Matthijs Montsma Msc.
Sponsor	Maersk Line
Client	Maersk Line

Wageningen UR Food & Biobased Research
P.O. Box 17
NL-6700 AA Wageningen
Tel: +31 (0)317 480 084
E-mail: info.fbr@wur.nl
Internet: www.wageningenur.nl/en/fbr

This report can be downloaded for free from September 2019 at https://doi.org/10.18174/563047/ or at www.wur.nl/wfbr (under publications).

Abstract

In some frozen mode shipments the moisture load may be so high that frost accumulates in the reefer unit. This happens on components above the evaporator coil, the highest component being the return air grid. The extended defrost function, available in the current controller software, suffices to also defrost the return air grid. Now Starcool is considering the launch of a new design for the return air grid and a new design for the evaporator fan motor assembly.
The aim of this test is to experimentally assess if the existing extended defrost function suffices to remove all frost in case of the new designs.
To that end, a reefer container with a Starcool refrigeration unit is placed in a climate chamber. The unit is set at -20 °C and it is subjected to an extreme moisture load for multiple days.
The results show that the existing extended defrost function suffices to remove all frost from the new designs for return air grid and the evaporator fan motor assembly. The areas with bigger openings in the new return air grid are even beneficial in the sense that they clog less quickly.

Content

1 Introduction

In some frozen mode shipments the moisture load may be so high that frost accumulates in the reefer unit. This happens on components above the evaporator coil, the highest component being the return air grid. This is especially a well-known phenomenon when carrying loads of wet frozen tuna.

Standard defrost termination logic aims at terminating defrosts when the evaporator coil is clean. In case frost accumulates on components above the evap. coil that is not enough (see Lukasse & Staal, 2013). For that scenario the manually activated extended defrost function has been developed, and practical experience has proven its efficacy for existing Starcool units.

Now Starcool considers to modify the design of both the return air grid and the evaporator fan motor assemblies, and wants to exclude the possibility that the existing extended defrost function is insufficient to remove all frost from the new designs for return air grid and the evaporator fans.

The aim of this test is to experimentally assess if the existing extended defrost function suffices to remove all frost from the new designs for return air grid and the evaporator fan motor assembly.

2 Test equipment

All tests are performed in our test chamber for refrigerated transport equipment (Fig. 1).
Power supply during all tests: 50 Hz / 400 V.

Fig. 1, climate chamber used.

A series of tests has been performed on container MMAU103858[2] (Fig. 2) after applying three modifications:

1. The evap. fan on FAE-inlet side is replaced by the new design (Fig. 6, Fig. 7).
2. The standard upper rear panel is replaced by the new design (Fig. 8).
3. The metal drain cup is replaced by the one mounted in the new upper rear panel (Fig. 4).

See Table 1 and Table 2 for further specs of the test equipment.

Fig. 2, test container in climate chamber.

Table 1, photos of tested equipment.

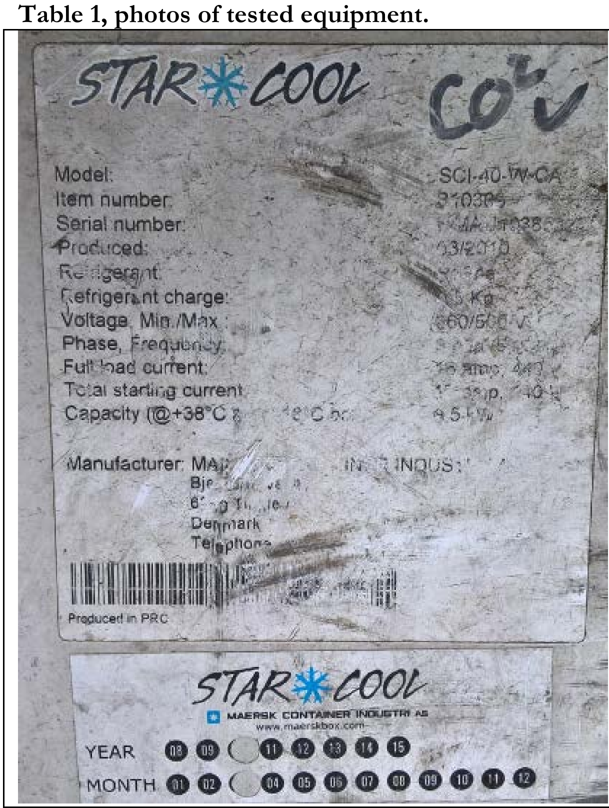


Table 2, characteristics of equipment used in tests.

	manufacturer	man. date	model no.	identification no.	last PTI
container	N/A	N/A	N/A	MMAU103858[2]	N/A
unit	Starcool	March 2010	SCI-40-W-CA	Unreadable	24 May 2016
box	MCI Qingdao	Febr. 2010	MQRS-40HS-062A	MMAU103858[2]	N/A

Fig. 3, original (single) drain pan, directly connected to drain line.

