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TITLE

EVALUATION OF A NEW TECHNOLOGY NEARLY DRY SUIT \(MAC 200\) FOR THE CANADIAN AIR FORCE OPEN OCEAN STUDY

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EVALUATION OF A NEW TECHNOLOGY NEARLY DRY SUIT (MAC 200) FOR THE CANADIAN AIR FORCE
OPEN OCEAN STUDY

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PREPARED FOR
DEFENCE AND CIVIL INSTITUTE OF ENVIRONMENTAL MEDICINE
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1.0 INTRODUCTION

1.1 *BACKGROUND:*

The CORD Group Limited had received a request from the Department of National Defence to assist in the evaluation of the Mustang Nearly Dry (MAC 200) Immersion Suit. The Mustang MAC 200 is a novel approach to immersion protection recently developed and under consideration for the use in the Canadian Air Force. The suit system is reported to have advantages in the comfort and mobility and DND through the Defence and Civil Institute of Environmental Medicine wished to test the thermal performance of the suit to determine it's appropriateness for use.

1.2 *OBJECTIVES:*

The CORD Group Limited under contract with the Defence and Civil Institute of Environmental Medicine (DCIEM) and the Deputy Director of DCIEM developed the following scope of work:

1. To provide comparative data on the performance of the Mustang MAC 200 using the standard CF lifejacket and the Mustang MD1128A lifejacket on a thermal manikin and on human subjects in open sea conditions.

1.3 *DIVISION OF LABOUR:*

The responsibilities for this experiment were divided as follows:

1. DCIEM was the principle investigator and had overall control of the whole experiment and also provided the physiological and technical team to develop the protocol and conduct the human experiments as well as instrument the manikin identically to the humans to get comparative data.

2. DCIEM provided a medical doctor to screen and give medical examinations to the subjects and to be responsible for the overall well being of the subjects.

3. The Department of National Defence provided the vessel as the test platform at sea.

4. The CORD Group Limited was responsible for the planning and logistics of the experiment, conducting the Thermal Manikin testing and physically placing and removing the human subjects in the water and providing a safety watch during the experiments.

This report presents the data recorded from the Thermal Instrumented Manikin. DCIEM will analyze the human data and the data obtained from the additional sensors placed on the manikin and compare this information with the manikin results.

2.0 METHOD

2.1 *THERMAL INSTRUMENTED MANIKIN TEST SYSTEM:*

The Multi-Sectional 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. This system is the most advanced immersible manikin in the world and the only system in Canada. 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 immersed in a suitable 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 suit due to the temperature difference across it. The power and 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 suits, different sections of the manikin can be included or eliminated from the test as required. Even users unfamiliar with computers should find the system easy to use.

The basic philosophy on which the design is based is that the thermal performance of a garment can best be evaluated by unmanned tests on the whole garment under conditions identical or similar to actual operating conditions. The philosophy dictates that the system employ a life-sized, watertight manikin capable of being heated to and maintained at a selected temperature. The visible components of the Thermally Instrumented Manikin (TIM) are 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 combination 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 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

2.1 *THERMAL INSTRUMENTED MANIKIN TEST SYSTEM Cont.)*

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.

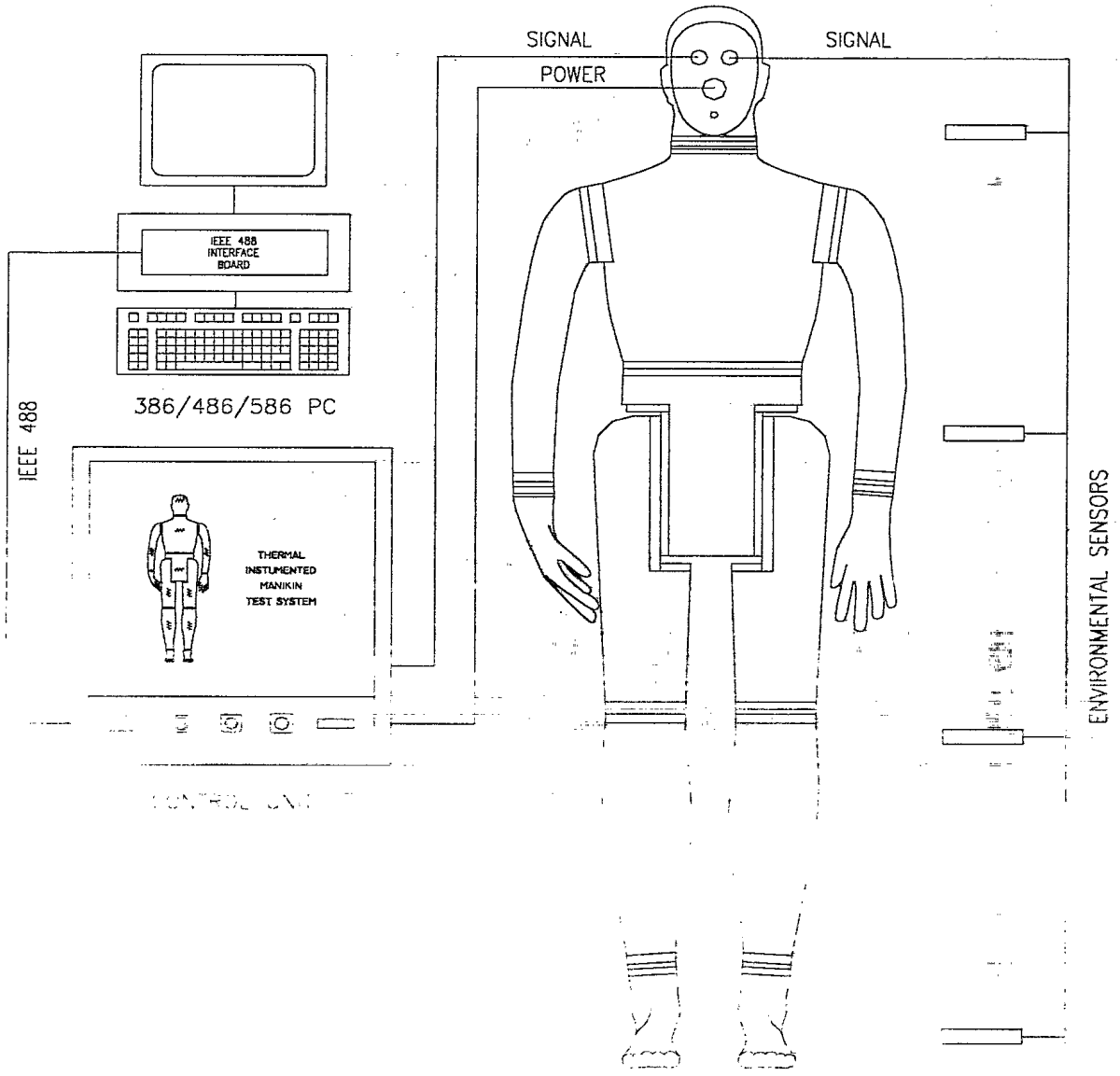


FIGURE 1

2.2 *TEST SET UP:*

2.2.1 MANIKIN AND HUMAN TESTING AT SEA:

Prior to the testing at sea, modifications to the thermal manikin data collecting software was completed and tested to allow testing with different sectional skin temperatures on the manikin and allow real time graphing capabilities to determine steady state condition at sea.

In addition to the Mustang Nearly Dry (MAC 200) Immersion Suits, Mustang MD 1128A lifejackets, and LPSV lifejackets, DCIEM supplied four (4) current Constant Wear Suits and their liners for comparative testing.

