

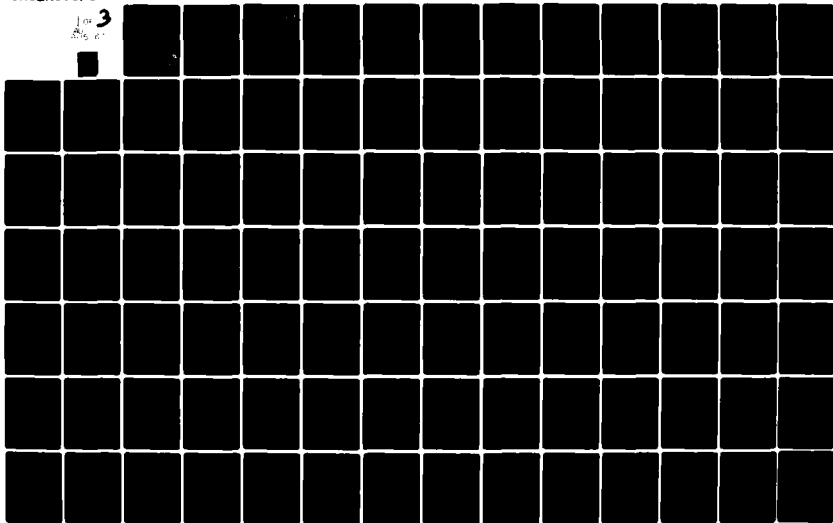
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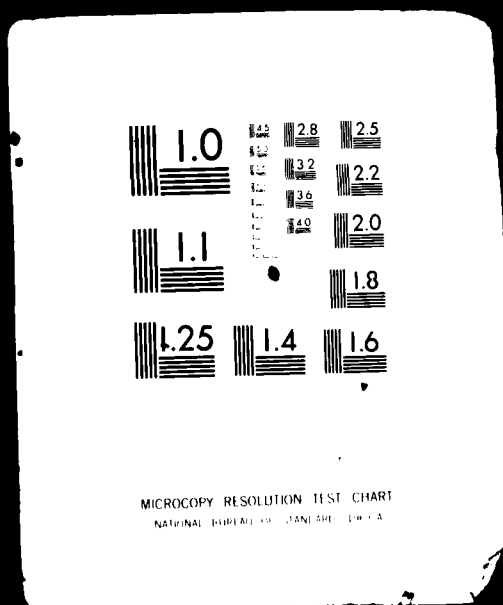
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TECHNICAL REPORT

Volume 2

THE DEVELOPMENT OF PREDICTIVE ENGINEERING FORMULATIONS FOR DIVER HEATING

by

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for

Naval Medical Research and Development Command

and

Office of Naval Research

N00014-79-C-0379
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APPENDICES

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APPENDIX A

ORGANIZATION OF THE DIRECT ACCESS EXPERIMENTAL DATA FILES

The first record of each file contains one integer variable (NREC) followed by up to 196 alphanumeric characters. This record is formatted 1I4,196A1. The variable, NREC, contains the number of discrete experimental times that follow in records 2 through NREC+1. Each of these experimental records has 29 data points associated with it. They are stored in array EXP and are read in by the format 13F8.2,15F6.2,F6.1. The first variable, EXP(1), contains the experimental times; EXP(2) thru EXP(13) contain rates of heat flow from sites 1 to 12; variables EXP(14) thru EXP(25) contain temperatures from sites 1 to 12; variable EXP(26) is the rectal temperature; EXP(27) is the ambient temperature; variable EXP(28) is the Hody mean skin temperature, which is calculated by using the twelve experimental temperatures found in EXP(14) to EXP(25); and EXP(29) contains the Hody mean skin rate of heat flow, which is computed by using the twelve experimental rates of heat flow contained in EXP(2) to EXP(13). The variable names appearing above correspond to the actual names used in the interactive program. The sites referred to as 1 to 12, above, correspond to the segments identified in Figure 2 and Table 1 of Chapter I.

The name given to an experimental data file is totally up to the user. It is assumed that the user is knowledgeable enough of the file structure and naming conventions prescribed by the computer's operating system that the file names will not be in violation of these conventions. The conventions which apply to the RSX-11M system can be found in Chapter 1 of reference 52.



Accession For	
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DTIC TAB	☐
Unannounced	☐
Justification	<i>for file</i>
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APPENDIX B

COMPOSITE DATA FILE LISTINGS FOR FILES
RHL1AR1, DTP1ART, DTP2AR1, AND DTP3AR1

Each composite data file has temperature and rate of heat loss data listed for the Head (HEAD), Chest (CHST), Abdomen (ABD), Upper Back (UBAC), Lower Back (LBAC), Arm (ARM), Hand (WRST), Front Thigh (F-TH), Front Calf (FCLF), Rear Thigh (R-TH), Rear Calf (RCLF), and Foot (FOOT) segments. The composite segmental temperature listings also contain the Rectal (RECT) and Ambient (AMB) temperatures. All temperatures are in °C and the rates of heat loss are in watts. The composite data file surface areas are 2.04 M², 1.91 M², 2.017 M² and 1.99M²; and the number of component subjects are 5, 4, 3, and 3; for RHL1AR1, DTP1ART, DTP2AR1, and DTP3AR1 data files, respectively. The composite surface areas were determined by averaging the component subject's surface areas. These files are listed in Tables B.1.A-B.4.B as described below.

