



UNIVERSITI KUALA LUMPUR
MALAYSIA FRANCE INSTITUTE

FINAL EXAMINATION
SEPTEMBER 2014 SESSION

SUBJECT CODE : FRB30603
SUBJECT TITLE : COLD ROOM AND REFRIGERATED SHOWCASE
LEVEL : BACHELOR
TIME/DURATION : 9.00 AM - 11.00 AM
(2 HOURS)
DATE : 4 JANUARY 2015

INSTRUCTIONS TO CANDIDATES

1. All documents authorized (Open Book Examination)
 2. Please read the instructions given in the question paper **CAREFULLY**.
 3. This question paper is printed on both sides of the paper.
 4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
 5. This question paper consists only one section. Answer all questions.
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THERE ARE 3 PRINTED PAGES OF QUESTIONS, EXCLUDING THIS PAGE

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

Question 1

(a) The freezer room having a dimension of 4.5m x 3m x 3.0 height and the wall thickness is 60mm with the inside design temperature -25°C .

Floor insulation has a total coefficient of transmission of $0.25 \text{ W/m}^2\text{K}$ while walls and roof made of insulation panels of $K = 0.25 \text{ W/m}^2\text{K}$.

Outside temperature for 4 walls is 28°C , ground temperature is 27°C and roof 35°C .

Storage capacity is 450 kg with daily loading/unloading rate 45 kg at -18°C and a specific heat of 1.8 kJ/kgK .

It handling by 2 motorized pallet truck of 2 kW each and daily net 3 hours are operating inside the cold room.

There is 1 automatic door for entry and exit each, have a dimension 2.0 m H x 1.5 m W equipped with air curtains.

External conditions is 28°C , RH 70 % enthalpy 64 kJ/kg density 1.15 kg/m^3 and internal conditions -20°C , RH 95 % enthalpy -25 kJ/kg density 1.43 kg/m^3 .

Time for opening of the door for the passing of power lifts: 50 kg: 45 s

Lighting is 6 x 200W operating for a duration of 8 hours net per day

2 occupants for a net duration of 2 hours net per day and release heat 250 W/ person

Calculate the hourly refrigerating power for a maximum running time 18 hours per day.

(4 marks)

(b) In order to save energy, it is proposed that the incandescent lights be replaced by 3 high efficiency fluorescent tubes, each consuming 40W. If the lights are on for an average of 8 hr a day, every day, determine the amount of electrical energy and money this facility will save per year? Assume the refrigeration system has a COP of 3 and the cost of electricity is $\$0.35/\text{kWh}$.

(2 marks)

Question 2

Draw the complete refrigerating diagram of principle on the basis of three (3) screw compressor, common oil separator, common oil cooler, air cooled condenser, high pressure bottle, expansion valve and low pressure bottle without pump (using gravity force) supplying the evaporator.

(4 marks)

Question 3

(i) Explain clearly about control of microorganisms in food highlighting the following:

- i. What are the major causes of food spoilages?
- ii. Differentiate between (a)enzymes (b)Yeast (c)Bacteria (d)Mold
- iii. four environmental factors that affects growth of microorganism
- iv. How can the microorganisms in foods be destroyed

(2Marks)

(ii) Fresh strawberries with a water content of 80.9%(by mass) at 26°C are stored in 0.8kg boxes made of polyethylene ($C_p=2.3\text{kJ/kg } ^\circ\text{C}$). Each box contain 25 kg strawberries , and the strawberries are to be frozen to an average temperature of -16C at a rate of 80 boxes per hour. The enthalpy of the strawberries is given to be 367 kJ/kg at 0 °C and 54kJ/kg at -16 °C. Taking the average specific heat of the strawberries above freezing temperature to be $C_p =3.94\text{kJ/kg } .^\circ\text{C}$, determine the rate of heat removal from the strawberries and their boxes, in kJ/h.

(2Marks)

QUESTION 4

The chilling room of a meat plant is 18m x 18m x 6m in size and has a capacity of 350 beef carcasses. The power consumed by the fans and the lights of the chilling room are 22 kW and 2kW, respectively, and the room gains heat through its envelope at a rate of 11kW. The average mass of beef carcasses is 300kg. The carcasses enter the chilling room at 35 C, after they are washed to facilitate evaporative cooling, and are cooled to 16 C in 10hr. The water is expected to evaporate at a rate of 0.080 kg/s. The air enters the evaporator section of the refrigeration system at 0.5 °C and leaves at -2.2 °C. The air side of evaporator is heavily finned, and the overall heat transfer coefficient of the evaporator based on the air side is 22 W/m².°C. Also, the average temperature difference between the air and the refrigerant in the evaporator is 6.5 °C. Determine:

- (i) The refrigeration load of the chilling room
- (ii) The volume flow rate of air
- (iii) The heat transfer surface area of the evaporator on the air side.

(4 marks)

QUESTION 5

{i} An R-134a commercial refrigerator has a design capacity of 4 tons and operates with a saturated suction temperature of 40° F and a saturated condensing temperature of 120°F. The copper suction line is 52 ft long and has 20 equivalent ft of fittings and valves. Select the proper size for the suction line.

(ii) An R-134a commercial refrigerator has a design capacity of four tons. It operates with a saturated suction temperature of 40°F and a saturated condensing temperature of 120°F. The copper discharge line is 30 ft long and has 10 equivalent ft of fittings and valves. Select the proper diameter for the discharge line.

(iii) Sketch the location of hot gas de-frost line and explain its function.