Preliminary testing at The CORD Group Limited's test facility included adding ice to the water to lower the water temperature to a point where it was the same as the actual ocean temperature. The air temperature was lowered to the actual outside ambient temperature by using 2 of the 48" extraction fans from the wind tunnel. Testing began with human testing in still water after which human skin temperatures were given to The CORD Group Limited to be used for the manikin testing in the same test condition. The CORD Group Limited placed eleven (11) heat flow transducers on the Helly Hansen two (2)-piece light polyester underwear in the same location as the human subjects were instrumented. All suits were fitted with eleven (11) thermistors on both the liners and outer shells in the same location as the heat flow transducers on the two (2)-piece underwear. After completing the donning of the suit system, an additional thermistor was fitted to the head of the manikin and an additional heat flow transducer fitted to the hood.

On the arrival to the HMCS ANTICOSTI, which was used for the at sea test platform, the thermal manikin and data acquisition system for the human subjects was set up and made ready. A pre-sea trial was performed to ensure procedures and equipment was ready for the rest of the at sea testing. For the tests using the LPSV lifejacket, the manikin was placed in the standard manikin immersion frame and lowered aft of the human subjects. Foam buoyancy was added to the immersion frame until an anticipated survivor flotation position was achieved with the manikin assuming a positive buoyant position. To ensure that the manikin would stay in the general test area during the test conditions, rope was attached to the frame back to the positioning boom and was controlled back aft by The CORD Group Limited. Half-inch surgical tubing acting as a weak link in a rope provided enough surge protection from the waves. For the tests using the Mustang MD 1128A lifejacket, the manikin was positioned so that the torso angle was as close to perpendicular to the horizontal as possible, the rope was attached to the ankles of the manikin,

2.2.1 MANIKIN AND HUMAN TESTING AT SEA (Cont.):

a flotation buoy also attached to the ankles, and additional buoyancy foam secured to the arms of the manikin. For all tests, the manikin was dressed in the Helly Hansen light 2-piece underwear, light coverall, and the suit ensemble including neoprene hood, boots, and inflatable mitts. Heat Flow Transducers were placed on the underwear corresponding to the sensors on the suit liner and outer shell. Depending on the lifejacket used for testing, the manikin was then placed in the previously described position and the tests were conducted under open ocean wave conditions. The human tests were conducted simultaneously. After each test, the manikin suit and undergarment ensembles were removed and placed in plastic bags for weighing at dockside to determine the amount of leakage that occurred during each test.

3.0 RESULTS

3.1 NON-UNIFORM SKIN TEMPERATURE TESTING USING THE THERMAL INSTRUMENTED MANIKIN

TABLE 3.1 Test results from the runs in still water and open ocean waves with the two (2) suit systems using the two (2) lifejacket configurations. The raw data for these results is contained in Annex "A".

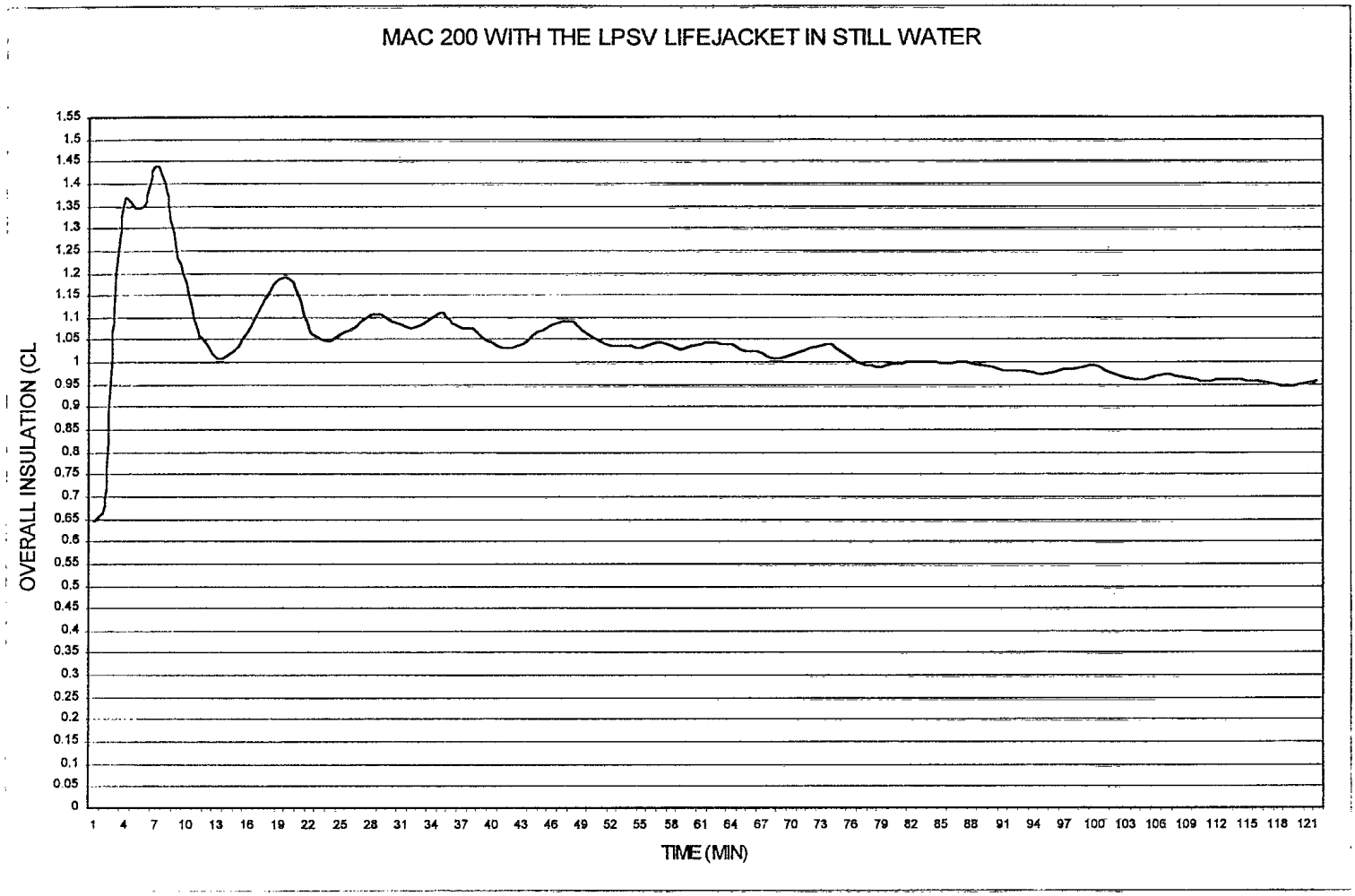
Description	Run #	Insulation (CLO)		Power (W)	
		60 min	Final	60 min	Final
Still Water:					
MAC 200 with LPSV Lifejacket	TIM 1C	N/A	0.9572	N/A	245.182
MAC 200 with MD 1129 Lifejacket	TIM 2C	1.2599	1.2518	176.741	177.582
Constant Wear with LPSV Lifejacket	TIM 3C	1.4764	1.5399	147.931	142.837
Open Ocean:					
MAC 200 with MD 1129 Lifejacket	TIM 3W	0.7189	0.6633	294.339	319.240
Constant Wear with LPSV Lifejacket	TIM 4W	0.6083	0.5027	359.455	428.652
MAC 200 with LPSV Lifejacket	TIM 5W	0.3850	0.3425	480.188	546.543

