# Qualification Report For the NanoCool Long Haul Shipping System 2-153985B

## Purpose

This report outlines testing for the qualification of the 2-153985B NanoCool Long Haul shipping system. The 2-153985B systems were tested in triplicate against ten different ambient profiles for durations of up to one week. Three 2-153985B systems were drop tested against a modified ISTA-3A drop procedure.

## Summary

An extended duration system has been developed for nominal 2 to 8 °C shipments with durations (depending upon the ambient temperatures) of four to seven days. As with all NanoCool systems, this system is designed to start at ambient temperature with no preconditioning.

As shipment durations increase in length because of either international shipping with the possibility of customs delays or because of a move to ground shipping to lower freight costs, the ambient temperature profile that the NanoCool system will be subjected to becomes more uncertain. Therefore, we have tested the systems against ten different ambient profiles that are used in a range of geographies. These include:

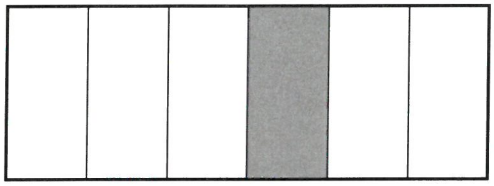
- Modified ISTA-7D 96 hour summer and winter profiles where an additional 24 hour 30 °C (summer) or 10 °C (winter) plateau was added to the 72 hour ISTA-7D profiles
- ISC Silver and Gold summer and winter profiles.
- EU summer high, summer low, winter high and winter low profiles

## Thermal Test Procedures

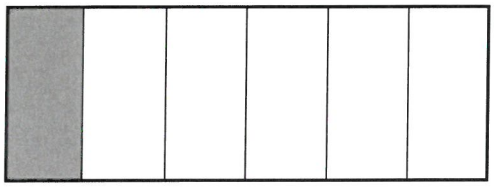
Testing was conducted using twelve 60 mL bottles as a placebo product. The bottles formed two layers in the 2-153985B payload area. All placebo products contained deionized water. The bottle that was data logged for all tests is indicated in gray in the top view of the top layer illustrated in Figure 1. For many tests, a second bottle located on the outside of the bottom layer was also logged

**Figure 1. 2-153985B horizontal 60 mL bottle configuration**

- Top Layer



- Bottom Layer



Prepare for testing:

- Precondition the 60 mL bottles at 3-5°C for 24 hours
- Prepare TIS (test information sheets), assign logger and chamber
- Prepare NanoCool shipping systems according to TIS sheet
- Obtain appropriate coolers for testing
- Assign coolers to boxes, documenting cooler numbers and box numbers on TIS

When coolers, boxes, products and chambers are prepared, start hook-up procedures.

## Hook-Up Procedure

- Open box and remove cooler
- Place cooler upside down, dome up, and activate
- Obtain twelve 60 mL bottles with one or two of them probed with the thermocouple assigned on the TIS
- Place bottles in the payload cavity
- Place cooler onto the box
- Close outer box

- Place systems in the chamber
- Ensure that boxes are not touching
- Close chamber
- Turn on logger
- Turn on chamber with correct testing profile

## Downloading and Autopsy Procedure

- Download loggers according to download procedures
- Graph experiments according to graphing procedures and information on the test information sheet
- Analyze data to determine minimum and maximum temperatures over 96 hours
- The chamber and loggers used for each test are shown in the Table 1

Table 1. Chamber and logger identification.

| Run Number | Profile | Chamber | Logger |
|---|---|---|---|
| WFB2010-#73 | 96 HR ISTA Summer | ZP0453561 | EL-8175 |
| WFB2010-#75 | 96 HR ISTA Winter | ZP0453562 | EL-8110 |
| WFB2010-#89 | ISC Silver Summer | ZP0453561 | EL-7516 |
| WFB2010-#91 | ISC Silver Winter | ZP0453562 | EL-8175 |
| WFB2010-#103 | ISC Gold Summer | ZP0453561 | EL-8175 |
| WFB2010-#101 | ISC Gold Winter | ZP0453562 | EL-7516 |
| WFB2010-#112 | EU Summer High | ZP0553773 | EL-8110 |
| WFB2010-#119 | EU Summer Low | ZP0553773 | EL-8173 |
| WFB2010-#117 | EU Winter High | ZP0453562 | EL-7516 |
| WFB2010-#121 | EU Winter Low | ZP0453562 | EL-8173 |

## Drop Test Procedures

The purpose of this test is to evaluate the durability of the 2-153985B NanoCool shipping system. Three 2-153985B NanoCool shipping systems were drop tested against the ISTA-3A protocol (see Table 2) with the addition of two 60" face one drops during the procedure. The two 60" drops on face one test the integrity of the NanoCool shipping system's engine. After the completion of the ISTA test sequence, the NanoCool shipping system is opened and inspected to see if it passes the acceptance criteria (see page 6). If the system passes the acceptance criteria guidelines the units are inspected again after twenty-four hours.

**Table 2: Drop Sequence**

| Modified ISTA-3A Drop Sequence | | |
|---|---|---|
| **Drop #** | **Drop Height (in)** | **Orientation** |
| **1** | 18" | Edge 3-4 |
| **2** | 18" | Edge 3-6 |
| **3** | 18" | Edge 4-6 |
| **4** | 18" | Corner 3-4-6 |
| **5** | 18" | Corner 2-3-5 |
| **6** | 18" | Edge 2-3 |
| **7** | 18" | Edge 1-2 |
| **8** | 36" | Face 3 |
| **9** | 18" | Face 3 |
| **10** | 60" | Face 1 on Hazard |
| **11** | 18" | Edge 3-4 |
| **12** | 18" | Edge 3-6 |
| **13** | 18" | Edge 1-5 |
| **14** | 18" | Corner 3-4-6 |
| **15** | 18" | Corner 1-2-6 |
| **16** | 18" | Corner 1-4-5 |
| **17** | 36" | Face 1 |
| **18** | 60" | Face 1 |

## Set-up

Each unit will be assembled in the following manner prior to the initiation of ISTA-3A.

