

# WP.11/2005/61st/INF.6

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ECONOMIC COMMISSION FOR EUROPE

INLAND TRANSPORT COMMITTEE

Working Party on the Transport of Perishable Foodstuffs

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Item 10 of the provisional agenda

PROCEDURES FOR THE APPROVAL OF MULTI-COMPARTMENT  
MULTI-TEMPERATURE VEHICLES

Transmitted by the expert from Germany

# MULTITEMP

Summary of testresults  
and  
proposed for tests

Carrier Transicold

Frigoblock Grosskopf

Thermo King

TÜV SÜD ATP-Teststation

# ATP Multitemp: Results of TÜV Measurements

"Theoretical" cooling capacity: measured in single temperature operation at -20°C

parallel operation of all evap.

individual capacity of single evaporators

temperature (°C)	950 MT		Evaporator 1450		Evaporator 1100		Evaporator 700	
	nominal cap. host unit (W)	% of nom. cap. host unit	individual capacity (W)	% of nom. cap. host unit	individual capacity (W)	% of nom. cap. host unit	individual capacity (W)	% of nom. cap. host unit
-20 / +30	5.606	100%	5.167	92%	4.320	77%	3.352	60%
			100%		100%		100%	

Up to 50% reduction of useful cooling capacity in multitemp operation at -20°C

	temperature (°C)	Total Capacity		Evaporator 1450		Evaporator 1100		Evaporator 700	
		sum. capacity (W)	% of nom. cap. host unit	capacity (W)	% of individual capacity	capacity (W)	% of individual capacity	capacity (W)	% of individual capacity
2 compartments cooling	-20 / 0	5.161	92%	4.583	89%			578	
		5.028	90%	4.327	84%			701	
		5.075	91%	3.917	76%			1.158	
		5.114	91%	3.775	73%			1.339	
	0 / -20	3.237	58%	577				2.660	79%
		3.608	64%	1.163				2.445	73%
		4.040	72%	2.065			1.975	59%	
3 compartments cooling	-20 / 0 / 0	4.847	86%	3.725	72%	561		561	
		4.755	85%	3.227	62%	859		669	
		4.900	87%	2.661	51%	1.121		1.118	
	0 / -20 / 0	4.134	74%	563		3.007	70%	564	
		4.489	80%	1.037		2.779	64%	673	
		4.404	79%	1.123		2.166	50%	1.115	
	0 / 0 / -20	3.237	58%	560		563		2.114	63%
		3.720	66%	1.037		869		1.814	54%
		4.198	75%	1.121		1.120		1.957	58%
3 compartments cooling and heating	0 / +20 / -20	3.733	67%	1.040		1.054		2.693	80%
		3.566	64%	1.038		2.305		2.528	75%
	-20 / +20 / 0	5.011	89%	4.337	84%	1.165		674	
		5.002	89%	4.321	84%	2.310		681	

blue = max. cooling capacity at -20°C, green = cooling capacity at 0°C, red = heating capacity at +20°C

