THE SPLITTER BOARD SYSTEM FOR IMPROVING TEMPERATURE DISTRIBUTION IN ISO CONTAINERS

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ABSTRACT

Certain cargoes need to be carried under extremely close temperature control to ensure an outturn of quality. CRT have developed and tested a system which splits the airstream at the door end and significantly improves the temperature distribution. Results and the system design are presented.

1. INTRODUCTION

Certain cargoes, such as chilled meat and certain fruit require extremely tight temperature control to maintain low bacteriological counts and to ensure there is no insect infestation. The product particularly targeted for the splitter board was chilled lamb which is currently shipped vacuum packed under conditions of tight temperature control at a specified temperature of -1.0°C ±0.5°C. If the lamb becomes colder than -1.5°C there becomes a possibility of freezing and warmer than -0.5°C the shelf life becomes limited due to more rapid bacterial growth. This temperature specification is difficult to achieve throughout a journey crossing the equator. Heap & Pryor, 1993; Heap &Lawton, 1995).

2. SPLITTER BOARD CONCEPT

The splitter board is a method of regulating the temperatures distribution of cargo in a container. It works by acknowledging that air will warm as it passes through a container by a combination of heat ingress through the insulation, release of kinetic energy from the slowing air and to some extent cooling of the cargo. The warmest air will therefore be furthest away from the evaporator coil and closest to the most weakly insulated section of the container which of course is the door end.

The design concept behind the splitter board is to split the stream of air at the door into two, one to cool the door and one to cool the cargo. The splitter comprises an “L” shaped board with battens attached. The purpose of the battens is twofold, to provide a airspace on each side of the splitter board and to direct the cooling air.

Air at the door end is at slightly different temperatures depending on which section of floor it has travelled down. The air at the centre of the floor is coolest as this has a uniform section of insulation beneath, this air is directed over the cargo. Air flowing down the edges of the container will be slightly warmer as this area has more structure and is therefore more weakly insulated, this air is used to cool the door.

The overall effect is that there is two streams of air flowing at the door end one slightly warmer than the other divided by the splitter board. The temperature difference is at most only a few degrees centigrade and therefore provided the board is not made of metal it will be a sufficiently good insulator.

3. SPLITTER BOARD DESIGN

The design principle is for the cooling air at the rear of the container to be separated into two streams by an air separator board. This has a first limb located over the top of the cargo, and a second limb extending approximately at right angles to the first limb down the door.

The splitter comprises an "L" shaped board with battens attached, each arm of the L preferably measures approximately 2500mm x 2500mm x 6mm thick, as shown in Figures 1, 2 & 3 below. On its inner face, each board has a plurality of projecting ribs, arranged in the form of a fan, to distribute the first air stream over the surface of the cargo, and on its outer face, further parallel spaced ribs are provided, which channel the other air stream across the door, and then along the roof of the rear of the container. The battens are preferably of rectangular cross section with dimensions from about 50mm to about l00mm wide. It is envisaged that further air separator boards may be connected to the L-shaped board at the rear of the container along the length of the container. The splitter is referred to in more detail in UK patent 2 282 873 B (Lawton, 1994).