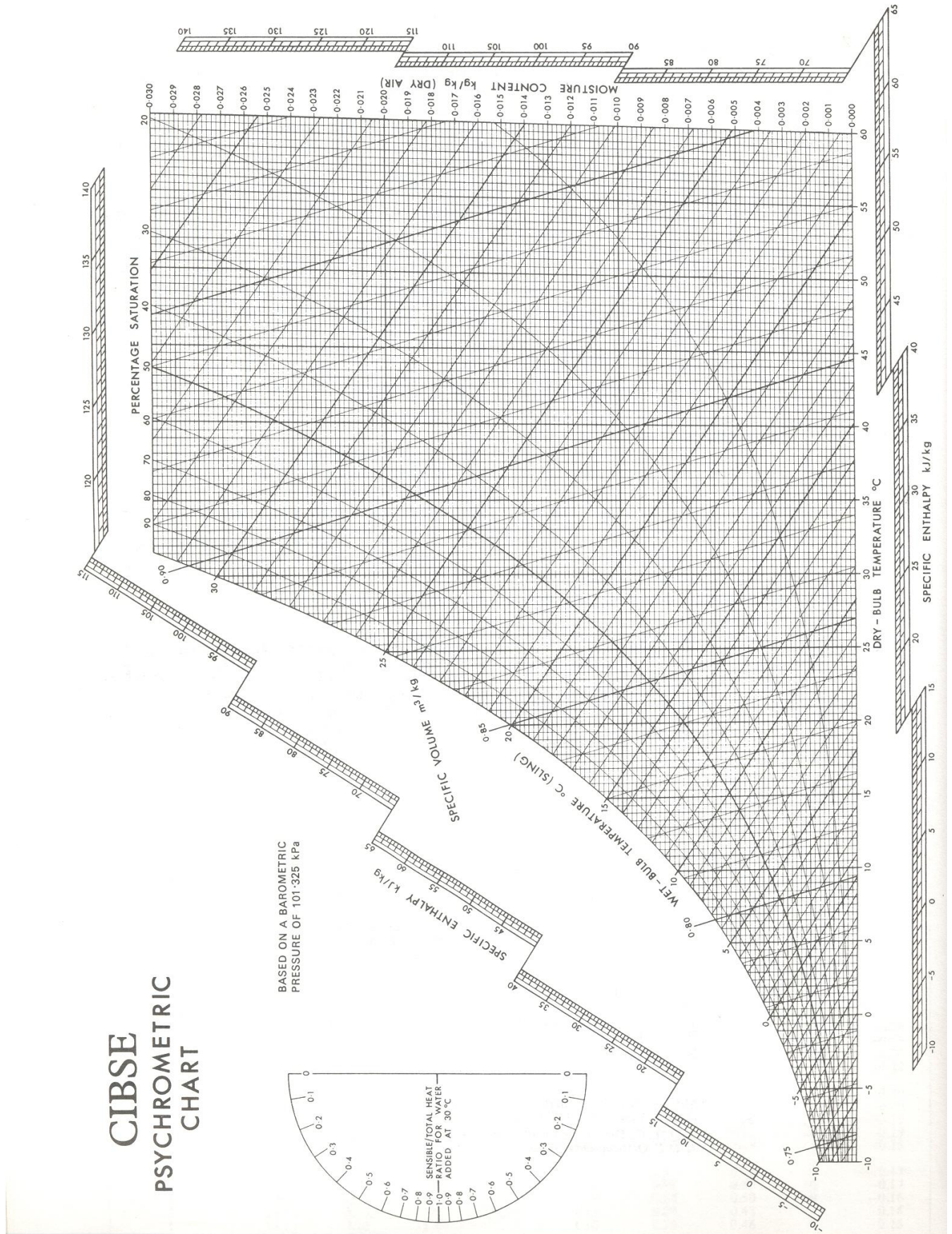
(2 marks)

END OF QUESTION

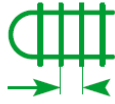
APPENDIX 1: (MUST BE RETURNED)

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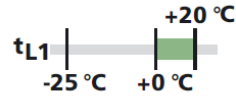
CIBSE GUIDE



