iii. Refrigerator Cycle Calculations

The process requirements for the RHIC helium refrigerator to meet the baseline heat load are presented here. The compressor flow required for the refrigerator to meet the baseline load is approximately 50% of the installed compressor capacity. The reference schematic for these calculations is shown in Figures 3-3A and 3-3B. The calculated process state points for this case are given in Tables 3-7A and 3-7B. The electric power currently required for the main compressors to satisfy this operating point is 7.3 MW.

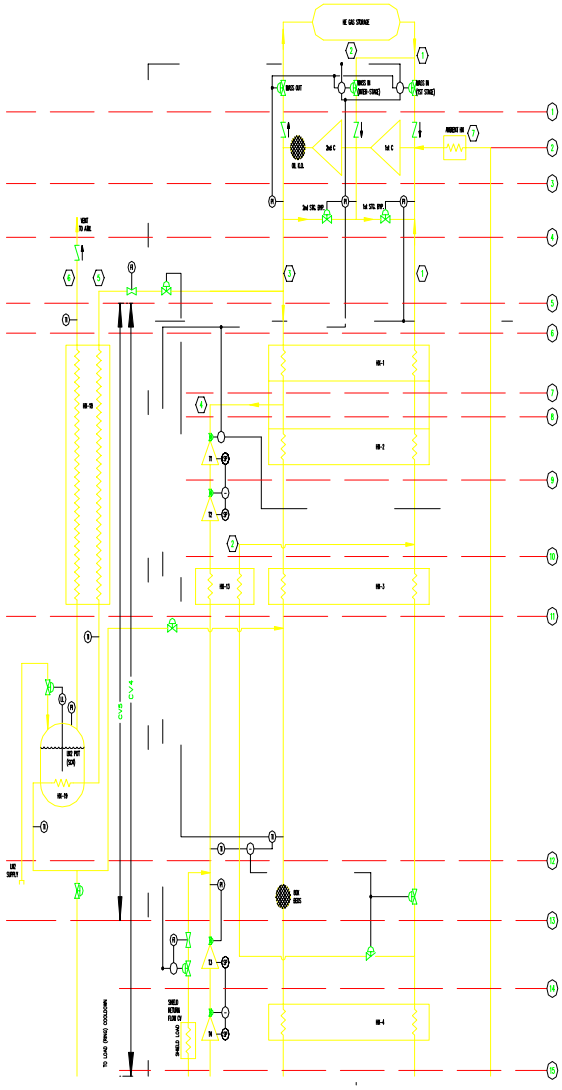

Fig. 3-3A. RHIC refrigerator schematic.

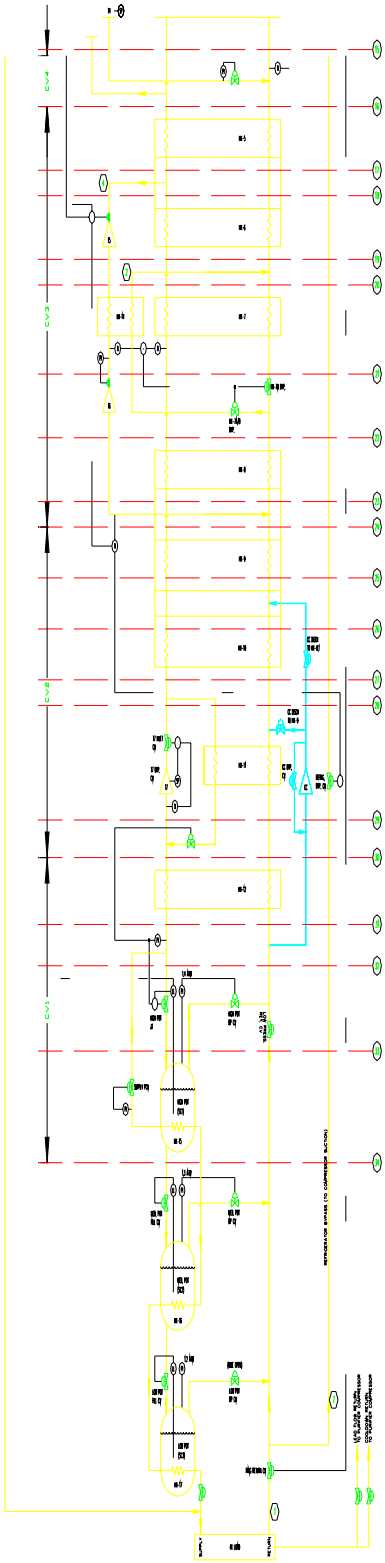

Fig. 3-3B. RHIC refrigerator schematic.

