

Image Cover Sheet

CLASSIFICATION

UNCLASSIFIED

SYSTEM NUMBER

511093



TITLE

Manikin Testing of New Concepts of Immersion Suits and Liners

System Number:

Patron Number:

Requester:

Notes:

DSIS Use only:

Deliver to:





DCIEM CR 1999-050

**MANIKIN TESTING OF NEW CONCEPTS OF IMMERSION SUITS
AND LINERS**

by

W. Durnford

P. Potter

Of

The CORD Group Limited

50A Mount Hope Avenue

Dartmouth, Nova Scotia, CANADA

B2Y 4K9

Project Manager:

Mr. Paul Potter

Telephone: (902) 465-5544

Government of Canada Contract No.W7711-8-7500/001/SRV

On behalf of

DEPARTMENT OF NATIONAL DEFENCE

As represented by

Defence and Civil Institute of Environmental Medicine

1133 Sheppard Avenue West

Toronto, Ontario, CANADA

M3M 3B9

DCIEM Technical Authority:

Mr. Michel B. Ducharme, Ph.D

(416) 635-2186

31 March 1999

© HER MAJESTY THE QUEEN IN RIGHT OF CANADA (1999)

as represented by the Minister of National Defence

EXECUTIVE SUMMARY

At the last *Aerospace Life Support Equipment Project Review Meeting* held at DCIEM during the summer 1998, DCIEM was tasked to test the new MAC 200 suit introduced on the market by Mustang Survival in September 1998. In addition, DCIEM was asked to test also new liners for the current Constant Wear Dry immersion suit which should provide better thermal protection in cases of water leakage.

The CORD Group Limited was contracted by the Defence and Civil Institute of Environmental Medicine to determine the thermal resistance of the MAC 200 immersion suit and the current Constant Wear Dry immersion suit with different liners [current liner, closed cell foam liner (3 mm), and variable insulation liner (closed cell foam with 3 mm on the front and 12 mm on the back)], some of them being under developmental phase. The thermal resistance of these suits and liners was determined utilizing a thermal instrumented manikin test system.

This report describes the thermal manikin test system, the protocols and the results for each item tested. A total of 10 tests were conducted, with each test measuring the thermal resistance of each suit and liner. The tests were all conducted with the manikin immersed in water with a significant wave height of 30 cm with a wave period of 2.5 seconds. Tests were conducted in 3 conditions: no artificial leakage, 2 liters of leakage, and 4 liters of leakage.

During dry tests, the thermal resistance of the MAC 200 immersion suit was about 10% higher than the thermal resistance of the Constant Wear Dry immersion suit, and the difference between the two suits doubled to about 20% during the wet tests. For both immersion suits, the variable insulation liner had on average a thermal resistance 42% higher than the current liner and 41% higher than the closed cell foam liner, in both no artificial and artificial leakage conditions. Based on these preliminary tests, there appears to be sufficient differences in the results to warrant further study using human subjects. In conclusion, the results from the thermal manikin indicate that the MAC 200 immersion suit has a slightly higher thermal resistance than the Constant Wear Dry suit for both dry and wet conditions, and that the new variable insulation liner provides better thermal protection during cold water immersion as compared to current liner and the 3 mm closed cell liner.

TABLE OF CONTENTS

1.0 INTRODUCTION	1
1.1 BACKGROUND:	1
1.2 AIM:	1
1.3 STATEMENT OF WORK:	1
2.0 REFERENCES	2
3.0 METHOD	3
3.1 METHODOLOGY:	3
3.2 THERMAL MANIKIN TEST SYSTEM:	3
4.0 TEST EQUIPMENT	5
5.0 TEST CONDITIONS	6
6.0 TEST ITEMS	7
7.0 TEST PROCEDURE	8
8.0 RESULTS	9

ANNEX "A" RAW DATA

1.0 INTRODUCTION

1.1 BACKGROUND:

At the last *Aerospace Life Support Equipment Project Review Meeting* held at DCIEM during the summer 1998, DCIEM was tasked to test the new MAC 200 suit introduced on the market by Mustang Survival in September 1998. In addition, DCIEM was asked to test also new liners for the current Constant Wear Dry immersion suit which should provide better thermal protection in cases of water leakage.

The tests are scheduled to be performed at sea under realistic field conditions. In order to decide the test conditions at sea, it is necessary to test the different potential configurations on a thermal manikin. The series of manikin tests will save time and money during the sea trial by excluding non-essential test conditions.

The objective of the present manikin tests is to define the thermal resistance of the MAC 200 immersion suit and the current Constant Wear Dry immersion suit with different liners, some of them being under developmental phase.

1.2 AIM:

To measure the thermal resistance of the MAC 200 immersion suit and the current Constant Wear Dry immersion suit with different liners, some of them being under developmental phase.

