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**U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT  
COMMAND TEST BRANCH**

**Test Summary:  
Collins Box Payload Protection Performance**

## Test Summary

The U.S. Army Medical Research and Development Command (USAMRDC) Test Branch tested Collins Box shipping containers to provide data regarding payload protection times under environmental temperature and humidity exposures anticipated during operational conditions.

### Test Method

Fresh Frozen Plasma (FFP) and Packed Red Blood Cells (PRBCs) were loaded for simulated shipments into Collins Boxes IAW established Armed Services Blood Program (ASBP) protocols, with the following exceptions:

- **Two Data Measurement Locations:**
  - **“Warmest Area of Payload” Temperature Instrumentation.** Two data measurement devices were used to measure the payload temperatures in the center bottom of the box; this area of the payload was positioned furthest away from the coolant. A TempTale<sup>®</sup> data logger, like those used by the ASBP during blood product shipment, was placed beside an independent thermocouple to compare the results of the two temperature measurements and ensure data accuracy.
  - **“Coldest Area of Payload” Temperature Instrumentation.** A second thermocouple was placed on the top of the PRBC units, below the cubed wet ice bags, to monitor for temperatures below 1°C.
- **No Re-icing.** Both the PRBC and FFP ASBP packing protocols call for re-icing (FFP with dry ice, PRBCs with wet ice) the payload every 48 hours during shipment. However, re-icing was not performed because the purpose of this testing was to determine if the payload remained within the required temperature parameters (FFP  $\leq -18^{\circ}\text{C}$ , PRBC 1-10°C) for a 48-hour time period (or longer), measuring thermal protection time between re-icing periods.

### Test Findings

#### Packed Red Blood Cells (PRBCs)

The Collins Box provided thermal protection of the PRBC payload for greater than 48 hours when held at room temperature (22°C, 72°F, 50% RH) and when refrigerated at 4°C (39.2°F), which was inside the target temperature range of 1-10°C. **All other test exposures resulted in less than 48 hours of thermal payload protection.**

#### Fresh Frozen Plasma (FFP)

**The Collins Box provided thermal protection of the FFP payload for at least 48 hours in all tests other than the Hot Humid (60°C, 95% RH) exposure.** During that test the contents reached  $>-18^{\circ}\text{C}$  at 47.8 hours (per the thermocouple, the TempTale measured 48.0 hours).

**Table 1 displays the total duration of both the PRBC and FFP payloads within their specified temperature ranges.**

Table 1. Environmental Exposure Test Results

<b>Collins Box Blood Shipping Container</b>		
<b>Simulated Climatic Condition</b>	<b>Total Duration of Payload Within Specified Temperature Range</b>	
	<b>Packed Red Blood Cells 1-10°C (34-50°F)</b>	<b>Fresh Frozen Plasma ≤ -18°C (0°F)</b>
<u>Hot Dry</u> 60°C (140°F)	≥ 10°C at: 12.4 Hours <sup>1</sup> 13.3 Hours <sup>2</sup>	≥ -18°C at: 51.9 Hours <sup>1</sup> 51.8 Hours <sup>2</sup>
<u>Hot Humid</u> 60°C (140°F), 95% RH	≥ 10°C at: 6.6 Hours <sup>1</sup> 9.6 Hours <sup>2</sup>	≥ -18°C at: 48.0 Hours <sup>1</sup> 47.8 Hours <sup>2</sup>
<u>Room Temperature</u> 22°C (72°F), 50% RH	≥ 10°C at: 107.7 Hours <sup>1</sup> 110.8 Hours <sup>2</sup>	≥ -18°C at: 75.7 Hours <sup>1</sup> 75.3 Hours <sup>2</sup>
<u>Refrigerated</u> 4°C (39.2°F)	N/A Within PRBC target parameters	≥ -18°C at: 94.5 Hours <sup>1</sup> 96.1 Hours <sup>2</sup>
<u>Basic Cold*</u> -20°C (-4°F)	< 1°C at: 1.6 Hours <sup>1</sup> 3.3 Hours <sup>2</sup>	N/A Within FFP target parameters
<u>Severe Cold*</u> -51°C (-60°F)	< 1°C at: 6.4 Hours <sup>1</sup> 8.3 Hours <sup>2</sup>	N/A Within FFP target parameters
<u>Basic Hot Dry</u> 43.3°C (110°F)	≥ 10°C at: 21.4 Hours <sup>1</sup> 28.2 Hours <sup>2</sup>	Not Tested due to >48 hour thermal protection time at 60°C
<u>Basic Hot Humid</u> 43.3°C (110°F), 90% RH	≥ 10°C at: 12.2 Hours <sup>1</sup> 19.3 Hours <sup>2</sup>	

<sup>1</sup>TempTale, <sup>2</sup>Bottom Thermocouple

- Red Shading  indicates payload temperature outside of target range in <48 hours.
- Green Shading  indicates payload temperature remained within target range for ≥ 48 hours.

\*The Basic Cold (-20°C) and the Severe Cold (-51°C) exposure results appear to be counterintuitive, in that the PRBC payload reached temperatures below 1°C and 0°C faster during the -20°C exposure than during the exposure at -51°C. This is due to the fact that the Severe Cold exposure was conducted in a static air, ultra-cold freezer whereas the Basic Cold and all other exposures were performed in a forced air test chamber (air velocity is 2 m/s at test item location). In both cases the PRBC payload temperature dropped to damaging levels well before the required 48-hour threshold.