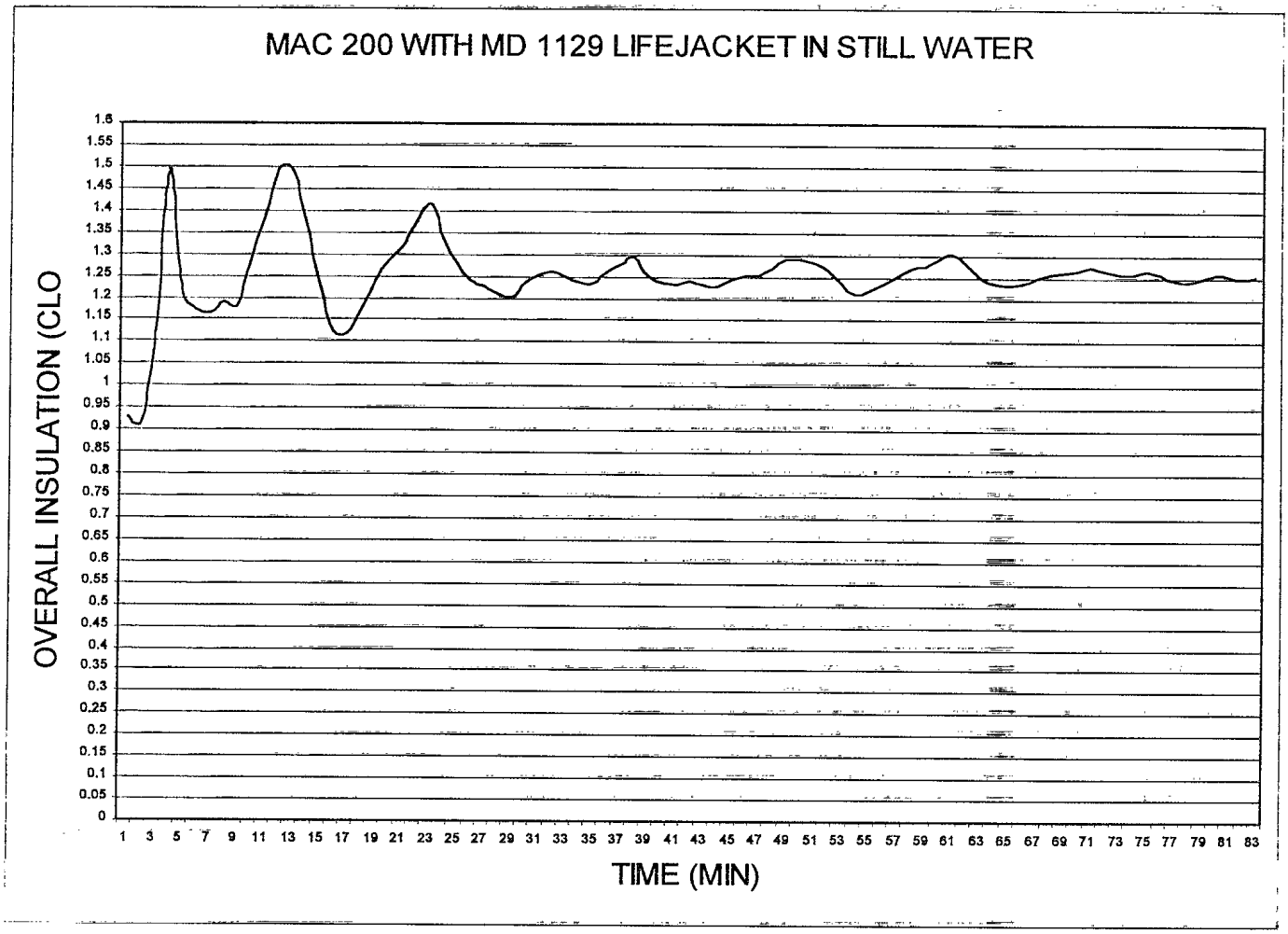
3.2 MANIKIN NON-UNIFORM SKIN TEMPERATURE DATA

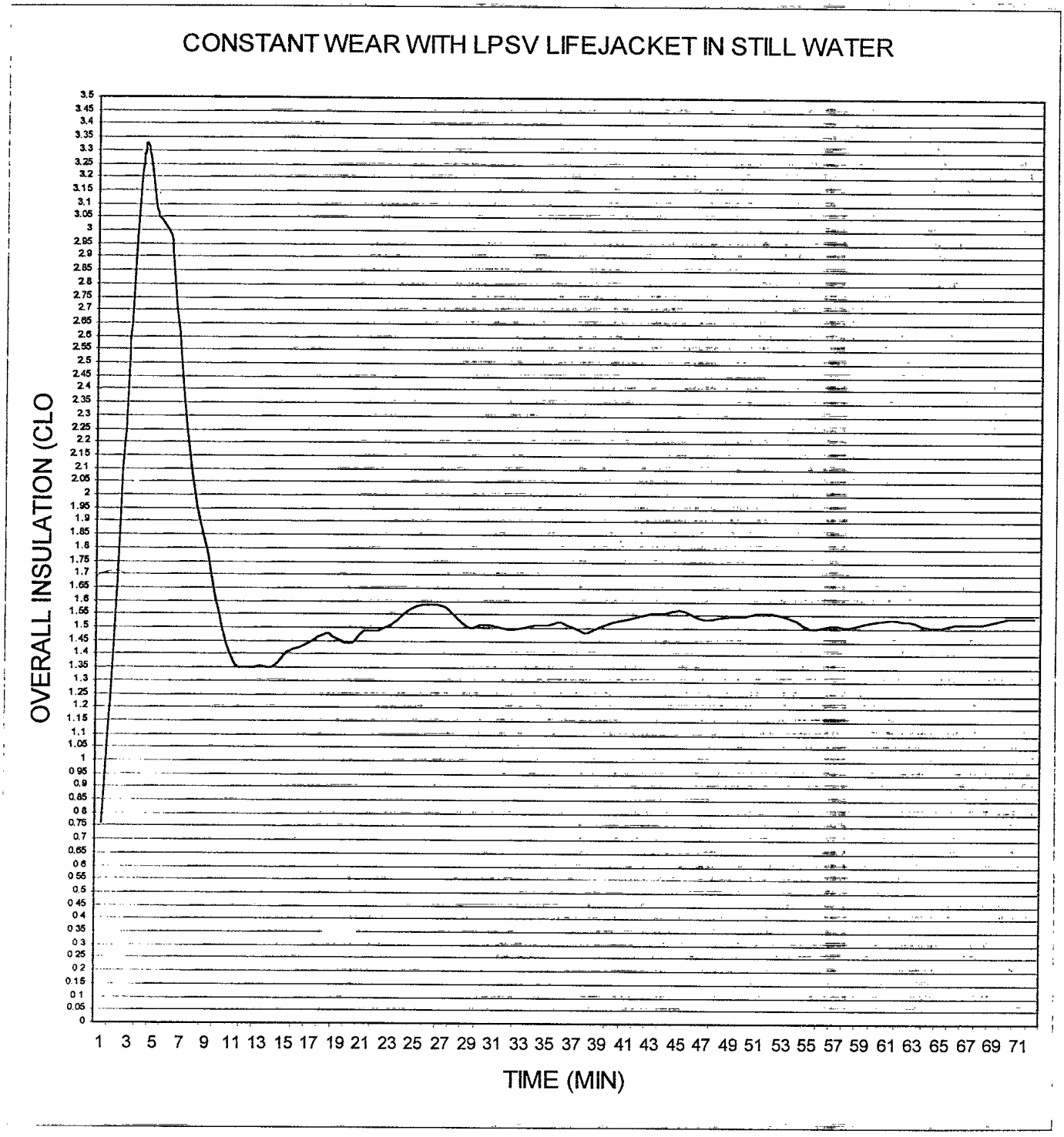
TABLE 3.2 Non-uniform human skin temperatures used for manikin testing including deviation from the set point.