# **ATP Multitemp: Results of TÜV Measurements**

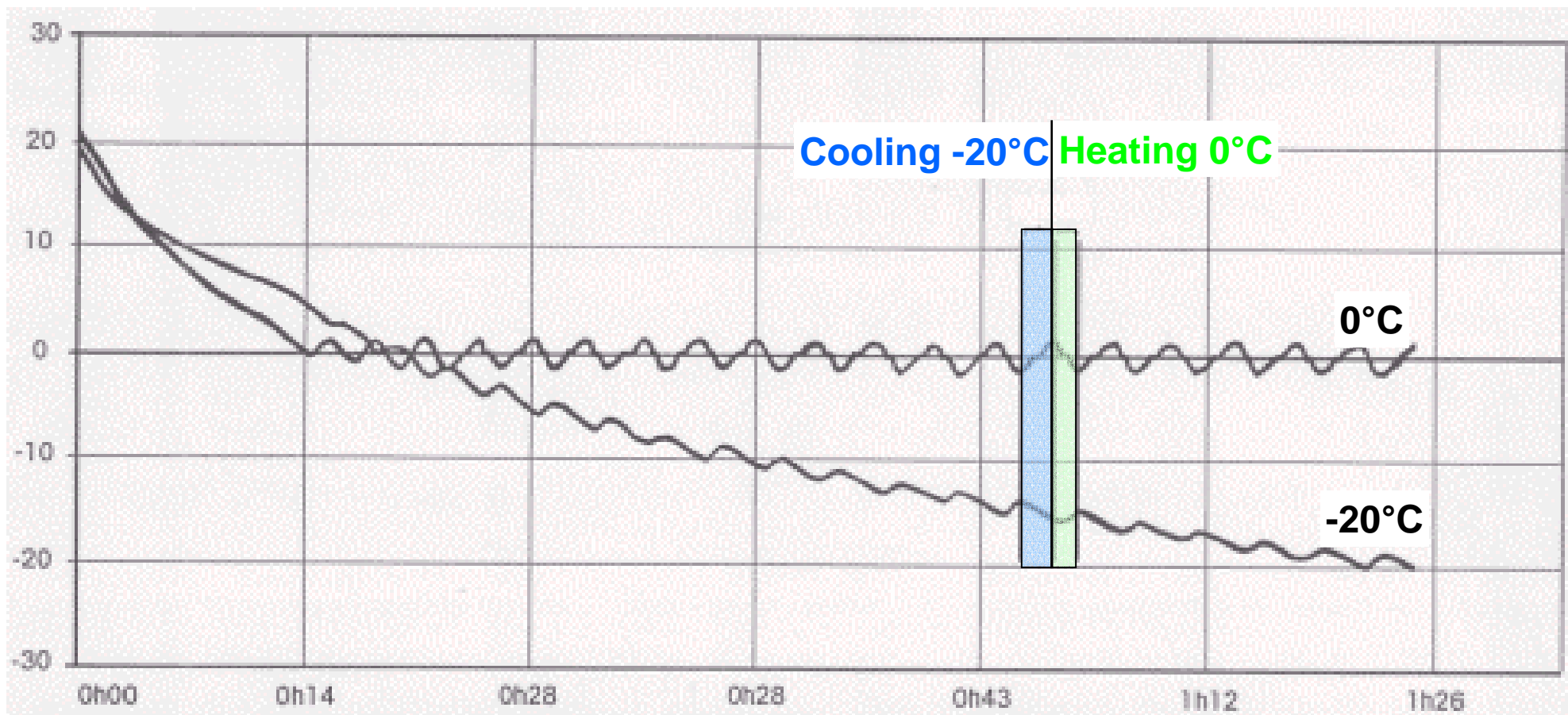
## **Total cooling capacity of the host unit in multitemp operation**

- **up to 42% reduction in comparison to monotemp operation**
- **depending on the size/individual capacity of the frozen evaporator**

## **Useful cooling capacity of the evaporators at -20°C in multitemp operation**

- **up to 50% reduction compared with the individual capacities**
- **considerable reduction with increasing cooling demand for the chilled evaporators**

# Regulation Characteristic of a Multitemp Refrigeration Unit



**No operation of frozen evaporator at -20°C when the chilled evaporator is cooling at 0°C, therefore reduced runtime of frozen evaporator**

**Useful cooling capacity in multitemp operation = runtime x individual capacity at -20°C**

# Calculation of the Reduced Useful Cooling Capacity in Multitemp Operation

Temp. (°C)	Total Cooling Cap.			Evaporator 1450		Evaporator 1100		Evaporator 700	
	measured (W)	calculated (W)	Dev. (%)	measured cooling cap.(W)	calculated cooling cap. (W)	measured cooling cap.(W)	calculated cooling cap. (W)	measured cooling cap.(W)	calculated cooling cap. (W)
<b>ind. Capacity at -20°C</b>				<b>5.167</b>		<b>4.320</b>		<b>3.352</b>	
<b>-20 / 0</b>	5.161	4.854	-5,9%	4.583	4.276			578	
	5.028	4.787	-4,8%	4.327	4.086			701	
	5.075	4.540	-10,5%	3.917	3.382			1.158	
	5.114	4.442	-13,1%	3.775	3.103			1.339	
<b>0 / -20</b>	3.237	3.555	9,8%	577				2.660	2.978
	3.608	3.761	4,2%	1.163				2.445	2.598
	4.040	4.077	0,9%	2.065				1.975	2.012
<b>-20 / 0 / 0</b>	4.847	4.753	-1,9%	3.725	3.631	561		561	
	4.755	4.636	-2,5%	3.227	3.108	859		669	
	4.900	4.342	-11,4%	2.661	2.103	1.121		1.118	
<b>0 / -20 / 0</b>	4.134	4.249	2,8%	563		3.007	3.122	564	
	4.489	4.296	-4,3%	1.037		2.779	2.586	673	
	4.404	4.182	-5,0%	1.123		2.166	1.944	1.115	
<b>0 / 0 / -20</b>	3.237	3.675	13,5%	560		563		2.114	2.552
	3.720	3.911	5,1%	1.037		869		1.814	2.005
	4.198	3.997	-4,8%	1.121		1.120		1.957	1.756
<b>average deviation</b>			<b>Ø 6,3%</b>	<b>red</b>	calculated	<b>blue</b>	measured		