1.3 STATEMENT OF WORK:

The project will determine, utilizing a standardized, validated and reliable protocol (formally agreed upon between contractor and technical authorities), the thermal resistance of the following clothing configurations in stirred water:

1. MAC 200 immersion suit with the current liner (3mm); no artificial leak;
2. MAC 200 immersion suit with a variable insulation liner; no artificial leak;
3. MAC 200 immersion suit with the current liner (3mm); 2000 ml water leak;
4. MAC 200 immersion suit with a variable insulation liner; 2000 ml water leak;
5. Constant Wear Dry immersion with closed cell liner (3mm); no artificial leak;
6. Constant Wear Dry immersion with variable insulation liner; no artificial leak;
7. Constant Wear Dry immersion with the current liner; 2000 ml water leak;
8. Constant Wear Dry immersion with closed cell liner (3mm); 2000 ml leak;
9. Constant Wear Dry immersion with variable insulation liner; 2000 ml water leak;
10. Constant Wear Dry immersion with variable insulation liner; 4000 ml water leak;

2.0 REFERENCES

- 2.1 CORD Document No. R95-018 (1995). Implementation of Test Protocol of Thermal Manikin Test System. The CORD Group Limited, Dartmouth: May 1995.

3.0 METHOD

3.1 METHODOLOGY:

The thermal resistance of the MAC 200 immersion suit and the current Constant Wear Dry immersion suit with different liners, some of them being under developmental was determined using a Thermal Instrumented Manikin Test System. During each test, environment, temperature, skin temperature and power consumption was recorded.

3.2 THERMAL MANIKIN TEST SYSTEM:

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.

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 temperature differences 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.

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 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.

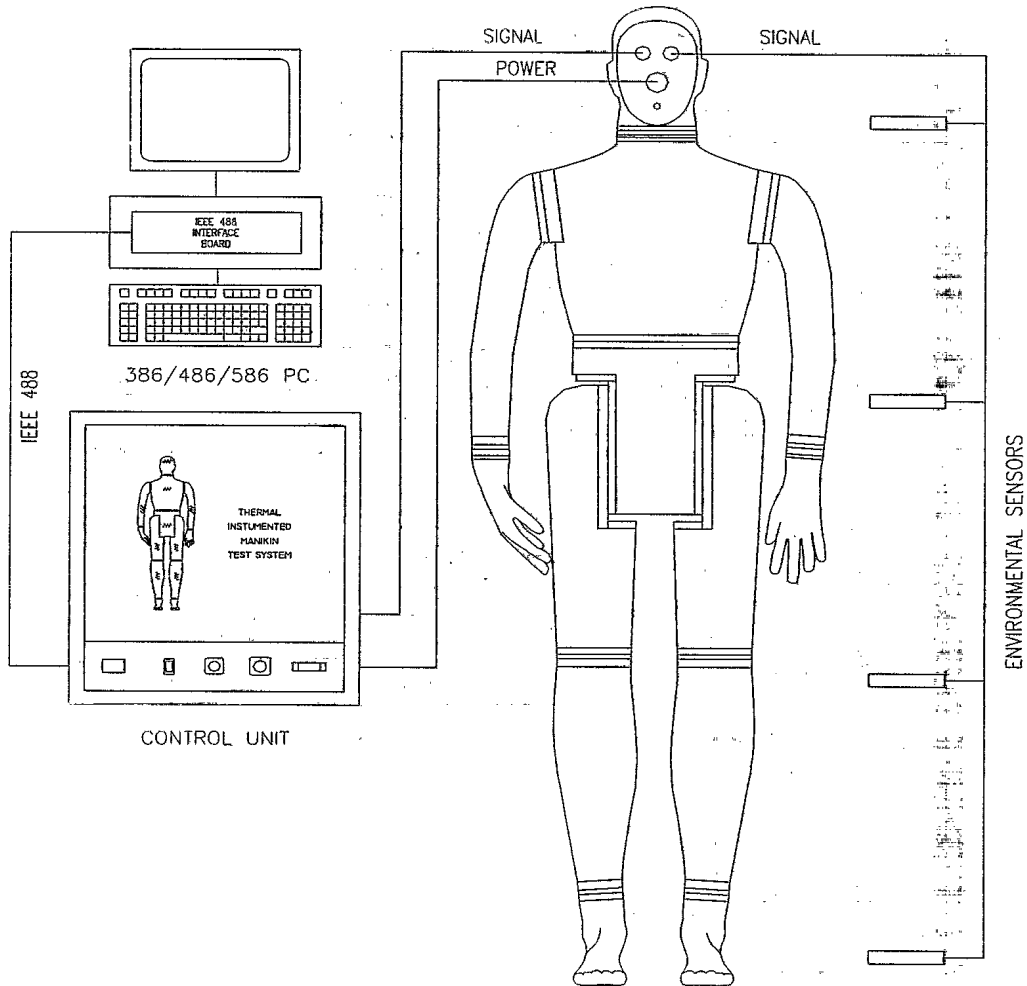


FIGURE 1

4.0 TEST EQUIPMENT

- 4.1 Control Module.
Model #: Micro-Mac 5000. Serial #: 98-9109404-001.
Last Calibration Date: March 31, 1998.
Calibration Due Date: March 31, 1999.
- 4.2 Instrumented Manikin.
Model #: TIM 1.
Last Calibration Date: March 31, 1998.
Calibration Due Date: March 31, 1999.
- 4.3 Desktop Computer.
Model #: AP 65. Serial #: 1505.
Calibration not required.