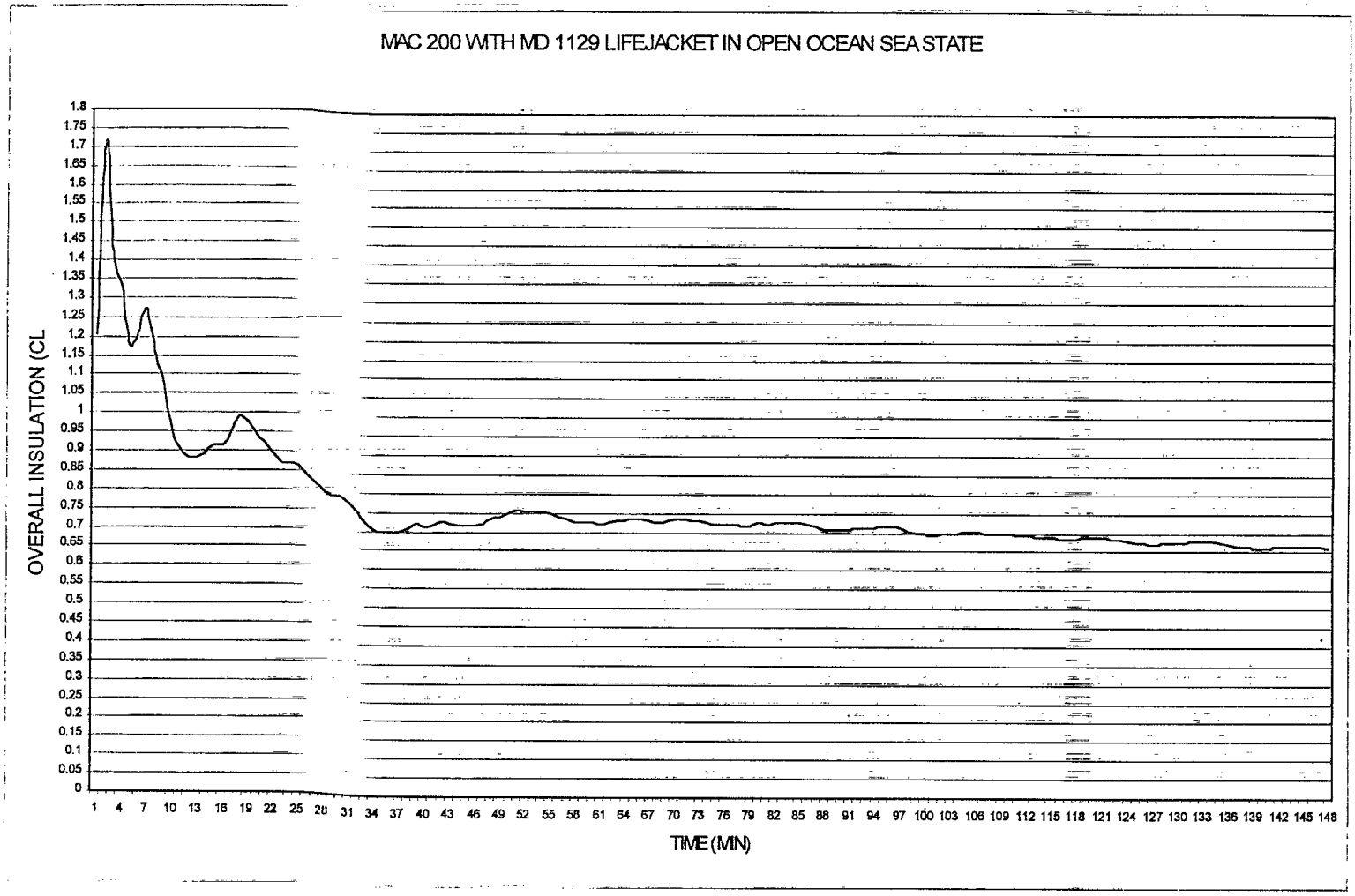
SECTION	TIM 1C		TIM 2C		TIM 3C		TIM 3W		TIM 4W		TIM 5W	
	SET	DEV	SET	DEV	SET	DEV	SET	DEV	SET	DEV	SET	DEV
HEAD	32.1		32.5		32.3		21.5		26.9		23.0	
UPPER TORSO	28.7		30.8		30.6		32.1		29.7		27.4	
LOWER TORSO	28.2		30.0		29.3		31.6		28.7		27.1	
ARMS	25.9		30.9		27.8		28.7		27.1		24.6	
LEGS	26.0		26.8		28.4		23.9		28.1		24.5	
HANDS	16.5		12.0	14.5	12.0	12.7	12.0		12.0		12.0	
FEET	16.5		12.0	13.0	12.0	13.0	N/A		N/A		12.0	

