4 ● Discuss the difference in results obtained in cooling and dehumidifying in an air washer from those obtained in a surface cooling coil.

Air leaves a dehumidifying air washer in a saturated condition at a dew point temperature which can be easily maintained at a constant level by controlling the spray water temperature. This saturated air may then be reheated to proper delivery temperature by reheating coils or by mixing with by-passed air.

For a set air velocity and a set mean refrigerant temperature, a given cooling coil is capable of absorbing a definite amount of heat. Whether the air leaving the coil is saturated or not depends then on the entering dry- and wet-bulb temperatures. From practical operating standpoint, the easiest way to control the output of the cooling coil is by means of the dry-bulb temperature of the conditioned space. This means then that the final dew point will vary somewhat depending on entering air conditions.

Summarizing then, the air washers permit close control over both final dry-bulb and final dew point temperatures, while the surface coolers permit close control over the final dry-bulb only.

5 ● For condensing purposes, an air conditioning system uses city water which has an average 70 F supply temperature. The following table lists the number of hours per year during which definite wet-bulb temperatures and corresponding refrigeration rates pertain.

Wet-Bulb Temperature F	No. of Hours per Year	Refrigeration Required Tons
80	6	284
79 – 75	100	233
74 – 70	277	183
69 – 65	330	157
64 – 60	277	144
59 – 55	158	79
54 – 50	52	37
	Total 1200 hours	

If the power requirements of a dichlorodifluoromethane refrigeration system are in accordance with the following data on partial load operation, determine the seasonal power cost at 2 cents per kwhr:

Tons of Refrigeration	284	233	183	157	144	79	37
Kw per ton	0.89	0.89	0.87	0.86	0.86	0.93	0.97

Seasonal power cost:

Wet-Bulb Temperature F	Ton-Hours	Kwhr
80	6 × 284 = 1,704	1,704 × 0.89 = 1,517
79 – 75	100 × 233 = 23,300	23,300 × 0.89 = 20,750
74 – 70	277 × 183 = 50,700	50,700 × 0.87 = 44,100
69 – 65	330 × 157 = 51,800	51,800 × 0.86 = 44,500
64 – 60	277 × 144 = 39,900	39,900 × 0.86 = 34,300
59 – 55	158 × 79 = 12,500	12,500 × 0.93 = 11,600
54 – 50	52 × 37 = 1,920	1,920 × 0.97 = 1,860
Totals	181,824 ton-hours	158,627 kwhr

The 158,627 kwhr at 2 cents per kwhr will cost $3,173.

The average consumption will be $\frac{158{,}627 \text{ kwhr}}{181{,}824 \text{ ton-hours}} = 0.873$ kw per ton.

6 ● Using the data from Question 5, if city water costs 20 cents per thousand gallons, and if 1.25 gallons are used per minute per ton, estimate the annual water cost.

$60 \times 1.25 = 75$ gal per ton-hour.

$181{,}824$ ton-hours $\times\, 75 = 13{,}620{,}000$ gal per year.

$\frac{13{,}620{,}000 \times \$0.20}{1000} = \$2{,}724$, the yearly cooling water cost.

7 ● Using the data of Question 5, if a cooling tower were installed for re-using the condensing water, estimate the annual operating cost of a dichlorodifluoromethane refrigeration system if the final temperatures of the water leaving the cooling tower and the kilowatt input per ton are the following:

Tons	284	233	183	157	144	79	37
Temperature of water leaving tower, F	86.7	81.8	76.5	72.1	66.4	61.3	55.6
Kw input per ton	1.10	0.94	0.85	0.80	0.74	0.59	0.62

Wet-Bulb Temperature F	Ton-Hours		Kw per Ton		Kwhr
80	1,704	×	1.10	=	1,875
79 – 75	23,300	×	0.94	=	21,900
74 – 70	50,700	×	0.85	=	43,300
69 – 65	51,800	×	0.80	=	41,400
64 – 60	39,900	×	0.74	=	29,500
59 – 55	12,500	×	0.59	=	7,370
54 – 50	1,920	×	0.62	=	1,200
Totals	181,824 ton-hours				146,545 kwhr

The 146,545 kwhr at 2 cents per kwhr will cost $2,931.

The average consumption will be $\frac{146{,}545 \text{ kwhr}}{181{,}824 \text{ ton-hours}} = 0.805$ kw per ton.

8 ● If a steam ejector system were used to secure the refrigeration for the air conditioning system of Question 5, compute the annual steam cost if steam is sold for 53 cents per thousand pounds and if there is an average steam consumption of 20 lb of steam per hour per ton when used with a cooling tower system.

181,824 tons × 20 lb of steam per ton ≐ 3,636,480 lb of steam.

The 3,636,480 lb at 53 cents per thousand pounds will cost $1,929.

9 ● From the data given in the following table covering auxiliary equipment, make a comparison between the operating costs of the complete dichlorodifluoromethane system of Question 7 and the complete steam ejector cooling system of Question 8. A cooling tower is used for condenser water recovery.

Plant Operation	Dichlorodifluoromethane System	Steam Ejector System
Hours of operation	1200	1200
Cooling tower fan, bhp	17.8	35.6
Cooling tower pump, bhp	30.2	47.8
Chilled water, gpm	1200	1200
Discharge head on chilled water system, ft	75	75
Pump efficiency, per cent	75	75
Motor efficiency, per cent	80	80
Chilled water temperature, F	46	46

The flash tank or evaporator of the steam ejector system is of the open type, the flash water being pumped directly to the sprays of the washer used for cooling the air.