5.0 TEST CONDITIONS

5.1 For the testing performed in March 1999, testing was conducted in turbulent water with a significant wave height of 30 cm with a peak wave height of 45 cm and a wave period of 2.5 seconds.

5.1.1 Water Temperature: 11.48 – 12.28 ° C

5.1.2 Relative Humidity: 55.0 - 65.0 ± 5 %

Despite the unintentional changes in the water temperature conditions, the water temperature conditions are not critical to the results rather it is the difference between the water temperature and body temperature, and that the latter was maintained constant across all conditions.

6.0 TEST ITEMS

- 6.1 Thermal Instrumented Manikin dressed in test garment ensembles described in table 6.2.1, 6.3.1, and 6.4.1.
- 6.2 Table 6.2.1 illustrates the undergarment requested.
- 6.3 Table 6.3.1 illustrates the auxiliary components required for testing.
- 6.4 Table 6.4.1 illustrates the suit and liner requested.

Run #	Undergarments
1 - 10	Long sleeve cotton shirt, denim trousers, underwear (briefs), medium weight dress socks

Table 6.2.1

Run #	Auxiliary Components
1 - 4	LP/SV lifejacket (inflated), inflated mitts, 5mm neoprene hood, leather flight boots
5 - 10	LP/SV lifejacket (inflated), neoprene mitts, 5mm neoprene hood, leather flight boots

Table 6.3.1

Run #	Auxiliary Components
1	MAC 200 immersion suit with the current liner (3mm); no artificial leak
2	MAC 200 immersion suit with a variable insulation liner (3mm front, 8mm back); no artificial leak
3	MAC 200 immersion suit with the current liner (3mm); 2000 ml water leak
4	MAC 200 immersion suit with a variable insulation liner (3mm front, 8mm back); 2000 ml water leak
5	Constant Wear Dry immersion with closed cell liner (3mm); no artificial leak
6	Constant Wear Dry immersion with variable insulation liner (3mm front, 8mm back); no artificial leak
7	Constant Wear Dry immersion with the current liner; 2000 ml water leak
8	Constant Wear Dry immersion with closed cell liner (3mm); 2000 ml leak
9	Constant Wear Dry immersion with variable insulation liner (3mm front, 8mm back); 2000 ml water leak
10	Constant Wear Dry immersion with variable insulation liner (3mm front, 8mm back); 4000 ml water leak

Table 6.4.1

7.0 TEST PROCEDURE

The MAC 200 immersion suit and the Constant Wear Dry immersion ensembles were tested using the procedures as directed in CORD Document No. R95-018 Implementation of Test Protocol of Thermal Manikin Test System, May 1995. The manikin was lifted using an overhead hoist. The manikin was dressed in the above undergarment ensemble. The test garment was placed over the undergarment ensemble and secured. The manikin was positioned into the positioning cradle and then lowered into the water and positioned in the centre of the test tank in the natural flotation position. The environmental sensors were attached to the positioning cradle to provide the environmental temperature. A wave machine consisting of a pivoting paddle and a hydraulic ram was started to produce a significant wave height of 30 cm with a wave period of 2.5 seconds.

Entering all pertinent information into the system's computer started a warm up period, while all sections of the manikin were warming up to the selected skin temperature. During that time, the conditions for the prescribed tests were implemented. Once all sections of the manikin reached the set point, the test automatically commenced. The test duration was four (4) hours to achieve steady state condition.