3.3 GRAPHICAL REPRESENTATION OF THE OVERALL CLO RESULTS OVER TEST TIME PERIOD

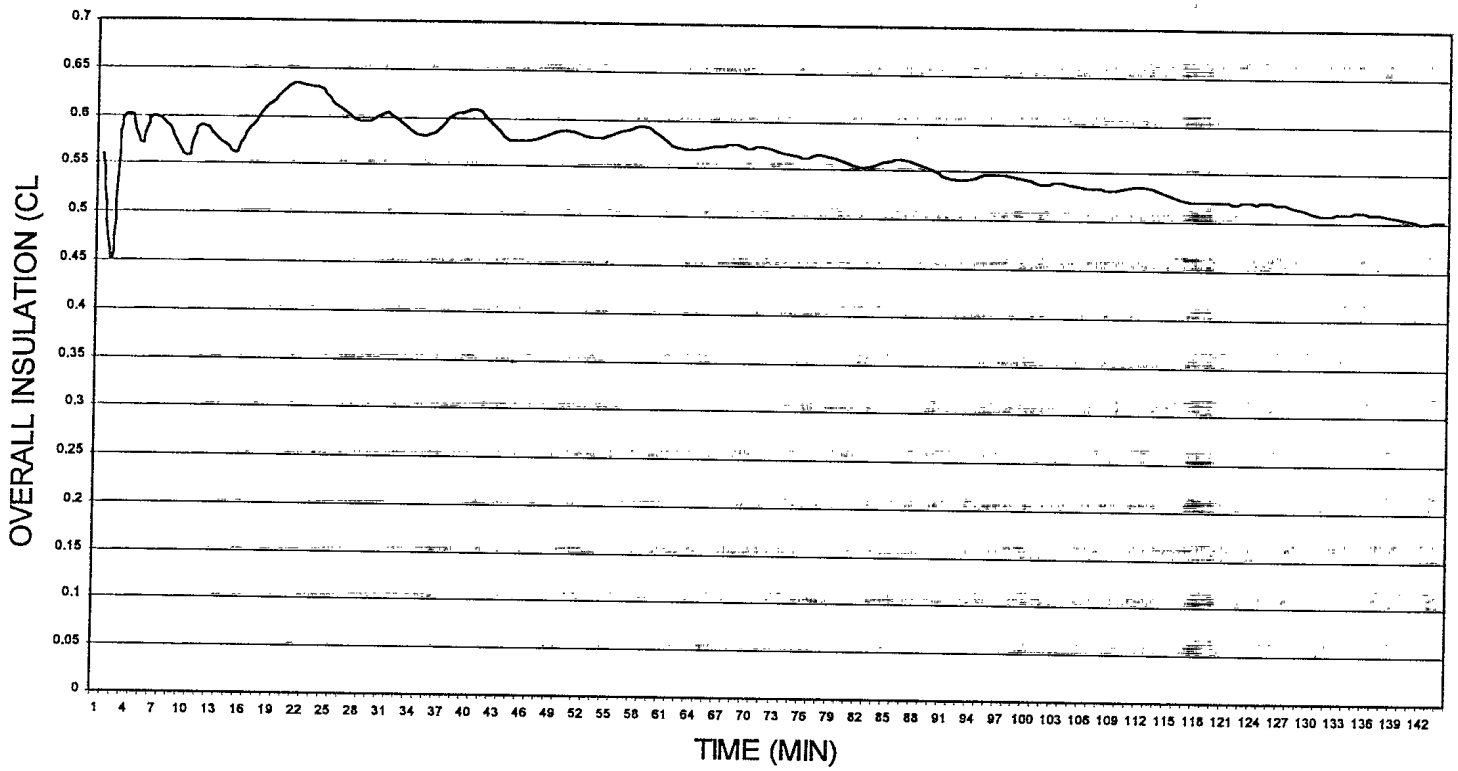


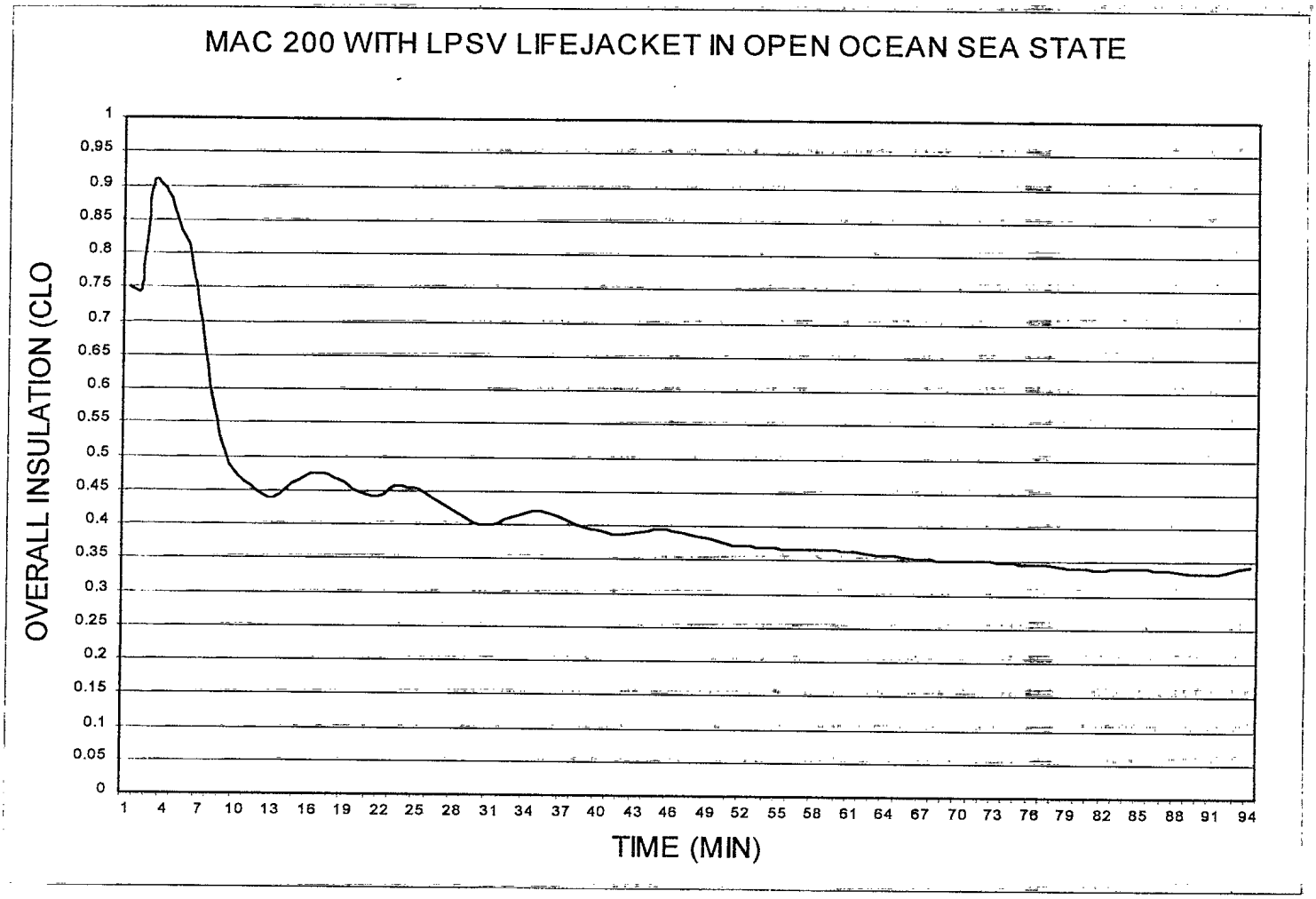

MAC 200 WITH MD 1129 LIFEJACKET IN STILL WATER
OVERALL INSULATION (CLO
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83
TIME (MIN)


CONSTANT WEAR WITH LPSV LIFEJACKET IN STILL WATER
OVERALL INSULATION (CLO
3.5
3.45
3.4
3.35
3.3
3.25
3.2
3.15
3.1
3.05
3
2.95
2.9
2.85
2.8
2.75
2.7
2.65
2.6
2.55
2.5
2.45
2.4
2.35
2.3
2.25
2.2
2.15
2.1
2.05
2
1.95
1.9
1.85
1.8
1.75
1.7
1.65
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71
TIME (MIN)


MAC 200 WITH MD 1129 LIFEJACKET IN OPEN OCEAN SEA STATE
OVERALL INSULATION (CL
1.8
1.75
1.7
1.65
1.6
1.55
1.5
1.45
1.4
1.35
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94 97 100 103 106 109 112 115 118 121 124 127 130 133 136 139 142 145 148
TIME (MN)

CONSTANT WEAR WITH LPSV LIFEJACKET IN OPEN OCEAN SEA STATE




MAC 200 WITH LPSV LIFEJACKET IN OPEN OCEAN SEA STATE
OVERALL INSULATION (CLO
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82 85 88 91 94
TIME (MIN)

4.0 OBSERVATIONS AND CONCLUSIONS

There were a number of observations made during these sea trials, they were:

1. The ship's power supply was unreliable, for future sea trials a generator should be obtained to power the manikin test system.
2. There was not a provision to hang the manikin inside for dressing. Dressing the manikin on the open deck of the vessel caused the manikin to cool and also had the potential of the under garments getting wet during the dressing. For future trials, an inside dressing area would be desirable.
3. A dedicated wave rider that could be free floated would insure accurate wave data, regardless of the ship's location.
4. A statement of requirement should be provided to the ship's commanding officer so that the experiment's objectives are clear.