- Obtain correct systems
- Ensure package component integrity prior to testing
- Remove cooler and activate if specified
- Replace cooler engine
- Close NanoCool shipping unit
- Using packing-style adhesive tape, seal the shipping units in the manner indicated by the shipping unit graphics, sealing face 2 to face 5, face 2 to face 6, and face 2 to face 3
- Number outer shipping box according to ISTA-3A drop testing procedures
- Establish 18", 36" and 60" drop testing height

## Inspection and Acceptance Criteria

Visually inspect the NanoCool shipping systems for the following:

- Rips in the corrugate shipping case material
- Adhesion of the foam pad to the inside of Face 1
- Cooler engine integrity
  - Burst bladder
  - Loss of vacuum
- Integrity of the vacuum insulation panel (VIP)
  - Loss of vacuum
  - Structure maintained

Failure: loss of cooler or VIP integrity as listed above.
Document all other observations related to above criteria.

# Summary of Results

## ISTA-7D 96 Hour Summer Profile

Test WFB2010-#73 tested three 2-153985B NanoCool shipping systems against the modified ISTA-7D summer 96 hour profile (Figure 2). Two layers of 60 mL bottles, each layer with 6 bottles, were used as a placebo product. The product temperature stayed within a range of 2 and 8° for between 103 and 108 hours.

Figure 2: ISTA-7D Summer

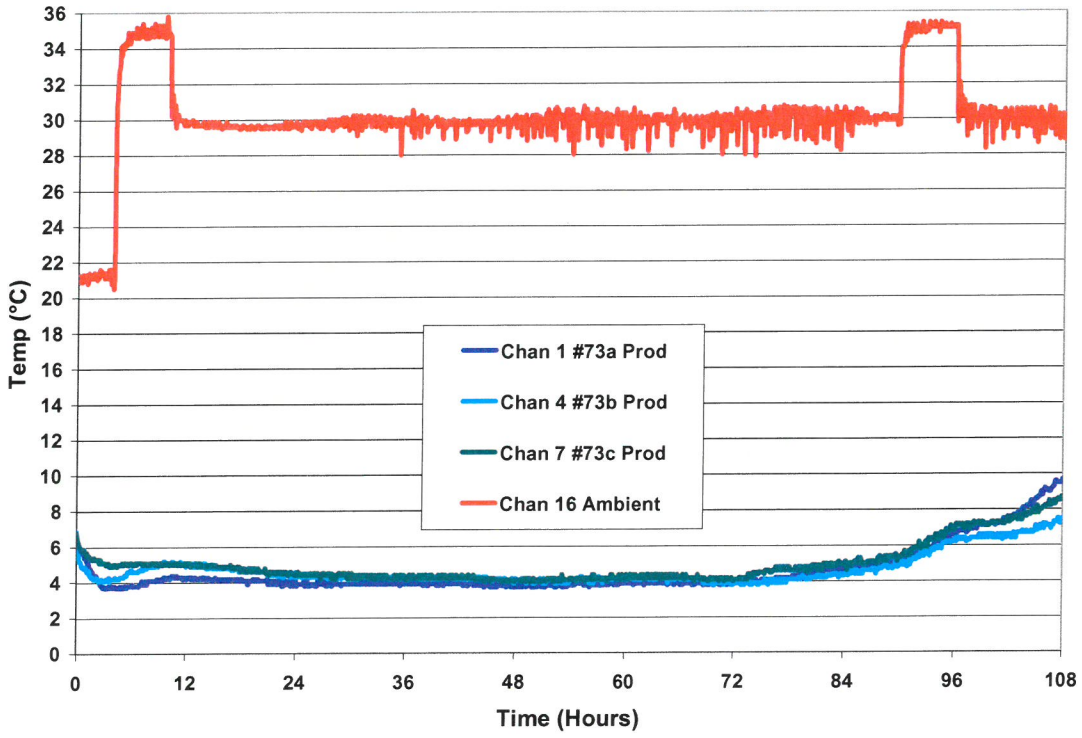



**Table 3. Minimum and maximum temperature for the first 96 hours of test**

| | 73a | 73b | 73c |
|---|---|---|---|
| **Minimum Temperature** | 3.7 | 3.8 | 4.0 |
| **Maximum Temperature** | 6.6 | 6.2 | 7.1 |

## ISTA-7D 96 Hour Winter Profile

Test WFB2010-#75 tested three 2-153985B NanoCool shipping systems against the ISTA-7D winter 96 hour profile (see Figure 3). Twelve 60 mL bottles were used as a placebo product. All three systems performed identically and maintained product temperatures between 2-8°C for approximately 92 hours of the test.

