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SET A

UNIVERSITI KUALA LUMPUR

MALAYSIA FRANCE INSTITUTE

FINAL EXAMINATION

JANUARY 2011 SESSION

SUBJECT CODE	: FRB 40103
SUBJECT TITLE	: TECHNOLOGY OF INDUSTRIAL REFRIGERATION
LEVEL	: BACHELOR
TIME/DURATION	: 9.00 AM – 12.00 PM (3 HOURS)
DATE	: 6 MAY 2011

INSTRUCTIONS TO CANDIDATES

1. All documents authorized (OPEN BOOK EXAMINATION)
2. This question paper is printed on both sides of the paper.
3. Answer should be written in blue or black ink except for sketching, graphic and illustration.
4. This question paper consists only one section. Answer all questions.
5. Answer all questions in English.

THERE ARE 3 PRINTED PAGES OF QUESTIONS AND 3 PAGES OF APPENDICE, EXCLUDING THIS PAGE

INSTRUCTION: Answer ALL questions.

Please use the answer booklet provided.

A freezing system for prepared food products requires a freezing capacity of 200 kW at -38/+35°C. The selected refrigerant is the R22. Superheat at suction is +5K, liquid subcooling is 0K.

In these working conditions, the isentropic efficiency of the system is estimated as $\eta_{is} = 1-0.041\tau$ where τ is the compression ratio.

PART A

Question 1

Calculate the discharge temperature for an isentropic compression for the defined cycle temperature

(2 marks)

Question 2

Calculate the real discharge temperature one can expect with a single stage compression system in the defined conditions.

(2 marks)

Question 3

Comment on the value you obtain

(2 marks)

PART B

The retained solution is based on the use of a screw compressor with Economizer as described in Appendix 1. The saturated vapour used for injection is obtained with an intermediate pressure receiver.

Question 4

Explain the advantages and drawbacks of this solution

(2 marks)

Question 5

Explain the role of the oil in this application, and especially, comment on the value of the proposed oil volume rate and the consequence of this value and on the value of the oil cooler load.

(2 marks)

Question 6

Calculate the condensing capacity required for this application.

(2 marks)

PART C

The oil content at the outlet of the separator is 50 ppm.

Question 7

Assuming that the compressor is running 16 hours a day, calculate the quantity of oil susceptible to be accumulated in the low pressure receiver after a 2 months running period.

(2 marks)

PART D

In the purpose to prevent some troubles, the maximum oil content we can accept in the low pressure receiver is 0.5%

Question 8

Explain the nature of the troubles we want to prevent

(2 marks)

Question 9

Calculate the volume flow rate to be rectified to prevent these troubles.

(2 marks)

Question 10

Build up the diagram of the refrigeration system, with the compressor(s), receivers, oil recuperation, oil cooler, and all other necessary annexes at the adequate position on the diagram.

(2 marks)

END OF QUESTION

Appendix 1: Open Screw Compressors of R22 at -38/+35 ° C with ECO
Appendix 2 R22 Saturated table.
Appendix 3 P-H diagram of R22

Appendix 1

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BITZER-Software Version 5.1.2
(c) 2009, BITZER, Germany. All data subject to change.
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22/11/2010

Compressor Selection: Open Screw Compressors
Input Values:

Compressor model	OSN8571-K
Refrigerant	R22
Reference temperature	Dew point temp.
Evaporating SST	-38°C
Condensing SDT	35°C
Operating mode	ECO
Liquid temperature	Auto
Discharge gas temp.	80°C
Suct. gas superheat	5K
Useful superheat	100%
Speed	2900 /min
Capacity Control	100%

Output:

Compressor model	OSN8571-K
Cooling capacity	100.2 kW
Cooling capacity *	102.3 kW
Evaporator capacity	100.2 kW
Power input	63.8 kW
Condensing capacity	XXXXX kW
COP/EER	1.57
COP/EER *	1.59
Mass flow LP	1803 kg/h
Mass flow HP	2349 kg/h
Operating mode	ECO
Liquid temp. (sc)	-5.55 °C
Mass flow ECO	546 kg/h
sub cooler load	24.8 kW
sat. ECO Temp.	-15.55 °C
ECO pressure	2.90 bar
Oil volume flow	2.75 m³/h
Oil cooler outlet	60.9 °C
Oil cooler load	25.1 kW
Necces. driving motor	90.0 kW

