Thammasat English Programme of Engineering (TEPE)
Thammasat University

2nd examination 1st Semester 2010
ME 434 Refrigeration and air-conditioning systems Section 750001
Sep 16th, 2010: 18.00 – 21.00

Name_____ ID No._____ Seat No._____

Instruction

1. Total scores are 35 points
2. Write Name, surname, student ID in both **answer book and enclosed documents**
3. Total examination papers composed of questions, attached documents, graph and table are 32 pages
4. Total main questions are 4
5. Answer question 1 to 3 in answer book. **Do question 4 in attached documents** (page 5 and page 6)
6. Total graph and table for calculation are 26 pages (page 7 to page 32)
7. Allow **one page of A4** for short note
8. Allow all types of calculator
9. In case of missing of any information, student must appropriately assume it.
10. Not allow to go out from examination room before submitting your answer book
11. During exam, prohibit borrowing anything from other people.

1. Answer the following questions

1.1 Defrost

1.1.1 Why do we need to do defrost on the surface of evaporating coils? (0.5 point)

1.1.2 Explain the defrost method by hot gas (1 point)

1.1.3 Explain the defrost method by electric heater (1 point)

1.2 Cooling system in refrigeration system

1.2.1 Draw schematic diagram of the system using water-cooled condenser and identify the name of each equipment in this system (1 point)

1.2.2 Draw schematic diagram of the system using air-cooled condenser, and identify the name of each equipment in this system (1 point)

1.3 Cooling tower

1.3.1 Explain the principle of operation of the counter-flow cooling tower and the cross - flow cooling tower. (1 point)

1.3.2 Answer the following questions

1.3.2.1 What is drift loss? And how to reduce it? (1 point)

1.3.2.2 What is re-circulation? And what is the cause of re-circulation? (1 point)

1.3.2.3 What is the purpose of bleed off (purge or blow down)? (0.5 point)

1.3.3 If it is found that exiting water from cooling tower can not reduced temperature to a desired temperature, what are the causes? (Answer at least 4 causes) And explain the details of each cause? (1 point)

1.4 Sight glass in refrigeration system

1.4.1 What is the function of sight glass? (0.5 point)

1.4.2 If it is found from sight glass that refrigerant is bubble gas, what is happened in this refrigeration system? Explain at least 2 causes (1 point)

2 Refrigerant

2.1 How many types of refrigerant, which is categorized by EIT (The Engineering Institute of Thailand Under H.M. The King's Patronage)? And what are they? (1.5 point)

2.2 From Figure 2.1, which shows the thermodynamic properties of various refrigerants at evaporating temperature of 15^{O}C, and condensing temperature of 30^{O}C. Answer the following questions:

Refrig-erant	Evap-orating pressure, kPa	Condens-ing pressure, kPa	Pressure ratio	Refrig-erating effect, kJ/kg	Suction vapor flow per kW of refrigeration, L/s	COP
11	20.4	125.5	6.15	155.4	4.90	5.03
12	182.7	744.6	4.08	116.3	0.782	4.70
22	295.8	1192.1	4.03	162.8	0.476	4.66
502	349.6	1308.6	3.74	106.2	0.484	4.37
717	236.5	1166.6	4.93	1103.4	0.462	4.76

Figure of problem 2.1

2.2.1 Which refrigerant must be considered extremely about the leakage problem? And what is the parameter in the table to use for this considering? (1 point)

2.2.2 Which refrigerant must be considered about low volumetric efficiency of compressor? And what is the parameter in the table to use for this considering? (1 point)

2.2.3 If volume flow rate is low, what will be happened in the refrigeration system? (0.5 point)

2.2.4 If R-717 (Ammonia) is used in the refrigeration system, what should we be careful about Ammonia? (0.5 point)

2.2.5 Which refrigerant is suitable to use at a very low temperature? (Selecting based on the minimum freezing temperature) (0.5 point)

2.2.6 Which refrigerants lead to ozone depletion? (0.5 point)

2.2.7 What the difference between ozone depletion and global warming? (1 point)

3 Compute heat transfer coefficient of fluid flowing in a 30-mm-inner-diameter pipe with velocity of 2 m/s. If

3.1 Case 1 Refrigerant is water, which has temperature of 10^{O}C and viscosity of 0.0016 Pa.s. Moreover, thermal conductivity is 0.584 W/m.K, density of water is 1000 kg/m^3, and specific heat is 4.19 kJ/kg.K (2 point)

3.2 Case 2 Refrigerant is a mixture of water and 30% anti-freeze Ethylene glycol. Define working temperature to be at -10 ^{O}C (2 point)

4 A five-star hotel has a heavy-usage cold-storage room for freezing fresh pork. The cold storage is located in the building. Dimensions of the cold storage room are 16 m (wide) × 12 m (long) × 3.4 m (high), as shown in the Figure of problem 4. Temperature of the cold storage room is maintained at –10 ^{O}C. East wall of the cold storage room is adjacent to an area, which is also maintained temperature at 2 ^{O}C, and west wall is adjacent to a loading dock, which is maintained temperature at 2 ^{O}C. Other details are shown as following:

- Wall construction: each wall, floor, and ceiling is composed of double walls of gypsum board, where thickness of each board is 25 mm. In addition, between gypsum walls is filled with 100-mm-thickness fiber-glass insulation. In order to find overall heat transfer coefficient factor (U factor), define the total equivalent thickness is 150 mm for each wall.
- All walls of the cold storage room are in building. Temperature inside building is 25 ^{O}C, and temperature outside building is 35 ^{O}C.
- Define fresh pork is packed in twenty boxes. Total weight of each box is 101 kg, which is 100 kg for pork, and 1 kg for a box. Freezing temperature of box is much lower than –10 ^{O}C. Define a desired cooling time is 5 hr per day. And define chilling rate factor 0.75 for fresh pork, and 1 for box.
- Temperature of fresh pork and boxes before entering the cold storage room is 20 ^{O}C
- Inside the cold storage room has five 200-watt lamps, and average usage is 3 hr per day.
- Two people works in this room for 3 hr per day

Find total cooling loads in kW, and determine the required equipment capacity in kW based on a 20 hr operating time.

Note Fill data in the attached paper by not showing solution in answer book.

Define

- Specific heat of box is 2.5 kJ/kg.K
- Chilling rate factor for box is 1
- Safety factor is 10%

(14 point)

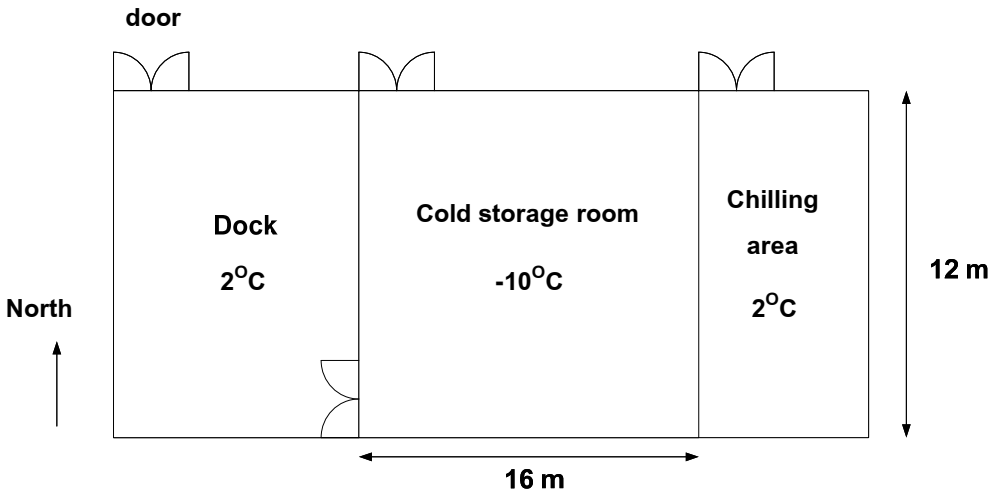


Figure of problem 4

Attached paper for problem 4

Name_____Surname _____ID_____

Project

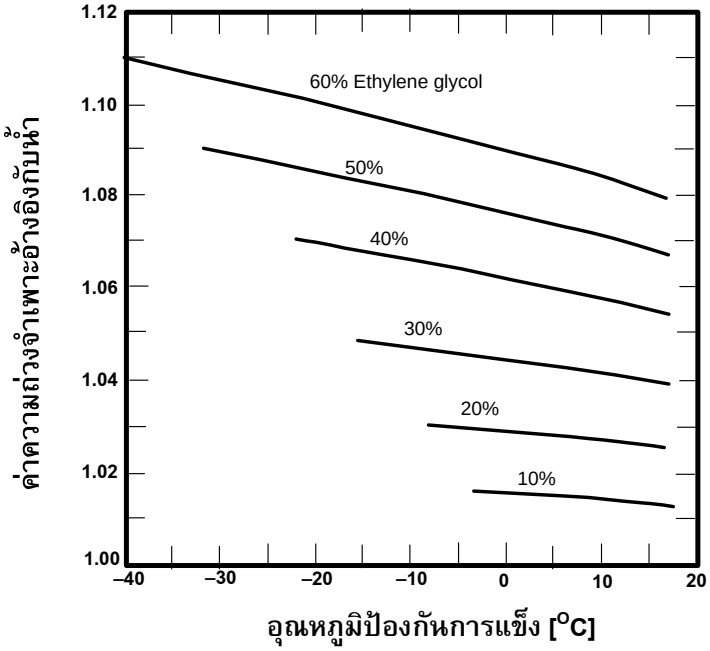
Product

item							
1	Wall heat gain load	U [W/m2.K]	A [m^2]	TD [^oC]	formula		load [kW]
1.1	North						
1.2	East						
1.3	South						
1.4	West						
1.5	Ceiling						
1.6	Floor						
sum of product load							
2	Air change load	Volume	Air change factor [kJ/liter]	Air change rate [liter/s]	formula		load [kW]
2.1							
2.2							
sum ofl air change load							
3	Product load	mass kg	Cp kJ/kg.K	TD [^oC]	Chilling rate factor	formula	load [kW]
3.1							
3.2							
3.3							
3.4							
3.5							
3.6							
sum of product load							
4	Respiration load	mass		respiration rate		formula	load [kW]
4.1							
4.2							
4.3							
	sum of respiration load						