Figure 3. ISTA-7D Winter profile

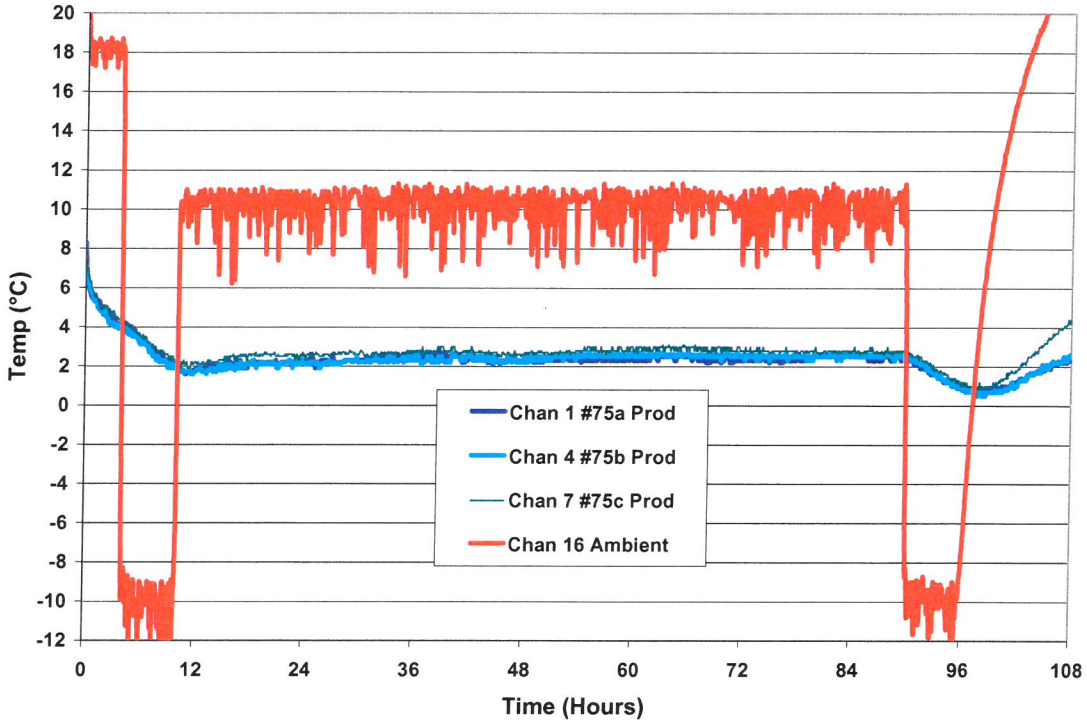



**Table 4. Minimum and maximum temperature for the first 96 hours of test**

| | 75a | 75b | 75c |
|---|---|---|---|
| **Minimum Temperature** | 0.9 | 0.9 | 1.0 |
| **Maximum Temperature** | 6.3 | 6.6 | 6.7 |

## ISC Silver Summer Profile

Test WFB2010-#89 tested three 2-153985B NanoCool shipping systems against the ISC Silver Summer profile which was repeated for the 168 hours of the test (see Figure 4). Two layers of six 60 mL bottles were used as a placebo product. Two bottle locations, which should have the largest spread of temperature, were logged for each system. All three systems performed identically and maintained product temperatures between 2-8°C for approximately 109 and 119 hours.

Figure 4. ISC Silver Summer Profile

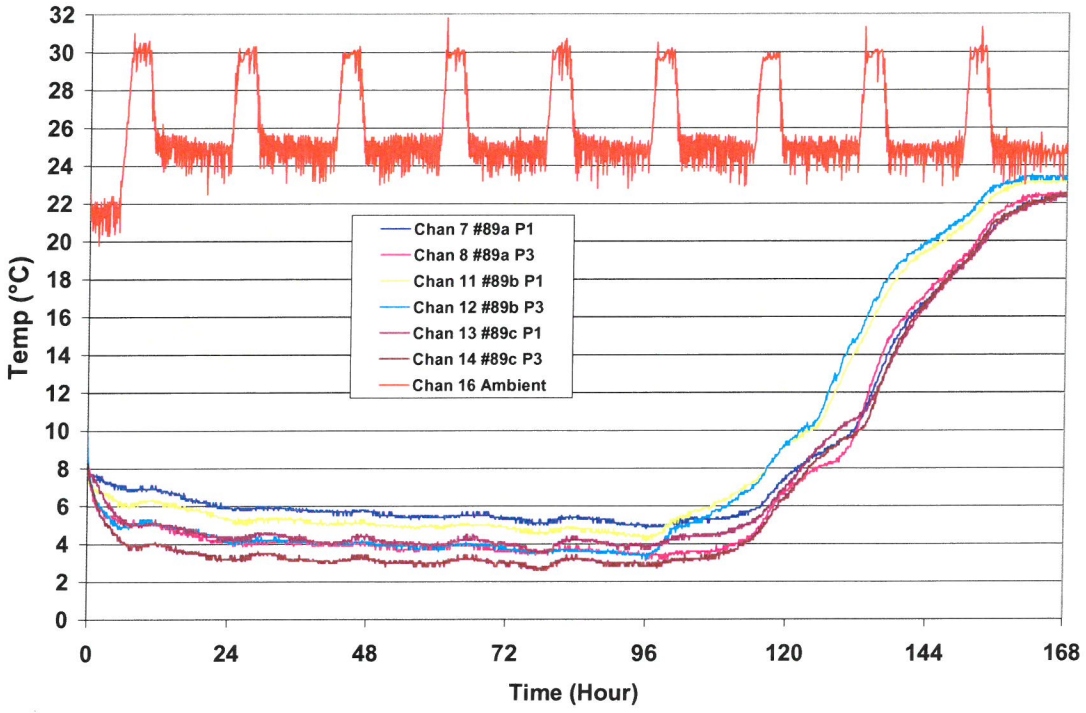



**Table 5. Minimum and maximum temperature for the first 96 hours of test**

| | 89a P1 | 89a P3 | 89b P1 | 89b P3 | 89c P1 | 89c P3 |
|---|---|---|---|---|---|---|
| **Minimum Temperature** | 4.8 | 3.1 | 4.1 | 3.2 | 3.5 | 2.6 |
| **Maximum Temperature** | 7.8 | 8.2 | 7.6 | 8.2 | 7.8 | 7.7 |

## ISC Silver Winter Profile

Test WFB2010-#91 tested three 2-153985B NanoCool shipping systems against the ISC Silver Winter profile which was repeated for the 168 hours of the test (see Figure 5). All three systems performed identically and maintained product temperatures between 2-8°C for approximately 163 hours of the test.