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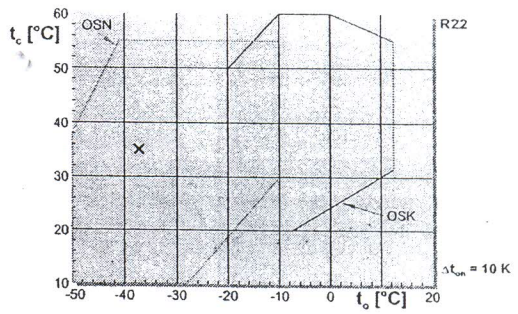
*According to EN12900 (10K suction gas superheat, liquid subcooling in Economiser with 5K temperature difference)

Application Limits (Standard)

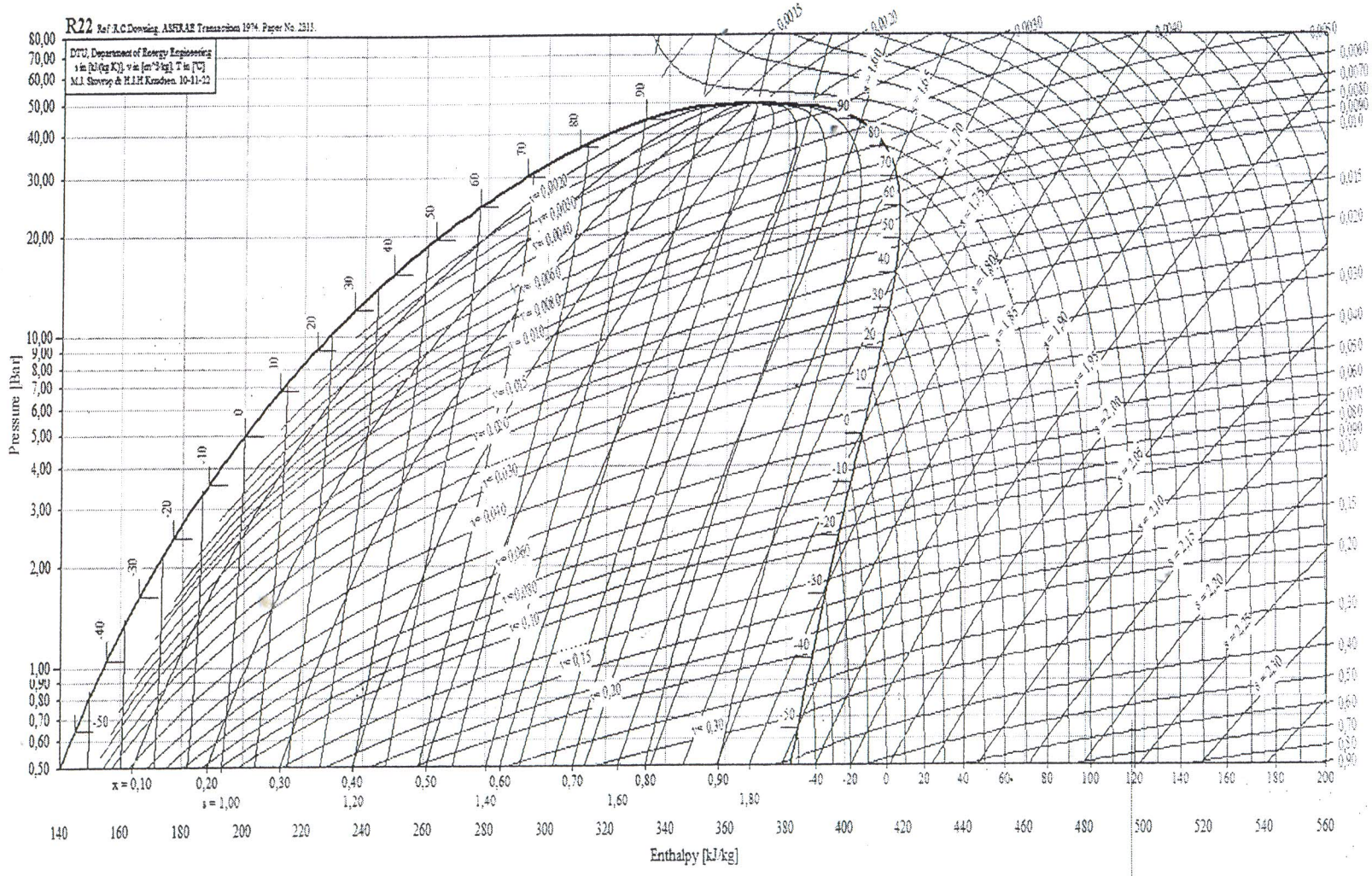


Appendix 2

Refrigerant: R22, CHClF2, Chlorodifluoromethane
Reference: R.C.Downing. ASHRAE Transactions 1974. Paper No. 2313.

T	P	Vl	Vg	Hl	Hg	R	Sl	Sg
-C	Bar	dm^3/kg	m^3/kg	kJ/kg	kJ/kg	kJ/kg	kJ/(kgK	)kJ/(kgK)
-50	0,644	0,6952	0,32461	144,94	383,93	238,99	0,7791	1,8501
-45	0,827	0,7022	0,25703	150,14	386,29	236,15	0,8021	1,8372
-40	1,049	0,7093	0,20578	155,4	388,62	233,22	0,8248	1,8251
-35	1,317	0,7168	0,16642	160,73	390,91	230,18	0,8474	1,8139
-30	1,635	0,7245	0,13586	166,13	393,15	227,02	0,8697	1,8034
-25	2,01	0,7325	0,11187	171,6	395,34	223,74	0,8918	1,7935
-20	2,448	0,7409	0,09286	177,13	397,48	220,34	0,9138	1,7842
-15	2,957	0,7496	0,07763	182,74	399,55	216,81	0,9356	1,7755
-10	3,543	0,7587	0,06535	188,42	401,56	213,14	0,9572	1,7672
-5	4,213	0,7683	0,05534	194,17	403,51	209,33	0,9787	1,7593
0	4,976	0,7783	0,04714	200	405,37	205,37	1	1,7519
5	5,838	0,7889	0,04036	205,9	407,15	201,25	1,0212	1,7447
