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Thermal Conditions for Portable Military Electronic Equipment (12 Point New Times Roman)

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Extended Abstract

SUMMARY (all text from here is 10pt New Times Roman)

Soldiers and Marines rely on electronics for capabilities such as communication and precisely determining location. Increasing these capabilities, such as with longer range and higher bandwidth communication, generally comes at a price of greater power consumption and a corresponding increase in system power dissipation/thermal load. This increased thermal load can limit the functional capabilities of systems when used in thermally challenging environments. One of these thermally challenging environments is inside the packs used by dismounted troops to carry the electronics. This paper presents the results of testing to determine the thermal resistance associated with operating electronics within packs that are typical of those that may be used by soldiers and Marines. Thermal mock-up systems were tested in two types of backpacks under various orientations and thermal loads. Steady state and transient temperature test results are compared to predictions generated with a spreadsheet-based analysis.

Contributions provided by this paper:

1) Based on a brief literature review on this topic, it appears that this paper would be the first publication to report the thermal resistance associated with placing electronics inside a military backpack.
2) While this work focused on military applications, one of the backpacks used in the testing is similar to that used by civilians for uses such as hiking, etc. Therefore, it is expected that the results of this study can be extended to provide guidance to designers of consumer equipment that may be used in similar conditions.
3) The paper will include a brief tutorial on the use of spreadsheets for conducting a transient analysis

1. INTRODUCTION

The miniaturization of electronics over the past decades has allowed for a significant increase in the amount of electronics that may be carried by personnel in military operations. These electronic systems may be used for functions such as GPS, night vision and voice/data communications capabilities. New systems will continue to increase the electronic capabilities of soldiers and Marines [1, 2]. One critical factor that inhibits the greater use of electronics by individuals on the battlefield is the ability to effectively provide sufficient power for an operation. It is common that soldiers embarking on a three day patrol may need to carry more than 7 kg of batteries alone to power their equipment [3]. In response to this, military organizations are actively developing alternative methods for providing electrical power to dismounted troops [3, 4].

Increases in the electrical energy available to individuals through technologies such as improved batteries, fuel cells and energy harvesting are beneficial from weight and logistics perspectives. However this greater availability of energy that can be consumed will increase the power dissipated and thus leads to greater challenges in the system-level thermal management of portable electronics. This study documents temperature measurements of test modules when used in in military-style packs to provide guidance on the thermal resistance induced by these packs. While this work is targeted at military electronics applications, the results may also be applicable to other fields, such as consumer products and public safety, in which electronics devices may be operated while stored in a backpack or other transportation system that provide a relatively poor thermal connection to the surrounding environment.

2. EXPERIMENTAL/NUMERICAL METHODS

Testing was conducted with two different rucksack styles with two different mockup systems. The two packs used in the testing were a 5.11 RUSH 24 Backpack [**Error! Reference source not found.**], which is the 'Backpack' shown in Figure 1, and a Yote Modular Assault Pack [**Error! Reference source not found.**] (the 'Rucksack shown in Figure 1).

Figure 1 Pack Styles Tested

The test modules were instrumented with Type T thermocouples and power was dissipated from sets of load resistors. Two test modules were fabricated; these are shown in Figure 2. The 'Small' test module consisted of an anodized aluminum heat sink with a sheet metal cover that was attached to the edges of the heat sink to cover the heating resistors. The 'Large' test module was machined from aluminum and had an aluminum cover.

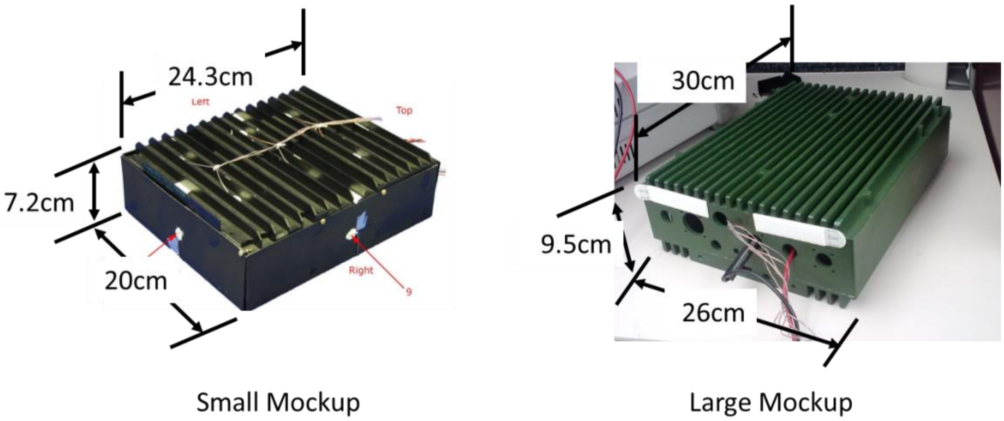

Figure 2 Thermal Test Modules

Type T thermocouples were applied to the test modules and that dissipated power ranging from 20 - 80W. Modules were allowed to stabilize such that the temperature variation was less than 0.1°C/min.

