Thermal mannequin testing of Arctic clothing ensembles

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SUMMARY

This report summarizes the findings of the thermal mannequin testing done at the National Research Council – Institute for Ocean Technology as a continuation of the work performed in 2009 by the CORD Group Limited. The test period was done in two parts, one that included no-wind and wind conditions, and the second part was comprised of immersion tests. These were done for eight different ensembles. The tests found that wind and immersions separately caused decreases in clothing insulation values. These findings will be useful for search and rescue personnel in determining survival times for those in arctic emergency situations.

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TR-2012-02

Stephanie Power-MacDonald, John Monk, Jonathan Power,
Peter Hackett, and Lise Petrie

March 2012

ACKNOWLEDGEMENTS

The research team would like to acknowledge the previous work done in this area by the CORD Group Limited. We would also like to acknowledge the hard work and dedication of the staff who made these tests possible at The Institute for Ocean Technology. Finally, this work would not be possible without the financial support of Transport Canada's Search and Rescue New Initiatives Fund (SARNIF).

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GLOSSARY

CLO	Clothing Insulation Value
IOT	Institute for Ocean Technology
NRC	National Research Council
PPE	Personal protective Equipment

1.0 INTRODUCTION

In recent years, air and maritime traffic in the Arctic has increased, especially in Arctic cruise ship tourism (Steward & Draper, 2006). Cruise ships can carry hundreds to thousands of passengers, with some of worlds' largest cruise ships carrying close to six thousand people (Cruise Lines International Association, 2011). With increased traffic, there is a higher probability that a major air or maritime disaster could occur in the Canadian Arctic. If an emergency situation were to occur, it is highly probable that mass rescue capabilities would be required. It is acknowledged that rescue in the Arctic will likely take 5 days or more (IMO, 2006). While the Arctic Marine Shipping Assessment (AMSA) (Protection of the Arctic Marinine Environment Working Group (PAME), 2009) has recommended that countries work together to support and develop the International Maritime Organization's (IMO) Enhanced Contingency Planning Guidance for Passenger Ships operating in Areas Remote from SAR Facilities, the infrastructure is not yet ready to meet the needs of a large scale Arctic maritime disaster (Boileau, Mak, &Kuzora, 2010). This highlights the importance for survivors to be able to rely on their group and personal survival equipment to sustain themselves for days while they await rescue.

It is relatively well known that an approved marine abandonment immersion suit provides the best chance for survival in extremely cold conditions (Hayward, 1984). Although an immersion suit is recommended for every passenger in the IMO Guidelines for Ships Operating in Polar Waters (2010) it is not a mandatory requirement for operators. For this reason we investigated the thermal properties of various ensembles that could be present or made available to persons in a cruise ship abandonment situation in the Arctic.

This study was carried out in two parts, building on the existing work described in the report "Report on the Thermal Evaluation of the SS Maria Project Clothing Ensembles", (CORD, 2010, Appendix A). Part 1 included tests with wetted ensembles in both wind and no wind conditions. Part 2 included tests with ensembles immersed until a steady state was reached. This was done to simulate a variety of situations that could be possible for Arctic emergency situations. The testing took place using the NEMO thermal mannequin at the National Research Council's Institute of Ocean Technology in St. John's NL.

2.0 PROJECT OBJECTIVES

The main objective of the study was to determine the clothing insulation (clo) values of clothing ensembles designed for Arctic cruise populations and major aid relief. Golden and Tipton (2002) define one clo "as the equivalent to the amount of insulation required to keep a subject comfortable in air at a temperature of 21°C, relative humidity of less than 50 percent, and air movement of 0.1 meters per second". (p. 43) Movement of a fluid such as air or water over the surface of the clothing, resulting in increased heat flow due to increased convection (Power & Simoes Ré, 2011) can alter clo value. Other factors include compression of the insulation removing trapped air (Hall & Polte 1956), and water leakage underneath the garment (Ligher et al. 1987; Tipton & Balmi, 1996).

3.0 METHODOLOGY

3.1 Test Program

The test program was divided into two parts, to test three different conditions. Part 1 of the program covered a series of tests in both a zero speed wind condition as well as a 7m/sec wind speed condition for each clothing ensemble. The thermal mannequin was dressed in the required ensemble and then fully immersed to wet the clothing.

Several tests were run to verify that one minute of full immersion was adequate to fully wet the clothing. The verification method used to determine this length of time was to weigh the dressed and wetted mannequin after 10 minutes of immersion and compare it to the weight of the same ensemble after one minute of full immersion. The amount of absorbed water was found to be the same for both the one and 10 minute cases.

A variable speed fan was used to generate the 7m/sec wind field. A Gill Windsonic ultrasonic wind speed sensor was set-up at the location where the mannequin would be tested and the wind speed was verified. This sensor was monitored during the wind fan speed adjustment using the facility's data acquisition system. A data sheet for the wind sensor is provided in Appendix B.

Part 1 covered five ensembles (Table 3.1) and the procedure involved dressing, then wetting the mannequin, through immersing it into water up to the lower lip, in a given ensemble for one minute. The dressed and wetted mannequin was then placed at the test position and allowed to drip dry for two minutes prior to being energized to start the test. The mannequin was then energized and operated in "Constant Temperature" mode with a setpoint of 30°C and the data collection was started. The test was terminated when the setpoint temperature was reached and maintained for at least 30 minutes. The picture in Figure 3.1 shows the experimental set-up. During this series of tests the three ambient sensors were placed as indicated in the picture.

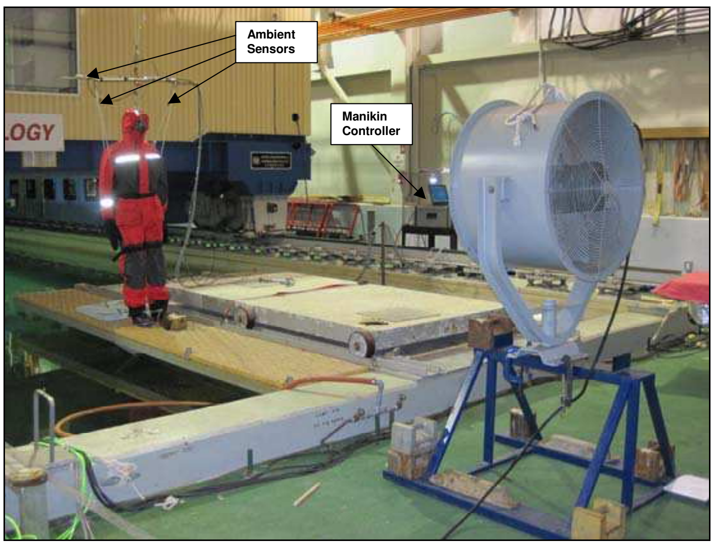

Figure 3.1: Test Set up for Part 1 (Showing fan for wind condition)

Part 2 involved a series of tests that consisted of dressing the thermal mannequin in the required clothing ensemble, energizing and operating it in "Constant Temperature" mode at a setpoint of 30°C, as well as starting data collection for the experiment. The mannequin was then immersed to a few millimeters below his bottom lip. The experiment was terminated when the setpoint temperature was reached and maintained for at least 30 minutes. Figure 3.2 shows the experimental set-up. The ambient sensors were placed as shown by the red arrows (Figure 3.2). One temperature sensor was immersed, while the second was in air.

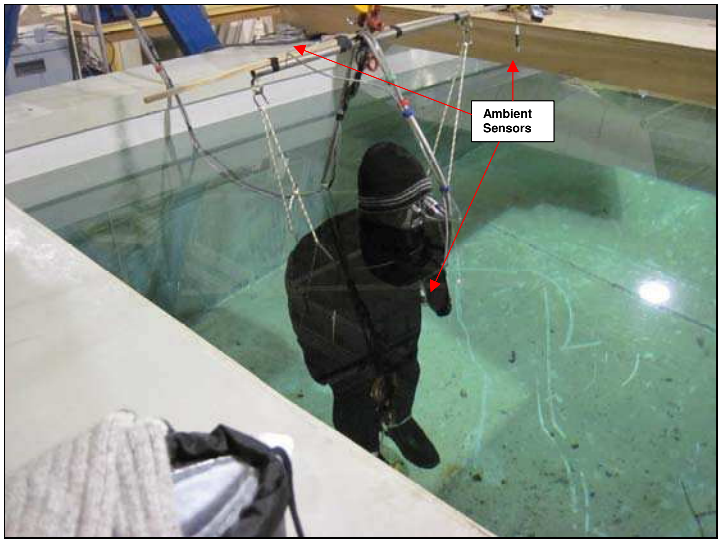

Figure 3.2: Mannequin Immersed in Part 2

3.2 Clothing Ensembles

The clothing ensembles used in Part 1 (Table 3.1) and Part 2 (Table 3.2) are described below. Figures showing the mannequin in each ensemble follow the tables.

Table 3.1: Part 1: Clothing Ensembles

Ensemble	Description
1	Deck Wear (Figure 3.4) Stanfield's long underwear (long sleeve shirt (6623) and Pants (6602)), Denver Hayes JMC 61001 Denim Jeans, Cherokee 100% cotton long sleeve flannel shirt, 90% cotton socks ((% nylon + 1% Lycra Spandex), Denver Hayes 100% cotton boxer shorts, Dakota leather shoes (Style #MDNS308NST), Helly Hansen Soft Pile jacket and pants, Helly Hansen Compass jacket (AJ301) and pants (U310), Wind River toque with fleece lining (Style 47-2694HH), Wind River fleece mittens (Style 71-9-85905).
2	Expedition Wear #2 (Figure 3.6) Deck Wear – except socks replaced with wool socks and Baffin Industrial boots Polar Proven -40 degrees Celsius 5 layer liner (Style ASTM 2413-05), and Helly Hansen Compass jacket and pants replaced with Mustang Survival MS195 Integrity Suit (Size XL).
3	Abandonment Wear #1a (Figure 3.7) Deck Wear plus Helly Hansen P2000 Passenger Suit/Thermal Protective Aid (TPA), SOLAS Life Vest (Lalizas 70169 BV), wool socks, fleece mittens, and deck shoes.

4	Abandonment Wear #1b (Figure 3.8) Deck Wear plus Mustang Survival Coverall (Once Only Suit – Anti-exposure Model MSD685), SOLAS Life Vest (Lalizas 70169 BV), wool socks.
5	Abandonment Wear #2 (Figure 3.9) Deck Wear with wool socks minus footwear plus Mustang SOLAS Immersion Suit, SOLAS Life Vest (Lalizas 70169 BV), fleece mittens, and wool socks.

Table 3.2: Part 2: Clothing Ensembles

Ensemble	Description
1	Cabin Wear (Figure 3.3) Denver Hayes JMC 61001 Denim Jeans, Cherokee 100% cotton long sleeve flannel shirt, 90% cotton socks ((% nylon + 1% Lycra Spandex), Denver Hayes 100% cotton boxer shorts, Dakota leather shoes (Style #MDNS308NST).
2	Deck Wear Cabin Wear plus Stanfield's long underwear (long sleeve shirt (6623) and Pants (6602)), Helly Hansen Soft Pile jacket and pants, Helly Hansen Compass jacket (AJ301) and pants (U310), Wind River toque with fleece lining (Style 47-2694HH), Wind River fleece mittens (Style 71-9-85905).
3	Expedition Wear # 1 (Figure 3.5) Deck Wear except wool socks and Baffin Industrial boots ASTM 2413-05 Polar Proven -40˚C with five layer liner
4	Expedition Wear #2 Expedition Wear #1 except Helly Hansen Compass Jacket and pants replaced by Mustang Survival MS195 HX Integrity Suit (XL), and fleece mittens.
5	Abandonment Wear #1a Deck Wear plus Helly Hansen P2000 Passenger Suit/Thermal Protective Aid (TPA), SOLAS Life Vest (Lalizas 70169 BV), wool socks, and deck shoes.
6	Abandonment Wear #1b Deck Wear plus Mustang Survival Coverall (Once Only Suit – Anti-exposure Model MSD685), SOLAS Life Vest (Lalizas 70169 BV), wool socks, fleece gloves, and deck shoes.
7	Abandonment Wear #2 Deck Wear with wool socks minus footwear plus Mustang SOLAS Immersion Suit, SOLAS Life Vest (Lalizas 70169 BV), fleece mittens, and wool socks.

8	Major Aid (MAJAID) #1 (Figure 3.10) Cabin wear without Dakota Shoes, Parka, Pants, Mittens, toque, boots

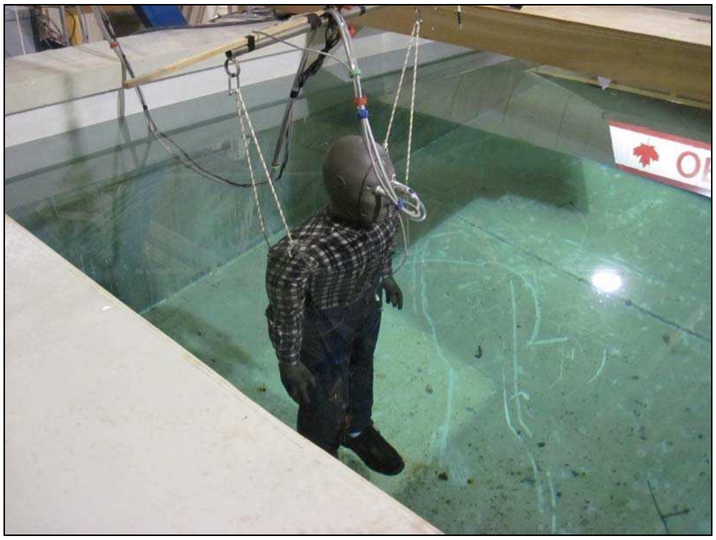

Figure 3.3: Cabin Wear

Figure 3.4: Deck Wear

Figure 3.5: Expedition Wear #1

Figure 3.6: Expedition Wear #2

Figure 3.7: Abandonment Wear #1a

Figure 3.8: Abandonment Wear #1b

Figure 3.9: Abandonment Wear #2

Figure 3.10: Major Aid Wear

4.0 DATA ACQUISITION

The following description and figures are from Mak et al. (2010). A Measurement Technology Northwest (Seattle, Washington, USA) NEMO 23-zone submersible thermal mannequin was used in this study (Figure 4.1). Its stature represents a 50th percentile adult North American male, weighting 71 kg. The mannequin shell is made of aluminum.

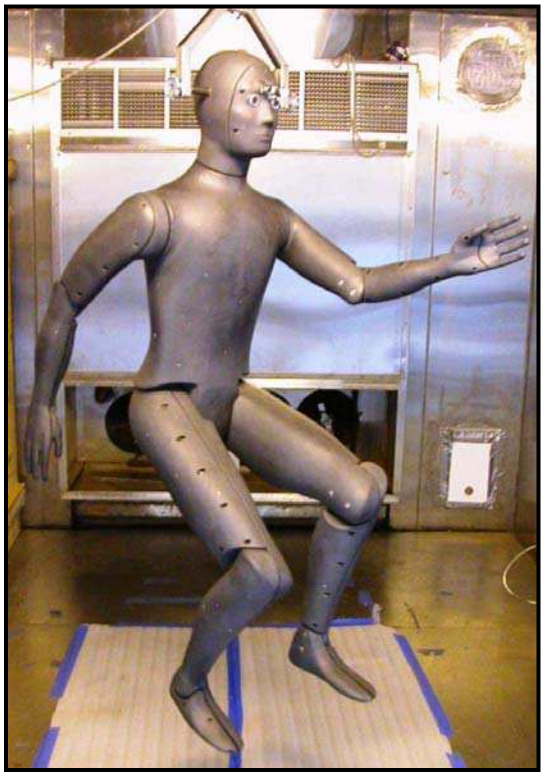

Figure 4.1: NEMO 23-zone submersible thermal mannequin

The 23 independently heated thermal zones are shown in Figure 4.2. Each thermal zone is equipped with heaters to generate uniform heating of the aluminum shell and two precision thermistors to measure skin temperature.

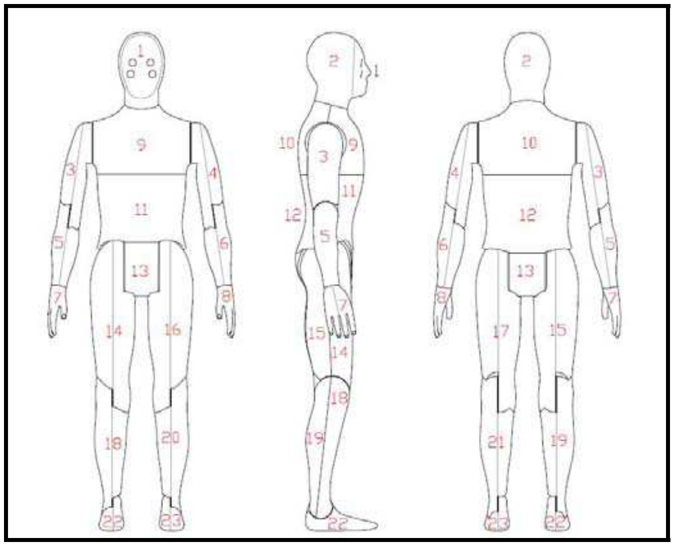

Figure 4.2: NEMO submersible thermal mannequin zones

The main components of the thermal mannequin are shown in Figure 4.3 and include:

- Thermal mannequin with heaters, sensors and internal controllers for regulation and monitoring
- Power supply enclosure which includes the heater power supply, ground isolation meter, serial data converter module, master zone controller, and an air pressure regulator.
- Ambient sensors (2 temperature, 1 relative humidity and 1 wind speed)
- Interconnect cabling and air pressure supply hose
- Laptop with ThermDAC control software.

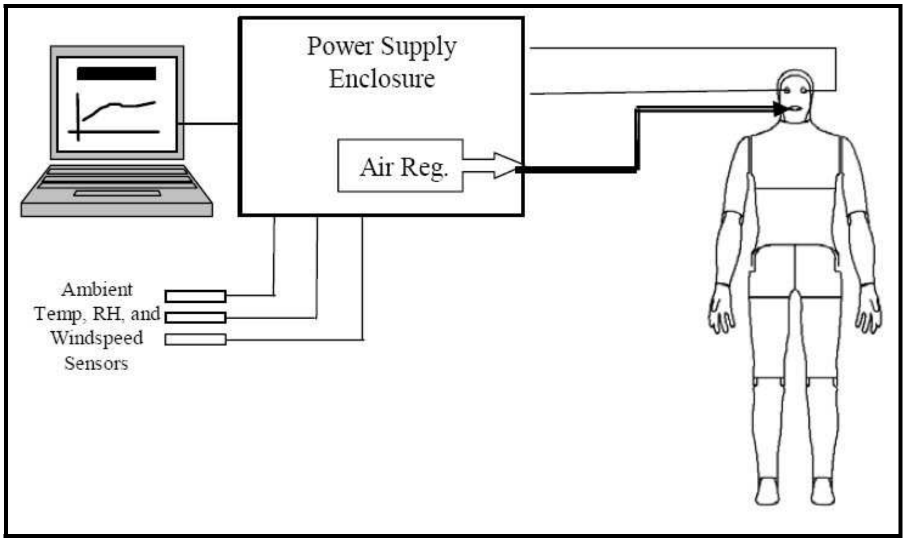

Figure 4.3: NEMO Thermal Mannequin Block Diagram

The NEMO thermal mannequin operates on 60Hz AC electrical power, 200-250 VAC with a maximum current of 20 Amps. The ThermDAC control software is a 32-bit Windows based program that controls, records and displays real-time zone information numerically and graphically. Each thermal zone is individually controlled using either a temperature control, constant heat flux or comfort equation output. ThermDAC is a fully automated data acquisition and control program. It has two independent methods of data logging. Full Data logging provides a complete data set of the entire run, at user selectable intervals. Steady State logging will write steady state average values to the file once the system has stabilized. These logging methods can be used individually or together. ThermDAC also includes an automatic steady state detection, which can initiate data logging. For an in-depth explanation of the calibration process for the mannequin, please see Mak et al. (2010). Sections 1.0 and 2.0 of the Submersible Thermal Mannequin Operator’s Manual (Appendix C) contains detailed information regarding the thermal mannequin set-up, testing, and data analysis procedures.

5.0 ANALYSIS

Tests generate comma delimited (*.CSV) data files suitable for direct importing into Excel or any other Windows compatible spreadsheet program. The data file contains a header with the data file name, test date, comments entered at test start, set point, and logging interval. The data consists of a time stamp, followed by, in order, all zone temperatures, all zone heat fluxes, area weighted average temperature, area weighted heat flux, area weighted thermal resistance, ambient temperature, and relative humidity.

The windows based program IGOR (Wave Metrics, Portland, Oregon) was used for data reduction. Clo value was calculated by the following equation from Romet et al. (1991). which uses the temperature gradient between the objectand the water, and the mean heat flow.

$$\boxed{\text{Insulation (clo)} = [T_{SK} – T_W/MHF] / 0.155}$$

T_{SK} = Mean skin temperature of the mannequin (°C)

T_W= Water temperature (°C)

MHF = Mean heat flow from the mannequin ($W·m^{-2}$)

The variables were collected from measures from the 23 segments of Nemo to give a weighted average of mean skin temperature and heat flow. Once the mannequin reached steady state the tests were terminated.

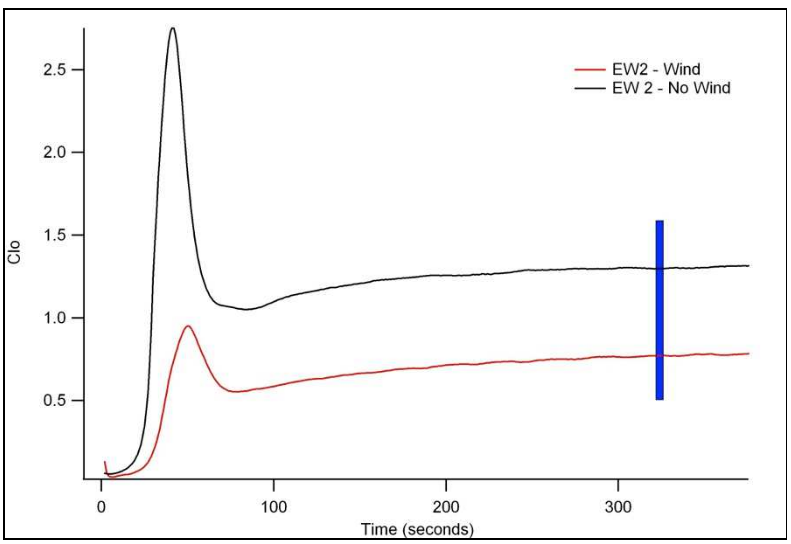

Figure 5.1: Example of steady state (blue bar) for Expedition Wear #2 (Part 1)

6.0 RESULTS

The clo values for Part 1 are presented in Table 6.1. These tests were done with Nemo attached to a crane, lowered into the tank and wetted for one minute, then taken out to hang until steady state was reached.

Table 6.1: Part 1 Conditions and Clo values

Ensemble	Wind	Clo Value
Deck Wear	Yes	0.45
Deck Wear	No	1.0
Expedition Wear #2	Yes	0.78
Expedition Wear #2	No	1.47
Abandonment Wear #1a	Yes	1.22
Abandonment Wear #1a	No	2.04
Abandonment Wear #1b	Yes	0.65
Abandonment Wear #1b	No	1.15
Abandonment Wear #2	Yes	1.15
Abandonment Wear #2	No	1.66

The clo values for Part 2 are presented in Table 6.2. These tests were done with Nemo attached to a crane, lowered into the tank and immersed until steady state was reached.

Table 6.2: Part 2 Clo values

Ensemble	Clo Value
Cabin Wear	0.05
Deck Wear	0.16
Expedition Wear #1	0.17
Expedition Wear #2	0.30
Abandonment Wear #1a	0.17
Abandonment Wear #1b	0.19
Abandonment Wear #2	0.55
Major Aid Wear	0.12

Not all ensembles were tested during Parts 1 &2 , as some were done in a previous experiment (CORD, 2010). The clo values for those data points for Cabin Wear (wind/no wind), Expedition Wear #1 (wind/no wind), and Major Aid Wear (wind/no wind) were extracted (Table 6.3 - highlighted) and displayed with the data points from Part 1 & 2 for comparison (Figure 6.1).

Table 6.3: Clo values from previous work (highlighted), Part 1, and Part 2

Ensemble	Wind	No Wind	Immersed
CW	0.28	0.97	0.05
DW	0.45	1.00	0.16
EW#1	0.68	1.27	0.17
EW#2	0.78	1.47	0.30
AW#1a	1.22	2.04	0.17
AW#1b	0.65	1.15	0.19
AW#2	1.15	1.66	0.55
MAJADW	0.68	1.50	0.12

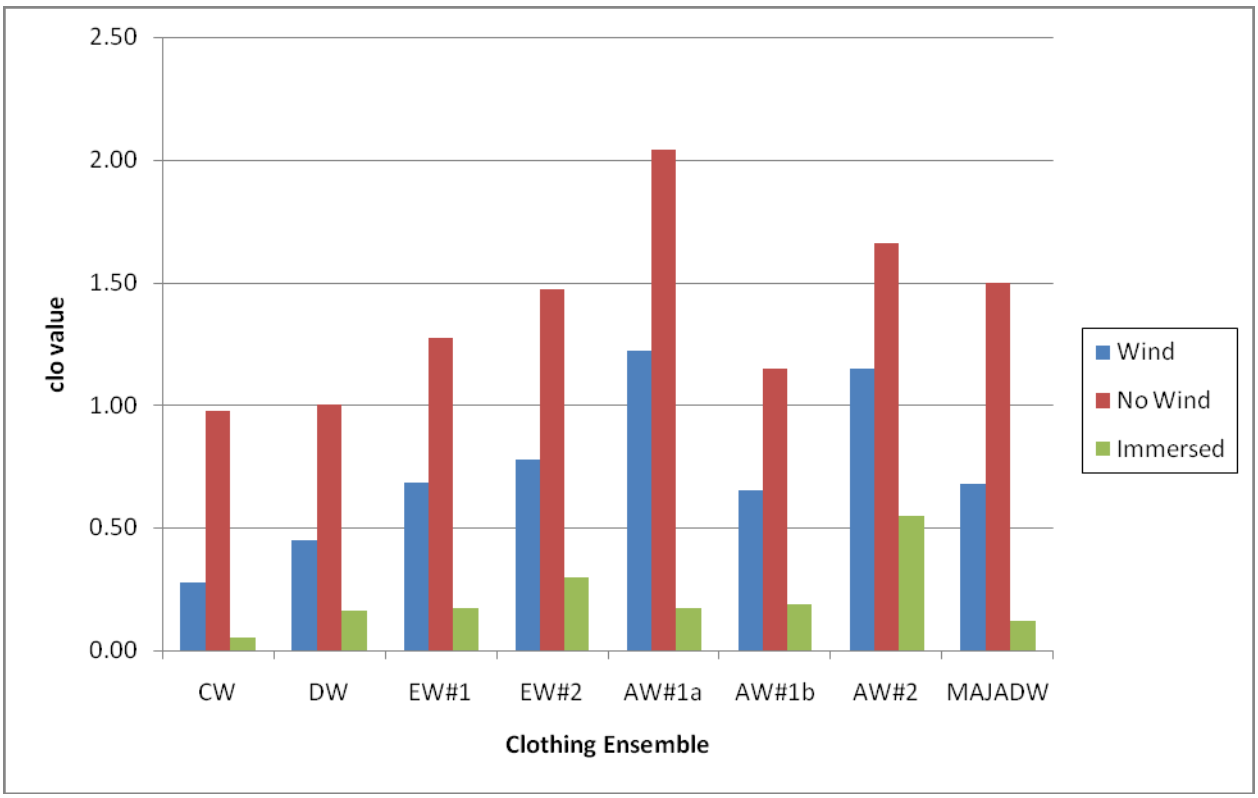

Figure 6.1: Comparison of Clo Values

7.0 CONCLUSION

The findings from this study highlight the fact that as weather and environmental conditions worsen, in terms of wind and immersion, the insulation value of the given clothing ensembles decreases. This information provides insight for Search and Rescue personnel for predicting survival times. A reduction in clo can lead to reduced survival times, as predicted by a thermal model (Keefe &Tikusis, 2008).

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REPORT ON THE THERMAL EVALUATION OF THE SS MARIA PROJECT CLOTHING ENSEMBLES

CONDUCTED BY:
THE CORD GROUP LIMITED
DARTMOUTH, NOVA SCOTIA, CANADA

REPORT PREPARED FOR
LAWRENCE MAK
INSTITUTE FOR OCEAN TECHNOLOGY
ST. JOHN'S, NEWFOUNDLAND
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MARCH 9, 2010

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1.0 INTRODUCTION

The CORD Group Limited was contracted by Institute for Ocean Technology (IOT) to conduct a thermal evaluation on a number of clothing ensembles that could be worn by survivors of a cruise ship abandonment in the Arctic. The clothing ensembles were tested in still air, 7 meters per second (m/s) wind, in dry and wet conditions, and some configurations were tested at -15˚C. These tests were conducted using the Thermal Instrumented Manikin (TIM) in December 2009 and January 2010 at CORD's test facilities in Dartmouth, Nova Scotia, Canada. The tests conducted at -15˚C were conducted at the Composites Atlantic Environmental Simulations Lab in Dartmouth, Nova Scotia, Canada.

2.0 METHOD

2.1 METHODOLOGY:

The thermal evaluation of these clothing configurations was conducted using CORD's Thermal Instrumented Manikin (TIM) Test System. The tests were simultaneously completed using IOT's NEMO immersible thermal manikin. This current report only describes the results from TIM.

2.2 THERMAL MANIKIN TEST SYSTEM:

2.2.1 Introduction:

The Thermal Manikin Test System is a means for evaluating the thermal insulation of thermal protective clothing. In particular, this refers to survival suits for ocean emergencies and, in general, it refers to any human-use apparel. The system consists of a hollow aluminum manikin equipped with temperature sensors and electric heaters connected to a computer system. During the testing, environment temperature, skin temperature and power consumption were recorded.

In operation, the manikin is dressed in the human-use apparel to be tested and placed in an appropriate environment. The computing equipment then controls the heaters to maintain the skin of the manikin at a set temperature and measures the electrical power required to do so. This power is equivalent to the heat that escaped through the clothing due to the temperature difference across it. The power and the temperature difference are then used, along with the known surface area of the manikin to calculate the thermal resistance offered by the apparel.

The system is designed for flexibility and ease of operation. To allow for different types of clothing, different sections of the manikin can be included or eliminated from the test as required.

2.2.2 General Description:

The basic philosophy on which the design is based is that the thermal performance of a garment can be evaluated by unmanned tests on the whole garment under conditions identical or similar to actual operating conditions. This philosophy dictates that the system employs a life-sized watertight manikin capable of being heated to and maintained at a selected temperature.

Figure 1 gives a total view of the system. The visible components are the Thermally Instrumented Manikin (TIM), the control module, the computer, the environmental temperature sensors and the cables connecting these components. Basically, the manikin provides a shape of human proportions to fit inside the test garment. The combinations of the aluminum shell of the manikin and the output of heaters inside it provide for an approximately uniform temperature over the manikin surface. This temperature is sensed by sensors embedded in the manikin’s shell and is then passed to the control module.

The control module houses the programmed data acquisition system, the heater relays and other circuit components. The data acquisition system receives data from the temperature sensors on the manikin and controls the heater relays so that the manikin surface temperature remains constant. It also measures the environment temperature and the power applied to the manikin and is programmed with the surface area of the manikin. With this temperature, power and area data, it calculates the insulation value of the garment and passes this, along with other pertinent data to the computer. The computer acts as a control and display terminal and post-processor.