APPENDIX 2



4.5 mm 1.6 kW 52 kW



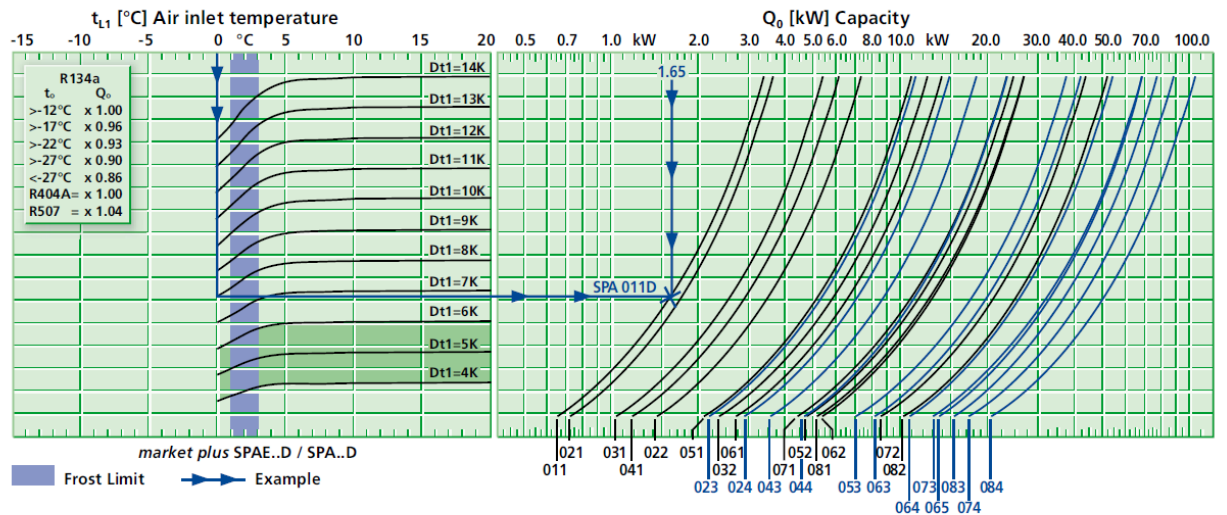
SPA(E)...C Technical data

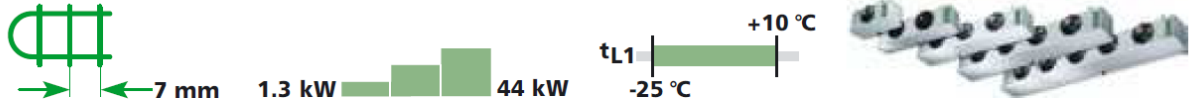
Type	Power Q at 50 Hz DT1, R404A		Cooling area	Air flow	Air throw	Tube volume	Connections		Sound LWA***	Fans (operating values at 50 Hz)				
	t _{L1} ±0 °C DT1 = 8 K	t _{L1} +10 °C DT1 = 10 K					Inlet	Outlet		Blades	Current type	Per fan		
	kW	kW	m ²	m ³ /h	m	dm ³	Ø mm	Ø mm	dB(A)	Pcs. x Ø mm	V ±10 %	rpm	W	A
SPA 011D	1.65	2.44	6.9	820	4	1.4	10	12	63	1 x 250	230V -1	1347	85	0.59
SPA 021D	1.80	2.65	9.1	760	4	1.9	10	12	63	1 x 250	230V -1	1347	85	0.59
SPA 031D	2.65	3.93	10.3	1380	6	2.1	10	18	70	1 x 300	230V -1	1340	80	0.36
SPA 041D	3.00	4.44	13.6	1300	5	2.8	12*	22	70	1 x 300	230V -1	1340	80	0.36
SPA 051D	6.05	8.98	20.5	3020	8	4.2	12*	28	77	1 x 400	230V -1	1420	188	0.83
SPA 061D	6.83	10.1	30.6	2720	7	6.3	12*	28	77	1 x 400	230V -1	1420	188	0.83
SPA 071D	11.3	16.8	36.3	5800	17	7.6	15*	35	83	1 x 500	400V -3	1362	560	1.01
SPA 081D	13.1	19.3	54.2	5270	16	11.1	15*	35	83	1 x 500	400V -3	1362	560	1.01
SPA 022D	3.62	5.34	18.2	1520	6	3.6	12*	22	66	2 x 250	230V -1	1347	85	0.59
SPA 032D	5.33	7.90	20.6	2760	8	4.1	12*	28	73	2 x 300	230V -1	1340	80	0.36
SPA 042D	6.02	8.92	27.3	2600	7	5.5	12*	28	73	2 x 300	230V -1	1340	80	0.36
SPA 052D	11.9	17.7	40.9	6040	12	8.2	15*	35	80	2 x 400	230V -1	1420	188	0.83
SPA 062D	13.4	19.7	60.9	5440	11	12.1	15*	35	80	2 x 400	230V -1	1420	188	0.83
SPA 072D	21.7	31.9	72.7	11600	22	14.3	15*	42	86	2 x 500	400V -3	1362	560	1.01
SPA 082D	25.7	37.9	108.3	10540	21	21.5	22*	42	86	2 x 500	400V -3	1362	560	1.01
SPA 023D	5.51	8.16	27.3	2280	8	5.3	12*	28	68	3 x 250	230V -1	1347	85	0.59
SPA 043D	8.96	13.3	40.9	3900	10	8.0	15*	35	75	3 x 300	230V -1	1340	80	0.36
SPA 053D	18.2	27.0	61.4	9060	15	12.0	22*	42	82	3 x 400	230V -1	1420	188	0.83
SPA 063D	20.6	30.4	91.5	8160	13	18.0	22*	42	82	3 x 400	230V -1	1420	188	0.83
SPA 073D	33.4	49.5	109.2	17400	26	21.3	22*	54	88	3 x 500	400V -3	1362	560	1.01
SPA 083D	38.3	56.3	162.7	15810	24	32.2	22*	54	88	3 x 500	400V -3	1362	560	1.01
SPA 024D	7.26	10.7	36.3	3040	9	7.1	12*	28	69	4 x 250	230V -1	1347	85	0.59
SPA 044D	11.7	17.2	54.5	5200	12	10.6	15*	35	76	4 x 300	230V -1	1340	80	0.36
SPA 064D	26.9	39.6	122.0	10880	16	23.7	22*	42	83	4 x 400	230V -1	1420	188	0.83
SPA 074D	43.5	64.1	145.5	23200	28	28.6	22*	54	89	4 x 500	400V -3	1362	560	1.01
SPA 084D	51.6	76.1	216.9	21080	26	41.0	28*	54	89	4 x 500	400V -3	1362	560	1.01
SPA 065D	34.1	50.4	152.4	13600	18	28.9	22**	54	84	5 x 400	230V -1	1420	188	0.83

Multiple injection via * flow distributor, ** KÜBA-CAL® distributor
 *** Modification of sound power level, see page 47

See page 47 for information about Q_y diagram

Q_y Diagram (R22, R134A, R404A, R507)





