

TED-AJ03-326

A New Environmental Control System Assessment Model for Shelters

J. Howard ArthurDepartment of Mechanical Engineering, Virginia Military Institute, Lexington, VA
24450-0304**J. Taylor Beard and Robert J. Ribando**

Department of Mechanical, Aerospace Engineering, University of Virginia, PO Box 400746, Charlottesville, VA 22901

Ashok Patil and Nicholas P. Johnston

Environmental Systems and Fuel Cells Branch, US Army CECOM RD&E Center, Ft. Belvoir, VA 22060-5817

Keywords: Transient Heating and Cooling Simulation, Design Heating and Cooling Loads

ABSTRACT

The mathematical algorithms were developed for evaluating the Heating, Ventilating and Air Conditioning (HVAC) loads and the associated transient thermal responses for mobile shelters used by the United States Army. The algorithms have provisions for determining the heating and cooling loads needed for sizing HVAC equipment for shelters. The algorithms will accommodate the energy gains of equipment and personnel, and HVAC equipment operational features. These algorithms are based on the ASHRAE energy balance principles as presented in the 2001 ASHRAE Handbook of Fundamentals.

The computational techniques use simultaneous transient energy balances on the various surfaces and components of a shelter. The shelter assessment model is based upon a multi-node lumped-capacity model.

An algorithm is included for determining if the required psychrometric process for a particular cooling application is possible. Under certain loading and environmental conditions, it may not be impossible to achieve the desired inside temperature and humidity conditions with simple air conditioning equipment. For instance, an air conditioner for a shelter with a high latent load (low sensible heat ratio) may be unable to remove enough moisture to maintain the specified indoor design conditions. The algorithm determines if adequate condensation can occur at the cooling coil by checking to see if the process path through the coil approaches the saturation line on the psychrometric chart (at the apparatus dew point).

The algorithms described above are the foundation of a new environmental assessment model for shelters. The environmental assessment model has the ability to determine heating and cooling loads for shelters at specified locations or under standard outdoor environmental conditions. The user is able to select weather data from various geographic sites around the world. Alternatively, the user can specify the standard environmental conditions designated by the US Army (AR 70-38).

This model differs from standard HVAC load models in the form of transient responses that are predicted for the shelter. Currently available commercial and public domain HVAC models predict transient load variations and energy usage based upon a fixed inside design temperature. The new shelter environmental assessment model has the ability to predict inside temperature as a function of variations in environment condition, HVAC equipment performance, and inside load conditions.

NOMENCLATURE

ρ	material density, kg/m ³
C	material specific heat, kJ/kgK
V	material volume, m ³
L	wall thickness, m
k	material thermal conductivity, W/mK
h_o	outside wall convection coefficient, W/m ² K
h_i	inside wall convection coefficient, W/m ² K
h_{eq}	convection coefficient for the equipment mass node, W/m ² K
h_r	radiation heat transfer coefficient for the inside surfaces, W/m ² K

Copyright © 2003 JSME