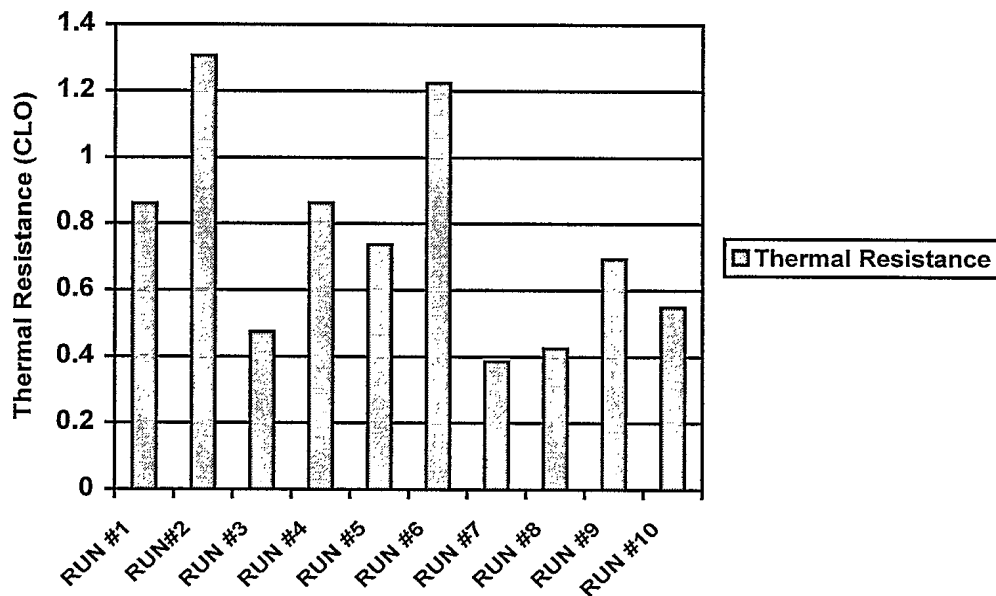
8.0 RESULTS

8.1 Table 8.1.1 illustrates final results of the thermal resistance testing rounded to four decimal points.

Run #	Auxiliary Components	Result CLO
1	MAC 200 immersion suit with the current liner (3mm); no artificial leak	0.8585
2	MAC 200 immersion suit with a variable insulation liner (3mm front, 8mm back); no artificial leak	1.3060
3	MAC 200 immersion suit with the current liner (3mm); 2000 ml water leak	0.4738
4	MAC 200 immersion suit with a variable insulation liner (3mm front, 8mm back); 2000 ml water leak	0.8608
5	Constant Wear Dry immersion with closed cell liner (3mm); no artificial leak	0.7375
6	Constant Wear Dry immersion with variable insulation liner (3mm front, 8mm back); no artificial leak	1.2234
7	Constant Wear Dry immersion with the current liner; 2000 ml water leak	0.3868
8	Constant Wear Dry immersion with closed cell liner (3mm); 2000 ml leak	0.4252
9	Constant Wear Dry immersion with variable insulation liner (3mm front, 8mm back); 2000 ml water leak	0.6941
10	Constant Wear Dry immersion with variable insulation liner (3mm front, 8mm back); 4000 ml water leak	0.5494

Table 8.1.1

8.2 Graph 8.2.1 illustrates the final results of the thermal resistance testing.



Graph 8.2.1

**ANNEX "A"
RAW DATA**

TEST NUMBER: 1565
TEST TITLE: MANIKIN TESTING OF NEW CONCEPTS OF IMMERSION SUITS AND LINERS.
FILE NAME: c:\TIM I_V 1.22\M904TW10.TM1

DATE OF TEST: 03-15-1999
START TIME: 12:13:27
DESCRIPTION OF SUIT TESTED: MUSTANG MAC 200 IMMERSION SUIT, INFLATED LP/SV
LIFEJACKET, NEOPRENE HOOD, INFLATED MITTS, LEATHER FLIGHT BOOTS.
UNDERGARMENTS: LONG SLEEVE COTTON SHIRT, DENIM TROUSERS, BRIEFS, MEDIUM WEIGHT DRESS SOCKS.
ENVIRONMENT: SIGNIFICANT WAVE HEIGHT OF 30 CM WITH A WAVE PERIOD OF 2.5 SEC.
POSITION: NATURAL FLOTATION POSITION.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: NO ADDITIONAL LEAKAGE.

STOP TIME: 16:13:11 MINUTES SINCE START OF TEST: 239.9
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 11.48 AVERAGE OVER TEST TIME: 11.52

SECTION	SETPOINT	SKINTEMP	TEMP DIFF (Deg C)		POWER (WATTS)		INSULATION (CLO)	
	(Deg C)	(Deg C)	INSTANT	AVERAGE	ST	LT	ST	LT
Head	32.00	31.99	20.52	20.47	29.83	33.18	0.6021	0.5401
Chest	32.00	32.12	20.65	20.62	17.11	16.08	1.2118	1.2884
Back	32.00	32.06	20.58	20.52	26.45	32.37	0.8348	0.6803
Abdomen	32.00	32.01	20.53	20.50	2.96	2.88	2.4533	2.5180
Buttocks	32.00	32.03	20.55	20.53	16.51	13.88	0.6917	0.8217
Right Arm	32.00	32.04	20.57	20.53	16.58	14.50	0.9093	1.0378
Left Arm	32.00	32.06	20.58	20.58	19.97	15.28	0.6782	0.8863
Right Hand	32.00	32.01	20.53	20.51	9.25	8.41	0.7030	0.7727
Left Hand	32.00	32.03	20.55	20.52	8.43	8.17	0.7585	0.7810
Right Leg	32.00	32.02	20.54	20.49	31.26	45.68	1.5105	1.0313
Left Leg	32.00	32.00	20.52	20.48	41.91	46.34	1.0487	0.9462
Right Foot	32.00	32.03	20.56	20.49	13.77	15.02	0.6596	0.6032
Left Foot	32.00	32.03	20.56	20.53	17.31	15.77	0.5164	0.5659
Overall					251.35	267.55	0.9158	0.8585