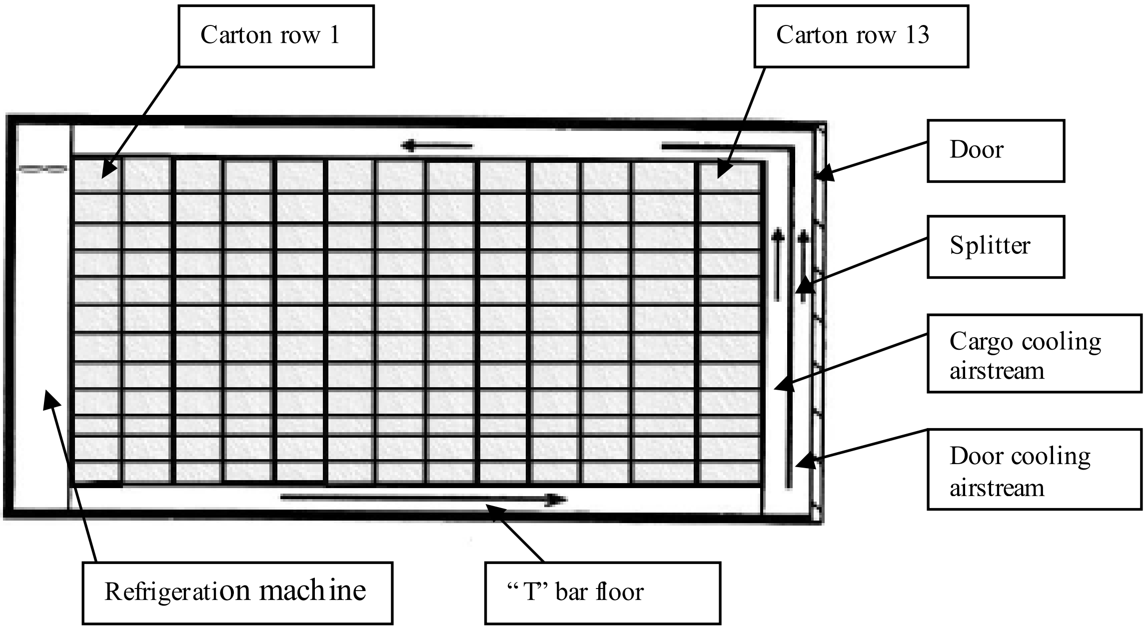

Figure 1: Schematic diagram of splitter installed in a container

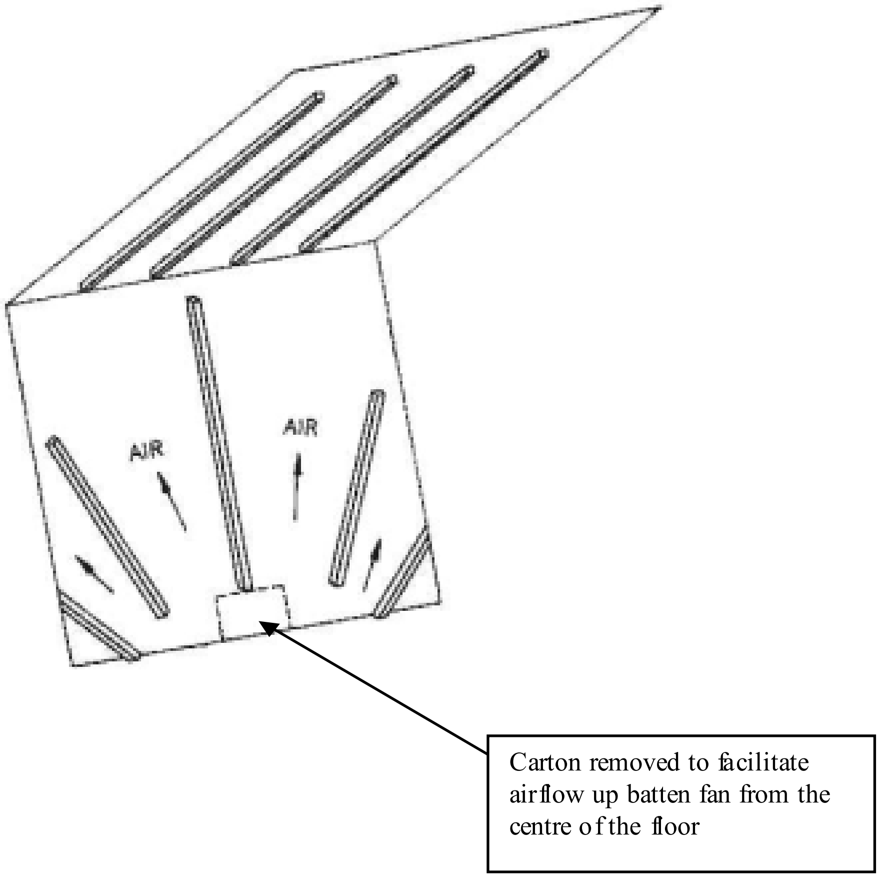

Figure 2: Inside surface of splitter board

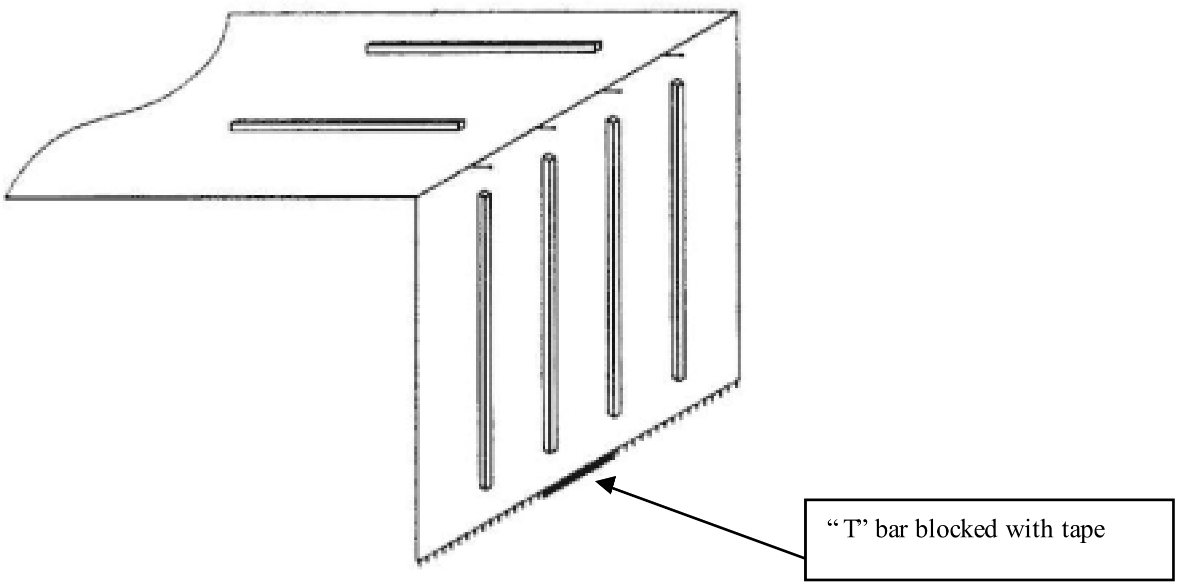

Figure 3: Outside surface of splitter board

4. INTEGRAL CONTAINER PERFORMANCE

An integral refrigerated container was on loan from a shipping company for the purpose of this experimental work. It was a Seacold refrigeration unit fitted to an Inta Eimar Insulated container.

Temperature control for this unit is achieved by hot gas modulation under the control of a microprocessor controller. Air is delivered from the machinery at the setpoint temperature ±0.25°C, temperature spread across the delivery air into the "T" bar floor is up to 0.5°C. It is therefore possible for delivery air temperature at any one point in the "T" bar to be setpoint ±0.75°C.

Air then travels down the container floor and up through the cargo at around 120 air changes each hour. Once the air has reached the door end it will have lost some of its kinetic energy and will have warmed slightly. It will also have picked up heat coming in through the insulation before travelling up the door picking up still more heat. The door tends to be a thermally weaker point due to strength requirements and sealing. At the top of the door in a 40°C ambient the air can have gained up to 1 to 2°C of temperature, with a corresponding cargo temperature gain before returning to the machinery and mixing with the air coming up through the cargo.

5. EXPERIMENTAL PROCEDURE

In order to test the various designs of splitter board, the container described above was loaded with an experimental cargo and series of experiments carried out on different configurations of dunnage within the container. The trial was carried out with the cargo at a delivery air setpoint of -1.5°C in ambients of +20°C and +40°C

5.1 Experimental Cargo