Fig. 4, upper drain pan connected to new rear panel design. For this test directly connected to drain pan, would in final implementation drain to lower drain pan, which is connected to drain line.

Fig. 5, old fan design.

Fig. 6, new fan design.

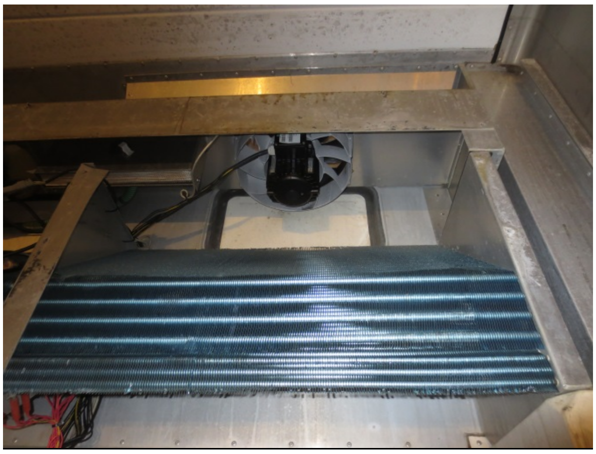


Fig. 7, new fan design as mounted during test (cable connection box facing rear panel, while it would usually be mounted facing the unit's front panel).

Fig. 8, unit's new upper rear panel with upper drain pan.

3 Materials and methods

Table 3, test conditions equal during all tests.

Parameter	**Value**
Tset	-20.0 °C
Tchamber,set	max. +25 °C (cooling only), result: mostly +22 ~ +25 °C,
software version	0354r7
unit's defrost interval (O02)	Option not available in menu, hence assume it to be AUTO according to Maersk Line standard.
unit's extended defrost (O11)	ON

Two tests were run (Table 4).

Table 4, test specific conditions

parameter	**test 1**	**test 2**
r_{hum}	2 L/h	0.25 L/h
start	9 Aug. 2016 13:55	12 Aug. 2016 10:13
end	11 Aug. 2016 13:44	15 Aug. 2016 13:10
duration	2 days	3 days

During the tests the container's interior is humidified with an ultrasonic humidifier (manufacturer Contronics, type HU-45). For more details see http://www.contronics.nl/product/detail/21/31/Humidifier-HU-45. To avoid freezing of the humidifier the humidifier is placed outside the container. The fog is blown into the container through a chink between the container door's. The remainder of the chink is closed as well as possible with EPS foam blocks (see Fig. 10).
Four cameras are mounted in the reefer unit. Fig. 9 depicts how these are mounted. The cameras record both videos and photos at 1 minute intervals. Fig. 11 shows the screen, placed in the test chamber, at which the four images are shown life. The cameras are so-called HDCVI (High Definition Composite Video Interface) infrared analogue dome night vision cameras. 42 IR leds are integrated in the cameras, providing them with night vision at distances upto 40 meters. The cameras are meant for surveillance purposes. For more details see https://www.camerashop24.nl/beveiligingscamera-s/bullet-camera-hd-cvi-bracket-1/dome-camera-hd-cvi-1/hd-dome-camera/hd-cvi-ir-dome-camera-6.html.

