

**MARTIN MARIETTA ENERGY SYSTEMS, INC.**POST OFFICE BOX 2009  
OAK RIDGE, TENNESSEE 37831

October 25, 1996

Davis I. Rawal, President  
Rawal Devices, Inc.  
P.O. Box 2035  
Waterbury, CT 06722

Dear Mr. Rawal:

## Performance Testing of Rawal APR Controller

Enclosed is a copy of the energy efficiency tests performed on the Rawal APR controller by the Oak Ridge Centers for Manufacturing Technology (ORCMT) on Technical Assistance Agreement #MTAC960722002. Copies of the Hourly-Daily Climatological Records from the National Oceanic and Atmospheric Administration (NOAA) in Oak Ridge, Tennessee has been included for reference purposes only; however, they were not used for any performance calculations.

The Rawal APR Controller, Model #APR-2, was installed on a Trane self-contained air conditioner located adjacent to Building 9709 at the Oak Ridge Y-12 Plant. The APR Controller was donated by Rawal Devices, and will remain in the air conditioner and not be returned. The Trane unit supplies heating and cooling for an office area at the east-end of the building, and is rated at 12.5-Ton cooling capacity, has two 6 1/4-Ton compressors, a nominal 5000 CFM horizontal airflow, 480-Volt/3-Phase/60Hz power, three 1/2 HP condenser fan motors, one 3 HP evaporator fan motor, and two refrigeration circuits using 9.5# of R-22 refrigerant on each circuit. Manufacturer's data shows the unit is rated at 17.3 kW and has an Energy Efficiency Ratio (EER) of 8.4.

Test data was taken with a Metrosonics pa-7 Power Analyzer connected to the 480 Volt electrical power supply. Separate tests were performed under full-load conditions and when the air conditioner cycled on and off during normal operating conditions. To simulate full-load conditions, thermostatic controls were adjusted to force the air conditioning unit to operate at full-load, and test data was taken from 10:00 a.m. to 12:00 noon on August 19, 1996 prior to installation of the Rawal APR Controller. The Rawal APR Controller was subsequently installed, thermostatic adjustments were again made, and a second set of test data was taken on September 9, 1996 from 12:00 noon to 2:00 p.m. while the unit operated at full-load.

Electrical power usage prior to installation of the APR Controller averaged 14.87 KWH, and power usage after installation of the controller averaged 13.90 KWH. This represents an efficiency gain or improvement of 6.55%. The improvement in energy efficiency may have been reduced somewhat due to lower thermostatic settings that forced the air conditioner to operate at full-load during the test, and the APR Controller may have been unable to effectively modulate

the system.

In order to simulate normal operating conditions, electrical power data was collected from 11:00 a.m. on August 21, 1996 to 12:00 p.m. on September 2, 1996 prior to installation of the APR Controller, and from 1:00 p.m. on September 13, 1996 to 11:00 a.m. on September 23, 1996 after the Controller was installed. No thermostatic adjustments were made, and the air conditioner was allowed to cycle on and off during normal operating conditions. The thermostat in the office was set at 72-degrees Farenheit (F), and there was no evening set-back to a lower temperature setting. Test data was recorded and averaged to calculate the increased energy efficiency when the Rawal APR Controller was in-service. Electrical power usage before installing the APR Controller averaged 14.20 KWH, and after the Controller was installed the average power usage was 11.30 KWH. This represents an increase in energy efficiency of 19.8%.

The field test data indicates the Rawal APR Controller can increase operating efficiencies and produce significant energy savings when installed on air conditioning systems. Greater energy savings may be possible on older air conditioning systems and specialized continuous dehumidification systems. The ORCMT is attempting to locate an additional installation site for the second APR Controller donated by Rawal Devices. Any installation costs and tests that may be performed on the second APR Controller will not be part of this Technical Assistance Agreement. We are examining several potential installation sites in computer rooms, and if possible, will attempt to take test data before and after the APR Controller is installed.

In conclusion, we feel the Rawal APR Controller should be considered for energy-saving applications at Government facilities, and highly recommend additional testing and analysis be performed in the environmental chamber at the Oak Ridge National Laboratory (ORNL). The system testing and analysis is a value added service we can offer through a Work for Others contractual agreement, and provide important system performance data that can be used to help open new markets within the Government for inexpensive and effective energy-saving retrofit equipment. Please feel free to contact me at (423) 574-1094 should you have any questions.