Figure 5. ISC Silver Winter Profile

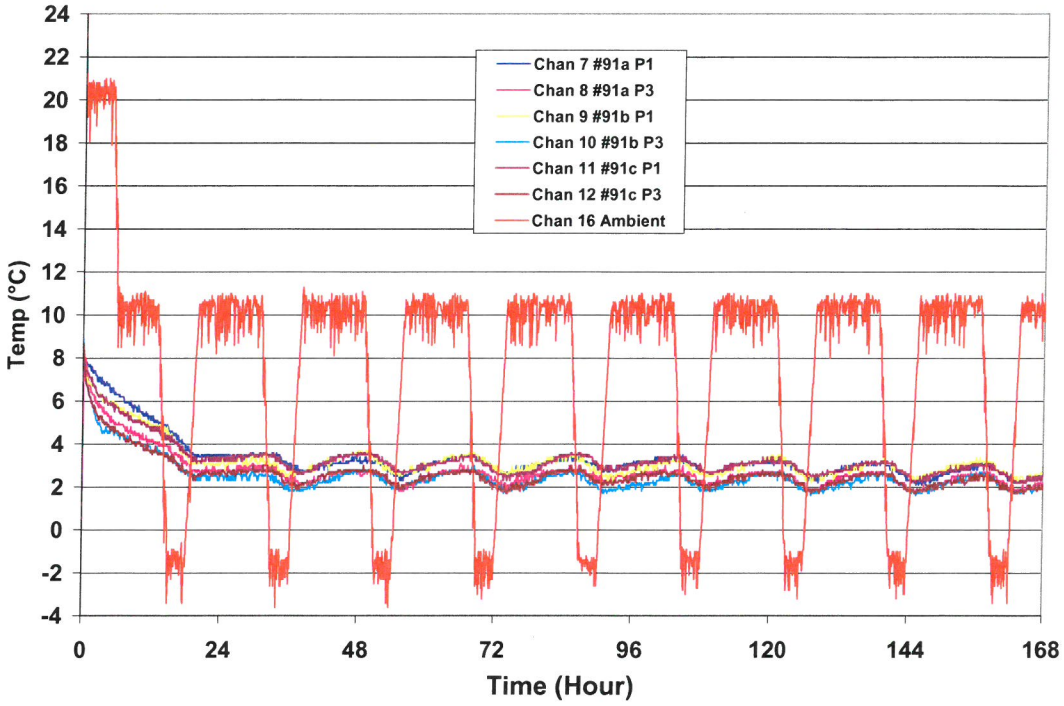



**Table 6. Minimum and maximum temperature for the first 96 hours of test**

| | 91a P1 | 91a P3 | 91b P1 | 91b P3 | 91c P1 | 91c P3 |
|---|---|---|---|---|---|---|
| **Minimum Temperature** | 2.3 | 2.5 | 2.3 | 2.8 | 2.6 | 2.7 |
| **Maximum Temperature** | 6.7 | 5.5 | 5.9 | 6.3 | 7.4 | 6.3 |

## ISC Gold Summer Profile

Test WFB2010-#103 tested three 2-153985B NanoCool shipping systems against the ISC Gold Summer profile which was repeated for the 168 hours of the test (see Figure 6). Two layers of 60 mL bottles were used as a placebo product. Two bottle locations, which should have the largest spread of temperature, were logged for each system. Against the extreme continued warmth of this profile (average temperature is 33°C), these NanoCool systems maintain 2-8°C for approximately 83 to 97 hours.

