Case – 1 The Basics of Refrigeration Cycle P-H Diagram Analysis & Refrigerant Flow Diagram

Case Background:

This case is to review the practical use of the Pressure-Enthalpy (P-H) diagram and the thermodynamic analysis of the refrigeration cycle using the P-H diagram; the Refrigerant Flow Diagram corresponding to the P-H Diagram.

This case is also to evaluate various cycles such as with penalties, economizing for a single stage compression refrigeration systems which are based on the same CT, ET and TR as the following:

Condensing Temperature (CT):	102℉
Evaporative Temperature (ET):	-20℉
Capacity:	73 TR
Refrigerant:	R-22

Assuming compressor is screw and screw efficiencies:
Adiabatic Eff.	76.5%
Mechanical Eff.	94.6%.

Related Technical Data and Engineering Information for the Case:

The related engineering data and technical information for this case are as the following:

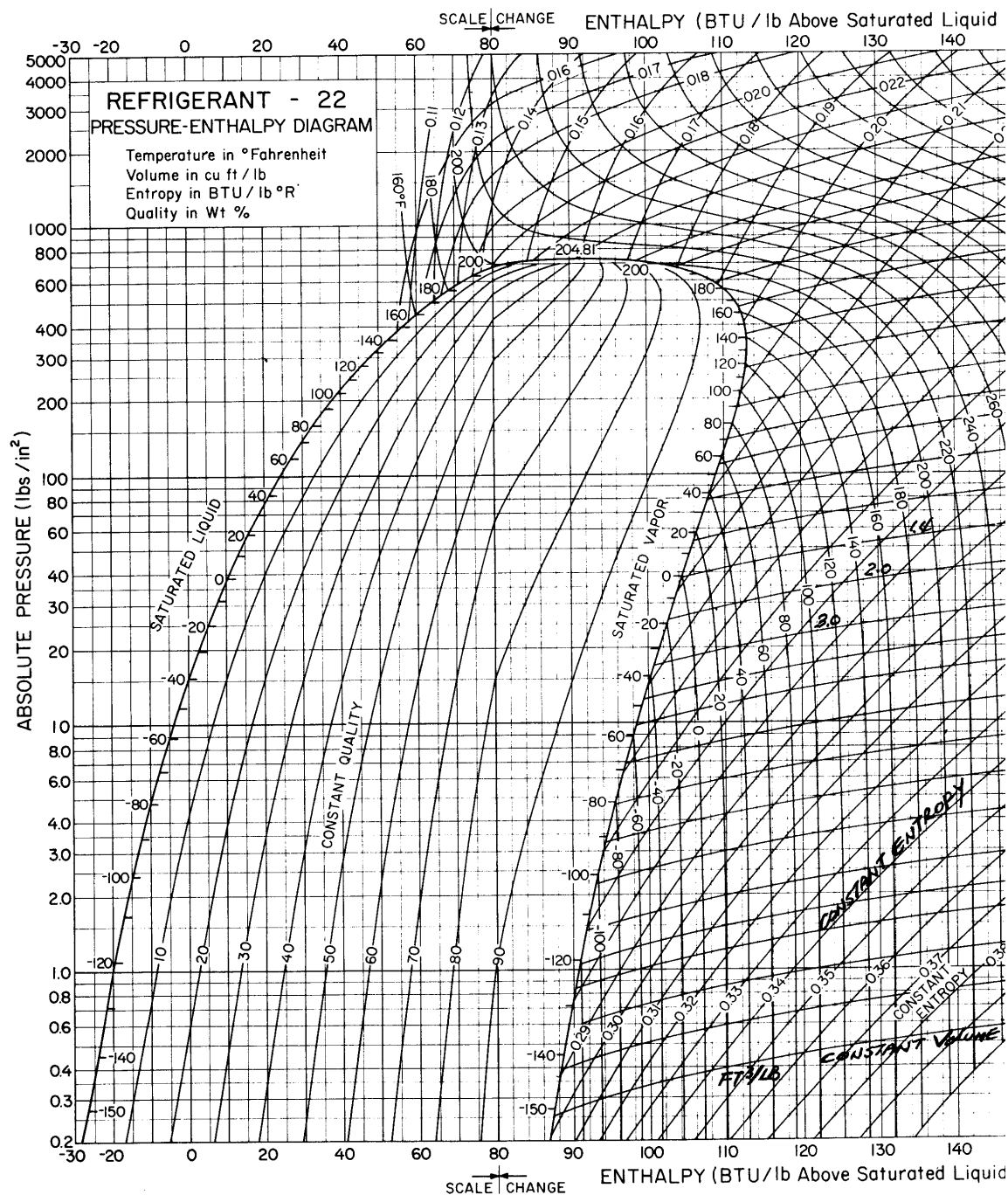|	
Figure 1-1	Pressure-Enthalpy Diagram for R-22
Figure 1-2	Properties of Liquid and Saturated Vapor for R-22, -50℉ to 14℉.
Figure 1-3	Saturated Properties for R-22, 10℉ to 64℉ .
Figure 1-4	Properties of Liquid and Saturated Vapor for R-22, 80℉ to 144℉ .

Figure 1-1   Pressure-Enthalpy Diagram for R-22

TABLE .. PROPERTIES OF LIQUID AND SATURATED VAPOR (continued)

TEMP F	PRESSURE lb per sq in		VOLUME cu ft per lb		DENSITY lb per cu ft		ENTHALPY ** Btu per lb			ENTROPY ** Btu per (lb) ($^{\circ}$R)		Temp F
t	Absolute P	Gage p	Liquid v_f	Vapor v_g	Liquid $1/v_f$	Vapor $1/v_g$	Liquid h_f	Latent h_{fg}	Vapor h_g	Liquid s_f	Vapor s_g	t
-50	11.674	6.154*	0.011235	4.2224	89.004	0.23683	- 2.511	101.656	99.144	-0.00604	0.24209	-50
-49	11.996	5.498*	.011248	4.1166	88.905	.24292	- 2.262	101.519	99.257	- .00543	.24176	-49
-48	12.324	4.829*	.011261	4.0140	88.806	.24913	- 2.012	101.381	99.369	- .00483	.24143	-48
-47	12.660	4.144*	.011273	3.9145	88.707	.25546	- 1.762	101.242	99.480	- .00422	.24110	-47
-46	13.004	3.445*	.011286	3.8179	88.607	.26192	- 1.511	101.103	99.592	- .00361	.24078	-46
-45	13.354	2.732*	0.011298	3.7243	88.507	0.26851	- 1.260	100.963	99.703	-0.00301	0.24046	-45
-44	13.712	2.002*	.011311	3.6334	88.407	.27523	- 1.009	100.823	99.814	- .00241	.24014	-44
-43	14.078	1.258*	.011324	3.5452	88.307	.28207	- 0.757	100.683	99.925	- .00181	.23982	-43
-42	14.451	0.498*	.011337	3.4596	88.207	.28905	- 0.505	100.541	100.036	- .00120	.23951	-42
-41	14.833	0.137	.011350	3.3764	88.107	.29617	- 0.253	100.399	100.147	- .00060	.23919	-41
-40	15.222	0.526	0.011363	3.2957	88.006	0.30342	0.000	100.257	100.257	0.00000	0.23888	-40
-39	15.619	0.923	.011376	3.2173	87.905	.31082	0.253	100.114	100.367	.00060	.23858	-39
-38	16.024	1.328	.011389	3.1412	87.805	.31835	0.506	99.971	100.477	.00120	.23827	-38
-37	16.437	1.741	.011402	3.0673	87.703	.32602	0.760	99.826	100.587	.00180	.23797	-37
-36	16.859	2.163	.011415	2.9954	87.602	.33384	1.014	99.682	100.696	.00240	.23767	-36
-35	17.290	2.594	0.011428	2.9256	87.501	0.34181	1.269	99.536	100.805	0.00300	0.23737	-35
-34	17.728	3.032	.011442	2.8578	87.399	.34992	1.524	99.391	100.914	.00359	.23707	-34
-33	18.176	3.480	.011455	2.7919	87.297	.35818	1.779	99.244	101.023	.00419	.23678	-33
-32	18.633	3.937	.011469	2.7278	87.195	.36660	2.035	99.097	101.132	.00479	.23649	-32
-31	19.098	4.402	.011482	2.6655	87.093	.37517	2.291	98.949	101.240	.00538	.23620	-31
-30	19.573	4.877	0.011495	2.6049	86.991	0.38389	2.547	98.801	101.348	0.00598	0.23591	-30
-29	20.056	5.360	.011509	2.5460	86.888	.39278	2.804	98.652	101.456	.00657	.23563	-29
-28	20.549	5.853	.011523	2.4887	86.785	.40182	3.061	98.503	101.564	.00716	.23534	-28
-27	21.052	6.536	.011536	2.4329	86.682	.41103	3.318	98.353	101.671	.00776	.23506	-27
-26	21.564	6.868	.011550	2.3787	86.579	.42040	3.576	98.202	101.778	.00835	.23478	-26
-25	22.086	7.390	0.011564	2.3260	86.476	0.42993	3.834	98.051	101.885	0.00894	0.23451	-25
-24	22.617	7.921	.011578	2.2746	86.372	.43964	4.093	97.899	101.992	.00953	.23423	-24
-23	23.159	8.463	.011592	2.2246	86.269	.44951	4.352	97.746	102.098	.01013	.23396	-23
-22	23.711	9.015	.011606	2.1760	86.165	.45956	4.611	97.593	102.204	.01072	.23369	-22
-21	24.272	9.576	.011620	2.1287	86.061	.46978	4.871	97.439	102.310	.01131	.23342	-21
-20	24.845	10.149	0.011634	2.0826	85.956	0.48018	5.131	97.285	102.415	0.01189	0.23315	-20
-19	25.427	10.731	.011648	2.0377	85.852	.49075	5.391	97.129	102.521	.01248	.23289	-19
-18	26.020	11.324	.011662	1.9940	85.747	.50151	5.652	96.974	102.626	.01307	.23262	-18
-17	26.624	11.928	.011677	1.9514	85.642	.51245	5.913	96.817	102.730	.01366	.23236	-17
-16	27.239	12.543	.011691	1.9099	85.537	.52358	6.175	96.660	102.835	.01425	.23210	-16
-15	27.865	13.169	0.011705	1.8695	85.431	0.53489	6.436	96.502	102.939	0.01483	0.23184	-15
-14	28.501	13.805	.011720	1.8302	85.326	.54640	6.699	96.344	103.043	.01542	.23159	-14
-13	29.149	14.453	.011734	1.7918	85.220	.55810	6.961	96.185	103.146	.01600	.23133	-13
-12	29.809	15.113	.011749	1.7544	85.114	.56999	7.224	96.025	103.250	.01659	.23108	-12
-11	30.480	15.784	.011764	1.7180	85.008	.58207	7.488	95.865	103.353	.01717	.23083	-11
-10	31.162	16.466	0.011778	1.6825	84.901	0.59436	7.751	95.704	103.455	0.01776	0.23058	-10
- 9	31.856	17.160	.011793	1.6479	84.795	.60685	8.015	95.542	103.558	.01834	.23033	- 9
- 8	32.563	17.867	.011808	1.6141	84.688	.61954	8.280	95.380	103.660	.01892	.23008	- 8
- 7	33.281	18.585	.011823	1.5812	84.581	.63244	8.545	95.217	103.762	.01950	.22984	- 7
- 6	34.011	19.315	.011838	1.5491	84.473	.64555	8.810	95.053	103.863	.02009	.22960	- 6
- 5	34.754	20.058	0.011853	1.5177	84.366	0.65887	9.075	94.889	103.964	0.02067	0.22936	- 5
- 4	35.509	20.813	.011868	1.4872	84.258	.67240	9.341	94.724	104.065	.02125	.22912	- 4
- 3	36.277	21.581	.011884	1.4574	84.150	.68615	9.608	94.558	104.166	.02183	.22888	- 3
- 2	37.057	22.361	.011899	1.4283	84.042	.70012	9.874	94.391	104.266	.02241	.22864	- 2
- 1	37.850	23.154	.011914	1.4000	83.933	.71431	10.142	94.224	104.366	.02299	.22841	- 1
0	38.657	23.961	0.011930	1.3723	83.825	0.72872	10.409	94.056	104.465	0.02357	0.22817	0
1	39.476	24.780	.011945	1.3453	83.716	.74336	10.677	93.888	104.565	.02414	.22794	1
2	40.309	25.613	.011961	1.3189	83.606	.75822	10.945	93.718	104.663	.02472	.22771	2
3	41.155	26.459	.011976	1.2931	83.497	.77332	11.214	93.548	104.762	.02530	.22748	3
4	42.014	27.318	.011992	1.2680	83.387	.78865	11.483	93.378	104.860	.02587	.22725	4
5	42.888	28.192	0.012008	1.2434	83.277	0.80422	11.752	93.206	104.958	0.02645	0.22703	5
6	43.775	29.079	.012024	1.2195	83.167	.82003	12.022	93.034	105.056	.02703	.22680	6
7	44.676	29.980	.012040	1.1961	83.057	.83608	12.292	92.861	105.153	.02760	.22658	7
8	45.591	30.895	.012056	1.1732	82.946	.85237	12.562	92.688	105.250	.02818	.22636	8
9	46.521	31.825	.012072	1.1509	82.835	.86892	12.833	92.513	105.346	.02875	.22614	9
10	47.464	32.768	0.012088	1.1290	82.724	0.88571	13.104	92.338	105.442	0.02932	0.22592	10
11	48.423	33.727	.012105	1.1077	82.612	.90275	13.376	92.162	105.538	.02990	.22570	11
12	49.396	34.700	.012121	1.0869	82.501	.92005	13.648	91.986	105.633	.03047	.22548	12
13	50.384	35.688	.012138	1.0665	82.389	.93761	13.920	91.808	105.728	.03104	.22527	13
14	51.387	36.691	.012154	1.0466	82.276	.95544	14.193	91.630	105.823	.03161	.22505	14