Total Power (W) For All Sections: 267.553

Total Area (Square Meters): 1.736

Overall Insulation Resistance (CLO): 0.8585

TEST NUMBER: 1581
 TEST TITLE: MANIKIN TESTING OF NEW CONCEPTS OF IMMERSION SUITS AND LINERS.
 FILE NAME: c:\TIM I_V 1.22\M904TW12.TM1

DATE OF TEST: 03-16-1999
 START TIME: 13:07:32
 DESCRIPTION OF SUIT TESTED: MUSTANG MAC 200 IMMERSION SUIT, INFLATED LP/SV LIFEJACKET, NEOPRENE HOOD, INFLATED MITTS, LEATHER FLIGHT BOOTS.
 UNDERGARMENTS: LONG SLEEVE COTTON SHIRT, DENIM TROUSERS, BRIEFS, MEDIUM WEIGHT DRESS SOCKS, VARIABLE INSULATION LINER.
 ENVIRONMENT: SIGNIFICANT WAVE HEIGHT OF 30 CM WITH A WAVE PERIOD OF 2.5 SEC.
 POSITION: NATURAL FLOTATION POSITION.
 HUMIDITY: 62
 ENV. FLOW SPEED:
 DIRECTION:
 CABLE LENGTH: Short (50ft)
 ADDITIONAL INFORMATION: NO ADDITIONAL LEAKAGE.

STOP TIME: 17:07:27 MINUTES SINCE START OF TEST: 239.90
 ENVIRONMENT TEMPERATURE:
 INSTANTANEOUS: 11.50 AVERAGE OVER TEST TIME: 11.48

SECTION	SETPOINT	SKINTEMP	TEMP DIFF (Deg C)		POWER (WATTS)		INSULATION (CLO)	
	(Deg C)	(Deg C)	INSTANT	AVERAGE	ST	LT	ST	LT
Head	32.00	32.02	20.53	20.55	32.69	29.64	0.5496	0.6068
Chest	32.00	32.17	20.67	20.68	13.67	12.71	1.5189	1.6341
Back	32.00	32.14	20.64	20.66	9.95	11.33	2.2255	1.9552
Abdomen	32.00	32.08	20.58	20.64	2.58	2.16	2.8245	3.3866
Buttocks	32.00	32.07	20.57	20.60	6.81	7.38	1.6775	1.5503
Right Arm	32.00	32.07	20.57	20.61	12.83	9.98	1.1754	1.5140
Left Arm	32.00	32.15	20.65	20.70	10.11	9.53	1.3442	1.4296
Right Hand	32.00	32.08	20.58	20.60	5.31	5.49	1.2272	1.1877
Left Hand	32.00	32.08	20.58	20.61	5.24	4.89	1.2207	1.3117
Right Leg	32.00	32.00	20.50	20.57	25.05	26.45	1.8818	1.7878
Left Leg	32.00	32.03	20.53	20.55	27.39	26.61	1.6050	1.6531
Right Foot	32.00	32.02	20.52	20.54	15.31	15.05	0.5923	0.6030
Left Foot	32.00	32.04	20.54	20.56	14.81	15.28	0.6033	0.5854
Overall					181.75	176.51	1.2665	1.3060

Total Power (W) For All Sections: 176.509
 Total Area (Square Meters): 1.736
 Overall Insulation Resistance (CLO): 1.3060

TEST NUMBER: 1580
TEST TITLE: MANIKIN TESTING OF NEW CONCEPTS OF IMMERSION SUITS AND LINERS.
FILE NAME: c:\TIM I_V 1.22\M904TW11.TM1

DATE OF TEST: 03-15-1999
START TIME: 15:56:13
DESCRIPTION OF SUIT TESTED: MUSTANG MAC 200 IMMERSION SUIT, INFLATED LP/SV LIFEJACKET, NEOPRENE HOOD, INFLATED MITTS, LEATHER FLIGHT BOOTS.
UNDERGARMENTS: LONG SLEEVE COTTON SHIRT, DENIM TROUSERS, BRIEFS, MEDIUM WEIGHT DRESS SOCKS.
ENVIRONMENT: SIGNIFICANT WAVE HEIGHT OF 30 CM WITH A WAVE PERIOD OF 2.5 SEC.
POSITION: NATURAL FLOTATION POSITION.
HUMIDITY: 65
ENV. FLOW SPEED:
DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION: 2 LITRES OF ADDITIONAL LEAKAGE ADDED TO THE BACK.