**Figure 6. ISC Gold Summer Profile**

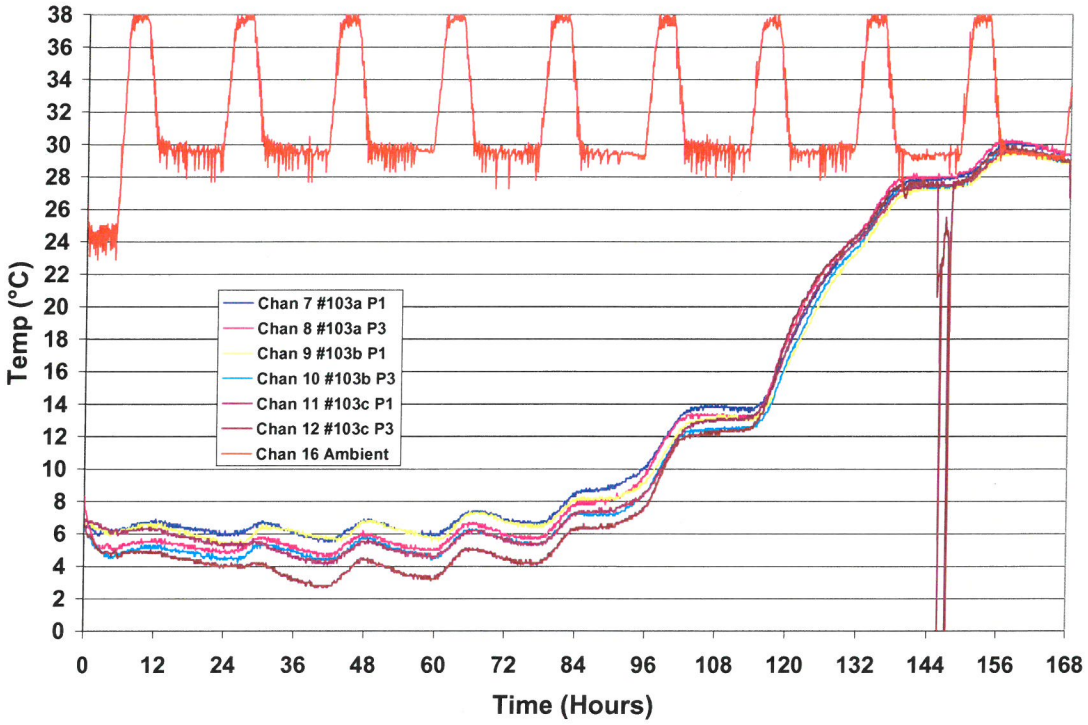



**Table 7. Minimum and maximum temperature for the first 96 hours of test**

| | 103a P1 | 103a P3 | 103b P1 | 103b P3 | 103c P1 | 103c P3 |
|---|---|---|---|---|---|---|
| **Minimum Temperature** | 5.5 | 4.5 | 5.3 | 4.2 | 4.1 | 2.7 |
| **Maximum Temperature** | 10.2 | 9.9 | 9.4 | 8.6 | 8.6 | 7.7 |

## ISC Gold Winter Profile

Test WFB2010-#101 tested three 2-153985B NanoCool shipping systems against the ISC Gold Winter profile which was repeated for the 168 hours of the test (see Figure 7). Two layers of 60 mL bottles (12 in total) were used as a placebo product. Two bottles, locations which should have the largest spread of temperature, were logged for each system. Against the extreme continued cold of this profile (average temperature is ~0 °C) these particular NanoCool systems can only stay above 2 °C for approximately 48 hours. In addition, for some systems, the water in the NanoCool system freezes which retards its' cooling which causes a minor warm deviation for one system.

Figure 7. ISC Gold Winter Profile

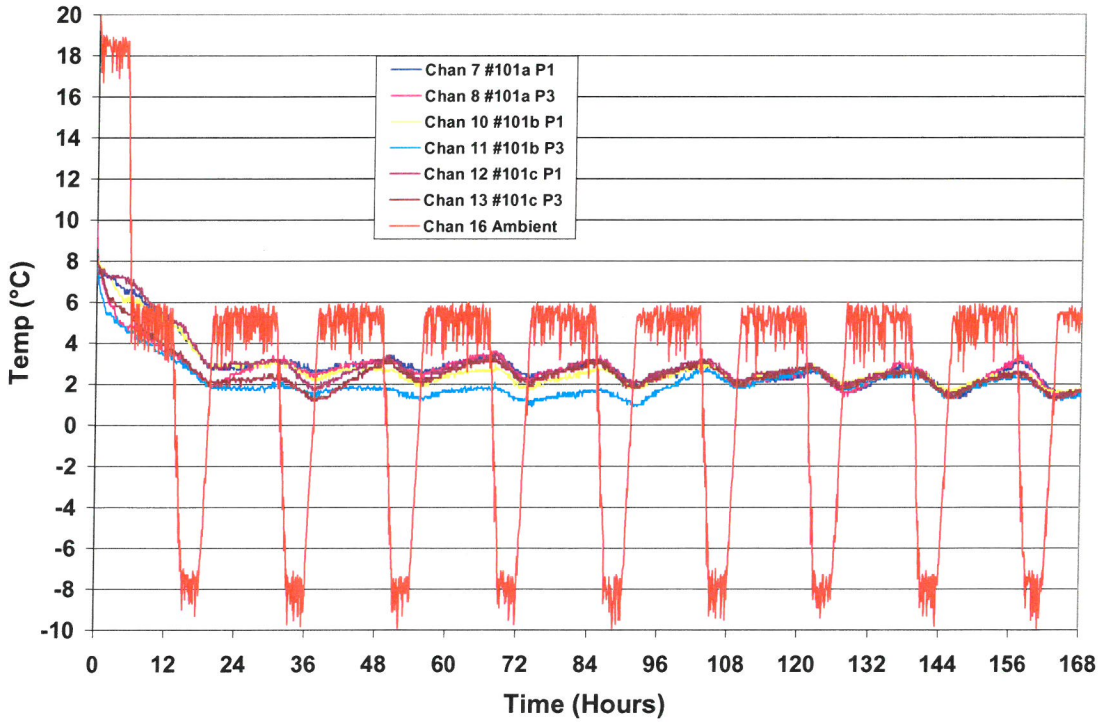



**Table 8. Minimum and maximum temperature for the first 96 hours of test**

| | 101a P1 | 101a P3 | 101b P1 | 101b P3 | 101c P1 | 101c P3 |
|---|---|---|---|---|---|---|
| **Minimum Temperature** | 1.8 | 1.7 | 1.7 | 0.9 | 1.7 | 1.2 |
| **Maximum Temperature** | 7.4 | 8.2 | 8.0 | 7.4 | 7.6 | 7.8 |

## EU Summer High Profile

Test WFB2010-#112 tested three 2-153985B NanoCool shipping systems against the EU summer high profile which was repeated for the 168 hours of the test (see Figure 8). Two layers of 60 mL bottles were used as a placebo product. Two bottle locations, which should have the largest spread of temperature, were logged for each system. Despite this being the EU summer high profile, product stayed in the range of 2 to 8 °C for between 165 and 167 hours.