*Inches of mercury below one standard atmosphere.

Figure 1-2   Properties of Liquid and Saturated Vapor
For R-22, -50°F to 14°F

"FREON-22" SATURATION PROPERTIES—TEMPERATURE TABLE

TEMP. °F	PRESSURE		VOLUME cu ft/lb		DENSITY lb/cu ft		ENTHALPY Btu/lb			ENTROPY Btu/(lb)(°R)		TEMP. °F
	PSIA	PSIG	LIQUID v_f	VAPOR v_g	LIQUID $1/v_f$	VAPOR $1/v_g$	LIQUID h_f	LATENT h_{fg}	VAPOR h_g	LIQUID s_f	VAPOR s_g	
10	47.464	32.768	0.012088	1.1290	82.724	0.88571	13.104	92.338	105.442	0.02932	0.22592	10
11	48.423	33.727	0.012105	1.1077	82.612	0.90275	13.376	92.162	105.538	0.02990	0.22570	11
12	49.396	34.700	0.012121	1.0869	82.501	0.92005	13.648	91.986	105.633	0.03047	0.22548	12
13	50.384	35.688	0.012138	1.0665	82.389	0.93761	13.920	91.808	105.728	0.03104	0.22527	13
14	51.387	36.691	0.012154	1.0466	82.276	0.95544	14.193	91.630	105.823	0.03161	0.22505	14
15	52.405	37.709	0.012171	1.0272	82.164	0.97352	14.466	91.451	105.917	0.03218	0.22484	15
16	53.438	38.742	0.012188	1.0082	82.051	0.99188	14.739	91.272	106.011	0.03275	0.22463	16
17	54.487	39.791	0.012204	0.98961	81.938	1.0105	15.013	91.091	106.105	0.03332	0.22442	17
18	55.551	40.855	0.012221	0.97144	81.825	1.0294	15.288	90.910	106.198	0.03389	0.22421	18
19	56.631	41.935	0.012238	0.95368	81.711	1.0486	15.562	90.728	106.290	0.03446	0.22400	19
20	57.727	43.031	0.012255	0.93631	81.597	1.0680	15.837	90.545	106.383	0.03503	0.22379	20
21	58.839	44.143	0.012273	0.91932	81.483	1.0878	16.113	90.362	106.475	0.03560	0.22358	21
22	59.967	45.271	0.012290	0.90270	81.368	1.1078	16.389	90.178	106.566	0.03617	0.22338	22
23	61.111	46.415	0.012307	0.88645	81.253	1.1281	16.665	89.993	106.657	0.03674	0.22318	23
24	62.272	47.576	0.012325	0.87055	81.138	1.1487	16.942	89.807	106.748	0.03730	0.22297	24
25	63.450	48.754	0.012342	0.85500	81.023	1.1696	17.219	89.620	106.839	0.03787	0.22277	25
26	64.644	49.948	0.012360	0.83978	80.907	1.1908	17.496	89.433	106.928	0.03844	0.22257	26
27	65.855	51.159	0.012378	0.82488	80.791	1.2123	17.774	89.244	107.018	0.03900	0.22237	27
28	67.083	52.387	0.012395	0.81031	80.675	1.2341	18.052	89.055	107.107	0.03958	0.22217	28
29	68.328	53.632	0.012413	0.79604	80.558	1.2562	18.330	88.865	107.196	0.04013	0.22198	29
30	69.591	54.895	0.012431	0.78208	80.441	1.2786	18.609	88.674	107.284	0.04070	0.22178	30
31	70.871	56.175	0.012450	0.76842	80.324	1.3014	18.889	88.483	107.372	0.04126	0.22158	31
32	72.169	57.473	0.012468	0.75503	80.207	1.3244	19.169	88.290	107.459	0.04182	0.22139	32
33	73.485	58.789	0.012486	0.74194	80.089	1.3478	19.449	88.097	107.546	0.04239	0.22119	33
34	74.818	60.122	0.012505	0.72911	79.971	1.3715	19.729	87.903	107.632	0.04295	0.22100	34
35	76.170	61.474	0.012523	0.71655	79.852	1.3956	20.010	87.708	107.719	0.04351	0.22081	35
36	77.540	62.844	0.012542	0.70425	79.733	1.4199	20.292	87.512	107.804	0.04407	0.22062	36
37	78.929	64.233	0.012561	0.69221	79.614	1.4447	20.574	87.316	107.889	0.04464	0.22043	37
38	80.336	65.640	0.012579	0.68041	79.495	1.4697	20.856	87.118	107.974	0.04520	0.22024	38
39	81.761	67.065	0.012598	0.66885	79.375	1.4951	21.138	86.920	108.058	0.04576	0.22005	39
40	83.206	68.510	0.012618	0.65753	79.255	1.5208	21.422	86.720	108.142	0.04632	0.21986	40
41	84.670	69.974	0.012637	0.64643	79.134	1.5469	21.705	86.520	108.225	0.04688	0.21968	41
42	86.153	71.457	0.012656	0.63557	79.013	1.5734	21.989	86.319	108.308	0.04744	0.21949	42
43	87.655	72.959	0.012676	0.62492	78.892	1.6002	22.273	86.117	108.390	0.04800	0.21931	43
44	89.177	74.481	0.012695	0.61448	78.770	1.6274	22.558	85.914	108.472	0.04855	0.21912	44
45	90.719	76.023	0.012715	0.60425	78.648	1.6549	22.843	85.710	108.553	0.04911	0.21894	45
46	92.280	77.584	0.012735	0.59422	78.526	1.6829	23.129	85.506	108.634	0.04967	0.21876	46
47	93.861	79.165	0.012755	0.58440	78.403	1.7112	23.415	85.300	108.715	0.05023	0.21858	47
48	95.463	80.767	0.012775	0.57476	78.280	1.7398	23.701	85.094	108.795	0.05079	0.21839	48
49	97.085	82.389	0.012795	0.56532	78.157	1.7689	23.988	84.886	108.874	0.05134	0.21821	49
50	98.727	84.031	0.012815	0.55606	78.033	1.7984	24.275	84.678	108.953	0.05190	0.21803	50
51	100.39	85.69	0.012836	0.54698	77.909	1.8282	24.563	84.468	109.031	0.05245	0.21785	51
52	102.07	87.38	0.012856	0.53808	77.784	1.8585	24.851	84.258	109.109	0.05301	0.21768	52
53	103.78	89.08	0.012877	0.52934	77.659	1.8891	25.139	84.047	109.186	0.05357	0.21750	53
54	105.50	90.81	0.012898	0.52078	77.534	1.9202	25.429	83.834	109.263	0.05412	0.21732	54
55	107.25	92.56	0.012919	0.51238	77.408	1.9517	25.718	83.621	109.339	0.05468	0.21714	55
56	109.02	94.32	0.012940	0.50414	77.282	1.9836	26.008	83.407	109.415	0.05523	0.21697	56
57	110.81	96.11	0.012961	0.49606	77.155	2.0159	26.298	83.191	109.490	0.05579	0.21679	57
58	112.62	97.93	0.012982	0.48813	77.028	2.0486	26.589	82.975	109.564	0.05634	0.21662	58
59	114.46	99.76	0.013004	0.48035	76.900	2.0818	26.880	82.758	109.638	0.05689	0.21644	59
60	116.31	101.62	0.013025	0.47272	76.773	2.1154	27.172	82.540	109.712	0.05745	0.21627	60
61	118.19	103.49	0.013047	0.46523	76.644	2.1495	27.464	82.320	109.785	0.05800	0.21610	61
62	120.09	105.39	0.013069	0.45788	76.515	2.1840	27.757	82.100	109.857	0.05855	0.21592	62
63	122.01	107.32	0.013091	0.45066	76.386	2.2190	28.050	81.878	109.929	0.05910	0.21575	63
64	123.96	109.26	0.013114	0.44358	76.257	2.2544	28.344	81.656	110.000	0.05966	0.21558	64