For the purpose of the trial, 520 chilled meat cartons were filled with an anti-freeze mixtures in two one gallon plastic containers, those cartons with temperature sensors contained meat substitute (Karlsruhe compound).

5.2 Instrumentation

Temperatures during the trials were measured using type 'T' thermocouples connected to two data loggers. A total of 149 thermocouples were installed in the carton and air spaces inside the container, and a further 12 external thermocouples measuring ambient temperature to cover the test programme.

Data logger one, a Schlumberger Orion 3530 was connected to 78 thermocouples installed into the cartons for monitoring purposes. The second data logger, a Fluke 2240B monitored air temperatures in the delivery and air return using 71 thermocouples. These covered the air path externally to the cartons including air delivery and return sensors, 1/4 way, 1/2 way, 3/4 way in the floor, the roof, walls and doors of the container.

5.3 Stowage

The container was stowed manually and had 13 rows x 4 cartons wide x 10 cartons high, the stowage varied slightly once the dunnaged splitter board was installed. The final design for the dunnaged splitter board is shown in figures 1,2 & 3.

Dunnage battens measuring 20mm x 10mm were installed into the load. In the control test the battens were installed every other tier from the front bulkhead. In the final design test, the battens started at row 9 and were installed in every row up to row 13.

5.4 Test Programme

For each test the cargo was equilibrated and the temperature monitored at ambient temperature of 20°C and 40°C using the cargo and stowage plan outlined above with slight variations in the stowage and battens as described in detail below.

6. RESULTS

It was found that in an ambient temperature of 40°C using battens in the second half of the container and using the dunnaged splitter board, the best temperature distribution throughout the cartons was found. The warmest carton was -0.1°C, coldest carton -1.5°C and a spread through the container of 1.4°C. This compares with a range of 2.3°C from –1.6 to +0.7 without the splitter board.