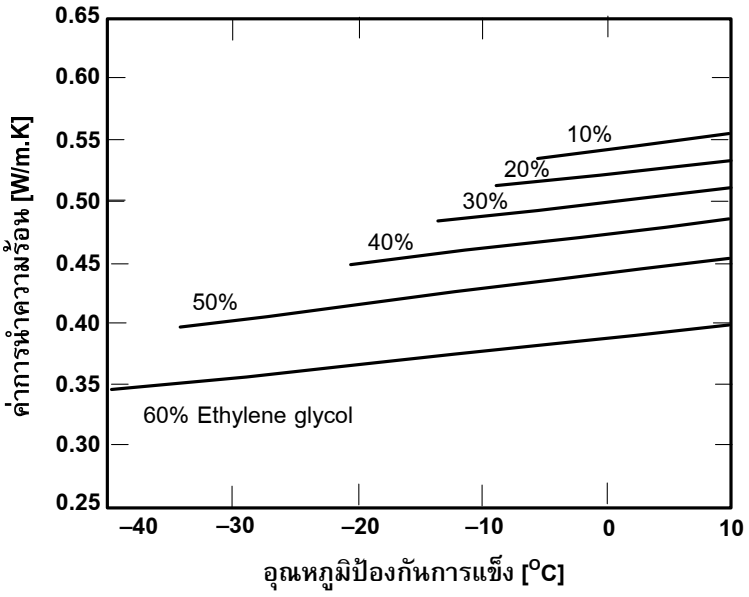
Attached paper for problem 4

Name_____Surname _____ID_____

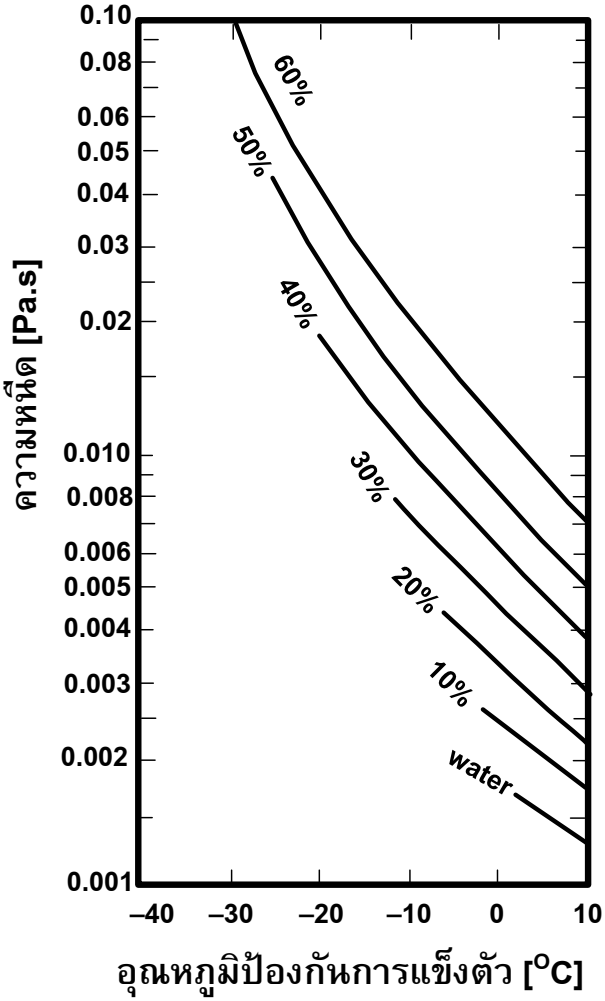
5	Miscellaneous load	Number	heat equilavent W	Operating time hr	formula	load [kW]
5.1						
5.2						
5.3						
Total miscellaneous load						
					Formula	load [kW]
6	Sum of cooling load [kW]					
7	10% Safety factor [kW]					
8	Total cooling load [kW]					
9	Required refrigeration capacity [kW]					



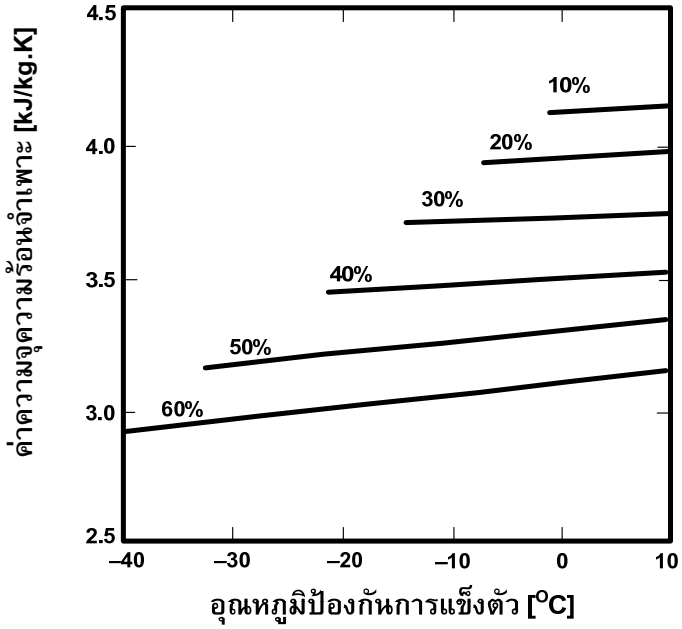
Specific gravity of ethylene glycol-water solutions based on water at $4^{O}C$ (density = 1000 kg/m^{3})



Thermal conductivity of ethylene glycol-water solutions



Viscosity of ethylene glycol-water solutions



Specific heat of ethylene glycol-water solutions

ภาคผนวก ข

ตาราง ข-1 ค่าการนำความร้อนของวัสดุที่ใช้ทำผนังห้องเย็น

Material	Description	Thermal conductivity (k)	Thermal conductance (C)
		[W/m.K]	$W/m^2.K$
Material	Brick, common	0.72	
	Brick, face	1.30	
	Concrete, mortar or plaster	0.72	
	Concrete, sand aggregate	1.73	
	Concrete block		
	Sand aggregate 100 mm		7.95
	Sand aggregate 200 mm		5.11
	Sand aggregate 300 mm		4.43
	Cinder aggregate 100 mm		5.11
	Cinder aggregate 200 mm		3.29
	Cinder aggregate 300 mm		3.01
	Gypsum plaster 13 mm		17.72
	Tile, hollow lay 100 mm		5.11
	Tile, hollow lay 150 mm		3.75
	Tile, hollow lay 200 mm		3.07
Wood	Maple, oak, similar hardwoods	0.16	
	Fire, pine, similar softwoods	0.12	
	Plywood 13 mm		9.09
	Plywood 19 mm		6.08
Rooting	Asphalt roll roofing		36.91
	Built-up rooting 9 mm		17.03
Insulating	Blanket or ball, mineral or glass fiber	0.039	
Materials	Board or slab		
	Cellalar glass	0.058	
	Corkboard	0.043	
	Glass fiber	0.036	
	Expanded polystyrene(smooth)	0.029	
	Expanded polystyrene(cut cell)	0.036	
	Expanded polyurethane	0.025	
	Loose fill		
	Milled paper or wood pulp	0.039	
	Sawdust or shavings	0.065	
	Mineral wool (rock, glass, slag)	0.039	
	Redwood bark	0.037	
	Wood fiber (soft woods)	0.043	
Surface	Still air		9.37
conductance	Moving air (3.35 ms/ or 12 m/h)		22.70
(convection coefficient)	Moving air (6.7 ms/ or 24 m/h)		34.10

ตาราง ข-1 ค่าการนำความร้อนของวัสดุที่ใช้ทำผนังห้องเย็น

Material	**Description**	**Thermal conductivity** (k)	**Thermal conductance** (C)
		[W/m.K]	W/m2.K
Glass	Single pane		6.42
	Two pane		2.61
	Three pane		1.65
	Four pane		1.19