# ATP Test for Multitemps

**Test of the host unit in combination with any number of evaporators**

- **Test I\*:** nominal cooling capacity of the host unit in parallel operation with all evaporators at +30°C ambient and -20°C box temperature
- **Test II:** individual cooling capacity of all evaporators at +30°C ambient and -20°C box temperature
- **Test III:** individual heating capacity of all evaporators at -20°C ambient and +12°C box temperature
- **Test IV\*:** functional test and examination of the calculated results for the useful cooling capacity in multitemp operation  
- cooling at -20°C and 0°C, heating at +12°C

\* Test I and IV with 2 or 3 evaporators  
(more than 3 evaporators: test with largest, mid-sized and smallest evaporator)

# Test IV: Examination of Useful Capacity in Multitemp Operation

## Test of useful cooling capacity of -20°C evaporators

- cooling capacity of chilled evaporators in the 0°C boxes corresponding to 20% of the nominal cooling capacity of the host unit at -20°C
- heating capacity of the evaporators in the +12°C boxes corresponding to 40% of the nominal cooling capacity of the host unit at -20°C

- 2 Evaporators	Evap 1 (small)	Evap 2 (large)
Test 1	-20 °C	+12°C
Test 2	+12°C	-20°C
Test 3	-20°C	0°C

- 3 Evaporators	Evap 1 (smallest)	Evap 2 (mid-size)	Evap 3 (largest)
Test 1	-20 °C	+12°C	0°C
Test 2	0°C	-20°C	+12°C
Test 3	+12°C	0°C	-20°C



# Agreed Calculation Basis for Multitemps

- **k-value necessary for refrigerated vehicle body:  $k \leq 0,4 \text{ W/m}^2\text{K}$  according ATP (FRC)**
- **no measurements of k-values for internal bulkheads**
- **k-values for all internal bulkheads including thermal bridges in walls, roof, floor and sealing components**

	k-value [W/m <sup>2</sup> K]		min. thickness of PUR foam [mm]
	fixed	movable	
longitudinal	1,5	2,5	25
transverse	1,0	2,0	40

- **maximum thermal conductivity of insulation  $\lambda=0,025 \text{ W/mK}$   
(PUR rigid foam: no XPS or PVC hard foam, no flexible foam)**

- **ATP dimensioning factor of at least 2.25 required for multitemps for international long distance transport instead of 1.75 (as a safety margin with respect to the theoretical k-values of the internal bulkheads, inevitable air leakages, inaccuracy of calculations, ...)**

# Agreed Calculation Basis for Multitemps

**Determination for alternating chilled and frozen operation for all evaporators  
(regular temperature change of chilled and frozen compartments)**

## **Calculation of the cooling capacity**

- **for each evaporator always for worst case combinations**
  - **maximum difference of temperatures**
  - **maximum cooling and heating demand**
  - **most unfavourable position of internal bulkheads**

- **cooling**
  - **frozen compartment** **-20°C**
  - **chilled compartment** **0°C and +12°C**
  - **dry freight compartment** **+30°C**
  - **outside ambient** **+30°C**
- **heating**
  - **chilled compartments** **+12°C**
  - **outside ambient** **-20°C**

# **Examination of the Actual Useful Cooling, Heating and Air Capacity in Multitemp Operation**

- **useful cooling capacity for the maximum size of the frozen compartment**
- **cooling and heating capacity of all chilled evaporators at maximum size of the chilled compartments**
- **total cooling and heating capacity of the host unit in multitemp operation for all combinations of temperatures and compartment size**
- **air throw and air flow rates of all evaporators at maximum compartment sizes (60 air changes per hour?)**