<u>Table Number</u>	<u>Contents</u>
B.1.A	RHL1AR1, Temperatures
B.1.B	RHL1AR1, Rates of Heat Loss
B.2.A	DTP1ART, Temperatures
B.2.B	DTP1ART, Rates of Heat Loss
B.3.A	DTP2AR1, Temperatures
B.3.B	DTP2AR1, Rates of Heat Loss
B.4.A	DTP3AR1, Temperatures
B.4.B	DTP3AR1, Rates of Heat Loss

Table B.1.A

TIME	HEAD	CHBT	ABD	USAC	TEMPERATURE C		MRBT	RHLIARI DAT		R-TH	RCLF	FDOT	RECT	AMB
					LBAC	ARM		F-TH	FCLF					
3.00	28.50	28.10	28.60	29.15	27.60	27.65	26.75	28.40	27.60	27.30	26.30	26.10	0.00	20.00
4.00	28.73	27.67	28.40	28.83	28.00	28.18	27.20	28.13	28.00	27.30	27.33	27.03	0.00	21.03
5.00	28.70	27.48	27.80	28.70	27.80	28.58	27.15	27.83	27.98	27.25	27.50	27.27	0.00	21.00
6.00	28.45	27.38	28.00	28.53	27.58	28.50	27.23	27.50	27.83	26.88	27.27	27.00	0.00	20.68
7.00	28.30	27.30	27.80	28.28	27.40	28.35	27.15	27.23	27.65	26.73	27.20	26.90	0.00	20.50
8.00	28.27	27.10	28.20	28.15	27.20	28.30	27.23	27.00	27.60	26.55	27.03	26.90	0.00	20.43
9.00	27.98	27.03	28.90	28.03	27.00	27.88	26.80	27.05	27.53	26.40	26.97	26.67	0.00	20.70
10.00	28.12	27.05	29.20	27.90	26.95	27.80	26.98	27.05	27.45	26.33	27.13	26.53	0.00	20.80
11.00	28.18	26.90	28.20	27.80	26.93	27.88	26.98	27.10	27.55	26.10	27.33	26.27	0.00	19.87
12.00	28.15	26.73	28.00	27.80	26.80	27.55	26.43	27.23	27.63	25.90	26.87	25.97	0.00	20.40
13.00	28.05	26.68	28.00	27.75	26.65	27.43	26.10	27.18	27.38	25.75	26.80	25.77	0.00	19.95
14.00	28.03	26.78	28.00	27.65	26.55	27.30	26.13	27.00	27.15	25.90	26.90	25.57	0.00	20.00
15.00	27.88	26.80	27.90	27.58	26.38	27.40	25.55	26.90	26.95	25.58	26.33	25.33	0.00	20.10
16.00	27.93	26.85	27.60	27.55	26.35	26.97	25.48	26.98	27.03	25.68	26.27	25.30	0.00	20.10
17.00	27.95	26.85	27.60	27.53	26.35	26.97	25.48	26.77	26.90	25.73	26.10	25.27	0.00	20.18
18.00	28.03	26.98	27.40	27.58	26.28	26.90	25.48	26.63	26.83	25.67	26.03	25.17	0.00	20.18
19.00	27.98	26.93	27.80	27.53	26.20	27.25	25.45	26.53	26.85	25.60	25.87	25.13	0.00	20.15
20.00	27.93	27.18	27.80	27.53	26.15	27.35	25.13	26.43	26.75	25.55	25.80	25.00	0.00	20.18
21.00	27.70	26.93	27.60	27.35	26.05	27.43	24.93	26.30	26.68	25.52	25.90	25.07	0.00	20.25
22.00	27.78	26.88	27.20	27.35	26.05	27.43	24.93	26.30	26.70	25.98	25.87	25.07	0.00	20.25
23.00	27.85	26.75	27.20	27.33	26.08	28.12	25.24	26.38	26.34	25.84	25.50	25.20	0.00	20.52
24.00	27.70	26.70	27.30	27.62	26.26	28.12	25.24	26.38	26.34	25.84	25.50	25.20	0.00	20.52
25.00	27.42	26.54	27.20	27.56	26.28	27.74	24.85	26.40	26.36	25.86	25.38	25.18	0.00	20.44
26.00	27.28	26.52	26.90	27.60	26.16	27.66	24.83	26.32	26.26	25.78	25.40	25.10	0.00	20.42
27.00	27.38	26.60	27.00	27.64	26.06	27.96	24.75	26.32	26.32	25.62	25.23	24.98	0.00	20.10
28.00	27.30	26.48	27.00	27.60	25.92	27.80	24.85	26.26	26.22	25.56	25.23	24.95	0.00	20.05
29.00	27.28	26.40	26.80	27.52	25.92	27.80	24.75	26.24	26.18	25.54	25.15	24.85	0.00	19.90
30.00	27.24	26.36	26.90	27.54	25.96	27.78	24.65	26.18	26.12	25.54	25.13	24.83	0.00	19.78
31.00	27.22	26.32	26.70	27.48	25.90	28.02	24.63	26.14	26.04	25.38	25.15	24.70	0.00	19.68
32.00	27.14	26.26	26.80	27.50	25.86	28.18	24.55	25.88	26.00	25.28	25.03	24.55	0.00	19.58
33.00	27.12	26.30	26.80	27.42	25.78	28.16	24.43	26.02	25.94	25.36	25.00	24.50	0.00	19.58
34.00	27.06	26.08	26.90	27.34	25.76	27.13	24.23	26.02	25.86	25.34	24.93	24.45	0.00	19.60
35.00	27.00	26.24	26.80	27.24	25.66	27.05	24.13	25.84	25.76	25.42	24.75	24.28	0.00	19.74
36.00	27.02	26.28	26.80	27.22	25.64	26.93	24.78	25.86	25.72	25.46	24.75	24.20	0.00	19.63
37.00	27.20	26.50	26.80	27.18	25.58	26.80	24.54	25.84	25.62	25.58	24.65	24.03	0.00	19.84
38.00	27.14	26.64	26.70	27.14	25.58	26.80	24.52	25.82	25.54	25.50	24.63	23.95	0.00	19.86
39.00	27.16	26.80	26.70	27.14	25.54	26.77	24.40	25.80	25.52	25.50	24.58	23.85	0.00	19.88
40.00	27.14	26.84	26.60	27.14	25.54	26.77	24.40	25.80	25.52	25.50	24.58	23.85	0.00	19.88
41.00	26.98	26.58	26.60	27.14	25.62	26.70	23.93	25.66	25.40	25.50	24.45	23.88	0.00	19.90
42.00	26.92	26.32	26.50	27.14	25.54	26.77	23.78	25.62	25.38	25.56	24.38	23.83	0.00	19.94