# Table of Contents

<b>1. Introduction .....</b>	<b>1</b>
1.1 Statement of Purpose.....	1
1.2 Program Background.....	1
<b>2. The Collins Box Blood Shipping Container .....</b>	<b>2</b>
2.1 PRBC (liquid) Packing and Test Configuration.....	3
2.2 Fresh Frozen Plasma (FFP) Packing and Test Configuration .....	4
<b>3. Test Method .....</b>	<b>5</b>
<b>4. Packed Red Blood Cells (PRBCs) Test Results .....</b>	<b>7</b>
4.1 Hot Dry Exposure at 60°C (140°F) .....	7
4.2 Hot Humid Exposure at 60°C (140°F), 95% Relative Humidity .....	7
4.3 Room Temperature Exposure: 22°C (72°F), 50% RH .....	7
4.4 Refrigerated Exposure: 4°C (39.2°F) .....	7
4.5 Basic Cold Exposure: -20°C (-4°F)* .....	7
4.6 Severe Cold Exposure: -51°C (-60°F)* .....	7
4.7 Basic Hot Dry Exposure: 43.3°C (110°F) .....	8
4.8 Basic Hot Humid Exposure: 43.3°C (110°F), 90% RH .....	8
<b>5. Fresh Frozen Plasma (FFP) Test Results .....</b>	<b>9</b>
5.1 Hot Dry Exposure at 60°C (140°F) .....	9
5.2 Hot Humid Exposure at 60°C (140°F), 95% Relative Humidity .....	9
5.3 Room Temperature Exposure: 22°C (72°F), 50% RH .....	9
5.4 Refrigerated Exposure: 4°C (39.2°F) .....	9
5.5 Basic Cold Exposure: -20°C (-4°F).....	9
5.6 Severe Cold Exposure: -51°C (-60°F).....	9
5.7 Basic Hot Exposure: 43.3°C (110°F) .....	9
5.8 Basic Hot Humid Exposure: 43.3°C (110°F), 90% RH .....	9
<b>6. Complete Environmental Exposure Results .....</b>	<b>10</b>
<b>7. References .....</b>	<b>11</b>
<b>8. Points of Contact .....</b>	<b>11</b>

## List of Figures

Figure 1. Collins Box Exterior.....	2
Figure 2. Collins Box Interior.....	2
Figure 3. PRBC Temperature Monitoring Configuration.....	3
Figure 4. FFP Temperature Monitoring Configuration .....	4
Figure 5. Environmental Testing Configuration.....	5

## List of Tables

Table 1. Environmental Exposure Test Results.....	iii
Table 2. Weights and Measurements Performed by Test Branch.....	2
Table 3. Simulated Climates and Corresponding Exposures.....	6
Table 4. Complete Environmental Exposure Test Results .....	10

## List of Graphs

Graph 1. Hot Dry: High Temperature at 60°C.....	12
Graph 2. Hot Humid: High Temperature at 60°C with 95% Relative Humidity.....	12
Graph 3. Room Temperature: 22°C with 50% Relative Humidity .....	13
Graph 4. Refrigerated: 4°C .....	13
Graph 5. Basic Cold: -20°C .....	14
Graph 6. Severe Cold: -51°C .....	14
Graph 7. Basic Hot Dry: 43.3°C .....	15
Graph 8. Basic Hot Humid: 43.3°C with 90% Relative Humidity .....	15

# **1. Introduction**

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## **1.1 Statement of Purpose**

The U.S. Army Medical Research and Development Command (USAMRDC) Test Branch conducted performance testing on Collins Box shipping containers to measure the payload protection duration provided by the boxes under different environmental conditions.

## **1.2 Program Background**

Interoperability of the blood supply with North Atlantic Treaty Organization (NATO) partners is critical to preserving the lives of Service Members in future large-scale combat operations (LSCO) with NATO partners. However, each NATO partner has their own requirements for transfusion and transport of blood products. A key gap that has been identified by the NATO Blood Panel, an official panel under the NATO Committee of the Chiefs of Military Medical Services (COMEDS), has been that some NATO partners will not accept blood supplies that have been transported using passive cooling methods without temperature monitoring in transit.

The testing conducted at the USAMRDC Test Branch evaluation is designed to provide data regarding payload protection times provided by Collins Boxes under environmental thermal exposures anticipated during operational conditions. The ASBP may utilize the results to initiate further discussions with NATO partners to support acceptance of U.S.-collected blood products by all NATO partners.

## 2. The Collins Box Blood Shipping Container

The “Collins Box” is the approved blood-shipping container used by the Armed Services Blood Program. This is a reusable cardboard and Styrofoam container, which holds approximately 20 units Whole Blood, 30 units Packed Red Blood Cells (PRBCs), or 15 units Fresh Frozen Plasma (FFP). It weighs approximately 45-55 pounds when loaded with 25 pounds of dry ice or 14 pounds of wet ice and blood products.

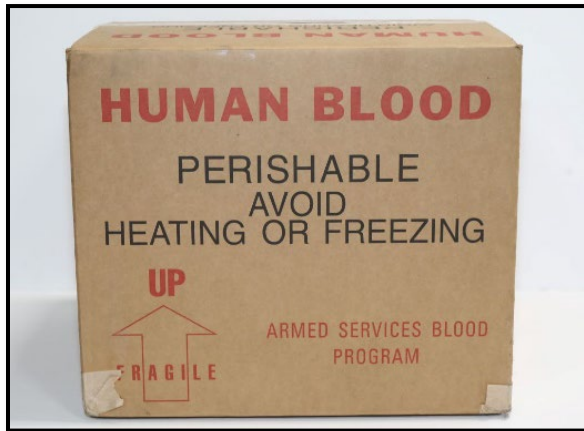


Figure 1. Collins Box Exterior



Figure 2. Collins Box Interior

Table 2. Weights and Measurements Performed by Test Branch

Description	Dimensions (w x d x h)	Weight
Collins Box (empty)	Exterior: 48.0 x 46.7 x 42.7cm (18.9" x 18.4" x 16.8") Interior: 38.1 x 36.3 x 26.7cm (15.0" x 14.3" x 10.5")	3.0 kg (6.6 lbs.)
Packaged FFP box (25 lbs. of dry ice and 15 x FFP units)	N/A	19.9 kg (43.8 lbs.)
Packaged PRBC box (14 lbs. of cubed wet ice and 30 x PRBC units)	N/A	22.7 kg (50.0 lbs.)