STOP TIME: 19:56:08 MINUTES SINCE START OF TEST: 239.90
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 11.50 AVERAGE OVER TEST TIME: 11.49

SECTION	SETPOINT	SKINTEMP	TEMP DIFF (Deg C)		POWER (WATTS)		INSULATION (CLO)	
	(Deg C)	(Deg C)	INSTANT	AVERAGE	ST	LT	ST	LT
Head	32.00	31.98	20.47	20.50	32.88	33.10	0.5452	0.5422
Chest	32.00	32.06	20.55	20.59	26.70	24.03	0.7731	0.8607
Back	32.00	31.87	20.36	20.39	76.73	75.52	0.2847	0.2897
Abdomen	32.00	31.98	20.48	20.50	6.13	5.19	1.1833	1.4000
Buttocks	32.00	31.91	20.40	20.17	40.27	43.49	0.2814	0.2576
Right Arm	32.00	31.96	20.46	20.48	33.63	30.41	0.4458	0.4936
Left Arm	32.00	32.00	20.49	20.53	28.55	27.63	0.4724	0.4889
Right Hand	32.00	32.01	20.51	20.53	9.09	8.83	0.7143	0.7368
Left Hand	32.00	32.03	20.53	20.55	8.44	8.06	0.7563	0.7926
Right Leg	32.00	31.94	20.43	20.45	104.43	101.48	0.4497	0.4633
Left Leg	32.00	31.99	20.48	20.49	86.36	95.31	0.5078	0.4603
Right Foot	32.00	32.00	20.50	20.52	14.69	14.76	0.6166	0.6145
Left Foot	32.00	31.97	20.47	20.49	15.37	15.40	0.5792	0.5784
Overall					483.27	483.21	0.4738	0.4738

Total Power (W) For All Sections: 483.213

Total Area (Square Meters): 1.736

Overall Insulation Resistance (CLO): 0.4738

TEST NUMBER: 1582
 TEST TITLE: MANIKIN TESTING OF NEW CONCEPTS OF IMMERSION SUITS AND LINERS.
 FILE NAME: c:\TIM I_V 1.22\M904TW13.TM1

DATE OF TEST: 03-17-1999
 START TIME: 09:22:41
 DESCRIPTION OF SUIT TESTED: MUSTANG MAC 200 IMMERSION SUIT, INFLATED LP/SV LIFEJACKET, NEOPRENE HOOD, INFLATED MITTS, LEATHER FLIGHT BOOTS.
 UNDERGARMENTS: LONG SLEEVE COTTON SHIRT, DENIM TROUSERS, BRIEFS, MEDIUM WEIGHT DRESS SOCKS, VARIABLE INSULATION LINER.
 ENVIRONMENT: SIGNIFICANT WAVE HEIGHT OF 30 CM WITH A WAVE PERIOD OF 2.5 SEC.
 POSITION: NATURAL FLOTATION POSITION.
 HUMIDITY: 65
 ENV. FLOW SPEED:
 DIRECTION:
 CABLE LENGTH: Short (50ft)
 ADDITIONAL INFORMATION: 2 LITRES OF ADDITIONAL LEAKAGE ADDED TO THE BACK.

STOP TIME: 13:22:46 MINUTES SINCE START OF TEST: 240.10
 ENVIRONMENT TEMPERATURE:
 INSTANTANEOUS: 11.56 AVERAGE OVER TEST TIME: 11.56

SECTION	SETPOINT	SKINTEMP	TEMP DIFF (Deg C)		POWER (WATTS)		INSULATION (CLO)	
	(Deg C)	(Deg C)	INSTANT	AVERAGE	ST	LT	ST	LT
Head	32.00	31.98	20.42	20.42	34.78	34.85	0.5141	0.5131
Chest	32.00	32.14	20.58	20.57	16.08	16.11	1.2852	1.2832
Back	32.00	32.08	20.52	20.51	22.20	23.73	0.9917	0.9275
Abdomen	32.00	32.13	20.57	20.55	2.03	3.25	3.5840	2.2426
Buttocks	32.00	32.01	20.45	20.43	20.76	22.67	0.5472	0.5008
Right Arm	32.00	32.00	20.44	20.44	20.25	17.86	0.7398	0.8387
Left Arm	32.00	32.16	20.59	20.58	8.11	11.29	1.6715	1.1991
Right Hand	32.00	32.07	20.51	20.51	5.55	5.32	1.1712	1.2222
Left Hand	32.00	32.08	20.52	20.52	4.65	4.91	1.3724	1.2998
Right Leg	32.00	32.12	20.56	20.52	43.15	49.08	1.0951	0.9611
Left Leg	32.00	32.06	20.50	20.50	46.61	47.01	0.9416	0.9338
Right Foot	32.00	32.01	20.45	20.45	14.99	14.70	0.6029	0.6147
Left Foot	32.00	31.98	20.41	20.41	15.56	15.73	0.5703	0.5642
Overall					254.71	266.51	0.9008	0.8608