(Table B.1.A, continued)

43.00	26.96	26.56	26.50	27.24	25.56	26.75	23.83	25.58	25.40	25.54	24.35	23.85	0.00	19.98
44.00	26.94	26.52	26.80	27.16	25.50	26.83	23.85	25.68	25.44	25.63	24.40	23.77	0.00	20.06
45.00	26.90	26.38	26.70	27.16	25.54	26.68	23.85	25.66	25.50	25.58	24.40	23.85	0.00	20.12
46.00	27.02	26.30	26.80	27.12	25.66	26.52	23.88	25.60	25.46	25.65	24.40	23.85	0.00	20.58
47.00	26.96	26.26	26.90	27.14	25.62	26.45	24.28	25.64	25.52	25.63	24.43	23.80	0.00	20.16
48.00	26.94	26.24	26.90	27.08	25.62	26.43	24.36	25.58	25.50	25.63	24.40	23.83	0.00	20.10
49.00	26.88	26.24	27.00	27.14	25.62	26.30	24.32	25.60	25.48	25.58	24.40	23.83	0.00	20.14
50.00	26.88	26.20	26.90	27.12	25.56	26.20	24.28	25.68	25.44	25.42	24.40	23.85	0.00	20.06
51.00	26.88	26.14	26.70	27.16	25.54	26.20	24.40	25.72	25.42	25.42	24.38	23.85	0.00	20.15
52.00	26.76	26.12	26.90	27.14	25.56	26.18	24.24	25.72	25.38	25.35	24.33	23.80	0.00	20.12
53.00	26.82	26.12	26.90	27.20	25.56	26.28	24.20	25.70	25.42	25.30	24.30	23.77	0.00	20.12
54.00	26.80	26.20	27.00	27.38	25.54	26.33	24.08	25.72	25.44	25.33	24.30	23.78	0.00	20.08
55.00	26.84	26.42	26.90	27.24	25.50	26.28	23.98	25.72	25.30	25.35	24.30	23.58	0.00	20.04
56.00	26.96	26.46	26.60	27.20	25.50	26.35	23.86	25.78	25.32	25.38	24.27	23.55	0.00	20.02
57.00	26.96	26.58	26.30	27.24	25.50	26.20	23.86	25.68	25.30	25.40	24.27	23.45	0.00	19.98
58.00	27.08	26.78	26.50	27.28	25.48	26.43	23.92	25.70	25.26	25.40	24.23	23.48	0.00	20.08
59.00	27.02	26.82	26.60	27.28	25.46	26.23	23.82	25.70	25.24	25.48	24.15	23.40	0.00	20.05
60.00	26.92	26.86	26.60	27.36	25.48	26.23	23.78	25.74	25.22	25.60	24.13	23.38	0.00	20.22
61.00	26.86	26.68	26.50	27.36	25.48	26.33	23.80	25.80	25.34	25.63	24.05	23.30	0.00	20.03
62.00	26.82	26.56	26.60	27.44	25.52	26.30	23.83	25.84	25.40	25.50	24.00	23.32	0.00	20.38
63.00	26.96	26.62	26.70	27.48	25.56	26.33	23.94	25.74	25.30	25.60	23.98	23.27	0.00	20.33
64.00	26.86	26.60	26.70	27.48	25.56	26.33	23.92	25.74	25.26	25.58	24.09	23.27	0.00	20.50
65.00	26.86	26.60	26.80	27.48	25.52	26.37	23.80	25.70	25.24	25.60	24.03	23.15	0.00	20.40
66.00	26.82	26.42	26.80	27.46	25.56	26.33	23.72	25.72	25.14	25.56	23.90	23.10	0.00	20.42