SPB(E)...C **Technical data**

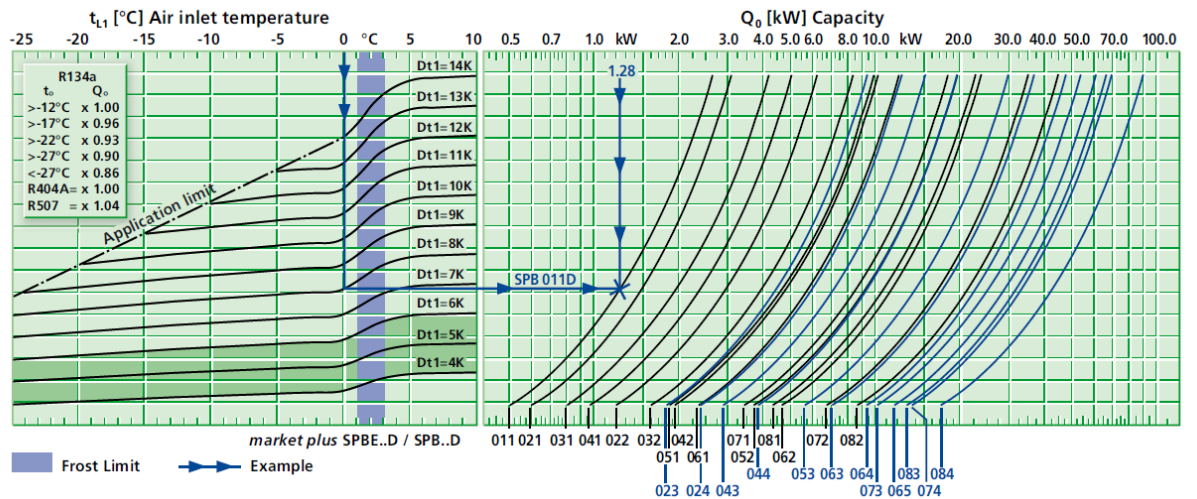
Type	Power Q at 50 Hz DT1, R404A		Cooling area	Air flow	Air throw	Tube volume	Connections		Sound L _{WA} **	Fans (operating values at 50 Hz)				
	t _{L1} ±0 °C DT1 = 8 K	t _{L1} -18 °C DT1 = 7 K					Inlet	Outlet		Blades	Current type	Per fan		
	kW	kW	m ²	m ³ /h	m	dm ³	Ø mm	Ø mm	dB(A)	Pcs. x Ø mm	V ±10 %	rpm	W	A
SPB 011D	1.28	1.01	4.6	880	4	1.4	10	12	63	1 x 250	230V-1	1347	85	0.59
SPB 021D	1.51	1.20	6.0	850	4	1.9	10	12	63	1 x 250	230V-1	1347	85	0.59
SPB 031D	2.03	1.61	6.9	1450	7	2.1	10	18	70	1 x 300	230V-1	1340	80	0.36
SPB 041D	2.45	1.94	9.1	1420	6	2.8	10*	22	70	1 x 300	230V-1	1340	80	0.36
SPB 051D	4.78	3.78	13.7	3320	9	4.2	12*	28	77	1 x 400	230V-1	1420	188	0.83
SPB 061D	5.93	4.70	20.4	3080	8	6.3	12*	28	77	1 x 400	230V-1	1420	188	0.83
SPB 071D	8.75	6.92	24.3	6250	18	7.6	15*	35	83	1 x 500	400V-3	1362	560	1.01
SPB 081D	11.1	8.76	36.3	5880	17	11.1	15*	35	83	1 x 500	400V-3	1362	560	1.01
SPB 022D	3.03	2.41	12.2	1700	6	3.6	10*	22	66	2 x 250	230V-1	1347	85	0.59
SPB 032D	4.05	3.21	13.7	2900	9	4.1	10*	28	73	2 x 300	230V-1	1340	80	0.36
SPB 042D	4.89	3.88	18.2	2840	8	5.5	12*	28	73	2 x 300	230V-1	1340	80	0.36
SPB 052D	9.49	7.52	27.3	6640	13	8.2	15*	35	80	2 x 400	230V-1	1420	188	0.83
SPB 062D	11.7	9.31	40.7	6160	12	12.1	15*	35	80	2 x 400	230V-1	1420	188	0.83
SPB 072D	17.1	13.5	48.6	12500	23	14.3	15*	42	86	2 x 500	400V-3	1362	560	1.01
SPB 082D	21.9	17.4	72.5	11760	22	21.5	22*	42	86	2 x 500	400V-3	1362	560	1.01
SPB 023D	4.59	3.63	18.2	2550	8	5.3	12*	28	68	3 x 250	230V-1	1347	85	0.59
SPB 043D	7.31	5.80	27.3	4260	11	8.0	15*	35	75	3 x 300	230V-1	1340	80	0.36
SPB 053D	14.4	11.4	41.0	9960	16	12.0	22*	42	82	3 x 400	230V-1	1420	188	0.83
SPB 063D	17.8	14.1	61.1	9240	14	18.0	22*	42	82	3 x 400	230V-1	1420	188	0.83
SPB 073D	26.0	20.6	73.0	18750	27	21.3	22*	54	88	3 x 500	400V-3	1362	560	1.01
SPB 083D	32.6	25.9	108.8	17640	25	32.2	22*	54	88	3 x 500	400V-3	1362	560	1.01
SPB 024D	6.08	4.82	24.3	3400	9	7.1	12*	28	69	4 x 250	230V-1	1347	85	0.59
SPB 044D	9.63	7.65	36.5	5680	13	10.6	15*	35	76	4 x 300	230V-1	1340	80	0.36
SPB 064D	23.5	18.7	81.6	12320	17	23.7	22*	42	83	4 x 400	230V-1	1420	188	0.83
SPB 074D	34.2	27.1	97.1	25000	30	28.6	22*	54	89	4 x 500	400V-3	1362	560	1.01
SPB 084D	43.8	34.7	144.8	23520	28	41.0	28*	54	89	4 x 500	400V-3	1362	560	1.01
SPB 065D	29.7	23.5	101.9	15400	19	28.9	22*	54	84	5 x 400	230V-1	1420	188	0.83

Multiple injection via * KÜBA-CAL® distributor

** Modification of sound power level, see page 47

See page 47 for information about Q_y diagram

Q_y Diagram (R22, R134A, R404A, R507)



APPENDIX 3

R134a



Leistungswerte

bezogen auf 20°C Sauggasttemperatur mit Flüssigkeits-Unterkühlung, 50 Hz

Performance data

based on 20°C suction gas temperature with liquid subcooling, 50 Hz

Données de puissance

se référant une température de gaz aspiré de 20°C avec sous-refroidissement, 50 Hz