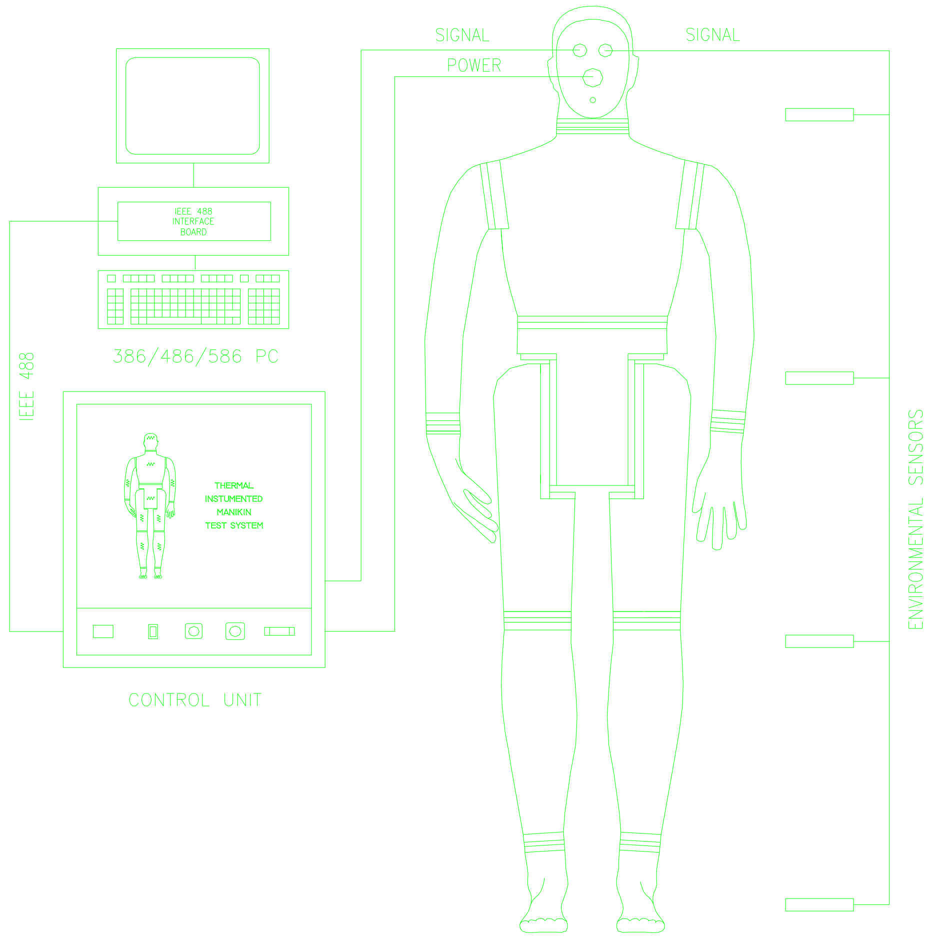

Figure 1 Thermal manikin general setup

2.3 TEST DESCRIPTION:

The following are the clothing configurations used for the testing:

Ensemble	Description
1	<u>Cabin Wear</u> Denver Hayes JMC61001 Denim Jeans, Cherokee 100% cotton long sleeve flannel shirt, 90% cotton socks (9% nylon + 1% Lycra Spandex), Denver Hayes 100% cotton boxer shorts, Dakota Style #MDNS308NST leather shoes
2	<u>Deck Wear</u> Cabin Wear plus Stanfield's long underwear (long sleeve Shirt (6623) and Pants (6602)), Helly Hansen Soft Pile jacket and Pants, Helly Hansen Compass Jacket (AJ301) and Pants (U310), Wind River toque, Style 47-2694HH with fleece lining, Wind River Style 71-9-85905 fleece mittens
3	<u>Expedition Wear #1</u> Deck Wear except wool socks and Baffin Industrial ASTM 2413-05 Polar Proven -40˚C with five layer liner
4	<u>Expedition Wear #2</u> Expedition Wear #1 plus except Helly Hansen Compass Jacket and pants replaced by Mustang Survival MS195 HX Integrity Suit (XL).
5	<u>Abandonment Wear 1a</u> Deck Wear plus Helly Hansen P2000 Passenger Suit /Thermal Protective Aid (TPA), SOLAS Life Vest (Lalizas 70169 BV) (gloves replaced by fleece mittens because TPA has gloves), wool socks
6	<u>Abandonment Wear 1b</u> Deck Wear plus Mustang Survival Coverall (Once Only Suit) Anti-exposure Model MSD685, SOLAS Life Vest (Lalizas 70169 BV) (gloves replaced by fleece mittens because TPA has gloves), wool socks
7	<u>Abandonment Wear 2</u> Deck Wear with wool socks minus footwear plus Mustang SOLAS Immersion suit, SOLAS Life Vest (Lalizas 70169 BV), (gloves replaced by fleece mittens because TPA has gloves), wool socks
8	<u>MAJAID #1</u> Cabin wear without Dakota Shoes Parka, Pants, Mittens, tuque, boots
9	<u>MAJAID #2a</u> MAJAID #1 ensemble inside Down Filled Casualty bag.
10	<u>MAJAID #2b</u> MAJAID #1 ensemble inside Synthetic filled Casualty bag.

Test Conditions:

Most of the tests conducted as part of this test program were completed in the CORD wind tunnel with TIM hanging from underarm hooks.

Tests in the CORD wind tunnel were completed in the following conditions:

1. Still air @ 5˚C(dry and wet)
2. 7 m/s wind @ 5˚C (dry and wet)

Tests were also completed using the facilities of Composites Atlantic Environmental Simulation Lab (ESL) in Dartmouth, Nova Scotia.

The tests completed at ESL were:

1. Still Air @ -15˚C

Manikin Set Up Procedure:

Dry

1. The manikin was dressed in the required clothing configuration (See Table 1).
2. All zippers, closures, cinch straps, and attachments (including hood) of the clothing ensembles were closed and secured.
3. The manikin was hung on underarm hooks so that the feet were firmly touching the floor, but the manikin was standing upright.
4. The environmental sensors were positioned around TIM

Wet

1. The manikin was dressed in the required clothing configuration (See Table 1).
2. All zippers, closures, cinch straps, and attachments (including hood) of the clothing ensembles were closed and secured.
3. The manikin was lifted by the head and lowered into a water tank to the level of the neck so that all of the clothing was submerged. Once the manikin was immersed to the neck, it remained immersed for 1 minute.
4. After 1 minute of immersion, the manikin was hoisted fully out of the water and the footwear was removed and drained. The footwear was removed for 5 minutes and then replaced. During this time, the toque was also lightly wrung out and replaced on the manikin head.
5. The environmental sensors were positioned around TIM

Test Procedure:

1. Enter all pertinent information into the test system's computer to start a test.
2. Start warm-up period and allow thermal manikin to reach set temperature and go into test period.
3. Monitor the short term and long-term insulation for all sections until steady state is achieved.
    a) The Short term and long term calculations performed by the TIM software describe the averaging cycle. The Long Term calculation of insulation is the average calculation for the entire test duration. The Short term calculation is a shorter averaging cycle that is set by the operator. In these tests, the short term calculation was set at 20 minutes, therefore the averaging of short term calculation of insulation was restarted every 20 minutes during each test.

3.0 RESULTS

Table 1 Overall Insulation (Clo) Results

File	Ensemble	Description	Result CLO (ST)	Result CLO (LT)
M0918WT2	2	Deck Wear (with hat and gloves) Still Air Dry	3.09	2.20
M0918WT3	2	Deck Wear (without hat and gloves) Still Air Dry	1.94	2.18
M0918WT5	3	Expedition 1 7 m/s wind Dry	1.53	1.54
M0918WT6	3	Expedition 1 Still Air Dry	2.52	2.91
M0918WT7	2	Deck Wear 7m/s wind Dry	0.87	0.88
M0918WT8	6	Abandonment 1b Still Air Dry	2.93	3.06
M0918WT9	6	Abandonment 1b 7 m/s wind Dry	1.70	1.65
M0918WT10	5	Abandonment 1a 7 m/s wind Dry	2.41	2.14
M0918WT11	5	Abandonment 1a Still Air Dry	3.20	3.21
M0918WT12	7	Abandonment 2 Still Air Dry	3.26	3.30
M0918WT14	7	Abandonment 2 7m/s wind Dry	2.27	2.08
M0918WT15	4	Expedition 2 Still Air Dry	3.77	3.45

M0918WT16	4	Expedition 2 7m/s wind Dry	2.25	2.2
M0918WT17	1	Cabin Wear Still Air Dry	1.23	1.32
M0918WT18	1	Cabin Wear 7m/s wind Dry	0.39	0.39
M0918WT20	1	Cabin Wear Still Air Wet	0.83	0.67
M0918WT21	1	Cabin Wear 7m/s wind Wet	0.29	0.24
M0918WT22	3	Expedition 1 Still Air Wet	1.14	1.09
M0918WT23 b	3	Expedition 1 7m/s wind Wet	0.55	0.62
M1004SA1	8	MAJAID 1 Still Air Dry	2.48	2.70
M1004SA3	9	MAJAID 2a (Down Bag) 7 m/s wind Dry	6.82	5.98
M1004SA4	10	MAJAID 2b (Synthetic Bag) 7 m/s wind Dry	4.41	3.94
M1004SA5	8	MAJAID 1 Still Air @-15˚C Wet	1.42	1.29
M1004SA6	1	Cabin Wear Still Air @ -15˚C Wet	0.62	0.56
M1004SA7	3	Expedition 1 Still air @ -15˚C Wet	1.24	1.15
M1004TA2	8	MAJAID 1 7 m/s wind Dry	1.03	1.09
M1004TA4	9	MAJAID 2a (Down) 7 m/s wind Dry	2.79	3.15
M1004TA5	10	MAJAID 2b (Synthetic) 7 m/s wind Dry	2.59	2.61

M1004TA6	8	<u>MAJAID 1</u> 7 m/s wind Wet	0.68	0.63
M1004TA7	2	<u>Deck Wear</u> 7 m/s wind Dry Repeat of M0918WT7	1.48	1.46

4.0 TEST PHOTOGRAPHS

Representatives of IOT took a thorough photo documentation of these test proceedings for both TIM and NEMO.

APPENDIX A:
RAW DATA

TEST NUMBER:
TEST TITLE: SS Maria
FILE NAME: M0918WT2.TM1
DATE OF TEST: 12-16-2009
START TIME: 17:29:11
DESCRIPTION OF SUIT TESTED: Deck Wear
UNDERGARMENTS:
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY:
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 01:29:08 MINUTES SINCE START OF TEST: 479.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 14.43 AVERAGE OVER TEST TIME: 14.74

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	30.00	29.98	15.55	15.27	17.18	10.95	0.7924	1.2209
Chest	30.00	30.13	15.70	15.37	0.04	3.76	394.272	4.1062
Back	30.00	30.18	15.75	15.36	0.06	4.70	281.637	3.5063
Abdomen	30.00	30.05	15.62	15.29	0.01	2.14	553.250	2.5307
Buttocks	30.00	30.04	15.61	15.30	0.47	2.32	18.4492	3.6633
Right Arm	30.00	30.01	15.58	15.27	1.72	4.36	6.6387	2.5668
Left Arm	30.00	30.01	15.59	15.27	4.68	4.17	2.1921	2.4097
Right Hand	30.00	29.96	15.53	15.26	3.81	3.23	1.2912	1.4966
Left Hand	30.00	30.04	15.62	15.26	1.27	3.04	3.8247	1.5610
Right Leg	30.00	29.99	15.56	15.27	25.35	15.50	1.4110	2.2646
Left Leg	30.00	30.01	15.59	15.27	1.35	15.29	24.7279	2.1385
Right Foot	30.00	30.14	15.71	15.38	0.33	3.59	21.0388	1.8933
Left Foot	30.00	30.10	15.67	15.33	0.12	4.50	56.7827	1.4814
Overall					56.39	77.57	3.0904	2.2070

Total Power (W) For All Sections: 77.569
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.2070

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT3.TM1

DATE OF TEST: 12-17-2009
START TIME: 11:13:16
DESCRIPTION OF SUIT TESTED: Deckwear
UNDERGARMENTS:
ENVIRONMENT: 7 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION:
without hat and gloves

STOP TIME: 12:33:46 MINUTES SINCE START OF TEST: 80.50
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 4.93 AVERAGE OVER TEST TIME: 4.91

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	29.99	25.06	25.08	26.23	25.47	0.8364	0.8621
Chest	30.00	30.10	25.18	25.21	10.52	4.77	2.4043	5.3090
Back	30.00	30.11	25.18	25.20	3.86	6.53	6.9989	4.1405
Abdomen	30.00	30.01	25.08	25.11	5.37	2.77	1.6542	3.2108
Buttocks	30.00	30.02	25.09	25.11	5.09	3.24	2.7381	4.3050
Right Arm	30.00	30.00	25.07	25.09	5.85	5.39	3.1408	3.4116
Left Arm	30.00	30.00	25.07	25.09	5.89	5.40	2.8010	3.0576
Right Hand	30.00	30.00	25.08	25.09	13.12	11.06	0.6055	0.7186
Left Hand	30.00	29.99	25.06	25.09	12.89	11.41	0.6046	0.6838
Right Leg	30.00	30.00	25.07	25.09	21.24	19.62	2.7132	2.9396
Left Leg	30.00	30.00	25.08	25.09	15.36	19.94	3.4963	2.6943
Right Foot	30.00	30.08	25.15	25.20	12.42	5.48	0.8949	2.0323
Left Foot	30.00	30.04	25.12	25.15	6.66	7.39	1.6401	1.4799
Overall					144.50	128.47	1.9443	2.1883

Total Power (W) For All Sections: 128.474
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.1883

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT5.TM1

DATE OF TEST: 12-17-2009
START TIME: 16:00:19
DESCRIPTION OF SUIT TESTED: Expedition 1
UNDERGARMENTS: nude
ENVIRONMENT: 7 M/S WIND.

POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION:

STOP TIME: 17:04:10 MINUTES SINCE START OF TEST: 63.85
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 4.32 AVERAGE OVER TEST TIME: 4.17

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	29.99	25.67	25.81	59.85	62.40	0.3755	0.3621
Chest	30.00	30.15	25.83	26.02	8.61	7.21	3.0135	3.6252
Back	30.00	30.08	25.76	25.95	10.89	8.27	2.5379	3.3666
Abdomen	30.00	30.00	25.68	25.84	5.61	5.39	1.6213	1.6980
Buttocks	30.00	30.04	25.72	25.86	3.29	3.63	4.3426	3.9572
Right Arm	30.00	30.00	25.68	25.83	7.42	7.51	2.5365	2.5208
Left Arm	30.00	30.00	25.67	25.83	9.83	7.77	1.7185	2.1876
Right Hand	30.00	30.02	25.70	25.83	11.98	12.79	0.6796	0.6397
Left Hand	30.00	30.00	25.68	25.83	9.46	10.10	0.8441	0.7953
Right Leg	30.00	30.01	25.69	25.83	26.08	28.36	2.2643	2.0936
Left Leg	30.00	30.00	25.68	25.83	24.95	25.11	2.2039	2.2027
Right Foot	30.00	30.08	25.75	25.91	3.85	3.90	2.9558	2.9360
Left Foot	30.00	30.04	25.72	25.90	5.98	5.00	1.8702	2.2525
Overall					187.81	187.45	1.5321	1.5438

Total Power (W) For All Sections: 187.448
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.5438

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT6.TM1
DATE OF TEST: 12-18-2009
START TIME: 02:22:43
DESCRIPTION OF SUIT TESTED: Expedition 1
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 08:13:21 MINUTES SINCE START OF TEST: 350.65
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 7.50 AVERAGE OVER TEST TIME: 7.45

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	18.00	18.04	10.54	10.57	4.76	5.63	1.9386	1.6437
Chest	18.00	18.06	10.56	10.63	4.64	2.75	2.2861	3.8829
Back	18.00	18.06	10.56	10.62	3.88	3.11	2.9201	3.6637
Abdomen	18.00	18.05	10.55	10.61	0.90	0.77	4.1519	4.8805
Buttocks	18.00	18.06	10.56	10.60	0.60	1.17	9.7765	5.0326
Right Arm	18.00	18.01	10.51	10.56	2.26	2.04	3.4083	3.7939
Left Arm	18.00	18.01	10.51	10.57	2.92	2.23	2.3686	3.1192
Right Hand	18.00	18.00	10.50	10.55	1.63	1.76	2.0406	1.8988
Left Hand	18.00	18.01	10.50	10.55	1.68	1.72	1.9435	1.9074
Right Leg	18.00	18.00	10.50	10.56	12.19	8.62	1.9800	2.8161
Left Leg	18.00	18.01	10.51	10.56	8.18	7.94	2.7512	2.8479
Right Foot	18.00	18.07	10.57	10.61	1.12	1.31	4.1708	3.5793
Left Foot	18.00	18.04	10.54	10.60	1.95	1.53	2.3504	3.1026
Overall					46.71	40.58	2.5223	2.9190

Total Power (W) For All Sections: 40.581
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.9190

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT7.TM1
DATE OF TEST: 12-18-2009
START TIME: 09:33:06
DESCRIPTION OF SUIT TESTED: Deck Wear
UNDERGARMENTS: nude
ENVIRONMENT: 7 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 10:26:18 MINUTES SINCE START OF TEST: 53.20
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 4.84 AVERAGE OVER TEST TIME: 4.91

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	18.00	17.96	13.11	13.06	62.23	62.15	0.1844	0.1840
Chest	18.00	18.14	13.30	13.22	4.05	4.52	3.2988	2.9380
Back	18.00	18.08	13.23	13.17	3.29	3.95	4.3144	3.5772
Abdomen	18.00	18.02	13.18	13.11	2.79	2.59	1.6732	1.7928
Buttocks	18.00	18.03	13.18	13.12	2.85	2.50	2.5689	2.9152
Right Arm	18.00	18.01	13.16	13.10	3.52	3.30	2.7401	2.9094
Left Arm	18.00	18.01	13.17	13.10	3.25	3.60	2.6667	2.3946
Right Hand	18.00	17.76	12.92	12.90	31.49	31.48	0.1300	0.1298
Right Leg	18.00	18.00	13.16	13.09	19.29	17.74	1.5682	1.6962
Left Leg	18.00	18.00	13.16	13.10	16.59	15.45	1.6986	1.8156
Right Foot	18.00	18.09	13.24	13.18	8.60	7.95	0.6804	0.7327
Left Foot	18.00	18.06	13.22	13.16	6.40	6.42	0.8982	0.0914
Overall					164.34	161.66	0.8683	0.8793

Total Power (W) For All Sections: 161.662
Total Area (Square Meters): 1.688
Overall Insulation Resistance (CLO): 0.8793

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT8B.TM1
DATE OF TEST: 12-18-2009
START TIME: 11:53:09
DESCRIPTION OF SUIT TESTED: Abandonment 1
UNDERGARMENTS:
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 13:55:00 MINUTES SINCE START OF TEST: 121.85
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 4.24 AVERAGE OVER TEST TIME: 3.98

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	30.00	30.03	25.79	26.02	8.05	13.43	2.8048	1.6962
Chest	30.00	30.12	25.88	26.12	3.54	4.38	7.3438	5.9904
Back	30.00	30.11	25.87	26.13	4.61	6.35	6.0208	4.4150
Abdomen	30.00	30.01	25.77	26.03	3.00	3.05	3.0425	3.0228
Buttocks	30.00	30.05	25.81	26.05	1.67	3.07	8.5851	4.7135
Right Arm	30.00	30.00	25.76	26.02	8.58	6.28	2.2004	3.0366
Left Arm	30.00	30.02	25.77	26.02	5.60	5.91	3.0283	2.8973
Right Hand	30.00	30.01	25.77	26.02	4.21	4.64	1.9390	1.7764
Left Hand	30.00	29.99	25.74	26.02	4.84	4.33	1.6538	1.8687
Right Leg	30.00	30.01	25.77	26.02	18.16	17.56	3.2620	3.4062
Left Leg	30.00	29.99	25.75	26.02	28.99	19.48	1.9020	2.8602
Right Foot	30.00	30.22	25.98	26.27	2.61	2.92	4.3990	3.9759
Left Foot	30.00	30.05	25.81	26.06	4.63	4.03	2.4240	2.8119
Overall					98.49	95.44	2.9310	3.0555

Total Power (W) For All Sections: 95.439
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.0555

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT9.TM1
DATE OF TEST: 12-18-2009
START TIME: 13:59:33
DESCRIPTION OF SUIT TESTED: ENSEMBLE Abandonment 1b
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 14:59:33 MINUTES SINCE START OF TEST: 60.00
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 5.46 AVERAGE OVER TEST TIME: 4.99

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF(Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.00	24.54	24.95	54.87	57.47	0.3916	0.3801
Chest	30.00	30.14	24.68	25.15	5.19	5.88	4.7768	4.2965
Back	30.00	30.12	24.66	25.12	7.14	7.35	3.7056	3.6668
Abdomen	30.00	30.02	24.56	25.02	3.30	3.54	2.6361	2.5034
Buttocks	30.00	30.03	24.58	25.04	2.95	3.20	4.6284	4.3467
Right Arm	30.00	30.01	24.55	25.00	6.88	8.07	2.6152	2.2705
Left Arm	30.00	30.00	24.55	25.01	7.60	8.20	2.1257	2.0071
Right Hand	30.00	30.00	24.54	25.00	10.85	10.90	0.7633	0.7265
Left Hand	30.00	30.00	24.54	25.00	10.38	10.45	0.7352	0.7439
Right Leg	30.00	30.00	24.54	25.00	22.95	23.30	2.4580	2.4664
Left Leg	30.00	30.00	24.55	25.00	21.42	23.36	2.4542	2.2916
Right Foot	30.00	30.23	24.77	25.23	2.94	3.22	3.7234	3.4627
Left Foot	30.00	30.05	24.59	25.05	5.30	4.83	2.0175	2.2552
Overall					161.78	169.76	1.7000	1.6493

Total Power (W) For All Sections: 169.763
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.6493

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT10.TM1
DATE OF TEST: 12-18-2009
START TIME: 16:46:18
DESCRIPTION OF SUIT TESTED: Abandonment 1a
UNDERGARMENTS: nude
ENVIRONMENT: 7 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 17:46:21 MINUTES SINCE START OF TEST: 60.05
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 5.38 AVERAGE OVER TEST TIME: 5.14

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	30.00	29.99	24.62	24.85	27.57	25.12	0.7818	0.8661
Chest	30.00	30.13	24.75	24.98	2.99	5.51	8.3150	4.5540
Back	30.00	30.15	24.78	24.97	3.44	6.99	7.7286	3.8327
Abdomen	30.00	30.03	24.65	24.88	1.46	3.40	5.9800	2.5919
Buttocks	30.00	30.05	24.68	24.89	1.44	2.89	9.5204	4.7841
Right Arm	30.00	30.00	24.63	24.86	8.89	7.29	2.0305	2.4993
Left Arm	30.00	30.02	24.64	24.86	8.44	8.04	1.9212	2.0348
Right Hand	30.00	30.03	24.65	24.86	5.89	7.31	1.3257	1.0773
Left Hand	30.00	29.99	24.61	24.86	9.42	7.26	0.8124	1.0648
Right Leg	30.00	30.00	24.63	24.86	28.14	24.34	2.0120	2.3478
Left Leg	30.00	30.00	24.63	24.86	13.13	24.72	4.0168	2.1534
Right Foot	30.00	30.06	24.68	24.94	1.86	3.44	5.8640	3.2040
Left Foot	30.00	30.08	24.70	24.92	1.97	4.15	5.4520	2.6111
Overall					114.64	130.45	2.4100	2.1353

Total Power (W) For All Sections: 130.454
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.1353

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT11.TM1
DATE OF TEST: 12-18-2009
START TIME: 17:46:42
DESCRIPTION OF SUIT TESTED: Abandonment 1a
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 08:43:35 MINUTES SINCE START OF TEST: 896.90
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 3.79 AVERAGE OVER TEST TIME: 7.25

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.01	26.21	22.76	12.76	10.02	1.7983	1.9886
Chest	30.00	30.11	26.32	22.85	2.79	3.40	9.4763	6.7509
Back	30.00	30.11	26.31	22.85	6.36	5.16	4.4384	4.7511
Abdomen	30.00	30.02	26.23	22.77	2.69	2.33	3.4537	3.4614
Buttocks	30.00	30.03	26.24	22.78	2.50	2.56	5.8304	4.9429
Right Arm	30.00	30.00	26.21	22.75	5.33	4.99	3.6040	3.3414
Left Arm	30.00	30.00	26.21	22.76	5.95	5.40	2.8988	2.7736
Right Hand	30.00	30.01	26.22	22.75	5.21	4.31	1.5942	1.6791
Left Hand	30.00	30.01	26.21	22.75	5.17	4.29	1.5765	1.6491
Right Leg	30.00	30.00	26.21	22.75	19.51	15.84	3.0881	3.3015
Left Leg	30.00	30.00	26.21	22.75	17.82	15.81	3.1495	3.0812
Right Foot	30.00	30.10	26.31	22.83	2.44	2.31	4.7653	4.3677
Left Foot	30.00	30.05	26.26	22.80	3.26	2.92	3.5027	3.3953
Overall					91.79	79.34	3.1998	3.2136

Total Power (W) For All Sections: 79.344
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.2136

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT12.TM1
DATE OF TEST: 12-19-2009
START TIME: 10:04:02
DESCRIPTION OF SUIT TESTED: Abandonment 2
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 12:03:38 MINUTES SINCE START OF TEST: 119.60
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 7.18 AVERAGE OVER TEST TIME: 6.59

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.01	22.83	23.43	10.91	9.84	1.8320	2.0846
Chest	30.00	30.12	22.94	23.53	3.35	3.80	6.8787	6.2201
Back	30.00	30.09	22.91	23.51	3.99	5.81	6.1605	4.3415
Abdomen	30.00	30.03	22.84	23.44	1.93	2.10	4.1916	3.9535
Buttocks	30.00	30.03	22.85	23.45	2.93	2.66	4.3320	4.8970
Right Arm	30.00	30.01	22.82	23.45	5.29	5.67	3.1616	3.0311
Left Arm	30.00	30.01	22.82	23.46	5.68	4.78	2.6438	3.2297
Right Hand	30.00	30.00	22.82	23.41	3.41	3.42	2.1199	2.1683
Left Hand	30.00	30.00	22.82	23.41	3.51	3.46	2.0217	2.1040
Right Leg	30.00	30.00	22.82	23.45	17.74	15.13	2.9570	3.5628
Left Leg	30.00	30.01	22.82	23.43	11.87	14.55	4.1166	3.4481
Right Foot	30.00	30.08	22.90	23.50	3.22	3.48	3.1430	2.9843
Left Foot	30.00	30.07	22.88	23.49	4.68	4.79	2.1259	2.1324
Overall					78.50	79.48	3.2580	3.3045

Total Power (W) For All Sections: 79.481
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.3045

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT14.TM1
DATE OF TEST: 12-19-2009
START TIME: 13:40:17
DESCRIPTION OF SUIT TESTED: Abandonment 2
UNDERGARMENTS:
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 14:25:35 MINUTES SINCE START OF TEST: 45.30
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 5.06 AVERAGE OVER TEST TIME: 4.97

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.00	24.93	25.00	29.95	29.16	0.7287	0.7506
Chest	30.00	30.12	25.06	25.15	5.61	5.21	4.4872	4.8491
Back	30.00	30.10	25.04	25.13	6.08	7.41	4.4187	3.6386
Abdomen	30.00	30.02	24.96	25.04	3.22	2.78	2.7455	3.1903
Buttocks	30.00	30.04	24.98	25.06	2.70	3.02	5.1393	4.6094
Right Arm	30.00	30.00	24.94	25.02	6.52	7.53	2.8035	2.4352
Left Arm	30.00	30.00	24.94	25.03	7.87	8.05	2.0854	2.0461
Right Hand	30.00	30.00	24.94	25.03	4.60	5.00	1.7175	1.5858
Left Hand	30.00	30.00	24.94	25.03	4.85	5.14	1.5991	1.5148
Right Leg	30.00	30.00	24.94	25.03	18.21	22.07	3.1483	2.6070
Left Leg	30.00	30.01	24.95	25.02	19.52	23.92	2.7369	2.2398
Right Foot	30.00	30.10	25.03	25.08	3.87	5.47	2.8583	2.0263
Left Foot	30.00	30.06	25.00	25.06	10.00	9.78	1.0871	1.1142
Overall					123.02	134.52	2.2720	2.0841

Total Power (W) For All Sections: 134.523
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.0841

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT15.TM1
DATE OF TEST: 12-19-2009
START TIME: 14:56:56
DESCRIPTION OF SUIT TESTED: Expedition 2
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 16:27:23 MINUTES SINCE START OF TEST: 90.45
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 3.49 AVERAGE OVER TEST TIME: 3.09

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF(Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.02	26.52	26.92	9.95	10.03	2.3335	2.3498
Chest	30.00	30.09	26.60	27.02	4.25	3.89	6.2871	6.9774
Back	30.00	30.11	26.62	27.01	4.62	5.54	6.1820	5.2309
Abdomen	30.00	30.01	26.52	26.94	3.16	1.95	2.9725	4.8933
Buttocks	30.00	30.05	26.55	26.95	1.39	2.41	10.6101	6.2117
Right Arm	30.00	30.01	26.51	26.91	5.23	6.56	3.7150	3.0065
Left Arm	30.00	30.00	26.51	26.91	6.50	6.74	2.6839	2.6274
Right Hand	30.00	30.00	26.51	26.91	3.83	4.26	2.1926	2.0010
Left Hand	30.00	30.00	26.50	26.91	4.55	4.66	1.8111	1.7957
Right Leg	30.00	30.01	26.51	26.92	15.64	16.82	3.8963	3.6790
Left Leg	30.00	30.01	26.52	26.91	13.26	17.90	4.2826	3.2191
Right Foot	30.00	30.08	26.59	27.00	2.90	2.94	4.0521	4.0586
Left Foot	30.00	30.06	26.56	26.97	3.56	3.64	3.2442	3.2219
Overall					78.83	87.33	3.7691	3.4536

Total Power (W) For All Sections: 87.327
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.4536

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918TW16.TM1
DATE OF TEST: 12-19-2009
START TIME: 16:28:02
DESCRIPTION OF SUIT TESTED: ENSEMBLE 2
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION:

STOP TIME: 17:59:11 MINUTES SINCE START OF TEST: 91.15
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 4.45 AVERAGE OVER TEST TIME: 5.28

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.00	25.55	24.72	25.46	25.16	0.8786	0.8602
Chest	30.00	30.11	25.66	24.85	5.52	4.97	4.6695	5.0226
Back	30.00	30.10	25.64	24.82	5.88	6.26	4.6784	4.2539
Abdomen	30.00	30.02	25.57	24.74	3.56	3.72	2.5440	2.3556
Buttocks	30.00	30.04	25.58	24.75	1.98	2.65	7.1764	5.1880
Right Arm	30.00	30.00	25.55	24.72	7.49	8.09	2.5001	2.2395
Left Arm	30.00	30.00	25.54	24.72	9.87	8.72	1.7028	1.8655
Right Hand	30.00	30.00	25.54	24.72	8.57	8.22	0.9440	0.9526
Left Hand	30.00	30.00	25.55	24.72	7.60	7.55	1.0454	1.0182
Right Leg	30.00	30.00	25.54	24.73	23.68	21.61	2.4793	2.6306
Left Leg	30.00	30.00	25.55	24.72	20.80	21.37	2.6303	2.4770
Right Foot	30.00	30.09	25.63	24.80	2.58	3.22	4.3902	3.4037
Left Foot	30.00	30.08	25.62	24.79	4.21	4.39	2.6462	2.4555
Overall					127.20	125.93	2.2502	2.1996

Total Power (W) For All Sections: 125.931
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.1996

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918TW17.TM1
DATE OF TEST: 12-19-2009
START TIME: 22:43:52
DESCRIPTION OF SUIT TESTED: Cabin Wear
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 08:15:22 MINUTES SINCE START OF TEST: 571.50
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 7.69 AVERAGE OVER TEST TIME: 6.97

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	18.00	18.01	10.32	11.05	10.68	11.34	0.8460	0.8531
Chest	18.00	18.14	10.45	11.18	4.38	5.25	2.3966	2.1391
Back	18.00	18.10	10.41	11.16	7.56	7.23	1.4774	1.6561
Abdomen	18.00	18.02	10.33	11.06	2.70	2.80	1.3551	1.3991
Buttocks	18.00	18.03	10.34	11.06	2.76	2.91	2.0811	2.1112
Right Arm	18.00	18.00	10.32	11.04	5.65	5.88	1.3387	1.3761
Left Arm	18.00	18.00	10.32	11.04	6.21	5.97	1.0936	1.2169
Right Hand	18.00	18.00	10.31	11.03	4.82	5.08	0.6776	0.6878
Left Hand	18.00	18.00	10.31	11.03	4.76	4.87	0.6735	0.7043
Right Leg	18.00	18.00	10.31	11.04	20.33	18.53	1.1657	1.3695
Left Leg	18.00	18.00	10.31	11.04	18.66	18.51	1.1831	1.2771
Right Foot	18.00	18.10	10.42	11.14	2.21	2.31	2.0837	2.1312
Left Foot	18.00	18.04	10.35	11.09	3.36	3.18	1.3395	1.5165
Overall					94.08	93.87	1.2300	1.3194

Total Power (W) For All Sections: 93.868
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.3194

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME:M0918WT18.TM1
DATE OF TEST: 12-20-2009
START TIME: 08:47:10
DESCRIPTION OF SUIT TESTED: Cabin Wear
UNDERGARMENTS: nude
ENVIRONMENT: 7 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 09:27:10 MINUTES SINCE START OF TEST: 40.00
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 5.14 AVERAGE OVER TEST TIME: 5.04