Sincerely,



Thomas H. Kevil  
Oak Ridge Center for  
Manufacturing Technology

cc: W. D. Brosey, ORCMT  
M. Olszewski, ORCMT  
E. Merriweather, IHEM  
B. A. Shanks, ORCMT  
W. L. Turner, LMES  
O. S. Messner, LMES

APPENDIX “C”  
METROSONICS  
KILOWATT-HOUR DATA

Filename.....9709-AIR  
 Customer/Dept...J MILLER  
 Account/Meter #.9709-air ~~BEFORE~~  
 Address One.....  
 Address Two.....  
 City,State,Zip..  
 Phone Number....

TEST 2

PARAMETER: Total KWH  
 STARTING DATE:08/21/96

	WED	THU	FRI	SAT	SUN	MON	TUE	AVG
TIME	08/21	08/22	08/23	08/24	08/25	08/26	08/27	
01:00		14.43	14.28	14.44	13.92	13.92	14.08	14.18
02:00		14.41	14.25	14.32	12.04	13.85	13.97	13.81
03:00		14.30	14.16	14.19	8.78	10.15	13.97	12.59
04:00		14.24	14.11	14.15	11.74	8.69	14.07	12.84
05:00		14.19	14.06	14.08	13.93	13.45	13.97	13.95
06:00		14.08	13.99	14.04	13.90	13.72	9.33	13.18
07:00		14.09	13.91	13.96	13.88	13.74	10.86	13.41
08:00		14.07	13.87	13.96	9.71	9.78	13.90	12.55
09:00		14.14	10.38	14.03	8.80	12.67	14.00	12.34
10:00		14.30	14.10	14.13	13.83	13.93	14.18	14.08
11:00	14.75	14.43	14.39	14.42	13.96	14.12	14.32	14.34
12:00	15.03	14.68	14.72	14.73	14.12	14.39	14.40	14.58
13:00	15.24	15.03	15.02	15.02	14.26	14.76	14.54	14.84
14:00	15.33	15.17	15.20	15.14	14.46	15.00	14.64	14.99
15:00	15.35	15.26	15.27	14.47	14.53	15.02	14.75	14.95
16:00	15.38	15.24	15.21	14.07	14.64	15.04	14.91	14.93
17:00	15.37	15.02	15.19	14.04	14.68	14.91	14.92	14.87
18:00	15.42	14.88	15.32	14.02	14.69	14.70	15.03	14.86
19:00	15.39	14.88	15.35	14.05	14.72	14.45	14.96	14.83
20:00	15.30	14.86	15.21	14.03	14.59	14.32	14.75	14.72
21:00	14.98	14.71	14.98	13.99	14.35	14.25	14.26	14.50
22:00	14.83	14.56	14.82	14.03	14.20	14.23	14.00	14.38
23:00	14.64	14.46	14.65	13.92	14.09	14.17	13.91	14.27
24:00	14.55	14.35	14.54	13.94	13.97	14.11	13.88	14.19
TOTAL	211.56	349.78	346.99	341.17	321.79	327.36	335.60	
AVG	15.11	14.57	14.46	14.22	13.41	13.64	13.98	
MAX	15.42	15.26	15.35	15.14	14.72	15.04	15.03	
TIME	18:00	15:00	19:00	14:00	19:00	16:00	18:00	
MIN	14.55	14.07	10.38	13.92	8.78	8.69	9.33	
TIME	24:00	08:00	09:00	23:00	03:00	04:00	06:00	

Filename.....9709-AIR  
 Customer/Dept...J MILLER  
 Account/Meter #.9709-air  
 Address One.....  
 Address Two.....  
 City,State,Zip..  
 Phone Number....