ANNEX "A"
RAW DATA

TEST NUMBER: 1489
TEST TITLE: M718SW1
FILE NAME: C:\TIM I_V 1.22\M718sw1.tm1

DATE OF TEST: 11-21-1997
START TIME: 11:52:34
DESCRIPTION OF SUIT TESTED: MAC 200,NEOPRENE HOOD/BOOTS,INFLATED MITTS/LPSV LIFEJACKET.
UNDERGARMENTS: HELLY HANSEN LIGHT 2-PIECE UNDERWEAR,LIGHT COVERALL,HELLY HANSEN PILE SOCKS.
ENVIRONMENT: STILL WATER.
  POSITION: FLOATING IN FRAME.
  HUMIDITY: 90
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION:
 Test with actual skin temperatures, immersion start time: 10:51. Reference TIM C1.

STOP TIME: 13:53:14 MINUTES SINCE START OF TEST: 120.65 (Total test duration)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 6.46 AVERAGE OVER TEST TIME: 6.42

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	32.10	32.07	25.61	25.64	17.25	35.80	1.3000	0.6271
Chest	28.70	28.79	22.33	22.38	0.72	10.23	20.0000	2.1975
Back	28.70	28.73	22.27	22.26	40.25	39.37	0.5936	0.6064
Abdomen	28.20	28.18	21.71	21.86	6.32	3.35	1.2176	2.3094
Buttocks	28.20	28.15	21.68	21.74	20.80	28.12	0.5790	0.4295
Right Arm	25.90	26.23	19.77	19.70	0.40	5.42	20.0000	2.6627
Left Arm	25.90	26.01	19.55	19.79	0.56	7.37	20.0000	1.7683
Right Hand	16.50	16.69	10.22	10.15	0.18	2.18	18.3821	1.4764
Left Hand	16.50	16.64	10.18	10.13	0.32	4.24	9.7890	0.7437
Right Leg	26.00	26.12	19.65	19.61	4.37	55.89	10.3409	0.8066
Left Leg	26.00	25.98	19.52	19.63	14.48	50.94	2.8864	0.8251
Right Foot	16.50	16.58	10.12	10.14	0.07	1.15	20.0000	3.8788
Left Foot	16.50	16.50	10.03	10.11	0.07	1.12	20.0000	3.9228
Overall					105.79	245.18	2.2137	0.9572

Total Power (W) For All Sections: 245.182
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.9572

TEST NUMBER: 1497
TEST TITLE: m718atsea7
FILE NAME: C:\TIM I_V 1.22\m718sw2.TM1

DATE OF TEST: 11-29-1997
START TIME: 13:27:34
DESCRIPTION OF SUIT TESTED: MAC 200,Neoprene Hood/Boots,Inflated Mitts/MD 1129 Lifejacket.
UNDERGARMENTS: Helly Hansen Light 2-piece Underwear,Light Coverall,Helly Hansen Pile socks.
ENVIRONMENT: Still Water.
  POSITION: Floating Freely in Lifejacket.
  HUMIDITY: 90
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION:
 Test with actual skin temperatures, immersion start time: 12:58. Reference TIM 2C.

STOP TIME: 13:58:34 MINUTES SINCE START OF TEST: 31.00 (After 1 hr immersion)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 8.15 AVERAGE OVER TEST TIME: 8.15

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	32.50	32.71	24.55	24.55	21.29	21.29	1.0097	1.0097
Chest	30.80	30.86	22.71	22.71	9.82	9.82	2.3216	2.3216
Back	30.80	30.91	22.76	22.76	11.18	11.18	2.1836	2.1836
Abdomen	30.00	30.09	21.94	21.94	5.68	5.68	1.3675	1.3675
Buttocks	30.00	30.04	21.88	21.88	12.44	12.44	0.9774	0.9774
Right Arm	30.90	30.86	22.71	22.71	10.47	10.47	1.5889	1.5889
Left Arm	30.90	30.94	22.78	22.78	7.21	7.21	2.0792	2.0792
Right Hand	14.50	14.85	6.69	6.69	1.53	1.53	1.3869	1.3869
Left Hand	14.50	14.82	6.66	6.66	1.35	1.35	1.5389	1.5389
Right Leg	26.80	26.86	18.71	18.71	42.32	42.32	1.0164	1.0164
Left Leg	26.80	26.88	18.73	18.73	51.79	51.79	0.7742	0.7742
Right Foot	13.00	13.29	5.14	5.14	1.45	1.45	1.5654	1.5654
Left Foot	13.00	13.04	4.89	4.89	0.21	0.21	10.1381	10.1381
Overall					176.74	176.74	1.2599	1.2599

Total Power (W) For All Sections: 176.741
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.2599

STOP TIME: 14:49:10 MINUTES SINCE START OF TEST: 81.60 (Total test immersion)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 8.14 AVERAGE OVER TEST TIME: 8.15

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	32.50	32.71	24.57	24.56	21.77	20.22	0.9882	1.0633
Chest	30.80	30.86	22.72	22.71	10.65	9.72	2.1433	2.3477
Back	30.80	30.91	22.78	22.76	10.53	11.46	2.3212	2.1308
Abdomen	30.00	30.11	21.98	21.96	5.16	5.67	1.5087	1.3707
Buttocks	30.00	30.03	21.90	21.89	12.86	12.08	0.9457	1.0061
Right Arm	30.90	30.86	22.72	22.71	10.87	10.61	1.5323	1.5687
Left Arm	30.90	30.91	22.77	22.76	7.22	8.07	2.0765	1.8548
Right Hand	14.50	14.56	6.43	6.51	0.00	0.67	20.0000	3.0790
Left Hand	14.50	14.53	6.39	6.48	0.09	0.66	20.0000	3.0688
Right Leg	26.80	26.85	18.71	18.72	60.61	48.28	0.7097	0.8910
Left Leg	26.80	26.87	18.73	18.73	55.27	48.95	0.7258	0.8195
Right Foot	13.00	13.14	5.00	5.04	0.57	0.88	3.8995	2.5307
Left Foot	13.00	13.01	4.87	4.87	0.46	0.31	4.5652	6.9106
Overall					196.05	177.58	1.1334	1.2518

Total Power (W) For All Sections: 177.582
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.2518

TEST NUMBER: 1498
TEST TITLE: m718sw3
FILE NAME: C:\TIM I_V 1.22\m718sw3.TM1

DATE OF TEST: 11-29-1997
START TIME: 17:13:02
DESCRIPTION OF SUIT TESTED: Constant Wear,Neoprene Hood/Boots,Inflated Mitts/LPSV Lifejacket.
UNDERGARMENTS: Helly Hansen Light 2-piece Underwear,Light Coverall,Helly Hansen Pile socks.
ENVIRONMENT: Still Water
POSITION: Floating in Frame
HUMIDITY: 90
ENV. FLOW SPEED:
DIRECTION:
CABLE LENGTH: Short (50ft)
ADDITIONAL INFORMATION:
Test with actual skin temperatures, immersion start time: 16:30. Reference TIM 3C.