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	17.00	16.99	11.85	11.95	58.65	58.70	0.1769	0.1782
Chest	17.00	17.09	11.95	12.04	37.21	36.49	0.3226	0.3314
Back	17.00	17.11	11.97	12.07	15.28	13.71	0.8405	0.9446
Abdomen	17.00	17.00	11.86	11.95	10.21	10.10	0.4114	0.4191
Buttocks	17.00	17.04	11.90	11.99	4.72	4.43	1.1005	1.5034
Right Arm	17.00	17.00	11.86	11.96	28.57	28.75	0.3042	0.3049
Left Arm	17.00	17.00	11.86	11.96	25.36	25.36	0.3078	0.3103
Right Hand	17.00	16.99	11.85	11.96	30.01	30.19	0.1251	0.1255
Left Hand	17.00	17.00	11.86	11.96	29.96	30.21	0.1231	0.1231
Right Leg	17.00	17.00	11.86	11.96	42.23	42.72	0.6456	0.6436
Left Leg	17.00	17.00	11.86	11.95	40.23	41.53	0.6313	0.6161
Right Foot	17.00	17.08	11.94	12.05	6.34	6.00	0.8323	0.8876
Left Foot	17.00	17.03	11.89	11.98	11.67	11.81	0.4430	0.4411
Overall					340.44	339.99	0.3906	0.3943

Total Power (W) For All Sections: 339.990
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.3943

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: m0918wt20.tm1
DATE OF TEST: 12-20-2009
START TIME: 18:29:30
DESCRIPTION OF SUIT TESTED: Cabin Wear
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front

CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: Wetted

STOP TIME: 03:25:30 MINUTES SINCE START OF TEST: 536.00
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 10.72 AVERAGE OVER TEST TIME: 10.30

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	30.00	30.01	19.28	19.70	21.14	23.80	0.7985	0.7247
Chest	30.00	30.19	19.46	19.82	27.07	33.44	0.7221	0.5954
Back	30.00	30.10	19.38	19.80	18.19	21.92	1.1431	0.9691
Abdomen	30.00	30.01	19.28	19.71	9.57	11.25	0.7136	0.6205
Buttocks	30.00	30.04	19.32	19.73	7.15	10.05	1.5010	1.0905
Right Arm	30.00	30.00	19.28	19.70	13.65	20.01	1.0352	0.7215
Left Arm	30.00	30.00	19.28	19.71	14.81	19.72	0.8567	0.6577
Right Hand	30.00	30.00	19.27	19.70	8.91	10.15	0.6851	0.6148
Left Hand	30.00	30.00	19.28	19.70	9.15	10.61	0.6552	0.5774
Right Leg	30.00	30.00	19.28	19.70	50.53	70.57	0.8771	0.6471
Left Leg	30.00	30.00	19.28	19.70	47.00	61.01	0.8784	0.6914
Right Foot	30.00	30.01	19.29	19.70	16.33	18.75	0.5220	0.4643
Left Foot	30.00	30.01	19.28	19.71	16.16	16.34	0.5188	0.5245
Overall					259.65	327.61	0.8326	0.6742

Total Power (W) For All Sections: 327.609
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.6742

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: m0918wt21.TM1
DATE OF TEST: 12-21-2009
START TIME: 10:33:02
DESCRIPTION OF SUIT TESTED: Cabin Wear
UNDERGARMENTS: nude
ENVIRONMENT: 7 M/S WIND.
  POSITION: HANGING VERTICAL IN WIND TUNNEL.
  HUMIDITY: 65
  ENV. FLOW SPEED:
  DIRECTION: From Front
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: Wetted

STOP TIME: 14:43:02 MINUTES SINCE START OF TEST: 250.00
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 7.30 AVERAGE OVER TEST TIME: 7.17

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF(Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	15.00	15.01	7.71	7.83	37.38	40.82	0.1806	0.1679
Chest	15.00	15.13	7.83	7.92	29.07	33.49	0.2706	0.2376
Back	15.00	15.08	7.78	7.91	18.31	20.13	0.4559	0.4216
Abdomen	15.00	15.01	7.71	7.83	11.59	14.27	0.2356	0.1943
Buttocks	15.00	15.04	7.74	7.86	6.45	9.24	0.6666	0.4725
Right Arm	15.00	15.01	7.70	7.83	18.70	22.58	0.3018	0.2541
Left Arm	15.00	15.00	7.70	7.83	19.47	22.40	0.2603	0.2300
Right Hand	15.00	15.00	7.70	7.83	20.91	22.52	0.1167	0.1101
Left Hand	15.00	15.00	7.70	7.83	19.88	21.89	0.1204	0.1112
Right Leg	15.00	15.00	7.70	7.83	42.04	57.07	0.4210	0.3154
Left Leg	15.00	15.00	7.70	7.83	39.63	55.01	0.4160	0.3048
Right Foot	15.00	14.96	7.66	7.81	20.24	19.60	0.1673	0.1761
Left Foot	15.00	15.00	7.69	7.83	16.21	17.74	0.2063	0.1919
Overall					299.88	356.76	0.2881	0.2462

Total Power (W) For All Sections: 356.764
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.2462

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: m0918wt22.TM1
DATE OF TEST: 12-21-2009
START TIME: 17:18:19
DESCRIPTION OF SUIT TESTED: Expedition 1
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION: Wetted

STOP TIME: 01:18:15 MINUTES SINCE START OF TEST: 479.95
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 10.07 AVERAGE OVER TEST TIME: 9.53

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	30.00	30.00	19.94	20.47	16.77	18.09	1.0410	0.9907
Chest	30.00	30.17	20.11	20.65	8.26	8.31	2.4456	2.4962
Back	30.00	30.14	20.08	20.60	10.96	18.14	1.9657	1.2184
Abdomen	30.00	30.01	19.94	20.48	5.92	6.05	1.1930	1.1990
Buttocks	30.00	30.04	19.97	20.50	5.04	5.56	2.2010	2.0481
Right Arm	30.00	30.00	19.94	20.47	9.12	11.06	1.6024	1.3565
Left Arm	30.00	30.00	19.94	20.47	10.44	11.02	1.2569	1.2224
Right Hand	30.00	30.00	19.93	20.47	7.88	8.12	0.8012	0.7986
Left Hand	30.00	30.00	19.94	20.47	8.37	8.74	0.7408	0.7283
Right Leg	30.00	30.00	19.94	20.47	44.86	43.43	1.0218	1.0835
Left Leg	30.00	30.00	19.93	20.47	42.51	42.14	1.0039	1.0402
Right Foot	30.00	30.05	19.98	20.49	14.50	16.70	0.6090	0.5422
Left Foot	30.00	30.02	19.96	20.49	11.83	13.71	0.7337	0.6499
Overall					196.45	211.07	1.1375	1.0873

Total Power (W) For All Sections: 211.067
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.0873

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M0918WT23B.TM1
DATE OF TEST: 12-22-2009
START TIME: 11:00:53
DESCRIPTION OF SUIT TESTED: Expedition 1
UNDERGARMENTS: nude
ENVIRONMENT: 7 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION: Wetted

STOP TIME: 16:00:53 MINUTES SINCE START OF TEST: 300.00
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 8.68 AVERAGE OVER TEST TIME: 8.37

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	18.00	18.00	9.31	9.63	26.48	30.00	0.3078	0.2810
Chest	18.00	18.16	9.48	9.80	6.14	7.15	1.5509	1.3768
Back	18.00	18.08	9.39	9.72	6.06	5.99	1.6625	1.7410
Abdomen	18.00	18.01	9.33	9.64	4.79	5.37	0.6899	0.6358
Buttocks	18.00	18.03	9.34	9.66	3.65	3.92	1.4214	1.3689
Right Arm	18.00	18.01	9.32	9.63	4.89	5.77	1.3969	1.2232
Left Arm	18.00	18.01	9.32	9.64	5.18	6.74	1.1840	0.9412
Right Hand	18.00	18.00	9.32	9.63	6.90	7.34	0.4279	0.4156
Left Hand	18.00	18.00	9.32	9.63	9.15	10.60	0.3167	0.2825
Right Leg	18.00	18.00	9.32	9.63	26.42	29.57	0.8109	0.7486
Left Leg	18.00	18.00	9.32	9.63	25.45	28.22	0.7842	0.7307
Right Foot	18.00	18.01	9.32	9.64	17.65	18.30	0.2334	0.2328
Left Foot	18.00	15.75	7.07	9.48	35.21	14.91	0.0873	0.2765
Overall					177.97	173.87	0.5520	0.6203

Total Power (W) For All Sections: 173.871
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.6203

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M1002SA1.TM1
DATE OF TEST: 01-17-2010
START TIME: 14:17:50
DESCRIPTION OF SUIT TESTED: MAJAID 1
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 08:16:08 MINUTES SINCE START OF TEST: 1078.30
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 4.95 AVERAGE OVER TEST TIME: 11.85

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	TEMP DIFF (Deg C) AVERAGE	POWER (WATTS) ST	POWER (WATTS) LT	INSULATION (CLO) ST	INSULATION (CLO) LT
Head	30.00	30.00	25.05	18.16	9.90	7.05	2.2152	2.2551
Chest	30.00	30.13	25.18	18.26	6.10	4.07	4.1465	4.5067
Back	30.00	30.10	25.15	18.24	6.01	4.58	4.4898	4.2729
Abdomen	30.00	30.03	25.08	18.19	1.99	1.57	4.4639	4.1037
Buttocks	30.00	30.03	25.08	18.18	2.90	2.41	4.8040	4.1903
Right Arm	30.00	30.00	25.05	18.15	7.64	5.22	2.4030	2.5483
Left Arm	30.00	30.00	25.05	18.16	6.91	5.09	2.3856	2.3478
Right Hand	30.00	30.00	25.05	18.15	5.11	3.40	1.5529	1.6910
Left Hand	30.00	30.00	25.05	18.15	5.54	3.51	1.4061	1.6080
Right Leg	30.00	30.00	25.05	18.15	28.15	16.65	2.0456	2.5058
Left Leg	30.00	30.00	25.05	18.15	25.97	16.33	2.0654	2.3799
Right Foot	30.00	30.08	25.13	18.23	3.25	2.52	3.4172	3.1970
Left Foot	30.00	30.07	25.12	18.21	3.92	2.88	2.7865	2.7494
Overall					113.38	75.28	2.4757	2.7030

Total Power (W) For All Sections: 75.278
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 2.7030

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M1002SA3.TM1
DATE OF TEST: 01-18-2010
START TIME: 11:54:23
DESCRIPTION OF SUIT TESTED: MAJAID 2 and Down Bag
UNDERGARMENTS: nude
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION:

STOP TIME: 15:24:35 MINUTES SINCE START OF TEST: 210.20
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 3.45 AVERAGE OVER TEST TIME: 3.65

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF(Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.01	26.56	26.35	5.43	5.40	4.2823	4.2720
Chest	30.00	30.09	26.64	26.43	2.84	2.84	9.4226	9.3484
Back	30.00	30.07	26.63	26.41	2.31	3.20	12.3686	8.8548
Abdomen	30.00	30.02	26.57	26.39	2.19	1.06	4.2972	8.8181
Buttocks	30.00	30.04	26.60	26.39	1.14	1.31	12.9613	11.1902
Right Arm	30.00	30.01	26.56	26.36	2.48	2.73	7.8492	7.0767
Left Arm	30.00	30.01	26.57	26.35	2.50	2.88	6.9939	6.0208
Right Hand	30.00	30.00	26.55	26.35	1.88	2.00	4.4736	4.1735
Left Hand	30.00	30.01	26.56	26.35	1.55	2.06	5.3286	3.9777
Right Leg	30.00	30.01	26.56	26.35	8.46	11.51	7.2168	5.2625
Left Leg	30.00	30.01	26.57	26.35	8.77	9.75	6.4874	5.7870
Right Foot	30.00	30.08	26.63	26.42	2.19	2.23	5.3739	5.2358
Left Foot	30.00	30.06	26.62	26.40	1.90	2.42	6.0923	4.7437
Overall					43.63	49.38	6.8216	5.9792

Total Power (W) For All Sections: 49.383
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 5.9792

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M1002SA4.TM1
DATE OF TEST: 01-18-2010
START TIME: 19:11:41
DESCRIPTION OF SUIT TESTED: MAJAID 2with Synthetic Casualty bag
UNDERGARMENTS: Majaid
ENVIRONMENT: 0 M/S WIND.
POSITION: HANGING VERTICAL IN WIND TUNNEL.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION:

STOP TIME: 07:59:50 MINUTES SINCE START OF TEST: 768.15
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 9.82 AVERAGE OVER TEST TIME: 8.51

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.01	20.20	21.50	4.39	5.43	4.0284	3.4665
Chest	30.00	30.08	20.26	21.58	2.93	3.28	6.9459	6.6090
Back	30.00	30.07	20.25	21.57	3.31	3.41	6.5638	6.7867
Abdomen	30.00	30.04	20.22	21.54	1.22	0.99	5.8703	7.7064
Buttocks	30.00	30.05	20.23	21.53	1.21	1.62	9.2871	7.3824
Right Arm	30.00	30.01	20.19	21.50	3.84	3.66	3.8535	4.3053
Left Arm	30.00	30.03	20.21	21.50	1.51	3.45	8.8076	4.1010
Right Hand	30.00	30.00	20.18	21.49	2.19	2.54	2.9190	2.6801
Left Hand	30.00	30.00	20.18	21.49	2.23	2.30	2.8140	2.9055
Right Leg	30.00	30.00	20.19	21.50	12.95	14.41	3.5839	3.4297
Left Leg	30.00	30.00	20.18	21.50	10.63	14.49	4.0650	3.1772
Right Foot	30.00	30.10	20.28	21.58	2.09	2.45	4.2883	3.8926
Left Foot	30.00	30.06	20.24	21.55	2.83	3.14	3.1099	2.9843
Overall					51.32	61.17	4.4083	3.9383

Total Power (W) For All Sections: 61.168
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 3.9383

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M1002SA5.TM1
DATE OF TEST: 01-19-2010
START TIME: 15:14:31
DESCRIPTION OF SUIT TESTED: MajAId 1
UNDERGARMENTS:
ENVIRONMENT: 0 M/S WIND. -15C
POSITION: HANGING VERTICAL
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION: Wetted

STOP TIME: 07:57:39 MINUTES SINCE START OF TEST: 1003.15
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: -15.93 AVERAGE OVER TEST TIME: -15.84

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	25.00	24.99	40.93	40.84	22.55	23.73	1.5891	1.5067
Chest	25.00	25.16	41.09	41.01	20.47	23.65	2.0164	1.7419
Back	25.00	25.07	41.01	40.94	24.58	20.75	1.7901	2.1269
Abdomen	25.00	25.00	40.93	40.85	9.04	11.38	1.6037	1.2714
Buttocks	25.00	25.03	40.97	40.87	5.19	7.27	4.3850	3.1228
Right Arm	25.00	24.99	40.93	40.84	16.96	17.55	1.7687	1.7055
Left Arm	25.00	25.00	40.93	40.84	14.84	16.16	1.8150	1.6631
Right Hand	25.00	25.01	40.95	40.84	11.08	14.65	1.1707	0.8831
Left Hand	25.00	25.00	40.93	40.84	12.26	14.83	1.0382	0.8564
Right Leg	25.00	24.99	40.93	40.84	71.29	73.29	1.3198	1.2809
Left Leg	25.00	25.00	40.94	40.84	57.22	70.73	1.5321	1.2364
Right Foot	25.00	24.91	40.84	40.79	29.49	29.57	0.6120	0.6096
Left Foot	25.00	25.00	40.93	40.78	27.35	29.74	0.6507	0.5963
Overall					322.33	353.31	1.4223	1.2947

Total Power (W) For All Sections: 353.310
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.2947

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: c:\Documents and Settings\Default\Desktop\Tim_2005\NEW PROGRAM\M1002SA6.TM1
DATE OF TEST: 01-20-2010
START TIME: 10:42:47
DESCRIPTION OF SUIT TESTED: Cabin Wear
UNDERGARMENTS:
ENVIRONMENT: 0 M/S WIND. -15C
POSITION: HANGING VERTICAL
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION: Wetted

STOP TIME: 15:45:50 MINUTES SINCE START OF TEST: 303.05
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: -16.24 AVERAGE OVER TEST TIME: -16.22

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	9.00	9.02	25.27	25.22	39.50	44.20	0.5601	0.4995
Chest	9.00	9.10	25.34	25.30	35.20	35.36	0.7231	0.7187
Back	9.00	9.09	25.33	25.25	23.81	39.10	1.1414	0.6929
Abdomen	9.00	8.99	25.24	25.23	12.59	12.86	0.7101	0.6949
Buttocks	9.00	9.00	25.24	25.24	16.01	12.74	0.8757	1.1005
Right Arm	9.00	9.00	25.24	25.22	29.87	30.94	0.6193	0.5974
Left Arm	9.00	9.01	25.25	25.22	29.62	33.25	0.5610	0.4991
Right Hand	9.00	9.00	25.24	25.21	30.38	30.84	0.2632	0.2589
Left Hand	9.00	9.00	25.25	25.22	25.94	25.87	0.3027	0.3032
Right Leg	9.00	9.01	25.25	25.22	89.66	97.81	0.6474	0.5927
Left Leg	9.00	9.01	25.26	25.22	85.23	91.87	0.6346	0.5878
Right Foot	9.00	8.96	25.21	25.18	21.40	23.12	0.5206	0.4813
Left Foot	9.00	9.00	25.25	25.21	20.19	22.26	0.5428	0.4925
Overall					459.40	500.21	0.6157	0.5648

Total Power (W) For All Sections: 500.213
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.5648

TEST NUMBER:
TEST TITLE: SS MARIA
FILE NAME: M1002SA7.TM1
DATE OF TEST: 01-20-2010
START TIME: 19:18:36
DESCRIPTION OF SUIT TESTED: Expedition 1
UNDERGARMENTS: nude

ENVIRONMENT: 0 M/S WIND. -15C
POSITION: HANGING VERTICAL
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION: From Front
CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION: Wetted

STOP TIME: 08:19:08 MINUTES SINCE START OF TEST: 780.55
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: -16.40 AVERAGE OVER TEST TIME: -16.39

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF (Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	20.00	19.99	36.38	36.39	39.52	37.46	0.8059	0.8508
Chest	20.00	20.15	36.54	36.58	29.18	21.69	1.2579	1.6941
Back	20.00	20.10	36.49	36.49	10.32	20.77	3.7936	1.8849
Abdomen	20.00	20.01	36.41	36.41	7.64	8.32	1.6880	1.5500
Buttocks	20.00	20.03	36.43	36.42	2.92	8.07	6.9302	2.5069
Right Arm	20.00	19.99	36.39	36.39	17.23	14.06	1.5479	1.8969
Left Arm	20.00	20.02	36.41	36.39	11.57	15.54	2.0709	1.5410
Right Hand	20.00	19.98	36.38	36.39	11.66	12.09	0.9884	0.9535
Left Hand	20.00	19.99	36.39	36.39	11.74	15.52	0.9639	0.7291
Right Leg	20.00	20.02	36.41	36.39	64.15	74.14	1.3047	1.1283
Left Leg	20.00	20.00	36.40	36.39	53.50	60.16	1.4569	1.2952
Right Foot	20.00	19.96	36.36	36.35	34.49	33.54	0.4659	0.4790
Left Foot	20.00	19.97	36.36	36.33	33.48	34.39	0.4722	0.4594
Overall					327.40	355.75	1.2452	1.1457

Total Power (W) For All Sections: 355.750
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.1457

TEST NUMBER:

TEST TITLE: SS MARIA

FILE NAME: M1002TA2.TM1

DATE OF TEST: 01-18-2010

START TIME: 08:22:50

DESCRIPTION OF SUIT TESTED: MAJAID 1

UNDERGARMENTS: nude

ENVIRONMENT: 7 M/S WIND.

POSITION: HANGING VERTICAL IN WIND TUNNEL.

HUMIDITY: 65

ENV. FLOW SPEED:

DIRECTION: From Front

CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 11:11:50 MINUTES SINCE START OF TEST: 169.00

ENVIRONMENT TEMPERATURE:

INSTANTANEOUS: 6.16 AVERAGE OVER TEST TIME: 6.63

SECTION	SETPOINT	SKINTEMP	TEMP DIFF(Deg C)		POWER (WATTS)		INSULATION (CLO)	
	(Deg C)	(Deg C)	INSTANT	AVERAGE	ST	LT	ST	LT
Head	30.00	30.00	23.84	23.36	42.04	38.27	0.4965	0.5344
Chest	30.00	30.12	23.96	23.48	26.68	26.68	0.9021	0.8840
Back	30.00	30.07	23.92	23.46	19.38	15.11	1.3242	1.6658
Abdomen	30.00	30.01	23.85	23.37	9.58	9.66	0.8818	0.8569
Buttocks	30.00	30.03	23.87	23.39	6.62	6.51	2.0029	1.9958
Right Arm	30.00	30.01	23.85	23.37	12.96	12.61	1.3487	1.3583
Left Arm	30.00	30.00	23.84	23.37	14.85	13.12	1.0564	1.1722
Right Hand	30.00	30.00	23.85	23.37	6.33	6.40	1.1935	1.1567
Left Hand	30.00	30.00	23.84	23.37	7.31	7.14	1.0142	1.0178
Right Leg	30.00	30.00	23.84	23.37	53.80	49.17	1.0186	1.0926
Left Leg	30.00	30.00	23.85	23.36	46.46	44.13	1.0992	1.1335
Right Foot	30.00	30.07	23.92	23.43	4.82	4.61	2.1932	2.2461
Left Foot	30.00	30.04	23.89	23.41	8.13	7.46	1.1278	1.3646
Overall					258.97	240.84	1.0319	1.0873

Total Power (W) For All Sections: 240.845

Total Area (Square Meters): 1.736

Overall Insulation Resistance (CLO): 1.0873

TEST NUMBER:

TEST TITLE: SS MARIA

FILE NAME: M1002TA4.TM1

DATE OF TEST: 01-18-2010

START TIME: 15:25:38

DESCRIPTION OF SUIT TESTED: MAJAID 2 with Down Casualty bag

UNDERGARMENTS: Majaid

ENVIRONMENT: 7 M/S WIND.

POSITION: HANGING VERTICAL IN WIND TUNNEL.

HUMIDITY: 65

ENV. FLOW SPEED:

DIRECTION: From Front

CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 17:15:38 MINUTES SINCE START OF TEST: 110.00

ENVIRONMENT TEMPERATURE:

INSTANTANEOUS: 4.10 AVERAGE OVER TEST TIME: 4.32

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF(Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.00	25.90	25.68	23.82	23.23	0.9519	0.9678
Chest	30.00	30.11	26.01	25.79	4.46	4.00	5.8582	6.4766
Back	30.00	30.08	25.99	25.77	3.98	3.93	7.0062	7.0353
Abdomen	30.00	30.01	25.92	25.71	2.85	2.19	3.2213	4.1581
Buttocks	30.00	30.04	25.94	25.72	1.62	1.62	8.8946	8.8192
Right Arm	30.00	30.01	25.92	25.69	3.60	4.11	5.2769	4.5811
Left Arm	30.00	30.01	25.91	25.69	4.25	3.91	4.0119	4.3237
Right Hand	30.00	30.00	25.91	25.68	3.19	3.12	2.5729	2.6073
Left Hand	30.00	30.00	25.91	25.69	2.77	2.67	2.9087	2.9920
Right Leg	30.00	29.99	25.90	25.68	24.68	19.54	2.4123	3.0210
Left Leg	30.00	29.99	25.90	25.68	21.60	16.89	2.5676	3.2557
Right Foot	30.00	30.08	25.99	25.75	3.18	3.03	3.6119	3.7557
Left Foot	30.00	30.05	25.96	25.73	3.73	3.21	3.0264	3.4855
Overall					103.72	91.47	2.7978	3.1457

Total Power (W) For All Sections: 91.471

Total Area (Square Meters): 1.736

TEST NUMBER:

TEST TITLE: SS MARIA

FILE NAME: M1002TA5.TM1

DATE OF TEST: 01-18-2010

START TIME: 17:34:11

DESCRIPTION OF SUIT TESTED: MAJAID 2 with Synthetic Casualty bag

UNDERGARMENTS:

ENVIRONMENT: 7 M/S WIND.

POSITION: HANGING VERTICAL IN WIND TUNNEL.

HUMIDITY: 65

ENV. FLOW SPEED:

DIRECTION: From Front

CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 19:05:47 MINUTES SINCE START OF TEST: 91.60

ENVIRONMENT TEMPERATURE:

INSTANTANEOUS: 3.62 AVERAGE OVER TEST TIME: 3.79

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF(Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.00	26.38	26.20	21.32	22.16	1.0833	1.0351
Chest	30.00	30.12	26.49	26.31	3.48	4.53	7.6464	5.8342
Back	30.00	30.12	26.50	26.31	4.62	5.99	6.1541	4.7125
Abdomen	30.00	30.01	26.38	26.22	3.40	2.19	2.7481	4.2406
Buttocks	30.00	30.02	26.39	26.23	3.12	3.03	4.6985	4.8087
Right Arm	30.00	30.00	26.38	26.20	7.14	7.09	2.7078	2.7083
Left Arm	30.00	30.00	26.38	26.20	6.60	7.24	2.6303	2.3814
Right Hand	30.00	30.00	26.38	26.20	4.78	4.42	1.7482	1.8777
Left Hand	30.00	30.00	26.38	26.20	4.25	4.31	1.9302	1.8903
Right Leg	30.00	30.00	26.38	26.20	25.32	22.73	2.3949	2.6496
Left Leg	30.00	30.00	26.37	26.20	23.11	20.89	2.4434	2.6856
Right Foot	30.00	30.07	26.45	26.28	3.10	3.19	3.7707	3.6408
Left Foot	30.00	30.06	26.44	26.26	4.08	4.48	2.8179	2.5489
Overall					114.30	112.25	2.5855	2.6155

Total Power (W) For All Sections: 112.248

Total Area (Square Meters): 1.736

Overall Insulation Resistance (CLO): 2.6155

TEST NUMBER:

TEST TITLE: SS MARIA

FILE NAME: m1002ta6.TM1

DATE OF TEST: 01-21-2010

START TIME: 13:36:50

DESCRIPTION OF SUIT TESTED: MAJAID 1

UNDERGARMENTS:

ENVIRONMENT: 7 m/s

POSITION: HANGING VERTICAL IN WIND TUNNEL.

HUMIDITY: 65

ENV. FLOW SPEED:

DIRECTION: From Front

CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION: Wetted

STOP TIME: 17:48:32 MINUTES SINCE START OF TEST: 251.70

ENVIRONMENT TEMPERATURE:

INSTANTANEOUS: 6.40 AVERAGE OVER TEST TIME: 7.39

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF(Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	25.00	25.00	18.60	17.61	25.86	28.60	0.6297	0.5391
Chest	25.00	25.11	18.71	17.69	20.78	25.85	0.9045	0.6874
Back	25.00	25.09	18.69	17.70	11.39	10.89	1.7605	1.7438
Abdomen	25.00	24.99	18.59	17.61	16.94	15.59	0.3887	0.4001
Buttocks	25.00	25.01	18.61	17.63	8.03	7.03	1.2874	1.3931
Right Arm	25.00	25.00	18.60	17.61	18.32	17.48	0.7441	0.7384
Left Arm	25.00	25.00	18.60	17.61	17.26	17.55	0.7092	0.6603
Right Hand	25.00	25.00	18.60	17.61	10.74	12.78	0.5486	0.4365
Left Hand	25.00	25.00	18.60	17.61	8.42	10.52	0.6869	0.5205
Right Leg	25.00	25.00	18.60	17.61	64.35	63.14	0.6644	0.6411
Left Leg	25.00	25.00	18.60	17.61	61.23	60.52	0.6505	0.6231
Right Foot	25.00	24.98	18.58	17.60	19.15	19.16	0.4288	0.4060
Left Foot	25.00	24.98	18.59	17.59	22.08	22.21	0.3661	0.3444
Overall					304.57	311.32	0.6842	0.6337

Total Power (W) For All Sections: 311.323

Total Area (Square Meters): 1.736

Overall Insulation Resistance (CLO): 0.6337

TEST NUMBER:

TEST TITLE: SS MARIA

FILE NAME: M1002TA7.TM1

DATE OF TEST: 01-22-2010

START TIME: 11:55:40

DESCRIPTION OF SUIT TESTED: Deck Wear

UNDERGARMENTS:

ENVIRONMENT: 7 m/s

POSITION: HANGING VERTICAL IN WIND TUNNEL.

HUMIDITY: 65

ENV. FLOW SPEED:

DIRECTION: From Front

CABLE LENGTH: Short (50ft)

ADDITIONAL INFORMATION:

STOP TIME: 14:55:40 MINUTES SINCE START OF TEST: 180.00

ENVIRONMENT TEMPERATURE:

INSTANTANEOUS: 7.07 AVERAGE OVER TEST TIME: 6.78

SECTION	SETPOINT (Deg C)	SKINTEMP (Deg C)	TEMP DIFF(Deg C) INSTANT	AVERAGE	POWER (WATTS) ST	LT	INSULATION (CLO) ST	LT
Head	30.00	30.00	22.93	23.22	43.38	43.48	0.4628	0.4675
Chest	30.00	30.13	23.05	23.37	5.59	6.73	4.1421	3.4882
Back	30.00	30.10	23.03	23.33	6.07	7.64	4.0707	3.2763
Abdomen	30.00	30.01	22.94	23.23	4.06	4.89	2.0013	1.6826
Buttocks	30.00	30.02	22.95	23.25	3.87	3.80	3.2941	3.3987
Right Arm	30.00	30.01	22.93	23.23	6.54	7.46	2.5696	2.2822
Left Arm	30.00	30.01	22.93	23.23	6.83	6.75	2.2093	2.2647
Right Hand	30.00	30.00	22.92	23.22	7.62	7.93	0.9528	0.9276
Left Hand	30.00	30.00	22.93	23.22	7.62	7.82	0.9358	0.9234
Right Leg	30.00	30.00	22.92	23.22	27.27	27.03	1.9320	1.9747
Left Leg	30.00	30.00	22.93	23.22	26.44	26.37	1.8570	1.8855
Right Foot	30.00	30.02	22.95	23.25	13.33	13.19	0.7609	0.7790
Left Foot	30.00	30.00	22.92	23.22	14.89	15.46	0.6693	0.6531
Overall					173.53	178.54	1.4801	1.4574

Total Power (W) For All Sections: 178.539

Total Area (Square Meters): 1.736

Overall Insulation Resistance (CLO): 1.4574

WindSonic

User Manual

Doc No. 1405-PS-0019

Issue 15

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Contents

1 FOREWORD

Thank you for purchasing the WindSonic manufactured by Gill Instruments Ltd. The unit has no customer serviceable parts and requires no calibration or maintenance. To achieve optimum performance we recommend that you read the whole of this manual before proceeding with use. Do NOT remove black "rubber" transducer caps.

Gill products are in continuous development and therefore specifications may be subject to change and design improvements without prior notice.

The information contained in this manual remains the property of Gill Instruments and should not be copied or reproduced for commercial gain.

2 INTRODUCTION

The Gill WindSonic wind sensor is a very robust, lightweight unit with no moving parts, outputting wind speed and direction. The units of wind speed, output rate and formats are all user selectable.

The WindSonic can be used in conjunction with a PC, datalogger or other device, provided it is compatible with one of the standard communication formats provided by the WindSonic.

WindSonic (option 2 or 3 only) is designed to connect directly to the Gill WindDisplay unit to provide a complete wind speed direction system without any configuration by the user.

WindSonic (options 1, 2 and 3) may be configured using WindCom software which is available, free of charge, from the Gill website www.gill.co.uk.

WindSonic (option 4) SDI-12 may not be re-configured in any Gill output format.

The output message format can be configured in Gill format, in Polar or UV (2-axis) format, and to either Polled (requested by host system) or Continuous output. Alternatively, it can be configured in NMEA (0183 Version 3) or SDI-12 (V1.3). These are described in Section 9 MESSAGE FORMATS and Section 11 SDI-12 COMMANDS.

3 FAST TRACK SET-UP

If you are in a hurry to try out the WindSonic (options 1, 2 or 3) and are familiar with Gill equipment and coupling to a PC using RS232, go to the following sections :

- Section 7 INSTALLATION
- Section 9 MESSAGE FORMATS
- Section 10 CONFIGURING

After you have successfully set up the WindSonic, we strongly advise that you then go back and read the rest of the manual to ensure that you get the best results from the WindSonic.

4 PRINCIPLE OF OPERATION

The WindSonic measures the times taken for an ultrasonic pulse of sound to travel from the North transducer to the South transducer, and compares it with the time for a pulse to travel from S to N transducer. Likewise times are compared between West and East, and E and W transducer.

If, for example, a North wind is blowing, then the time taken for the pulse to travel from N to S will be faster than from S to N, whereas the W to E, and E to W times will be the same. The wind speed and direction can then be calculated from the differences in the times of flight on each axis. This calculation is independent of factors such as temperature.