67.00	26.76	26.38	26.90	27.48	25.60	26.20	23.72	25.68	25.16	25.56	23.95	23.08	0.00	20.34
68.00	26.76	26.30	26.90	27.44	25.56	26.13	23.66	25.66	25.14	25.62	23.93	23.05	0.00	20.30
69.00	26.82	26.24	26.90	27.44	25.56	26.23	23.66	25.64	25.08	25.64	23.88	22.98	0.00	20.16
70.00	26.84	26.36	26.80	27.42	25.60	26.27	23.56	25.60	25.08	25.64	23.88	22.85	0.00	20.18
71.00	26.76	26.28	26.80	27.40	25.56	26.43	23.52	25.56	24.98	25.55	24.00	22.68	0.00	20.24
72.00	26.66	26.22	26.60	27.30	25.50	26.43	23.52	25.56	24.98	25.55	24.00	22.68	0.00	20.24
73.00	26.72	26.14	26.40	27.36	25.50	26.45	23.60	25.80	24.94	25.58	23.95	22.80	0.00	20.18
74.00	26.66	26.28	26.50	27.22	25.54	26.35	23.52	25.70	25.02	25.58	23.95	22.80	0.00	20.20
75.00	26.58	26.32	26.40	27.18	25.50	26.08	23.46	25.54	24.98	25.60	23.88	22.73	0.00	20.20
76.00	26.62	26.66	26.40	27.18	25.50	26.13	23.42	25.58	24.96	25.60	23.85	22.70	0.00	20.22
77.00	26.74	26.88	26.50	27.16	25.46	26.18	23.56	25.60	24.94	25.58	23.90	22.65	0.00	20.28
78.00	26.78	27.02	26.50	27.22	25.48	26.20	23.60	25.54	25.02	25.55	24.00	22.60	0.00	20.30
79.00	26.84	27.06	26.50	27.22	25.44	26.13	23.56	25.50	25.02	25.55	23.92	22.63	0.00	20.36
80.00	26.78	27.16	26.50	27.26	25.48	26.15	23.50	25.54	24.98	25.55	23.95	22.58	0.00	20.50
81.00	26.58	26.96	26.50	27.28	25.46	26.25	23.44	25.58	25.02	25.55	23.85	22.60	0.00	20.54
82.00	26.85	26.86	26.60	27.30	25.50	26.20	23.44	25.62	25.06	25.44	23.95	22.63	0.00	20.62
83.00	26.54	26.74	26.50	27.36	25.54	26.33	23.48	25.62	25.10	25.56	23.85	22.58	0.00	20.62
84.00	26.68	26.78	26.50	27.46	25.54	26.33	23.68	25.62	25.04	25.68	23.83	22.55	0.00	20.54
85.00	26.63	26.66	26.50	27.48	25.56	26.27	23.42	25.64	25.08	25.76	23.88	22.52	0.00	20.52
86.00	26.55	26.56	26.40	27.42	25.54	26.10	23.80	25.58	25.04	25.84	23.83	22.45	0.00	19.98
87.00	26.55	26.48	26.50	27.42	25.56	26.13	23.83	25.54	25.00	25.94	23.75	22.42	0.00	19.98
88.00	26.63	26.42	26.50	27.40	25.56	26.13	23.83	25.56	24.94	25.94	23.70	22.38	0.00	19.93
89.00	26.55	26.60	26.50	27.38	25.56	26.13	23.80	25.58	24.98	25.98	23.65	22.30	0.00	20.13

(Table B.1.A, continued)