Figure 1-3   Saturated Properties for R-22, 10°F to 64°F

TABLE   .. PROPERTIES OF LIQUID AND SATURATED VAPOR (continued)

TEMP F	PRESSURE lb per sq in		VOLUME cu ft per lb		DENSITY lb per cu ft		ENTHALPY ** Btu per lb			ENTROPY ** Btu per (lb) (°R)		TEMP F
t	Absolute P	Gage p	Liquid v_f	Vapor v_g	Liquid $1/v_f$	Vapor $1/v_g$	Liquid h_f	Latent h_{fg}	Vapor h_g	Liquid s_f	Vapor s_g	t
80	158.33	143.63	0.013492	0.34621	74.116	2.8885	33.109	77.943	111.052	0.06846	0.21288	80
81	160.68	145.99	.013518	.34099	73.978	2.9326	33.412	77.701	111.112	.06901	.21271	81
82	163.07	148.37	.013543	.33587	73.839	2.9774	33.714	77.457	111.171	.06956	.21255	82
83	165.48	150.78	.013569	.33083	73.700	3.0227	34.018	77.212	111.230	.07011	.21238	83
84	167.92	153.22	.013594	.32588	73.560	3.0686	34.322	76.966	111.288	.07065	.21222	84
85	170.38	155.68	0.013620	0.32101	73.420	3.1151	34.626	76.719	111.345	0.07120	0.21205	85
86	172.87	158.17	.013647	.31623	73.278	3.1622	34.931	76.470	111.401	.07175	.21188	86
87	175.38	160.69	.013673	.31153	73.137	3.2100	35.237	76.220	111.457	.07230	.21172	87
88	177.93	163.23	.013700	.30690	72.994	3.2583	35.543	75.968	111.512	.07285	.21155	88
89	180.50	165.80	.013727	.30236	72.851	3.3073	35.850	75.716	111.566	.07339	.21139	89
90	183.09	168.40	0.013754	0.29789	72.708	3.3570	36.158	75.461	111.619	0.07394	0.21122	90
91	185.72	171.02	.013781	.29349	72.564	3.4073	36.466	75.206	111.671	.07449	.21106	91
92	188.37	173.67	.013809	.28917	72.419	3.4582	36.774	74.949	111.723	.07504	.21089	92
93	191.05	176.35	.013836	.28491	72.273	3.5098	37.084	74.690	111.774	.07559	.21072	93
94	193.76	179.06	.013864	.28073	72.127	3.5621	37.394	74.430	111.824	.07613	.21056	94
95	196.50	181.80	0.013893	0.27662	71.980	3.6151	37.704	74.168	111.873	0.07668	0.21039	95
96	199.26	184.56	.013921	.27257	71.833	3.6688	38.016	73.905	111.921	.07723	.21023	96
97	202.05	187.36	.013950	.26859	71.685	3.7232	38.328	73.641	111.968	.07778	.21006	97
98	204.87	190.18	.013979	.26467	71.536	3.7783	38.640	73.375	112.015	.07832	.20989	98
99	207.72	193.03	.014008	.26081	71.386	3.8341	38.953	73.107	112.060	.07887	.20973	99
100	210.60	195.91	0.014038	0.25702	71.236	3.8907	39.267	72.838	112.105	0.07942	0.20956	100
101	213.51	198.82	.014068	.25329	71.084	3.9481	39.582	72.567	112.149	.07997	.20939	101
102	216.45	201.76	.014098	.24962	70.933	4.0062	39.897	72.294	112.192	.08052	.20923	102
103	219.42	204.72	.014128	.24600	70.780	4.0651	40.213	72.020	112.233	.08107	.20906	103
104	222.42	207.72	.014159	.24244	70.626	4.1247	40.530	71.744	112.274	.08161	.20889	104
105	225.45	210.75	0.014190	0.23894	70.472	4.1852	40.847	71.467	112.314	0.08216	0.20872	105
106	228.50	213.81	.014221	.23549	70.317	4.2465	41.166	71.187	112.353	.08271	.20855	106
107	231.59	216.90	.014253	.23209	70.161	4.3086	41.485	70.906	112.391	.08326	.20838	107
108	234.71	220.02	.014285	.22875	70.005	4.3715	41.804	70.623	112.427	.08381	.20821	108
109	237.86	223.17	.014317	.22546	69.847	4.4354	42.125	70.338	112.463	.08436	.20804	109
110	241.04	226.35	0.014350	0.22222	69.689	4.5000	42.446	70.052	112.498	0.08491	0.20787	110
111	244.25	229.56	.014382	.21903	69.529	4.5656	42.768	69.763	112.531	.08546	.20770	111
112	247.50	232.80	.014416	.21589	69.369	4.6321	43.091	69.473	112.564	.08601	.20753	112
113	250.77	236.08	.014449	.21279	69.208	4.6994	43.415	69.180	112.595	.08656	.20736	113
114	254.08	239.38	.014483	.20974	69.046	4.7677	43.739	68.886	112.626	.08711	.20718	114
115	257.42	242.72	0.014517	0.20674	68.883	4.8370	44.065	68.590	112.655	0.08766	0.20701	115
116	260.79	246.10	.014552	.20378	68.719	4.9072	44.391	68.291	112.682	.08821	.20684	116
117	264.20	249.50	.014587	.20087	68.554	4.9784	44.718	67.991	112.709	.08876	.20666	117
118	267.63	252.94	.014622	.19800	68.388	5.0506	45.046	67.688	112.735	.08932	.20649	118
119	271.10	256.41	.014658	.19517	68.221	5.1238	45.375	67.384	112.759	.08987	.20631	119
120	274.60	259.91	0.014694	0.19238	68.054	5.1981	45.705	67.077	112.782	0.09042	0.20613	120
121	278.14	263.44	.014731	.18963	67.885	5.2734	46.036	66.767	112.803	.09098	.20595	121
122	281.71	267.01	.014768	.18692	67.714	5.3498	46.368	66.456	112.824	.09153	.20578	122
123	285.31	270.62	.014805	.18426	67.543	5.4272	46.701	66.142	112.843	.09208	.20560	123
124	288.95	274.25	.014843	.18163	67.371	5.5058	47.034	65.826	112.860	.09264	.20542	124
125	292.62	277.92	0.014882	0.17903	67.197	5.5856	47.369	65.507	112.877	0.09320	0.20523	125
126	296.33	281.63	.014920	.17648	67.023	5.6665	47.705	65.186	112.891	.09375	.20505	126
127	300.07	285.37	.014960	.17396	66.847	5.7486	48.042	64.863	112.905	.09431	.20487	127
128	303.84	289.14	.014999	.17147	66.670	5.8319	48.380	64.537	112.917	.09487	.20468	128
129	307.65	292.95	.015039	.16902	66.492	5.9164	48.719	64.208	112.927	.09543	.20449	129
130	311.50	296.80	0.015080	0.16661	66.312	6.0022	49.059	63.877	112.936	0.09598	0.20431	130
131	315.38	300.68	.015121	.16422	66.131	6.0893	49.400	63.543	112.943	.09654	.20412	131
132	319.29	304.60	.015163	.16187	65.949	6.1777	49.743	63.206	112.949	.09711	.20393	132
133	323.25	308.55	.015206	.15956	65.766	6.2674	50.087	62.866	112.953	.09767	.20374	133
134	327.23	312.54	.015248	.15727	65.581	6.3585	50.432	62.523	112.955	.09823	.20354	134
135	331.26	316.56	0.015292	0.15501	65.394	6.4510	50.778	62.178	112.956	0.09879	0.20335	135
136	335.32	320.63	.015336	.15279	65.207	6.5450	51.125	61.829	112.954	.09936	.20315	136
137	339.42	324.73	.015381	.15059	65.017	6.6405	51.474	61.477	112.951	.09992	.20295	137
138	343.56	328.86	.015426	.14843	64.826	6.7374	51.824	61.123	112.947	.10049	.20275	138
139	347.73	333.04	.015472	.14629	64.634	6.8359	52.175	60.764	112.940	.10106	.20255	139
140	351.94	337.25	0.015518	0.14418	64.440	6.9360	52.528	60.403	112.931	0.10163	0.20235	140
141	356.19	341.50	.015566	.14209	64.244	7.0377	52.883	60.038	112.921	.10220	.20214	141
142	360.48	345.79	.015613	.14004	64.047	7.1410	53.238	59.670	112.908	.10277	.20194	142
143	364.81	350.11	.015662	.13801	63.848	7.2461	53.596	59.298	112.893	.10334	.20173	143
144	369.17	354.48	.015712	.13600	63.647	7.3529	53.955	58.922	112.877	.10391	.20152	144