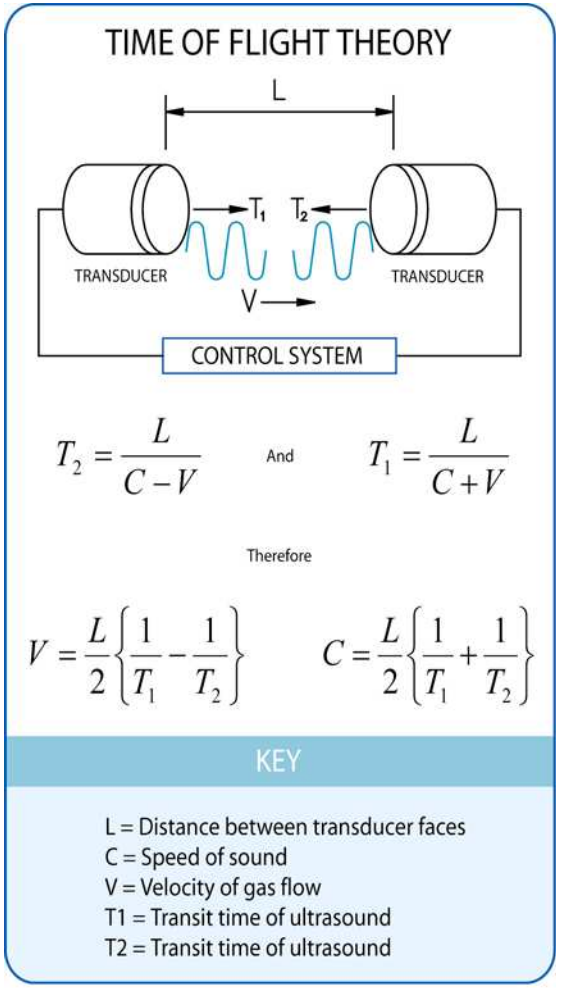


Figure 1 Time of Flight details

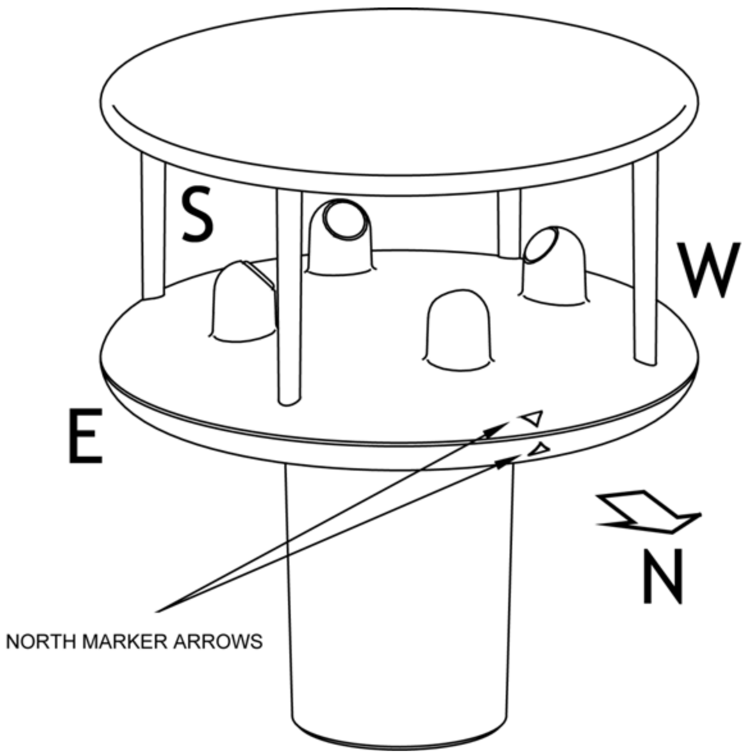


Figure 2 Compass Points

WindSonic Doc No 1405 PS 0019 Issue 15 August 2006

5 SPECIFICATION

Output		
Units of measure	Metres/second (m/s), Kilometres per hour (kph),	Knots, Miles per hour (mph), Feet per minute (fpm)
Output frequency	1, 2, or 4 outputs per second	
	Digital	Analogue
Parameters	Polar - Speed and Direction	Polar - Speed and Direction
or	UV - 2 axis, signed Speed	Tunnel - U Speed and U Direction
Wind Speed		0 – 5m/s, 0 – 10m/s, 0 – 20m/s,
Range	0 – 60 m/s	0 – 30m/s, 0 – 50m/s, 0 – 60m/s,
Accuracy	± 2% (at 12m/s)	± 2% (at 12m/s)
Resolution	0.01 m/s	0.01 m/s
Wind Direction		
Range	0 - 359°	0 - 359 ° or 0 - 539° (Wraparound mode)
Accuracy	± 3° (20m/s)	±3° (at 20m/s)
Resolution	1°	1°
Analogue output formats		
0-5V 4-20mA	± 1% of full scale N.B. Analogue output impedance = 1KΩ	
Digital output formats		
Gill	Continuous or Polled (output on request by host system) Polar (Speed and Direction) or UV (2 axis, signed Speed)	
Marine – NMEA	NMEA 0183 version 3	
Data Logger	SDI-12 V1.3	
Communication formats		
WindSonic Option 1	RS232	
WindSonic Option 2	RS232, RS422, RS485	
WindSonic Option 3	RS232, RS422, RS485, and Analogue (0 – 5V or 4 – 20mA)	
WindSonic Option 4	SDI-12 Note: WindSonic Option 4 is not compatible with WindCom	
Anemometer status	Status OK and Error codes included as part of standard output message	
Environmental		
Moisture protection	IP65	
Temperature	Operating -35°C to +70°C Storage -40°C to +80°C	
Humidity	Operating <5% to 100%	
EMC	EN 61000-6 - 3 (Emissions) EN 61000-6 - 2 (Immunity)	
Standards	Manufactured within ISO9001: 2000 quality system	

Power requirement	9 – 30 V DC. Current drain depends on variant i.e. RS232 approximately 14mA rising to 44mA for Analogue variant.
Mechanical	
Size / weight	142mm diameter x 160mm 0.5kg
Mounting	Pipe mounting 1.75 inches (44.45mm) diameter
Material	External - Acrylate Styrene Acrylonitrile, Polycarbonate blend.

6 PRE-INSTALLATION

6.1 Equipment supplied

Item		Quantity
WindSonic		1
Connector assembly comprising	9 Way connector	1
	Contacts	9
	Sealing Gland	1
	Washer	1
Washer shake proof		4
Screws – M5 stainless steel		4
User Manual		1

WindCom software is available free of charge from the Gill website – www.gill.co.uk

NOTE: WindSonic Option 1 – RS 232 output only
WindSonic Option 2 – RS 232, 422 & 485 output
WindSonic Option 3 – RS 232, 422, 485 & analogue output
WindSonic Option 4 – SDI-12

Optional extras:

Item	Part No
Cable 4 Pair (Option 3 & 4 WindSonic)	026-03156
Cable 3 Pair (Option 1 & 2 WindSonic)	026-02660
WindSonic connector (1 supplied as standard see above)	1405-PK-050
WindSonic Support Tube	1405-30-056

6.2 Packaging

Whilst the WindSonic is being moved to its installation site, the unit should be kept in its inner packaging. All the packaging should be retained for use if the unit has to be returned at any time, or if a self test is performed.

6.3 Installation requirements

Host system - One of the following:

- PC fitted with a suitable interface to match the chosen communication format (RS232, RS422, or RS485), compatible with the WindSonic option selected, and a suitable Terminal Emulation software package. (For example Hyperterminal for Windows™ 9x, Windows™ 2000 and XP or Terminal for Windows™ 3.n will normally be available on your PC.) WindCom is available from the Gill website.
- Gill WindDisplay (WindSonic option 2 or 3 only)
- Other equipment with input/output compatibility to the WindSonic Option selected.

  For example, Chart recorder or Data logger, using the WindSonic Analogue output or SDI-12 output.

Cable - To connect between the WindSonic and the host system

See Section 7.3 Cable type for cable specification.

- There are restrictions on the maximum cable lengths for correct operation.
- The cable should be routed up the inside of the mounting tube.

Mounting tube

- Standard tube 1.75 inches (44.45mm) Outside Diameter x 3mm wall thickness

  See Figure 3 in section 7.4 Alignment & Mounting Details
- For non-hostile environments, Aluminium tube can be used.
- For hostile environments, you should select a material suitable for the intended environment. For example, stainless steel 316 for marine use.

6.4 Cable Assembly

Open the pack of parts provided with the WindSonic or as 1405-PK-050

Strip the cable and solder the contact pins to the cores (please note that the connector supplies the correct strain relief for cables with an outside diameter of 6-12mm).

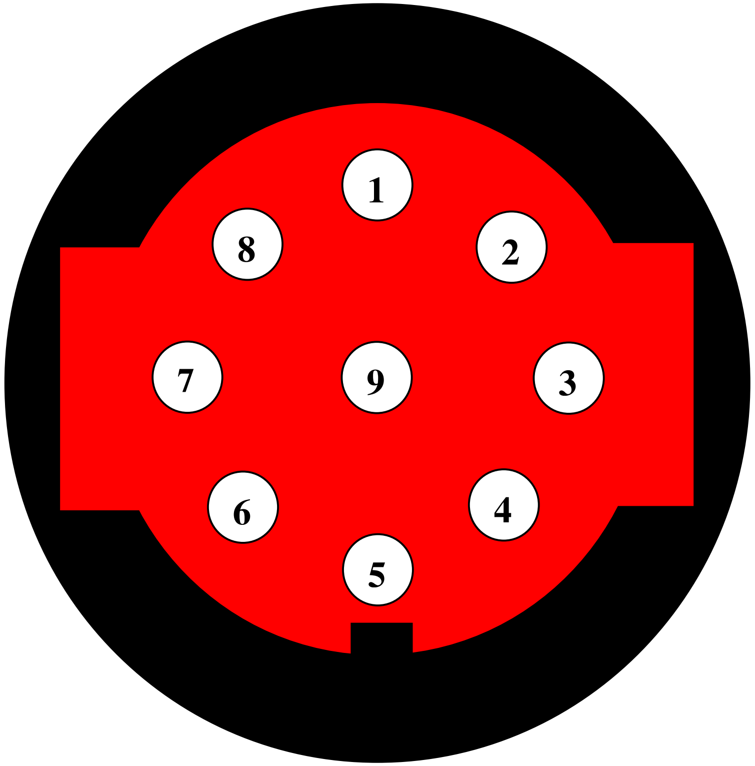
Put the parts on the cable in the order as shown below.

Whilst squeezing the red retainer in the direction of ARROWS A, pull in the direction of ARROW B.

Your connector should now resemble the connector in the picture below.

Insert each contact pin until you feel a slight click. If you have inserted the contact into the incorrect hole it can be removed at this point by simply pulling it out. Please note there will be some resistance.

Rear View of Connector



Continue to insert all of the contacts you require. Once all of the contacts are inserted push the red retainer into place. NB. The retainer can only be pushed back into place if the contacts are fully engaged.

Fit the connector to the WindSonic so that you can finish assembling the connector.

Screw the backshell onto the connector until it is fully in place. Please note that the final rotations can be slightly stiff.

Now screw the next part of the connector into place.

Now screw the cable-clamping nut into place.

The connector can now be removed from the WindSonic.

NOTE: To disassemble the connector, reverse this procedure.

6.5 WindCom

WindCom is available for the customer to download, free of charge, from the Gill Instruments Ltd website www.gill.co.uk.

WindCom features include:

- Data Display
- Data Logging
- Wind Alarms

NOTE: WindCom is not compatible with WindSonic Option 4 – SDI-12.

7 INSTALLATION

Do NOT remove the black "rubber" transducer caps. Warranty is void if the coloured security seal is damaged or removed.

7.1 Installation Guidelines

The WindSonic has been designed to meet and exceed the stringent standards listed in its specification. Operating in diverse environments all over the world, WindSonic requires no calibration and adjustment whatsoever.

As with any sophisticated electronics, good engineering practice should be followed to ensure correct operation.

- Always check the installation to ensure the WindSonic is not affected by other equipment operating locally, which may not conform to current standards, e.g. radio/radar transmitters, boat engines, generators etc.

  Guidelines –

  - Avoid mounting in the plane of any radar scanner – a vertical separation of at least 2m should be achieved.
  - Radio transmitting antennas, the following minimum separations (all round) are suggested
    - VHF IMM – 1m
    - MF/HF – 5m
    - Satcom – 5m (avoid likely lines of sight)
- Use cables recommended by Gill. If cables are cut and re-connected incorrectly (perhaps in a junction box) then EMC performance may be compromised if cable screen integrity is not maintained.
- Earth loops should not be created – wire the system in accordance with the installation guidelines.
- Ensure the power supply operates to the WindSonic specification at all times.

Avoid turbulence caused by surrounding structures that will affect the accuracy of the WindSonic such as trees, masts and buildings. The WMO make the following recommendations:

- The standard exposure of wind instruments over level open terrain is 10m above the ground. Open terrain is defined as an area where the distance between the sensor and any obstruction is at least 10 times the height of the obstruction.

7.2 Bench system test

Note : Prior to physically mounting the WindSonic in its final location, we strongly recommend that a bench system test is carried out to confirm the system is configured correctly, is fully functional and electrically compatible with the selected host system and cabling (preferably utilising the final cable length). The required data format, units, output rate, and other options should also all be set up at this stage.

7.3 Electrical

Cable

Cable type

A RS422 compatible cable should be used, with the number of twisted pairs matching the application.

Generic description – Twisted pairs with drain wire, screened with aluminised tape, with an overall PVC sheath. Wire size 7/0.2mm (24 AWG)

The table shows some suitable manufacturers' references; other manufacturers' equivalents can be used.

Application	No. of pairs	Gill ref.	Belden ref.	Batt electronics ref.
WindDisplay	2	-	9729	-
RS 232	3	026-02660	9730	91030
RS 422/485	4	026-03156	9728	91199
SDI-12	2	-	9729	-

Cable length

The maximum cable length is dependent on the chosen communication format (RS232, RS422 or RS485), the baud rate, and, to a lesser extent, on the cable type and the local electrical 'noise' level.

The table shows the typical maximum lengths at the given baud rates, using the recommended cable. If any problems of data corruption etc are experienced, then a slower baud rate should be used. Alternatively, a thicker or higher specification cable can be tried.

WindSonic Option	Communication format	Baud rate	Max. cable length
Option 1	RS232	9600	6.5 m (20 ft)
Option 2	RS422/485	9600	1 km (3200 ft)
Option 3	Analogue – Voltage o/p	N/A	6.5 m (20 ft)
	Analogue – Current o/p	N/A	Resistance dependent (max 300 Ω)
Option 4	SDI-12	1200	90m (300ft)

Power supply

The WindSonic requires a DC supply of between 9 – 30 V DC. Current drain depends on variant i.e. RS232 approximately 14mA rising to 44mA for Analogue variant.

Note that the relative polarity of the connection of the DC supply to the WindSonic can be reversed. This is used for options 2 & 3, when the unit is configured in AUTO mode, to select the communication format.

See Section 10 Configuring

Configuring Hyperterminal

Note – Other terminal emulators are configured in a very similar way.

1. Decide on an available Com port that you want to use (Usually Com1).
2. Run Hypertrm.exe (Typically accessed via Start →Programs →Accessories →Hyperterminal)
3. Create a New Connection (File → New Connection)
4. Enter a Name (eg WindSonic 1) .
5. Change 'Connect Using' to 'Direct to Com 1' (or other Com port as required)
6. Adjust the Port settings to match WindSonic settings. WindSonic default settings are :

Bits per second 9600 **Data bits** 8 **Parity** None
Stop bits 1 **Flow Control** (Handshaking) None

Example of message format:

□ Q, 229, 002.74, M, 00, □ 06

See Section 10 Configuring if you need to change WindSonic settings.

Auto Mode

WindSonic (options 1, 2 and 3) are factory configured in Auto Mode (E1). This facility enables the customer to select RS232 or RS422/RS485 output when available by changing the wiring on the mating connector, see the following sections for further details.

WindSonic option 4 SDI-12 is factory configured in SDI-12 mode, see Section 11 SDI-12 Commands for details.

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Connecting to a PC using RS232 (Options 1, 2 or 3)

Notes

1. Some PCs have a Serial RS232 interface and a suitable terminal emulation package already installed, which can easily be utilised with the WindSonic. (Hyperterminal for Windows™ 9x, Windows™ 2000 and XP or Terminal for Windows™ 3.n)
2. The cable length for reliable operation is limited to 6.5m (20ft).
   (See Section 7.3 Cable length.)
3. For longer cable runs, we recommend using the WindSonic configured with RS422 output, and a RS422/232 converter at the PC. *See Connecting to a PC using RS422.*

WindSonic 9 Way circular connector			**PC Typical 9 Way 'D' Connector**	
Signal names	**Pin nos.**	**Cable – 3 twisted pairs**	**Signal names**	**Pin nos**
TXD	5		RXD	2
RXD	7		TXD	3
Signal Ground	1		Signal Ground	5
Do NOT connect at this end	N/A	Screen and drain wires	Chassis ground	N/A
V supply	2		–	DC Power supply 9 – 30V
V supply	3		+	

NOTE: Options 2 and 3 only reverse the polarity of the DC power supply to select RS422 output.

Connecting to a Gill WindDisplay

For further details see Section 8 USING WITH THE GILL WINDDISPLAY, and the WindDisplay User Manual for the method of operation.

Notes

1. WindSonic Option 2 or 3 must be used.
2. Use the WindSonic in the factory default mode – i.e. do not reconfigure.
3. The WindDisplay can provide power to the WindSonic

WindSonic 9 Way circular connector			WindDisplay	
Signal names	**Pin nos.**	**Cable – 2 twisted pairs**	**Signal names**	**Terminal nos.**
TXD +	4		TXD +	8
TXD –	5		TXD –	7
Do NOT connect at this end	N/A	Screen and drain wires	Ground (Earth)	
V supply	2		+	2
V supply	3		O	1

Default Settings

The WindSonic is factory configured with the following default settings:

M2, U1, O1, L1, P1, B3, F1, H1, NQ, E3

See Section 10 Configuring for further details

Connecting to a PC using RS422 (Option 2 or 3)

WindSonic 9 Way circular connector			PC with RS422/232 converter
Signal names	**Pin nos.**	**Cable – 4 twisted pairs**	**Signal names**
TXD+	4		RXD +
TXD –	5		RXD –
RXD+	6		TXD +
RXD –	7		TXD –
Signal Ground	1		Signal Ground
Do NOT connect at this end	N/A	Screen and drain wires	Chassis ground
V supply	2		+ DC Power supply
V supply	3		– 9 – 30V

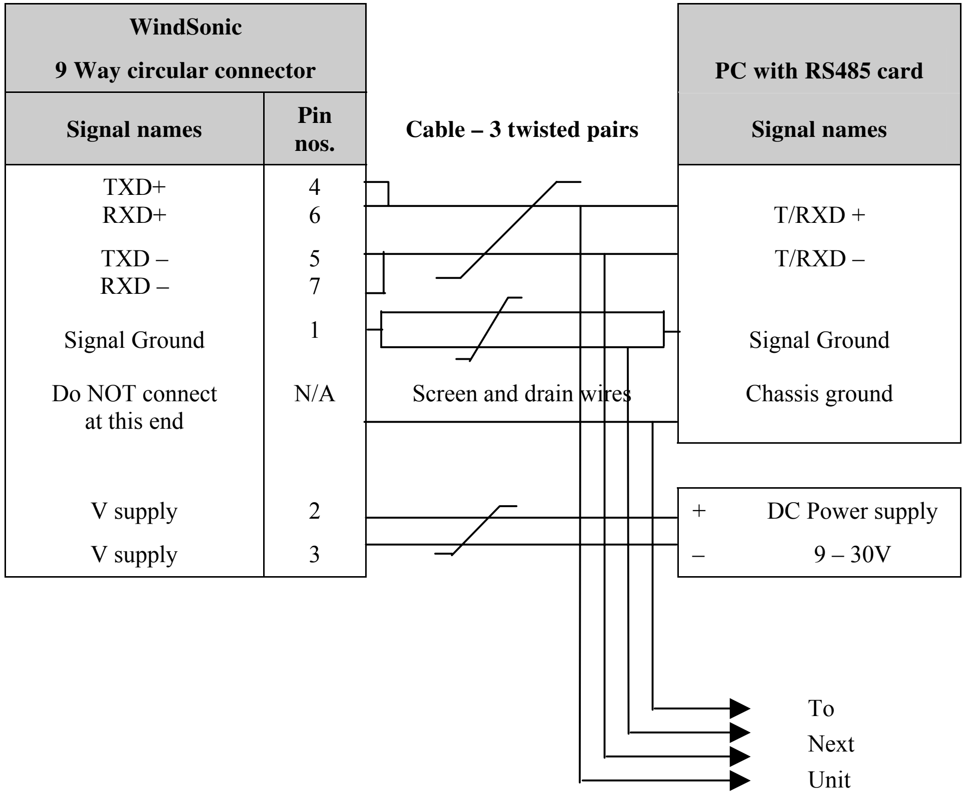
Configure the terminal emulator as previously described.

See Section 10 Configuring if you need to change WindSonic settings.

Networking using RS485 (Option 2 or 3)

Notes

1. Up to 10 WindSonic units can be "daisy chained".
2. WindSonics must be set in Polled mode, with each device given a unique node address.
   See Section 9.1 WindSonic node address.
3. Customers may poll using terminal software (NOT supplied).



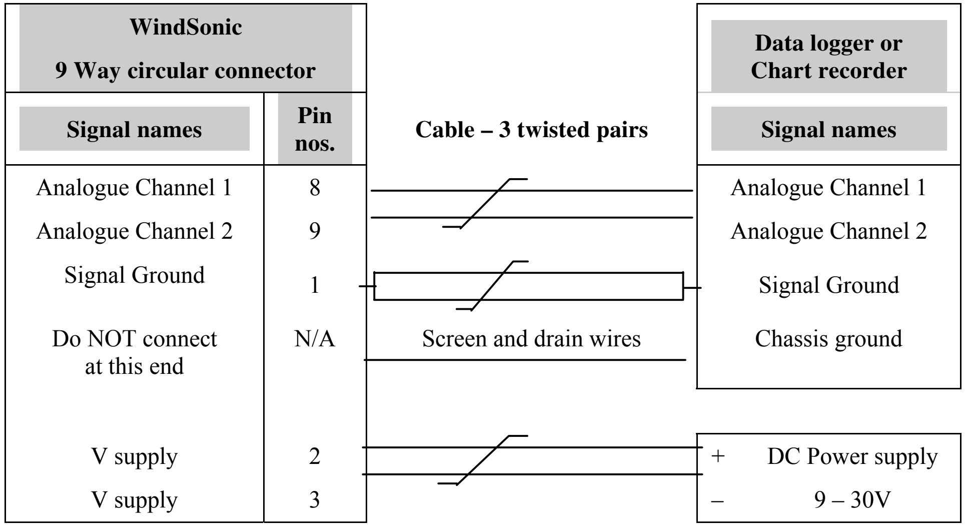
NOTE: Power needs to be supplied to each unit in the network

NOTE: WINDCOM will not work in polled mode

Using the Analogue Output (Option 3)

Notes

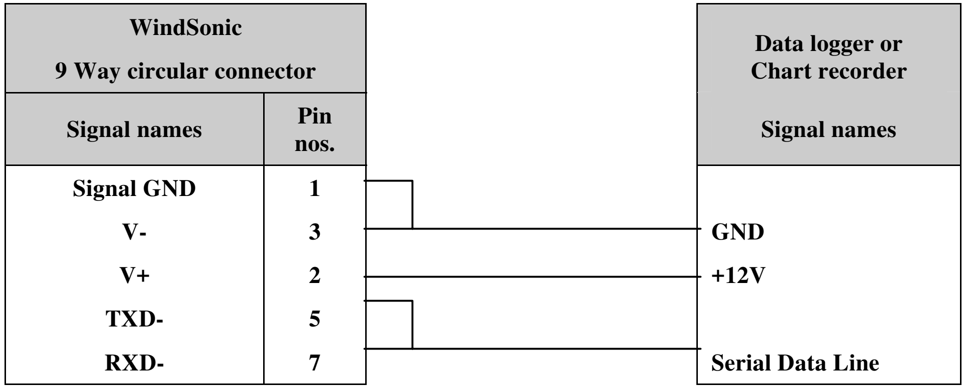
1. If the Current output is used, the total output load **MUST** be below 300 ohms, including the cable resistance.
2. The current output loads must be returned to Signal Ground.
3. Reconfiguration of the analogue output requires a digital connection (*See sections 9 & 10*)
4. In addition, the digital output can be connected if required using RS232, 422 or 485, as shown in the previous sections.



Note: Power supply connections above provide for analogue and RS422 outputs.

Reverse wires on pins 2 and 3 for analogue and RS232 output.

Connecting to an SDI-12 Interface (Option 4)



7.4 Mechanical

Before installing, see note at Section 7.2 Bench system test.

Orientation

Normally the WindSonic is mounted on a vertical tube, ensuring a horizontal Measuring Plane.

See Figure 3 Alignment & Mounting details

For indoor use the unit may be mounted with the Measurement Plane set to any required orientation.

Alignment

The WindSonic should be aligned to point to North, or any other reference direction –for example, the bow of a boat.

There are two arrows, a coloured rectangle, and an alignment notch to aid alignment.

See Figure 3 Alignment & Mounting Details

Note : It is usually simpler to work first with a compass at ground level and identify a suitable landmark and its bearing.

Mounting

The support tube requires three 3 equally spaced holes, tapped M5, 7.5mm from the top of the tube. Pass the cable (fitted with the 9 way Clipper plug) through the tube.

Note: the customer must fit appropriate strain relief to the cable.

Connect the plug by twisting it whilst pushing it gently into the socket on the WindSonic. When it locates, twist the outer sleeve clockwise to connect and lock the plug.

Fix the WindSonic to the tube using the 3 stainless steel screws provided. (Maximum mounting screw torque 4 Nm.)

It is the responsibility of the customer to ensure that the WindSonic is mounted in a position clear of any structure which may obstruct the airflow or induce turbulence.

Do NOT mount the WindSonic in close proximity of high powered radar or radio transmitters. A site survey may be required if there is any doubt about the strength of external electrical noise.

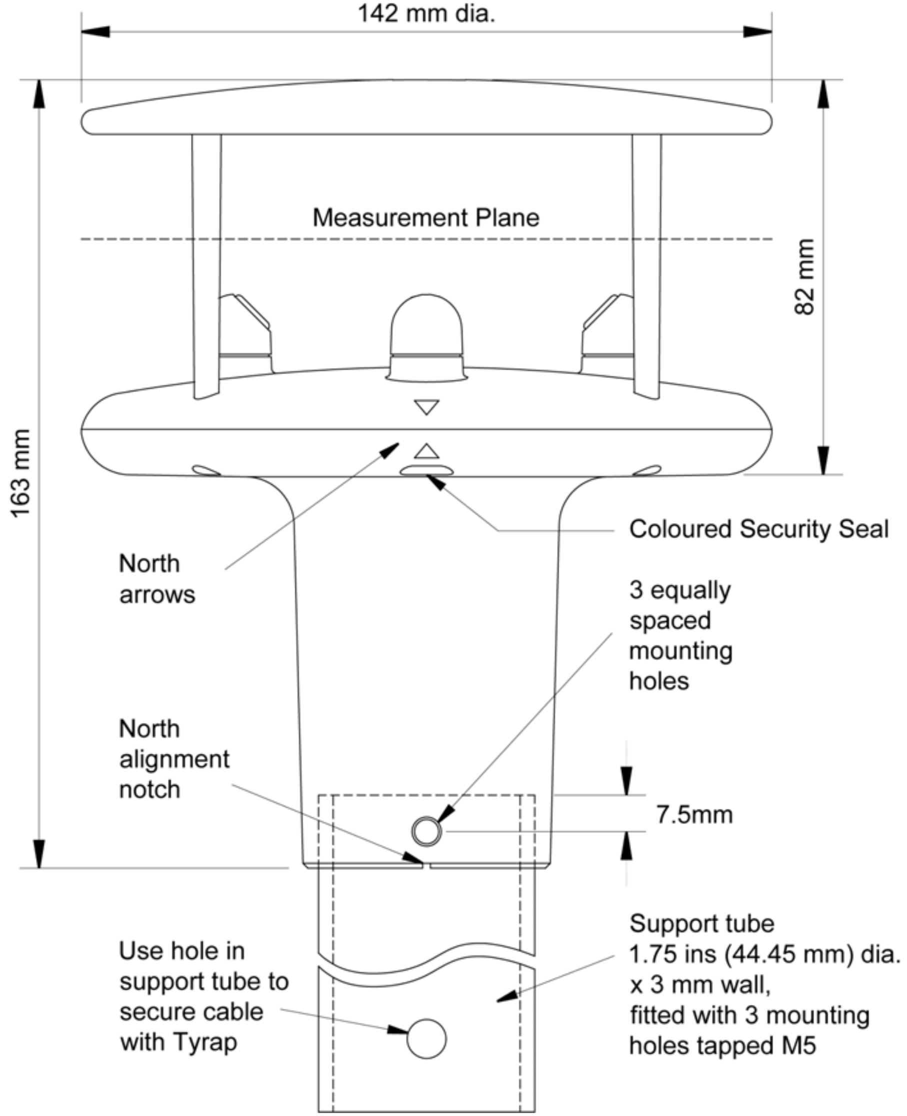


Figure 3 Alignment & Mounting details

8 USING WITH THE GILL WindDisplay

The WindSonic is designed to link directly to the Gill WindDisplay unit to provide a complete wind speed and direction system.

After coupling to a WindDisplay, the Wind Speed units and the Averaging period can be selected using the WindDisplay controls. *See the WindDisplay User Manual.*

Important :

- WindSonic Option 2 or 3 must be used, connected as shown in Section 7.3 Connecting to a Gill WindDisplay.
- The WindSonic must be used as supplied, set to the factory default settings. It must **NOT** be reconfigured.
- Note that although the WindDisplay can display wind speed in various units, these are calculated within the WindDisplay. The data coming to the WindDisplay must be in metres/sec (ie the factory default output setting).

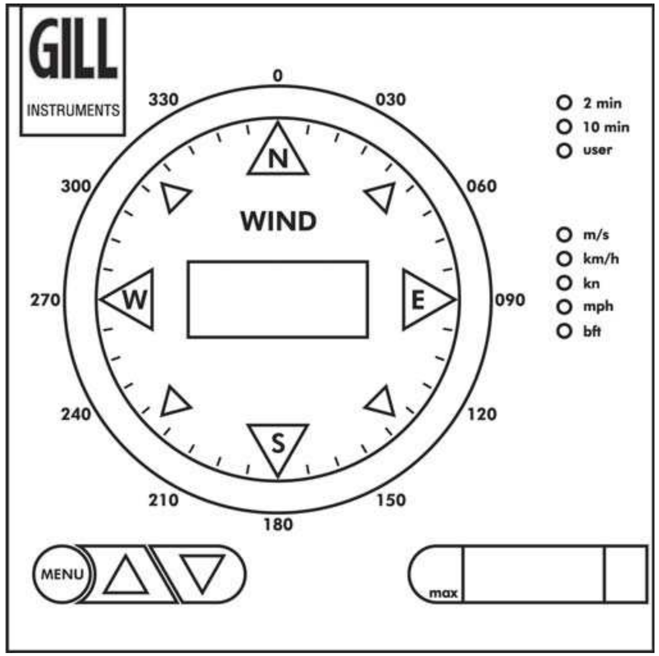


Figure 4 WindDisplay

9 MESSAGE FORMATS

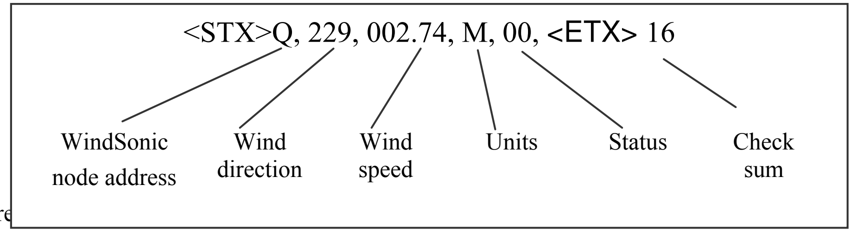
On applying power to the WindSonic, it will provide wind measurements in one of the following formats:

- Gill – Polar, Continuous (**default format**)
- Gill - UV, Continuous
- Gill – Polled (Polar or UV)
- NMEA
- SDI-12 (Polled)

Each of these is described below.

Information on how to change the formats and settings follows in Section 10 CONFIGURING. If you purchased a WindSonic Option 4 SDI-12 refer to Section 11 SDI-12 COMMANDS. Sections 9 and 10 do NOT apply to WindSonic Option 4 SDI-12.

9.1 Gill format– Polar, Continuous (Default format)



Where

<STX>	=	Start of string character (ASCII value 2)
WindSonic node address	=	Unit identifier
Wind direction	=	Wind Direction
Wind speed	=	Wind Speed
Units	=	Units of measure (knots, m/s etc)
Status	=	Anemometer status code (*see Section 12.5 for further details)*
<ETX>	=	End of string character (ASCII value 3)
Checksum	=	This is the EXCLUSIVE – OR of the bytes between (and not including) the <STX> and <ETX> characters.

WindSonic node address

The default setting is ‘Q’. If there is more than one WindSonic in a network, the others must be renamed (R to Z), so that each WindSonic is uniquely identified.

Wind direction

Indicated in degrees, from 0 to 359°, with respect to the WindSonic North marker.