[ที่มา ASHRAE Handbook. Fundamental volume, 1972]

ตาราง ข-2 ค่าสัมประสิทธิ์การถ่ายเทความร้อน (ตัวประกอบ U) สำหรับ ผนัง หลังคา และ พื้น ของห้องเย็น [W/m².K]

Insulation thickness	**Insulation k Factor [W/m.K]**							
[mm]	**0.025**	**0.03**	**0.035**	**0.040**	**0.045**	**0.050**	**0.055**	**0.060**
25	0.732	0.834	0.931	0.013	0.091	1.163	1.229	1.289
50	0.42	0.489	0.556	0.617	0.675	0.731	0.784	0.834
75	0.295	0.346	0.397	0.443	0.489	0.533	0.576	0.617
100	0.227	0.267	0.308	0.346	0.383	0.42	0.455	0.489
125	0.182	0.218	0.252	0.283	0.315	0.346	0.376	0.405
150	0.153	0.184	0.213	0.240	0.267	0.294	0.32	0.346
175	0.136	0.159	0.185	0.208	0.232	0.256	0.279	0.302
200	0.119	0.140	0.163	0.184	0.206	0.227	0.247	0.267

ตาราง ข-3.1 สภาวะอากาศสำหรับประเทศแคนนาดา (อุณหภูมิในหน่วยองศาเซลเซียส)

WINTER											SUMMER			
Col.1	Col.2		Col.3		Col.4	Col.5		Col.6			Col.7	Col.8		
Province and station	Latitude		Longitude		Elevation [m]	Design	Dry-bulb	Design dry bulb and mean coincident wet-bulb			Mean daily range	Design wet bulb		
						99%	97.5%	1%	2.5%	5%		1%	2.5%	5%
ALBERTA														
Calgary AP	51	6	114	1	1079	-33	-31	29/17	27/16	26/17	14	18	17	17
Edmonton AP	53	34	113	31	676	-34	-32	29/19	28/18	26/17	13	20	19	18
Grande Prairie AP	55	11	118	53	668	-39	-36	28/18	27/17	26/16	13	19	18	17
Jasper	52	53	118	4	1061	-35	-32	28/18	27/17	26/16	16	19	18	17
Lethbridge AP (S)	49	38	112	48	920	-33	-30	32/18	31/18	29/17	16	20	19	18
McMurray AP	56	39	111	13	371	-41	-39	30/19	28/18	26/18	14	21	19	18
Medicine Hat AP	50	1	110	43	81	-34	-31	34/19	32/18	31/18	16	21	20	19
Red Deep AP	52	11	113	54	904	-35	-32	29/18	27/18	26/17	14	19	19	18
BRITISH COLUMBIA														
Dawson Creek	55	44	120	11	660	-38	-36	28/18	26/17	24/16	14	19	18	17
Fort Nelson	58	50	122	35	375	-42	-40	29/18	27/17	26/17	13	19	18	18
Kainloops CO	50	43	120	25	345	-29	-26	34/19	33/18	31/18	16	20	19	18
Nanaimo (S)	49	11	123	58	70	-9	-7	28/19	27/18	25/18	12	20	19	18
New Westminster	49	13	122	54	15	-10	-8	29/20	27/19	26/19	11	21	20	19
Penticton AP	49	28	119	36	342	-18	-16	33/20	32/19	31/19	17	21	20	19
Prince George AP(S)	53	53	122	41	676	-36	-33	29/18	27/17	25/16	14	19	18	17
Prince Rupert CO	54	17	130	23	52	-19	-17	18/15	17/14	16/13	7	16	14	14
Trail	49	8	117	44	427	-21	-18	33/19	32/18	30/18	18	20	19	18
Vancouver	49	11	123	10	5	-9	-7	26/19	25/19	23/18	9	20	19	19
Victoria CO	48	25	123	19	69	-7	-5	25/18	23/17	23/18	9	18	17	16

ตาราง ข-3.2 สภาวะอากาศสำหรับประเทศต่าง ๆ (อุณหภูมิในหน่วยองศาเซลเซียส)

			Winter			Summer						
Col.1	Col.2	Col.3	Col.4			Col.5			Col.6	Col.7		
Country and Station	Latitude Longitude	Elevation [m]	Mean of Annual Extremes	99%	97½%	Design Dry-Bulb			Outdoor Daily Range	Design Dry-Bulb		
						1%	2½%	5%		1%	2½%	5%
ADEN: Aden	12 50N/45 02E	3	17	20	21	39	38	37	6	28	28	28
AFGHANISTA : Kabul	34 35N/69 12E	1815	-19	-14	-13	37	36	34	13	19	18	18
ALGERIA : Algiers	36 46N/3 03E	59	3	6	7	35	33	32	8	25	24	24
ARGENTINA												
Buenos Aires	34 35S/58 29W	27	-3	0	1	33	32	32	12	25	24	24
Cordoba	31 22S/64 15W	423	-6	-2	0	38	36	34	15	24	24	24
Tucuman	26 50S/65 10W	427	-4	0	2	39	37	36	13	24	24	24
ASTRALIA												
Adelaide	34 56S/138 35E	43	2	3	4	37	34	33	14	22	21	20
Alice Springs	23 48S/133 53E	547	-2	1	3	40	39	38	15	24	23	22
Brisbane	27 28S/153 02E	42	4	7	8	32	31	30	10	25	24	24
Darwin	12 28S/130 51E	27	16	18	19	34	34	33	9	28	27	27
Melbourne	37 49S/144 58E	35	-1	2	3	35	32	30	12	22	21	20
Perth	31 57S/115 51E	64	3	4	5	38	37	34	12	24	23	23
Sydney	33 52S/151 12E	42	3	4	5	32	29	27	7	23	23	22
AUSTRIA												
Vienna	48 15N/16 22E	196	-17	-14	-12	31	30	28	9	22	21	19
AZORES												
Lajes (Terceira)	38 45N/27 05W	52	6	8	9	27	26	25	6	23	22	22
BAHAMAS												
Nassau	25 05N/77 21W	3	13	16	17	32	32	31	7	27	26	26

ตาราง ข-3.2 สภาวะอากาศสำหรับประเทศต่าง ๆ (อุณหภูมิในหน่วยองศาเซลเซียส)

				Winter, °C			Summer, °C									
Col.1	Col.2		Col.3	Col.4			Col.5			Col.6	Col.7			Prevailing Winds		
Country and Station	Lat	Long	Elevation [m]	Mean of Annual Extremes	99%	97½%	Design Dry-Bulb			Outdoor Daily Range[°C]	Design Dry-Bulb			Winter	m/s	Summer
							1%	2½%	5%		1%	2½%	5%			
United States																
ALABAMA																
Bimingham	33 34	86 45	189		-8	-6	36/23	34/24	33/23	12	26	25	24	NNW	4	WNW
CALIFORNIA																
Los Angeles	34 03	118 14	82		3	4	34/21	32/21	30/21	11	22	22	21	NW	2	NW
DELAWARE																
Wilmington	39 40	75 36	23		-12	-10	33/23	32/23	31/23	11	25	24	24	WNW	5	WSW
FLORIDA																
Miami	25 48	80 16	2		7	8	33/25	32/25	32/25	8	26	26	26	NNW	4	SE
GEORGIA																
Atlanta	33 39	84 26	308		-8	-6	34/23	33/23	32/23	11	25	24	24	NW	6	NW
HAWAI																
Honolulu	21 20	157 55	4		17	17	31/23	30/23	29/22	7	24	24	23	ENE	6	ENE
ILLINOIS																
Chicago	41 47	87 45	185		-21	-18	34/23	33/23	31/22	11	25	24	23	NW	6	SW
AFGHANISTAN																
Kabul	34 35N	69 12E	1816	-17	-14	-13	37	36	34	18	19	18	18	N	2	N
ARGENTINA																
Buenos Aires	34 35S	58 29W	27	-3	0	-1	33	32	30	12	25	24	24	SW	5	NNE
BURMA																
Rangoon	16 47N	96 09E	5	15	17	17	38	37	35	14	28	28	28	W	3	W

ตาราง ข-3.2 สภาวะอากาศสำหรับประเทศต่าง ๆ (อุณหภูมิในหน่วยองศาเซลเซียส)