90.00	26.58	26.64	26.50	27.30	25.48	25.98	23.68	25.58	24.92	26.08	23.65	22.25	0.00	20.03
91.00	27.40	26.40	26.50	26.93	25.33	25.85	23.03	25.43	25.18	25.77	23.90	22.03	0.00	20.10
92.00	27.27	26.43	26.50	26.88	25.33	25.88	23.07	25.43	25.13	25.78	23.83	22.03	0.00	19.95
93.00	27.07	26.39	26.50	26.90	25.25	26.00	22.87	25.48	25.10	25.78	23.83	21.97	0.00	19.85
94.00	27.00	26.33	26.60	26.85	25.23	26.13	22.83	25.35	25.10	25.90	23.77	21.90	0.00	19.75
95.00	26.80	26.38	26.40	26.68	25.15	25.93	22.73	25.30	24.93	25.07	23.80	21.55	0.00	19.60
96.00	26.83	26.35	26.40	26.73	25.17	25.90	22.57	25.35	25.03	25.13	23.80	21.50	0.00	19.55
97.00	26.90	26.63	26.40	26.73	25.10	26.09	22.63	25.35	25.09	25.03	23.90	21.50	0.00	19.40
98.00	26.93	26.78	26.30	26.80	25.13	26.00	22.63	25.38	25.05	25.00	23.83	21.45	0.00	19.45
99.00	26.88	26.83	26.30	26.75	25.08	26.03	22.63	25.38	25.13	24.90	23.83	21.50	0.00	19.45
100.00	26.75	26.68	26.70	26.70	25.10	26.03	22.40	25.38	25.18	25.07	23.83	21.73	0.00	19.50
101.00	26.75	26.60	26.10	26.78	25.10	26.02	22.53	25.33	25.18	24.93	23.80	21.70	0.00	19.45
102.00	26.75	26.60	26.20	26.88	25.08	25.95	22.53	25.33	25.13	24.83	23.60	21.77	0.00	19.63
103.00	26.75	26.58	26.10	26.95	25.13	26.03	22.65	25.70	25.27	24.93	23.53	21.77	0.00	19.67
104.00	26.73	26.65	26.10	27.00	25.08	26.00	22.65	25.90	25.30	25.03	23.57	21.77	0.00	19.70
105.00	26.85	26.63	26.10	26.85	25.15	26.00	22.88	25.95	25.25	24.87	23.47	21.77	0.00	19.77
106.00	26.85	26.63	26.10	26.90	25.15	26.00	22.43	26.10	25.23	25.58	23.57	21.73	0.00	19.77
107.00	26.90	26.50	26.00	26.95	25.13	25.93	22.47	26.18	25.35	25.63	23.53	21.73	0.00	19.80
108.00	27.10	26.55	26.10	27.03	25.15	25.95	23.05	25.07	25.30	25.68	23.50	21.73	0.00	19.77
109.00	26.93	26.50	26.10	27.13	25.20	26.08	22.95	25.07	25.38	25.73	23.57	21.70	0.00	19.87
110.00	26.93	26.50	26.20	27.15	25.27	26.10	22.85	25.10	25.30	25.80	23.53	21.70	0.00	19.83
111.00	27.00	26.45	26.30	27.15	25.28	26.00	22.80	24.93	25.28	25.83	23.47	21.73	0.00	19.87
112.00	27.08	26.48	26.30	27.15	25.25	26.05	22.78	25.00	25.35	25.90	23.50	21.70	0.00	19.90
113.00	27.05	26.60	26.20	27.00	25.20	26.10	22.68	25.03	25.28	25.92	23.43	21.67	0.00	19.87
114.00	27.08	26.63	26.30	26.92	25.20	26.00	22.68	25.10	25.30	25.98	23.53	21.67	0.00	19.87
115.00	26.83	26.52	26.30	26.93	25.08	26.09	22.53	24.93	25.25	25.07	23.53	21.50	0.00	19.83
116.00	26.90	26.75	26.30	26.85	25.08	26.08	22.43	25.00	25.33	25.07	23.53	21.50	0.00	19.80
117.00	26.90	26.77	26.40	26.88	25.08	26.18	22.45	24.97	25.30	25.03	23.67	21.47	0.00	19.80
118.00	26.88	26.80	26.40	26.83	25.08	26.28	22.40	24.97	25.35	25.03	23.67	21.40	0.00	19.80
119.00	26.33	26.73	26.40	26.43	24.83	26.27	22.33	25.03	24.90	25.30	23.35	21.40	0.00	20.20
120.00	26.23	26.77	26.30	26.23	24.87	26.23	22.30	25.07	24.97	25.30	23.30	21.30	0.00	20.20