Results are summarised in the following, table1 the control test and table 2 the container fitted with the splitter.

Table 1: Temperature Distribution in a Standard Twenty Foot Container

Carton	Control Ambient 40°C		
Row	Mean°C	Min°C	Max °C
Row 1	-0.9	-1.3	-0.3
Row 3	-1.1	-1.6	-0.6
Row 5	-0.8	-1.4	-0.1
Row 7	-1.0	-1.6	-0.3
Row 9	-0.7	-1.2	0.2
Row 11	-0.1	-0.2	0.3
Row 12	-0.2	-1.1	0.7
Row 13	0.3	-0.6	2.5

Table 2: Temperature Distribution in a Twenty Foot Container with Splitter

Carton	Splitter fitted ambient 20°C			Splitter fitted ambient 40°C		
Row	Mean °C	Min°C	Max °C	Mean°C	Min°C	Max °C
Row 1	-0.7	-1.1	-0.3	-0.9	-1.5	-0.1
Row 3	-0.8	-1.1	-0.3	-1.0	-1.3	-0.3
Row 5	-0.8	-1.0	-0.3	-0.8	-1.3	-0.2
Row 7	-0.9	-1.1	-0.5	-1.0	-1.4	-0.4
Row 9	-0.7	-1.0	0.0	-0.8	-1.2	-0.1
Row 11	-0.8	-1.1	-0.6	-0.7	-1.1	-0.4
Row 12	-0.8	-1.3	-0.2	-0.8	-1.4	-0.2
Row 13	-0.6	-0.9	-0.2	-0.5	-1.0	-0.1

7. CONCLUSIONS

The experimental work showed a substantial improvement in temperature range could be achieved by the use of a dunnaged splitter at the door end. In a 40°C ambient the average temperature in the last tier of cartons was reduced from +0.3°C to -0.5°C. The warmest temperature was -0.1°C.

The dunnaged splitter board may find applications for improving temperature distribution in cargoes other than chilled meat such as fruit requiring insect disinfestation under USDA rules.

8. REFERENCES

1. Heap R.D., Lawton A.R., 1995, Developments in container refrigeration, *19th International Congress of Refrigeration,* IIF/IIR, The Hague.
2. Heap R.D., Pryor G.J.P.,1993, Cargo temperatures in containerised transport , *IIF/IDR Commissions B1,B2 D1,D2/3,* IIF/IIR, Palmerston North New Zealand.
3. Lawton A.R., 1994., A method of controlling the temperature of a cargo within a container. *UK Patent GB 2282 873*

PANNEAUX DE SEPARATION POUR AMELIORER LA DISTRIBUTION DE LA TEMPERATURE DANS LES CONTENEURS ISO

RÉSUMÉ: Certains chargements ont besoin d'être effectués avec un contrôle de température extrêmement rigoureux afin d'assurer un rendement de qualité. La CRT a développé et testé un système qui divise le courant atmosphérique à la porte et qui améliore ainsi de manière significative la distribution de la température. On présentera les résultats et la conception du système.

DISCUSSION

H.F.Th. MEFFERT (Netherlands) - Can you indicate the improvement of the "Configuration Coefficient" with and without splitter board?

R. LAWTON - We have not looked at any improvement to the configuration coefficient by the splitter board.

A. STERA (UK) -
1. Have you measured air velocities on both sides of the splitter board?
2. What is the thickness of battens on the inside of splitter board?

R. LAWTON -
1. No we did not measure the air velocity.
2. The battens were 50mm diameter.

B. MCDONALD (New Zealand) - Our experience has shown that containers without ribbing on the side walls can cool product more efficiently than those with ribbing - by forcing more air up between the cartons in bulk stows. Is there any difference in the performance of the splitter-board in containers with and without wall ribs?

R. LAWTON - We did not try this but generally the rule is that the free area needs to be below 5%

A.K. SHARP (Australia) - In your slides I noticed some stows were not very tight. Would you agree that a splitter board should be used only in a tight stow?

R. LAWTON - I think most stows of this type of product have to be tight to avoid movement. Again free area should be below 5%

T. PHAM (Australia) - This system is a very good idea but depends a lot on correct installation. I think it is important that you determine the effect of incorrect installation and do surveys to see if the instructions are followed in commercial use.

R. LAWTON - Correct installation is important. Blocking off the door air stream can make the temperature distribution worse.