Figure 8. EU Summer High Profile

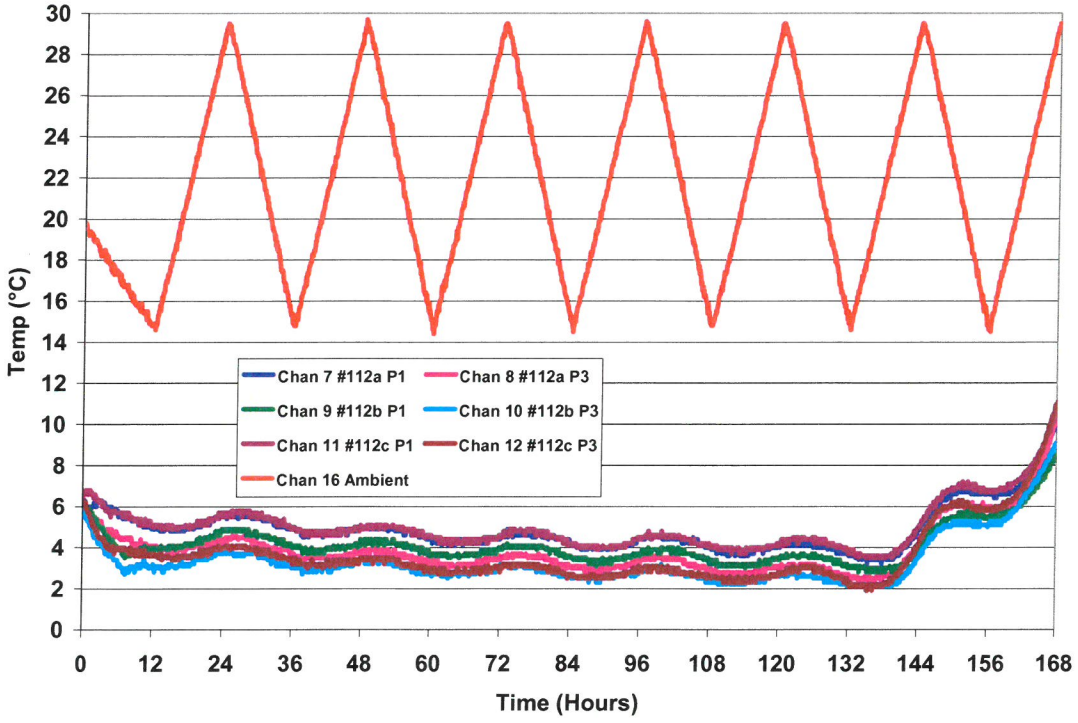



**Table 9. Minimum and maximum temperature for the first 96 hours of test**

| | 112a P1 | 112a P3 | 112b P1 | 112b P3 | 112c P1 | 112c P3 |
|---|---|---|---|---|---|---|
| **Minimum Temperature** | 3.9 | 2.8 | 3.1 | 2.3 | 3.9 | 2.5 |
| **Maximum Temperature** | 6.3 | 6.2 | 6.0 | 5.8 | 6.8 | 6.2 |

## EU Summer Low Profile

Test WFB2010-#119 tested three 2-153985B NanoCool shipping systems against the EU summer low profile which was repeated for the 168 hours of the test (see Figure 9). Two layers of 60 mL bottles were used as a placebo product. Two bottle locations, which should have the largest spread of temperature, were logged for each system. Most product temperatures stayed in the range of 2 to 8 °C for the entire 168 hours of the test.