## 2.1 PRBC (liquid) Packing and Test Configuration

Both the PRBCs and FFP were packed IAW the “Shipping and Storage of Blood Products, Version 3.0” protocol<sup>1</sup> supplied by the Armed Services Blood Program.

1. Thirty expired PRBC units (450-500 cc/unit) were preconditioned at 4°C (39.2°F) prior to packing.
2. A layer of absorbent “Pig-roll Mat” was placed in the bottom of the Collins Box.
3. A thermocouple connected to a DataQ model DI-718B-E Data Logger (calibrated 7/8/21) was placed in the center bottom of the box, to monitor the temperature of the payload area. This area of the payload was positioned furthest away from the coolant and likely the first area to exceed the acceptable temperature parameters. A TempTale<sup>®</sup> Ultra Bio Data Logger (Exp. 8/31/22) was placed beside the thermocouple, its data downloaded following the test to compare the results of the two temperature measurements and ensure data accuracy.
4. A large plastic bag was then placed inside the box’s Styrofoam container and another layer of “Pig-roll Mat” placed in its bottom. This bag was prepared to hold the PRBC units.
5. A second plastic bag was filled with 14 lbs. of cubed wet ice and closed with a tie. This bag was then “double bagged” inside another bag and closed with a tie to prevent leakage.
6. The preconditioned PRBC units were placed in the plastic bag inside the Collins Box. The time from refrigerator removal to packaging in the plastic bag was no more than 15 minutes.
7. A second thermocouple was placed on the top of the PRBC units, below the cubed wet ice bags to monitor for temperatures below 1°C.
8. Once the units were packed, the ice bag was placed on top of the blood products and the Styrofoam lid closed.
9. The payload temperature was monitored throughout the test, and the test concluded when it departed from the following temperatures: 0-22°C (32-71.6°F).

Note: According to the ASBP protocol, this packing configuration should maintain a temperature of 1 to 10°C for 48 hours.

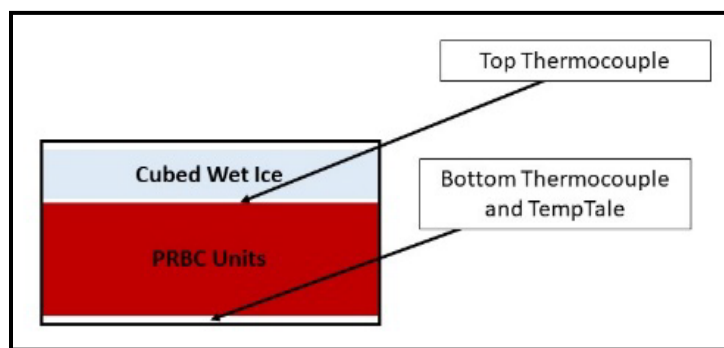


Figure 3. PRBC Temperature Monitoring Configuration

## 2.2 Fresh Frozen Plasma (FFP) Packing and Test Configuration

1. Fifteen expired FFP units (250-300 cc/unit) were preconditioned at  $-25^{\circ}\text{C}$  ( $-13^{\circ}\text{F}$ ) prior to packing. This was consistent with the FFP storage temperature provided by the Armed Services Whole Blood Processing Laboratory East (WBAMC-East).
2. A thermocouple connected to a data logger was placed on the bottom center of the box to monitor the temperature of the plasma payload. This area of the box was chosen for placement because it is positioned furthest away from the coolant and likely the first to exceed the acceptable temperature parameters. A TempTale<sup>®</sup> Ultra Dry Ice Probe monitor (Exp. 8/31/22) was placed beside the thermocouple, its data downloaded following the test to compare the results of the two temperature measurements and ensure data accuracy.
3. The preconditioned FFP units, packed in their individual cardboard boxes, were placed inside the Collins Box. The products were evenly distributed in the shipment container so each unit was in contact with the dry ice.
4. Once the units were packed 25 lbs. of pelleted dry ice was added on top of the blood products and the Styrofoam lid closed.
5. The payload temperature was monitored throughout the test, and the test concluded when it reached  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ).

Note: According to the ASBP protocol, this packing protocol should maintain a temperature of  $-18^{\circ}\text{C}$  or colder for 48 hours.

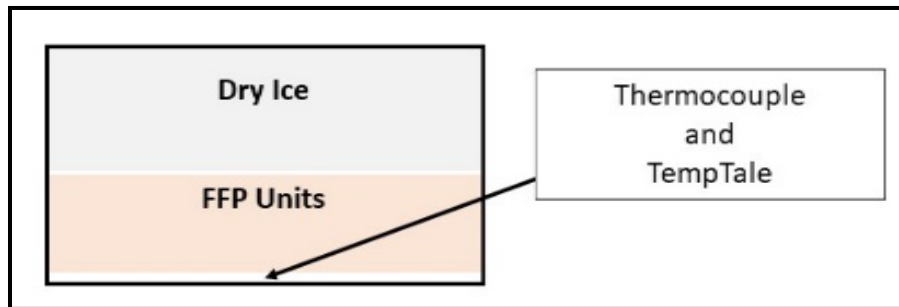


Figure 4. FFP Temperature Monitoring Configuration

### 3. Test Method

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Temperature and humidity tests were conducted in accordance with tailored provisions of MIL-STD-810H, Methods 501.7 (High Temperature), 502.7 (Low Temperature) and 507.6 (Humidity).