In fixed field mode and when the wind speed is below 0.05 metres/sec, the direction will not be calculated, but the last calculated direction above 0.05 m/s will be output.

Wind speed and units

Shows the Wind Speed in the Measurement Plane *(See Figure 3 Alignment & Mounting details)* in one of the following units:

Units	Identifier
Metres per second (default)	**M**
Knots	N
Miles per hour	P
Kilometres per hour	K
Feet per minute	F

Status

This indicates either

	Correct operation	Code 00
or	Error codes	*See Section 12.5 for explanation of codes.*

Checksum

This enables the host system to check that the data has been correctly received. This is the EXCLUSIVE – OR of the bytes between (and not including) the <STX> and <ETX> characters.

Output rate (not displayed)

The WindSonic samples continuously and delivers wind information at 1 (default setting), 2, or 4 outputs / second.

9.2 Gill format – UV, Continuous

In this mode, the output is given as signed (ie. positive or negative) speeds along the 'U' (= South – North) axis and the 'V' (= East – West) axis.

<STX>Q, +001.59, - 002.74, M, 00, <ETX> 2D

WindSonic node address | U axis speed and polarity | V axis speed and polarity | Units | Status | Check sum

Where:

<STX>	=	Start of string character (ASCII value 2)
WindSonic node address	=	Unit identifier
U axis	=	speed & polarity
V axis	=	speed & polarity
Units	=	Units of measure (knots, m/s etc)
Status	=	Anemometer status code (*see Section 12.5 for further details)*
<ETX>	=	End of string character (ASCII value 3)
Checksum	=	This is the EXCLUSIVE – OR of the bytes between (and not including) the <STX> and <ETX> characters

The WindSonic unit identifier, Units, and Checksum are as described in Section 9.1 above.

Figure 4 shows the polarity of U and V if the wind components along the U and V axis are blowing in the direction of the respective arrows.

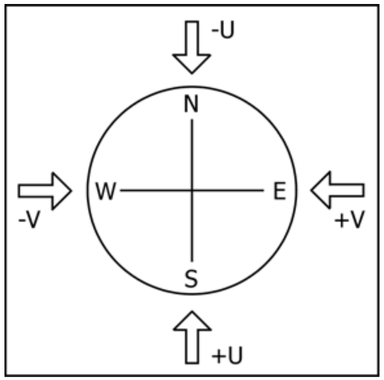


Figure 4 UV Polarity

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9.3 Gill format – Polled (Polar or UV)

When in the Polled mode, an output is only generated when the host system sends a Poll signal to the WindSonic consisting of the WindSonic Unit Identifier – that is, the relevant letter Q – Z.

The output formats are otherwise as described in Sections 9.1 and 9.2.

The commands available in this mode are :

Description	Command	WindSonic response
WindSonic Unit Identifier	Q ….. Z	Wind speed output generated
Enable Polled mode	?	(none)
Disable Polled mode	!	(none)
Request WindSonic Unit Identifier	&	Q ….. Z (as configured)
Enter Configuration mode	*<N>	CONFIGURATION MODE

Where <N> is the unit identifier (See Section 10.13).

9.4 NMEA Format

$ IIMWV, 120, R, 002.10, M, A*5D

Start of string | Instrument type | Wind direction | Relative wind measurement | Wind speed | Units | Status | Check sum

The **Wind Direction, Wind Speed,** and **Units** are as described in Section 9.1.

The **Instrument Type** – IIMWV - is a mnemonic for Integrated Instrument Mean Wind direction & Velocity.

The **Status** codes are :

A Valid measurement
V Invalid measurement

A typical WindSonic configuration suitable for NMEA (See Section 10):

M5, U1, O1, L1, P1, B2, F1, H1, NQ, E1

Consult specification NMEA 0183 version 3 (available on the web) for complete interface details.

9.5 Analogue outputs and options

Note : Analogue outputs are only available from WindSonic Option 3.

Voltage or Current output

The WindSonic (Option 3) can be configured for either Voltage (0 – 5 V) or Current (4 – 20 mA) outputs.

Important :

1. When using the current outputs, the load resistance between the Analogue outputs (Pins 8 & 9) and Signal Ground must be <= 300 ohms, including cable resistance.
   This is to ensure that the voltage levels on Pins 8 & 9 do not exceed 5V.
2. The current outputs must be returned to Signal Ground (Pin 1).

Polar and Tunnel modes

If the WindSonic is configured in Gill Polar mode or NMEA mode, the analogue outputs will be in Polar mode.

If the WindSonic is configured in Gill UV mode, the analogue outputs will be in 'Tunnel' mode.

Analogue outputs	Polar mode	Tunnel mode
Channel 1 (Pin 8)	Wind speed	U speed
Channel 2 (Pin 9)	Wind direction	U direction

Polar mode direction wraparound

The Wind Direction in Polar mode can be configured for either Standard (0 - 359°) or Wraparound (0 - 539°) options. If the Standard mode is used with a chart recorder, large swings of the recorder pen will be experienced each time the wind direction passes between 0 and 359°. Using the Wraparound mode, when the wind first changes from 0° to 359°, there will be a step change on the output, but after this first time the output will change smoothly each time the wind passes through 360°. (Similarly, the first time the wind veers from 539° to 180°, there will be a step change, after which the output will change smoothly).

Wind direction (degrees)	Voltage output (V)		Current output (mA)	
	Standard	Wraparound	Standard	Wraparound
0	0	0	4.00	4.00
180	2.5	1.67	12.00	9.33
360	5.0	3.33	20.00	14.67
540	n/a	5.0	n/a	20.00

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Low wind speeds in polar mode

Whilst the wind speed is below 0.05 metres/sec, the wind direction will not be calculated. In CSV mode, the Channel 2 output will switch between 0 and 5V (or 4 and 20mA) at the output rate selected.

In fixed field mode, the last valid direction will be output until a new value can be calculated.

Wind Speed scaling

The Wind Speed output can be configured such that full-scale output represents 5, 10, 20, 30, 50 or 60 metres/sec.

In all cases zero Wind Speed is represented by 0V or 4mA.

Tunnel mode

When configured in Tunnel mode, Channel 1 output represents the wind speed along the U axis (South – North) scaled as described above.

Channel 2 gives the direction of the wind along the U axis, where a –U vector (= wind from the N direction) is represented by 0V (or 4mA), and a +U vector is represented by 5V (or 20mA).

10 CONFIGURING

WindCom may be used to configure WindSonic, alternatively, the user may elect to use another terminal emulator package.This section describes the commands used to change User and Communications settings.

10.1 Entering Configuration mode

From Continuous mode	**From Polled mode**
*	* <N>
	where <N> is the Unit identifier

The WindSonic responds with a CONFIGURATION MODE message, stops reporting wind measurements, and waits for a command (as detailed below).

10.2 Returning to Measurement mode

Q ENTER

The WindSonic responds with wind measurements immediately when in Continuous mode, or on receipt of a Poll signal when in Polled mode.

10.3 Checking the configuration

We recommend that, as a standard procedure, you use this command prior to, and after, changing any settings. It shows the current settings for all the alterable settings.

*

D 3 ENTER

The WindSonic responds with the default settings shown below:

M2, U1, O1, L1, P1, B3, F1, H1, NQ, E1

We suggest you note down the settings, so that you can easily return to them.

Return to measurement mode

Q ENTER

All of these settings are explained in the following sections.

10.4 Changing a setting

To change a setting, refer to the sections below, and enter the command of the new setting required, followed by ENTER . If successful, the new setting will be sent as a message by the WindSonic.

For example, to change the message format to NMEA, enter M 5 ENTER

The WindSonic will reply M5. When the unit is returned to the Measurement mode, it will be in NMEA format.

Note : The factory-set (default) settings are shown in **bold** in the following sections.

10.5 Measurement settings

Item	Options	Command
Message format	Gill, UV, Continuous	M1
	Gill, Polar, Continuous	**M2**
	Gill, UV, Polled	M3
	Gill, Polar, Polled	M4
	NMEA	M5

10.6 Output Units

Item	Options		Command
Output units	**Metres per second**	**(M)**	**U1**
	Knots	(N)	U2
	Miles per hour	(P)	U3
	Kilometres per hour	(K)	U4
	Feet per minute	(F)	U5

10.7 ASCII output format

Item	Options	Command
ASCII output format	**Comma separated format (CSV)**	**O1**
	Fixed field	O2

10.8 Message Terminator

Item	Options	Command
Message terminator	**<CR> <LF>** <CR>	**L1** L2

10.9 Output Rate

Item	Options	Command
Output rate	**1 per second** 4 per second 2 per second	**P1** P2 P3

10.10 Baud rate

Item	Options	Command
Baud rate	2400 4800 **9600** 19200 38400	B1 B2 **B3** B4 B5

If a request is sent to change the Baud rate, before it changes it must be confirmed by entering B ENTER at the new Baud rate.

eg. If set to B3 (9600 baud), to change to B5 (38400 baud), enter B 5 ENTER , change host terminal to 38400 baud, and confirm by entering B ENTER.

NOTE: a random echo will be generated after the B5 confirmation

10.11 Data and parity options

Item	Options	Command
Data and parity options	**8 bits, no parity**	**F1**

10.12 Power-up Message

Item	Options	Command
Power –up message	**ON** OFF	**H1** H2

If the power up message is On, then a message similar to that below is output, whenever the unit goes into Measurement mode (ie. when power is first applied to the unit, or unit returns to Measurement mode from Configuration mode).

WINDSONIC (Gill Instruments Ltd)
FIRMWARE: 2231 - 102
RS232 (CFG) RS 232(Auto)
CHECKSUM ROM 9F5E 9F5E *PASS*
CHECKSUM FAC 04F4 04F4 *PASS*
CHECKSUM ENG 0824 0824 *PASS*
CHECKSUM CAL DFBF DFBF *PASS*

If any of these checksums fail, the word PASS will be replaced by FAIL and the unit will use its default settings. If the checksum repeatedly fails after power on – contact your supplier.

NOTE: The exact message above will vary.

10.13 Node Address

Item	Options	Command
Node Address	**Q……..Z**	**N<Q>**

10.14 Communications Protocol

Item	Options	Command
Communications protocol	**AUTO** RS422 / RS485 RS232	**E1** E2 E3

Changes must be confirmed by entering E ENTER.

e.g. If set to E1 (AUTO), to change to E2 (RS422/RS485), enter E 2 ENTER, change over the communications wiring (unit must remain powered up) and then confirm in terminal package by entering E ENTER.

10.15 Analogue settings

The following commands are only valid for the WindSonic Option 3 :

Item	Options		Command
Voltage or Current output	**0 - 5 Volt**		**T1**
	4 – 20 mA		T2
Analogue range	0 – 10 metres per second		S1
	0 – 20 metres per second		S2
	0 – 30 metres per second		**S3**
	0 – 50 metres per second		S5
	0 – 60 metres per second		S6
	0 – 5 metres per second		S7
	Analogue output disabled		S9
Analogue Wraparound	Wrap around	0 – 539°	C1
	Normal	**0 - 359°**	**C2**

Where:

Analogue range	=	Customer selected range
Analogue wraparound	=	Chart recorder facility
Voltage or current output	=	Output type

Polar mode direction calculation

The system will not calculate a wind direction when the measured velocity falls below 0.05m/s. When configured for fixed field mode the direction output will hold the last setting until a new direction can be calculated. If the unit is in CSV mode, the output will switch between 0 and 5V (or 4 to 20mA) at the output rate selected.

Magnitude scaling

The magnitude output can be scaled such that the full scale output represents either 5, 10, 20, 30, 50 or 60ms^{-1}.

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Error conditions

If a valid wind measurement cannot be calculated (for example all paths blocked), the outputs 1 and 2 will switch between 0 and 5V (or 4 to 20mA) at the output rate selected.

Disabled outputs

If the analogue outputs are not required, they can be disabled (Command S9).

10.16 Configuration / Diagnostic Information

Each of these commands causes a response from the WindSonic.

Item	Command	Response
Type and serial No.	D1	TYPE: Y SERIAL NO.: 012345
Software version	D2	FIRMWARE: 2231-102
Unit configuration	D3	M2,U1,O1,L1,P1,B3,F1,H1,NA,E3,
Analogue ID (if present)	D4	EXP MOD ID: 0 D4 = 0 (No Analogue outputs) D4 = 1 (Analogue outputs enabled)
Self test	D6	*See Section 13.2 Self-Test (Still Air)*

11 SDI-12 COMMANDS

WindSonic Option 4 complies with SDI-12 Interface Standard V1.3

We advise that you download the full SDI-12 specification from www.sdi-12.org

All other commands not defined below respond with a ‘zero data values ready’ response.

All units of measurement are in metres per second. This cannot be re-scaled.

Name	Command	Gill Output
Continuous Measurement (Polar)	aR0!	a<dir><mag><status><CR><LF>
Continuous Measurement (UV)	aR1!	a<U><V><status><CR><LF>
Continuous Measurement with CRC (Polar)	aRC0!	a<dir><mag><status><CRC><CR><LF>
Continuous Measurement with CRC (UV)	aRC1!	a<U><V><status><CRC><CR><LF>
Start Measurement (Polar)	aM!	a0003
Send Data	aD0!	a<dir><mag><status><CR><LF>
Start Measurement (UV)	aM1!	a0003
Send Data	aD0!	a<U><V><status><CR><LF>
Start Measurement with CRC (Polar)	aMC!	a0003
Send Data	aD0!	a<dir><mag><status><CRC><CR><LF>
Start Measurement with CRC (UV)	aMC1!	a0003
Send Data	aD0!	a<U><V><status><CRC><CR><LF>
Acknowledge Active	a!	a<CR>< LF>
Send Identification	aI!	a13GillInst 1405 SDI v101 <sn><CR><LF>
Change Address	aAb!	b<CR><LF>
Address Query	?!	a<CR><LF>
Measurement on demand	aXLPM!	0LP<CR><LF>
Continuous Reading	aXHPM!	0HP<CR><LF>
	Default operating mode aXHPM!	

Gill Output Message Format

a13GillInst 1405 SDIv***

SDI-12 address	SDI-12 version	Gill Model No	Gill WindSonic Software Version

***** Software Version may change**

12 MAINTENANCE & FAULT-FINDING

12.1 Cleaning

If there is any build up of deposit on the unit, it should be gently cleaned with a cloth moistened with soft detergent. Solvents should not be used, and care should be taken to avoid scratching any surfaces. The unit must be allowed to defrost naturally after being exposed to snow or icy conditions, do NOT attempt to remove ice or snow with a tool.

Do NOT remove black "rubber" transducer caps.

12.2 Servicing

There are no moving parts or user-serviceable parts requiring routine maintenance.

Opening the unit or breaking the security seal will void the warranty and the calibration.

In the event of failure, prior to returning the unit to your authorised Gill distributor, it is recommended that :

1. All cables and connectors are checked for continuity, bad contacts, corrosion etc.
2. A bench test is carried out as described in Section 13.1.
3. You contact your supplier for advice

12.3 Fault Finding

Symptom	Solution
No output	Check DC power to WindSonic, cable and connections. Check comms settings of WindSonic (*as detailed in Section 10)* and host system match, including correct Com port Check unit is in Continuous mode Check that in-line communication devices are wired correctly. NOTE: It is usual for Anemometer TX + to be connected to converter device RX +
Corrupted output	Check comms settings of WindSonic and host system match. Try a slower baud rate. Check cable lengths and type of cable.
One way communication	Check WindSonic and host system are both set to the same protocol RS232, RS422, or RS485. Check wiring is in accordance with the manual.
Failed / Incorrect WindSonic ouput, data invalid flag	Check that transducer path is not blocked

12.4 Returning Unit

If the unit has to be returned, it should be carefully packed in the original packaging and returned to your authorised Gill distributor, with a full description of the fault condition.

12.5 Status

The Status code is sent as part of each wind measurement message.

Code	Status	Condition
00	**OK**	**Sufficient samples in average period**
01	Axis 1 failed	Insufficient samples in average period on U axis
02	Axis 2 failed	Insufficient samples in average period on V axis
04	Axis 1 and 2 failed	Insufficient samples in average period on both axes
08	NVM error	NVM checksum failed
09	ROM error	ROM checksum failed
10	System gain at maximum	Wind velocity reported could be in error
A	-	NMEA data valid
V	-	NMEA data invalid

13 TESTS

13.1 Bench test

1. Couple the WindSonic to the host system and power supply, using a known working test cable.
2. Check that the unit is correctly configured by going into Configuration mode and using D3 *See Section 10.3 Checking the configuration.*
3. Check for normal output data, and that the Status Code is OK – 00 (or A for NMEA format).
4. If the status code is other than 00, refer to Section 12.5 Status (error) codes.
5. Use an office fan or similar to check that the unit is sensing wind, turning the unit to simulate changing wind direction and to check that both axes are functioning.
6. Note that this a quick functional test. There are no calibration adjustments; the unit is designed NOT to require re-calibration within its lifetime.

13.2 Self-Test (Still Air)

This test checks Alignment, Gain and Checksums.

Alignment tests : The unit performs a transducer geometry check and compares the result with its factory setting.

Gain tests : The unit performs a check of its operating gain against its factory setting.

Checksum tests : The unit performs a check of its program and data memory.

Important *This test is a stringent laboratory test which will only be passed if carried out under still air conditions at room temperature (17-23˚C). NOTE: Option 4 SDI-12 units must be in Gill mode for the self test to function (see Section 11) .*

1. Use the original packing box (inner and outer) to enclose the unit. (The packaging is designed as a zero wind enclosure).
2. Go into Configuration Mode * ENTER .
3. Carry out the Self-test by entering D 6 ENTER .

   A message similar to that shown below will be generated :

   ALIGNMENT LIMITS:0D59,0CF5
   ALIGNMENT U:OD15 *PASS*
   ALIGNMENT V:OD16 *PASS*
   GAIN 0:0001 *PASS*
   GAIN 1:0001 *PASS*
   GAIN 2:0001 *PASS*
   GAIN 3:0001 *PASS*
   CHECKSUM ROM:AB7D AB7D *PASS*
   CHECKSUM FAC:04F4 04F4 *PASS*
   CHECKSUM ENG:082A 082A *PASS*
   CHECKSUM CAL:A9C1 A9C1 *PASS*

   For each of the Alignment and Gain tests a Pass or Refer to Manual message is generated.

   For each of the Checksum tests a Pass or Fail message is generated.

4. If any of the tests fail, contact your supplier.

   If a “refer to manual” message appears please *see Section 12.3 Fault Finding.*

   Note that it will only pass if the specified temperature and zero wind conditions are met.
   Check that there are no visible obstructions or damage to the unit before contacting Gill or your authorised distributor for further advice.

13.3 Calibration

A Custom calibration is available from Gill Instruments. This must be specified at the time of order or the unit must be returned to Gill Instruments for retrospective calibration.

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14 APPENDICES

14.1 Glossary & Abbreviations

Item	Meaning
CAL	Calibration
CR	Carriage Return
CSV	Comma Separated Variable
ENG	Engineering
FAC	Factory
KPH	Kilometres per Hour
LF	Line Feed
MPH	Miles per Hour
NMEA 0183 (version 3)	National Marine Electronics Association standard for interfacing marine electronic navigational devices
NVM	Non-Volatile Memory
PC	IBM compatible Personal Computer
ROM	Read Only Memory
RS232	Communications standard
RS422	Communications standard
RS485	Communications standard
RXD	Received Data
TXD	Transmitted Data
SDI-12	Serial – Data Interface standard for microprocessor based sensors
WMO	World Meteorological Organisation

14.2 Guarantee

For terms of guarantee contact your supplier.

Warranty is void if the coloured security seal is damaged or broken, or the transducer caps have been damaged.

14.3 Electrical Conformity

EC DECLARATION OF CONFORMITY
ACCORDING TO COUNCIL DIRECTIVE
89/336/EEC

We, Gill Instruments Ltd., declare under our sole responsibility that the products :

WindSonic Ultrasonic Anemometer – Options 1, 2 , 3 and 4

Manufactured by : Gill Instruments Ltd

to which this declaration relates, are in conformity with the protection requirements of Council Directive 89/336/EEC on the approximation of the laws relating to electromagnetic compatibility.

This Declaration of Conformity is based upon compliance of the product with the following harmonised standards:

Emissions EN61000 - 6 -3
Immunity EN61000 - 6 -2 *
* Excluding 150kHz to 250kHz Conducted Immunity

Signed by:

A.C.R. Stickland – Director

Date of issue: 30/5/2003

Place of issue: Gill Instruments Ltd
Saltmarsh Park, 67 Gosport Street,
Lymington, SO41 9EG, UK

Operator's Manual

For

NEMO

Revised 7 April 2007

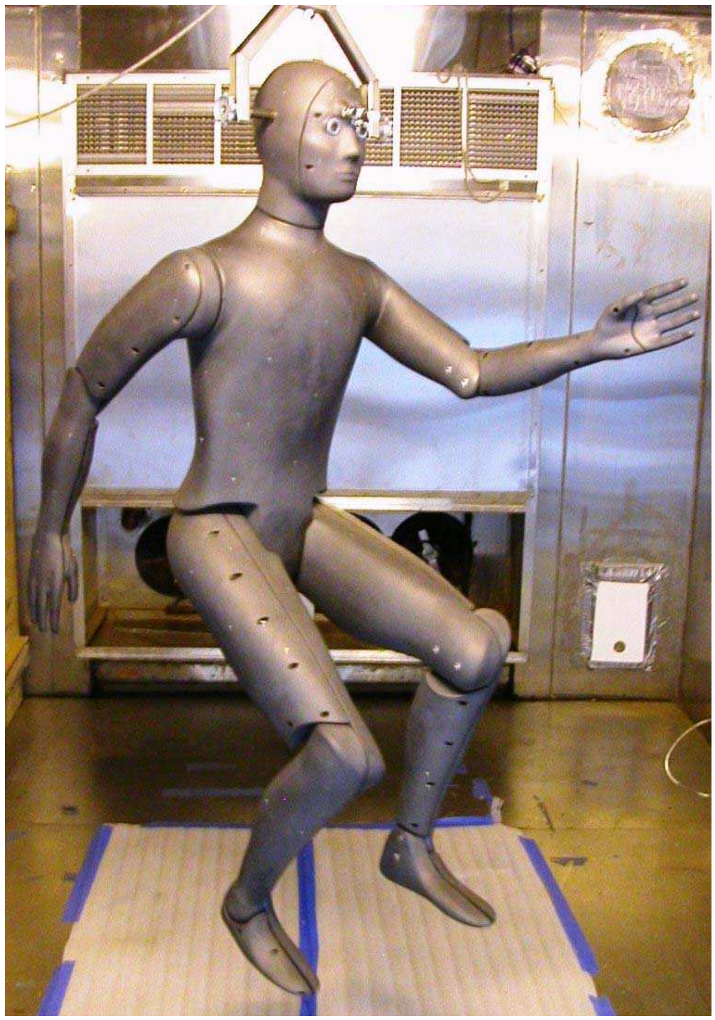

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Table of Contents

Section 1.0 - System Description

1.1 - Manual Overview

This manual describes the features, operation, and maintenance of NEMO, a 23-zone Submersible Thermal Manikin. Before using the system, it is highly recommended to read Section 1.4 and 1.5 about System Startup and Important Precautions.

1.2 - System Description

The major components of NEMO are shown schematically in Figure 1.2.1 below and in greater detail in Appendix B in the system drawings. These components include:

- Thermal Manikin with heaters, sensors, and internal controllers for regulation and monitoring
- Power Supply Enclosure including air pressure regulator
- Ambient Sensors (2 temperature, 1 RH, 1 windspeed)
- Interconnect cabling and air pressure supply hose
- Laptop PC w/ ThermDAC Control Software

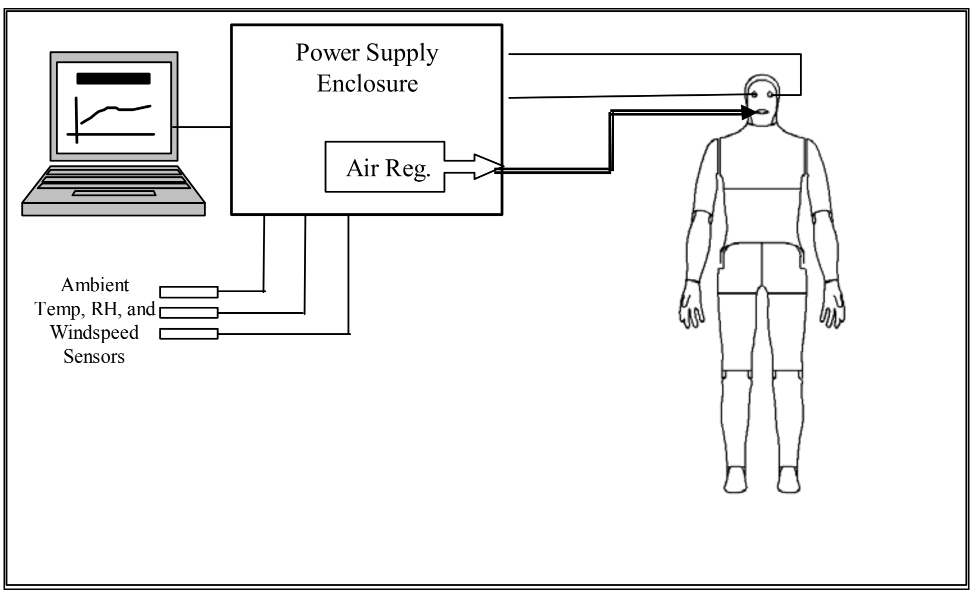


Figure 1.2.1 Thermal Manikin System Block Diagram

The manikin consists of 23 independently heated thermal zones (shown in Figure 1.2.2). All thermal zones are fit with heaters to generate uniform heating of the aluminum shell and 2 precision thermistors each for measuring skin temperature.

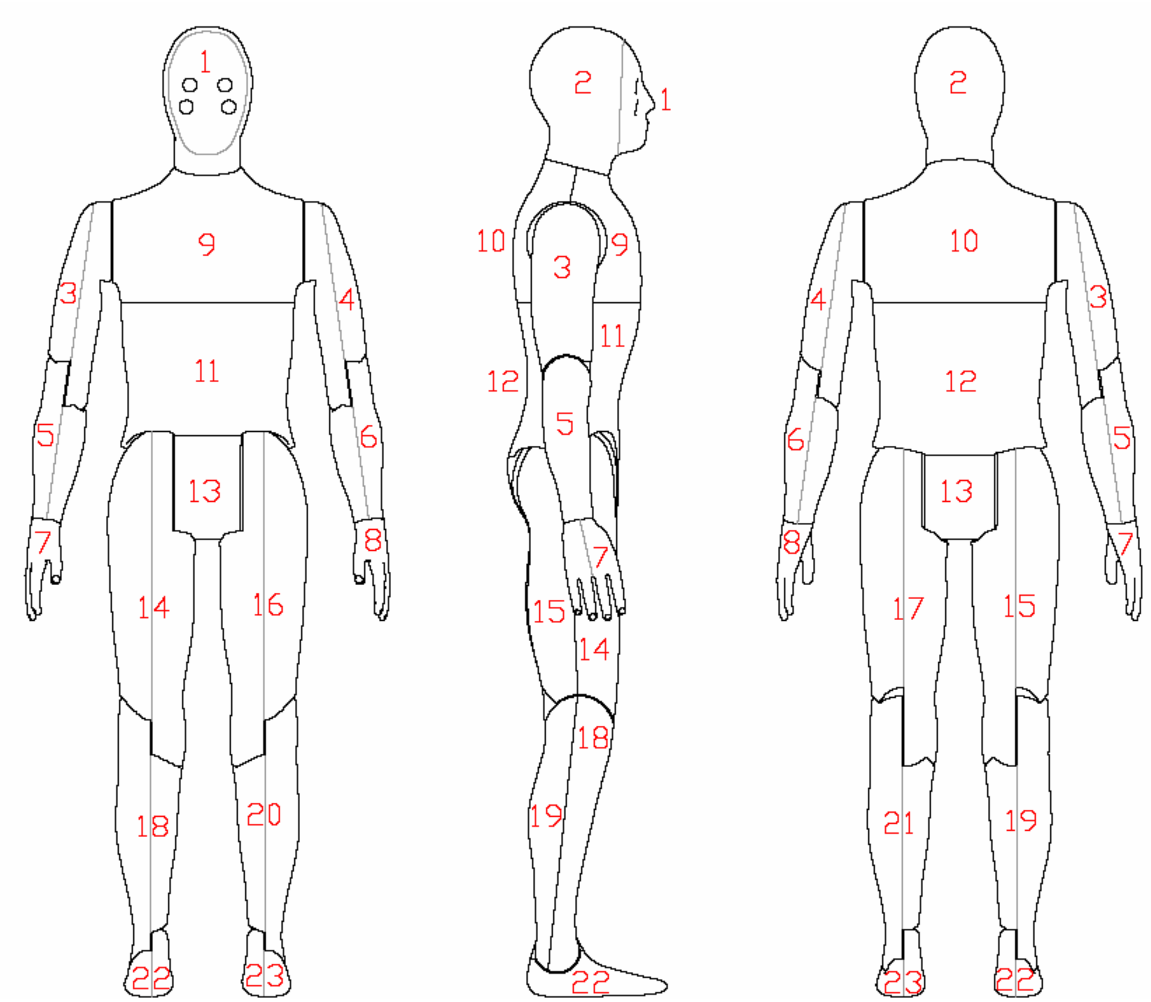


Figure 1.2.2 - NEMO Zone Detail

Power Enclosure

The Power Supply Enclosure (Figure 1.2.3) contains the power supplies, manikin pressurization, indicator lights, and fuses for NEMO, along with the USB interface to the PC, which runs the ThermDAC software. Figure 1.2.3 shows a Power Supply Enclosure including sweating capabilities. The fluid supply components are not installed in this manikin, but they can be added at a later date.

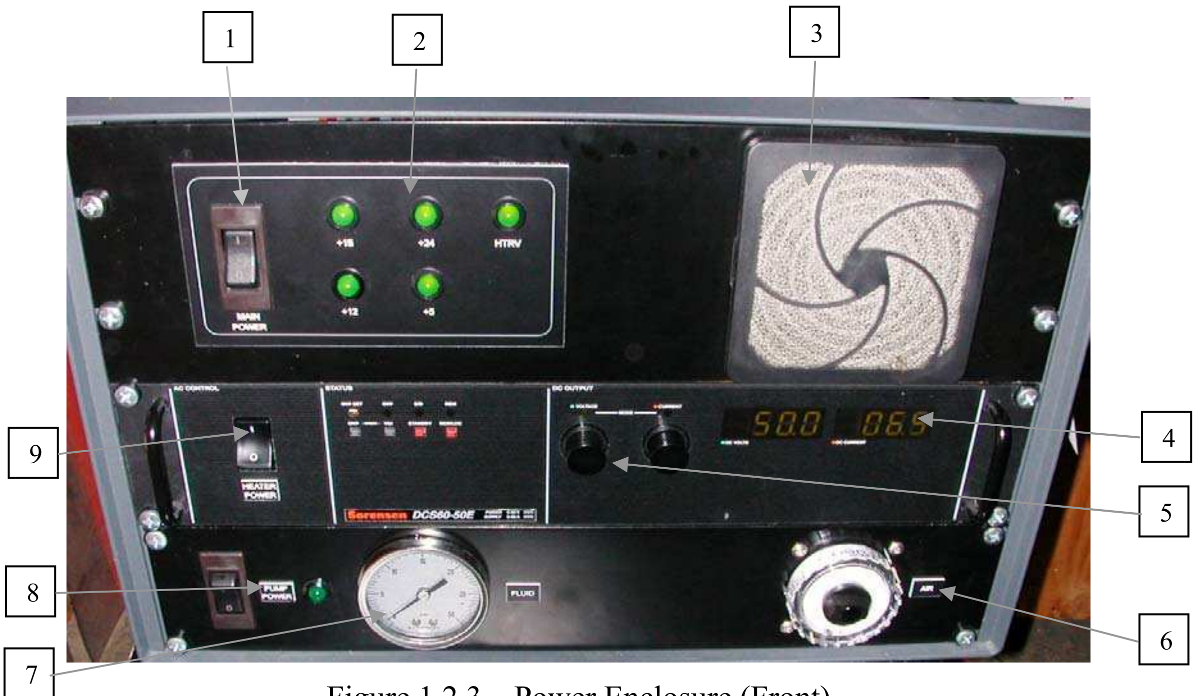


Figure 1.2.3 – Power Enclosure (Front)

1. Main Power Switch – Turns on manikin communication and switched AC to heater power and fluid power switches (see 7 and 8 below)
2. Power Indicators – Each DC power form in the system has an indicator light. The light for VHTR will dim with lower heater voltages (see 5 below).
3. Fan Inlet – This allows ventilation of the enclosure, particularly for the heater power supply. DO NOT BLOCK THE FAN INLET!
4. Voltage/Current Readout – This displays the voltage and current being put out by the heater power supply. Maximum voltage in this system is 60V.
5. Heater Voltage/Current Limit Adjust - This allows the user to adjust the heater voltage and maximum current from the nominal setting. A lower voltage may be desirable when testing highly insulative garments, or in any other situation requiring a low heat flux to maintain temperature.