Figure 9. EU Summer Low Profile

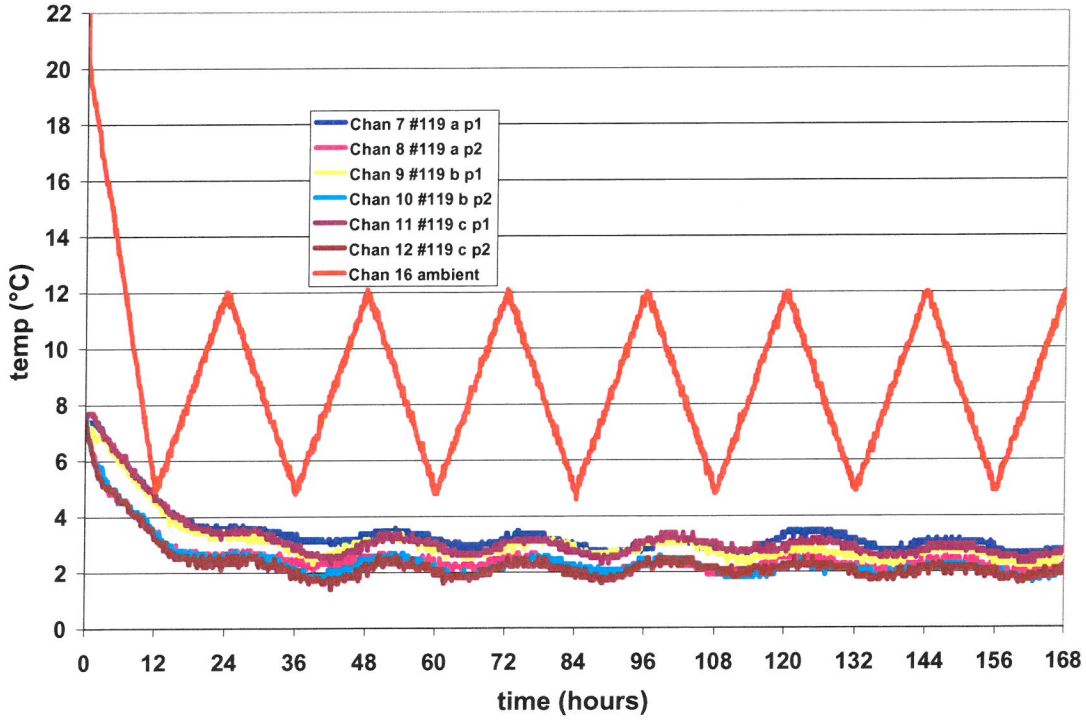



**Table 10. Minimum and maximum temperature for the first 96 hours of test**

| | 119a P1 | 119a P3 | 119b P1 | 119b P3 | 119c P1 | 119c P3 |
|---|---|---|---|---|---|---|
| **Minimum Temperature** | 2.6 | 1.7 | 2.3 | 1.7 | 2.7 | 1.4 |
| **Maximum Temperature** | 7.4 | 7.6 | 7.4 | 7.6 | 7.7 | 7.2 |

## EU Winter High Profile

Test WFB2010-#117 tested three 2-153985B NanoCool shipping systems against the EU winter high profile which was repeated for the 168 hours of the test (see Figure 10). Two layers of 60 mL bottles were used as a placebo product. Two bottle locations, which should have the largest spread of temperature, were logged for each system. The product stayed in the range of 2 to 8 °C for the entire 168 hours of the test.

Figure 10. EU Winter High Profile

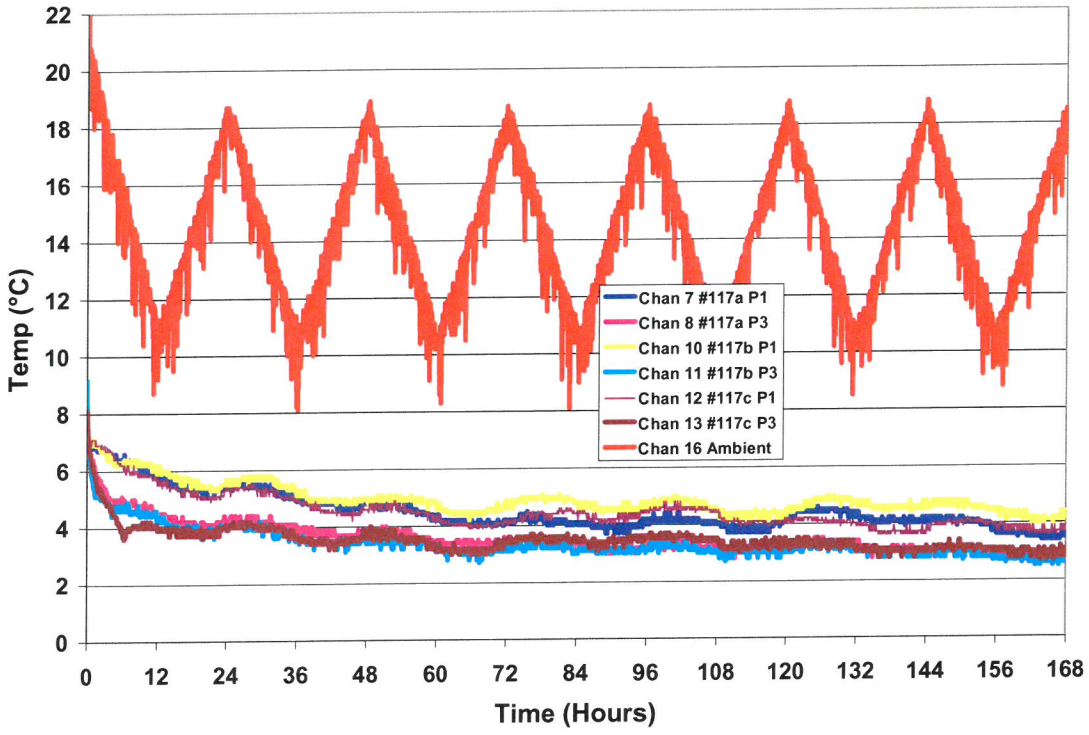



**Table 11. Minimum and maximum temperature for the first 96 hours of test**

| | 117a P1 | 117a P3 | 117b P1 | 117b P3 | 117c P1 | 117c P3 |
|---|---|---|---|---|---|---|
| **Minimum Temperature** | 3.7 | 3.0 | 4.2 | 2.7 | 3.9 | 3.0 |
| **Maximum Temperature** | 7.1 | 8.0 | 7.1 | 6.9 | 7.1 | 7.2 |

## EU Winter Low Profile

Test WFB2010-#121 tested three 2-153985B NanoCool shipping systems against the EU winter low profile which was repeated for the 168 hours of the test (see Figure 11). Two layers of 60 mL bottles were used as a placebo product. Two bottle locations, which should have the largest spread of temperature, were logged for each system. The product stayed in the range of 1 to 8 °C for the full 168 hours of the test.