Table 3-7A CYCLE SIMULATION FOR BNL REFRIGERATOR

	HIGH PR.				TURBINE				LOW PR.			
I	T (K)	P (A)	H (J/G)	W (G/S)	T (K)	P (A)	H (J/G)	W (G/S)	T (K)	P (A)	H (J/G)	W (G/S)
1	300.30	15.05	1579.18	.00					292.30	1.05	1532.95	.00
2	300.30	15.05	1579.18	.00					292.30	1.10	1532.97	.00
3	300.30	15.05	1579.18	.00					292.30	1.10	1532.97	.00
4	300.30	15.05	1579.18	1470.15					292.30	1.10	1532.97	1468.15
5	300.30	15.00	1579.17	1470.15					292.30	1.10	1532.97	1468.15
6	300.30	15.00	1579.17	1470.15					292.30	1.10	1532.97	1468.15
7	157.76	14.85	838.56	1470.15					149.03	1.15	788.90	1468.15
8	157.76	14.85	838.56	1190.99	157.76	14.85	838.56	279.16	149.03	1.15	788.90	1468.15
9	129.23	14.75	690.09	1190.99	147.86	11.80	786.12	279.16	125.69	1.18	667.64	1468.15
10	129.23	14.75	690.09	1190.99	137.83	9.30	733.22	279.16	123.82	1.18	657.95	1273.02
11	42.52	14.70	235.52	1190.99	72.12	9.25	390.95	279.16	41.73	1.20	231.35	1273.02
12	42.33	14.70	234.52	1190.99	72.12	9.25	390.95	279.16	41.73	1.20	231.35	1273.02
13	42.34	14.68	234.68	1190.99	72.12	9.25	390.95	297.77	41.73	1.20	231.35	1273.02
14	42.34	14.68	234.68	1190.99	55.52	4.20	303.46	297.77	41.73	1.20	231.35	1468.15
15	40.62	14.64	225.34	1190.99	40.22	1.21	223.49	297.77	40.22	1.21	223.49	1468.15
16	40.62	14.64	225.34	1172.38					40.22	1.21	223.49	1170.38
17	16.70	14.60	90.85	1172.38					14.40	1.22	88.26	1170.38
18	16.70	14.60	90.85	432.77	16.70	14.60	90.85	739.61	14.40	1.22	88.26	1170.38
19	14.53	14.58	77.21	432.77	15.53	7.80	88.34	739.61	13.38	1.22	82.79	1170.38
20	14.53	14.58	77.21	432.77	15.53	7.80	88.34	739.61	12.38	1.22	77.45	785.96
21	11.39	14.56	56.49	432.77	13.19	7.78	74.26	739.61	10.21	1.23	65.72	785.96
22	11.39	14.56	56.49	432.77	13.20	7.80	74.26	739.61	10.21	1.23	65.72	1170.38
23	10.19	14.53	47.53	432.77	9.59	1.23	62.32	739.61	9.59	1.23	62.32	1170.38
24	10.19	14.53	47.53	432.77					9.59	1.23	62.32	430.77
25	4.62	14.51	17.03	432.77					4.60	1.23	31.45	430.77
26	4.62	14.51	17.03	432.77	4.60	1.23	31.45	136.48	4.60	1.23	31.45	294.29
27	4.57	14.48	16.89	432.77	4.45	1.23	29.90	136.48	4.60	1.23	31.45	294.29
28	4.57	14.48	16.89	432.77	4.45	1.23	29.90	136.48	4.60	1.23	31.45	294.29
29	4.57	14.48	16.89	432.77	4.45	1.23	29.90	136.48	4.60	1.23	31.45	294.29
30	4.57	14.48	16.89	432.77	4.45	1.23	29.90	136.48	4.60	1.23	31.45	294.29
31	4.57	14.48	16.89	432.77	4.45	1.23	29.90	136.48	4.60	1.23	31.45	294.29
32	4.57	14.48	16.89	296.29	4.45	1.23	29.90	136.48	4.60	1.23	31.45	294.29
33	5.44	4.50	16.89	296.29	4.45	1.23	29.90	136.48	4.60	1.23	31.45	294.29
34	4.50	4.50	11.91	296.29					4.60	1.23	31.45	294.29