   Heater power is calculated by the formula $P = (V^2/R) \cdot D.C.$ (D.C. = Heater Duty Cycle), so decreasing the voltage by ½ will decrease the maximum available heater power to ¼ of nominal.

6. Air pressure Regulator – The enclosure includes filtration, front panel regulator, and an overpressure valve (~12 PSI) to generate a positive pressure within the manikin body cavity for underwater testing. This should be set at 5psi for normal operation.
7. Pressure Indicator – This gauge shows the operating pressure of the fluid system in the enclosure. Due to break valves and line drops between the enclosure and the manikin, the pressure here is typically higher than the pressure measured by the zone controllers inside the manikin.
8. Pump Power – This switch turns on the fluid pump for the sweat delivery system. During dry testing, the manikin can be operated with this switch in the Off position.
9. Heater Power – This switch turns on the heater power supply. With this switch in the Off position, it is still possible to communicate and run fluid to the manikin.

The rear of the enclosure includes the following:

1. USB Connection – For communication with the PC running ThermDAC.
2. Communication Cable – The smaller of the two round connectors is carries all communication and low-level power to the manikin
3. Heater Cable – The larger of the two round connectors carries all heater power to the manikin
4. Ambient Connectors –All ambient sensors (temp, RH, windspeed, & dewpoint) plug in to labeled locations on the rear panel of the power enclosure.
5. AC Power – This system accepts single-phase 200-250 60Hz power only.
6. Fluid Connection (manikin) – These connections provide both fluid supply (large fitting) and return (small fitting) to the manikin.
7. Fluid Connection (reservoir) – These connections provide both fluid supply (large fitting) and return (small fitting) to the fluid reserovir.
8. Manikin Air Pressure – A single quick-disconnect coupler provides air at the pressure set by the front panel regulator
9. System Air Supply Inlet. – A standard pneumatic disconnect fitting on the enclosure should be connected to a clean compressed air supply (90 psi max)
10. Fan Exhaust – These vents allow the heater power supply to vent excess heat. DO NOT BLOCK THE FAN EXHAUST!

Cabling

In addition to the AC power cables, the following cables are necessary for operating NEMO Consult the cable diagram in Appendix A.

1. USB Communication Cable – This connects from the Control Computer USB port to the Interface Enclosure. Note that a driver must be installed on the target computer before plugging in this cable, otherwise it may not properly recognize the device.
2. Heater Cable – This connects between the 4-pin circular connector on the Power Enclosure and the corresponding circular connector on the cable at NEMO's face.
3. Control Cable 1 – This connects to the multipin connector on the Power Enclosure for low voltage supply and communications and also connects at NEMO's face.
4. Four ambient sensors are provided with the manikin and plug in on the rear of the power enclosure – two for measuring air temperature, one for relative humidity, and one for windspeed. All ambient sensors consist of a sensor head mounted to jacketed instrumentation cable with a connector at the end.

All of the above cables are uniquely sized and keyed, so it is impossible to plug them into the wrong socket.

ThermDAC Software

ThermDAC control software was developed by MTNW and is a 32-bit Windows based program that provides control capabilities, data recording, and real-time numerical and graphical displays of section temperatures. Each test zone is individually controlled using either a temperature control, constant heat flux, or comfort equation output. **Section 3.0** contains a detailed description of the control software and operation functions.

1.3 - System Requirements

Electrical power requirements are 60Hz AC power, 200-250 VAC with a maximum current of 20 Amps. The AC supply power should be clean with no large electrical transients that could damage the computer or electronics.

Measurements should be performed in an environmental chamber with temperature variation of ±0.5°C or less. Humidity variation should also be kept to a minimum, typically 5%. In general, excessive environmental variation can result in poor temperature control or variations in test results. The system may also be used in stable indoor environments, but comparative testing and replicated tests should be performed to determine the error tolerances on the ambient conditions.

1.4 – System Setup

The system, as delivered, needs very little preparation to operate. The following tasks should be performed prior to running tests.

1) Unpack NEMO, attach his hanging bracket hand-tight to both ears and support him from a suitable overhead structure.
2) Plug the AC power cord into the Power Enclosure and connect to an appropriate supply as described in Section 1.3.

3) If this is the first time the computer has ever been used with the manikin, install the USB plug-and-play driver (supplied with computer media).
4) Connect the USB cable from the back of the computer to the mating receptacle on the Control Electronics
5) Connect the two grey cables between the manikin’s eyes , and the Power Enclosure
6) Connect the ambient sensors to the corresponding connectors.
7) Turn on the switch on the Power Supply Enclosure prior to running the software
8) Double-click the ThermDAC icon on the PC desktop to begin the program
9) Detailed descrptions of ThermDAC, manikin handling, and sample test procedures can be found in Section 2 & 3 of this manual, and the Appendix.

1.5 – Important Precautions

The manikin must be used and handled with care in order to avoid damage or operator injury. The following precautions should be observed at all times during use and handling.

- Handle your manikin safely, both for his health and operator safety. The system weights approximately 150 lbs before dressing. Follow proper lifting procedures and use multiple people for any lifting or carrying needs.
- Avoid lateral loads on the manikin joints. Do not apply excessive side-loading to any of the manikin’s rotating joints. When lifting and handling, be cautious of the limbs, since the arms and legs act as levers to amplify forces on the shoulders and hips. Side loading while immersed will flex the joints enough to allow air leakage past the o-rings
- The air supply system has the capability to deliver pressure up to ~10-12 psi to the inside of the manikin. It is not recommended to exceed 5 psi, otherwise the flange gaskets may creep and begin leaking.
- Do not over-lubricate the manikin flange gaskets. Too much can cause the gaskets to creep when manikin body cavity is pressurized
- Do not plug the air vents on front or rear of the power Supply Enclosure. All heater power for the manikin is generated within that enclosure by a high efficiency switching power supply. This supply needs a regular supply of ambient air to keep cool.
- When moving the joints, keep fingers clear of the possible pinch points at each joint.
- **Ensure the manikin eye connectors are dry before plugging in cables**. NEMO’s electrical connectors are rated for continuous immersion, but cannot be mated when they are wet or electrical shorting may occur between pins. Blow them out thoroughly with dry air if any water is present.

- **Handle the manikin as a static-sensitive device.** Static discharge can be harmful to the manikin's internal electronics. When the electrical cables are not plugged into the eyes, the manikin is ungrounded and can hold a charge. Plugging in the cables provides a high-quality chassis ground, and can result in transient surges if the manikin is not grounded first.
- When immersed tests, don't leave the manikin wetted after the end of the test. It will improve the manikin's service life if it is dried off after each use. Over time, condensation will cause residual water to collect in the body cavities, which can be driven out by periodically by following the air purge procedure as described in the maintenance section.

Section 2.0 - System Operation

2.1 – Basic Operation and Dressing

Operators of NEMO should generally follow a standard procedure to obtain repeatable results. Several thermal manikin test standards are currently in use for dry, sweating, and microclimate cooling tests. If none of these methods meets your evaluation needs, then a new or modified procedure should be defined and documented. A sample test procedure outline has been included in Appendix F.

Dressing of the manikin can be a complex process, depending on the garment, but consider the following general guidelines:

- Maintain the joint tension at a high enough level that the manikin can weight-bear. The hips, knees, and ankles should be adjusted if the manikin is buckling in the knees.
- Any garment that goes over the manikin's head will require turning off power and disconnecting manikin cables to pull it over the head. For undergarments, they can sometimes be cut up the back and reclosed with pins, tape, staples, etc, but this should be tested and validated before it is accepted as standard practice.
- The ear bolts on the lifting frame can be removed and reinstalled one-at-a-time, to pull the garment/headwear/sweating skin layer over the head. If the manikin is standing on the ground, this allows safe dressing by a single person.
- The hands are at their closest-together point when the elbows are bent 90 deg. This will sometimes help with donning shirts.

Ensure that the manikin is repeatably positioned in the test environment, and that his clothes do not have any unrealistic air pockets or asymmetries. Position the ambient sensors to be representative of his thermal surroundings, or as defined by the test procedure. Remember to remove protective caps from RH and wind sensors when used.

Be certain to periodically monitor the manikin's internal humidity level and run an air dryout cycle as needed when the humidity exceeds 80%

2.2 – Immersed Tests

Immersion testing follows all the same general guidelines as the dry or sweating tests, but adds another layer of complexity and challenge. It is recommended that the manikin be continuously pressurized to 5 PSI while doing underwater testing. This results in identifiable air leaks outside the manikin, rather than inaccessible water leaks to the manikin interior.

It should be noted that moving the limbs while the manikin is pressurized (or underwater) could result in a small air leakage from the joints. These leaks typically stop once the joint is static again, unless the o-ring seals need cleaning and regreasing.

2.3 - Data Analysis

ThermDAC performs numerous automatic data analysis functions, including Thermal Resistance and Area Weighted Averages. All of these calculations are performed on data which has been logged to the .csv file (ie based on the user-defined logging interval). The user can easily perform further data analysis by opening the .csv file in Excel or another Windows spreadsheet program.

The equations used in calculations are as follows:

Dry Thermal Resistance, R_{ct}

Calculated in SI units for each zone by the formula:

$$R_{ct} = \frac{(T_{skin} - T_{amb})}{Q/A}$$

R_{ct} = Thermal resistance $(m^2 \cdot °C)/W$
T_{skin} = Zone average temperature (°C)
T_{amb} = Ambient temperature (°C)
Q/A = Area weighted Heat Flux (W/m^2)

The conversion to Clo units is as follows:

$$R_{Clo} = R_{ct} \cdot 6.45$$

Cooling Rate (Heat Diff)

$$ECR = \Sigma Q_{i(new)} - \Sigma Q_{i(old)}$$

ECR = Effective Cooling Rate (W)
$Q_{i(old)}$ = Zone power outputs from baseline test (W)
$Q_{i(new)}$ = Zone power outputs from new test (W)

Weighted Averaging

$$R_{wtd}\text{ (serial)} = \frac{\Sigma (R_i \cdot A_i)}{A_{tot}}$$

R_i = Zone resistance
A_i = Zone surface area (see Appendix A)
A_{tot} = Total surface area

$$R_{wtd}\text{ (parallel)} = \frac{1}{\Sigma (A_i / (A_{tot} \cdot R_i))}$$

R_i = Zone resistance
A_i = Zone surface area (see Appendix A)
A_{tot} = Total surface area

Section 3.0 – ThermDAC Control Software

ThermDAC is a fully automated data acquisition and control program with real time displays to let the operator view test progress. The Windows based control system is designed to be user-friendly and intuitive to operate.

Two independent methods of data logging can be used to facilitate production testing or detailed analysis. Full Data logging provides a complete data set of the entire run, at user selectable intervals. Steady State logging will write steady state average values to the file once the system has stabilized. These logging methods can be used individually or together. ThermDAC also includes an automatic steady state detection which can initiate data logging.

Tests generate comma delimited (*.CSV) data files suitable for direct importing into Excel or any other Windows compatible spreadsheet program. The data file contains a header with the data file name, test date, comments entered at test start, setpoint, and logging interval. The data consists of a time stamp, followed by, in order, all zone temperatures, all zone heat fluxes, area weighted average temperature, area weighted heat flux, area weighted thermal resistance, ambient temperature, and relative humidity.

The following is a description of ThermDAC operation and features, broken down by the major software screens:

Main Screen:

The Main Screen (see Figure 3.1) is what the user sees when ThermDAC is first invoked and after tests are completed. The screen has indicators which show connection status with the Control Electronics. If everything is working properly, these indicators should be flashing between blue and green. Additionally, there are three numerical displays for Ambient sensors – the user can select between averaged ambient temperature, individual ambient temperature readings, relative humidity, and an auxiliary voltage input (0-5V range).

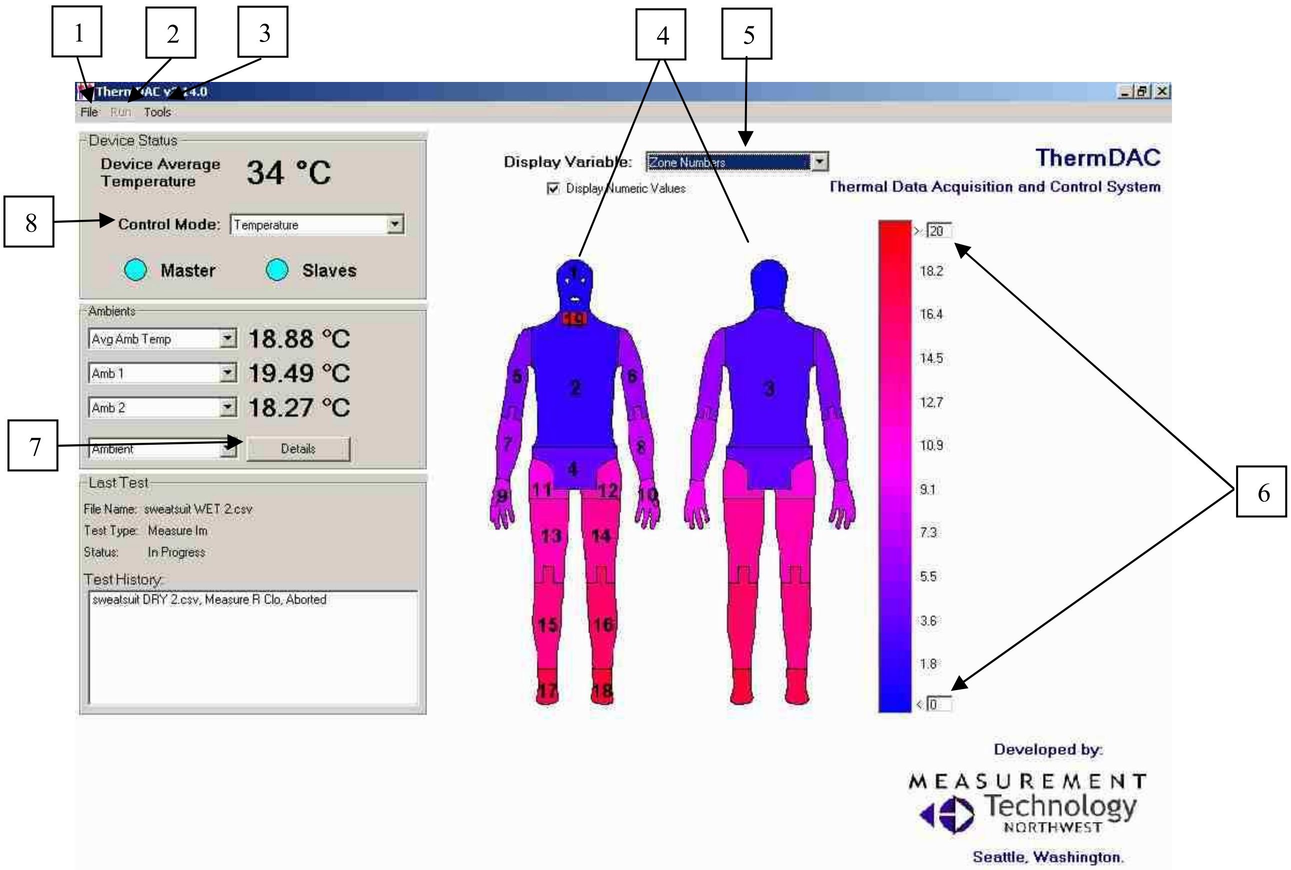


Figure 3.1 – ThermDAC Main Screen

(1) File Menu – This menu contains the Load Experiment Data command. This allows the user to recall previous data files into the runtime screen for analysis.

(2) Run Menu – This menu has four items. If an experiment is already in progress, then this menu will be grayed out.

   a. Dry Test – This is the normal method for beginning a non-sweating experiment for calculating Rct, dry thermal resistance.

   b. Wet Test – This is the normal method for beginning a sweating experiment for calculating Ret, wet evaporative resistance. For a non-sweating manikin, this test method will be disabled.

c. Heat Diff Test – This mode is used for evaluating Personal Cooling Systems (PCS). Using a previous baseline test as a reference, the total amount of heat removed by the PCS is calculated and output in Watts.
d. Work Cycle Simulation – This allows the user to control an experiment with several temperature and/or heat flux setpoints. These setpoints are defined in a Work Cycle .csv file (see Appendix E for details).

(3) Options Menu – This menu has several items which control the configuration of the ThermDAC software.
a. Device Parameters – This option will bring up the Device Parameters screen, which displays configuration variables (such as setpoints) and real time output data (such as temperature and heat flux) of each zone on the manikin. See Device Parameters Screen section below for details.
b. User Mode – This selects one of three modes: Basic, Advanced, and Diagnostic. Basic is the default mode and allows the user enough access to control NEMO for a vast majority of experiments. The Advanced and Diagnostic modes allow the user to change such things as sensor gains and offsets, heater control gains, and electronics calibration parameters. These parameters can drastically alter the performance of the manikin and should only be used by experienced personnel.
c. Diagnostics – This menu has several items which allow the user to monitor system activity and is only accessible from the Diagnostic User Mode described above. This is intended to be used with the direct guidance of MTNW personnel only.
d. Device Defaults – This menu allows the user to save all current parameters to flash memory as the default conditions, or, conversely, to restore all parameters from the flash memory to the manikin. This menu item is only accessible from the Advanced or Diagnostic User Mode. Caution should be taken when using the save function as it will permanently change the manikin operating parameters. Again, many of these parameters can drastically alter the operation of the manikin, so only experienced personnel should attempt to change them.

(4) Manikin Graphic Display (Front and Back) – The main screen shows a front and back picture of the manikin form, with a data readout over each zone. This zone can be configured to display any parameter, including Temperature, Heat Flux, and Setpoints. The parameter is selected in the Display Variable drop-down menu (see 8 below). The manikin display is color coded based on the range selected (see 5 below). In addition to viewing the data, the user may also click on any zone. This action will display a pop-up window which contains information on every parameter in that zone. It is possible to click on more than one zone to display information about multiple zones simultaneously.

(5) Display Variable – This pull-down menu selects the variable displayed on the Manikin Graphic Display (see 4 above). In Basic mode, the following parameters can be displayed: Zone Number, Zone Status, Average Surface Temperature, Heat Flux, Heater % On, Temperature Setpoint, and Heat Flux Setpoint.

(6) Manikin Display Color Range – When a parameter is displayed on the manikin graphic display, the color range is auto-scaled by the ThermDAC software. The user

may change the scale by typing the minimum and/or maximum values in the text boxes. This is especially useful for zooming in on a data range of interest (such as heat flux or temperature).

(7) Ambient Details Button – The Details button provides more information about the ambient sensors, including scale and offset.

(8) Control Mode – The manikin supports three control modes for its heaters:

   a. Temperature – In Temperature mode, the user provides a temperature setpoint (in deg C). The manikin then adjusts the heater power of each zone to reach and then maintain the desired temperature. This is the mode used in a majority of tests.
   b. Heat Flux – In this mode, the user provides a heat flux setpoint (in W/m^2). The manikin then adjusts the heater power of each zone to match the desired heat flux.
   c. Comfort Mode – In Comfort mode, the user provides a scale (in $W/m^2/°C$) and an offset (in W/m2), and the manikin controls the heat flux as a function of surface temperature.
   d. Manual Mode – In this mode, the user provides a heater duty cycle (0-100, with 0 being off, and 100 being full-on). This mode is typically used as a diagnostic tool only, as zone area is not taken into account.

Device Parameters Screen:

When Device Parameters is chosen from the Options menu on the Main Screen, the screen shown in Figure 3.2 is displayed. This screen allows the user to view and, if applicable, change the values of the displayed device parameters.

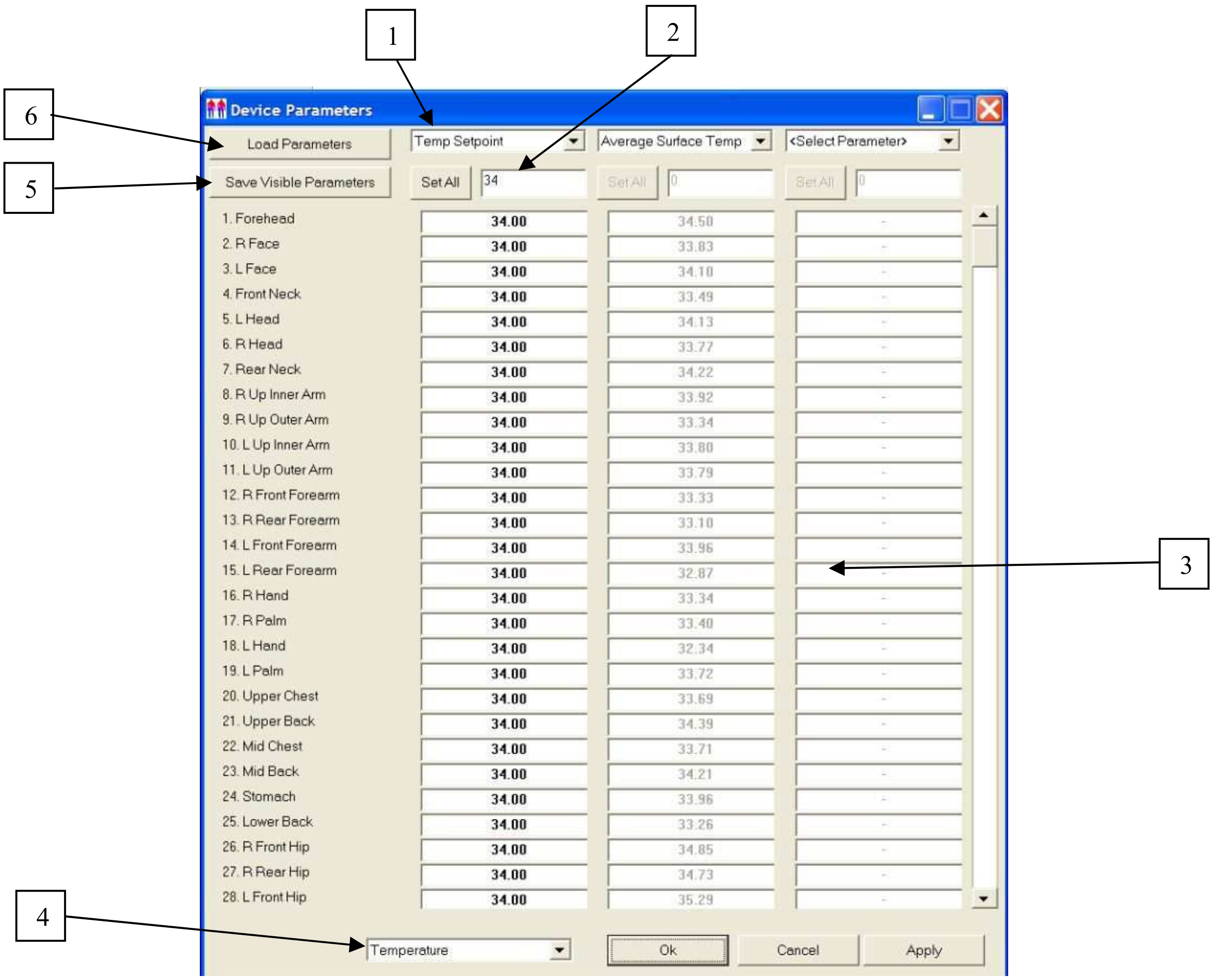


Figure 3.2 – Device Parameters Screen

The following items refer to Figure 3.2 above:

(1) Parameter Select – This pulldown menu allows the user to select the parameter to be displayed. For detailed information on the Device Parameters, see Section 4.2.

(2) Data Entry Text Box – This box allows the user to modify the value of a parameter *for all zones simulaneously*. If the parameter is editable, then the text in this box is black, and changes can be made. If the parameter is read-only, then the text in this box is greyed out, and changes are not possible. Once the value has been changed, then the user needs to click Set All, and then Apply or OK.

(3) Zone Data Fields – These text boxes display the value of the selected parameter for each individual zone. The text in this box is color coded. If it is black, then it is the current value and it is editable. If it is gray, then it is the current value and it is read-only. If it is

blue, then the value has been changed, but not entered. It is possible to change the value of parameters for individual zones by entering them here, or for ALL zones by using the Data Entry box and Set All button described in (2) above. The user must click Apply or OK at the bottom of the screen in order to enter the changed values.

(4) Control Mode – This pull-down menu is identical to the Control Mode menu on the main screen (see Figure 3.1, Item 8).

(5) Save Visible Parameters – This button will save the *currently displayed AND editable* parameter values to a file. This allows changes made by the user to be captured and reused at a later time.

(6) Load Parameters – This button will read a file (created in 5 above) of Device Parameters and load them into the manikin. Only parameters which were saved in the file will be affected by this action.

Test Parameters Screen:

When Experiment is selected from the Run menu on the main screen, then a Test Parameter screen appears (see Figure 3.3). This screen allows the user to enter comments to be recorded to data file, define setpoint(s), define which zones are to be used in the weighted average, and set data logging and steady state detection parameters.

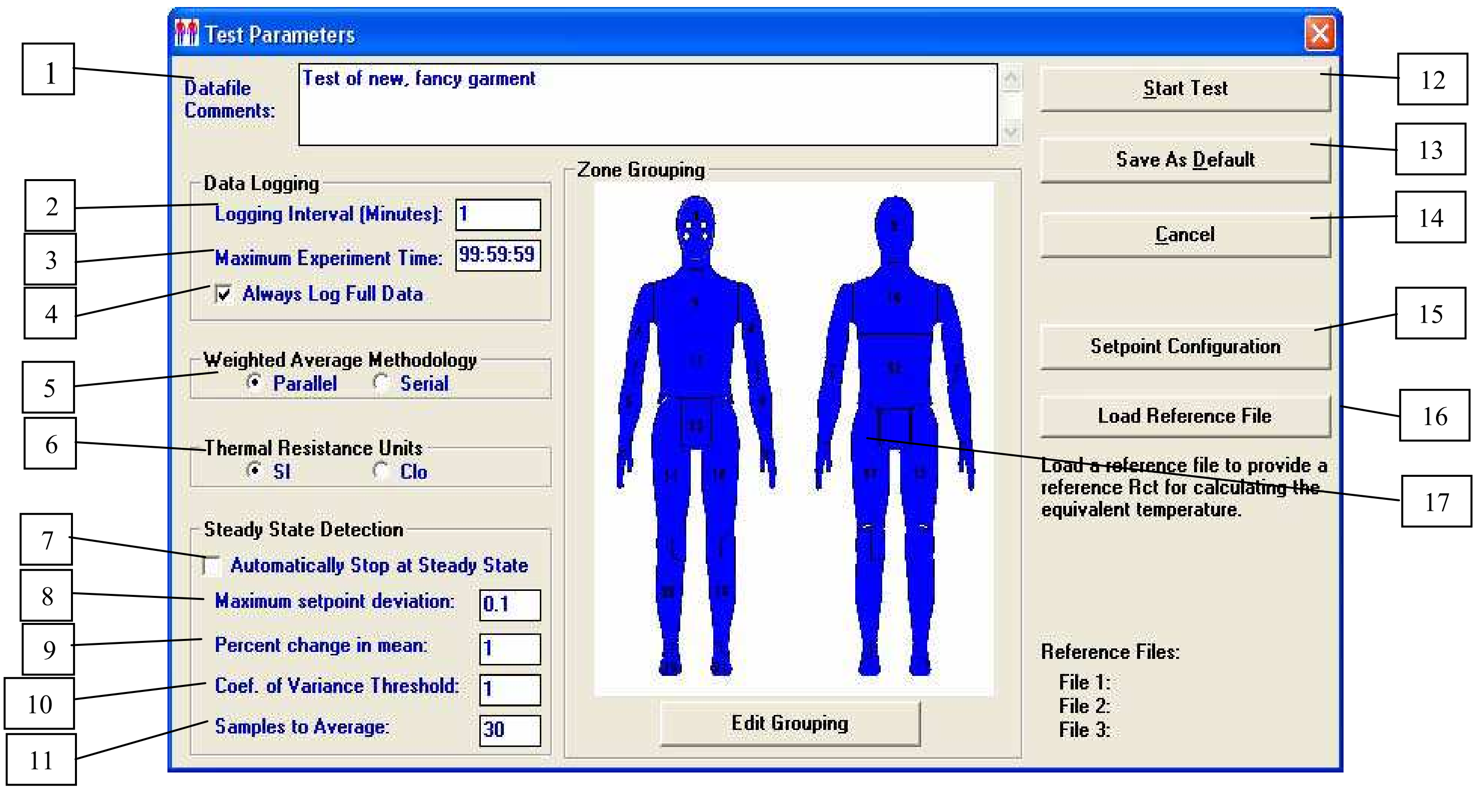


Figure 3.3 – Test Parameters Screen

The following items refer to Figure 3.3 above:

(1) Datafile Comments – This text box allows the user to enter comments which will be logged with the output datafile. It is recommended that this space be used to record any information which isn't otherwise recorded by the ThermDac software. Suggested entries include user name, information about the unit under test, environmental chamber settings, and anything else which might vary from test to test.

(2) Logging Interval (Minutes) – This defines how often the output .csv file is updated. Data is sampled by the ThermDAC system approximately once per second, so this is the *minimum* possible logging interval (1 second = 0.0167 minutes). **For most tests, MTNW recommends a logging interval of around 1 minute**. For longer duration tests, the user may want to consider a longer logging interval (5 or 10 minutes, or longer) to avoid creating a huge datafile.

(3) Maximum Experiment Time – When this time is reached, the test will end, regardless of the Steady State conditions.

(4) Always Log Full Data – When this box is checked, all data will be written to file at the logging interval defined above. Otherwise, only the steady state conditions will be recorded.

(5) Weighted Average Methodology – Select Parallel or Serial to select which model is used to calculated the area-weighted average thermal resistance. Note: Steady state reports always include both a parallel and serial calculation.

(6) Thermal Resistance Units – Select SI or Clo units for thermal resistance calculation. SI units are $(m^2 \cdot °C)/W$. Clo units are simply SI units multiplied by a scale factor of 6.45.

(7) Automatically Stop at Steady State – When this box is checked, the experiment will automatically end when the defined steady state conditions are reached. As with Maximum Experiment Time, it is possible to override this function in the Runtime screen.

(8) Maximum Setpoint Deviation – This defines the maximum deviation from the Temperature Setpoint of any zone. Until all zones are within this range, steady state will not be reached.

(9) Percent Change in Mean – This defines the maximum allowable percentage variation in Thermal Resistance of each zone at the *beginning* and *end* of the duration defined below in Samples to Average.

(10) Coefficient of Variance Threshold – This defines the maximum allowable relative variation of Thermal Resistance over the *entire duration* defined below in Samples to Average. The coefficient of variance is defined as the standard deviation divided by the mean.

(11) Samples to Average – This defines the time window over which Steady State will be evaluated. For a logging interval of 2 minutes, and Samples to Average set to 30, this duration will be 60 minutes (2 minutes/sample * 30 samples).

(12) Start Test – Clicking this button will begin the experiment. Before the test runs, the user will be asked to enter a filename for logging test data. ThermDAC supports long filenames in accordance with 32-bit Windows standards, and a .csv (Comma Separated Value) suffix will be automatically appended. In the case of a "Work Cycle" test, the user will also be asked for a work cycle file. A work cycle template has been included with the ThermDAC software. For detailed information about Work Cycle tests, see Appendix E.

(13) Save As Default – Clicking this button will save all logging, steady state, and setpoint configurations as the default test conditions. This is useful for avoiding reentering identical entries when running multiple tests under the same conditions.

(14) Cancel – Ignores all entries and returns to the Main Menu. Note: Cancel will not override a Save As Default command.

(15) Setpoint Configuration – Clicking this button brings up another screen, a scaled-down version of the Device Parameters screen in Figure 3.2, which allows the user to set the control mode and define the appropriate Temperature, Heat Flux, or Manual setpoints.

(16) Load Teq Reference – This button allows the user to load a previously run file as a reference for calculating equivalent temperature. Once thermal resistance values have

been measured for a set of clothing, these values can be used to calculate the temperature of the surrounding environment in a different test. The file loaded must be a ThermDAC generated steady state file with valid thermal resistance data.

(17) Zone Grouping – This section allows the user to define which zones are to be considered for averaging and steady state detection. In general, it is recommended to keep all zones highlighted to assure that the entire system is in steady state before terminating a test.

Runtime Screen:

The runtime screen (see Figure 3.4) displays real-time test conditions both numerically and graphically. This screen provides the user with a wide range of display and control options which are described in detail below.