Total Power (W) For All Sections: 266.505

Total Area (Square Meters): 1.736

Overall Insulation Resistance (CLO): 0.8608

TEST NUMBER: 1570
 TEST TITLE: MANIKIN TESTING OF NEW CONCEPTS OF IMMERSION SUITS AND LINERS.
 FILE NAME: c:\TIM I_V 1.22\M904TW6.TM1

DATE OF TEST: 03-01-1999
 START TIME: 11:07:36
 DESCRIPTION OF SUIT TESTED: CF CONSTANT WEAR IMMERSION SUIT, INFLATED LP/SV LIFEJACKET, NEOPRENE HOOD, NEOPRENE MITTS, LEATHER FLIGHT BOOTS.
 UNDERGARMENTS: LONG SLEEVE COTTON SHIRT, DENIM TROUSERS, BRIEFS, MEDIUM WEIGHT DRESS SOCKS, VARIABLE INSULATION LINER.
 ENVIRONMENT: SIGNIFICANT WAVE HEIGHT OF 30 CM WITH A WAVE PERIOD OF 2.5 SEC.
 POSITION: NATURAL FLOTATION POSITION.
 HUMIDITY: 55
 ENV. FLOW SPEED:
 DIRECTION:
 CABLE LENGTH: Short (50ft)
 ADDITIONAL INFORMATION: NO ADDITIONAL LEAKAGE.

STOP TIME: 15:07:40 MINUTES SINCE START OF TEST: 240.05
 ENVIRONMENT TEMPERATURE:
 INSTANTANEOUS: 12.19 AVERAGE OVER TEST TIME: 12.17

SECTION	SETPOINT	SKINTEMP	TEMP DIFF (Deg C)		POWER (WATTS)		INSULATION (CLO)	
	(Deg C)	(Deg C)	INSTANT	AVERAGE	ST	LT	ST	LT
Head	32.00	32.05	19.86	19.86	26.84	28.23	0.6480	0.6157
Chest	32.00	32.10	19.91	19.93	15.08	14.68	1.3262	1.3632
Back	32.00	32.15	19.96	19.96	9.79	10.73	2.1877	1.9957
Abdomen	32.00	32.12	19.93	19.95	2.80	2.53	2.5223	2.7961
Buttocks	32.00	32.06	19.88	19.90	7.98	7.83	1.3840	1.4126
Right Arm	32.00	32.08	19.89	19.89	11.16	12.93	1.3060	1.1275
Left Arm	32.00	32.08	19.89	19.97	15.67	11.57	0.8354	1.1356
Right Hand	32.00	32.06	19.87	19.90	7.49	7.71	0.8405	0.8178
Left Hand	32.00	32.04	19.85	19.87	9.22	8.35	0.6694	0.7396
Right Leg	32.00	32.21	20.02	20.15	23.14	19.52	1.9893	2.3729
Left Leg	32.00	32.09	19.90	19.99	30.28	25.03	1.4076	1.7098
Right Foot	32.00	31.97	19.79	19.80	18.14	18.15	0.4821	0.4820
Left Foot	32.00	31.99	19.80	19.82	14.92	15.10	0.5773	0.5707
Overall					192.51	182.37	1.1571	1.2234

Total Power (W) For All Sections: 182.372
 Total Area (Square Meters): 1.736
 Overall Insulation Resistance (CLO): 1.2234

TEST NUMBER: 1569
 TEST TITLE: MANIKIN TESTING OF NEW CONCEPTS OF IMMERSION SUITS AND LINERS.
 FILE NAME: c:\TIM I_V 1.22\M904TW5.TM1

DATE OF TEST: 02-26-1999
 START TIME: 11:38:16
 DESCRIPTION OF SUIT TESTED: CF CONSTANT WEAR IMMERSION SUIT, INFLATED LP/SV LIFEJACKET, NEOPRENE HOOD, NEOPRENE MITTS, LEATHER FLIGHT BOOTS.
 UNDERGARMENTS: LONG SLEEVE COTTON SHIRT, DENIM TROUSERS, BRIEFS, MEDIUM WEIGHT DRESS SOCKS, 3MM BREATHABLE FOAM LINER.
 ENVIRONMENT: SIGNIFICANT WAVE HEIGHT OF 30 CM WITH A WAVE PERIOD OF 2.5 SEC.
 POSITION: NATURAL FLOTATION POSITION.
 HUMIDITY: 55
 ENV. FLOW SPEED:
 DIRECTION:
 CABLE LENGTH: Short (50ft)
 ADDITIONAL INFORMATION: 2 LITRES OF ADDITIONAL LEAKAGE ADDED TO THE BACK.

