Development, Design and Validation of an "Iceless" Container for the Far Forward Storage of Red Blood Cells during Contingency Operations

FJ Rentas,[1] VW Macdonald,[1] DM Houchens,[2] W Mayer,[2] TJ Reid,[11] Walter Reed Army Institute of Research, Silver Spring, MD 20910

MINNESOTA THERMAL SCIENCE, LLC

Background

Recent military experiences in Afghanistan and the Middle East have demonstrated a need for a lightweight container capable of carrying Red Blood Cells (RBCs) , at the required temperature, far forward of the Forward Surgical Teams (FSTs). The use of small commercial coolers or rucksacks for this purpose has resulted in waste rates of over 50% due to RBCs not kept at the 1-10° C (33.8-50° F) temperature range required by the FDA.

The only approved container for the transport and storage of RBCs on the battlefield is the "Collins Box" (Figure 1), which keeps RBCs at the required shipping temperature for approximately 24 hours under ideal environmental conditions. This box is a reusable cardboard and Styro-foam container that can hold up to 30 RBCs and weighs 44 pounds when loaded with 14 pounds of wet ice. The weight, dimensions and storage characteristics of the "Collins Box" make it impossible for a medic to carry it farther forward than the FSTs.

A light, thermally efficient container capable of carrying 4 to 6 units of RBCs at the desired temperature for more than 48 hours under extreme conditions would solve the weight and temperature control problems that we now face. Weighing 10 pounds or less, it could be carried by medics during contingency operations. The transfusion of RBCs far forward from the FSTs will enhance medical treatment and increase the survivability of wounded soldiers before evacuation takes place.

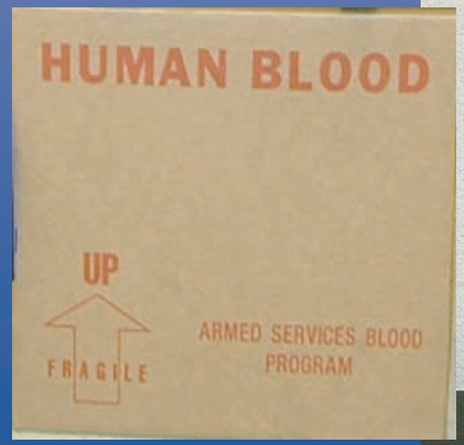

Fig 1. Collins Box

Fig 2. New Blood Container

Materials and Methods

Six different prototype containers and phase change materials (PCMs) were evaluated. Testing was conducted at -23° C (-5° F) and 40° C (104° F). Loads were tested for a minimum of 24 hours or when red cell units reached an unacceptable temperature (<1° C or >10° C), whichever was longer. Temperatures were recorded using a calibrated scanning thermocouple thermometer. Readings were recorded and stored every 10 minutes. A minimum of three thermocouple probes were used during testing. One was placed directly on a blood unit. A second probe was placed outside the box to monitor the ambient temperature while another was placed on the chamber holding the units. All loads exposed to 40° C (104° F) were placed in a calibrated temperature and humidity cabinet set at the appropriate temperature and humidity conditions (50% humidity). Loads exposed to -23° C (-5° F) were placed in a temperature controlled walk-in freezer. Data was downloaded and converted into an Excel file, and a chart generated.

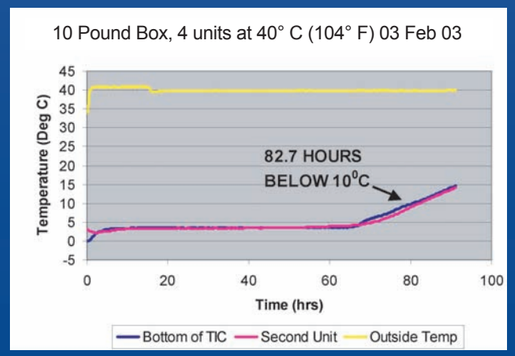

Fig 3. Testing at 40° C (104° F)

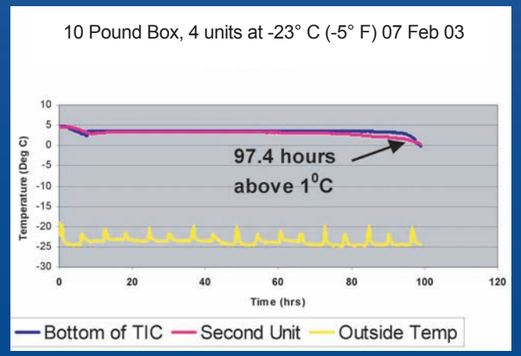

Fig 4. Testing at -23° C (-5° F)

Results

One container (Figure 2) weighing 10 pounds (fully loaded with four units of RBCs) was capable of holding the temperature of the units between 1-10° C (33.8-50° F) for more than 80 hours at 40° C (104° F) and for over 95 hours at -23° C (-5° F) (Figures 3 and 4).

No ice, batteries, or an external power source were required.

Thermal Isolation Chamber (TIC™) must be pre-staged at +3° C (+37.4° F) or below for use during hot weather, and at +4° C (39.2° F) to +6°C (42.8° F) for cold weather for a minmum of 2 hours.

Six independent evaluations performed at 40° C (104° F) and five performed at -23° C (-5° F) resulted in similar outcomes as the ones shown in figures 3 and 4.

Conclusions

A more efficient and lighter container that allows RBCs to be transfused farther forward than the FSTs has been validated and is now available with National Stock Numbers (NSNs). It is capable of keeping RBCs at required temperatures for over 72 hours under extreme environmental conditions. This container will increase the survivability of bleeding soldiers waiting to be evacuated. The applications for this container are endless.