Figure 1-4   Properties of Liquid and Saturated Vapor
For R-22, 80°F to 144°F

Practice-1: The thermodynamic data for the simple cycle

Take R-22 Pressure-Enthalpy Diagram Figure 1-1, draw a condensing temperature line of $105°F$, an evaporative temperature line of $-20°F$, constant throttling line from the $105°F$ condensing liquid to $-20°F$ line to represent the expansion and draw the line of constant Entropy from saturated $-20°F$ to condensing temperature of $105°F$, this line is the compression line without the suction and discharge penalties, this image is shown in Figure 1-5. This Cogitation is to base on idea simple cycle with no losses.
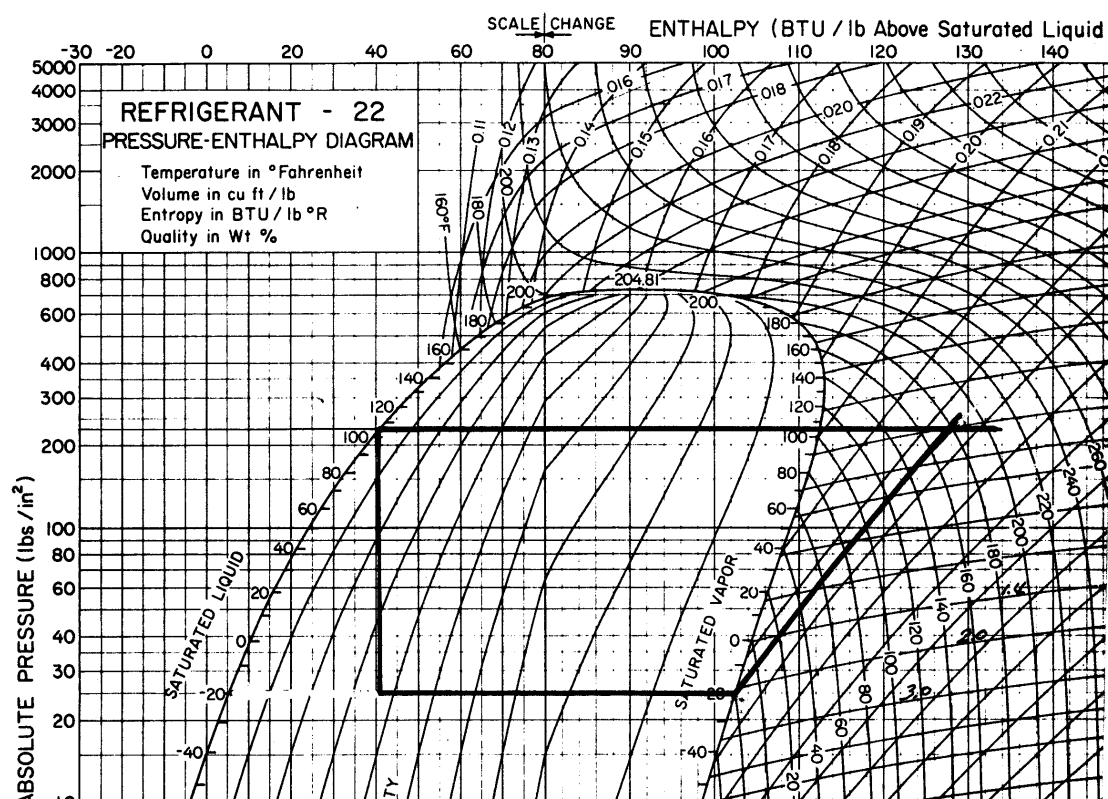
Figure 1-5   Refrigeration Cycle on the P-H Diagram

Take the structure image of this refrigeration cycle from Figure 1-5, it becomes the P-H diagram for engineering calculation as shown in Figure 1-6. The points which are required for engineering calculation are from H_1 to H_6 as shown in the Figure 1-6.

H_1 to H_2 is the adiabatic compression of the compressor for the simple refrigeration system without suction and discharge penalties
H_2 to H_5 is the condensing line of the condenser.
H_5 to H_6 is the adiabatic throttling expansion line.
H_6 to H_1 is the evaporation line.
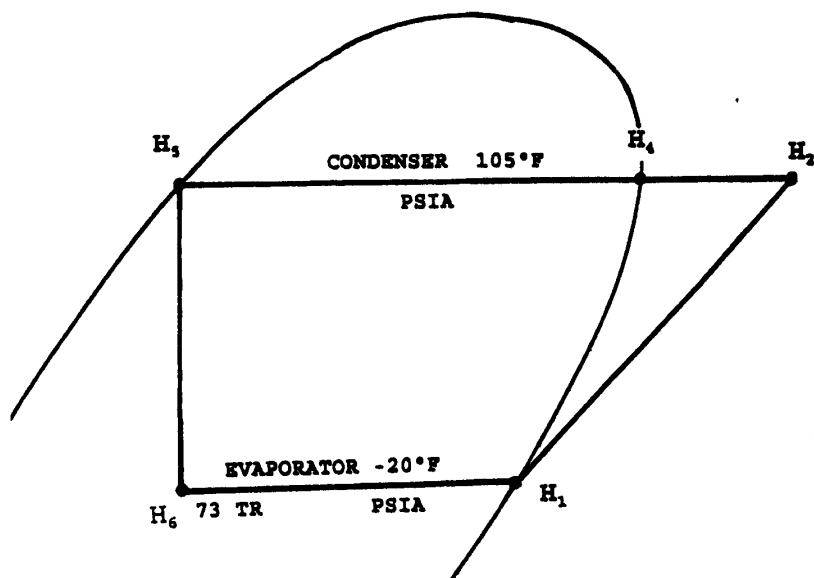
Figure 1-6   Refrigeration Cycle P-H Diagram Image

TABLE ... PROPERTIES OF LIQUID AND SATURATED VAPOR (continued)

TEMP F	PRESSURE lb per sq in		VOLUME cu ft per lb		DENSITY lb per cu ft		ENTHALPY ** Btu per lb			ENTROPY ** Btu per (lb) (°R)		Temp F
t	Absolute p	Gage p	Liquid v_f	Vapor v_g	Liquid $1/v_f$	Vapor $1/v_g$	Liquid h_f	Latent h_{fg}	Vapor h_g	Liquid s_f	Vapor s_g	t
-50	11.674	6.154*	0.011235	4.2224	89.004	0.23683	- 2.511	101.656	99.144	-0.00604	0.24209	-50
-49	11.996	5.498*	.011248	4.1166	88.905	.24292	- 2.262	101.519	99.257	- .00543	.24176	-49
-48	12.324	4.829*	.011261	4.0140	88.806	.24913	- 2.012	101.381	99.369	- .00483	.24143	-48
-47	12.660	4.144*	.011273	3.9145	88.707	.25546	- 1.762	101.242	99.480	- .00422	.24110	-47
-46	13.004	3.445*	.011286	3.8179	88.607	.26192	- 1.511	101.103	99.592	- .00361	.24078	-46
-45	13.354	2.732*	0.011298	3.7243	88.507	0.26851	- 1.260	100.963	99.703	-0.00301	0.24046	-45
-44	13.712	2.002*	.011311	3.6334	88.407	.27523	- 1.009	100.823	99.814	- .00241	.24014	-44
-43	14.078	1.258*	.011324	3.5452	88.307	.28207	- 0.757	100.683	99.925	- .00181	.23982	-43
-42	14.451	0.498*	.011337	3.4596	88.207	.28905	- 0.505	100.541	100.036	- .00120	.23951	-42
-41	14.833	0.137	.011350	3.3764	88.107	.29617	- 0.253	100.399	100.147	- .00060	.23919	-41
-40	15.222	0.526	0.011363	3.2957	88.006	0.30342	0.000	100.257	100.257	0.00000	0.23888	-40
-39	15.619	0.923	.011376	3.2173	87.905	.31082	0.253	100.114	100.367	.00060	.23858	-39
-38	16.024	1.328	.011389	3.1412	87.805	.31835	0.506	99.971	100.477	.00120	.23827	-38
-37	16.437	1.741	.011402	3.0673	87.703	.32602	0.760	99.826	100.587	.00180	.23797	-37
-36	16.859	2.163	.011415	2.9954	87.602	.33384	1.014	99.682	100.696	.00240	.23767	-36
-35	17.290	2.594	0.011428	2.9256	87.501	0.34181	1.269	99.536	100.805	0.00300	0.23737	-35
-34	17.728	3.032	.011442	2.8578	87.399	.34992	1.524	99.391	100.914	.00359	.23707	-34
-33	18.176	3.480	.011455	2.7919	87.297	.35818	1.779	99.244	101.023	.00419	.23678	-33
-32	18.633	3.937	.011469	2.7278	87.195	.36660	2.035	99.097	101.132	.00479	.23649	-32
-31	19.098	4.402	.011482	2.6655	87.093	.37517	2.291	98.949	101.240	.00538	.23620	-31
-30	19.573	4.877	0.011495	2.6049	86.991	0.38389	2.547	98.801	101.348	0.00598	0.23591	-30
-29	20.056	5.360	.011509	2.5460	86.888	.39278	2.804	98.652	101.456	.00657	.23563	-29
-28	20.549	5.853	.011523	2.4887	86.785	.40182	3.061	98.503	101.564	.00716	.23534	-28
-27	21.052	6.536	.011536	2.4329	86.682	.41103	3.318	98.353	101.671	.00776	.23506	-27
-26	21.564	6.868	.011550	2.3787	86.579	.42040	3.576	98.202	101.778	.00835	.23478	-26
-25	22.086	7.390	0.011564	2.3260	86.476	0.42993	3.834	98.051	101.885	0.00894	0.23451	-25
-24	22.617	7.921	.011578	2.2746	86.372	.43964	4.093	97.899	101.992	.00953	.23423	-24
-23	23.159	8.463	.011592	2.2246	86.269	.44951	4.352	97.746	102.098	.01013	.23396	-23
-22	23.711	9.015	.011606	2.1760	86.165	.45956	4.611	97.593	102.204	.01072	.23369	-22
-21	24.272	9.576	.011620	2.1287	86.061	.46978	4.871	97.439	102.310	.01131	.23342	-21
-20	24.845	10.149	0.011634	2.0826	85.956	0.48018	5.131	97.285	102.415	0.01189	0.23315	-20
-19	25.427	10.731	.011648	2.0377	85.852	.49075	5.391	97.129	102.521	.01248	.23289	-19
-18	26.020	11.324	.011662	1.9940	85.747	.50151	5.652	96.974	102.626	.01307	.23262	-18
-17	26.624	11.928	.011677	1.9514	85.642	.51245	5.913	96.817	102.730	.01366	.23236	-17
-16	27.239	12.543	.011691	1.9099	85.537	.52358	6.175	96.660	102.835	.01425	.23210	-16