Typ	Umgeb.-Temp.	Type	Ambient temp.	Type	Temp. ambiante °C	Kälteleistung Cooling capacity Puissance frigorifique			Q_o [Watt]	Leistungsaufnahme Power consumption Puissance absorbée			P_e [kW]			
						Verdampfungstemperatur °C				Evaporation temperature °C				Température d'évaporation °C		
						10	5	0		-5	-10	-15		-20	-25	-30
LH64/2CC-3.2Y	27	Q	11730	9950	8350	6910	5640	4520	3550	2710	2010					
		P	2,68	2,46	2,24	2,03	1,82	1,61	1,41	1,20	1,00					
	32	Q	11040	9360	7840	6480	5270	4210	3290	2500	1820					
		P	2,85	2,61	2,38	2,15	1,92	1,70	1,47	1,24	1,02					
	43	Q	9550	8090	6760	5560	4500	3560	2740	2040	1450					
		P	3,20	2,92	2,66	2,39	2,12	1,85	1,58	1,31	1,03					
LH84/2CC-4.2Y	27	Q	12270	10360	8650	7130	5800	4630	3620	2760	2030					
		P	2,55	2,35	2,16	1,97	1,78	1,58	1,39	1,19	1,00					
	32	Q	11560	9750	8120	6690	5420	4310	3360	2540	1850					
		P	2,72	2,51	2,30	2,09	1,88	1,66	1,45	1,23	1,02					
	43	Q	10050	8450	7020	5740	4620	3650	2800	2080	1470					
		P	3,08	2,83	2,59	2,33	2,08	1,82	1,56	1,29	1,03					
LH64/4FC-3.2Y	27	Q	12480	10570	8840	7290	5920	4710	3660	2760	2000					
		P	2,75	2,55	2,35	2,15	1,94	1,72	1,50	1,28	1,04					
	32	Q	11750	9950	8310	6840	5530	4380	3380	2520	1800					
		P	2,91	2,68	2,47	2,25	2,03	1,80	1,56	1,31	1,05					
	43	Q	10190	8610	7170	5870	4720	3700	2810	2050	1400					
		P	3,25	2,97	2,71	2,46	2,20	1,93	1,65	1,35	1,04					
LH84/4FC-5.2Y	27	Q	13090	11020	9160	7520	6080	4820	3730	2810	2040					
		P	2,71	2,51	2,31	2,11	1,90	1,69	1,48	1,27	1,05					
	32	Q	12330	10370	8610	7050	5670	4480	3450	2570	1830					
		P	2,89	2,68	2,46	2,24	2,01	1,78	1,54	1,30	1,05					
	43	Q	10740	9010	7450	6070	4850	3780	2860	2080	1410					
		P	3,28	3,02	2,76	2,49	2,22	1,94	1,64	1,34	1,04					
LH64/4EC-4.2Y	27	Q	15130	12930	10900	9070	7420	5970	4710	3630	2720					
		P	3,97	3,67	3,37	3,08	2,79	2,50	2,21	1,92	1,64					
	32	Q	14190	12120	10210	8480	6920	5550	4350	3320	2450					
		P	4,21	3,87	3,55	3,22	2,89	2,57	2,25	1,93	1,61					
	43	Q	12170	10390	8730	7210	5840	4630	3560	2640	1870					
		P	4,72	4,31	3,90	3,49	3,08	2,68	2,28	1,88	1,48					
LH84/4EC-6.2Y	27	Q	16200	13730	11490	9500	7740	6200	4860	3710	2750					
		P	3,68	3,44	3,20	2,96	2,70	2,44	2,16	1,88	1,59					
	32	Q	15220	12890	10780	8890	7220	5760	4490	3400	2490					
		P	3,95	3,68	3,40	3,11	2,82	2,52	2,21	1,89	1,56					
	43	Q	13110	11080	9230	7580	6110	4810	3690	2730	1910					
		P	4,53	4,16	3,79	3,41	3,03	2,64	2,24	1,85	1,44					
LH84/4DC-5.2Y	27	Q	18710	15940	13410	11130	9100	7300	5730	4370	3210					
		P	4,60	4,22	3,85	3,48	3,13	2,78	2,43	2,08	1,72					
	32	Q	17600	14990	12590	10430	8500	6800	5300	4010	2910					
		P	4,87	4,46	4,07	3,68	3,29	2,91	2,53	2,14	1,75					
	43	Q	15230	12940	10840	8940	7240	5740	4410	3270	2300					
		P	5,42	4,97	4,52	4,07	3,61	3,16	2,69	2,22	1,74					
LH104/4DC-7.2Y	27	Q	19590	16590	13890	11470	9340	7470	5840	4450	3270					
		P	4,39	4,05	3,71	3,38	3,05	2,72	2,39	2,06	1,74					
	32	Q	18470	15620	13050	10760	8730	6950	5410	4080	2960					
		P	4,67	4,30	3,94	3,58	3,22	2,85	2,49	2,12	1,75					
	43	Q	16060	13550	11280	9250	7460	5880	4510	3330	2330					
		P	5,25	4,83	4,40	3,97	3,54	3,10	2,65	2,20	1,73					
LH84/4CC-6.2Y	27	Q	21350	18340	15530	12970	10660	8610	6810	5240	3900					
		P	5,86	5,30	4,76	4,24	3,75	3,28	2,83	2,39	1,97					
	32	Q	20100	17220	14580	12150	9970	8020	6310	4820	3540					
		P	6,17	5,58	5,01	4,46	3,94	3,43	2,94	2,46	1,99					
	43	Q	17320	14850	12540	10420	8500	6780	5270	3940	2810					
		P	6,81	6,15	5,51	4,90	4,29	3,70	3,12	2,56	2,00					
LH114/4CC-9.2Y	27	Q	23400	19840	16640	13770	11240	9010	7070	5410	4000					
		P	5,35	4,91	4,47	4,04	3,61	3,18	2,76	2,35	1,96					
	32	Q	22000	18660	15630	12920	10510	8390	6550	4970	3630					
		P	5,71	5,22	4,75	4,27	3,80	3,34	2,88	2,43	1,99					
	43	Q	19040	16120	13470	11080	8970	7100	5470	4070	2880					
		P	6,43	5,86	5,30	4,74	4,19	3,64	3,09	2,54	2,01					

⓪ Leistungsaufnahme des Verdichters. Werte für Verflüssiger-Lüfter siehe "Technische Daten" (Seite 18 und 19)

⓪ Power consumption of compressor. Values for condenser fans see "Technical data" (page 18 and 19)

⓪ Puissance absorbée du compresseur. Pour les valeurs des condenseur-ventilateurs voir "Caractéristiques techniques" (page 18 et 19)

■ Zusatzkühlung durch Verflüssiger-Lüfter oder eingeschränkte Sauggasttemperatur. Bei Regelung der Lüfter-Drehzahl auf ausreichende Belüftung des Verdichters achten!

■ Additional cooling by means of condenser fan or limited suction gas temperature. With fan speed control mind sufficient ventilation of the compressor!

■ Refroidissement additionnel par ventilateur du condenseur ou température de gaz aspiré limitée. Avec régulation de la vitesse du ventilateur tenir compte à ventilation suffisante du compresseur!