				Winter, °C			Summer, °C									
Col.1	Col.2		Col.3	Col.4			Col.5			Col.6	Col.7			Prevailing Winds		
Country and Station	Lat	Long	Elevation [m]	Mean of Annual Extremes	99%	97½%	Design Dry-Bulb			Outdoor Daily Range[°C]	Design Dry-Bulb			Winter	m/s	Summer
							1%	2½%	5%		1%	2½%	5%			
CAMBODIA																
Phnom Penth	11 33N	104 51E	11	17	19	20	37	36	34	11	28	28	28	N	2	W
CHINA																
Shanghai	31 12N	121 26E	7	-9	-5	-3	34	33	32	9	27	27	27	WNW	3	S
DENMARK																
Copenhagen	55 41N	12 33E	13	-12	-9	-7	26	24	23	9	20	19	18	NE	6	N
EGYPT																
Cairo	29 52N	31 20E	116	4	7	8	39	38	37	14	24	24	23	N	5	NNW
FRANCE																
Paris	48 49N	2 29E	50	-9	-6	-4	32	30	28	12	21	20	19	NE	4	E
GREECE																
Athens	37 58N	23 43E	107	-2	1	2	36	34	33	10	22	22	22	N	5	NNE
HONG KONG																
Hong Kong	22 18N	114 10E	33	6	9	10	33	33	32	6	27	27	27	N	5	W
INDONESIA																
Djakata	6 11S	106 50E	8	21	22	22	32	32	31	8	27	26	26	N	6	N
ITALY																
Milan	47 27N	9 17E	104	-11	-8	-6	32	31	29	11	24	24	23	W	2	SW
JAPAN																
Tokyo	35 41N	139 46E	6	-6	-3	-2	33	32	31	8	27	27	26	SW	5	S

ตาราง ข-3.2 สภาวะอากาศสำหรับประเทศต่าง ๆ (อุณหภูมิในหน่วยองศาเซลเซียส)

				Winter, °C			Summer, °C									
Col.1	Col.2		Col.3	Col.4			Col.5			Col.6	Col.7			Prevailing Winds		
Country and Station	Lat	Long	Elevation [m]	Mean of Annual Extremes	99%	97½%	Design Dry-Bulb 1%	Design Dry-Bulb 2½%	Design Dry-Bulb 5%	Outdoor Daily Range[°C]	Design Dry-Bulb 1%	Design Dry-Bulb 2½%	Design Dry-Bulb 5%	Winter	m/s	Summer
KOREA																
Seoul	37 34N	126 58E	87	-18	-14	-13	33	32	31	9	27	26	26	NW	4	W
LEBANON																
Beirut	33 54N	35 28E	34	4	6	7	34	33	32	8	26	25	24	N	4	SW
MALASIA																
Kuala Lumpur	3 07N	101 42E	39	19	21	22	34	34	33	11	28	28	27	N	2	W
NEPAL																
Katmandu	27 42N	85 12E	1338	-1	1	2	32	31	30	14	26	25	24	W	2	NW
NEW ZEALAND																
Wellington	41 17S	174 46E	120	0	2	3	24	23	22	8	19	18	18	NE	3	NNE
PAKISTAN																
Karachi	24 48N	66 59E	4	7	9	11	38	37	35	8	28	28	27	N	2	SSW
PHILIPPINES																
Manila	14 35N	120 59E	14	21	23	23	34	33	33	11	28	27	27	N	2	ESE
RUMANIA																
Bucharest	44 25N	26 06E	82	-19	-16	-13	34	33	32	14	22	22	21			
SAUDI ARABIA																
Riyadh	24 39N	46 42E	591	-2	3	4	43	42	41	18	26	25	24	N	4	N

ตาราง ข-3.2 สภาวะอากาศสำหรับประเทศต่าง ๆ (อุณหภูมิในหน่วยองศาเซลเซียส)

				Winter, °C			Summer, °C									
Col.1	Col.2		Col.3	Col.4			Col.5			Col.6	Col.7			Prevailing Winds		
Country and Station	Lat	Long	Elevation [m]	Mean of Annual Extremes	99%	97½%	Design Dry-Bulb			Outdoor Daily Range[°C]	Design Dry-Bulb			Winter	m/s	Summer
							1%	2½%	5%		1%	2½%	5%			
SINGAPORE																
Singapore	1 18N	103 50E	10	21	23	23	33	33	32	8	28	27	27	N	2	SE
SOVIET UNION																
Moscow	55 46N	37 40E	154	-28	-24	-21	29	27	26	12	21	19	18	SW	6	S
SPAIN																
Barcelona	41 24N	2 09E	95	-1	1	2	31	30	29	7	24	23	23	N	5	S
TAIWAN																
Taipei	22 57N	120 12E	21	4	8	9	33	33	32	8	29	28	28	N	5	W
THAILAND																
Bangkok	13 44N	100 30E	12	14	16	17	36	35	34	10	28	28	27	N	2	S
UNITED KINGDOM																
London	51 29N	0 00	45	-7	-4	-3	28	26	24	9	20	19	18	W	4	E
VIETNAM																
Hanoi	21 02N	105 52E	16	8	10	12	37	36	35	9	29	29	29	NW	3	N

ตาราง ข-4 อุณหภูมิของพื้นดิน สำหรับห้องแช่เย็น [°C]

Outdoor Winter Design Temperature [°C]	Design Ground Temperature [°C]
-40°	7°
-35°	10°
-30°	12°
-25°	15°
-20°	17°
-15°	20°
-10°	22°
-5°	25°
0°	27°

ตาราง ข-5 Allowance for Solar Radiation (Degrees Celsius to be added to the normal temperature difference for heat leakage calculations to compensate for sun effect not to be used for air conditioning design)

Type of Surface	East Wall	South Wall	West Wall	Flat Roof
Dark-colored Surface such as: Slate roofing, Tar roofing, Black paints	5	3	5	11
Medium-colored Surface such as: Unpainted wood, Brick, Red tile Dark cement, Red, gray, or green paint	3	2	3	8
Light-colored Surface such as: White stone, Light-colored cement, White paint	2	1	2	5

[ที่มา ASHRAE Handbook, Design volume, 1957 – 1958.]

ตาราง ข-6.1 Kilojoules per liter Removed in Cooling Air to Storage Conditions Above 0°C

Storage Room Temp [°C]	Intel Air Temperature, °C									
	25°			30°			35°		40°	
	Intel Air RH, %									
	50	60	70	50	60	70	50	60	50	60
15°	0.0128	0.0186	0.0246	0.0281	0.0357	0.0441	0.0500	0.0563	0.0663	0.0795
10°	0.0266	0.0323	0.0382	0.0319	0.0491	0.0574	0.0591	0.0694	0.0792	0.0992
5°	0.0388	0.0445	0.0502	0.0536	0.0610	0.0693	0.0708	0.0810	0.0906	0.1036
0°	0.0493	0.0550	0.0606	0.0639	0.0713	0.0794	0.0808	0.0910	0.1003	0.1141

ตาราง ข-6.2 Kilojoules per liter Removed in Cooling Air to Storage Conditions Below 0°C

Storage Room Temp °C	Intel Air Temperature, °C									
	5°		10°		25°		30°		35°	
					Intel Air RH, %					
	70	80	70	80	50	60	50	60	50	60
0°	0.0092	0.0111	0.0142	0.0154	0.0505	0.0562	0.0650	0.0724	0.0820	0.0921
-5°	0.0193	0.0210	0.0235	0.0247	0.0592	0.0649	0.0736	0.0809	0.0903	0.1004
-10°	0.0271	0.0288	0.0309	0.0321	0.0662	0.0719	0.0805	0.0877	0.0970	0.1071
-15°	0.0350	0.0367	0.0383	0.0395	0.0732	0.0788	0.0873	0.0945	0.1037	0.1137
-20°	0.0427	0.0444	0.0456	0.0468	0.0801	0.0857	0.0941	0.1013	0.1102	0.1203
-25°	0.0501	0.0523	0.0525	0.0537	0.0866	0.0992	0.0998	0.1077	0.1165	0.1265
-30°	0.0571	0.0588	0.0591	0.0604	0.0929	0.0985	0.1067	0.1138	0.1225	0.1325
-35°	0.0640	0.0657	0.0656	0.0668	0.0989	0.1045	0.1126	0.1197	0.1283	0.1382
-40°	0.0708	0.0725	0.0720	0.0732	0.1050	0.1106	0.1185	0.1256	0.1341	0.1440

ตาราง ข-7 Average Air Infiltration Rates in L/s Due To Openings

	Infiltration Rates (L/s)	
Room Volume (m^3)	**Room Above 0° C**	**Room Below 0° C**
7	3.1	2.3
8.5	3.4	2.6
10	3.7	2.8
15	4.4	3.3
20	5.0	3.8
25	5.5	4.2
30	5.9	4.6
40	6.8	5.4
50	7.5	5.8
75	9	6.9
100	10.2	7.9
150	12.2	9.4
200	13.9	10.9
250	15.3	11.9
300	16.7	12.9
400	19	14.9
500	21.4	16.8
600	23.6	18.1
700	24.3	18.6
800	25.9	20.4
900	27.1	21.9
1000	28.9	23.1