Figure 11. EU Winter Low Profile

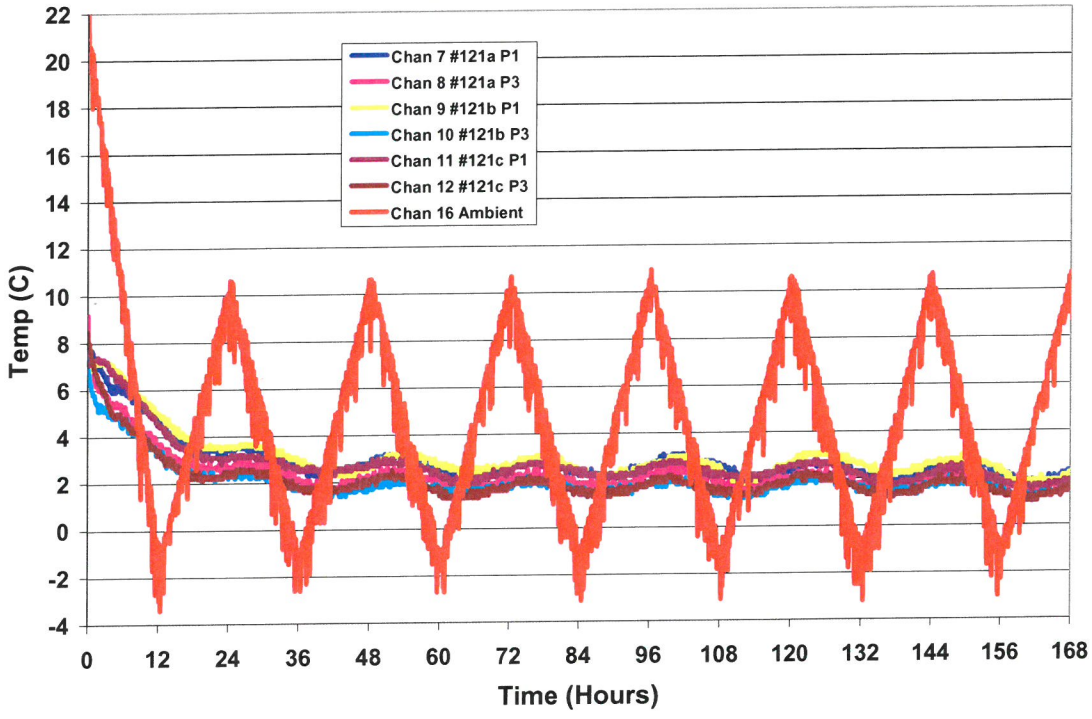



**Table 12. Minimum and maximum temperature for the first 96 hours of test**

| | 121a P1 | 121a P3 | 121b P1 | 121b P3 | 121c P1 | 1121c P3 |
|---|---|---|---|---|---|---|
| **Minimum Temperature** | 2.1 | 1.6 | 2.1 | 1.3 | 1.9 | 1.2 |
| **Maximum Temperature** | 7.7 | 7.3 | 7.2 | 6.7 | 7.4 | 8.0 |

### ISTA-3A Drop Test

Three 2-153985B NanoCool shipping systems were tested against a modified ISTA-3A drop sequence (Table 2). All of the systems passed when checked against the acceptance criteria outlined on page 6 of this report. The NanoCool cooler engines maintained vacuum and cooling properties. The insulation for all three systems maintained vacuum and there was no significant damage to the vacuum insulation panels.

## Conclusion

These tests have shown that this 2-153985B system maintains 2 to 8°C product temperature for a minimum of 96 hours for a wide range of ambient temperature profiles representing transit temperatures for a wide range of global temperature profiles. For several ambient profiles, the product temperatures remained within 2 and 8 °C for the full 168 hours of the test. Drop testing against the modified ISTA-3A drop sequence shows that the 2-153985B passed without any significant damage. These results are reported in good faith and the customer should use their judgment as to whether the system is appropriate for their application.

## Final QMOC/Protocol Approval

The signatures listed below indicate that these representatives have reviewed this document and approve of the QMOC/Protocol activities and data documented herein. When all approval signatures have been obtained, the QMOC/Protocol is considered complete.

**Approved By**

Signature: _____ Date: 4/27/16
**Product Development/Tech Services**

Signature: _____ Date: 4/27/16
**Operations**

Signature: _____ Date: 04/28/16
**Quality**

Signature: See e-mail WW 4/24/16 Date: 4/27/16
**Sales**

## Environmental Test Chamber Register

| Description | Dimensions | Model # | Serial # | Calibrated | Manufacturer | Range |
|---|---|---|---|---|---|---|
| Test Chamber #2, Everette | 38" x 38" x 38" | Z-Plus 32 | ZPO453561 | Annually | Cincinnati Sub-Zero | -20 °C to +50 °C |
| Test Chamber #3, Gordon | 38" x 38" x 38" | Z-Plus 32 | ZPO453562 | Annually | Cincinnati Sub-Zero | -20 °C to +50 °C |
| Test Chamber #5, Sammi | 30" x 30" x 30" | Z-Plus 16 | ZP0553773 | Annually | Cincinnati Sub-Zero | -20 °C to +50 °C |
| Register approved | Wendy White<br>Name ..... | | | November 2011<br>Date ..... | | |

## Data Logger Register

| Description | Note | Model # | Serial # | Calibrated | Manufacturer | Range |
|---|---|---|---|---|---|---|
| Data Logger Oscar | 16 temp. channels, 1 pulse channel, 1 event channel | 1035J | EL-7516 | Annually | Eltek Instruments | -200 °C to +200 °C |
| Data Logger T-Boy | 16 temp. channels, 1 pulse channel, 1 event channel | 1035J | EL-8110 | Annually | Eltek Instruments | -200 °C to +200 °C |
| Data Logger Rene | 16 temp. channels, 1 pulse channel, 1 event channel | 1035 | EL-8173 | Annually | Eltek Instruments | -200 °C to +200 °C |
| Data Logger Bubba | 16 temp. channels, 1 pulse channel, 1 event channel | 1035 | EL-8175 | Annually | Eltek Instruments | -200 °C to +200 °C |
| Register approved | Wendy White<br>Name ..... | | | February 2012<br>Date ..... | | |