Figure 1-7   Properties of Refrigerant at -20°F

TABLE ... PROPERTIES OF LIQUID AND SATURATED VAPOR (continued)

TEMP F	PRESSURE lb per sq in		VOLUME cu ft per lb		DENSITY lb per cu ft		ENTHALPY** Btu per lb			ENTROPY** Btu per (lb) (°R)		TEMP F
t	Absolute P	Gage p	Liquid v_f	Vapor v_g	Liquid $1/v_f$	Vapor $1/v_g$	Liquid h_f	Latent h_{fg}	Vapor h_g	Liquid s_f	Vapor s_g	t
80	158.33	143.63	0.013492	0.34621	74.116	2.8885	33.109	77.943	111.052	0.06846	0.21288	80
81	160.68	145.99	.013518	.34099	73.978	2.9326	33.412	77.701	111.112	.06901	.21271	81
82	163.07	148.37	.013543	.33587	73.839	2.9774	33.714	77.457	111.171	.06956	.21255	82
83	165.48	150.78	.013569	.33083	73.700	3.0227	34.018	77.212	111.230	.07011	.21238	83
84	167.92	153.22	.013594	.32588	73.560	3.0686	34.322	76.966	111.288	.07065	.21222	84
85	170.38	155.68	0.013620	0.32101	73.420	3.1151	34.626	76.719	111.345	0.07120	0.21205	85
86	172.87	158.17	.013647	.31623	73.278	3.1622	34.931	76.470	111.401	.07175	.21188	86
87	175.38	160.69	.013673	.31153	73.137	3.2100	35.237	76.220	111.457	.07230	.21172	87
88	177.93	163.23	.013700	.30690	72.994	3.2583	35.543	75.968	111.512	.07285	.21155	88
89	180.50	165.80	.013727	.30236	72.851	3.3073	35.850	75.716	111.566	.07339	.21139	89
90	183.09	168.40	0.013754	0.29789	72.708	3.3570	36.158	75.461	111.619	0.07394	0.21122	90
91	185.72	171.02	.013781	.29349	72.564	3.4073	36.466	75.206	111.671	.07449	.21106	91
92	188.37	173.67	.013809	.28917	72.419	3.4582	36.774	74.949	111.723	.07504	.21089	92
93	191.05	176.35	.013836	.28491	72.273	3.5098	37.084	74.690	111.774	.07559	.21072	93
94	193.76	179.06	.013864	.28073	72.127	3.5621	37.394	74.430	111.824	.07613	.21056	94
95	196.50	181.80	0.013893	0.27662	71.980	3.6151	37.704	74.168	111.873	0.07668	0.21039	95
96	199.26	184.56	.013921	.27257	71.833	3.6688	38.016	73.905	111.921	.07723	.21023	96
97	202.05	187.36	.013950	.26859	71.685	3.7232	38.328	73.641	111.968	.07778	.21006	97
98	204.87	190.18	.013979	.26467	71.536	3.7783	38.640	73.375	112.015	.07832	.20989	98
99	207.72	193.03	.014008	.26081	71.386	3.8341	38.953	73.107	112.060	.07887	.20973	99
100	210.60	195.91	0.014038	0.25702	71.236	3.8907	39.267	72.838	112.105	0.07942	0.20956	100
101	213.51	198.82	.014068	.25329	71.084	3.9481	39.582	72.567	112.149	.07997	.20939	101
102	216.45	201.76	.014098	.24962	70.933	4.0062	39.897	72.294	112.192	.08052	.20923	102
103	219.42	204.72	.014128	.24600	70.780	4.0651	40.213	72.020	112.233	.08107	.20906	103
104	222.42	207.72	.014159	.24244	70.626	4.1247	40.530	71.744	112.274	.08161	.20889	104
105	225.45	210.75	0.014190	0.23894	70.472	4.1852	40.847	71.467	112.314	0.08216	0.20872	105
106	228.50	213.81	.014221	.23549	70.317	4.2465	41.166	71.187	112.353	.08271	.20855	106
107	231.59	216.90	.014253	.23209	70.161	4.3086	41.485	70.906	112.391	.08326	.20838	107
108	234.71	220.02	.014285	.22875	70.005	4.3715	41.804	70.623	112.427	.08381	.20821	108
109	237.86	223.17	.014317	.22546	69.847	4.4354	42.125	70.338	112.463	.08436	.20804	109

Figure 1-8   Properties of the Refrigerant at 105°F

H_1 is the saturated suction of the compressor at -20° F. at no losses.
H_2 is the compressor discharge point at no losses.
H_5 is the saturated liquid at 105° F condensing temperature.

From Figure 1-5, 1-7 and Figure 1-8, the enthalpy values of the various points of the refrigeration cycle can be obtained as the following:

$$H_1 = 102.42 \text{ BTU/LB}$$
$$H_2 = 128.00 \text{ BTU/LB}$$
$$H_4 = 112.31 \text{ BTU/LB}$$
$$H_5 = 40.85 \text{ BTU/LB}$$
$$H_6 = 40.85 \text{ BTU/LB}$$

The other operating conditions and the essential data are calculated for the refrigeration system as the following:

(A)   NRE = Net Refrigeration Effect
       = H_1 - H_5 = 102.42 - 40.85   = 61.57 Btu/Lb

(B) V_g = Specific Volume at compressor suction   = 2.083 Ft³/Lb

(C)   Condensing Pressure   = 225.45 Psia
       Evaporative Pressure   = 24.85 Psia

(D)   Discharge line pressure drop   = 0 Psi

(E)   Saturated suction temperature   = -20°F

(F)   Saturated suction pressure   = 24.85 Psia

(G)   Saturated evaporative pressure   = 24.85 Psia

(H)   Compressor suction pressure   = 24.85 Psia

(I)   Suction line superheat   = 0°F

(J)   External suction pressure loss   = 0 Psi

(K)   Refrigerant flow in Lbs/Min
        = 200 x TR/NRE
        = 200 x 73/ 61.57   = 237.13 Lbs/Min

(L)   Compressor suction ACFM   = 493.94 CFM

(M)   Adiabatic compression head in feet
        = (H$_2$ - H$_1$) x 778
        = (128.0 - 102.42) x 778   = 19,901 FT.

(N)   Assuming: Adiabatic Eff. = 76.5%
                      Mechanical Eff.= 94.6%.

$$BHP = \frac{FLOW \times HEAD}{33000 \times 0.765 \times 0.945}$$

                FLOW = 237.13 Lbs/Min
                HEAD = 19,901 FT.

$$BHP = \frac{237.13 \times 19,901}{33000 \times 0.765 \times 0.945}$$ = 197.8 BHP

(O)   Heat rejection from condenser
            = BHP x 2545 + TR x 12000
            = 197.8 x 2545 + 73 x 12000   = 1,379,401 Btu/Hr
                                                              = 1,379 MBH

