

# Meat technology – information sheet

June 2007

## Temperature rises in frozen cartons when containers are off power

**When cartoned meat is at -18 °C or colder, a shipping container may be off power for 19 hours on a typical sunny summer day before the meat temperature at the corners rises to -10 °C and at least 56 hours before it reaches -5 °C.**

The majority of meat is exported from Australia in refrigerated shipping containers. The frozen meat is packed into the containers at the processing plant or cold store then transported by road and/or rail to the port.

During many of these journeys to the port, and from the port to cold store at the destination, the container will not be connected to power. Information on the length of time a container of frozen meat can remain off power before the contents are affected is of interest to processors, transporters, purchasers and regulators.

This Information Sheet was developed from the results of trials that were conducted in the container test facility at the North Ryde, NSW site of Food Science Australia. The facility enables transport equipment to be tested under varying ambient conditions.

The chamber can be maintained at temperatures ranging from -10°C to +50°C with humidity control between 40% and 90% above 10°C. The facility also has the capability of simulating radiant heat from direct sun exposure.

The tables in this Information Sheet replace the one in Meat Research Newsletter 78/5, which was based on results from trials conducted in 1969 on insulated containers that used clip-on refrigeration units.

### Containers off-power

A 12 m (40 ft) refrigerated container loaded with 1050, 27.2 kg cartons of frozen manufacturing beef and a 6 m (20 ft) container loaded with 700 cartons were tested.

Thermocouples were fitted to cartons and the temperature recorded. The thermocouples were inserted in the corners of the cartons (approximately 25 mm deep) and in the centres. The carton temperatures were brought to a uniform -18°C for each run before the power was switched off. For each run, the test facility was set to constant temperatures of 10°C, 25°C or 40°C, or conditions which reflect a summer day with solar radiation. The results enabled a model

to be developed which was used to calculate the extent of warming under a range of ambient conditions.

The following tables present times for the warmest part of the load to rise to -10°C and -5°C at constant ambient temperature with no solar radiation, and on a typical North Queensland summer day with and without sunshine. The warmest point was generally at the corner of cartons—not those adjacent to the doors as anticipated, but those along the top edge of the container, in from the ends.

A temperature of -10°C was selected because the International Institute of Refrigeration defines ‘frozen food’ as product that is stored at a temperature of -10°C or colder. The higher limit of -5°C was selected because at around this temperature, meat will start to soften and slow growth of some spoilage bacteria and fungi might begin.

**Table 1: 6 m (20 ft) container - predicted time (h) for meat temperature 25 mm from corner to reach -10°C when off refrigeration**

Meat temperature at power off	Constant ambient temperature (°C) (shade)							Summer day*	
	10	15	20	25	30	35	40	Sun	Shade
-20°C	62	49	39	31	26	21	18	23	29
-18°C	44	35	28	22	18	15	13	19	23
-16°C	28	22	18	14	12	10	8	11	15
-14°C	16	13	10	8	7	6	5	4	7
-12°C	8	6	5	4	3	3	2	1	2

\*A typical North Queensland summer day having a minimum temperature of 23.5°C and a maximum of 30°C. The container off-power period commenced at noon.

**Table 2: 6 m (20 ft) container - predicted time (h) for meat temperature 25 mm from corner to reach -5°C when off refrigeration**

Meat temperature at power off	Constant ambient temperature (°C) (shade)							Summer day*	
	10	15	20	25	30	35	40	Sun	Shade
-20°C	220	166	129	102	82	68	58	71	96
-18°C	194	147	113	89	72	59	50	63	83
-16°C	167	126	97	76	61	51	43	50	73
-14°C	140	105	81	63	51	42	35	45	58
-12°C	114	86	66	51	41	34	28	29	47

**Table 3: 12 m (40 ft) container - predicted time (h) for meat temperature 25 mm from corner to reach -10°C when off refrigeration**

Meat temperature at power off	Constant ambient temperature (°C) (shade)							Summer day*	
	10	15	20	25	30	35	40	Sun	Shade
-20°C	58	46	37	30	25	21	17	23	27
-18°C	42	33	27	22	18	15	13	19	22
-16°C	27	22	18	14	12	10	8	11	14
-14°C	16	13	10	8	7	6	5	5	7
-12°C	8	7	5	4	4	3	3	2	2

**Table 4: 12 m (40 ft) container - predicted time (h) for meat temperature 25 mm from corner to reach -5°C when off refrigeration**

Meat temperature at power off	Constant ambient temperature (°C) (shade)							Summer day*	
	10	15	20	25	30	35	40	Sun	Shade
-20°C	201	152	117	93	76	63	54	69	85
-18°C	180	136	105	83	67	56	47	56	76
-16°C	157	118	91	72	58	48	41	50	67
-14°C	134	101	77	61	49	40	34	45	55
-12°C	112	84	64	50	40	33	28	30	45

The times to warm (to -10 or -5°C) presented in these tables may not exactly duplicate a specific situation as the quality of the container insulation may differ. They were calculated based on a container heat leakage rate of 0.5 W/m<sup>2</sup>K which is representative of a container with below average quality of insulation.

The cartons in these trials were hand-stacked into the containers. Other loading patterns may have a small effect on the rate of warming.