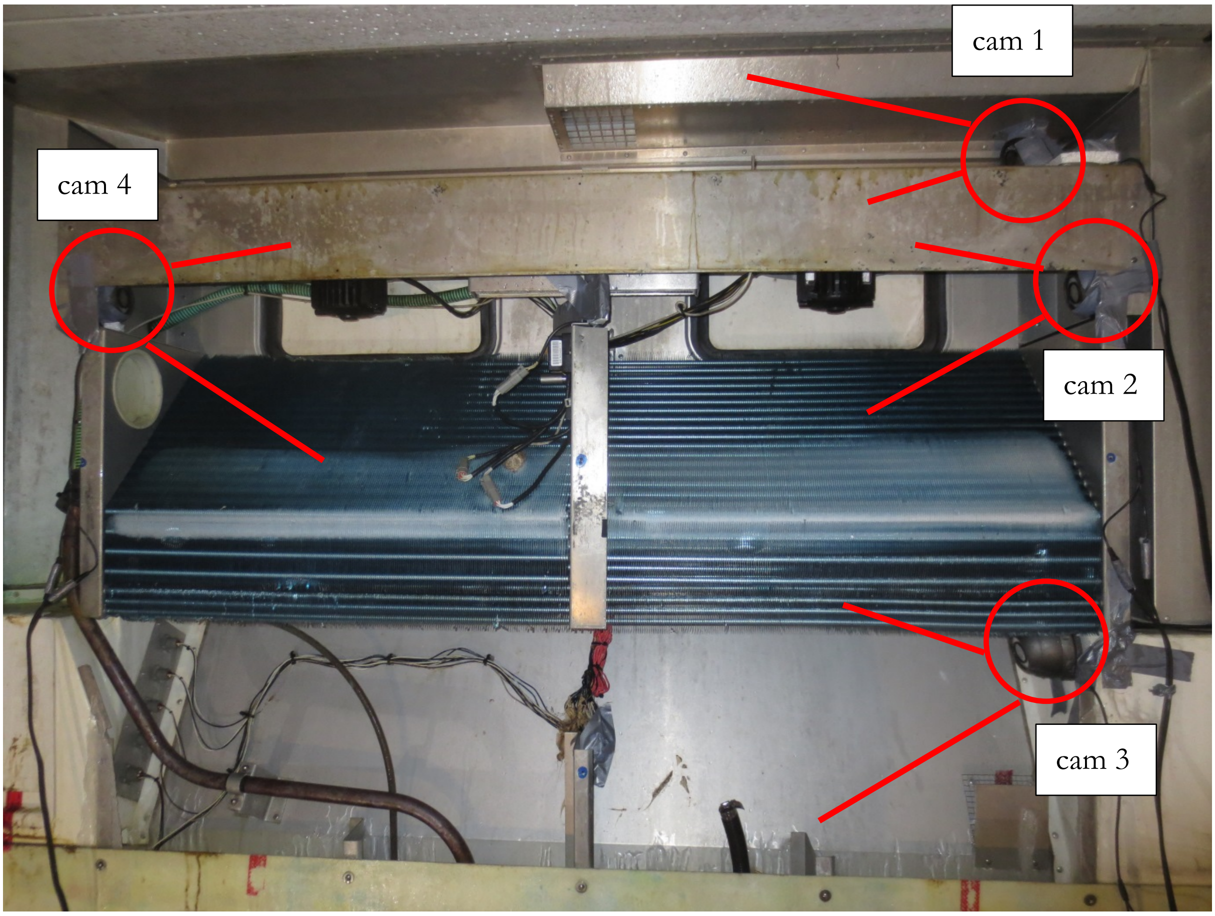


Fig. 9, four IR cameras and their field of view marked by the red lines.

Fig. 10, humidification through door chink.

Fig. 11, images collected by the four infrared cams are continuously recorded.

4 Results

Fig. 12 presents the unit's Tsup and Tret recorded during test 1, note the perfectly repetitive pattern in Tsup and Tret.

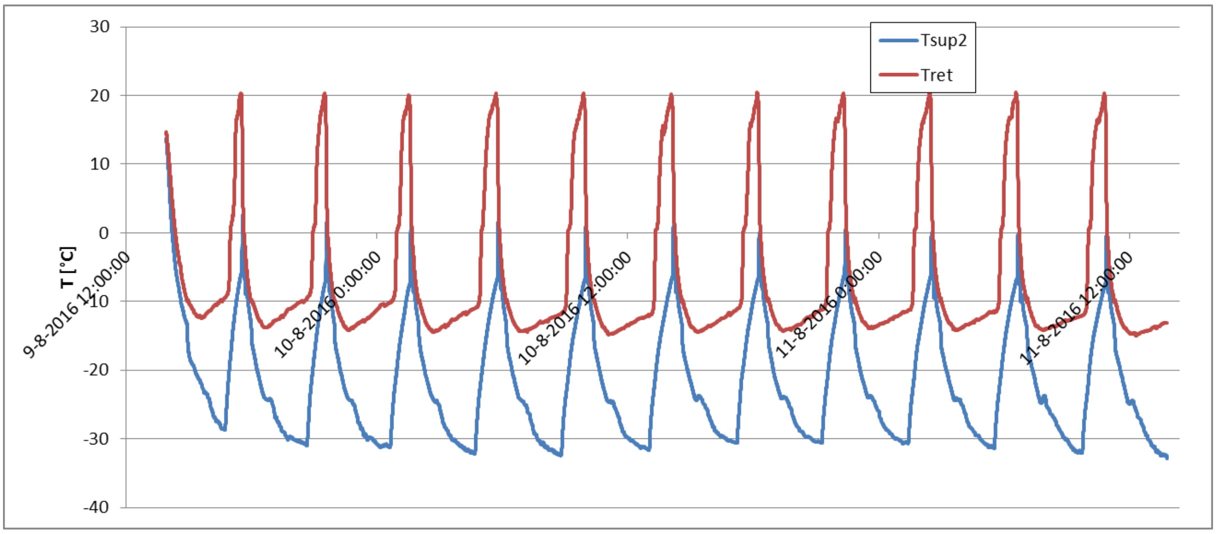


Fig. 12, Tsup and Tret recorded during test 1.