ตาราง ข-8 Design Data for meat storage

Meals	Type of Storage	Design Room conditions					Max. Storage Period	Chilling Data				Est. Prod. latent heat [kJ/kg] 24 Hours	Specific Heat [kJ/kg. K]		Latent heat of Fusion [kJ/kg]	Water Content [%]	Freezing Point [°C]	Maximum Room At Motion [sq.m]	Type of Unit Preferred
		Temperature		Relative Humidity		g/kg At Recommended Conditions		Product Temp [°C]		Time Hour	Rate Factor		Before Freezing	After Freezing					
		Recom-mended	Permissible Range	Recom-mended	Permissible			Start	Finish										
		°C	°C	%	%														
Bacon	Short Hardening Slicing room	12.75 -2.25 10.00	10-15.5 (-2.25).(-10) 10.12 75	65 75 40	56.65 70-80 35-40	5.95 2.34 3.04	15 D					5.81 2.79	2.09	1.26	6.9	20		0.75 0.45 0.30	S or B B S or B
Beef Combined Chill and Holding	Chill Start Chill finish	3.25 0.5		8.5 8.5		4.11 3.31		3.75	6.75	24	0.56	7.74 11.60	3.14	1.67	228	72	-0.5	1.25 0.45°	B
Beal-dried	Long	12.75	12.75-15.5	65	65.70	5.95	6 M					0.23	0.92-1.42	0.79-1.09	18.51	5.15		0.75	S or B
Beal-fresh	Short Long Chill Start Chill finish	1.75 -1.0 -1.0	1.75-4.50 (-1.00)-0	87 87 87 87	85.90 85.90	3.71 2.97 5.47 5.97	3 W	37.7 5	6.75	18	0.67	11.60 3.95 51.10 3.95	3.14	1.67	2228	72	-0.5	0.30 0.30 1.25 0.75	S or B
Buned Meef	Short Long	4.5 -0.5	4.5-7.25 (0.5)-0	85 85	80.85 80.85	4.42 3.04	6 M					2.32 1.86	314					0.75 0.75	S or B B
Cut meal	Short	1.0	10-1.5	87	85.00	3.54	5 D					13.00	3.01	1.67	221	65	-1.75	0.30	S
	Long Short long	-18.0 1.0 -1.0	 1.0-3.25 (-1.0)-0	85 85 85	80.85 80.85 80.85	6.64 3.74 2.91	6 M 15 D					0.23 13.25 0.93	3.18	1.72	235	70	-2.25	1.25 0.45 0.45	S or B S or B S or B
Hams and loins fresh smoked	Short Long Short Chill starts Chill starts	1.0 -2.0 12.75 15.5 12.75	1.0-3.25	85 85 65 70 70	85.87 85.87 55.65	3.47 2.64 5.95 7.70 6.40	 3 W	 40.5	 1.14	 8	 1.00	7.90 4.18 3.02 11.60 0.70	2.85 2.50	1.59 1.34	201	52 57	0.50	0.30 0.30 0.75 0.75 0.45	S or B B S or B S or B
Hog 18 H Chilling 4 H	Chill starts Chill finish Chill starts Chill finish	1.25 -1.0 3.25 -2.25		85 85 90 90		5.35 2.91 4.36 2.81		40.5 40.5	1.75 1.75	18 14	0.67 0.67	55.80 4.42 53.50 4.42	2.85	1.59	201	60	-2.75	1.25 0.75 1.25 0.75	B B
Lamb	Short Long Chill start Chill finish	1.0 -2.25 7.25 -1.0	10-3 2.5 (-2.25)-(1.0)	90 90 90 90	85-90 85-90	3.68 2.81 5.65 3.08	2W	37.7 5	4.5	5	0.75	7.90 3.02 44.20 3.02	2.80	1.26	194	58	-1.75	0.30 0.03 1.25 0.45	S or B B B
Offal (livers hearts etc.)	Chill start Chill finish	4.5 0		85 85		4.42 3.18		32.2 5	1.75	18	0.70	48.80 3.02	3.14	1.76	239	72		0.75 0.45	S or B

ตาราง ข-8 Design Data for meat storage

Meals	Type of Storage	Design Room conditions					Max. Storage Period	Chilling Data				Est. Prod. latent heat [kJ/kg] 24 Hours	Specific Heat [kJ/kg. K]		Latent heat of Fusion [kJ/kg]	Water Content [%]	Freezing Point [°C]	Max. Room At Motion [sq.m]	Type of Unit Preferred
		Temperature		Relative Humidity		g/kg At Recommended Conditions		Product Temp [°C]		Time Hour	Rate Factor		Before Freezing	After Freezing					
		Recom-mended	Permissible Range	Recom-mended	Permissible														
		°C	°C	%	%			Start	Finish										
Oysters shell	Short	1.75	1.75-4.5	90	85-90	3.82						9.76	3.47	1.84	270	80.4	-2.75	0.45	S
lub	Long	0	0-3.25	90	85-90	3.38	15 D					1.16						0.45	B
	Short	1.75	1.75-4.5	70	70-75	2.97						5.35	3.77	1.92	291	87	-2.75	0.25	S
	Long	0	0-3.25	71	70-75	2.65	10 D					0.48						0.75	S or B
Pork (fresh)	short	1.0	1.0-3.25	85	85-90	3.47	15 D					7.90	2.85	1.59	201	60	-2.25	0.45	S or B
Poultry																			
Fresh	Long	-2.25	(-2.25)-	87	85-90	2.71	10 D					0.90	3.18	1.55	246	74	-2.75	0.30	B
Frozen	Long	-16.0	(-1.0)	85	85-90	0.664	10 M	29.5	4.5	5	1.00	0.46						0.75	S
	Chill start	7.25		85		5.35						39.50						0.75	B
	Chill finish	0		85		3.18						0.93						0.45	
Sausage																			
Casings	Short	4.5	4.5-7.25	80	75-80	4.15						0.48	2.51					0.75	S or B
(salled)	long	0.5	(-0.5)-0	80	75-80	2.87	4					0						0.75	B
Franks and	Short	1.75	1.75-4.5	85	80-90	3.60	48 H					10.00	3.58	2.34	200	60	-1.75	0.30	S or B
smoked	Chill start	8.5		80		4.51		21.0	1.75	2	1.00	20.90						0.75	B
	Chill finish	0		80		3.01												0.30	
Fresh	Short	1.75	1.75-4.5	85	85-90	3.60	7 D					10.00	2.07	2.34	216	65	-3.25	0.30	S or B
	Chill start	5.5		85		4.80		21.0	1.75	2	1.00	20.90						0.75	B
	Chill finish	0		85		3.18												0.30	
Mig room		12.75	12.75-15.5	40	35.40	3.64						0						0.30	S or B
Smoked	Short	4.5	1.75-4.5	85	80-90	4.42	6 M					7.44	3.58	2.34	200	60	4	0.30	S or B
Summer	Drying	10.0	9-13.25	70	65-80	5.31						11.60						0.30	B
	Long	0	0-1.0	70	70-75	2.65	6-8 M					4.65						0.30	B
Wrapping Room		7.25	7.25-10.0	85	80-85	5.35						0						0.30	S or B
Veal	Short	1.0	1.0-3.25	87	85-90	3.54						8.37	1.65	1.63	212	83	-1.75	0.30	S or B
	Long	-2.25	(-2.25)-(-	87	85-90	2.71	15 days					3.02						0.30	B
	Chill start	7.25	1.0)	87		5.65		37.25	4.5	6	0.75	48.80						0.45	B
	Chill finish	1.0		87		3.08						3.02						0.30	

