Tent Foam Insulation Report

W9124Q-06-F-1204

Prepared for

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1 Summary

As part of the Rapid Equipping Force (REF) contract W9124Q-06-F-1204, Exponent was asked to examine a current proposal to insulate General Purpose (GP) U.S. Army tents installed in Forward Operating Bases (FOBs) with a layer of polyurethane (PU) foam. The goals of the proposal were to:

- Improve the living conditions inside the tents, by reducing dust infiltration and insulating from outside noise and adverse ambient conditions (e.g., wind, extreme temperatures);

- Save energy (and thus reduce fuel consumption) by reducing the air conditioning loads to the GP tents.

In order to examine this proposal, Exponent was asked to perform the following tasks:

- Quantify the air exchange rate for a foam-insulated GP tent, and compare it with a traditional (non-insulated) GP tent;

- Perform heating and cooling load calculations for the foam-insulated GP tent, and estimate energy consumption for different potential air conditioning (HVAC) units;

- Assess the relative fire safety of foam-insulated tents as compared with traditional non-insulated tents.

1.2 Design Heating and Cooling Loads

- The thermal resistance of walls and roof in the foam-insulated tent is comparable with the thermal resistance of walls and roof in permanent building structures. This represents a vast improvement towards reducing energy consumption for air conditioning, when compared with a non-insulated tent.

- For FOBs in cold climates, it is recommended that the wooden floor boards be covered by wear-resistant carpeting. This would both reduce the heat losses (and consequently the energy consumed to provide heat) and increase the feeling of comfort by the tent occupants.

- Heating and cooling loads due to the tent doors are small. The presence of vestibules is not expected to significantly reduce the HVAC loads; however, vestibules may be desirable if the goal is to reduce rain, dust, and sand intrusion into the tent when the door is opened.

- The cooling load due to lighting and other appliances can be a significant portion of the total cooling load. Exponent recommends that efforts be made wherever possible to

reduce this load, for example, by using energy-saving light bulbs or by limiting the number and size of personal electric and electronic devices.

- Ventilation heating and cooling loads represent a large fraction of the overall energy load for the tent. The load associated with the minimum outdoor air ventilation requirement for IAQ cannot be reduced, except by limiting the number of soldiers that may occupy the tent at any given time. Monitoring the air quality inside the tent, however, may help minimize the excess ventilation beyond the IAQ requirements and thus limit unnecessary energy use.

- The cooling load (sensible and latent) due to the presence of soldiers inside the tent also represents a large fraction of the overall cooling load. This load cannot be reduced, except by limiting the number of soldiers that may occupy the tent at any given time.

- The HVAC unit should be sized according to the "recommended unit size" calculation for the maximum number of soldiers that will be sleeping or resting in the tent at the same time (i.e., the number of beds), and based on historical weather data from the destination FOB.

- The HVAC unit operation should be controlled by a thermostat placed within the tent.

- The minimum size of the HVAC unit should be such that its capacity meets or exceeds the design heating and cooling loads for the tent. If the unit's capacity does not meet the design loads, the unit will not be capable of maintaining comfortable conditions within the tent in weather conditions approaching the outdoor design conditions.

- A high-efficiency HVAC unit (for example, an "Energy Star" labeled unit) should be used, to reduce the energy consumption per unit cooling or heating output. Values for SEER of 13 or higher and HSPF of 7 or higher indicate high-efficiency units.

- The unit's initial cost should factor into economic considerations. However, the unit's initial cost does not affect its energy consumption while in operation.

- The unit's capacity is a lesser factor in the overall energy consumption (i.e., units of different capacity but same efficiency will consume approximately the same amount of energy per kWh of air conditioning).

- The unit's expected maintenance and repair cycles, as a function of actual operating hours, should be taken into account. A smaller (lower capacity) unit will operate for longer periods to maintain the target indoor conditions and, therefore, may require more frequent maintenance and/or repairs.

6.4.2 Fire Safety Strategies – Interior Scenario

Preventing undesired events through regulatory control of design or operations, and managing impacts are generally two strategies used to reduce fire risk[1]. For the interior fire scenario, any contribution of the indirect impacts associated with thermal insulating layer can be mitigated by shielding energy sources, or by removing such energy sources from any contact with the foam assembly. Examples may include:

- Regulating the use of supplemental space (radiant) heating devices inside the tent;
- Proper ventilation of electrical appliances away from walls;
- Relocation of electrical power receptacles to the floor area;
- Shielding of light fixtures to prevent contact with interior surface; and
- Use of conduit and shielded cabling where penetration or contact with the wall is necessary.

If such a protocol is introduced and implemented into the current tactics, techniques, and procedures, the result could yield a net reduction in frequency of initiating exposures.

Managing the impact of a fire inside a foamed tent can be effective in reducing risk with an interior ignition scenario. Such management strategies may include:

- Implementation of fixed smoke alarms;
- Installing door hardware that facilitates emergency egress;
- Providing portable fire extinguishers for occupant use;
- Training occupants in firefighting techniques.

These features can provide earlier response and faster occupant egress in the event of a fire emergency, and a means to suppress a fire discovered in the early stages. This may lead to a reduction in the risk of occupant harm resulting from an internal fire. Although the calculated relative risk associated with the foam insulation assembly is greater than the untreated tent fabric for the interior fire scenario, the relative risk can be reduced by a combined implementation of prevention, management, and monitoring plans.

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[1] NFPA 550, *Guide to the Fire Safety Concepts Tree*, 2002 edition, National Fire Protection Association, Figure 4.3.