Thermal and humidity testing was conducted in the Russell Walk-In Thermal and Humidity Test Chamber Model WMD-336-ECMD-4-10-10 (calibrated 8/19/21). The Severe Cold (-51°C, -60°F) exposure was conducted in the New Brunswick Ultra-Low Temperature Freezer Model C585-86, S/N F585JQ030402, calibrated 9/13/21.



Figure 5. Environmental Testing Configuration

Eight external thermal temperature and humidity exposures were employed to test the shipping box to conditions likely to be experienced by blood products enroute. The temperature and humidity exposures for the simulated climates are displayed in Table 3.

Table 3. Simulated Climates and Corresponding Exposures

Simulated Climate	Temperature Exposure	Humidity
Hot Dry	60°C (140°F)	0%
Hot Humid	60°C (140°F)	95%
Basic Hot Dry	43.3°C (110°F)	0%
Basic Hot Humid	43.3°C (110°F)	90%
Room Temperature	22°C (72°F)	50%
Refrigerated	4°C (39.2°F)	0%
Basic Cold	-20°C (-4°F)	0%
Severe Cold	-51°C (-60°F)	0%

Per the request of the ASBP, these tests were conducted until the payload temperature was greater than the following temperatures:

- PRBCs: Room Temperature: > 22°C (71.6°F)
- \*FFP: > 0°C (32°F)

The length of time for the payload temperature to reach its specified test conclusion temperature was recorded. Both the collected thermocouple and the TempTale temperature data were graphed. Graphed data is illustrated in the appendix section of this summary.

\*NOTE: Several FFP packages were found to be leaking at the end of testing when the Collins Box contents were allowed to rise above freezing. Subsequent tests were terminated before the container contents reached 0°C, to prevent additional plasma leakage.

## 4. Packed Red Blood Cells (PRBCs) Test Results

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- PRBC Payload Temperature Target: 1 to 10°C for at least 48 hours
- Per the request of the ASBP, these tests were conducted until the PRBC payload temperature was greater than room temperature, 22°C (71.6°F).

### 4.1 Hot Dry Exposure at 60°C (140°F)

**Failed to maintain temperature within the required 1-10°C range for 48 hours**

(>10°C) at **13.3 hours** (Bottom Thermocouple), **12.4 hours** (TempTale Bio)

(>22°C) at 52.3 hours (Bottom Thermocouple), 53.0 hours (TempTale Bio)

Top Thermocouple Lowest Recorded Temperature: 3°C

### 4.2 Hot Humid Exposure at 60°C (140°F), 95% Relative Humidity

**Failed to maintain temperature within the required 1-10°C range for 48 hours:**

(>10°C) at **9.6 hours** (Bottom Thermocouple), **6.6 hours** (TempTale Bio)

(>22°C) at 43.7 hours (Bottom Thermocouple), 40.9 hours (TempTale Bio)

Top Thermocouple Lowest Recorded Temperature: 2°C

### 4.3 Room Temperature Exposure: 22°C (72°F), 50% RH

**Maintained target temperature range for more than 48 hours:**

(>10°C) at 110.8 hours (Bottom Thermocouple), 107.7 hours (TempTale)

Reached 22°C at 312.4 hours (Bottom Thermocouple), 306.6 hours (TempTale Bio)

Top Thermocouple Lowest Recorded Temperature: 1°C

### 4.4 Refrigerated Exposure: 4°C (39.2°F)

**Maintains target temperature range for longer than 48 hours, the thermal condition is within the target temperature range (refrigeration temperature).**

Top Thermocouple Lowest Recorded Temperature: 2°C

### 4.5 Basic Cold Exposure: -20°C (-4°F)\*

**Failed to maintain temperature within the required 1-10°C range for 48 hours:**

(<1°C) at **3.3 hours** (Bottom Thermocouple), **1.6 hours** (TempTale Bio)

(<0°C) at **4.3 hours** (Bottom Thermocouple), **1.8 hours** (TempTale Bio)

Top Thermocouple – temperature remained >1°C longer than bottom thermocouples monitoring payload

### 4.6 Severe Cold Exposure: -51°C (-60°F)\*

**Failed to maintain temperature within the required 1-10°C range for 48 hours:**

(<1°C) at **8.3 hours** (Bottom Thermocouple), **6.4 hours** (TempTale Bio)

(<0°C) at **9.1 hours** (Bottom Thermocouple), **7.1 hours** (TempTale Bio)

Top Thermocouple – temperature remained >1°C longer than bottom thermocouples monitoring payload

\*The Basic Cold (-20°C) and the Severe Cold (-51°C) exposure results appear to be counterintuitive, in that the PRBC payload reached temperatures below 1°C and 0°C faster during the -20°C exposure than during the exposure at -51°C. This is due to the fact that the Severe Cold exposure was conducted in a static air, ultra-cold freezer whereas the Basic Cold and all other exposures were performed in a forced air test chamber (air velocity is 2 m/s at test item location). In both cases, the PRBC payload temperature dropped to damaging levels well before the required 48-hour threshold.