Table B.1.B

TIME	HEAD	CHST	ABD	RATE OF HEAT LOSS (WATTS)				RHLIARI. DAT		F-TH	FCLF	R-TH	RCLF	FOOT
				UBAC	LBAC	ARM	WRBT							
3.00	41.33	34.44	36.77	45.82	39.22	52.42	16.60			17.90	24.65	34.13	21.59	24.56
4.00	36.75	38.51	32.52	44.67	33.44	58.57	18.48			37.13	23.83	29.64	25.17	24.52
5.00	33.29	33.28	32.78	41.57	31.55	46.04	14.97			35.29	22.83	25.94	21.96	21.30
6.00	34.48	27.20	29.42	41.18	32.13	47.00	12.53			30.54	24.07	30.41	23.11	22.20
7.00	32.48	31.73	27.89	41.46	30.00	49.94	12.57			34.43	22.63	24.07	21.52	18.98
8.00	31.45	30.15	24.27	40.62	29.64	45.97	11.31			29.24	22.22	26.29	22.44	18.13
9.00	31.47	32.02	31.49	37.68	30.49	53.24	15.34			30.67	21.45	26.82	20.40	20.11
10.00	30.55	24.98	27.46	39.96	28.24	41.74	6.37			27.94	22.74	25.45	26.57	17.93
11.00	31.30	27.49	25.61	38.52	27.09	43.31	11.03			21.18	20.28	26.98	23.11	17.38
12.00	31.32	27.77	22.89	37.00	27.49	42.73	14.52			21.87	16.71	25.76	22.94	18.73
13.00	30.69	27.66	21.85	34.45	28.34	39.78	14.42			24.12	22.20	26.25	19.20	16.35
14.00	30.60	27.79	24.13	35.26	26.85	36.26	12.18			27.45	19.71	23.83	24.30	16.52
15.00	28.95	24.56	24.90	34.71	27.55	39.12	13.84			21.56	20.57	24.04	22.89	15.09
16.00	28.89	23.61	23.21	36.76	25.90	38.51	13.41			23.50	19.67	18.48	21.35	16.42
17.00	30.34	24.40	24.03	35.28	25.57	43.12	13.35			22.00	19.19	18.82	21.87	13.07
18.00	29.28	23.25	22.56	33.75	24.99	33.71	10.94			27.16	19.73	18.76	23.06	13.96
19.00	30.59	22.89	23.00	31.88	24.76	38.29	10.38			27.15	19.33	19.78	19.95	13.62
20.00	30.30	19.97	23.29	33.73	25.14	29.01	11.02			24.88	17.46	20.38	23.43	12.99
21.00	30.56	29.01	19.38	32.50	24.96	29.46	10.19			25.96	19.06	20.65	21.25	14.18
22.00	31.24	28.45	27.85	32.59	25.38	28.96	10.43			28.24	18.62	19.62	20.96	13.10
23.00	30.50	27.64	27.03	33.55	24.00	36.38	8.81			24.56	17.54	18.89	19.29	11.99
24.00	29.05	28.03	23.35	34.93	24.53	30.07	10.00			24.79	17.61	19.88	20.43	13.75
25.00	28.05	29.94	24.64	34.75	24.45	35.25	11.30			24.41	16.36	19.84	20.37	13.33
26.00	29.86	27.76	23.43	34.10	25.79	35.20	9.78			25.56	17.99	19.84	17.96	13.26
27.00	28.93	29.02	18.11	33.39	26.51	39.08	9.53			24.38	16.28	21.09	20.63	14.11
28.00	29.68	30.00	25.20	33.32	25.44	33.52	10.10			24.37	17.79	19.19	18.74	14.33
29.00	30.84	29.77	29.88	32.60	26.10	31.97	9.91			25.61	17.16	19.55	17.92	15.43
30.00	30.52	31.22	28.10	35.48	24.90	28.39	9.77			25.30	18.20	21.22	17.17	14.26
31.00	29.24	27.88	27.15	32.33	24.92	26.19	9.59			25.09	17.13	21.25	17.45	13.69
32.00	31.06	27.03	26.81	35.17	25.08	25.24	7.63			25.00	17.60	21.50	17.75	14.21
33.00	30.64	30.29	22.32	34.43	25.72	21.42	8.56			25.41	16.78	19.78	20.19	13.28
34.00	31.10	28.49	23.74	33.97	25.79	26.97	9.59			24.03	17.07	20.55	19.97	12.78
35.00	29.20	26.60	21.53	37.88	25.09	31.84	9.24			26.11	16.88	22.47	22.38	11.41
36.00	28.94	23.17	28.02	33.46	24.72	20.97	8.63			23.69	16.36	20.20	22.08	13.16
37.00	28.14	25.79	30.30	32.87	22.71	33.26	9.36			25.24	16.96	19.48	19.97	11.53
38.00	27.41	26.64	29.86	33.55	22.74	29.27	10.03			24.49	16.79	20.04	20.75	12.22
39.00	28.08	25.10	27.76	33.83	23.40	27.96	9.44			24.79	17.18	20.11	20.26	12.18
40.00	28.72	26.99	28.78	33.72	23.50	33.79	10.12			28.39	16.65	21.89	20.84	11.96
41.00	29.51	31.31	24.40	35.22	22.48	29.68	9.06			26.62	16.93	21.60	22.33	11.12
42.00	30.57	30.40	21.33	36.15	23.11	33.08	7.94			27.66	17.02	22.42	22.00	11.67