STOP TIME: 15:38:10 MINUTES SINCE START OF TEST: 239.90
 ENVIRONMENT TEMPERATURE:
 INSTANTANEOUS: 12.28 AVERAGE OVER TEST TIME: 12.28

SECTION	SETPOINT	SKINTEMP	TEMP DIFF (Deg C)		POWER (WATTS)		INSULATION (CLO)	
	(Deg C)	(Deg C)	INSTANT	AVERAGE	ST	LT	ST	LT
Head	32.00	31.96	19.67	19.68	41.88	37.91	0.4113	0.4544
Chest	32.00	32.09	19.80	19.81	23.40	21.81	0.8502	0.9123
Back	32.00	31.89	19.60	19.60	64.79	65.88	0.3247	0.3192
Abdomen	32.00	32.07	19.79	19.80	7.38	6.97	0.9499	1.0059
Buttocks	32.00	31.93	19.65	19.06	38.08	42.88	0.2866	0.2469
Right Arm	32.00	31.97	19.68	19.67	20.89	23.38	0.6906	0.6169
Left Arm	32.00	32.02	19.73	19.75	21.29	19.39	0.6099	0.6705
Right Hand	32.00	32.00	19.72	19.72	11.00	10.49	0.5679	0.5952
Left Hand	32.00	31.97	19.68	19.70	12.63	11.52	0.4848	0.5317
Right Leg	32.00	31.93	19.65	19.62	101.73	108.66	0.4439	0.4150
Left Leg	32.00	31.96	19.67	19.67	99.24	103.35	0.4245	0.4075
Right Foot	25.50	25.41	13.12	13.11	22.66	23.13	0.2560	0.2505
Left Foot	25.50	25.45	13.17	13.16	18.54	19.74	0.3088	0.2899
Overall					483.49	495.12	0.4370	0.4252

Total Power (W) For All Sections: 495.116
 Total Area (Square Meters): 1.736
 Overall Insulation Resistance (CLO): 0.4252

TEST NUMBER: 1576
 TEST TITLE: MANIKIN TESTING OF NEW CONCEPTS OF IMMERSION SUITS AND LINERS.
 FILE NAME: c:\TIM I_V 1.22\M904TW7.TM1

DATE OF TEST: 03-08-1999
 START TIME: 11:23:44
 DESCRIPTION OF SUIT TESTED: CF CONSTANT WEAR IMMERSION SUIT, INFLATED LP/SV LIFEJACKET, NEOPRENE HOOD, NEOPRENE MITTS, LEATHER FLIGHT BOOTS.
 UNDERGARMENTS: LONG SLEEVE COTTON SHIRT, DENIM TROUSERS, BRIEFS, MEDIUM WEIGHT DRESS SOCKS, VARIABLE INSULATION LINER.
 ENVIRONMENT: SIGNIFICANT WAVE HEIGHT OF 30 CM WITH A WAVE PERIOD OF 2.5 SEC.
 POSITION: NATURAL FLOTATION POSITION.
 HUMIDITY: 55
 ENV. FLOW SPEED:
 DIRECTION:
 CABLE LENGTH: Short (50ft)
 ADDITIONAL INFORMATION: 2 LITRES OF ADDITIONAL LEAKAGE ADDED TO THE BACK.

STOP TIME: 15:23:38 MINUTES SINCE START OF TEST: 239.90
 ENVIRONMENT TEMPERATURE:
 INSTANTANEOUS: 11.75 AVERAGE OVER TEST TIME: 11.79

SECTION	SETPOINT	SKINTEMP	TEMP DIFF (Deg C)		POWER (WATTS)		INSULATION (CLO)	
	(Deg C)	(Deg C)	INSTANT	AVERAGE	ST	LT	ST	LT
Head	32.00	31.88	20.13	20.09	55.21	52.48	0.3192	0.3352
Chest	32.00	32.14	20.39	20.35	15.60	14.24	1.3126	1.4352
Back	32.00	32.10	20.35	20.31	15.72	15.92	1.3889	1.3687
Abdomen	32.00	32.08	20.33	20.32	6.03	4.00	1.1949	1.8010
Buttocks	32.00	32.02	20.27	20.23	17.96	17.55	0.6268	0.6403
Right Arm	32.00	31.95	20.20	20.17	14.35	14.05	1.0316	1.0524
Left Arm	32.00	31.96	20.20	20.18	10.89	9.95	1.2209	1.3342
Right Hand	32.00	32.01	20.26	20.22	9.19	8.98	0.6987	0.7137
Left Hand	32.00	32.00	20.25	20.21	10.91	10.26	0.5772	0.6128
Right Leg	32.00	32.03	20.28	20.25	56.10	54.78	0.8310	0.8496
Left Leg	32.00	32.05	20.30	20.25	42.99	47.44	1.0110	0.9139
Right Foot	25.50	25.41	13.66	13.60	23.72	27.31	0.2544	0.2201
Left Foot	25.50	25.44	13.69	13.65	22.74	24.25	0.2618	0.2448
Overall					301.40	301.21	0.7004	0.6941

Total Power (W) For All Sections: 301.214
 Total Area (Square Meters): 1.736
 Overall Insulation Resistance (CLO): 0.6941

#511093