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Westinghouse Astronuclear Laboratory

**FPMS LIFE TEST
ANNUAL REPORT**

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TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
	SUMMARY	1
1.0	INTRODUCTION	2
2.0	RESULTS	3
Appendix A	DATA SUMMARIES	11

LIST OF ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
2-1	System Efficiency and Fuel Loading	4
2-2	Converter Power Output and Open Circuit Voltage	5
2-3	Converter Internal Resistance and Temperature Drop	6
2-4	Stud and Converter Hot Cap Temperature	8
2-5	Converter-Stud Interface and Base Assembly Temperatures	9
2-6	Converter-Ambient Interface Temperatures	10

SUMMARY

The SNAP-23A Fueled Prototype Mockup System has been on system thermal and life test since February 1970. It has accumulated 18,700 hours of testing through June 30, 1972 of which 17,070 have been accumulated on life test with the Prototype Mockup Converter PMC-3. On June 30 the system was producing 63 watts at an overall efficiency of 6.1 percent. The fuel power level was 1025 watts corresponding to 5.7 years from the nominal fuel design loading of 1180 watts. During the life test period the system has performed as predicted without any apparent degradation of system components and interfaces. The only change in performance has been that due to fuel decay.

1.0 INTRODUCTION

At the end of Phase I, the Fueled Prototype Mockup System, FPMS, was assembled and testing was initiated on February 4, 1970. Initially testing was conducted with the PMC-2 converter for the purpose of evaluating the thermal performance of the system; results were documented in the Phase I Final Report - WANL 3800-46. The PMC-2 converter was removed on April 13, 1970 after 1634 hours of testing.

Testing of FPMS was resumed on May 12, 1970 with the PMC-3 converter and has continued on life test to date. The first 1170 hours of testing through June 30, 1970 was reported in the Phase II Final Report, WANL 4182-3.

The system was run on life tests at normal load conditions to produce 60 watts at 24 volts. During the first year from June 30, 1970 to June 30, 1971, a series of data points were taken quarterly with the system in thermal steady state at off load electrical conditions. WANL 4219-1 documents the results of life testing through that time period, included in that report was a description of the testing procedure and method of data collection and analysis. This report documents life test results collected through June 30, 1972. During the latest period off load testing was discontinued.

2.0 RESULTS

The FPMS with the PMC-3 converter has been on test since May 12, 1970, and has accumulated 18,700 hours of testing through June 30, 1972. During this period 58 data points were taken at normal and off load operating conditions of which 13 were taken during the past year. Summaries of these 13 data points are presented in Appendix A. Figures 2-1 to 2-3 show the thermal and thermoelectric performance of the system at normal loads. The predicted performance projected from the 1000 hour data based on the fuel decay rate is represented by the solid lines in the time dependent curves.

The initial period of FPMS/PMC-3 testing was performed with the converter operating near open circuit conditions such that the average hot cap temperature was held at 1070 °F. This was performed to accelerate reseating of the elements to reduce the increased internal resistance that was experienced during converter shipping prior to assembly. Initial life test data at normal load conditions was not reported until after 700 hours of testing.

Figure 2-1 shows the projected fuel power decay and system efficiency versus time. The system power level has decayed from about 1088 watts to 1025 watts during the life test period. System efficiency has dropped from 6.4 percent to 6.1 percent during this period. The experimental data has indicated the same rate of decay as that projected for the effects of fuel decay.

Figure 2-2 presents the open circuit voltage and converter power out versus time. The open circuit voltage has decayed from 46 to 42 volts and has remained close to the predicted curve. Similarly, the converter power output has decayed from 69 watts to 63 watts over the time span with good agreement to the predicted decay. Figure 2-3 is a plot of the converter temperature drop and internal resistance. The converter temperatures have shown good agreement with the projected values. The internal resistance dropped at a

Figure 2-1. System Efficiency and Fuel Loading

Figure 2-2. Converter Power Output and Open Circuit Voltage

Figure 2-3. Converter Internal Resistance and Temperature Drop

slightly faster rate in the 700 to 2000 hour range and then remained parallel to the predicted rate due to decay. The initial drop was attributed to the continued seating of the elements into the hot caps during the 700 - 2000 hour range. Figure 2-4 is a plot of the converter hot cap temperature and stud temperature versus time showing good agreement. Figure 2-5 plots the stud to hot cap temperature drop and the temperature of the base assembly at the inner ring of the hermetic seal. The temperature drop across the interface from the stud to the converter has remained stable with a total drop decaying with fuel decay from 110 to 105°F. Figure 2-6 contained plots of the drop across the interface from the converter outer case to the radiator base and the drop from the radiator base to the ambient 3 feet away. The interface has remained stable with a 10°F drop decaying to 9°F. The radiator to ambient drop has decayed from 63°F to 62°F.