Fig. 13 - Fig. 20 are the images taken by the four IR cameras at start and end of the defrost starting 10-8-2016 17:14 and ending 10-8-2016 18:09.

Fig. 13, cam 1 at start of defrost 7 (10-8-'16 17:14).

Fig. 14, cam 1 at end of defrost 7 (10-8-'16 18:09).

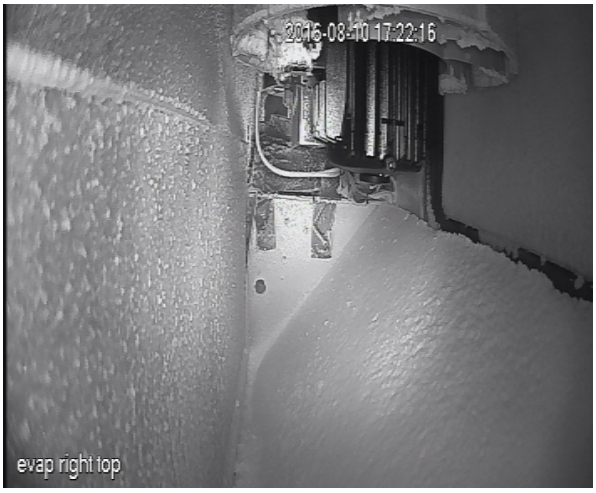


Fig. 15, cam 2 at start of defrost 7 (10-8-'16 17:14).

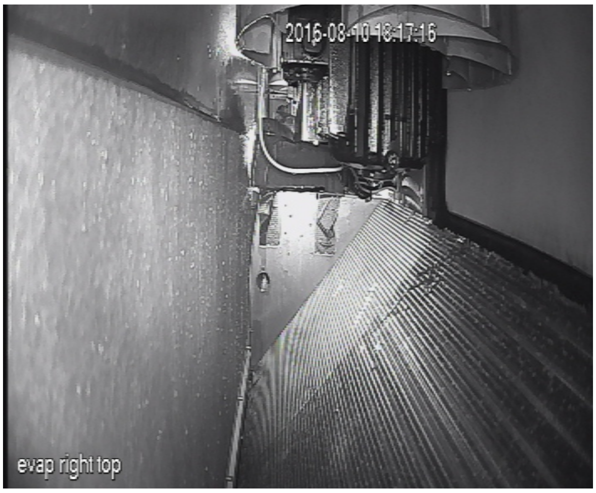


Fig. 16, cam 2 at end of defrost 7 (10-8-'16 18:09).

Fig. 17, cam 3 at start of defrost 7 (10-8-'16 17:14).

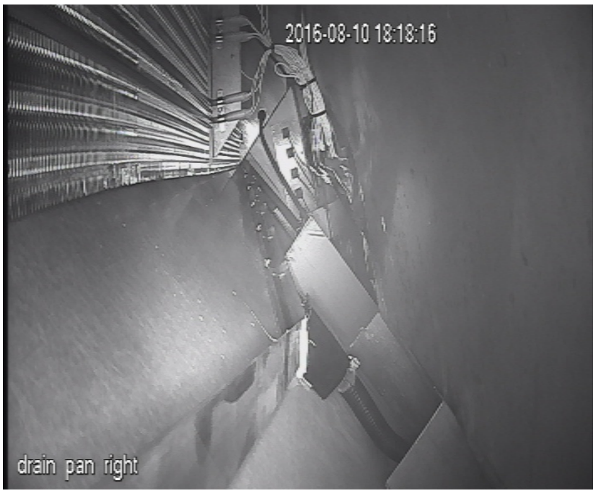


Fig. 18, cam 3 at end of defrost 7 (10-8-'16 18:09).