HEAT EXCHANGERS
==== ==========

HX	DTC (K)	DTH (K)	LMTD (K)	UA (W/K)	EFF	NTU	CMIN (W/K)	CMAX (W/K)	QLK (W)	QHX (W)	UAD (W/K)
1	8.729	8.000	8.359	130681.	.9471	17.14	7625.0	7664.0	3600.	1092409.	0.
2	3.545	8.729	5.753	30945.	.8895	4.96	6239.4	7625.0	1200.	178020.	0.
3	.783	5.410	2.394	226837.	.9910	36.22	6262.8	6615.8	1680.	543072.	0.
4	.400	.610	.498	23171.	.8118	3.47	6685.1	7612.2	400.	11532.	0.
5	2.301	.400	1.087	145670.	.9847	23.76	6130.1	6617.3	600.	158273.	0.
6	1.158	2.301	1.664	3845.	.6519	1.30	2952.2	6246.8	500.	6400.	0.
7	1.182	2.156	1.620	5690.	.7266	1.94	2935.7	4255.9	250.	9219.	0.
8	.600	1.182	.858	4636.	.6665	1.40	3318.6	6445.7	100.	3979.	0.
9	.018	.600	.166	79943.	.9968	33.52	2384.6	2662.5	100.	13296.	0.
10	.120	.018	.054	3922.	.8905	2.73	1434.3	4650.4	150.	212.	0.
13	30.383	1.200	9.031	10657.	.9875	10.51	1014.2	1464.6	720.	96243.	0.
14	2.982	.100	.849	12674.	.9812	6.15	2059.9	4596.1	250.	10757.	0.
15	.048	.989	.310	5720.	.9519	3.04	1883.5**********		300.	1775.	0.
TOTAL:				684392.		146.14			9850.		

EXPANDERS
=========

N	PI ATM	PO ATM	PR	TI K	TO K	TR	HI J/G	HO J/G	DH J/G	DI G/CC	DO G/CC	EFFEX	FLOW G/S	WORK W
1	14.85	11.80	1.26	157.73	147.89	1.07	838.39	786.12	52.28	.00453	.00385	.717	279.2	14594.
2	11.80	9.30	1.27	147.83	137.83	1.07	785.97	733.08	52.89	.00385	.00326	.750	279.2	14764.
3	8.85	4.20	2.11	72.12	55.53	1.30	390.90	303.46	87.45	.00589	.00366	.894	297.8	26039.
4	4.20	1.21	3.46	55.51	40.22	1.38	303.40	223.46	79.94	.00366	.00147	.704	297.8	23805.
5	14.60	7.80	1.87	16.70	15.53	1.08	90.84	88.47	2.37	.04433	.02566	.133	739.6	1756.
6	7.68	1.23	6.25	13.18	9.59	1.37	74.26	62.33	11.94	.03107	.00650	.382	739.6	8828.

DEWAR CONDITIONS
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PSHE ATM	TSHE K	DLIQ G/CC	HLIQ J/G	SLIQ J/G-K	DVAP G/CC	HVAP J/G	SVAP J/G-K	X
1.230	4.452	.120	10.958	3.698	.021	29.900	7.949	.313

HE Warm Make-Up	2.00 G/S	60.0 L/H
HE With-Drawl	.00 G/S	.0 L/H
HE 2-Phase Supply	136.48 G/S	
4K REF Load	5750. W	

COMPRESSOR
==========

NO. OF M/CS.= 10 COMP. TYPE= 321/165. COMP. CAP.(ACFM) = 3051.1
PS= 1.050 ATM PD= 3.550 ATM PR= 3.381 TS = 292.300 K
VOL EFF. = .913 MTR EFF. = .900 ISO EFF. = .608 TOT EFF. = .547

	FLOW (G/S)	ACFM	SCFM	ISO POWER (KW)	ACT POWER (KW)
TOTAL	2521.85	30511.1	32128.3	1867.1	3412.6