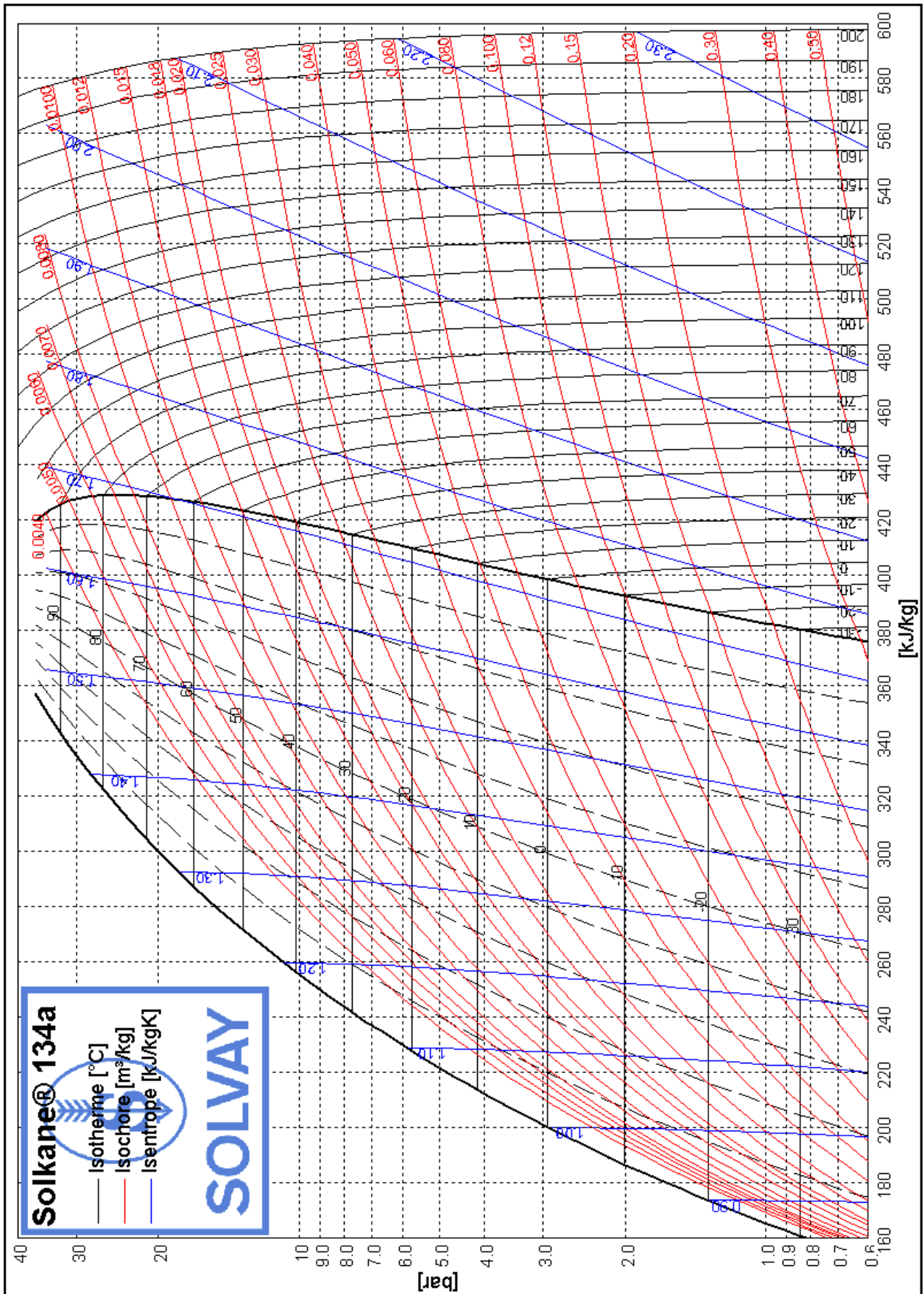
Technische Daten

Technical data

Caractéristiques techniques

Verflüssigungssatz Typ	Verdichter Compressor Compresseur		Lüfter Fan Ventilateur [⊕]			Sammler Receiver Réservoir				Gewicht (Stand.) Weight (Stand.) Poids (Stand.) kg	
	Motor- Anschluss ⊕	max. Betr.-Strom	Strom- aufnahme	Leistungs- aufnahme	Luftdurch- satz Verflüssiger	Standard Typ	Maximale Kälte- mittel-Füllung ⊕				Option größerer Sammler
	Motor connection ⊕	max. operating current	Current consumption	Power consumption	Air flow condenser	Standard type	Maximum refrigerant charge [⊕]				Option larger receiver
Groupe de condensation type	Raccorde- ment de moteur ⊕	Courant de service max.	Consom. de courant	Puissance absorbée	Debit d'air condenseur	Type standard	Charge maximum de fluide frigorigène ⊕			Option réservoir plus grand	
		A	A	Watt	m³/h		R134a kg	R404A R507A kg	R22 kg		kg
LH32/2KC-05.2(Y)	220 .. 240V Δ / 380 .. 420V Y / 3 / 50 Hz 265 .. 290V Δ / 440 .. 480V Y / 3 / 60 Hz	4,6/2,7	0,54	120	1750	FS36	3,3	2,9	3,3	FS56	70
LH32/2JC-07.2(Y)		6,0/3,5	0,54	120	1750	FS36	3,3	2,9	3,3	FS56	70
LH33/2HC-1.2(Y)		6,1/3,5	0,55	120	1710	FS36	3,3	2,9	3,3	FS56	71
LH33/2HC-2.2(Y)		7,4/4,3	0,55	120	1710	FS36	3,3	2,9	3,3	FS56	73
LH33/2GC-2.2(Y)		8,1/4,7	0,55	120	1710	FS36	3,3	2,9	3,3	FS56	73
LH44/2GC-2.2(Y)		8,1/4,7	0,56	125	1840	FS56	6,2	5,4	6,1	FS76	81
LH44/2FC-2.2(Y)		8,5/4,9	0,56	125	1840	FS56	6,2	5,4	6,1	FS76	80
LH44/2FC-3.2(Y)		10,0/5,8	0,56	125	1840	FS56	6,2	5,4	6,1	FS76	81
LH44/2EC-2.2(Y)		9,9/5,7	0,56	125	1840	FS56	6,2	5,4	6,1	FS76	98
LH64/2EC-3.2(Y)		12,0/6,9	1,41	301	3884	FS76	8,6	7,5	8,5	FS126	129
LH53/2DC-2.2(Y)		11,9/6,9	0,86	194	2528	FS56	6,2	5,4	6,1	FS76	114
LH64/2DC-3.2(Y)		13,5/7,8	1,41	301	3884	FS76	8,6	7,5	8,5	FS126	129
LH64/2CC-3.2(Y)		14,8/8,5	1,41	301	3884	FS76	8,6	7,5	8,5	FS126	128
LH84/2CC-4.2(Y)		16,4/9,4	3,08	485	4577	FS126	14,3	12,5	14,2	FS202	134
LH64/4FC-3.2(Y)		15,9/9,2	1,41	301	3884	FS76	8,6	7,5	8,5	FS126	140
LH84/4FC-5.2(Y)		18,7/10,8	3,08	485	4577	FS126	14,3	12,5	14,2	FS202	151
LH64/4EC-4.2(Y)		18,5/10,7	1,41	301	3884	FS76	8,6	7,5	8,5	FS126	142
LH84/4EC-6.2(Y)		22,9/13,2	3,08	485	4577	FS126	14,3	12,5	14,2	FS202	151
LH84/4DC-5.2(Y)		23,4/13,5	3,08	485	4577	FS126	14,3	12,5	14,2	FS202	153
LH104/4DC-7.2(Y)		27,5/15,9	2 x 1,47	2 x 316	7248	F152H	16,6	14,4	16,3	F302H	200
LH84/4CC-6.2(Y)	27,5/15,9	3,08	485	4577	FS126	14,3	12,5	14,2	FS202	157	
LH114/4CC-9.2(Y)	34,5/20,0	2 x 1,41	2 x 301	7804	F152H	16,6	14,4	16,3	F302H	217	