Comparison of individual thermocouple readings of the latest data points with the earliest data points have indicated good stability with only one thermocouple reading that has become erratic. Because of the small krypton leak in an inaccessible weld, the base assembly is filled with krypton and periodically serviced to maintain the base assembly pressure between 1 and 2 psig.

FPMS/PMC-3 SYSTEM LIFE TEST
(NORMAL LOAD AT 24 VOLTS)

8

Figure 2-4. Stud and Converter Hot Cap Temperature

Figure 2-5. Converter-Stud Interface and Base Assembly Temperatures

FPMS/PMC-3 SYSTEM LIFE TEST
(NORMSL LOAD AT 24 VOLTS)

Figure 2-6. Converter-Ambient Interface Temperatures

APPENDIX A

FPMS DATA POINT SUMMARIES

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT E 46

DESCRIPTION Normal RL

A.	Converter Performance	
	Voltage - volts	24.3
	Current - amps	2.70
	Power output - watts	65.6
	Open circuit voltage - volts	43.5
	Internal resistance - ohms	7.12
B.	System Output (P.C. out)	
	Load voltage - volts	23.5
	Load current - amps	2.56
	Net power output - watts	60.3
C.	Converter Temperatures °F	
	T hot frame web	893
	T hot cap	890
	T cold cap	172
	T outer case	152
D.	Base Assembly Temperatures	
	T external bottom	135
	T external side	120
	T bucket bottom	1171
	T bucket support ring	1157
	T inner ring-seal	1135
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	142
	T shroud	121
	T power transistor cover	120
	T ambient	80
F.	Heat Source Temperatures °F	
	T stud	997
	T neck	1132
G.	DATE	7/9/71
H.	WANL TEST TIME	10,150 hrs.

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT	E 47	
<u>DESCRIPTION</u>	Normal RL	
A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.68</u>
	Power output - watts	<u>65.1</u>
	Open circuit voltage - volts	<u>43.4</u>
	Internal resistance - ohms	<u>7.13</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.6</u>
	Load current - amps	<u>2.52</u>
	Net power output - watts	<u>59.4</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>891</u>
	T hot cap	<u>889</u>
	T cold cap	<u>171</u>
	T outer case	<u>150</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>135</u>
	T external side	<u>119</u>
	T bucket bottom	<u>1168</u>
	T bucket support ring	<u>1154</u>
	T inner ring-seal	<u>1132</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>141</u>
	T shroud	<u>120</u>
	T power transistor cover	<u>119</u>
	T ambient	<u>79</u>
F.	Heat Source Temperatures °F	
	T stud	<u>992</u>
	T neck	<u>1129</u>
G.	DATE	<u>7/31/71</u>
H.	WANL TEST TIME	<u>10,678 hrs.</u>

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT E 48

DESCRIPTION Normal RL

A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.68</u>
	Power output - watts	<u>65.1</u>
	Open circuit voltage - volts	<u>43.4</u>
	Internal resistance - ohms	<u>7.09</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.56</u>
	Net power output - watts	<u>60.3</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>890</u>
	T hot cap	<u>887</u>
	T cold cap	<u>172</u>
	T outer case	<u>150</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>136</u>
	T external side	<u>120</u>
	T bucket bottom	<u>1167</u>
	T bucket support ring	<u>1152</u>
	T inner ring-seal	<u>1130</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>141</u>
	T shroud	<u>120</u>
	T power transistor cover	<u>119</u>
	T ambient	<u>79</u>
F.	Heat Source Temperatures °F	
	T stud	<u>990</u>
	T neck	<u>1127</u>
G.	DATE	<u>8/16/71</u>
H.	WANL TEST TIME	<u>11,059 hrs.</u>

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT	E 49	
<u>DESCRIPTION</u>	Normal RL	
A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.68</u>
	Power output - watts	<u>65.1</u>
	Open circuit voltage - volts	<u>43.3</u>
	Internal resistance - ohms	<u>7.09</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.56</u>
	Net power output - watts	<u>60.3</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>890</u>
	T hot cap	<u>888</u>
	T cold cap	<u>173</u>
	T outer case	<u>151</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>139</u>
	T external side	<u>121</u>
	T bucket bottom	<u>1167</u>
	T bucket support ring	<u>1152</u>
	T inner ring-seal	<u>1130</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>141</u>
	T shroud	<u>122</u>
	T power transistor cover	<u>120</u>
	T ambient	<u>80</u>
F.	Heat Source Temperatures °F	
	T stud	<u>992</u>
	T neck	<u>1128</u>
G.	DATE	<u>9/8/71</u>
H.	WANL TEST TIME	<u>11,614 hrs.</u>