10	6,807	0,8	0,03472	211,88	408,84	196,96	1,0422	1,7378
15	7,891	0,8118	0,02999	217,92	410,44	192,52	1,0631	1,7312
20	9,099	0,8243	0,02601	224,07	411,93	187,86	1,0839	1,7247
25	10,439	0,8376	0,02263	230,31	413,3	182,99	1,1046	1,7183
30	11,919	0,8519	0,01974	236,65	414,54	177,89	1,1253	1,7121
35	13,548	0,8673	0,01727	243,1	415,64	172,54	1,1459	1,7058
40	15,335	0,8839	0,01514	249,67	416,57	166,9	1,1666	1,6995
45	17,29	0,902	0,01329	256,38	417,32	160,93	1,1873	1,6931
50	19,423	0,9219	0,01167	263,25	417,85	154,6	1,2081	1,6865
55	21,744	0,944	0,01025	270,31	418,13	147,82	1,2291	1,6796
60	24,266	0,9687	0,009	277,58	418,1	140,52	1,2504	1,6722
65	26,999	0,997	0,00789	285,13	417,7	132,56	1,2721	1,6641
70	29,959	1,0298	0,00689	293,03	416,82	123,79	1,2944	1,6551
75	33,161	1,0691	0,00598	301,4	415,31	113,91	1,3176	1,6448
80	36,623	1,1181	0,00515	310,42	412,91	102,49	1,3422	1,6325
85	40,368	1,1832	0,00436	320,5	409,11	88,61	1,3694	1,6168
90	44,425	1,2823	0,00357	332,6	402,67	70,07	1,4015	1,5945

Appendix 3


R22 Ref: A.C.Downing, ASHRAE Transactions 1974, Paper No. 2313.
DTU, Department of Energy Engineering
s in [kJ/(kg K)], v in [m^3/kg], T in [°C]
M.J. Skovrup & H.J.H. Knudsen, 10-11-22
Pressure [Bar]
Enthalpy [kJ/kg]