TEST 2

PARAMETER: Total KWH  
 STARTING DATE:08/27/96

	TUE	WED	THU	FRI	SAT	SUN	MON	AVG
TIME	08/27	08/28	08/29	08/30	08/31	09/01	09/02	
01:00		13.85	14.17	13.88	14.18	13.98	13.46	13.92
02:00		13.86	14.04	13.85	14.12	9.84	13.78	13.25
03:00		13.85	13.94	13.81	14.09	9.08	11.95	12.79
04:00		13.87	13.89	10.26	13.99	10.47	8.60	11.85
05:00		13.84	13.82	8.78	10.02	13.90	8.73	11.52
06:00		13.79	13.83	13.75	9.08	13.82	13.69	12.99
07:00		9.66	13.76	10.45	11.91	13.56	13.75	12.18
08:00		8.74	11.32	12.23	13.98	8.98	11.46	11.12
09:00		13.86	9.45	14.20	14.04	9.19	8.83	11.59
10:00		13.83	14.00	14.37	13.00	13.84	9.09	13.02
11:00	14.26	13.97	14.23	14.52	9.36	14.43	13.98	13.54
12:00	14.37	14.22	14.38	14.82	13.14	14.58	14.19	14.24
13:00	14.46	14.46	14.56	14.93	14.91	14.66	14.22	14.60
14:00	14.59	14.70	14.74	15.03	14.83	14.76	14.26	14.70
15:00	14.68	14.83	14.85	15.03	14.84	14.76	11.79	14.40
16:00	14.83	14.97	14.91	15.10	14.80	14.75	9.25	14.09
17:00	14.94	14.96	15.09	15.04	14.75	14.71	13.36	14.69
18:00	14.96	14.81	14.95	14.91	14.66	14.51	14.29	14.73
19:00	15.00	14.89	14.65	14.66	14.48	14.30	14.16	14.59
20:00	14.92	14.85	14.44	14.51	14.31	14.16	14.05	14.46
21:00	14.50	14.63	14.29	14.46	14.18	14.06	13.08	14.17
22:00	14.12	14.45	14.17	14.38	14.22	13.89	9.08	13.47
23:00	13.93	14.30	14.06	14.26	14.11	9.08	10.55	12.90
24:00	13.91	14.23	14.00	14.22	14.05	8.87	13.90	13.31
TOTAL	203.45	333.43	335.53	331.45	325.02	308.19	293.49	
AVG	14.53	13.89	13.98	13.81	13.54	12.84	12.23	
MAX	15.00	14.97	15.09	15.10	14.91	14.76	14.29	
TIME	19:00	16:00	17:00	16:00	13:00	14:00	18:00	
MIN	13.91	8.74	9.45	8.78	9.08	8.87	8.60	
TIME	24:00	08:00	09:00	05:00	06:00	24:00	04:00	

## &lt;&lt;&lt;&lt;&lt; WEEKLY ENERGY REPORT TEST NUMBER 1 &gt;&gt;&gt;&gt;&gt;

Filename.....9709-2A  
 Customer/Dept...j miller  
 Account/Meter #.9709-air cond.  
 Address One.....  
 Address Two.....  
 City,State,Zip..  
 Phone Number....