STOP TIME: 17:30:02 MINUTES SINCE START OF TEST: 17.00 (After 1 hr immersion)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 8.15 AVERAGE OVER TEST TIME: 8.15

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	32.30	32.49	24.34	24.34	18.37	18.37	1.1598	1.1598
Chest	30.60	30.65	22.49	22.49	13.04	13.04	1.7322	1.7322
Back	30.60	30.65	22.50	22.50	26.86	26.86	0.8989	0.8989
Abdomen	29.30	29.47	21.31	21.31	0.46	0.46	16.4047	16.4047
Buttocks	29.30	29.37	21.21	21.21	8.19	8.19	1.4380	1.4380
Right Arm	27.80	27.80	19.65	19.65	5.31	5.31	2.7136	2.7136
Left Arm	27.80	27.86	19.71	19.71	3.69	3.69	3.5165	3.5165
Right Hand	12.70	12.76	4.61	4.61	0.32	0.32	4.4976	4.4976
Left Hand	12.70	12.97	4.81	4.81	0.00	0.00	20.0000	20.0000
Right Leg	28.40	28.35	20.20	20.20	27.71	27.71	1.6760	1.6760
Left Leg	28.40	28.31	20.16	20.16	43.98	43.98	0.9815	0.9815
Right Foot	13.20	13.48	5.33	5.33	0.00	0.00	20.0000	20.0000
Left Foot	13.00	13.11	4.96	4.96	0.00	0.00	20.0000	20.0000
Overall					147.93	147.93	1.4764	1.4764

Total Power (W) For All Sections: 147.931
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.4764

STOP TIME: 18:23:17 MINUTES SINCE START OF TEST: 70.25 (Total test duration)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 8.15 AVERAGE OVER TEST TIME: 8.08

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	32.30	32.45	24.30	24.39	22.72	22.30	0.9365	0.9575
Chest	30.60	30.66	22.51	22.58	12.14	11.93	1.8632	1.9013
Back	30.60	30.66	22.51	22.58	26.70	26.48	0.9046	0.9147
Abdomen	29.30	29.44	21.29	21.35	0.01	1.33	20.0000	5.6828
Buttocks	29.30	29.35	21.20	21.31	9.32	8.68	1.2636	1.3642
Right Arm	27.80	27.79	19.64	19.71	7.32	6.59	1.9676	2.1921
Left Arm	27.80	28.24	20.09	19.85	0.02	3.63	20.0000	3.5986
Right Hand	12.70	12.73	4.58	4.75	0.43	0.44	3.3628	3.4350
Left Hand	12.70	12.71	4.57	4.83	0.01	0.99	20.0000	1.5183
Right Leg	28.40	28.37	20.22	20.28	28.51	29.02	1.6300	1.6065
Left Leg	28.40	28.36	20.21	20.27	31.26	31.45	1.3841	1.3805
Right Foot	13.20	14.27	6.12	5.80	0.00	0.00	20.0000	20.0000
Left Foot	13.00	13.51	5.36	5.23	0.00	0.00	20.0000	20.0000
Overall					138.44	142.84	1.5860	1.5399

Total Power (W) For All Sections: 142.837
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 1.5399

TEST NUMBER: 1492
TEST TITLE: m718atsea3
FILE NAME: C:\TIM I_V 1.22\m718atsea3.TM1

DATE OF TEST: 11-26-1997
START TIME: 11:36:58
DESCRIPTION OF SUIT TESTED: MAC 200,Neoprene Hood/Boots,Inflated Mitts/MD 1129 Lifejacket.
UNDERGARMENTS: Helly Hansen Light 2-piece Underwear,Light Coverall,Helly Hansen Pile Socks.
ENVIRONMENT: Open Ocean
  POSITION: Floating Freely in Lifejacket.
  HUMIDITY: 90
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Long (250ft)
ADDITIONAL INFORMATION:
  Additional flotation secured to manikin,run test with actual human skin temperatures,immersion start time: 11:23. Reference TIM 3W.

STOP TIME: 12:23:09 MINUTES SINCE START OF TEST: 46.20 (After 1 hr immersion)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 8.05 AVERAGE OVER TEST TIME: 8.05

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	21.50	21.63	13.58	13.58	32.26	32.26	0.3684	0.3684
Chest	32.10	32.21	24.16	24.16	19.22	19.22	1.2622	1.2622
Back	32.10	32.16	24.11	24.11	31.50	31.50	0.8213	0.8213
Abdomen	31.60	31.67	23.62	23.62	13.04	13.04	0.6413	0.6413
Buttocks	31.60	31.62	23.57	23.57	19.83	19.83	0.6602	0.6602
Right Arm	28.70	28.95	20.90	20.90	9.61	9.61	1.5941	1.5941
Left Arm	28.70	28.87	20.82	20.82	21.48	21.48	0.6379	0.6379
Right Hand	12.00	12.09	4.04	4.04	6.24	6.24	0.2053	0.2053
Left Hand	12.00	11.89	3.84	3.84	22.88	22.88	0.0522	0.0522
Right Leg	23.90	24.02	15.96	15.96	52.85	52.85	0.6942	0.6942
Left Leg	23.90	24.26	16.20	16.20	65.43	65.43	0.5303	0.5303
Right Foot	12.00	19.47	11.42	11.42	0.00	0.00	20.0000	20.0000
Left Foot	12.00	14.83	6.78	6.78	0.00	0.00	20.0000	20.0000
Overall					294.34	294.34	0.7189	0.7189

Total Power (W) For All Sections: 294.339
Total Area (Square Meters): 1.600
Overall Insulation Resistance (CLO): 0.7189

STOP TIME: 14:03:56 MINUTES SINCE START OF TEST: 146.95 (Total test duration)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 7.95 AVERAGE OVER TEST TIME: 8.02

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	21.50	21.61	13.66	13.64	32.99	29.15	0.3625	0.4096
Chest	32.10	32.20	24.25	24.19	21.11	19.84	1.1537	1.2248
Back	32.10	32.13	24.19	24.13	35.48	33.75	0.7315	0.7672
Abdomen	31.60	31.67	23.72	23.65	15.32	14.00	0.5486	0.5986
Buttocks	31.60	31.54	23.59	23.56	36.12	28.43	0.3629	0.4604
Right Arm	28.70	28.92	20.98	20.92	9.70	10.10	1.5856	1.5181
Left Arm	28.70	28.79	20.84	20.79	26.06	25.43	0.5263	0.5380
Right Hand	12.00	12.08	4.13	4.07	6.93	6.25	0.1886	0.2064
Left Hand	12.00	11.93	3.98	3.89	20.08	21.52	0.0616	0.0563
Right Leg	23.90	23.99	16.05	15.98	67.38	59.46	0.5474	0.6176
Left Leg	23.90	23.89	15.94	16.05	100.17	71.32	0.3408	0.4818
Right Foot	12.00	17.72	9.77	10.32	0.00	0.00	20.0000	20.0000
Left Foot	12.00	15.26	7.31	6.95	0.00	0.00	20.0000	20.0000
Overall					371.33	319.24	0.5718	0.6633

Total Power (W) For All Sections: 319.240
Total Area (Square Meters): 1.600
Overall Insulation Resistance (CLO): 0.6633

TEST NUMBER: 1493
TEST TITLE: m718atsea4
FILE NAME: C:\TIM I_V 1.22\m718atsea4.TM1

DATE OF TEST: 11-27-1997
START TIME: 11:53:50
DESCRIPTION OF SUIT TESTED: Constant Wear,Neoprene Hood/Boots,Inflated Mitts/LPSV Lifejacket.
UNDERGARMENTS: Helly Hansen Light 2-piece Underwear,Light Coverall,Helly Hansen Pile Socks.
ENVIRONMENT: Open Ocean
  POSITION: Floating in Frame.
  HUMIDITY:
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Long (250ft)
ADDITIONAL INFORMATION:
  Test with actual skin temperatures, immersion start time: 11:32. Reference TIM 4W.