The P-H Diagram of the refrigeration cycle with all the operating conditions are as the following:
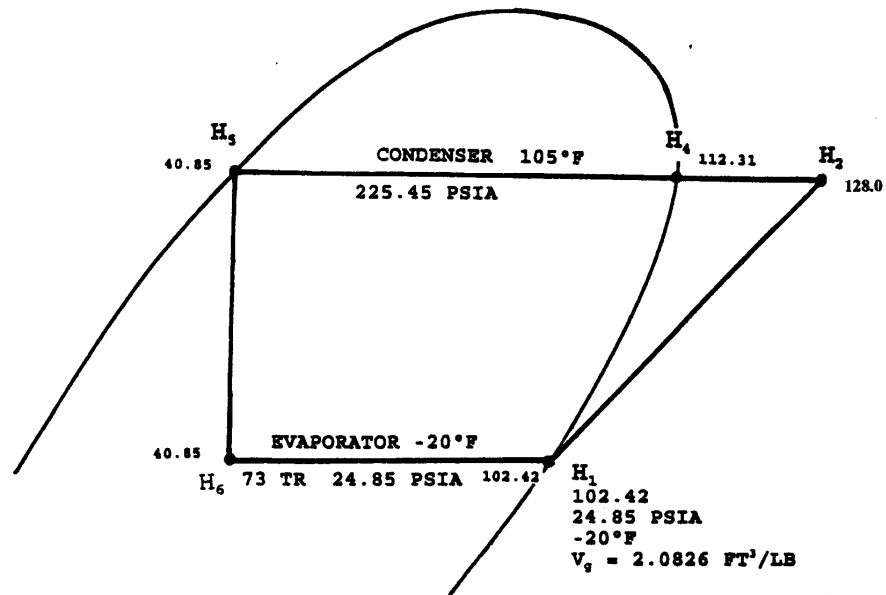
Figure 1-9   P-H Diagram for the Refrigeration System
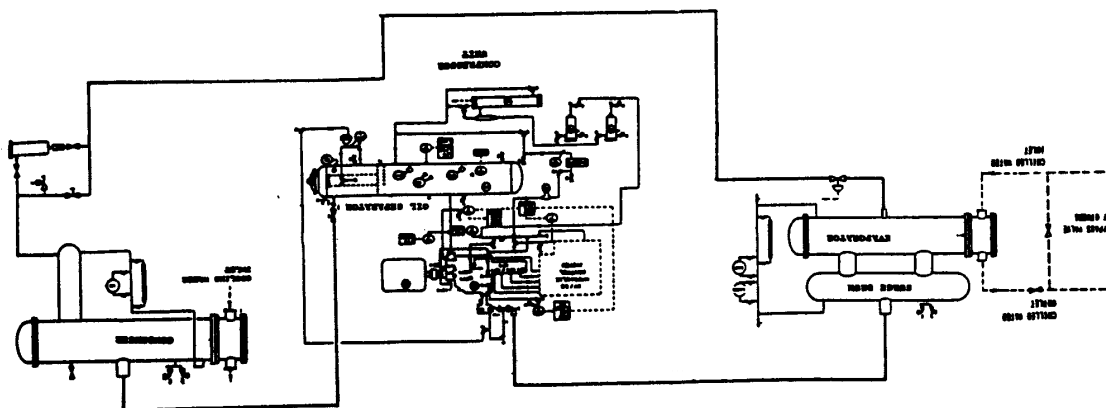
Figure 1-10 Refrigerant Flow Diagram for the Refrigeration System

Practice-2:   The CT, ET and TR are the same as Practice-1
                except the liquid is subcooled to 20° F using
                ET temperature of -20° F which is same as the
                main ET of -20° F.

This refrigeration system is the same as Cogitation-1 except with liquid subcooling. The liquid to evaporator is subcooled to a leaving temperature of 20° F; the NRE is increased as shown in Figure 2-1.
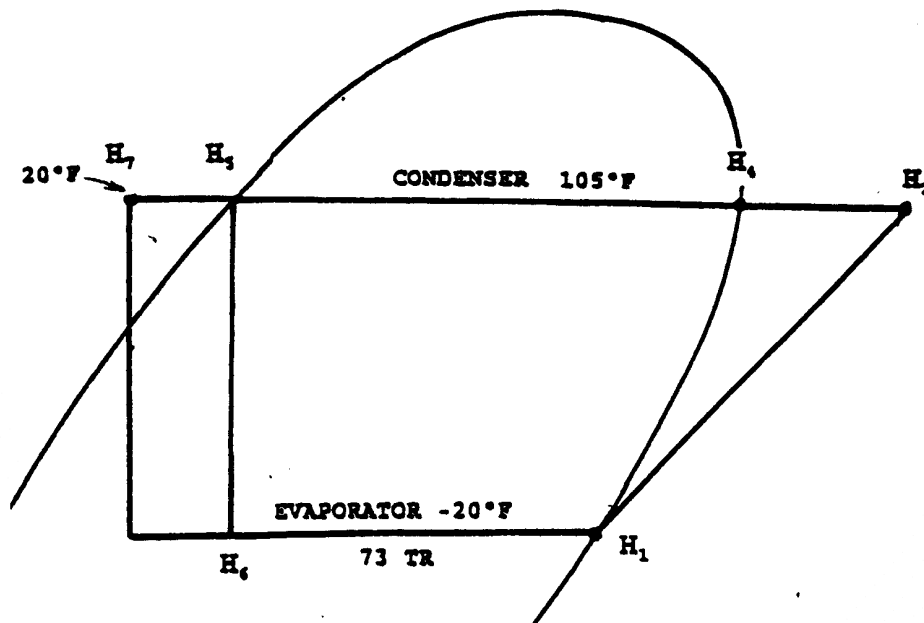
Figure 2-1   P-H Diagram for Refrigeration System of Cogitation-2

The enthalpy for the subcooled liquid of 20° F is 15.84 Btu/Lb from Figure 1-3; the ET for the subcooler is -20° F which is the same as the main evaporator.

The NRE is extended to H_7 instead of H_6.

   $NRE = H_1 - H_7 = 102.42 - 15.84 = 86.58$ Btu/Lb

   Evaporator Load, Refrigerant FLOW (1):

   $$FLOW\ (1) = \frac{200}{H_1 - H_7}\ x\ \ TR$$

$$= \frac{200}{102.42 - 15.84} \times 73$$

$$= 168.63 \text{ Lbs/Min}$$

The heat load to subcool the liquid from H_5 - H_7 is as the following:

$$\text{Load for subcooling} = \frac{\text{FLOW (1)} \times (H_5 - H_7)}{200}$$

$$= \frac{168.63 \times (40.85 - 15.84)}{200}$$

$$= 21.09 \text{ TR}$$

Liquid required for liquid subcooling, refrigerant FLOW (2):

$$\text{FLOW (2)} = \frac{200}{H_1 - H_5} \times \text{TR}$$

$$= \frac{200}{102.42 - 40.85} \times 21.09$$

$$= 68.50 \text{ Lbs/Min}$$

Compressor total suction flow:
$$= \text{FLOW (1)} + \text{FLOW (2)}$$
$$= 168.63 + 68.50$$
$$= 237.13 \text{ Lbs/Min}$$

Compressor total suction ACFM
$$= \text{FLOW} \times V_g$$
$$= 237.13 \times 2.083$$
$$= 493.94 \text{ CFM}$$

Power consumption:

$$BHP = \frac{FLOW \times HEAD}{33000 \times Adia.Eff. \times Mech.Eff.}$$

FLOW	= 237.13 Lbd/Min
HEAD	= 19,901 FT.
Adiabatic Eff.	= 76.5%
Mechanical Eff.	= 94.6%.

$$BHP = \frac{237.13 \times 19,901}{33000 \times 0.765 \times 0.945} = 197.81\ BHP$$

Heat rejection from condenser:
= BHP x 2545 + TR x 12000
= 197.81 x 2545 + 73 x 12000   = 1,379,426 Btu/Hr
= 1,379 MBH

The operating conditions for the system:

(A)	Compressor suction flow	= 237.13 LBS/MIN.
(B)	Compressor suction ACFM	= 494 CFM
(C)	Compression head	= 19,901 FEET
(D)	Power consumption	= 197.81 BHP
(E)	Heat rejection from condenser	= 1,379,426 BTU/HR

The P-H Diagram for the systems is shown in Figure 2-2 and the corresponding Refrigerant Flow Diagram is shown in Figure 2-3:
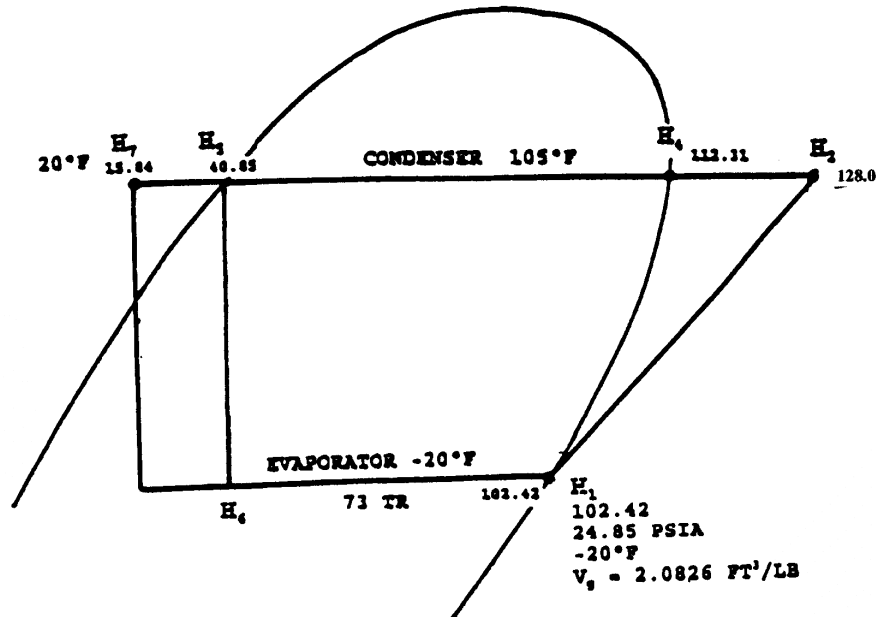
Figure 2-2   P-H Diagram for Refrigeration System Cogitation-2
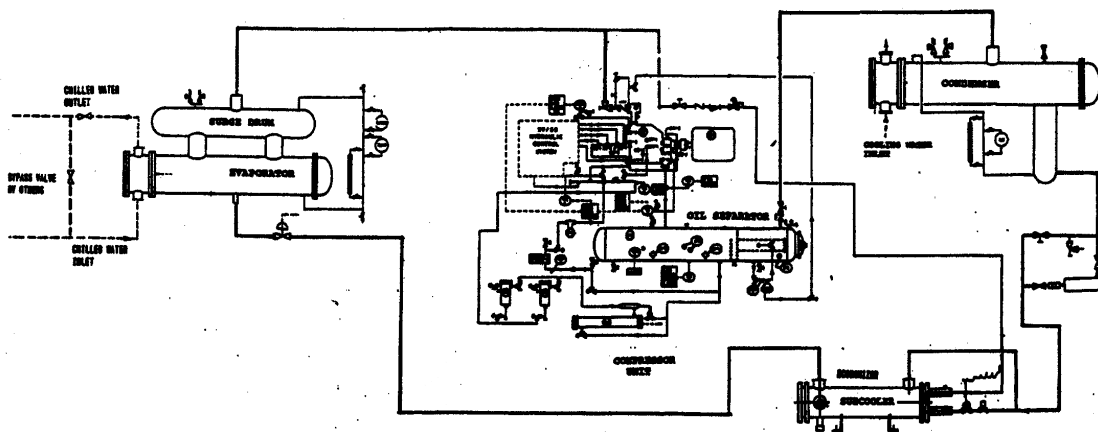
Figure 2-3   Refrigerant Flow Diagram for Refrigeration System Cogiattion-2