ตาราง ข-9 Design for Vegetable storage

Vegetable	Type of Storage	Design Room conditions				g/kg At Recom-mended Conditions	Max. Storage Period	Chilling Data				Est. Prod. Latent Heat kJ/kg 24 Hours	Specific Heat kJ/kg. K		Latent Heat of Fusion kJ/kg	Water Content [%]	Freezing Point [°C]	Max. Room At Motion [sq.m]	Type of Unit Preferred
		Temperature		Relative Humidity				Product Temp [°C]		Time Hour	Rate Factor		Before Freezing	After Freezing					
		Recom-mended	Permissible Range	Recom-mended	Permissible														
		°C	°C	%	%			Start	Finish										
Asparagus	Short	4.5	4.5-7.25	90	85-90	4.68						13.90	3.81	2.05	314	94.0	-1.25	0.45	S
	Long	0	0-2.25	90	85-90	3.38	30 days					1.16						0.30	S or B
	Chill start	4.5		90		4.42		15.5	1.0	24	0.90	30.20						0.75	S or B
	Chill finish	0.5		90		3.31						1.16						0.30	
Beans, green	Short	4.5	4.5-7.25	90	85-90	4.68						6.97	3.64	1.97	277	83.0	-1.25	0.45	S
	Long	0.5	0-4.5	90	85-90	3.15	30 days					1.63						0.30	S or B
	Chill start	4.5		85		4.42		26.5	1.75	20	0.67	34.90						0.75	S or B
	Chill finish	0.5		85		3.31						1.63						0.30	
Beans, (lime)	Short	4.5	4.5-7.25	90	85-90	4.68	15 days Shelled					6.97	3.26	1.51	230	68.5	-2.00	0.45	S
	Long	0.5	0-4.5	90	85-90	3.51	30 days Unshelled					1.39						0.30	S or B
Beats, Tops off	Short	4.5	4.5-7.25	90	85-90	4.68						4.65	3.77	2.01	300	90.0	-2.75	0.45	S
	Long	0	0-2.25	95	95-98	3.57	1.3 mo					0.70						0.30	S or B
Beats, Tops on	Short	4.5	4.5-7.25	90	85-90	4.68						6.97	3.77	2.01	300	90.0	-0.5	0.45	S
	Long	0	0-0.25	90	85-90	3.38	10-14					0.93						0.30	S or B
	Chill start	4.5		90		4.68	days	21.0	1.0	24	0.80	39.50						0.75	S or B
	Chill finish	0		90		3.38						0.93						0.30	
Broccoll	Short	4.5	4.5-7.25	90	90-95	4.68						9.30	3.77	2.01	314	93.0	-1.5	0.45	S
	Long	0	0-1.75	90	90-95	3.38	7-10 days					1.16						0.30	S or B
	Chill start	4.5		90		4.68		26.75	1.0	24	0.80	32.50						0.75	S or B
	Chill finish	0		90		3.51						1.16						0.30	
Brussel	Short	4.5	4.5-7.25	95	90-95	4.92						11.60	3.81	2.05	316	94.5	-0.5	0.45	S
	Chill start	15		80		8.81		1.0	1.0	24	1.0	30.20						1.25	S or B
	Chill finish	10		80		6.08						0.46						0.75	
Endive	Short	1.75	1.75-4.5	90	90-95	3.82						9.30	3.77	1.92	316	89.0	-0.5	0.45	S
	Long (iced)	1.75	0-2.25	90	90-95	3.82	2-3 wks					2.32						0.45	S or B
Lettuce	Short	1.75	1.75-4.5	90	90-95	3.82						16.3	3.77	1.92	316	89.0	-0.5	0.45	S
	Long (iced)	1.75	0-2.25	90	90-95	3.82	2-3 wks					2.32						0.30	S or B
Metons	Short	7.25	7.25-10	85	75-85	5.35						6.97	3.81	1.92	267	85.0	-1.75	0.45	S
Watermelons	Long	2.25	2.25-4.5	85	75-85	3.74	2-4 wks					0.46						0.75	
Honeydews	Long	0		85	75-85	3.18	7-10 days					0.46	3.81	1.97	298	89.0	-1.75	0.45	S or B
Cantaloupes	Chill start	4.5		85		4.42		26.75	1.0	24	0.90	32.50						1.25	S or B
	Chill finish	0		85		3.18						0.46						0.75	
Onions	Short	10	10-15.5	75	70-75	5.71						4.65	3.81	2.13	302	89.0	-1.0	0.75	S
	Long	0	0-2.25	75	70-75	2.82	6-8 mo					0.46						0.75	S or B
	Chill start	4.5		75		3.92		21.0	1.0	24	0.30	23.20						1.25	S or B
	Chill finish	0		75		2.82						0.46						0.75	

ตาราง ข-9 Design for Vegetable storage

Vegetable	Type of Storage	Design Room conditions				g/kg At Recom-mended Conditions	Max. Storage Period	Chilling Data				Est. Prod. Latent Heat kJ/kg 24 Hours	Specific Heat kJ/kg. K		Latent Heat of Fusion kJ/kg	Water Content [%]	Freezing Point [°C]	Max. Room At Motion [sq.m]	Type of Unit Preferred
		Temperature		Relative Humidity				Product Temp [°C]		Time Hour	Rate Factor		Before Freezing	After Freezing					
		Recom-mended	Permissible Range	Recom-mended	Permissible														
		°C	°C	%	%			Start	Finish										
Parsnips	Short	10	10-15.5	75	70-75	5.71						4.65	3.81	2.13	302	89.0	-1.0	0.75	S
	Long	0	0-2.25	75	70-75	2.82	6-8 mo					0.46						0.75	S or B
	Chill start	4.5		75		3.92		21.0	1.0	24	0.30	23.20						1.25	S or B
	Chill finish	0		75		2.82						0.46						0.75	
Peas	Short	1.75	1.75-4.5	90	85-90	3.82						6.97	3.43	1.88	249	80.0	-1.75	0.45	S
(green)	Long	0	0-2.25	90	85-90	3.38	1-2 wks					1.16						0.45	S or B
	Chill start	4.5		85		4.42		26.75	1.0	20	0.67	32.50						0.75	S or B
	Chill finish	0.5		85		3.31						1.16						0.45	
Potatoes		10	10-21	85	85-90	6.45						6.97	3.60	1.97	263	78.5	-1.75	0.75	S
Potatoes		2.25	2.25-10	85	85-90	3.37						1.16					-1.75	0.75	S or B
Sauerkraut	Short	7.25	7.25-10	80	75-80	5.04						6.97	3.85	2.14	298	89.0	-3.5	0.75	S
(in kegs)	Long	-1.0	(-1.0)-0	80	75-80	2.74	5 M					0.46						0.45	S
Spinach	Short	1.75	1.75-4.5	95	90-95	4.02						16.30	3.85	2.13	300	90.0	-1.0	0.45	S
	Long	0	0.2-25	95	90-95	3.57	10-14 D					1.16						0.30	S or B
Sweet	Short	12.75	12.75-15.5	85	80-85	7.78						6.97	3.60	0.42	237	78.0	-2.0	0.75	S
Potatoes	Long	12.75	12.75-15.5	85	80-85	7.78	4-6 M					0.93						0.75	S or B
Tomatoes	Short	12.75	12.75-15.5	85	85-90	7.78						6.97	3.85	1.92	307	95.0	-0.75	0.45	S
green	Long	12.75	12.75-15.5	85	85-90	7.78	3-5 W					1.16						0.30	S or B
	Ripening	18.25	18.25-21	85	85-90	11.17						4.65						0.45	S
	Chill start	21.0		85		13.32		26.75	1.0	34	1.0	32.50						0.75	S
	Chill finish	10		85		6.45						0.93						0.45	
	Long	7.25	4.5-10	85	85-90	5.35	7-10 D					6.97						0.45	S
Tumips	Short	1.75	1.75-4.5	95	95-98	4.02						9.30	3.77	1.88	298	89.5	-0.75	0.45	S
	Long	0	0-2.25	95	95-98	3.57	4-5 M					1.16						0.30	S or B
	Chill start	4.5		95		4.92		21.0	1.0	24	0.80	39.50						0.75	S or B
	Chill finish	0		95		3.57						1.18						0.30	
Vegetable	Short	4.5	4.5-7.25	85	85-90	4.42						11.60	3.77	1.88	302	90.0	-1.0	0.45	S
(wetted.	Long	1.75	1.75-4.5	87	85-90	3.71	2-4 M					2.79						0.45	
Mixed)	Chill start	10		90		6.85				18	0.70	53.50						0.75	S or B
	Chill finish	1.75		90		3.82		26.75	3.25			2.79						0.45	S or B

ตาราง ข-10 Design Data for fruit Storage

Fruit	Type of Storage	Design Room conditions				g/kg At Recom-mended Conditions	Max. Storage Period	Chilling Data				Est. Prod. Latent Heat kJ/kg 24 Hours	Specific Heat kJ/kg. K		Latent Heat of Fusion kJkg	Water Content [%]	Freezing Point [°C]	Max. Room At Motion [sq.m]	Type of Unit Preferred
		Temperature		Relative Humidity				Product Temp [°C]		Time Hour	Rate Factor		Before Freezing	After Freezing					
		Recom-mended	Permissible Range	Recom-mended	Permissible			Start	Finish										
		°C	°C	%	%														
Apples	Short Long Chill start Chill finish	1.75 -1.0 4.5 -1.0	1.75-4.5 (-1.0)-0	87 87 85 85	85-88 85-88	3.75 2.97 4.42 2.91	48 mo	26.75	0	24	0.67	9.30 0.46 55.79 0.70	3.72	1.82	284	84	-1.75	0.45 0.30 0.75 0.30	S B B
Apricots	Short Long Chill start Chill finish	1.75 0 4.5 0	1.75-4.5 (-0.5)-0	85 85 85 85	80-85 80-85	3.60 3.18 4.42 3.18	7-14 days	26.75	0.5	20	0.67	9.30 0.70 46.5 0.70	3.85	2.1	284	85	-2.25	0.45 0.30 0.75 0.30	S S or B B
Avocados	Short Long Chill start Chill finish	4.5 3.25 4.5 0.5	4.5-11.75 2.75-11.75	85 85 85 85	85-90 85-90	4.42 4.11 4.42 3.31	10 days	26.75	3.75	22	0.67	10.46 0.70 51.14 0.70	3.81	2.1	316	94	-2.75	0.45 0.45 1.25 0.45	S S S
Bananas (see Doc 2D-84)	Ripening Chill start Chill finish Holding green Holding ripe	21 21 13.5 13.5 13.5	16.75-21 13.25-15.5 13.25-15.5	95 95 90 92 87	90-95 90-95 85-90	14.95 14.95 8.57 8.57 8.28	10 days	heating 20.0	 13.25	13.3-12.1 12	 0.1	4.65 25.57 2.32 2.32 2.32	3.77		251	75	(-3.25) -(-1.0)	0.45 0.75 0.45 0.45 0.45	S S S S
Berries (general)	Short Long Chill start Chill finish	1.75 0 4.5 0	1.75-4.5 (-0.5)-0	85 85 85 85	80-85 80-85	3.60 3.18 4.42 3.18	10 days	26.75	1.0	20	0.67	14.64 0.70 46.50 0.70	3.77	2.1	279	84	(-2.25) -(-1.0)	0.45 0.30 1.25 0.30	S or B S or B S or B
Cranber-ries	Short Long Chill start Chill finish	2.25 2.25 4.5 2.25	2.25-4.5 2.25-4.5	85 85 85 85	85-90 85-90	3.77 3.77 4.42 3.74	1-3 mo	21.0	3.25	20	0.67	11.62 0.46 41.84 0.46	3.81	1.97	284	88	-2.75	0.45 0.45 0.75 0.45	S S or B S or B