#### **4.7 Basic Hot Dry Exposure: 43.3°C (110°F)**

**Failed to maintain temperature within the required 1-10°C range for 48 hours.**

(>10°C) at **28.2 hours** (Bottom Thermocouple), **21.4 hours** (TempTale Bio)

(>22°C) at 82.5 hours (Bottom Thermocouple), 78.3 hours (TempTale Bio)

Top Thermocouple - Lowest Recorded Temperature: 2°C

#### **4.8 Basic Hot Humid Exposure: 43.3°C (110°F), 90% RH**

**Failed to maintain temperature within the required 1-10°C range for 48 hours.**

(>10°C) at **19.3 hours** (Bottom Thermocouple), **12.2 hours** (TempTale Bio)

(>22°C) at 72.0 hours (Bottom Thermocouple), 70.2 hours (TempTale Bio)

Top Thermocouple - Lowest Recorded Temperature: 1°C

## 5. Fresh Frozen Plasma (FFP) Test Results

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- FFP Payload Temperature Target  $\leq -18^{\circ}\text{C} \geq 48$  Hours
- Per the request of the ASBP, initially these tests were conducted until the FFP payload temperature was higher than  $0^{\circ}\text{C}$  ( $32^{\circ}\text{F}$ ). However, several FFP packages were discovered to leak when allowed to rise above freezing. Subsequent tests were terminated before the container contents reached  $0^{\circ}\text{C}$  to prevent additional plasma leakage.

### 5.1 Hot Dry Exposure at $60^{\circ}\text{C}$ ( $140^{\circ}\text{F}$ )

#### Maintained temperature greater than 48 hours

( $> -18^{\circ}\text{C}$ ) at 51.8 hours (Thermocouple), 51.9 hours (TempTale)

( $> 0^{\circ}\text{C}$ ) at 55.8 hours (Thermocouple), 55.9 hours (TempTale)

### 5.2 Hot Humid Exposure at $60^{\circ}\text{C}$ ( $140^{\circ}\text{F}$ ), 95% Relative Humidity

#### Failed to maintain temperature below the required temperature ( $\leq -18^{\circ}\text{C}$ ) for 48 hours

( $> -18^{\circ}\text{C}$ ) at **47.8 hours** (Thermocouple), 48.0 hours (TempTale)

( $> 0^{\circ}\text{C}$ ) at 51.3 hours (Thermocouple), 51.3 hours (TempTale)

### 5.3 Room Temperature Exposure: $22^{\circ}\text{C}$ ( $72^{\circ}\text{F}$ ), 50% RH

#### Maintained temperature greater than 48 hours

( $> -18^{\circ}\text{C}$ ) at 75.3 hours (Thermocouple), 75.7 hours (TempTale)

( $> 0^{\circ}\text{C}$ ) at 92.1 hours (Thermocouple), 97.3 hours (TempTale)

### 5.4 Refrigerated Exposure: $4^{\circ}\text{C}$ ( $39.2^{\circ}\text{F}$ )

#### Maintained temperature greater than 48 hours

( $> -18^{\circ}\text{C}$ ) at 96.1 hours (Thermocouple), 94.5 hours (TempTale)

Exposure Stopped at 119.8 Hours:  $-2^{\circ}\text{C}$  (Thermocouple),  $-4^{\circ}\text{C}$  (TempTale)

### 5.5 Basic Cold Exposure: $-20^{\circ}\text{C}$ ( $-4^{\circ}\text{F}$ )

**Maintained temperature greater than 48 hours.** Thermal condition is within target temperature range.

### 5.6 Severe Cold Exposure: $-51^{\circ}\text{C}$ ( $-60^{\circ}\text{F}$ )

**Maintained temperature greater than 48 hours.** Thermal condition is within target temperature range.

### 5.7 Basic Hot Exposure: $43.3^{\circ}\text{C}$ ( $110^{\circ}\text{F}$ )

Not Performed (met specifications at higher temperature)

### 5.8 Basic Hot Humid Exposure: $43.3^{\circ}\text{C}$ ( $110^{\circ}\text{F}$ ), 90% RH

Not Performed (met specifications at higher temperature)

## 6. Complete Environmental Exposure Results

Table 4. Complete Environmental Exposure Test Results

<b>Collins Box Blood Shipping Container</b>					
<b>Simulated Climatic Condition</b>	<b>Total Duration of Payload Within Specified Temperature Range</b>				
	<b>Packed Red Blood Cells</b>			<b>Fresh Frozen Plasma</b>	
	<b>Optimum 1-10°C (34-50°F)</b>	<b>Critical 0-22°C (32-72°F)</b>	<b>Wet Ice Interface (Top Thermocouple) Target: ≥ 1°C (34°F)</b>	<b>Optimum ≤ -18°C (0°F)</b>	<b>Critical &lt; 0°C (32°F)</b>
<u>Hot Dry</u> 60°C (140°F)	≥ 10°C at: 12.4 Hours <sup>1</sup> 13.3 Hours <sup>2</sup>	≥ 22°C at: 53.0 Hours <sup>1</sup> 52.3 Hours <sup>2</sup>	Lowest Temp.: 3°C	≥ -18°C at: 51.9 Hours <sup>1</sup> 51.8 Hours <sup>2</sup>	≥ 0°C at: 55.9 Hours <sup>1</sup> 55.8 Hours <sup>2</sup>
<u>Hot Humid</u> 60°C (140°F), 95% RH	≥ 10°C at: 6.6 Hours <sup>1</sup> 9.6 Hours <sup>2</sup>	≥ 22°C at: 40.9 Hours <sup>1</sup> 43.7 Hours <sup>2</sup>	Lowest Temp.: 2°C	≥ -18°C at: 48.0 Hours <sup>1</sup> 47.8 Hours <sup>2</sup>	≥ 0°C at: 51.3 Hours <sup>1</sup> 51.3 Hours <sup>2</sup>
<u>Room Temperature</u> 22°C (72°F), 50% RH	≥ 10°C at: 107.7 Hours <sup>1</sup> 110.8 Hours <sup>2</sup>	Reached 22°C at: 306.6 Hours <sup>1</sup> 312.4 Hours <sup>2</sup>	Lowest Temp.: 1°C	≥ -18°C at: 75.7 Hours <sup>1</sup> 75.3 Hours <sup>2</sup>	≥ 0°C at: 97.3 Hours <sup>1</sup> 92.1 Hours <sup>2</sup>
<u>Refrigerated</u> 4°C (39.2°F)	N/A Within PRBC target parameters		Lowest Temp.: 2°C	≥ -18°C at: 94.5 Hours <sup>1</sup> 96.1 Hours <sup>2</sup>	End: 119.8 Hours -4°C <sup>1</sup> -2°C <sup>2</sup>
<u>Basic Cold*</u> -20°C (-4°F)	≤ 1°C at: 1.6 Hours <sup>1</sup> 3.3 Hours <sup>2</sup>	≤ 0°C at: 1.8 Hours <sup>1</sup> 4.3 Hours <sup>2</sup>	N/A	N/A Within FFP target parameters	
<u>Severe Cold*</u> -51°C (-60°F)	≤ 1°C at: 6.4 Hours <sup>1</sup> 8.3 Hours <sup>2</sup>	≤ 0°C at: 7.1 Hours <sup>1</sup> 9.1 Hours <sup>2</sup>	N/A	N/A Within FFP target parameters	
<u>Basic Hot Dry</u> 43.3°C (110°F)	≥ 10°C at: 21.4 Hours <sup>1</sup> 28.2 Hours <sup>2</sup>	≥ 22°C at: 78.3 Hours <sup>1</sup> 82.5 Hours <sup>2</sup>	Lowest Temp.: 2°C	Not Tested due to >48 hour thermal protection time at 60°C	
<u>Basic Hot Humid</u> 43.3°C (110°F), 90% RH	≥ 10°C at: 12.2 Hours <sup>1</sup> 19.3 Hours <sup>2</sup>	≥ 22°C at: 70.2 Hours <sup>1</sup> 72.0 Hours <sup>2</sup>	Lowest Temp.: 1°C		