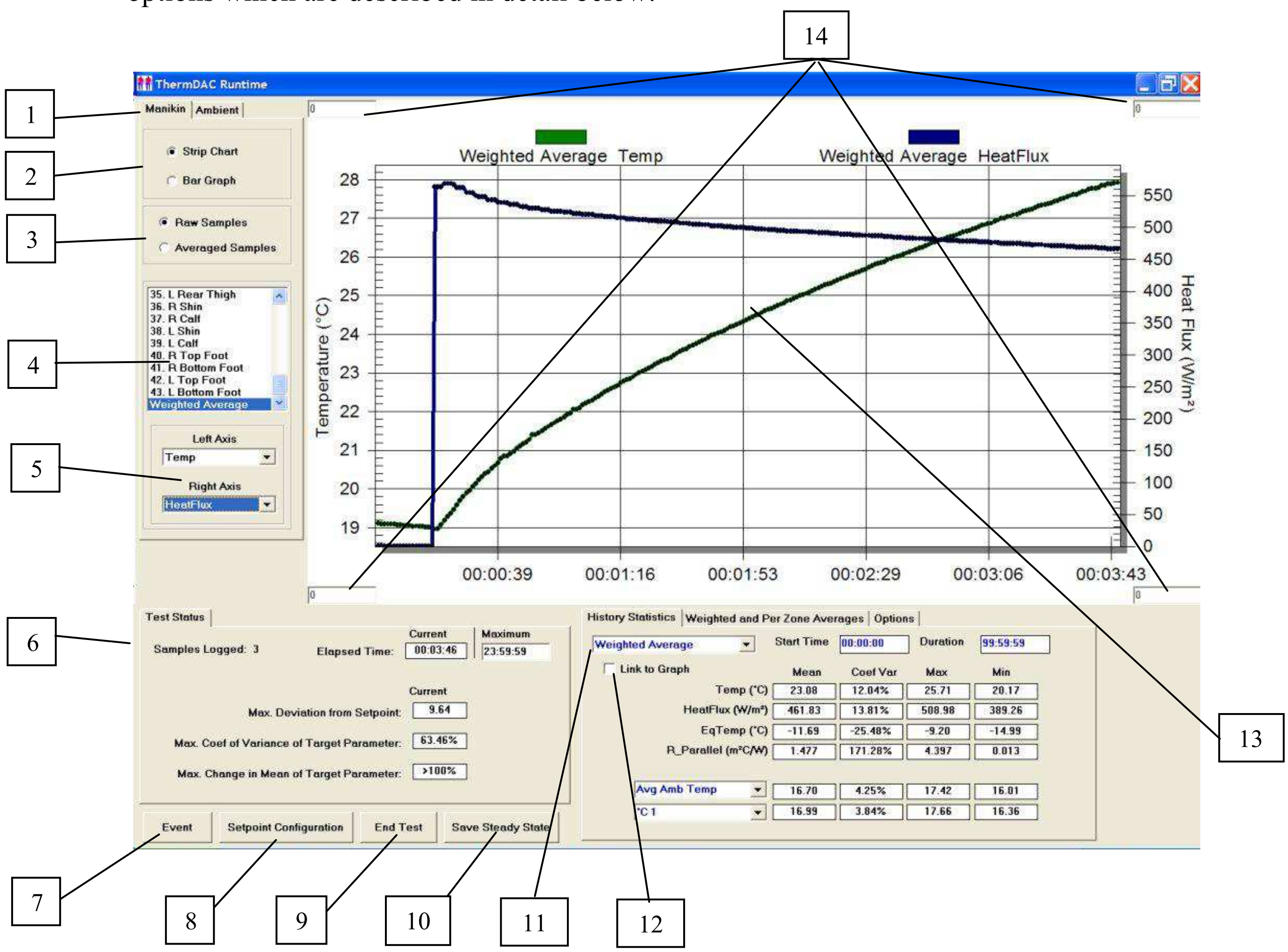


Figure 3.4 – ThermDAC Runtime Screen

The following items refer to Figure 3.4 above:

(1) Manikin/Ambient Display – This tab selects between the display of Manikin conditions (shown) or a similar display of Ambient conditions.

(2) Strip Chart/Bar Graph – The user can select between a Strip Chart (shown) and a Bar Graph display. The Bar Graph mode will automatically display the current data from ALL zones, while the Strip Chart will display time history data of zones selected in (4) below.

(3) Raw/Averaged Samples – This selects between Raw (approx 1 second samples) and Averaged Samples (user defined by the Logging Interval on the Test Parameters screen).

In general, it is recommended that Averaged Samples be selected as Raw Sample displays contain a very large amount of data (particularly during long tests).

(4) Zone Selection – This menu allows the user to select which zones are displayed in the Strip Chart display. It is possible to select more than one zone at one time by holding down the CTRL button while selecting them.

(5) Data Type – The user can select between Temperature, Heat Flux, Thermal R, and Equivalent Temperature (same as Temperature if a Teq file has not been loaded at the start of the test). For a Bar Graph display, only the left axis column is active, so only one parameter at a time will be shown. For the Stripchart display, two parameters can be selected at once. To display only one parameter on a stripchart (useful when displaying multiple zones at once), simply select the same parameter for both the Left and Right axes. NOTE: The Thermal R display is available only when in Averaged Samples mode (see 3 above).

(6) Test Status – This display shows the current status of the test. It shows the elapsed time, the user defined maximum time, and the current steady state conditions. If the elapsed time exceeds the maximum time, or all zones meet the steady state criteria defined in the Test Parameters screen, then the experiment will terminate automatically if these options were enabled at the start of the test.

(7) Event Button – If this button is clicked, the user can enter a text message which will be logged along with the test data. For example, if there are changes in the ambient conditions during a test, it is advisable to make a note of it to avoid confusion during post-test data analysis.

(8) Setpoint Configuration – Temperature or Heat Flux setpoints can be changed during a test by pressing this button. This allows the test setup to change without having to terminate and restart the data logging. During Wet tests, this window will also allow the user to set or modify the Flow setpoints.

(9) End Test – This button terminates the test and appends the current steady state conditions to the end of the data file.

(10) Save Steady State – The current steady-state conditions can be added to the datafile by clicking this button. It is possible to do this more than once during a test.

(11) History Statistics – This is ThermDAC's real-time data analysis window. By selecting a start time and duration, the software will read the data file and display statistics for the selected time and zone. This is very useful for monitoring the steady state conditions of each zone.

(12) Link to Graph – When this box is checked, the Start Time and Duration windows are automatically updated when the user zooms in on the stripchart. The history statistics will then analyze data over the same timeframe displayed on the stripchart (see 13 below and take care to display the same zone in both the stripchart and history statistics).

(13) Stripchart Display – This is the graphical data display. As described in (2) – (5) above, a variety of data types can be displayed here. Zooming in on data can be done by simply drawing a box with the mouse around the area of interest. Double-clicking on the display will "unzoom" back to the original graph.

(14) Stripchart Range – Another way to zoom in on areas of interest is to enter a minimum and maximum displayed value for each axis in the text boxes shown here. This can be done separately for each axis. To "unzoom" back to the auto-scaled graph, simply enter a 0 for the maximum value (or any number less than the minimum value).

Group Report Screen:

The Group Report (Figure 3.5) screen pops up when the user clicks Save Steady State from the Runtime Screen. It allows the user to define the time range and which zones are used for calculating manikin results.

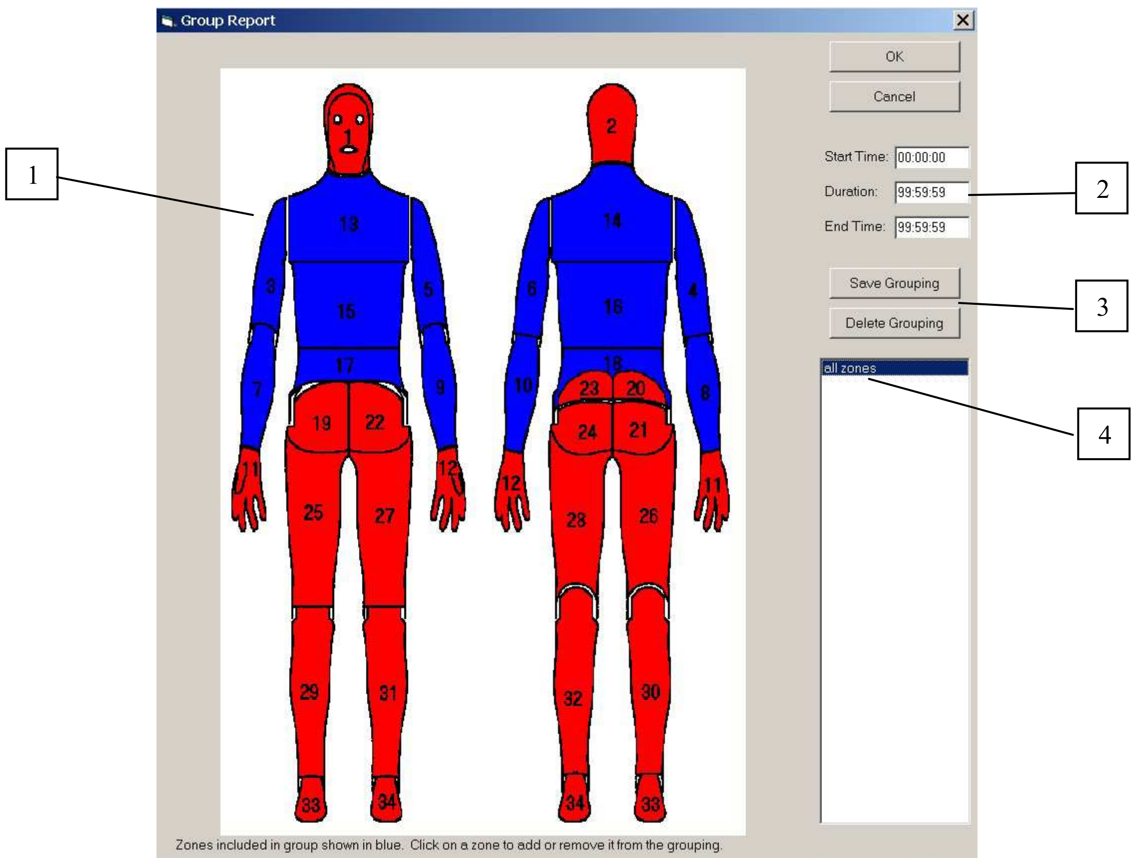


Figure 3.5 – ThermDAC Group Report Screen

The following items refer to Figure 3.5 above:

(1) Zone Selection Map – The user can select which zones are included in the group average reports by clicking on the desired zones. Selected zones are blue, while unselected zones are red.

(2) Start, Duration, and End Time – This section allows the user to select the data range to be used for calculating group averages. These values default to the time range selected in the History Statistics section of the Runtime Screen (see above).

(3) Save and Delete Grouping – Once a group of zones has been selected by the user, it is possible to save the subset as a file for use on subsequent tests.

(4) Group Lists – Once a group of zones has been saved, it is shown in this list for easy recall by the user. One suggested grouping for NEMO would be to select all zones except for the neck plate, which serves as a thermal guard and should not be included in Weighted Average or Steady State calculations. Other applications might require a grouping of torso zones only, or exclude the head, feet, or hands.

Section 4.0 – Calibration and Software Configuration

4.1 – Control System Overview

Each zone is controlled by its own embedded controller board, mounted on the inside of the manikin. These can be configured individually or together by using the Device Parameters screen, or by simply clicking on the zone of interest on the Main screen manikin display.

The operating principle of the manikin requires close temperature control capabilities and accurate measurement of applied heater power. Control of surface temperature is provided by the PI control algorithm in each zone. This algorithm drives a pulse-width modulated heater voltage. Heater power is calculated by measuring the heater voltage across a known heater resistance and applying Ohm's Law:

$P = (V^2 / R) \cdot \%DC$ %DC = Percent Heater Duty Cycle

4.2 – Calibration

Calibration of the manikin system can be performed by qualified technicians using traceable voltage and temperature references. The internal controllers digitize and scale all inputs into engineering units, and have their calibration constants saved in flash EEPROM. Contact MTNW for addition details on performing the calibration procedure or to request service.

All heaters are made with high precision, ultra-low temperature coefficient resistance wire. Heater resistances are accurately measured by MTNW at operating temperature during factory calibration. The device error induced by variations in heater resistance are typically less than 0.1% and do not usually need to be recalibrated. Consult MTNW if you suspect variations in heater resistance, since the manikin has a utility feature which can perform a diagnostic heater resistance measurement for comparison.

Please see **Section 5.1 - Periodic Maintenance** for additional information regarding service intervals.

4.3 – Basic Device Parameters

Each zone controller contains software parameters which define its mode of operation. The level of access is controlled by whether the user has selected Basic, Advanced, or Diagnostic mode from the Options menu on the main screen. For most conditions, the Basic mode provides enough access to let the user control the manikin appropriately. As previously discussed, the Advanced and Diagnostic modes should only be used by experienced personnel, as these parameters can have a serious affect on manikin performance and accuracy.

These parameters can be edited in the following ways.

1. Click on the zone of interest on the graphical Manikin display on the main screen.

2. Open the Device Parameters window from the Options menu on the main screen. Parameters can be changed here on a per zone basis, or globally throughout the manikin.
3. Load a previously saved parameter file (this is also done via the Device Parameters windows described in 2 above).

Table 4.3.1 contains a detailed list of all Basic Device Parameters.

Parameter	Description	Units	Editable?
Average Surface Temperature	Surface temperature of each zone	°C	No
Heat Flux Generated	Area-weighted heater power delivered to each zone	W/m^2	No
Heater % On	Duty cycle of heater for each zone (100% is full on, 0% is off)	%	Yes*
Temp Setpoint	Temperature to which the controller will heat and maintain each zone in Temperature Mode	°C	Yes
HF Setpoint	Area-weighted heat flux to which the controller will heat and maintain each zone in Heat Flux Mode	W/m^2	Yes
Comfort Mode Slope	Slope of heater response in Comfort Mode. This value is multiplied by the Average Surface Temperature to control the zone heat flux.	W/m^2/°C	Yes
Comfort Mode Offset	Offset of heater response in Comfort Mode. This value is added to the (Slope x Temperature) calculation described above to control the zone heat flux.	W/m^2	Yes
Flow Setpoint	This is the volumetric flow rate for each zone's sweating system (Wet Zones Only)	ml/hr/m^2	Yes
Firmware Version	This reports the version of the embedded software in each zone controller	-	No
Dev from Setpoint	This reports the delta between the actual zone temperature and the temperature setpoint	°C	No
Pressure	Reports pressure across capillary tube in fluid system (Wet Zones Only)	PSI	No
Sensor Eng Units	Reports temperature sensor output (1 or 2 per zone, see Table 4.4.1a for information on Ambient sensors)	°C	No

*Heater % On is editable in Manual control mode only

Table 4.3.1 – Basic Device Parameters

4.4 – Advanced Device Parameters

If more access to the Device Parameters are needed, then the user can entire the Advanced mode. This mode accesses all of the Basic parameters described above, in addition to those shown below in Table 4.4.1. **It is recommended that only experienced personnel attempt to modify any Advanced Device Parameters.**

Parameter	Description	Units	Editable?
Kp Gain	Proportional gain for Temperature Mode control algorithm	-	Yes
Ki Gain	Integral gain for Temperature Mode control algorithm	-	Yes
Surface Area	Surface area of zone	m^2	Yes
Heater Resistance	Resistance of heater wire in each zone	Ω	Yes
Heater Voltage	Displays the voltage of the Heater Bus	V	No
Vref	On-board voltage reference	V	Yes
Sensor Counts*	Raw A/D converter reading	counts	No
Sensor Volts*	A/D converter output translated from counts to volts (at input of A/D converter).	V	No
Sensor Scale*	Multiplier applied to (Volts/Vref)	°C/ (V/V)	Yes
Sensor Offset*	Offset applied to (Volts*Scale/Vref)	°C	Yes
Pressure Counts	Raw A/D converter reading	Counts	No
Pressure Volts	A/D converter output translated from counts to volts (at input of A/D converter).	V	No
Pressure Scale	Multiplier applied to pressure voltage	PSI/V	Yes
Pressure Offset	Offset applied to Pressure voltage * Pressure Scale	PSI	Yes
Flow Conductance	The sweat volume delivered through each zone's fluid capillary tube integrated with differential pressure and time	ml / (PSI · hr)	Yes
Valve Duty Cycle	Reports the current duty cycle of the fluid valve	%	No
Accumulated Volume	Reports the delivered volume rate for the current valve cycle	$ml/hr/m^2$	No

Table 4.4.1 – Advanced Device Parameters

*Each zone controller contains one or two temperature sensors. The ambient controller contains four separate sensor inputs (see below) They include two ambient temperature sensors, one relative humidity sensor, and a 0-5V auxillary input. Each sensor contains its own Counts, Volts, Scale, Offset, and Eng. Units registers.

Sensor #	Function	Eng. Units
1	Ambient Temp Sensor 1	°C
2	Ambient Temp Sensor 2	°C
3	Relative Humidity	%RH

Table 4.4.1a – Ambient Sensor Organization

4.5 – Diagnostic Device Parameters

For even more advanced troubleshooting, Diagnostic mode provides another level of detail into the Device Parameters. **It is recommended that Diagnostic mode only be used under the direct guidance of MTNW personnel.** This mode contains all Basic and Advanced Parameters, in addition to those shown below in Table 4.5.1.

Parameter	Description	Units	Editable?
Status Word	Contains software status and fault information	-	No
Config Word	Contains sensor enable, control mode, and reset bits	-	Yes
Valve DC Override	Allows manual control of valve duty cycle (must be enabled with Initialize word, described below)	%	Yes
Notch Filter Constant	A/D converter notch filter frequency constant.	-	Yes
A/D Sample Loop Constant	Number of samples used for sampling Heater Voltage.	-	Yes
PI Loop Sample Consant	Number of temperature samples used for calculating desired heat flux in Temperature Control mode	-	Yes
Avg Temp Sample Consant	Number of samples used in reporting average temperature	-	Yes
Reboot Cause/Timer	Debug variables which reports the cause and time since the last reboot.	-	No
Thermistor Enable	Configures sensors as wire (linear) sensors, or as thermistors.	-	Yes
Shunt Resistor	Shunt resistor used for measuring heater resistance	Ohms	Yes
Electronics Temp	On-board electronics temperature reading	°C	No
Steinhart-Hart Coeffs/Bit Shift/ Threshhold	Defines look-up table for thermistors	-	Yes
Debug 1-3	Memory allocated for software debugging	-	No
Initialize	1=Reset All Parameters (**CAUTION: this will overwrite manikin configuration settings!**), 2=Measure Heater Resistance, 4=Enable Valve Manual Override, 8=Zero Pressure Sensor	-	Yes
Recirculation Volume	Calculates volume of fluid recirculated through each zone	mL	No
Diagnostic Heater R	Result of the automated heater resistance measurement	Ohms	No
Config Word Init	Power-up initialization value for the Config Word	-	Yes

Table 4.5.1 – Diagnostic Device Parameters

Section 5.0 – Troubleshooting and Service

5.1 – Periodic Maintenance

The following is a guideline for keeping the manikin in good working order:

At the beginning and during every test:

- Check manikin software for active heater operation on all zones
- Check manikin internal RH sensor reading, and if the RH is above 80%, dry out the manikin interior using purge air through the heated manikin

Monthly:

- Test of nude manikin resistance and/or reference garment resistance*
- Air leakdown test. Pressurize the manikin to 5 psi and put a gauge on the eye connector. This pressure should be maintained overnight unless there are leaky gaskets/seals. Put manikin in tank to check for bubbles if leakdown test fails.

Yearly (or, if system drift is observed with reference clothing):

- Calibration of manikin electrical system and temperature sensors

*As a system check, it is recommended to maintain a set of reference clothing which can be tested occasionally. The results of these tests should be logged and compared. By using a set of clothing with known or expected thermal resistance values, long term equipment performance shifts can be identified.

5.2 – Thermal Regulation Troubleshooting

The design of MTNW's modular control system facilitates troubleshooting and isolation of faulty components. Each zone is heated and monitored by its own embedded controller. These controllers are designed to be easily replaced in the event of a failure. These repairs should only be attempted by an experienced electronics technician, and care should be taken not to damage internal cables and wires.

Table 5.2.1 details potential failures along with their possible causes and remedies. Please contact MTNW if there is any doubt or concern about the proper way to proceed on fixing a problem.

Problem	Possible Causes	Remedies
ThermDAC software cannot connect to the manikin	Power not on; cables improperly or not connected	Apply power; check fuses; check all cable connections (don't forget USB cable between PC and Power Supply Enclosure!). When in doubt, reboot computer.
Individual sensor reading at zero, "floating", or otherwise out of range	Failed controller or temperature sensor	Contact MTNW for service.
All displayed voltages zero, "floating", or otherwise out of range	Cables improperly or not connected	Check all cable connections; check fuses
Individual heaters not functioning properly	Failed controller or heater	Contact MTNW for service
All heaters not functioning properly	Blown fuse, cables not connected properly	Check all cables; check +48V fuse
System will not stabilize at setpoint temperature	Poorly tuned Kp and Ki gains	Correct gains in Device Parameters screen (Advanced mode)
System will not reach setpoint temperature	Poorly tuned Kp and Ki gains or environment temperature too low.	Adjust gains or increase environment temperature.

Table 5.2.1 – Troubleshooting Chart

5.3 – Manikin Joints and Seals

The highest potential maintainece liability for this manikin is the o-ring sealed joints and flange gaskets which keep the manikin water-sealed and pressure-tight. With careful handling and periodic retightening of flange bolts, problems can be minimized.

An exploded view drawing of the joints are shown in the Appendix, which also indicates the hardware and o-ring specifications for service. The operating principle is that the joints use the same bolts for tensioning, motion stops, and attachment of the limbs. The bolts compress a hardcoated aluminum flange between two oil-impregnated bronze friction plates. Only a small amount of torque on these bolts is necessary to produce a high level of friction.

To tension/loosen or remove the joints, the clamp bolts must be exposed. For the elbows, knees, and ankles, access is gained by removing the two pipe plugs on the inside of each joint. For the hips and shoulders, the flange bolts need to be removed and the manikin opened up.

IMPORTANT: If a joint is completely separated by removing all the bolts, the backing plate can fall out of position, making reinstallation difficult. Only separate joints when necessary.

Removing and reassembling joints is best performed with two people, or a single person with more than two hands, if you can find one. Removing is simple. Loosen the clamp bolts until the joint is free. DO NOT ALLOW THE BOLTS TO FALL INSIDE THE MANIKIN – THEY WILL BE HARD TO RETRIEVE. Whenever the joint is disassembled, inspect and regrease the o-ring seals if necessary to ensure watertightness. Reassembly of the joint is facilitated by installing a threaded rod in place of one of the clamp bolts. This rod can be used to hold the backing plate in the proper position while the other bolt(s) are installed.

The manikin's flange gaskets are adhesive-backed on one side, and were installed with a TINY amount of silicone vacuum grease on the mating surface to prevent the gasket from bonding to the casting flanges. Do not overgrease, or the gaskets will squirt out from between the parts during clamping and/or pressurization.

When disassembling the flanges, no special precautions are necessary, other than supporting the casting during removal. Once unbolted, they can typically hang from their electrical harness, which contains a load-bearing ground strap for this purpose. For reassembly, visually inspect the gasket surface and position before mating the casting halves. Install all bolts for several threads before tightening any of them. It is critical to use an even bolt torquing pattern, alternating from opposite sides of the flange. A precise torque specification is not provided, because it varies around the manikin. Begin by UNDER-tightening the bolts and perform a tank test with a pressurized manikin to check gasket integrity. Bolts can be tightened up during this test until bubbling stops.

5.4 – Technical Assistance

Please contact Measurement Technology Northwest in Seattle, WA, USA at (206) 634-1308 or (206) 634-1309 (fax) for technical assistance or servicing. Our office hours are weekdays 9:00 AM to 5:00 PM Pacific Time.

APPENDICES

Appendix A - System Constants

The following tables contain parameters for each zone controller and the ambient sensors. These consist of variables which can be used for making calculations from manikin data, temperature calibration data, control gains, and configuration information.

Zone #	Zone Name	Surface Area	Heater Resistance	Temp Offset 1	Temp Offset 2
1	Face	0.03601	70.072	-0.10	-0.10
2	Head	0.10965	22.637	-0.10	-0.05
3	R Upper Arm	0.09557	26.059	-0.11	-0.09
4	L Upper Arm	0.09557	26.052	-0.12	-0.05
5	R Forearm	0.06281	40.080	-0.07	-0.04
6	L Forearm	0.06281	40.005	-0.04	-0.12
7	R Hand	0.04181	52.466	-0.11	-0.12
8	L Hand	0.04181	52.487	-0.09	-0.08
9	Chest	0.10033	24.842	-0.08	-0.05
10	Shoulders	0.10369	21.813	-0.03	-0.02
11	Stomach	0.10528	23.833	0.03	0.03
12	Back	0.10673	22.923	0.03	-0.11
13	Cod Piece	0.06121	29.104	-0.08	-0.07
14	R Thigh Front	0.11928	20.880	-0.03	-0.07
15	R Thigh Back	0.11586	20.994	-0.06	-0.09
16	L Thigh Front	0.11928	20.849	-0.02	-0.05
17	L Thigh Back	0.11586	21.030	0.05	-0.07
18	R Calf Front	0.06211	40.366	-0.10	-0.09
19	R Calf Back	0.06368	39.440	-0.09	-0.03
20	L Calf Front	0.06211	40.405	-0.02	-0.05
21	L Calf Back	0.06368	39.531	-0.05	-0.01
22	R Foot	0.05817	43.504	-0.05	-0.06
23	L Foot	0.05817	43.510	-0.06	-0.02
	TOTAL	1.86148			

Appendix A - System Constants (continued)

Zone Globals

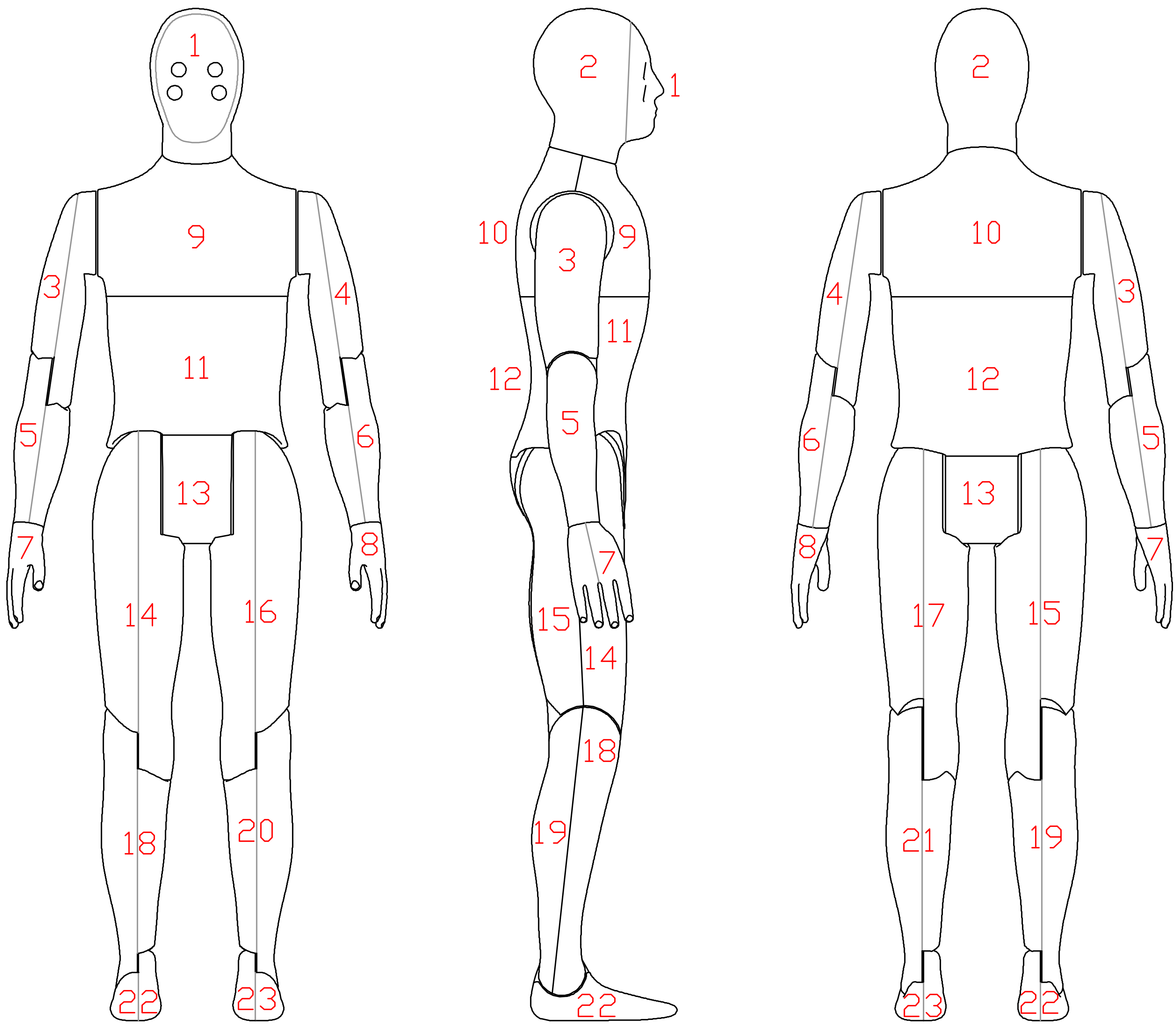
Parameter	Zones
Kp	0.1
Ki	0.001
Notch Filter Constant	4
A/D Sampling Constant	32
PI Loop Sampling Constant	8
VM03 Sampling Constant	2

Ambient Configuration

Parameter	Value
Temp Sensor 1 Scale (ºC/%FS)	1
Temp Sensor 1 Offset (ºC)	+0.041
Temp Sensor 2 Scale (ºC/%FS)	1
Temp Sensor 2 Offset (ºC)	-0.085
RH Sensor Scale (%RH/%FS)	180
RH Sensor Offset (%RH)	0
Wind Sensor Scale (m/sec/%FS)	2.25
Wind Sensor Offset (m/sec)	0
Notch Filter Constant	4
A/D Sampling Constant	32

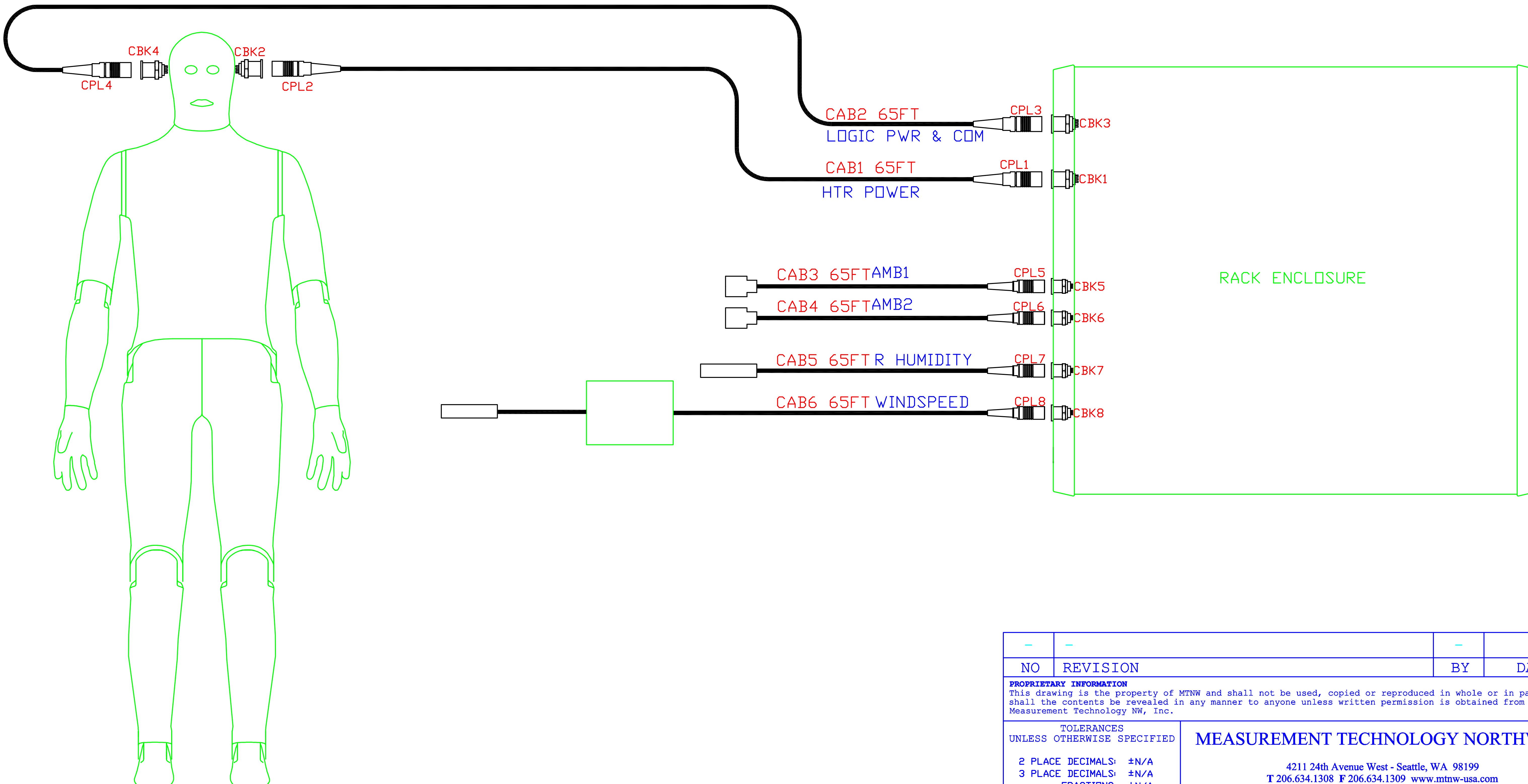
Appendix B - Control System Schematics and Mechanical Drawings