APPENDIX 4



Thermophysical Properties of Refrigerants

20.17

Refrigerant 134a (1,1,1,2-Tetrafluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °C	Pres- sure, MPa	Density, kg/m ³ Liquid	Volume, m ³ /kg Vapor	Enthalpy, kJ/kg		Entropy, kJ/(kg·K)		Specific Heat c _p , kJ/(kg·K)		c _p /c _v	Velocity of Sound, m/s		Viscosity, μPa·s		Thermal Cond., mW/(m·K)		Surface Tension, Temp.,* mN/m °C	
				Liquid	Vapor	Liquid	Vapor	Liquid	Vapor		Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor
-103.30 ^a	0.00039	1591.1	35.4960	71.46	334.94	0.4126	1.9639	1.184	0.585	1.164	1120	126.8	2175.0	6.46	145.2	3.08	28.07	-103.30
-100.00	0.00056	1582.4	25.1930	75.36	336.85	0.4354	1.9456	1.184	0.593	1.162	1103	127.9	1893.0	6.60	143.2	3.34	27.50	-100.00
-90.00	0.00152	1555.8	9.7698	87.23	342.76	0.5020	1.8972	1.189	0.617	1.156	1052	131.0	1339.0	7.03	137.3	4.15	25.79	-90.00
-80.00	0.00367	1529.0	4.2682	99.16	348.83	0.5654	1.8580	1.198	0.642	1.151	1002	134.0	1018.0	7.46	131.5	4.95	24.10	-80.00
-70.00	0.00798	1501.9	2.0590	111.20	355.02	0.6262	1.8264	1.210	0.667	1.148	952	136.8	809.2	7.89	126.0	5.75	22.44	-70.00
-60.00	0.01591	1474.3	1.0790	123.36	361.31	0.6846	1.8010	1.223	0.692	1.146	903	139.4	663.1	8.30	120.7	6.56	20.80	-60.00
-50.00	0.02945	1446.3	0.60620	135.67	367.65	0.7410	1.7806	1.238	0.720	1.146	855	141.7	555.1	8.72	115.6	7.36	19.18	-50.00
-40.00	0.05121	1417.7	0.36108	148.14	374.00	0.7956	1.7643	1.255	0.749	1.148	807	143.6	472.2	9.12	110.6	8.17	17.60	-40.00
-30.00	0.08438	1388.4	0.22594	160.79	380.32	0.8486	1.7515	1.273	0.781	1.152	760	145.2	406.4	9.52	105.8	8.99	16.04	-30.00
-28.00	0.09270	1382.4	0.20680	163.34	381.57	0.8591	1.7492	1.277	0.788	1.153	751	145.4	394.9	9.60	104.8	9.15	15.73	-28.00
-26.07b	0.10133	1376.7	0.19018	165.81	382.78	0.8690	1.7472	1.281	0.794	1.154	742	145.7	384.2	9.68	103.9	9.31	15.44	-26.07
-26.00	0.10167	1376.5	0.18958	165.90	382.82	0.8694	1.7471	1.281	0.794	1.154	742	145.7	383.8	9.68	103.9	9.32	15.43	-26.00
-24.00	0.11130	1370.4	0.17407	168.47	384.07	0.8798	1.7451	1.285	0.801	1.155	732	145.9	373.1	9.77	102.9	9.48	15.12	-24.00
-22.00	0.12165	1364.4	0.16006	171.05	385.32	0.8900	1.7432	1.289	0.809	1.156	723	146.1	362.9	9.85	102.0	9.65	14.82	-22.00
-20.00	0.13273	1358.3	0.14739	173.64	386.55	0.9002	1.7413	1.293	0.816	1.158	714	146.3	353.0	9.92	101.1	9.82	14.51	-20.00
-18.00	0.14460	1352.1	0.13592	176.23	387.79	0.9104	1.7396	1.297	0.823	1.159	705	146.4	343.5	10.01	100.1	9.98	14.21	-18.00
-16.00	0.15728	1345.9	0.12551	178.83	389.02	0.9205	1.7379	1.302	0.831	1.161	695	146.6	334.3	10.09	99.2	10.15	13.91	-16.00
-14.00	0.17082	1339.7	0.11605	181.44	390.24	0.9306	1.7363	1.306	0.838	1.163	686	146.7	325.4	10.17	98.3	10.32	13.61	-14.00
-12.00	0.18524	1333.4	0.10744	184.07	391.46	0.9407	1.7348	1.311	0.846	1.165	677	146.8	316.9	10.25	97.4	10.49	13.32	-12.00
-10.00	0.20060	1327.1	0.09959	186.70	392.66	0.9506	1.7334	1.316	0.854	1.167	668	146.9	308.6	10.33	96.5	10.66	13.02	-10.00
-8.00	0.21693	1320.8	0.09242	189.34	393.87	0.9606	1.7320	1.320	0.863	1.169	658	146.9	300.6	10.41	95.6	10.83	12.72	-8.00
-6.00	0.23428	1314.3	0.08587	191.99	395.06	0.9705	1.7307	1.325	0.871	1.171	649	147.0	292.9	10.49	94.7	11.00	12.43	-6.00
-4.00	0.25268	1307.9	0.07987	194.65	396.25	0.9804	1.7294	1.330	0.880	1.174	640	147.0	285.4	10.57	93.8	11.17	12.14	-4.00
-2.00	0.27217	1301.4	0.07436	197.32	397.43	0.9902	1.7282	1.336	0.888	1.176	631	147.0	278.1	10.65	92.9	11.34	11.85	-2.00
0.00	0.29280	1294.8	0.06931	200.00	398.60	1.0000	1.7271	1.341	0.897	1.179	622	146.9	271.1	10.73	92.0	11.51	11.56	0.00
2.00	0.31462	1288.1	0.06466	202.69	399.77	1.0098	1.7260	1.347	0.906	1.182	612	146.9	264.3	10.81	91.1	11.69	11.27	2.00
4.00	0.33766	1281.4	0.06039	205.40	400.92	1.0195	1.7250	1.352	0.916	1.185	603	146.8	257.6	10.90	90.2	11.86	10.99	4.00