ater change

PARAMETER: Total KWH  
 STARTING DATE:09/13/96

	FRI	SAT	SUN	MON	TUE	WED	THU	AVG
TIME	09/13	09/14	09/15	09/16	09/17	09/18	09/19	
01:00		8.62	10.50	13.30	9.10	8.28	8.41	9.70
02:00		8.59	13.95	13.20	8.40	12.68	8.34	10.86
03:00		8.57	13.93	10.00	8.46	13.26	8.32	10.42
04:00		8.50	11.07	8.27	11.94	13.79	8.33	10.32
05:00		8.42	8.48	8.31	13.35	9.07	12.28	9.98
06:00		8.41	8.44	8.28	13.24	8.44	13.46	10.05
07:00		8.40	8.39	12.08	9.86	8.38	13.40	10.08
08:00		8.35	8.35	13.03	8.27	8.34	9.74	9.35
09:00		8.23	8.24	9.76	12.03	8.59	8.12	9.16
10:00		8.35	8.44	10.31	13.08	13.07	10.15	10.56
11:00		11.23	8.37	13.01	12.94	12.74	13.49	11.96
12:00		13.22	12.83	13.03	12.98	12.74	12.77	12.93
13:00	12.39	12.51	13.32	13.12	13.08	11.45	12.89	12.68
14:00	9.93	8.69	10.97	13.39	13.26	12.68	9.08	11.14
15:00	13.53	8.88	8.93	13.41	13.26	13.30	9.67	11.57
16:00	13.49	8.84	8.97	13.58	13.34	12.71	13.43	12.05
17:00	13.45	12.11	11.61	13.57	13.21	11.72	13.40	12.72
18:00	13.39	13.81	13.79	13.80	13.24	13.17	13.33	13.50
19:00	13.23	13.73	13.76	13.81	13.38	11.52	13.12	13.22
20:00	12.58	13.66	13.69	13.82	13.24	12.99	11.57	13.08
21:00	11.66	11.02	12.46	13.56	13.12	13.12	13.12	12.58
22:00	13.20	8.25	8.48	13.56	10.27	12.90	12.85	11.36
23:00	13.19	8.47	8.36	13.51	8.17	10.55	11.97	10.60
24:00	10.21	8.71	11.88	13.41	8.14	8.32	8.24	9.85
TOTAL	150.25	237.54	257.18	295.12	279.36	273.81	269.49	
AVG	12.52	9.90	10.72	12.30	11.64	11.41	11.23	
MAX	13.53	13.81	13.95	13.82	13.38	13.79	13.49	
TIME	15:00	18:00	02:00	20:00	19:00	04:00	11:00	
MIN	9.93	8.23	8.24	8.27	8.14	8.28	8.12	
TIME	14:00	09:00	09:00	04:00	24:00	01:00	09:00	

## &lt;&lt;&lt;&lt;&lt; WEEKLY ENERGY REPORT TEST NUMBER 1 &gt;&gt;&gt;&gt;&gt;

Filename.....9709-2A  
 Customer/Dept...j miller  
 Count/Meter #.9709-air cond.  
 Address One.....  
 Address Two.....  
 City,State,Zip..  
 Phone Number.....