ตาราง ข-10 Design Data for fruit Storage

Fruit	Type of Storage	Design Room conditions				g/kg At Recom-mended Conditions	Max. Storage Period	Chilling Data				Est. Prod. Latent Heat kJ/kg 24 Hours	Specific Heat kJ/kg. K		Latent heat of Fusion kJkg	Water Content [%]	Freezing Point °C	Max. Room At Motion [sq.m]	Type of Unit Preferred
		Temperature		Relative Humidity				Product Temp [°C]		Time Hour	Rate Factor		Before Freezing	After Freezing					
		Recom-mended	Permissible Range	Recom-mended	Permissible			Start	Finish										
		°C	°C	%	%														
Dates (cured)	Short Long	1.75 -2.25	1.75-4.5 (-2.25)-0	70 70	65-75 65-75	2.92 2.20	3-6 mo					0.23 0.12	1.46		60	18	-15.5	0.75 0.75	S or B S or B
Dried fruits	Short Long	1.75 0	1.5-4.5 0-2.25	70 70	70-75 70-75	2.67 2.65	9-12 mo					0.23 0.16	1.9	1.34	100	30		0.75 0.75	S S or B
Figs and dates(fresh)	Short Long	4.5 1.0	4.5-10 1.0-2.25	75 70	65-75 65-75	3.92 2.85	15 days					11.62 0.93	2.97	1.84	270	90	-2.0	0.45 0.45	S S
Grapes (American Eastern)	Short Long Chill start Chill finish	1.75 -0.6 4.5 0	1.75-4.5 (-0.5)-0	85 85 85 85	80-85 80-85	3.60 3.04 4.42 3.18	3-8 wks	21.0	1.0	20	0.80	11.62 0.93 32.54 0.93	3.77	2.55	260	77	-2.0	0.45 0.45 0.25 0.45	S S or B S or B S or B
Grapes (Vinitera Calitornai)	Short Long Chill start Chill finish	1.25 -1.0 4.5 0	1.75-4.5 (-1.0)-0	85 85 85 85	85-90 85-90	3.60 2.91 4.42 3.18	3-6 mo	21.0	1.0	20	0.8	11.62 0.93 32.54 0.93	3.58	2.47	260	79	-4.25	0.45 0.45 1.25 0.45	S S or B S or B
Grapefruit	Short Long Chill start Chill finish	4.5 0 4.5 0	4.5-7.25 0-1.0	90 85 85 85	85-90 85-90	4.68 3.18 4.42 3.18	6-8 wks	24.0	1.0	22	0.70	4.65 0.70 44.16 0.70	3.81	2.1	298	88	-2	0.45 0.45 1.25 0.45	S S or B S or B
Lemons	Short Long Chill start Chill finish	12.75 12.75 15.5 12.75	12.75-15.5 12.75-15.5	85 85 85 85	85-90 85-90	7.78 7.78 9.35 7.78	1-4 mo	24	3.75	22	0.67	10.46 0.70 51.14 0.70	3.81	2.1	316	94	-2.75	0.45 0.45 1.25 0.45	S S S
Bananas (see Doc	Ripening Chill start Long ripe green Chill start Chill finish	21 21 4.5 10.0 7.25 3.25	16.75-21 4.5-7.25 10-15.5	95 95 85 90 85 85	90-95 85-90 85-90	14.95 14.95 4.42 6.85 5.35 4.11	2-4 wks 3-4 wks	Heating		13.3 – 12.1		4.65 25.57 0.23 0.23 55.79 0.23	3.77		251	75	(-3.25) -(-1.0) -1.25 -1.75	0.45 0.75 0.75 0.75 1.25 0.75	S S S or B S or B S or B
								29.5	4.5	3	0.67								
Plums and Prunes (fresh)	Short Long Chill start Chill finish	1.75 0 4.5 0	1.75-4.5 (-0.5)-1.0	85 85 80 80	80-85 80-85	3.60 3.18 4.15 3.01	3-8 wks	26.7 5	1.0	20	0.67	9.29 0.70 46.49 0.70	3.68	2	270	80	-2.25	0.45 0.45 1.25 0.45	S S or B S
Ouinces	Short Long Chill start Chill finish	1.75 0 4.5 0	1.75-4.5 (-0.5)-1.0	85 85 85 85	80-85 80-85	3.68 3.18 4.42 3.18	2-3 mo	26.7 5	0	24	0.67	9.29 0.70 55.79 0.70	3.77	2.1	284	85	-2.25	0.30 0.30 0.75 0.30	S B

ตาราง ข-11 Design Data for Miscellaneous Storage

Fruits	Type of Storage	Design Room conditions				g/kg At Recom-mended Conditions	Max. Storage Period	Chilling Data				Est. Prod. Latent Heat kJ/kg 24 Hours	Specific Heat kJ/kg. K		Latent heat of Fusion kJkg	Water Content %	Freezing Point °C	Max. Room At Motion [sq.m]	Type of Unit Preferred
		Temperature		Relative Humidity				Product Temp °C		Time Hour	Rate Factor		Before Freezing	After Freezing					
		Recom-mended	Permissible Range	Recom-mended	Permissible			Start	Finish										
		°C	°C	%	%														
Beer (Whole Saler)																			
Wooden keg	Short	1.75	1.75-4.5	85	80-85	3.60	6 M					16.3	4.18			92.0	-2.25	0.75	S
Metal keg	Short	1.75	1.75-4.5	70	65-70	2.97	6 M					0.93						0.75	S
Butter or	Short	4.5	1.75-7.25	80	75-80	4.65	10 D					4.65	2.68	1.42	34.9	15.0	-1.0	0.75	S
Honey butter	Long	-18	(-20.5)-(-18)	85	80-85	0.66	6 M					0.70						1.25	S
Candy	Long	18.25	15.5-21	55	50-55	0.18	6 M						0.93					0.30	S
Caviar	Short	4.50	4.5-7.25	85	80-85	4.42	15 D					4.65	3.89				-6.75	0.75	S
(in tubs)	Long	1.0	1.0-2.25	85	80-85	3.47						0.70						0.75	S or B
Cheese	Short	4.5	4.51-7.25	80	75-80	4.15	15 D					5.35	2.68	1.51	184	55.0	-8.25	0.45	S
American	Long	0	(-1)-1	80	75-80	3.01						1.16						0.45	S or B
Camembert	Short	4.5	4.5-7.25	85	80-85	4.22	90 D					5.81	2.93	1.67	200	60.0	-7.75	0.45	S
	Long	4.5	(-1)-1	85	80-85	4.42						0.46						0.45	S or B
Limburger	Short	4.50	4.5-7.25	85	80-85	4.42	60 D					5.81	2.93	1.67	200	60.0	-7.25	0.45	S
	Long	-0.5	(-1)-1	85	80-85	3.04						0.70						0.45	S or B
Roquelort	Short	7.25	7.25-1.0	80	75-80	5.04	60 D					4.65	2.72	1.34	184	55.0	-16.0	0.45	S
	Long	4.5	(-1)-1	80	75-80	4.15						0.46						0.45	S or B
Swiss	Short	4.50	4.5-7.25	80	75-80	4.15	60 D					5.35	2.68	1.51	184	55.0	-9.5	0.45	S
	Long	3.25	(-1)-1	80	75-80	3.85						0.46						0.45	S or B
Chocolate (forcoaling)	Long	15.5	15.5-21	55	50-55	6.01	6 M					2.32	2.34	1.26	93	0.5	-29.35	0.30	S
Cream	Short	1.75	1.75-4.5	80	75-80	3.4	4 M					4.65	3.65	1.67	209	55.0	-2.25	0.75	S
40%	Long	-15	(-20.5)-(-18)	80	80-85	0.81						0.23						0.75	S
Eggs craled	Short	4.5	4.5-7.25	85	80-85	4.42	12 M	-7.25	-1.0	10	0.85	8.37	3.56	1.88	232	74.2	-0.25	0.45	S
(see Doc 2D-85)	Long	-1.0	(-1)-(-0.5)	85	85-87	2.91						0.46						0.30	S or B
	Chill start	4.5		85		4.42						16.30						0.45	S or B
	Chill finish	-1.0		85		2.91						0.46						0.30	
Eggs frozen	Long	-15	(-20.5)-(-18)	60		0.60	60 M	4.5	-15	24	0.67	0.14		1.88	232			1.25	S
10 lb cans	Chill start	-18		85		0.66						9.90						1.25	S
Doc 2D-85	Chill finish	-18		85		0.66						0.14						1.25	
Flour	Long	25.5	25.5-28	60	60-65	12.28	6 M						1.59	1.17		13.5		0.30	S
Fut, woolens	Fumigated	1.75	1.75-4.5	65	60-65	2.75	6 M					0.23	1.67					0.75	S
(see Dec 2D-85)	Ret Only	-9.5	(-9.5)-(-7.75)	70	65-70	1.17	6 M					0.23						0.75	S
Flowers Cut Genersl		4.5	0.5-4.5	85	85-90	4.42	3-14 D					13.60 kJ	3.85				-3.10-1	0.30	S