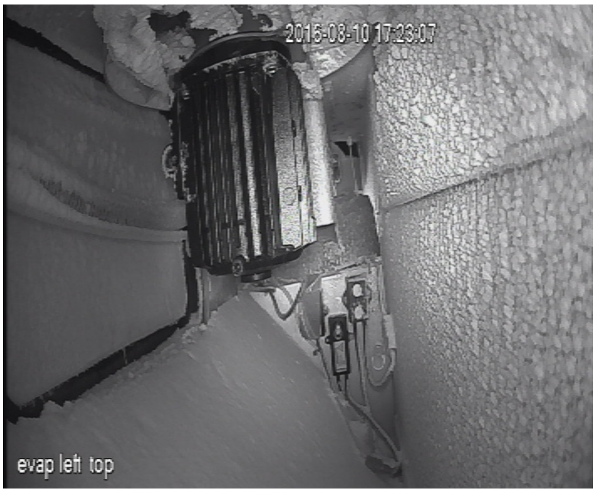


Fig. 19, cam 4 at start of defrost 7 (10-8-'16 17:14).

Fig. 20, cam 4 at end of defrost 7 (10-8-'16 18:09).

The return air grid integrated in the new rear panel has smaller openings near the evaporator fans, and larger ones elsewhere (Fig. 8, Fig. 14, Fig. 21). It is interesting to observe that during the tests primarily the smaller openings clogged up with frost (Fig. 13, Fig. 21).

Fig. 21, return air grid at end of test 1, just before defrost start.

Fig. 22, snow covered floor at end of test 1.

At the end of test 1 quite some ice had accumulated on the container floor underneath the unit, esp. at the far-left and far-right (Fig. 24 - Fig. 26).

Fig. 23, snow covered floor at end of test 1.

Fig. 24, some icicles behind the baffle plate at the end of test 1, esp. at the unit's front panel.

Fig. 25, ice on left-side of floor at end of test 1.

Fig. 26, ice on right-side of floor at end of test 1.

Only at the end of test 2 the upper rear panel was removed, enabling some new photos. At that moment the drain pan, gutters, and upper rear panel underneath the gutters was perfectly clean (Fig. 27). It was also observed that quite some icicles were attached to the unit's front panel (Fig. 29, Fig. 30).

Fig. 27, at end of test 2 the drain pan is clean and no icicles have formed at the rear panel underneath the drain gutters.

Fig. 28, ice behind unit's upper rear panel at far-left side at end of test 2.

Fig. 29, icicles attached to the unit's font panel at end of test 2.

Fig. 30, icicles attached to the unit's font panel at end of test 2.

Test 2 was a milder test than test 1. Also in test 2 no ice/frost accumulation in the air flow path occurred. The only difference worth noticing is the change in defrost pattern: the average defrost interval increased only a little, while the amount of melt water reduced by approx. 40% (Table 5).

Table 5, defrost characteristics.

	test 1	**test 2**
avg .defrost interval	approx. 180 min.	approx.. 200 min.
avg. amount of melt water collected per defrost	4.7 L/h	2.8 L/h

5 Discussion

The extended defrost function suffices to completely defrost the unit in case of the new rear panel design and a new evaporator fan motor assembly. This is proven by the persistently repetitive temperature cycle during two days of testing (Fig. 12): would frost or ice accumulate over time somewhere in the unit, then the pattern of the temperature cycle would change. Extra evidence is provided by the images not revealing any frost at the end of defrost no. 7 (Fig. 14, Fig. 16, Fig. 18, Fig. 20).

Apart from the far-left and far-right not much ice accumulates underneath the unit's rear panel (Fig. 24). Apparently all melt water reaching the drain gutters also reaches the drain pan: apparently the sealant between drain gutter and rear panel is effective.

The ice accumulation on the floor at the far-left and far-right (Fig. 25, Fig. 26) is caused by melt-water trickling down further to the sides than the reach of the drain gutters.

It was observed that quite some icicles were attached to the unit's front panel (Fig. 29, Fig. 30). It was also observed (not photographed) that the electric heaters were curved and hence in direct contact with the evaporator coil. These contact places are the most important points for initiation of icicle growth on the unit's front panel.

6 Conclusion

The existing extended defrost function suffices to remove all frost from the new design for return air grid and the new design for evaporator fan motor assembly. The areas with bigger openings in the new return air grid are even beneficial in the sense that they clog less quickly.

7 Recommendations

Address the curving of electric heater elements to reduce the amount of melt water not reaching the drain gutters. Note this issue is not specific for *extended* defrost, but affects every shipment.

References

L.J.S. Lukasse, M.G. Staal (2013). Reefer unit testing for frozen mode, icing and condensing. FBR report no. 1395.

Acknowledgements

We are grateful to Maersk Line, represented by Paul Clarke, and Starcool, represented by Morten Nylykke, for the smooth cooperation.