<sup>1</sup>TempTale, <sup>2</sup>Bottom Thermocouple

\*The Basic Cold (-20°C) and the Severe Cold (-51°C) exposure results appear to be counterintuitive, in that the PRBC payload reached temperatures below 1°C and 0°C faster during the -20°C exposure than during the exposure at -51°C. This is due to the fact that the Severe Cold exposure was conducted in a static air, ultra-cold freezer whereas the Basic Cold and all other exposures were performed in a forced air test chamber (air velocity is 2 m/s at test item location). In both cases the PRBC payload temperature dropped to damaging levels well before the required 48-hour threshold.

## 7. References

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1. 20 March 2018. "G.1 Shipping and Storage of Blood Products, Version 3.0". William Beaumont Army Medical Center Department of Pathology – Blood Services, 5005 N. Piedras Street, El Paso, TX 79920-5001.
2. 31 January, 2019. *Environmental Engineering Considerations and Laboratory Tests*. MIL-STD 810H, U.S. Army Developmental Test Command, Aberdeen Proving Ground, MD 21005-5055.
3. 1 September 2007. "TM 8-227-11, Operational Procedures for the Armed Services Program Elements". Headquarters, Departments of the Army, the Navy, and the Air Force.
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5. 3 September 2018. "AEI-226 Shipment of Blood Products, Version 1.0". Armed Services Whole Blood Processing Laboratory – East.

## 8. Points of Contact

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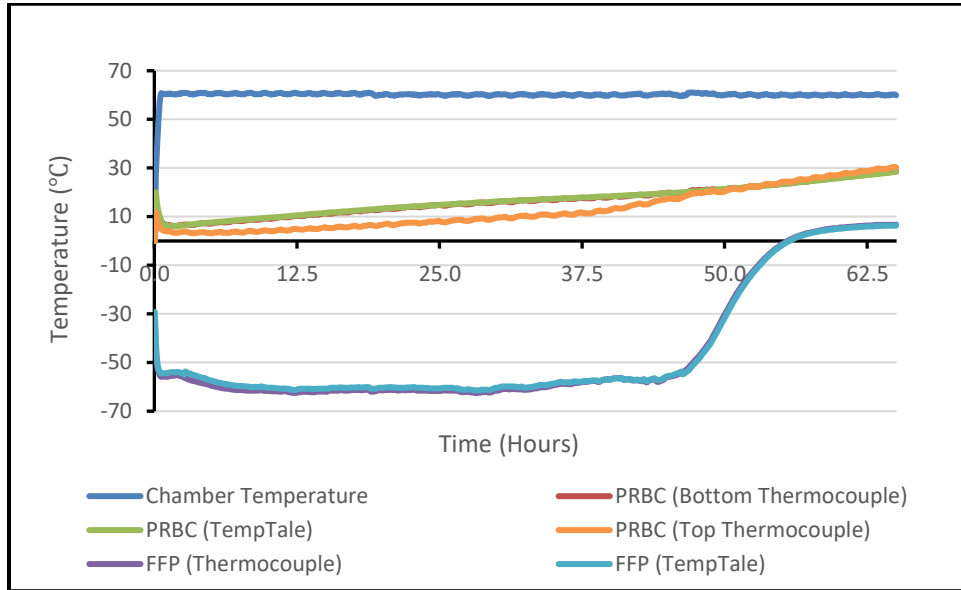
Dale S. Ruby  
Test Engineer