6.00	0.36198	1274.7	0.05644	208.11	402.06	1.0292	1.7240	1.358	0.925	1.189	594	146.7	251.2	10.98	89.4	12.04	10.70	6.00
8.00	0.38761	1267.9	0.05280	210.84	403.20	1.0388	1.7230	1.364	0.935	1.192	585	146.5	244.9	11.06	88.5	12.22	10.42	8.00
10.00	0.41461	1261.0	0.04944	213.58	404.32	1.0485	1.7221	1.370	0.945	1.196	576	146.4	238.8	11.15	87.6	12.40	10.14	10.00
12.00	0.44301	1254.0	0.04633	216.33	405.43	1.0581	1.7212	1.377	0.956	1.200	566	146.2	232.9	11.23	86.7	12.58	9.86	12.00
14.00	0.47288	1246.9	0.04345	219.09	406.53	1.0677	1.7204	1.383	0.967	1.204	557	146.0	227.1	11.32	85.9	12.77	9.58	14.00
16.00	0.50425	1239.8	0.04078	221.87	407.61	1.0772	1.7196	1.390	0.978	1.209	548	145.7	221.5	11.40	85.0	12.95	9.30	16.00
18.00	0.53718	1232.6	0.03830	224.66	408.69	1.0867	1.7188	1.397	0.989	1.214	539	145.5	216.0	11.49	84.1	13.14	9.03	18.00
20.00	0.57171	1225.3	0.03600	227.47	409.75	1.0962	1.7180	1.405	1.001	1.219	530	145.1	210.7	11.58	83.3	13.33	8.76	20.00
22.00	0.60789	1218.0	0.03385	230.29	410.79	1.1057	1.7173	1.413	1.013	1.224	520	144.8	205.5	11.67	82.4	13.53	8.48	22.00
24.00	0.64578	1210.5	0.03186	233.12	411.82	1.1152	1.7166	1.421	1.025	1.230	511	144.5	200.4	11.76	81.6	13.72	8.21	24.00
26.00	0.68543	1202.9	0.03000	235.97	412.84	1.1246	1.7159	1.429	1.038	1.236	502	144.1	195.4	11.85	80.7	13.92	7.95	26.00
28.00	0.72688	1195.2	0.02826	238.84	413.84	1.1341	1.7152	1.437	1.052	1.243	493	143.6	190.5	11.95	79.8	14.13	7.68	28.00
30.00	0.77020	1187.5	0.02664	241.72	414.82	1.1435	1.7145	1.446	1.065	1.249	483	143.2	185.8	12.04	79.0	14.33	7.42	30.00
32.00	0.81543	1179.6	0.02513	244.62	415.78	1.1529	1.7138	1.456	1.080	1.257	474	142.7	181.1	12.14	78.1	14.54	7.15	32.00
34.00	0.86263	1171.6	0.02371	247.54	416.72	1.1623	1.7131	1.466	1.095	1.265	465	142.1	176.6	12.24	77.3	14.76	6.89	34.00
36.00	0.91185	1163.4	0.02238	250.48	417.65	1.1717	1.7124	1.476	1.111	1.273	455	141.6	172.1	12.34	76.4	14.98	6.64	36.00
38.00	0.96315	1155.1	0.02113	253.43	418.55	1.1811	1.7118	1.487	1.127	1.282	446	141.0	167.7	12.44	75.6	15.21	6.38	38.00
40.00	1.0166	1146.7	0.01997	256.41	419.43	1.1905	1.7111	1.498	1.145	1.292	436	140.3	163.4	12.55	74.7	15.44	6.13	40.00
42.00	1.0722	1138.2	0.01887	259.41	420.28	1.1999	1.7103	1.510	1.163	1.303	427	139.7	159.2	12.65	73.9	15.68	5.88	42.00
44.00	1.1301	1129.5	0.01784	262.43	421.11	1.2092	1.7096	1.523	1.182	1.314	418	138.9	155.1	12.76	73.0	15.93	5.63	44.00
46.00	1.1903	1120.6	0.01687	265.47	421.92	1.2186	1.7089	1.537	1.202	1.326	408	138.2	151.0	12.88	72.1	16.18	5.38	46.00
48.00	1.2529	1111.5	0.01595	268.53	422.69	1.2280	1.7081	1.551	1.223	1.339	399	137.4	147.0	13.00	71.3	16.45	5.13	48.00
50.00	1.3179	1102.3	0.01509	271.62	423.44	1.2375	1.7072	1.566	1.246	1.354	389	136.6	143.1	13.12	70.4	16.72	4.89	50.00
52.00	1.3854	1092.9	0.01428	274.74	424.15	1.2469	1.7064	1.582	1.270	1.369	379	135.7	139.2	13.24	69.6	17.01	4.65	52.00
54.00	1.4555	1083.2	0.01351	277.89	424.83	1.2563	1.7055	1.600	1.296	1.386	370	134.7	135.4	13.37	68.7	17.31	4.41	54.00
56.00	1.5282	1073.4	0.01278	281.06	425.47	1.2658	1.7045	1.618	1.324	1.405	360	133.8	131.6	13.51	67.8	17.63	4.18	56.00
58.00	1.6036	1063.2	0.01209	284.27	426.07	1.2753	1.7035	1.638	1.354	1.425	350	132.7	127.9	13.65	67.0	17.96	3.95	58.00
60.00	1.6818	1052.9	0.01144	287.50	426.63	1.2848	1.7024	1.660	1.387	1.448	340	131.7	124.2	13.79	66.1	18.31	3.72	60.00
62.00	1.7628	1042.2	0.01083	290.78	427.14	1.2944	1.7013	1.684	1.422	1.473	331	130.5	120.6	13.95	65.2	18.68	3.49	62.00
64.00	1.8467	1031.2	0.01024	294.09	427.61	1.3040	1.7000	1.710	1.461	1.501	321	129.4	117.0	14.11	64.3	19.07	3.27	64.00
66.00	1.9337	1020.0	0.00969	297.44	428.02	1.3137	1.6987	1.738	1.504	1.532	311	128.1	113.5	14.28	63.4	19.50	3.05	66.00
68.00	2.0237	1008.3	0.00916	300.84	428.36	1.3234	1.6972	1.769	1.552	1.567	3							