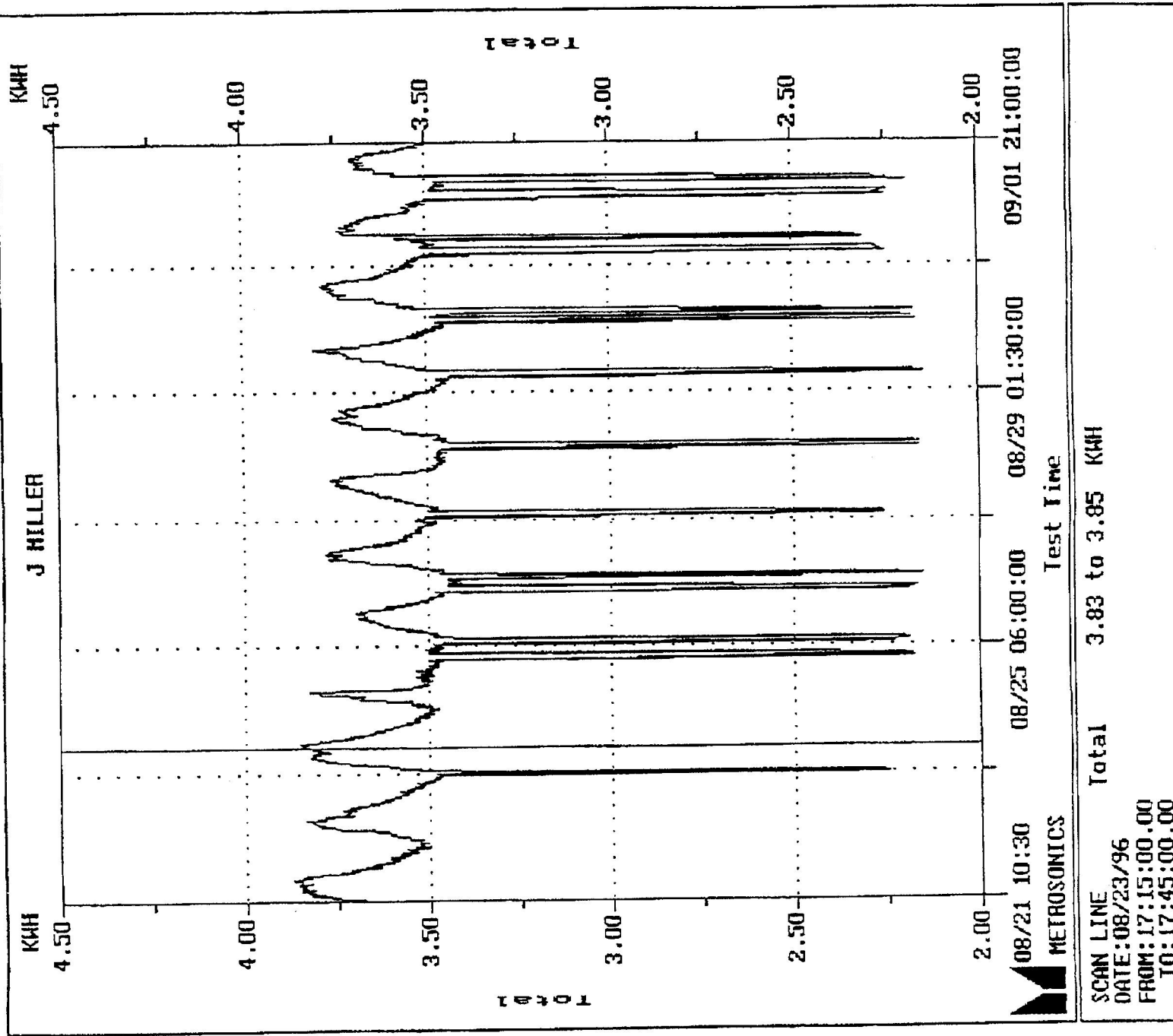
ater change

PARAMETER: Total KWH  
 STARTING DATE:09/19/96

	THU 09/19	FRI 09/20	SAT 09/21	SUN 09/22	MON 09/23	TUE 09/24	WED 09/25	AVG
TIME								
01:00		8.44	11.26	8.18	8.16			9.01
02:00		8.44	12.28	8.09	8.20			9.25
03:00		8.41	8.10	8.12	9.62			8.56
04:00		11.38	8.28	8.18	13.47			10.33
05:00		13.64	8.50	13.56	13.73			12.36
06:00		13.63	8.43	13.67	13.73			12.36
07:00		10.74	10.82	13.48	8.53			10.89
08:00		8.31	13.23	8.35	8.36			9.56
09:00		8.23	13.02	8.39	11.49			10.28
10:00		12.38	9.19	8.39	12.98			10.74
11:00		12.70	8.03	8.19	12.88			10.45
12:00		12.74	8.24	9.08				10.02
13:00	12.89	12.91	8.83	13.22				11.96
14:00	9.08	11.47	13.54	13.40				11.87
15:00	9.67	13.33	13.48	13.69				12.54
16:00	13.43	13.58	13.36	13.75				13.53
17:00	13.40	13.57	13.06	10.79				12.71
18:00	13.33	13.59	9.43	8.90				11.32
19:00	13.12	13.49	8.30	9.75				11.16
20:00	11.57	13.11	8.33	13.75				11.69
21:00	13.12	11.43	10.06	13.46				12.02
22:00	12.85	13.05	13.12	13.06				13.02
23:00	11.97	12.83	13.06	12.93				12.70
24:00	8.24	12.29	11.95	10.29				10.69
TOTAL	142.68	283.68	255.94	262.66	121.16			
AVG	11.89	11.82	10.66	10.94	11.01			
MAX	13.43	13.64	13.54	13.75	13.73			
TIME	16:00	05:00	14:00	16:00	05:00			
MIN	8.24	8.23	8.03	8.09	8.16			
TIME	24:00	09:00	11:00	02:00	01:00			

RANGES OF ALL DISPLAYED CHANNELS  
 Total 2.00 to 4.50 KWH

Filename.....9709-AIR  
 Customer Name...J MILLER  
 Account/Meter #.9709-air  
 Address One.....  
 Address Two.....  
 City,State,Zip..  
 Phone Number....  
 Comment 1.....TEST 2 BEFORE CHANGE  
 Comment 2.....