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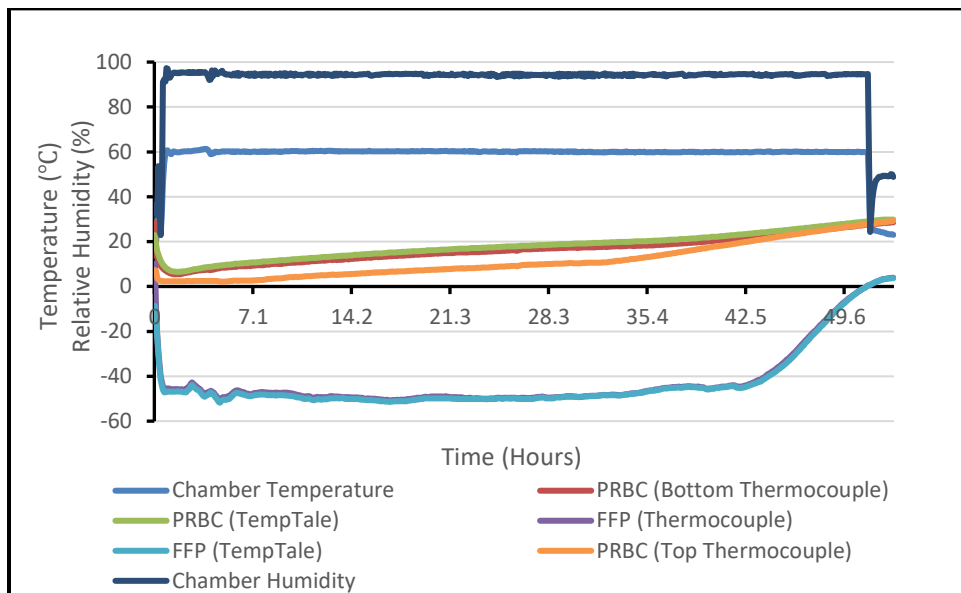
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## Appendix: Thermal Test Graphs

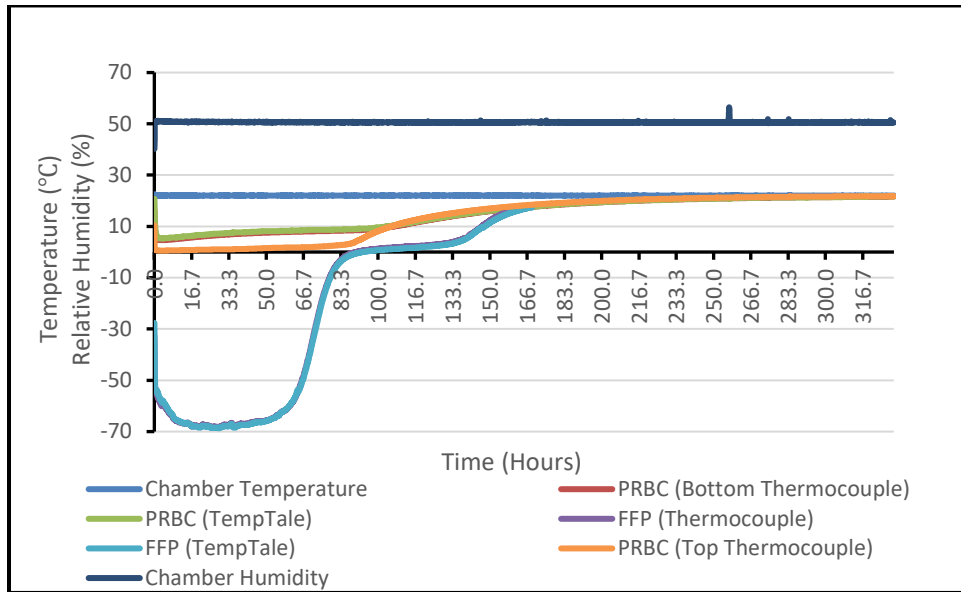
Graph 1. Hot Dry: High Temperature at 60°C



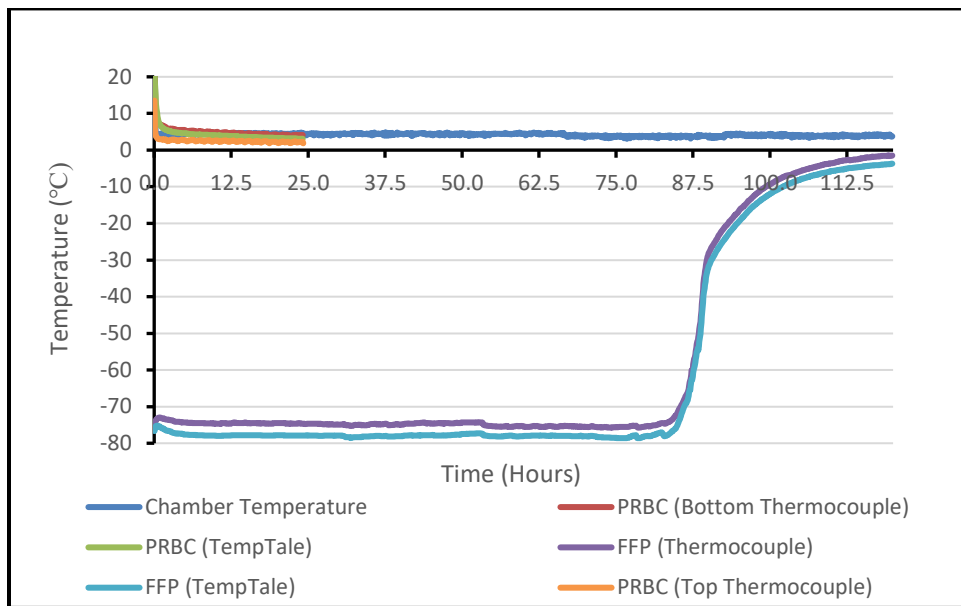
Graph 2. Hot Humid: High Temperature at 60°C with 95% Relative Humidity