ตาราง ข-11 Design Data for Miscellaneous Storage

Fruits	Type of Storage	Design Room conditions				g/kg At Recom-mended Conditions	Max. Storage Period	Chilling Data				Est. Prod. Latent Heat kJ/kg 24 Hours	Specific Heat kJ/kg. K		Latent heat of Fusion kJkg	Water Content %	Freezing Point °C	Max. Room At Motion [sq.m]	Type of Unit Preferred
		Temperature		Relative Humidity				Product Temp °C		Time Hour	Rate Factor		Before Freezing	After Freezing					
		Recom-mended	Permissible Range	Recom-mended	Permissible			Start	Finish										
		°C	°C	%	%														
Orchids Gardenias		7.25	7.25 - 10	85	85 - 90	5.35	1 W					Pem					-2.10-1	0.30	S
Hides curing storage	Long	12.75 2.25	10-12.75 0-4.5	85 75	80-85 70-75	7.78 3.30	5 Y					0.46 2.32	1.67 1.67					0.75 0.75	S S
Ice cream 5 gel. Cans (see Doc 2D-86)	Hardening Start Finish Start Finish	 -18 -29 -18 -29		 85 85 85 85				 -5.5 -3.25 	 - 23.25 - 23.25	 8 8 	 0.75 0.75 	 2.56 0.23 3.02 0.23	 3.22 		 86 144 	 60.0 	 (-2)-(-18) 	 1.25 1.25 1.25 1.25	 S S S S
Lard	Short Long	7.25 0	7.25-10 0-1	80 80	75-80 75-80	5.04 3.01	 6 mo					4.65 0.70	2.51 		209 		21 	0.75 0.75	S S
Maple sugar	Short Long	7.25 -0.5	7.25-10 (-11)-1	70 70	65-70 65-70	4.77 2.52	 5 mo					1.63 0.23	1.00 	0.86 	18.3 	5 	 	1.25 1.26	S S
Maple Sytup	Short Long	7.25 -0.5	7.25-10 (-1)-1	70 70	65-70 65-70	4.27 2.52	 5 mo					1.63 0.23	2.05 	1.30 	121 	36.0 	 	1.25 1.25	S S
Milk bottled And wet Doc 2D-59	Short Chill start Chill finish	1.75 4.5 1.0	1.75-4.5	70 80 80	65-70	2.97 4.15 3.28	5 days	7.25	1.75	10	0.85	4.65 8.60 0.23	3.77 	2.05 	288 	87.5 	-0.50 	1.25 1.25 1.25	S or B S or B
Nuls in shells	Short Long	4.50 0	4.5-7.25 0-4.5	70 70	65-70 65-70	3.61 2.65	 8-12 mo					1.16 0.19	1.05 	0.92 	2.23 	2.8 	 	0.75 0.75	S S or B
Nuls shelled	Short Long	4.50 0	4.5-7.25 0-4.5	70 70	65-70 65-70	3.61 2.65	 6-10 mo					1.16 0.19	1.26 	1.00 	9.33 	3-10 	 	0.75 0.75	S S or B
Oleo	Short Long	7.25 1.0	7.25-10 1-2	80 80	75-80 75-80	5.04 3.28	 90 days					4.65 0.70	1.12 					0.75 0.75	S S or B
Vaccine serum	Long	6.0	4.5-7.25	70	65-70	4.07	4 mo											0.75	S
Shrubs	Long	-2.25	(-4.5)-(-1.75)	70	60-80	2.20	6-8 mo						1.39	1.46		50.0			

ตาราง ข-12 Reaction Heat from Fruits and Vegetables

Fruits		
Commodity	Temperature	Watts Per kilogram
Apples	0	0.012
	5	0.019
	10	0.078
Apricots	0	0.015
	5	0.023
	16	0.110
Bananas		
Holding	12	0.044
Ripening	20	0.123
Chilling	21-13	0.319
Berries	2	0.074
	16	0.223
Cherries	0	0.021
	16	0.161
Cranberries	0	0.009
	5	0.012
	10	0.023
Dates fresh	0	0.009
	5	0.012
	10	0.023
Grapefruit	0	0.006
	5	0.014
	16	0.032

Fruits		
Commodity	Temperature	Watts Per kilogram
Grape	0	0.005
	5	0.009
	16	0.032
Lemons	0	0.008
	5	0.011
	16	0.040
Limes	0	0.008
	5	0.011
	10	0.044
Oranges	0	0.011
	5	0.010
	16	0.067
Peaches	0	0.015
	5	0.023
	16	0.110
Pears	0	0.010
	16	0.149
Quinces	0	0.012
	5	0.019
	16	0.078
Strawberries	0	0.044
	5	0.078
	16	0.233

Vegetables		
Commodity	Temperature	Watts Per kilogram
Asparagus	0	0.023
	5	0.110
Beans lima	0	0.110
	16	0.531
Beans.	0	0.064
string	5	0.090
	16	0.283
Beets	0	0.036
	5	0.055
	16	0.097
Brussel	0	0.046
sprouts	5	0.061
	16	0.181
Cabbage	0	0.038
	5	0.061
	16	0.181
Cauliflower	0	0.038
	5	0.061
	16	0.181
Carrots	0	0.029
	5	0.047
	16	0.110

Vegetables		
Commodity	Temperature	Watts Per kilogram
Celery	0	0.038
	5	0.061
	16	0.181
Corn sweet	0	0.023
	5	0.110
Cucumber	0	0.018
	5	0.026
	16	0.113
Endive	5	0.129
Lettuce	0	0.155
	5	0.213
	16	0.619
Melons	0	0.018
(except	5	0.026
watermelons)	16	0.113
Freshrooms	0	0.084
	10	0.297
Freships	0	0.378
	5	0.047
	16	0.110
Pees	0	0.110
	16	0.531
Peooers	0	0.037
	16	0.116

Vegetables		
Commodity	Temperature	Watts Per kilogram
Potatoes	0	0.009
	5	0.019
	18	0.039
Spinach	5	0.129
Sweet potatoes	5	0.047
Tomatoes	16	0.084
(green ripe)	5	0.081
Tulips	0	0.026
	5	0.032

[ที่มา Carrier Handbook, 1965]

ตาราง ข-13 Heat Equivalent of Electric Motors

Multiplying Factor				
Motor Rating Kilowatt Output	Motor Efficiency %	Connected Load In Refr. Space [a]	Motor Losses Outside Refr. Space [b]	Connected Load Outside Refr. Space [c]
0.1-0.5	33.3	1.67	1.0	0.67
0.5-2.0	55.0	1.45	1.0	0.45
2.0-15.0	85.0	1.15	1.0	0.15

a. For use when both useful output and motor loses are dissipated within refrigerated space; motors driving fans for forces circulated unit coolers

b. For use when motor loses are dissipated outside refrigerated space and useful work of motor is expended within refrigerated space; pump on a circulating brine or chilled water system, fan motor outside refrigerated space driving fan circulating air within refrigerated space.

c. For use when motor heat loses are dissipated within refrigerated space and useful work expended outside of refrigerated space; motor in refrigerated space driving pump or fan located outside space.

[ที่มา ASRE Data book, Design volume, 1949.]

ตาราง ข-14 Heat Equivalent to Occupancy

Cooler Temperature º C	Heat Equivalent/Person kW
10	0.211
5	0.242
0	0.275
-5	0.305
-10	0.347
-15	0.378
-20	0.407

[ที่มา ASRE Data book, Design volume, 1949.]

ตาราง ข-15 Usage Heat Gain, Watts per Cubic Meter Interior Volume per Kelvin Indoor-Outdoor Temperature Difference (W/m³.K)

Room	Service		Long-Term
Volume(m³)	Average	Heavy	Storage
0.6	3.63	3.97	
0.85	2.56	3.57	
1.5	1.77	2.76	
2	1.44	2.24	
3	1.25	1.96	
6	1.07	1.72	
8.5	1.01	1.61	
11	0.96	1.52	
14	0.94	1.45	
17	0.91	1.44	
23	0.86	1.37	
28	0.85	1.30	
34	0.77	1.23	
43	0.71	1.16	
57	0.65		0.60
85	0.58		0.45
140			0.31
200			0.24
280			0.19
560			0.16
1400			0.14
2100			0.14
2800			0.13