(Table B.1.B, continued)

43.00	29.12	27.70	20.28	33.37	23.14	31.81	7.86	24.81	15.34	21.21	20.19	10.25
44.00	29.64	29.98	22.03	34.55	22.10	31.21	7.58	23.40	15.22	19.60	18.94	10.95
45.00	29.48	30.36	27.83	32.47	22.34	36.05	8.66	25.53	15.07	22.27	19.19	10.05
46.00	27.82	28.76	27.83	33.87	21.31	34.52	8.34	26.00	16.48	20.60	20.79	9.80
47.00	28.38	29.46	22.52	33.77	21.97	37.26	8.34	24.09	15.41	21.49	18.39	10.37
48.00	29.54	28.61	21.50	35.66	21.09	31.88	6.62	23.70	14.58	22.38	18.04	10.11
49.00	28.60	28.17	20.98	33.11	22.60	30.86	6.14	22.22	16.21	20.79	18.28	10.22
50.00	28.84	29.27	22.27	35.25	23.65	34.42	6.65	22.66	16.79	19.78	17.63	9.87
51.00	28.46	28.61	25.65	34.47	23.46	37.14	6.48	22.93	15.84	20.01	18.90	9.08
52.00	29.69	29.99	22.21	34.10	21.81	32.99	7.11	22.50	15.16	19.12	17.79	10.27
53.00	28.90	28.65	22.52	34.22	22.76	31.14	7.24	24.34	15.80	19.96	17.97	9.94
54.00	28.29	28.33	21.46	33.38	23.92	29.57	7.02	23.33	15.67	19.41	17.62	9.13
55.00	28.12	27.84	22.98	34.61	23.97	29.92	6.56	25.57	17.03	19.47	17.07	9.46
56.00	27.60	25.03	27.32	33.90	22.62	27.76	7.25	22.94	15.21	19.87	16.79	9.17
57.00	26.82	25.22	24.48	33.16	22.56	33.25	7.09	25.15	15.29	18.67	16.34	9.05
58.00	26.42	25.87	24.58	33.62	22.92	23.33	6.91	23.96	15.25	19.34	17.16	8.56
59.00	27.91	24.67	26.41	33.93	23.08	27.76	7.13	23.35	14.67	19.86	17.28	8.96
60.00	27.01	27.28	26.01	35.20	22.44	34.75	7.82	24.20	15.86	21.28	16.72	8.53
61.00	29.91	31.44	25.10	32.55	22.33	33.78	5.33	20.57	14.98	19.19	17.21	8.77
62.00	28.09	30.06	24.63	34.76	22.47	30.48	6.70	22.41	15.45	17.78	17.51	8.29
63.00	26.83	28.58	23.60	32.05	22.70	32.25	5.97	26.70	15.46	20.35	17.39	7.92
64.00	27.92	30.51	23.25	30.16	21.88	32.12	6.74	24.69	15.24	18.55	17.18	7.92
65.00	28.57	28.57	22.71	32.26	21.89	33.05	6.12	25.81	15.12	19.14	15.78	7.95
66.00	29.18	29.97	22.87	33.11	22.47	33.00	6.90	25.26	15.16	20.83	17.42	8.10
67.00	29.45	28.62	20.95	33.84	23.56	33.73	6.75	25.47	16.01	20.27	18.40	8.78
68.00	28.30	29.10	22.37	32.56	21.98	33.49	6.74	24.01	14.92	21.81	16.15	8.12
69.00	27.84	31.05	23.27	32.70	22.91	32.59	6.86	24.95	14.90	18.07	16.56	7.99
70.00	27.38	29.20	20.04	34.28	22.60	31.20	6.21	24.94	15.17	19.31	16.70	8.20
71.00	28.47	28.80	19.65	33.91	23.87	29.89	7.88	26.39	14.77	18.70	17.03	7.96
72.00	29.67	29.81	23.98	36.40	22.87	34.12	7.58	25.60	15.41	21.22	17.08	7.84
73.00	28.10	33.67	17.73	32.63	23.78	30.73	5.94	21.80	15.92	21.06	16.57	6.51
74.00	28.29	27.72	23.75	35.08	22.62	33.06	5.97	24.42	14.46	19.96	17.55	8.27
75.00	28.45	27.85	25.42	34.24	23.72	33.61	6.45	27.33	14.77	22.83	17.53	7.69
76.00	26.57	24.45	25.42	34.95	21.59	30.78	5.87	25.11	14.17	21.44	16.48	7.83
77.00	26.06	26.26	25.39	33.63	22.02	28.24	5.34	24.60	14.57	22.83	16.59	7.31
78.00	26.07	24.81	24.09	34.35	22.31	31.40	6.16	25.09	14.36	21.81	15.19	7.34
79.00	26.47	27.03	21.94	31.61	21.80	32.73	6.45	26.75	13.50	21.49	16.77	7.20
80.00	26.76	28.75	26.03	34.87	21.69	36.05	6.54	26.27	14.47	21.42	17.58	7.54
81.00	26.40	26.75	22.50	31.59	21.65	28.56	5.90	23.59	12.92	18.49	17.85	6.61
82.00	29.53	30.81	21.55	32.76	21.51	36.54	5.52	23.77	13.14	18.46	18.05	6.66
83.00	28.07	29.19	23.71	33.29	21.28	30.72	6.57	24.96	13.40	18.86	17.04	6.69
84.00	28.12	30.44	26.02	33.94	22.06	33.13	6.97	24.30	14.12	19.62	15.56	6.96
85.00	28.88	30.85	24.28	33.26	22.47	37.12	6.16	25.62	13.50	18.52	15.47	6.86
86.00	29.12	31.04	22.48	33.33	22.49	33.38	6.73	26.76	13.70	16.63	15.47	7.32
87.00	27.96	30.30	24.41	33.21	22.70	32.06	5.72	25.99	13.95	16.09	16.83	6.86
88.00	27.14	31.93	23.28	33.40	23.46	33.09	5.85	26.55	14.13	16.12	17.44	7.00
89.00	27.90	29.66	23.88	33.80	23.94	32.92	5.55	25.46	13.96	19.52	16.10	7.58