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT E 50

DESCRIPTION Normal RL

A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.68</u>
	Power output - watts	<u>65.1</u>
	Open circuit voltage - volts	<u>43.2</u>
	Internal resistance - ohms	<u>7.04</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.56</u>
	Net power output - watts	<u>60.3</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>887</u>
	T hot cap	<u>885</u>
	T cold cap	<u>171</u>
	T outer case	<u>150</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>137</u>
	T external side	<u>120</u>
	T bucket bottom	<u>1164</u>
	T bucket support ring	<u>1150</u>
	T inner ring-seal	<u>1128</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>141</u>
	T shroud	<u>120</u>
	T power transistor cover	<u>118</u>
	T ambient	<u>78</u>
F.	Heat Source Temperatures °F	
	T stud	<u>989</u>
	T neck	<u>1125</u>
G.	DATE	<u>10/7/71</u>
H.	WANL TEST TIME	<u>12,306 hrs.</u>

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT E 51

DESCRIPTION Normal RL

A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.66</u>
	Power output - watts	<u>64.6</u>
	Open circuit voltage - volts	<u>43.0</u>
	Internal resistance - ohms	<u>7.04</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.56</u>
	Net power output - watts	<u>60.3</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>885</u>
	T hot cap	<u>882</u>
	T cold cap	<u>169</u>
	T outer case	<u>146</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>131</u>
	T external side	<u>117</u>
	T bucket bottom	<u>1161</u>
	T bucket support ring	<u>1146</u>
	T inner ring-seal	<u>1125</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>139</u>
	T shroud	<u>118</u>
	T power transistor cover	<u>116</u>
	T ambient	<u>76</u>
F.	Heat Source Temperatures °F	
	T stud	<u>990</u>
	T neck	<u>1123</u>
G.	DATE	<u>11/1/71</u>
H.	WANL TEST TIME	<u>12,906 hrs.</u>

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT E 52

DESCRIPTION Normal RL

A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.64</u>
	Power output - watts	<u>64.1</u>
	Open circuit voltage - volts	<u>42.9</u>
	Internal resistance - ohms	<u>7.05</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.56</u>
	Net power output - watts	<u>60.3</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>885</u>
	T hot cap	<u>882</u>
	T cold cap	<u>171</u>
	T outer case	<u>150</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>132</u>
	T external side	<u>119</u>
	T bucket bottom	<u>1160</u>
	T bucket support ring	<u>1145</u>
	T inner ring-seal	<u>1124</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>141</u>
	T shroud	<u>120</u>
	T power transistor cover	<u>118</u>
	T ambient	<u>79</u>
F.	Heat Source Temperatures °F	
	T stud	<u>991</u>
	T neck	<u>1121</u>
G.	DATE	<u>11/18/71</u>
H.	WANL TEST TIME	<u>13,320 hrs.</u>

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT	E 53	
<u>DESCRIPTION</u>	Normal RL	
A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.66</u>
	Power output - watts	<u>64.6</u>
	Open circuit voltage - volts	<u>42.7</u>
	Internal resistance - ohms	<u>6.92</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.56</u>
	Net power output - watts	<u>60.3</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>879</u>
	T hot cap	<u>877</u>
	T cold cap	<u>167</u>
	T outer case	<u>146</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>131</u>
	T external side	<u>116</u>
	T bucket bottom	<u>1154</u>
	T bucket support ring	<u>1140</u>
	T inner ring-seal	<u>1119</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>136</u>
	T shroud	<u>115</u>
	T power transistor cover	<u>114</u>
	T ambient	<u>75</u>
F.	Heat Source Temperatures °F	
	T stud	<u>985</u>
	T neck	<u>1117</u>
G.	DATE	<u>1/5/72</u>
H.	WANL TEST TIME	<u>14,471 hrs.</u>

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT	E 54	
<u>DESCRIPTION</u>	Normal RL	
A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.63</u>
	Power output - watts	<u>63.7</u>
	Open circuit voltage - volts	<u>42.2</u>
	Internal resistance - ohms	<u>6.91</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.55</u>
	Net power output - watts	<u>600</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>874</u>
	T hot cap	<u>872</u>
	T cold cap	<u>166</u>
	T outer case	<u>144</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>113 (127) *</u>
	T external side	<u>105 (113)</u>
	T bucket bottom	<u>1148</u>
	T bucket support ring	<u>1135</u>
	T inner ring-seal	<u>1114</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>135</u>
	T shroud	<u>115</u>
	T power transistor cover	<u>113</u>
	T ambient	<u>72</u>
F.	Heat Source Temperatures °F	
	T stud	<u>985</u>
	T neck	<u>1114</u>
G.	DATE	<u>2/11/72</u>
H.	WANL TEST TIME	<u>15,358 hrs.</u>