P308 - NEMO2 MANIKIN - ZONE DIVISIONS



PARTS LIST

ITEM NO.	NO. REQD.	P/N	MANUFACTURER/DESCRIPTION
-	-	-	-



NO	REVISION	BY	DATE
-	-	-	-

TOLERANCES
UNLESS OTHERWISE SPECIFIED

2 PLACE DECIMALS: ±N/A
3 PLACE DECIMALS: ±N/A
FRACTIONS: ±N/A
ANGLES: ±N/A

ALL DIMS ARE IN INCHES
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

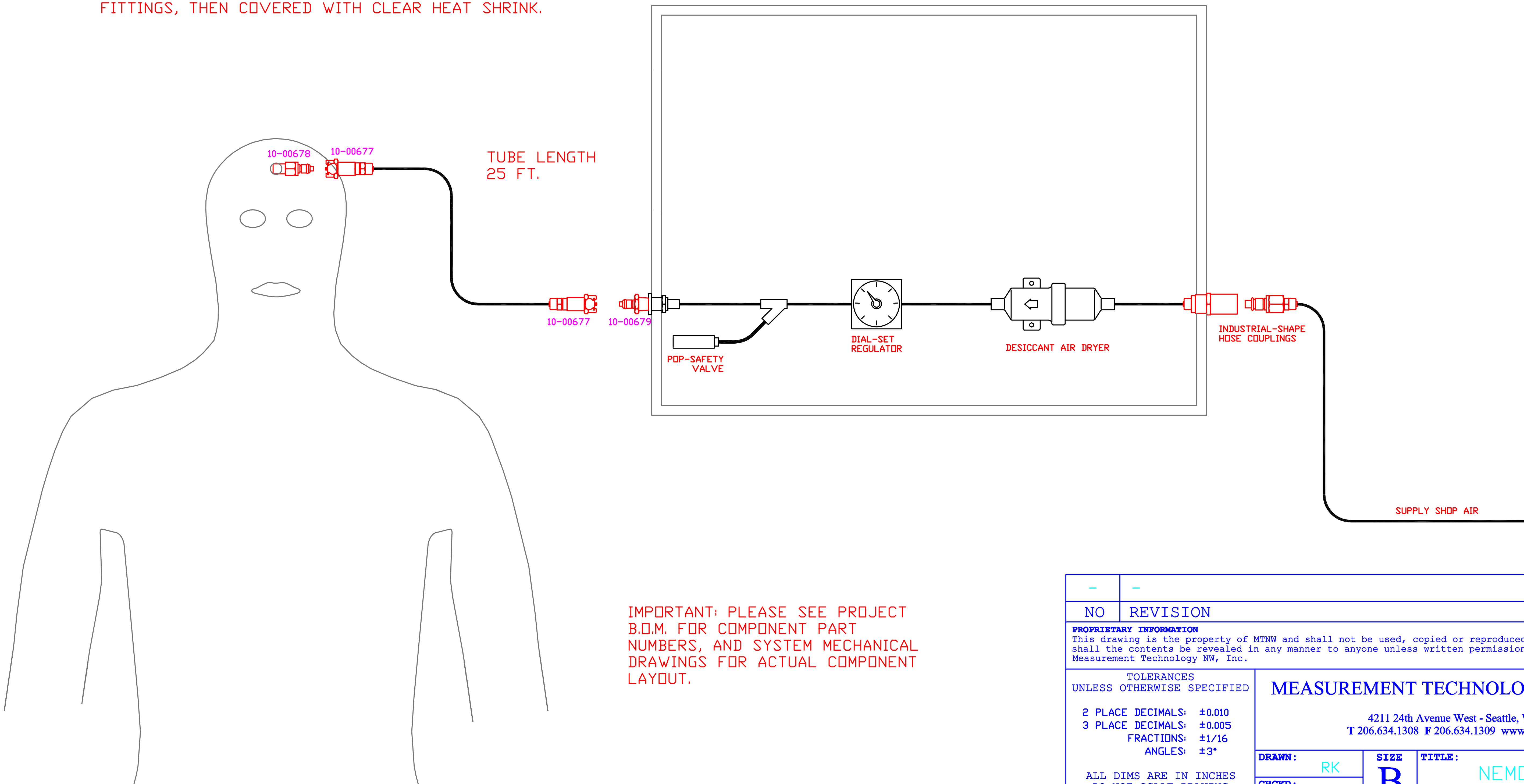
MEASUREMENT TECHNOLOGY NORTHWEST
4211 24th Avenue West - Seattle, WA 98199
T 206.634.1308 F 206.634.1309 www.mtnw-usa.com

DRAWN: STEVE R
CHCKD:
SIZE B
TITLE: SUBMERSIBLE MANIKIN CONTROL CABLES
DATE: 16 FEB 2007
PROJECT: 308
SHT: 1 OF 1
SCALE: NTS
DWG. NO: 308-E02R0
REV: -

PARTS LIST

ITEM NO.	NO. REQD.	P/N	MANUFACTURER/DESCRIPTION
-	-	-	-

NOTE:
FLUID LINES MARKED BY LABELING WHITE HEATSHRINK NEAR FITTINGS, THEN COVERED WITH CLEAR HEAT SHRINK.



IMPORTANT: PLEASE SEE PROJECT B.O.M. FOR COMPONENT PART NUMBERS, AND SYSTEM MECHANICAL DRAWINGS FOR ACTUAL COMPONENT LAYOUT.

NO	REVISION	BY	DATE
-	-	-	-

TOLERANCES
UNLESS OTHERWISE SPECIFIED

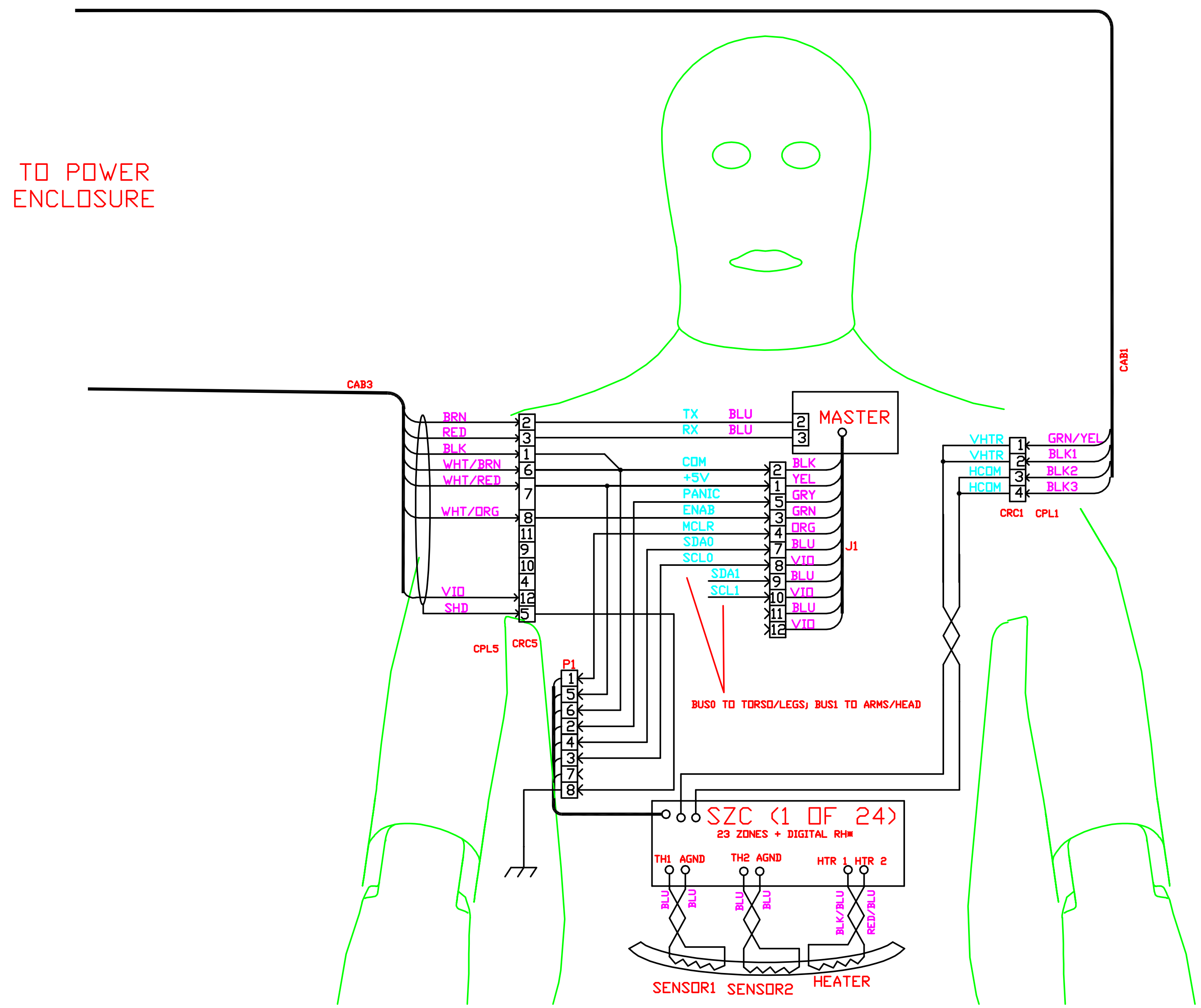
2 PLACE DECIMALS: ±0.010
3 PLACE DECIMALS: ±0.005
FRACTIONS: ±1/16
ANGLES: ±3°

ALL DIMS ARE IN INCHES
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

MEASUREMENT TECHNOLOGY NORTHWEST
4211 24th Avenue West - Seattle, WA 98199
T 206.634.1308 F 206.634.1309 www.mtnw-usa.com

DRAWN: RK
CHCKD: .
SIZE B
TITLE: NEMO MANIKIN AIR SCHEMATIC
DATE: MAR 12 2007
PROJECT: 308
SHT: 1 OF 1
SCALE: NTS
DWG. NO: 308-F01R0
REV: -



*DIGITAL RH CONTROLLER DOES NOT HAVE HEATERS, SENSORS, VHTR/HCOM, OR GND CONNECTION

PARTS LIST

ITEM NO.	NO. REQD.	P/N	MANUFACTURER/DESCRIPTION
-	-	-	-

NO	REVISION	BY	DATE

TOLERANCES
UNLESS OTHERWISE SPECIFIED

2 PLACE DECIMALS: ±0.010
3 PLACE DECIMALS: ±0.005
FRACTIONS: ±1/16
ANGLES: ±3°

ALL DIMS ARE IN INCHES
DO NOT SCALE DRAWING

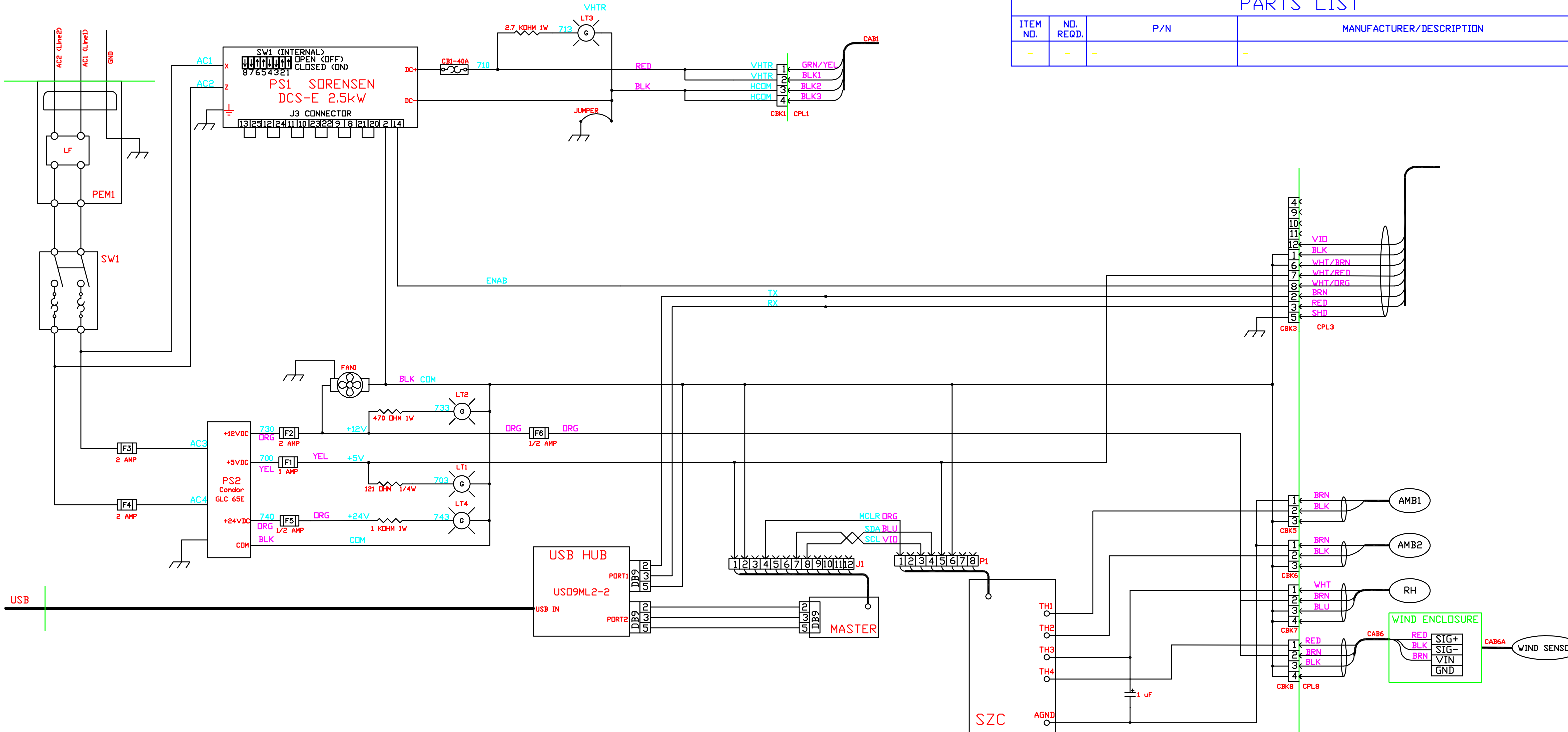
THIRD ANGLE PROJECTION

MEASUREMENT TECHNOLOGY NORTHWEST
4211 24th Avenue West - Seattle, WA 98199
T 206.634.1308 F 206.634.1309 www.mtnw-usa.com

DRAWN: STEVE R
CHCKD: -
SIZE B
TITLE: SUBMERSIBLE MANIKIN CONTROL SCHEMATIC
DATE: 01FEB2007
PROJECT: P308
SHT: 1 OF 1
SCALE: NTS
DWG. NO: 308-E03R0
REV: A

PARTS LIST

ITEM NO.	NO. REQD.	P/N	MANUFACTURER/DESCRIPTION
–	–	–	–



NOTES:

1. ALL WIRES ARE BLUE UNLESS OTHERWISE SPECIFIED
2. ALL WIRES ARE 20 GAGE WITH THE FOLLOWING EXCEPTIONS:
   1. ALL AC WIRING IS 14GA
   2. VHTR FROM THE POWER SUPPLY THROUGH THE CIRCUIT BREAKER TO THE TERMINAL BLOCKS, AND HCOM FROM THE PS TO THE TERMINAL BLOCKS IS 8GA.

NO	REVISION	BY	DATE

TOLERANCES
UNLESS OTHERWISE SPECIFIED

2 PLACE DECIMALS: ±0.010
3 PLACE DECIMALS: ±0.005
FRACTIONS: ±1/16
ANGLES: ±3°

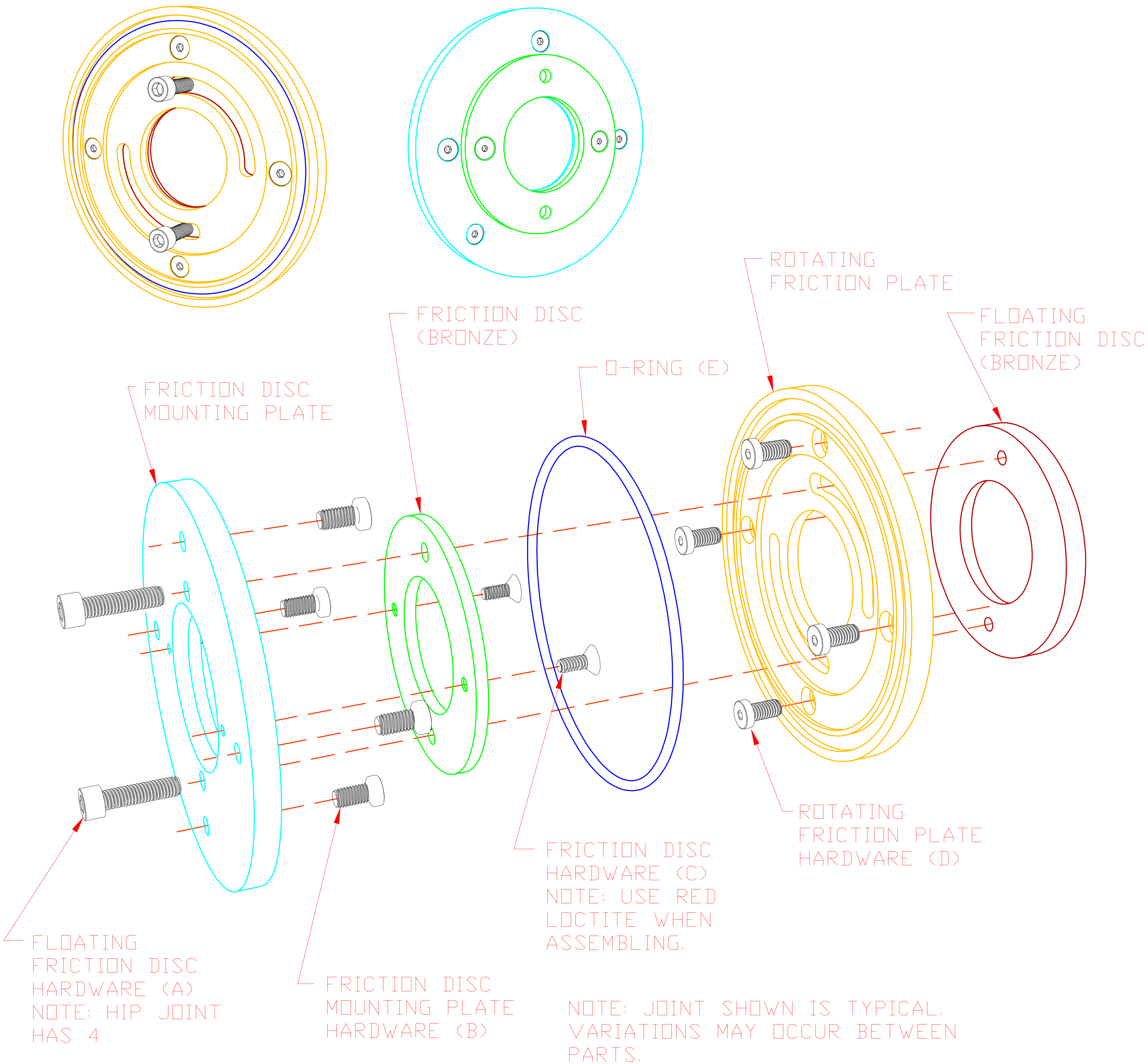
ALL DIMS ARE IN INCHES
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

MEASUREMENT TECHNOLOGY NORTHWEST

4211 24th Avenue West - Seattle, WA 98199
T 206.634.1308 F 206.634.1309 www.mtnw-usa.com

DRAWN: STEVE R	SIZE: B	TITLE: SUBMERSIBLE MANIKIN CONTROL SCHEMATIC	
CHCKD:			
DATE: 16 FEB 2007	PROJECT: P308		SHT: 1 OF 1
SCALE: NTS	DWG. NO: 308-E01R0		REV: –



NOTE: JOINT SHOWN IS TYPICAL. VARIATIONS MAY OCCUR BETWEEN PARTS.

SHOULDER JOINT

A	2	10-00482	10-32 X 7/8 SOCKET HEAD
B	4	10-00384	10-32 X 1/2 LOW HEAD
C	2	10-00465	6-32 X 3/8 FLAT HEAD
D	4	10-00624	10-32 X 3/8 LOW HEAD
E	1	MMC 90025K527	-247 1/8 X 4 5/8 X 4 7/8

ELBOW JOINT

A	2	10-00798	8-32 X 5/8 SOCKET HEAD
B	4	10-00623	8-32 X 1/4 LOW HEAD
C	2	10-00625	4-40 X 1/4 FLAT HEAD
D	4	10-00623	8-32 X 1/4 LOW HEAD
E	1	MMC 90025K457	-148 3/32 X 2 3/4 X 2 15/16

HIP JOINT

A	4	10-00482	10-32 X 7/8 SOCKET HEAD
B	4	10-00624	10-32 X 3/8 LOW HEAD
C	2	10-00465	6-32 X 3/8 FLAT HEAD
D	4	10-00624	10-32 X 3/8 LOW HEAD
E	1	MMC 90025K527	-247 1/8 X 4 5/8 X 4 7/8

KNEE JOINT

A	2	10-00482	10-32 X 7/8 SOCKET HEAD
B	4	10-00624	10-32 X 3/8 LOW HEAD
C	2	10-00465	6-32 X 3/8 FLAT HEAD
D	4	10-00624	10-32 X 3/8 LOW HEAD
E	1	MMC 90025K468	-239 1/8 X 3 5/8 X 3 7/8

ANKLE JOINT

A	2	10-00798	8-32 X 5/8 SOCKET HEAD
B	4	10-00623	8-32 X 1/4 LOW HEAD
C	2	10-00625	4-40 X 1/4 FLAT HEAD
D	4	10-00623	8-32 X 1/4 LOW HEAD
E	1	MMC 90025K457	-148 3/32 X 2 3/4 X 2 15/16

NO	REVISION	BY	DATE
-	-	-	-

TOLERANCES
UNLESS OTHERWISE SPECIFIED

2 PLACE DECIMALS: ±0.010
3 PLACE DECIMALS: ±0.005
FRACTIONS: ±1/16
ANGLES: ±3°

ALL DIMS ARE IN INCHES
DO NOT SCALE DRAWING

THIRD ANGLE PROJECTION

MEASUREMENT TECHNOLOGY NORTHWEST
4211 24th Avenue West - Seattle, WA 98199
T 206.634.1308 **F** 206.634.1309 www.mtnw-usa.com

DRAWN: RK	**SIZE** B	**TITLE:** NEMO MANIKIN JOINT EXPLODED VIEW	
CHCKD: .			
DATE: AUG 9 2006	**PROJECT:** 287	**SHT:** 1 OF 1	
SCALE: NTS	**DWG. NO:** 287-M25R0		**REV:** -

Appendix C – Replacement Parts List

Item #	Description	Manufacturer	Part No.	Qty
1	Humidity Sensor	Vaisala	HUMITTER 50U	1
2	Manikin Temperature Sensor	Betatherm	30K5A1B	46
3	Fuses (assorted, see table below)	See below	See below	7
4	120VAC, 20A Circuit Breaker	Schurter	3120-F321-P7T1-W01D-10A	1
5	+60V, 40A Circuit Breaker	Square D	MG24438	1
6	60VDC, 3000W Power Supply	Sorenson	DCS60-50E	1
7	+5, +12, +24V Power Supply	Condor	GLC65E	1
8	USB 2-channel serial port	B&B Electronics	USO9ML2-2	1

Fuse #	Rating	Size
Power F1	1.0 A	5x20mm
Power F2	2.0 A	5x20mm
Power F3	2.0 A	5x20mm
Power F4	2.0 A	5x20mm
Power F5	0.5 A	5x20mm
Power F6	0.5 A	5x20mm
Power F7	0.5 A	5x20mm

Manikin Fuses

This is not a complete parts list, but is intended to assist the user in replacing parts which have a reasonable chance of wearing out over time.

For questions about parts not appearing on this list, or for assistance in ordering replacements, please contact MTNW.

Appendix D - Thermistor Equation and Lookup Table (Ambient Sensors Only)

Vsupply =	4.5000 Volts
Rballast=	33000 Ohms

Temp (C) = [1/(A+B*ln(R)+C*(ln(R))^3] - 273.15

A=	9.331754E-04
B=	2.213978E-04
C=	1.263817E-07

Vtherm (Volts)	Rtherm (Ohms)	Ttherm (Deg C)
3.30	12000	47.63
3.26	12500	46.56
3.23	13000	45.54
3.19	13500	44.56
3.16	14000	43.63
3.13	14500	42.73
3.09	15000	41.86
3.06	15500	41.03
3.03	16000	40.23
3.00	16500	39.45
2.97	17000	38.71
2.94	17500	37.98
2.91	18000	37.28
2.88	18500	36.60
2.86	19000	35.94
2.83	19500	35.30
2.80	20000	34.68
2.78	20500	34.08
2.75	21000	33.49
2.72	21500	32.92
2.70	22000	32.36
2.68	22500	31.82
2.65	23000	31.29
2.63	23500	30.77
2.61	24000	30.27
2.58	24500	29.77
2.56	25000	29.29
2.54	25500	28.82
2.52	26000	28.36
2.50	26500	27.91
2.48	27000	27.47
2.45	27500	27.04
2.43	28000	26.61
2.41	28500	26.20
2.40	29000	25.79
2.38	29500	25.39
2.36	30000	25.00
2.34	30500	24.62
2.32	31000	24.24
2.30	31500	23.87
2.28	32000	23.50
2.27	32500	23.15
2.25	33000	22.80
2.23	33500	22.45

Vtherm (Volts)	Rtherm (Ohms)	Ttherm (Deg C)
2.22	34000	22.11
2.20	34500	21.78
2.18	35000	21.45
2.17	35500	21.13
2.15	36000	20.81
2.14	36500	20.49
2.12	37000	20.19
2.11	37500	19.88
2.09	38000	19.58
2.08	38500	19.29
2.06	39000	19.00
2.05	39500	18.71
2.03	40000	18.43
2.02	40500	18.15
2.01	41000	17.87
1.99	41500	17.60
1.98	42000	17.34
1.97	42500	17.07
1.95	43000	16.81
1.94	43500	16.55
1.93	44000	16.30
1.92	44500	16.05
1.90	45000	15.80
1.89	45500	15.56
1.88	46000	15.32
1.87	46500	15.08
1.86	47000	14.84
1.84	47500	14.61
1.83	48000	14.38
1.82	48500	14.15
1.81	49000	13.93
1.80	49500	13.71
1.79	50000	13.49
1.78	50500	13.27
1.77	51000	13.06
1.76	51500	12.84
1.75	52000	12.63
1.74	52500	12.42
1.73	53000	12.22
1.72	53500	12.02
1.71	54000	11.81
1.70	54500	11.62
1.69	55000	11.42
1.68	55500	11.22

Appendix E – Work Cycle Tests

Work cycle tests are a powerful tool with which the user can construct custom setpoint tests. With a Work Cycle file, Newton can be commanded into Temperature or Heat Flux mode, and each zone can be programmed individually or together.

Figure E.1 below shows part of a Work Cycle file (a software copy of this file has been included with the ThermDAC package).

1	User Comments Go in first 5 lines																				
2	Demo program file - runs in Temp control mode for first minute, changing the setpoints a few times, then goes to heat flux mode																				
3	and does high output, low output																				
4																					
5																					
Time	Mode	Htr1	Htr2	Htr3	Htr4	Htr5	Htr6	Htr7	Htr8	Htr9	Htr10	Htr11	Htr12	Htr13	Htr14	Htr15	Htr16	Htr17	Htr18	Htr19	Htr20
(min)	T, H, or X	Face	Head	Chest	Stom ach	Upper Back	Lower Back	R Upper Arm	R Forea rm	R Hand	L Upper Arm	L Forea rm	L Hand	R Hip	R Thigh	R Calf	R Foot	L Hip	L Thigh	L Calf	L Foot
0	T	30.1	30.2	30.3	30.4	30.5	30.6	30.7	30.8	30.9	31	31.1	31.2	31.3	31.4	31.5	31.6	31.7	31.8	31.9	32
0.5	T	35.1	35.2	35.3	35.4	35.5	35.6	35.7	35.8	35.9	36	36.1	36.2	36.3	36.4	36.5	36.6	36.7	36.8	36.9	37
1	T	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
1.5	H	100.1	100.2	100.3	100.4	100.5	100.6	100.7	100.8	100.9	101	101.1	101.2	101.3	101.4	101.5	101.6	101.7	101.8	101.9	102
2	H	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
2.25	H	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
2.5	X	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

When reading the Work Cycle file, the ThermDAC software looks at the time (in minutes), the setpoint mode (T for Temperature, H for Heat Flux, or X for Exit), and then reads the setpoints and flow rates for each zone. This file can be lengthened or shortened to meet the needs of the user.

Under each of the Htr# columns, the numerical value entered is either a temperature (°C), or a heat flux (W/m^2), depending on the selected mode.

Appendix F – Sample Test Procedure

The following procedures are examples of three different type of experiments – Dry, Wet, and Hdiff tests.

Typical Dry Experiment:

1. Dress the manikin as needed for test.
2. Set environmental chamber/area under test to the desired temperature and humidity conditions.
3. From the ThermDAC main screen, select “Run>Dry Experiment” in the pull-down menu.
4. Enter a filename at the prompt. *.csv will be automatically appended.
5. From the Test Parameters screen, enter test comments, logging information, and desired steady state conditions.
6. Click on “Setpoint Configuration”. From this screen, enter the desired skin temperature. Click “OK”. If this is a continuation from prior test, the setpoint will remain from the last test and do not need to be updated.
7. Click “Start Test”.
8. The test will start. If steady-state detection has been enabled, the test will terminate automatically when an accurate Dry Thermal Resistance measurement can be calculated. Steady state reports can be generated manually at any time using the Save Steady State button in the runtime screen.

Hdiff, or Heat Difference, tests are designed to measure the variation in Heat Flux created by a Personal Cooling System (PCS).

Typical Hdiff Experiment:

1. Run a Dry Experiment, as described above, using all garments to be tested, with the exception of the PCS.
2. Add the PCS to the manikin.
3. From the ThermDAC main screen, select “Run>Hdiff Experiment”pull-down menu.
4. Enter a filename at the prompt. *.csv will be automatically appended.
5. From the Test Parameters screen, enter test comments, logging information, and desired steady state conditions.
6. Click on Load Reference. A Reference file is any ThermDAC generated steady-state report which contains Heat Flux measurements. In this case, the difference in Heat Flux required to maintain skin temperature will be calculated and reported in total Watts.
7. Click on “Setpoint Configuration”. From this screen, enter the desired skin temperature and flow setpoints. For a nude manikin wearing only the sweat-skin layer, a flow rate of 250 ml/hr/m^2 is adequate to wet the entire manikin evenly. This will likely be lower when additional garments are added. For accurate measurements, the sweating skin needs to be thoroughly wetted, but not dripping. Click “OK”.
8. Click “Start Test”.
9. The test will start. If steady-state detection has been enabled, the test will terminate automatically when an accurate Hdiff measurement can be calculated. Steady state reports can be generated manually at any time using the Save Steady State button in the runtime screen.

Appendix G – Calibration Certificates

Certificate of Calibration

Calibration Date: 28 Mar 2007
Calibrated Thru: 28 Mar 2008
Contact Name: Lawrence Mak
Instrument Description: Nemo-23
Serial Number: 308

Calibration Information:

Temperature Sensors: Calibrated with precision reference probes to +/- 0.1 degC absolute.

Humidity: Calibrated by vendor (Vaisala) to +/- 3% RH. Voltage measurement verified by MTNW

Windspeed: Calibrated by vendor (TSI) to +/- 0.1 m/sec. Voltage measurement verified by MTNW

Heat Flux: Calibrated with precision voltmeter to +/- 1%

Certification:

This document certifies that this instrument has been built and tested in accordance with client and MTNW Specifications, and that it is rated for proper operation over the environmental range from -20 to 70 Deg C and water immersion up to 3 meters depth, with device conditions to be maintained between 0 Deg C and 50 Deg C. The device can perform in compliance with ASTM F1291, prEN13537 and static insulation (non-walking) for ISO 15831.

Calibration Instruments:

HP 34401A Digital Voltmeter
(This instrument calibrated in accordance with ISO/IEC 17025:1999, and traceable to NIST)

Hart-Scientific Model 5610 Thermistor Probe (Serial No: A270509) with Hart-Scientific Model 1521 Readout Module (Serial No: A2B477)
(These instruments calibrated in compliance with ANSI/NCSL Z540-1, and traceable to NIST)

Signed Date

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