STOP TIME: 12:32:53 MINUTES SINCE START OF TEST: 39.05 (After 1 hr immersion)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 8.09 AVERAGE OVER TEST TIME: 8.09

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	26.90	26.53	18.45	18.45	88.99	88.99	0.1815	0.1815
Chest	29.70	29.79	21.70	21.70	16.32	16.32	1.3355	1.3355
Back	29.70	29.55	21.47	21.47	79.32	79.32	0.2903	0.2903
Abdomen	28.70	28.78	20.70	20.70	4.39	4.39	1.6697	1.6697
Buttocks	28.70	28.57	20.48	20.48	40.51	40.51	0.2808	0.2808
Right Arm	27.10	27.34	19.26	19.26	6.70	6.70	2.1074	2.1074
Left Arm	27.10	27.47	19.39	19.39	4.59	4.59	2.7801	2.7801
Right Hand	12.00	12.12	4.03	4.03	1.80	1.80	0.7081	0.7081
Left Hand	12.00	12.12	4.04	4.04	2.14	2.14	0.5856	0.5856
Right Leg	28.10	28.10	20.01	20.01	73.82	73.82	0.6232	0.6232
Left Leg	28.10	28.24	20.15	20.15	40.86	40.86	1.0560	1.0560
Right Foot	12.00	17.73	9.65	9.65	0.00	0.00	20.0000	20.0000
Left Foot	12.00	13.62	5.54	5.54	0.00	0.00	20.0000	20.0000
Overall					359.46	359.46	0.6083	0.6083

Total Power (W) For All Sections: 359.455
Total Area (Square Meters): 1.600
Overall Insulation Resistance (CLO): 0.6083

STOP TIME: 14:16:16 MINUTES SINCE START OF TEST: 142.45 (Total test duration)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 7.92 AVERAGE OVER TEST TIME: 7.98

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	26.90	26.69	18.78	18.63	97.42	91.61	0.1687	0.1781
Chest	29.70	29.77	21.85	21.81	24.82	18.97	0.8846	1.1548
Back	29.70	23.34	15.42	18.71	86.71	84.97	0.1908	0.2363
Abdomen	28.70	28.82	20.90	20.83	6.66	5.34	1.1117	1.3821
Buttocks	28.70	24.30	16.38	18.75	49.17	46.97	0.1851	0.2218
Right Arm	27.10	27.19	19.27	19.32	19.37	12.14	0.7291	1.1658
Left Arm	27.10	27.35	19.43	19.46	12.53	8.08	1.0207	1.5843
Right Hand	12.00	12.12	4.20	4.14	2.57	2.12	0.5173	0.6195
Left Hand	12.00	12.11	4.19	4.13	1.63	1.79	0.8001	0.7180
Right Leg	28.10	28.09	20.17	20.10	111.59	93.20	0.4155	0.4958
Left Leg	28.10	28.10	20.19	20.20	84.98	63.46	0.5086	0.6817
Right Foot	12.00	16.56	8.64	8.90	0.00	0.00	20.0000	20.0000
Left Foot	12.00	13.47	5.56	5.44	0.00	0.00	20.0000	20.0000
Overall					497.43	428.65	0.4234	0.5027

Total Power (W) For All Sections: 428.652
Total Area (Square Meters): 1.600
Overall Insulation Resistance (CLO): 0.5027

TEST NUMBER: 1495
TEST TITLE: m718atsea6
FILE NAME: C:\TIM I_V 1.22\m718atsea6.TM1

DATE OF TEST: 11-28-1997
START TIME: 13:01:06
DESCRIPTION OF SUIT TESTED: MAC 200,Neoprene Hood/Boots,Inflated Mitts/LPSV Lifejacket.
UNDERGARMENTS: Helly Hansen Light 2-piece Underwear,Light Coverall,Helly Hansen Pile Socks.
ENVIRONMENT: Open Ocean
  POSITION: Floating in Frame.
  HUMIDITY:
  ENV. FLOW SPEED:
  DIRECTION:
CABLE LENGTH: Long (250ft)
ADDITIONAL INFORMATION:
 Test with actual skin temperatures, immersion start time: 12:48. Reference TIM 5W.

STOP TIME: 13:48:06 MINUTES SINCE START OF TEST: 47.00 (After 1 hr immersion)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 7.61 AVERAGE OVER TEST TIME: 7.61

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	23.00	22.49	14.88	14.88	87.45	87.45	0.1489	0.1489
Chest	27.40	27.50	19.89	19.89	20.08	20.08	0.9952	0.9952
Back	27.40	25.95	18.34	18.34	87.05	87.05	0.2261	0.2261
Abdomen	27.10	27.19	19.58	19.58	7.72	7.72	0.8991	0.8991
Buttocks	27.10	27.05	19.44	19.44	35.80	35.80	0.3016	0.3016
Right Arm	24.60	24.49	16.88	16.88	36.02	36.02	0.3436	0.3436
Left Arm	24.60	24.78	17.17	17.17	19.67	19.67	0.5745	0.5745
Right Hand	12.00	12.13	4.52	4.52	0.56	0.56	2.5602	2.5602
Left Hand	12.00	12.13	4.52	4.52	1.26	1.26	1.1182	1.1182
Right Leg	24.50	24.46	16.85	16.85	102.51	102.51	0.3778	0.3778
Left Leg	24.50	24.52	16.91	16.91	81.09	81.09	0.4465	0.4465
Right Foot	12.00	12.78	5.17	5.17	0.00	0.00	20.0000	20.0000
Left Foot	12.00	12.09	4.48	4.48	0.98	0.98	1.9794	1.9794
Overall					480.19	480.19	0.3850	0.3850

Total Power (W) For All Sections: 480.188
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.3850

STOP TIME: 14:33:44 MINUTES SINCE START OF TEST: 92.65 (Total test duration)
ENVIRONMENT TEMPERATURE:
INSTANTANEOUS: 7.19 AVERAGE OVER TEST TIME: 7.46

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	23.00	22.56	15.37	15.11	81.45	84.88	0.1651	0.1558
Chest	27.40	27.42	20.23	20.00	32.25	25.86	0.6299	0.7770
Back	27.40	25.71	18.53	18.32	85.74	86.38	0.2317	0.2276
Abdomen	27.10	27.14	19.95	19.71	16.93	11.85	0.4172	0.5893
Buttocks	27.10	27.03	19.84	19.58	38.66	36.91	0.2850	0.2946
Right Arm	24.60	24.34	17.15	16.96	51.32	44.26	0.2448	0.2808
Left Arm	24.60	24.40	17.21	17.15	44.81	31.57	0.2527	0.3574
Right Hand	12.00	12.14	4.95	4.68	1.52	0.86	1.0315	1.7252
Left Hand	12.00	12.13	4.95	4.67	1.73	1.40	0.8864	1.0387
Right Leg	24.50	24.44	17.26	16.99	141.52	123.16	0.2802	0.3170
Left Leg	24.50	24.46	17.27	17.03	117.53	98.60	0.3145	0.3698
Right Foot	12.00	14.89	7.70	6.20	0.00	0.00	20.0000	20.0000
Left Foot	12.00	12.09	4.90	4.62	0.93	0.83	2.2862	2.4284
Overall					614.40	546.54	0.3113	0.3425

Total Power (W) For All Sections: 546.543
Total Area (Square Meters): 1.736
Overall Insulation Resistance (CLO): 0.3425

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