* Rechecked surface temperatures

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT E 55

DESCRIPTION Normal RL

A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.64</u>
	Power output - watts	<u>64.2</u>
	Open circuit voltage - volts	<u>42.6</u>
	Internal resistance - ohms	<u>6.92</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.55</u>
	Net power output - watts	<u>60.0</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>876</u>
	T hot cap	<u>874</u>
	T cold cap	<u>165</u>
	T outer case	<u>145</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>113</u>
	T external side	<u>105</u>
	T bucket bottom	<u>1151</u>
	T bucket support ring	<u>1137</u>
	T inner ring-seal	<u>1116</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>134</u>
	T shroud	<u>112</u>
	T power transistor cover	<u>112</u>
	T ambient	<u>74</u>
F.	Heat Source Temperatures °F	
	T stud	<u>985</u>
	T neck	<u>1115</u>
G.	DATE	<u>2/24/72</u>
H.	WANL TEST TIME	<u>15,670 hrs.</u>

SNAP-23A

FPMS TEST POINT SUMMARY

TEST POINT E 56

DESCRIPTION Normal Load 24.3 V.

A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.59</u>
	Power output - watts	<u>63.0</u>
	Open circuit voltage - volts	<u>42.3</u>
	Internal resistance - ohms	<u>6.97</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.54</u>
	Net power output - watts	<u>59.8</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>876</u>
	T hot cap	<u>875</u>
	T cold cap	<u>170</u>
	T outer case	<u>148</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>131*</u>
	T external side	<u>118*</u>
	T bucket bottom	<u>1148</u>
	T bucket support ring	<u>1135</u>
	T inner ring-seal	<u>1114</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>140</u>
	T shroud	<u>119</u>
	T power transistor cover	<u>117</u>
	T ambient	<u>78</u>
F.	Heat Source Temperatures °F	
	T stud	<u>982</u>
	T neck	<u>1111</u>
G.	DATE	<u>4/5/72</u>
H.	WANL TEST TIME	<u>16,656 hrs.</u>

*Suspect Readings

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT	E 57	
<u>DESCRIPTION</u>	Normal RL	
A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.62</u>
	Power output - watts	<u>63.5</u>
	Open circuit voltage - volts	<u>42.2</u>
	Internal resistance - ohms	<u>6.85</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>23.5</u>
	Load current - amps	<u>2.54</u>
	Net power output - watts	<u>59.8</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>871</u>
	T hot cap	<u>870</u>
	T cold cap	<u>164</u>
	T outer case	<u>143</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>114</u>
	T external side	<u>106</u>
	T bucket bottom	<u>1144</u>
	T bucket support ring	<u>1131</u>
	T inner ring-seal	<u>1110</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>132</u>
	T shroud	<u>114</u>
	T power transistor cover	<u>112</u>
	T ambient	<u>73</u>
F.	Heat Source Temperatures °F	
	T stud	<u>975</u>
	T neck	<u>1106</u>
G.	DATE	<u>5/5/72</u>
H.	WANL TEST TIME	<u>17.370</u>

SNAP-23A
FPMS TEST POINT SUMMARY

TEST POINT E 58

DESCRIPTION Normal Load 24.3 V.

A.	Converter Performance	
	Voltage - volts	<u>24.3</u>
	Current - amps	<u>2.59</u>
	Power output - watts	<u>62.9</u>
	Open circuit voltage - volts	<u>42.1</u>
	Internal resistance - ohms	<u>6.89</u>
B.	System Output (P.C. out)	
	Load voltage - volts	<u>25.5</u>
	Load current - amps	<u>2.56</u>
	Net power output - watts	<u>65.3</u>
C.	Converter Temperatures °F	
	T hot frame web	<u>874</u>
	T hot cap	<u>872</u>
	T cold cap	<u>169</u>
	T outer case	<u>148</u>
D.	Base Assembly Temperatures	
	T external bottom	<u>137</u>
	T external side	<u>119</u>
	T bucket bottom	<u>1146</u>
	T bucket support ring	<u>1132</u>
	T inner ring-seal	<u>1111</u>
E.	Radiator/Ambient Temperatures °F	
	T radiator fin base	<u>139</u>
	T shroud	<u>118</u>
	T power transistor cover	<u>116</u>
	T ambient	<u>76</u>
F.	Heat Source Temperatures °F	
	T stud	<u>977</u>
	T neck	<u>1109</u>
G.	DATE	<u>5/31/72</u>
H.	WANL TEST TIME	<u>17,994 hrs.</u>