SCAN LINE  
 DATE:08/23/96  
 FROM:17:15:00.00  
 TO:17:45:00.00

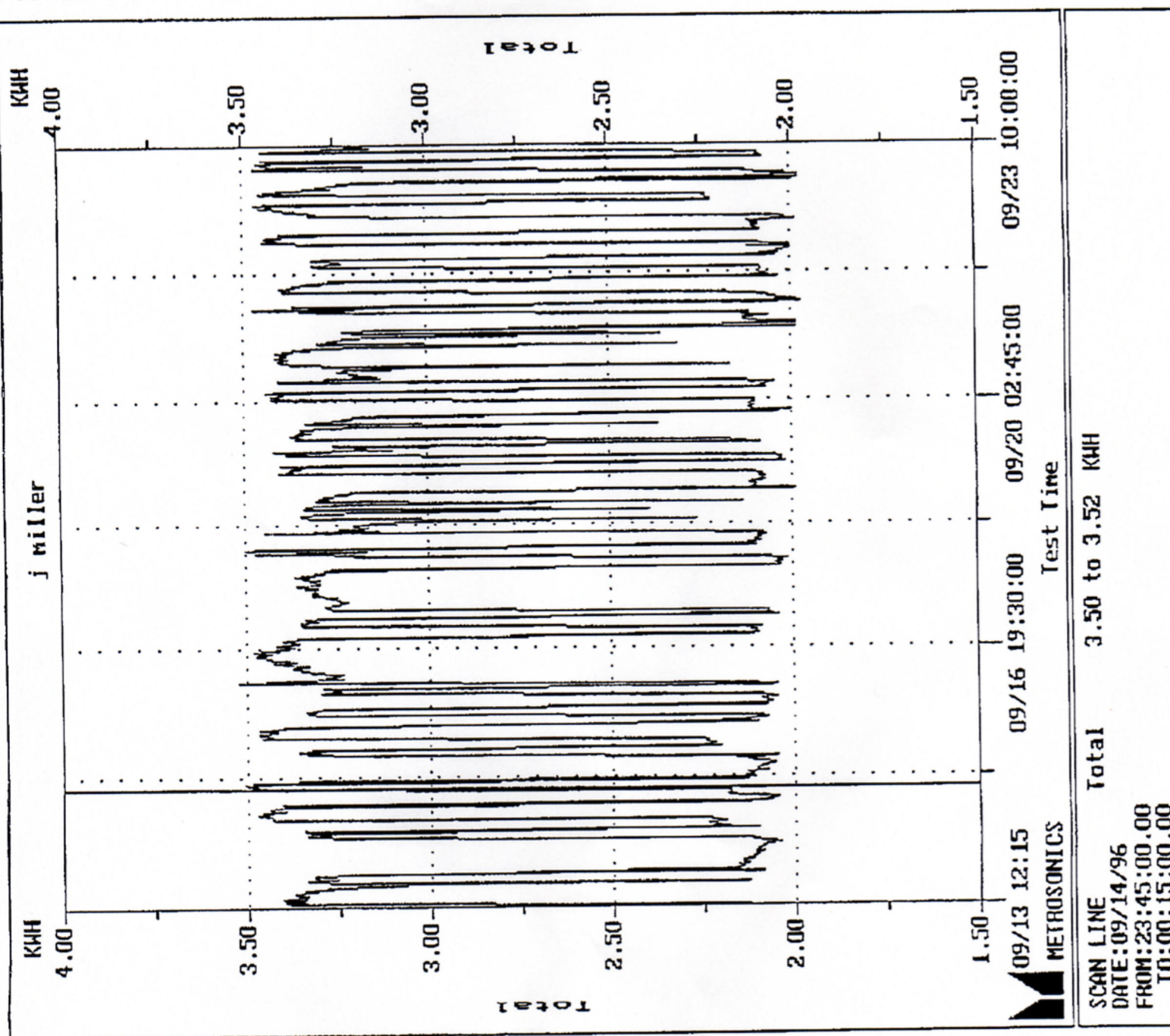
Total 3.83 to 3.85 KWH



# RANGES OF ALL DISPLAYED CHANNELS

Total 1.50 to 4.00 KWH

Filename.....9709-2A  
 Customer Name...j miller  
 Account/Meter #.9709-air cond.  
 Address One.....  
 Address Two.....  
 City,State,Zip..  
 Phone Number.....  
 Comment 1.....after change  
 Comment 2.....



SCAN LINE  
 DATE:09/14/96  
 FROM:23:45:00.00  
 TO:00:15:00.00