Practice-3   The CT, ET and compressor suction are the same
                    as Practice-1, except the liquid is subcooled
                    to 20°F using screw economizer.
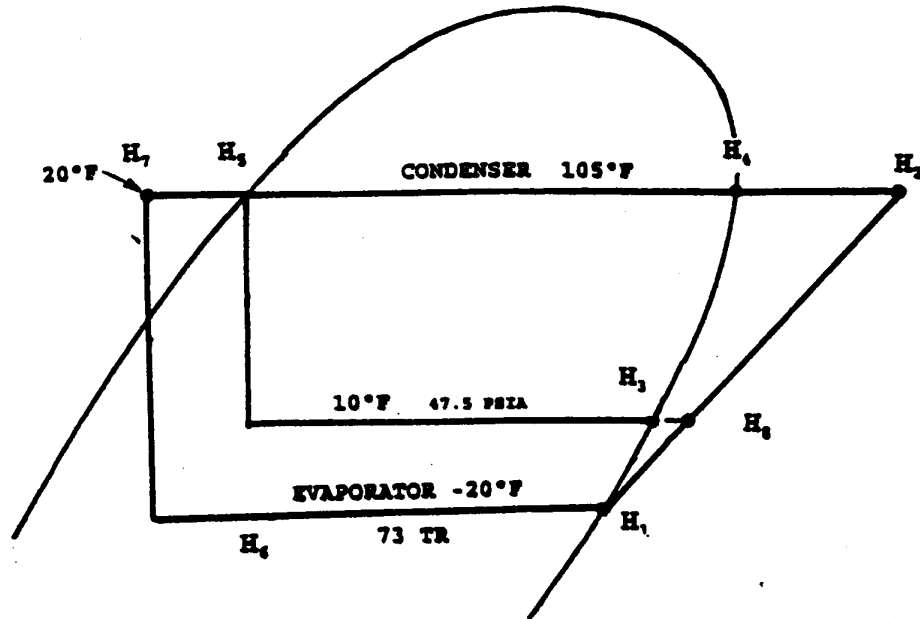
Figure 3-1   P-H Diagram for Cogitation-3

Assuming the ET for the subcooler is 10°F using the economizer of the screw compressor.
The P-H diagram for this Practice is shown in Figure 3-1.

$$NRE = H_1 - H_7$$
$$= 102.42 - 15.84$$
$$= 86.58 \text{ Btu/Lb}$$

Evaporator load, refrigerant FLOW (1):

$$FLOW\ (1) = \frac{200}{H_1 - H_7} \times TR$$

$$= \frac{200}{102.42 - 15.84} \times 73$$

$$= 168.63 \text{ Lbs/Min}$$

Liquid subcooling load and refrigerant FLOW (2) calculation:

$$\text{Liquid subcooling load} = \frac{\text{FLOW (1)} \times (H_5 - H_7)}{200}$$

$$= \frac{168.63 \times (40.85 - 15.84)}{200}$$

$$= 21.1 \text{ TR}$$

The enthalpy for H_3 is obtained from the Figure 1-3.

$$\text{FLOW (2)} = \frac{200}{H_3 - H_5} \times \text{TR}$$

$$= \frac{200}{105.44 - 40.85} \times 21.10$$

$$= 65.34 \text{ LBS/MIN}$$

Compressor suction flow
    = FLOW (1)
    = 168.63

Compressor suction ACFM
    = 168.63 x 2.0826
    = 351.2 CFM

Power consumption:

Adiabatic eff.   = 76.5%
Mechanical eff.= 94.6%.

FLOW(1)   = 168.63 LBS/MIN
HEAD(1)   = (128.0 - 102.42) x 778
               = 19,901 FT.

FLOW(2)   = 65.34 LBS/MIN
HEAD(2)   = (128.0 - 109.6) x 778
               = 14,315 FT.

$$BHP = \frac{FLOW(1) \times HEAD(1) + FLOW(2) \times HEAD(2)}{33000 \times Adia.Eff \times Mech.Eff}$$

$$BHP = \frac{168.63 \times 19901 + 65.34 \times 14315}{33000 \times 0.765 \times 0.945}$$

= 180 BHP

Heat rejection from condenser:

= BHP x 2545 + TR x 12000
= 180 x 2545 + 73 x 12000   = 1,334,100 Btu/Hr
                                             = 1,334 MBH

Summary:

(A)   Compressor suction flow   = 168.63 Lbs/Min.
(B)   Compressor suction ACFM   = 351 CFM
(C)   Compression head   = 19,901 Feet
(D)   Power consumption   = 180 BHP
(E)   Heat rejection from condenser = 1,334,100 Btu/Hr

P-H DIAGRAM AND P&I DIAGRAM OF THIS REFRIGERATION UNIT ARE SHOWN AS THE FOLLOWING:

R-22 REFRIGERANT
(USE HANDOUT INFORMATION)

20°F   H₇ 15.04   H₅ 40.05   CONDENSER   105°F   H₄ 112.31   H₂ 128.0

10°F   47.3 PSIA   H₃ 105.44   H₈ 109.6

EVAPORATOR -20°F

H₆   73 TR   102.42   H₁
102.42
24.85 PSIA
-20°F
V_g = 2.0826 FT³/LB

V_g = 2.189 ft³/lb
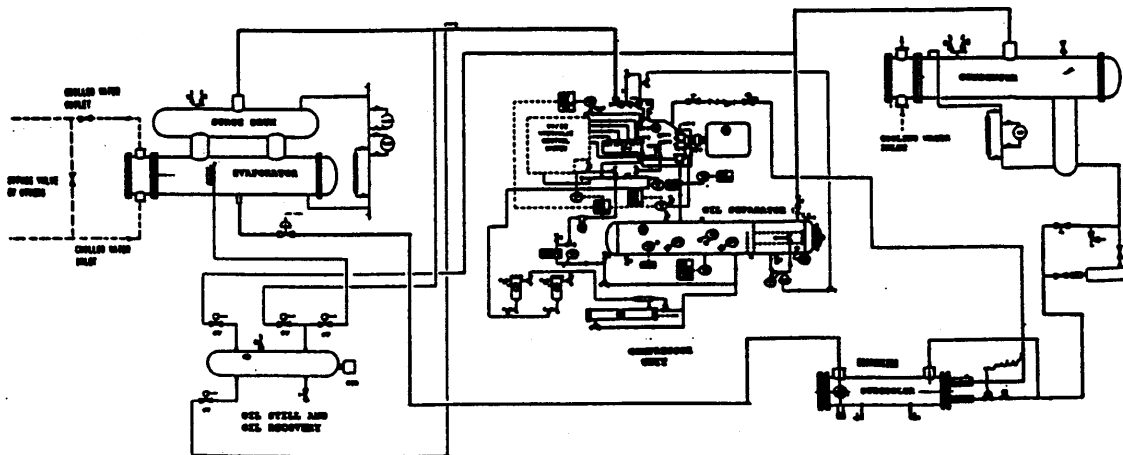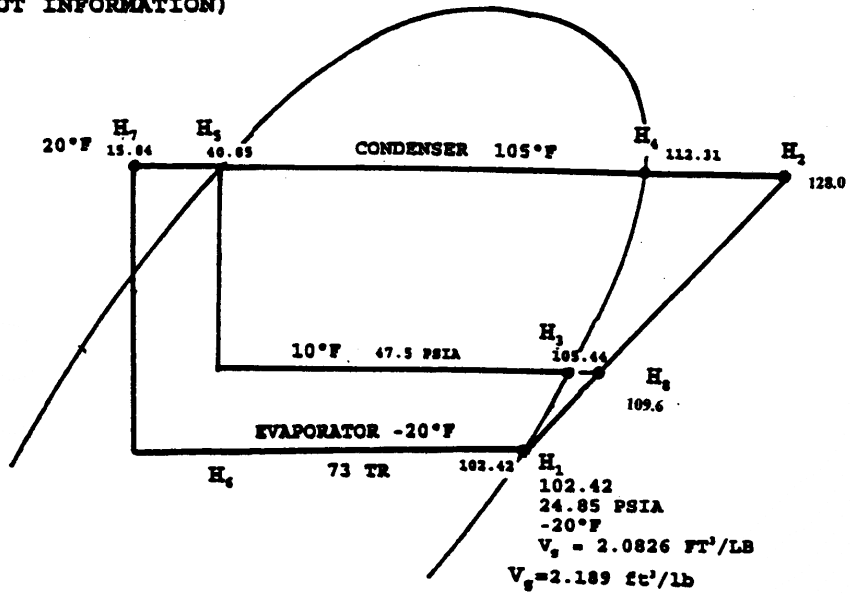
Practice-4   The CT, ET and system arrangement are the same as Practice-3 except the system is with suction and discharge penalties:

The P-H diagram and the suction and discharge penalties are shown in the Figur3-1:
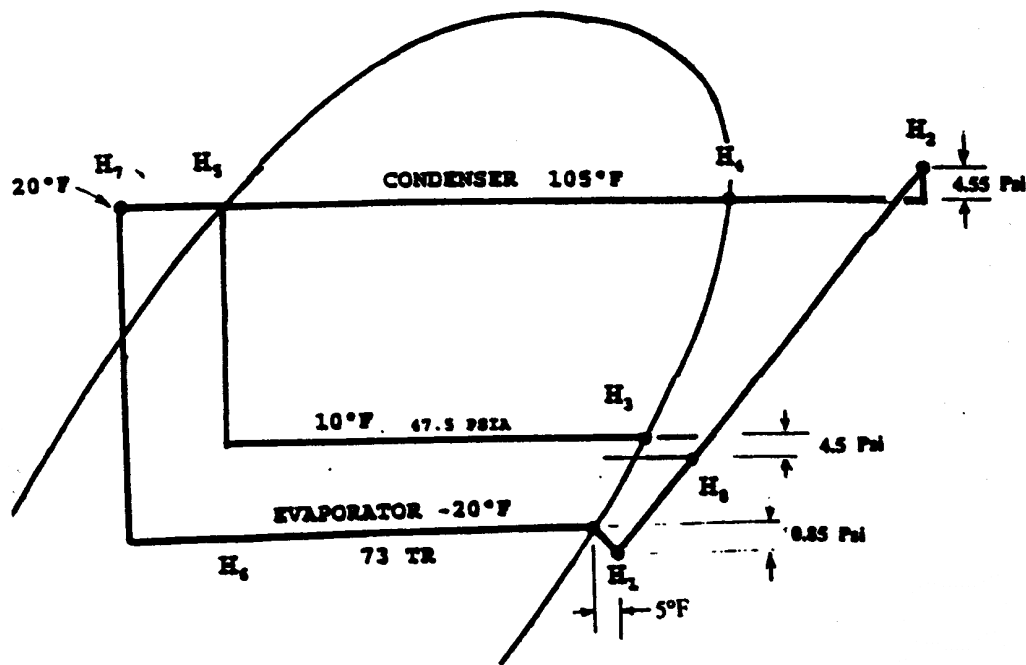
Figure 3-1   P-H Diagram for Cogitation-3

The Penalties:
Compressor suction pressure drop:	= 0.85 Psi
Compressor suction superheat:	= 5°F
Compressor discharge pressure drop	= 4.55 Psi
Economizer PD	= 4.5 Psi

The ET for subcooler is 10°F which is connected to the economizer of the compressor.

NRE = 86.58 Btu/Lb

Evaporator load, refrugerabt FLOW (1):

FLOW (1) = 168.63 Lbs/Min

Liquid subcooling load,

$$FLOW\ (2) = 65.34\ \ Lbs/Min$$

Compressor suction flow
$$= FLOW\ (1)$$
$$= 168.63\ Lbs/Min$$

Compressor suction with penalties:

Compressor suction pressure　= Saturated pressure – suction pressure drop
$$=\ 24.85 - 0.85$$
$$= 24\ Psia$$

Compressor suction temperature = Saturated suction temperature
$$+ \text{Suction superheat}$$
$$=\ -20°F + 5°F$$
$$=\ -15°F$$

Therefore, suction conditions are: 24 PSI & -15°F:

From Figure 1-1 or refrigerant program, the enthalpy and specific volume for this point are:

$$Vg = 2.25\ CU.FT/LB$$
$$H_1 = 103.5$$

Compressor suction ACFM:
$$= \text{Suction flow x suction specific volume}$$
$$= 168.63\ x\ 2.25$$
$$= 379.4\ CFM$$

Power consumption:

FLOW(1)	= 168.63 Lbs/Min
HEAD(1)	= (129.6 – 102.50) x 778
	= 21,084 Ft.
FLOW(2)	= 65.34 Lbs/Min
HEAD(2)	= (129.6 – 110.2) x 778
	= 15,092 Ft.
Adiabatic Eff.	= 76.5%
Mechanical Eff.	= 94.6%.

$$BHP = \frac{FLOW(1) \times HEAD(1) + FLOW(2) \times HEAD(2)}{33000 \times Adia.Eff. \times Mech.Eff}$$

$$BHP = \frac{168.63 \times 21084 + 65.34 \times 15092}{33000 \times 0.765 \times 0.945}$$

$$= 190.4 \; BHP$$

Heat rejection from condenser:

$$= BHP \times 2545 + TR \times 12000$$
$$= 190.4 \times 2545 + 73 \times 12000 \qquad\qquad = 1,360,568 \; Btu/Hr$$
$$= 1,361 \; MBH$$

Summary:

(A)	Compressor suction flow	= 168.63 Lbs/Min.
(B)	Compressor suction ACFM	= 379.4 CFM
(C)	Compression head	= 21,084 Feet
(D)	Power consumption	= 190.4 BHP
(E)	Heat rejection from condenser	= 1,360,568 Btu/Hr

The P-H Diagram and the refrigerant flow diagram are as the following:

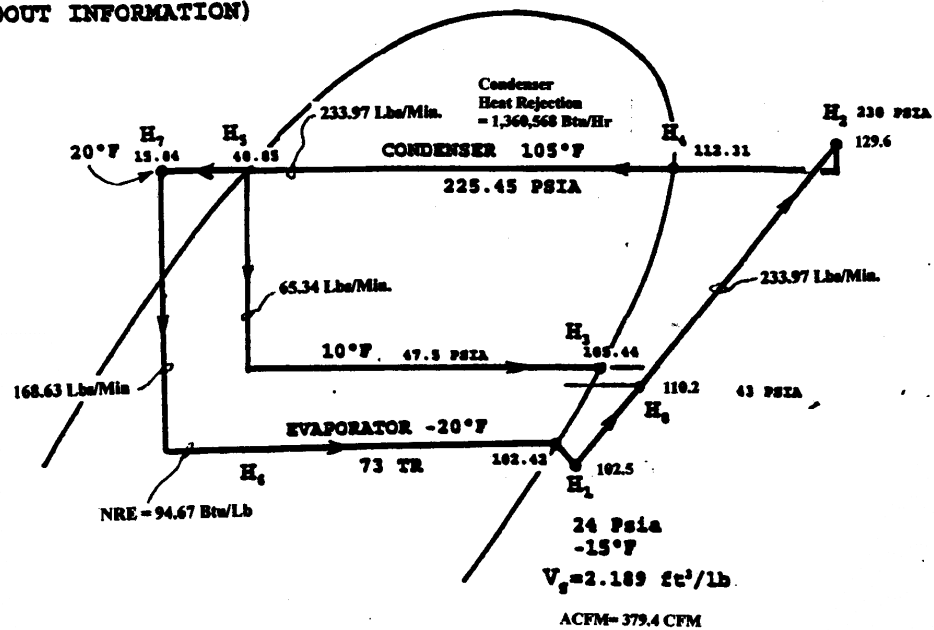Figure 4-2   P-H Diagram for the Refrigeration System
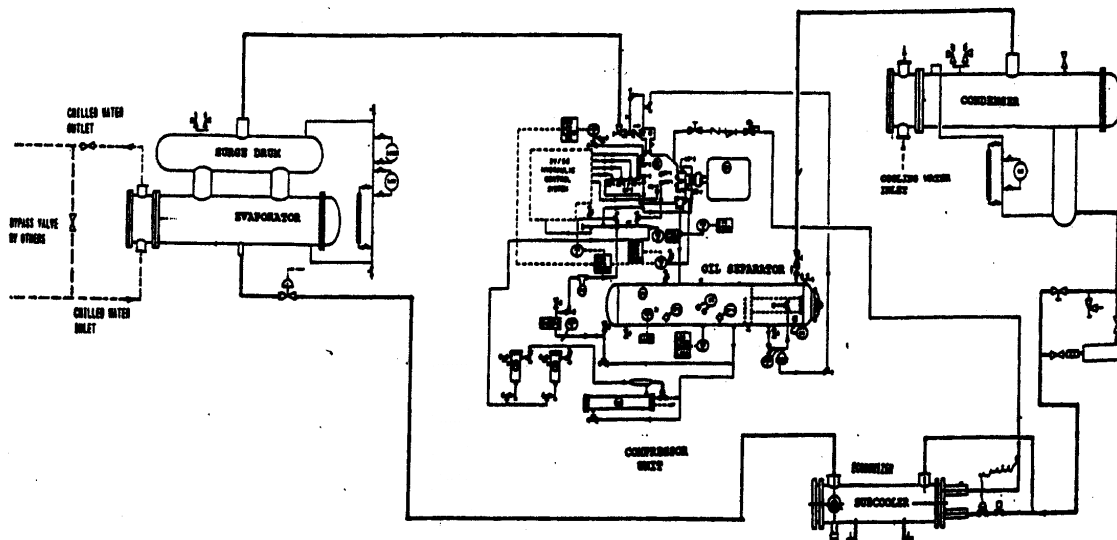

Figure 4-3   Refrigerant Flow Diagram for the Refrigeration System

Conclusion and Comparison:

	Practice-1 Without Intercooling No Ext. PD	**Practice-2** Subcool to 20°F At Evap. temp. No Ext. PD	**Practice-3** W/Economizing Subcool to 20°F No Ext. PD	**Practice-4** W/Economizing Subcool to 20°F With Ext. PD
Compressor Suction Flow, Lbs/Min	237.13 Lbs/Min	237.1348 Lbs/Min.	168.63 Lbs/Min	168.63 Lbs/Min
Compressor Suction. ACFM	493.94 ACFM	493.94 ACFM	351.2 ACFM	379.4 ACFM
Adiabatic Head Ft.	19,901 Ft.	19,901 Ft.	19,910 Ft.	21,084 Ft.
Power Consumption BHP	197.8 Bhp	197.8 Bhp	180 Bhp	190.4 Bhp
Condenser Heat Rejection MBH	1,379 MBH	1,379 MBH	1,334 MBH	1,360 MBH

NOTES:

(A)   Compare Practice-1 with Practice-2, the subcooling was no advantages over compression without subcooling if the subcooling with ET at the same temperature as main evaporator.

(B)   Compare Practice-2 and Practice-3, the compressor with proper economizing reduces compressor size and reduces BHP.

(C)   Compare Practice-3 and Practice-4, larger compressor and higher power consumption are required if external pressure drops are to be considered and included. For a system design, the penalties must be included for system function properly.