3. RESULTS

Figure 3 shows an IR image of the Backpack during a typical test in which the ambient temperature was 24°C and the power dissipation in the pack was 40W. Tests were conducted with the test modules oriented vertically, either on a table or lab bench (for baseline 'open air' conditions') or in a pack that was suspended to expose it to ambient air on the sides, front, bottom and top surfaces. Testing included evaluating the effect of venting the backpack by leaving the top zipper open ~15cm to produce a gap that was ~1-2cm wide. Testing was conducted with the backpack empty as well as it filled with items to better simulate conditions during use.

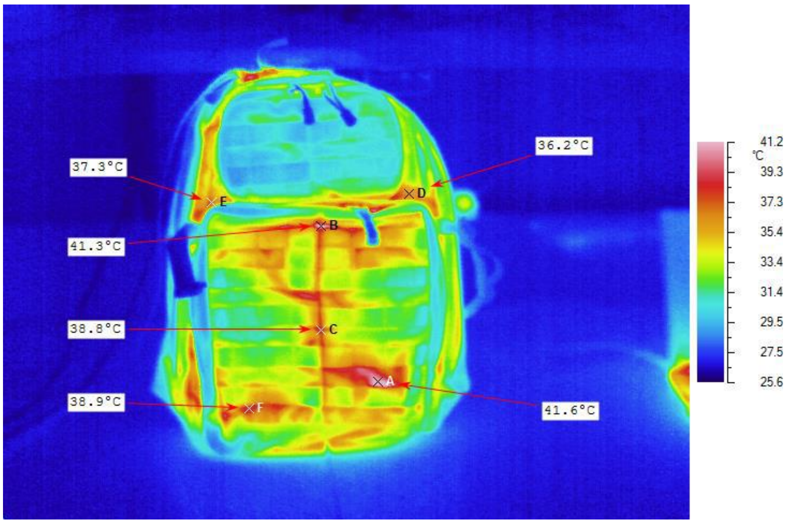

Figure 3 Infrared Image of Backpack

The maximum measured temperature rise above ambient temperature was divided by the power dissipated in the module to determine the overall thermal resistance of the system. Figure 4 shows an example of temperature data collected during testing with the results of the testing summarized in Table 1.

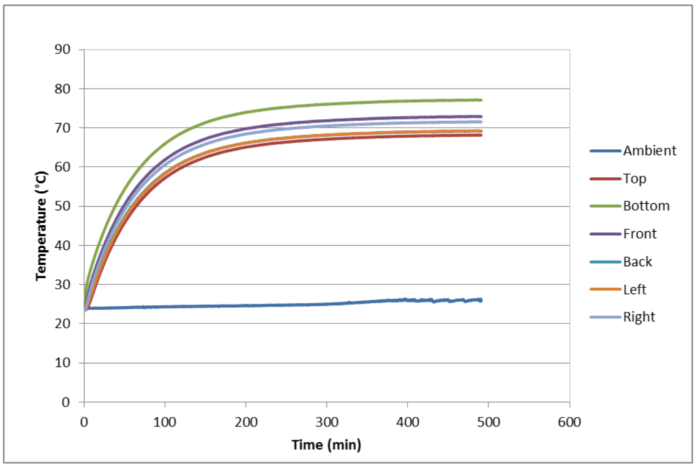

Figure 4 Typical Transient Temperatures on Chassis in Backpack (Power Dissipation of 50.4W)

Table 1 Thermal Resistance Measurements (values varied with power dissipation levels)

Pack	Small Test Module	Large Test Module
No Pack (baseline)	0.6-0.7	0.5 - 0.6
Rucksack	0.9 - 1.1	0.6-0.8
Backpack (vented)	1.5 - 1.6	1.0
Backpack (closed)	2.0 - 2.3	1.1

4. CONCLUSIONS

The final paper will provide details on the testing approach, more detailed results including transient temperature data, and analysis to account for the effects the chassis construction and size on system thermal resistance. Results will also be compared to test data for an actual military communication system operating inside and outside the rucksack used in this testing.

5. REFERENCES

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