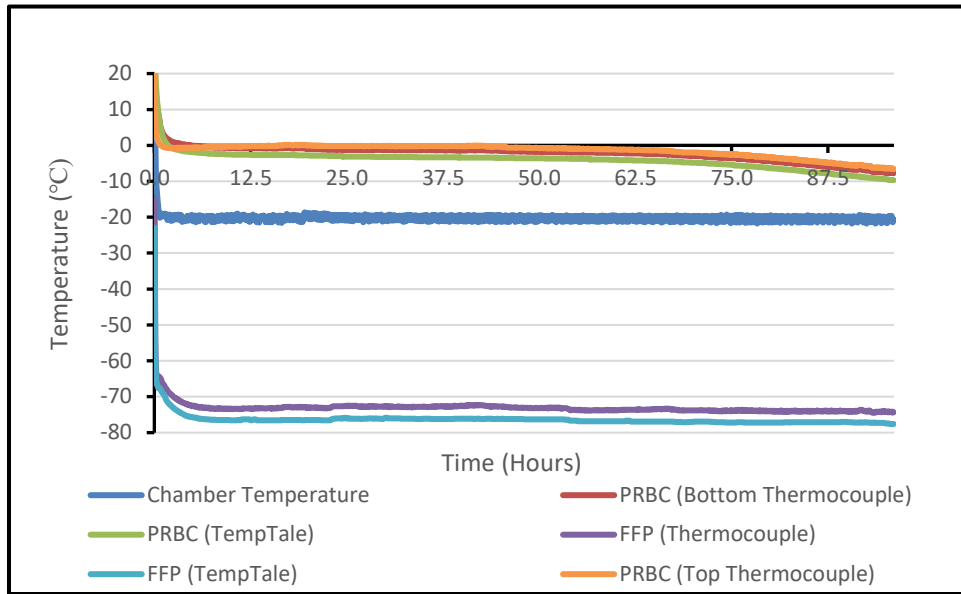
Graph 3. Room Temperature: 22°C with 50% Relative Humidity



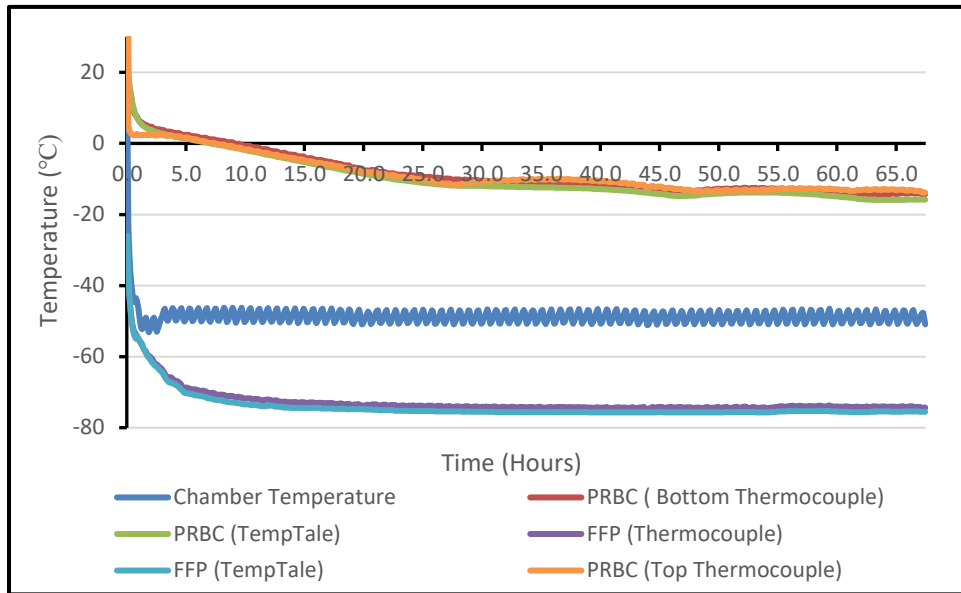
Graph 4. Refrigerated: 4°C



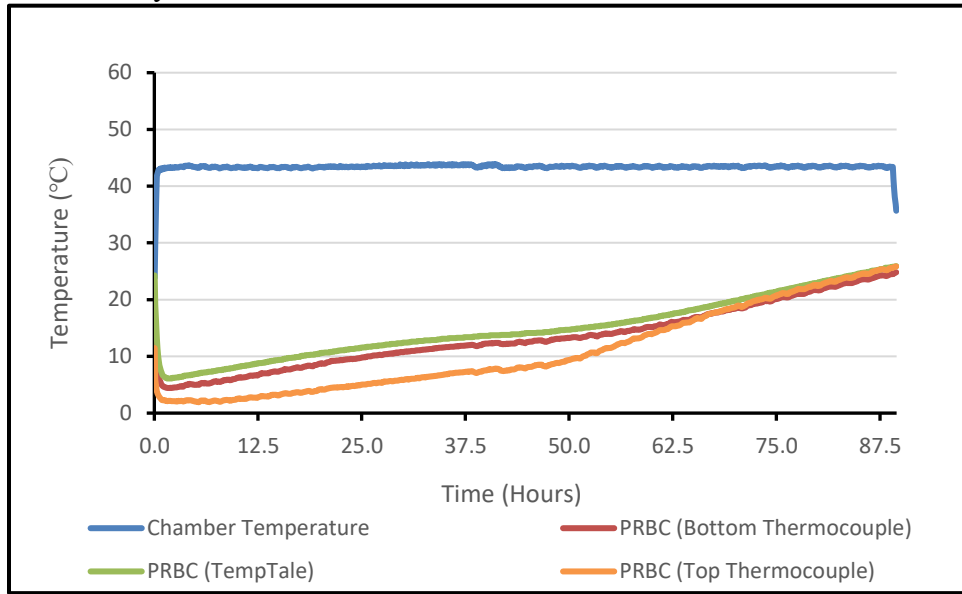
Graph 5. Basic Cold: -20°C



Graph 6. Severe Cold: -51°C



Graph 7. Basic Hot Dry: 43.3°C



Graph 8. Basic Hot Humid: 43.3°C with 90% Relative Humidity