(Table B.1.B, continued)

90.00	27.50	28.06	22.25	34.15	24.29	41.85	6.53	25.48	14.95	16.79	16.70	6.67
91.00	29.87	28.15	20.89	33.60	22.20	35.49	4.08	27.17	14.95	17.48	14.43	5.60
92.00	30.82	29.04	22.43	35.85	22.22	35.65	4.42	26.21	15.42	17.98	15.77	5.55
93.00	30.26	31.26	21.52	32.66	22.74	31.68	5.47	24.57	16.23	18.79	15.20	5.93
94.00	30.83	30.31	20.25	33.85	22.54	31.67	5.50	26.18	15.85	17.22	16.29	5.42
95.00	30.87	24.10	19.99	33.76	22.00	32.61	5.67	26.19	16.25	21.33	16.09	5.68
96.00	31.04	24.00	24.32	34.50	22.27	40.28	5.61	25.80	15.35	22.38	15.20	6.15
97.00	29.75	26.59	23.67	32.62	22.40	33.82	5.27	26.57	15.75	23.41	14.32	5.48
98.00	30.10	26.45	24.23	32.25	22.50	34.40	5.03	26.07	15.45	23.32	16.23	5.85
99.00	29.22	25.26	24.87	31.95	22.88	32.10	4.85	25.20	15.90	23.06	16.03	5.26
100.00	29.73	26.44	22.85	34.22	22.18	27.98	4.45	24.88	14.10	23.50	14.49	4.78
101.00	31.98	30.37	22.99	30.88	22.92	34.06	4.27	24.92	16.08	20.58	16.13	5.45
102.00	31.44	31.43	22.76	31.10	22.86	29.21	3.79	22.79	16.49	20.06	15.26	5.66
103.00	29.41	29.09	23.63	28.62	21.76	29.77	4.51	21.32	15.29	19.48	15.77	4.66
104.00	30.06	24.92	21.91	28.66	21.32	31.09	5.14	18.96	14.96	18.36	15.46	4.77
105.00	29.62	29.15	20.38	30.52	21.60	34.26	3.77	21.08	15.07	19.64	17.43	4.92
106.00	27.60	26.89	22.38	34.22	21.62	33.80	3.78	19.38	15.71	19.72	15.11	4.59
107.00	28.46	27.96	20.13	35.55	22.49	34.76	4.19	21.06	13.85	19.38	16.09	4.49
108.00	29.97	27.12	23.48	31.10	21.20	32.70	4.67	24.61	13.08	18.26	15.88	4.20
109.00	26.11	28.85	21.61	31.15	21.31	30.39	3.86	23.90	14.05	18.16	13.86	4.50
110.00	29.13	27.02	19.59	29.70	21.06	32.87	4.73	22.50	15.34	17.28	15.24	4.49
111.00	30.93	28.98	20.26	31.66	21.72	33.47	4.29	23.59	14.87	18.68	14.77	4.03
112.00	28.54	27.77	21.03	30.79	21.48	30.67	4.29	21.65	15.27	18.14	15.22	3.87
113.00	28.72	22.65	18.95	34.75	21.57	29.23	4.06	22.70	14.68	18.36	16.25	4.02
114.00	28.79	22.41	18.79	35.66	22.36	31.49	3.43	22.91	15.12	18.44	13.62	3.91
115.00	28.84	26.84	18.90	30.32	23.07	33.13	4.50	26.28	15.00	20.30	15.10	5.17
116.00	28.49	26.06	20.47	30.77	22.18	30.37	5.06	23.88	14.59	21.19	13.52	4.82
117.00	29.69	26.99	22.80	32.19	21.54	26.37	4.32	25.63	16.90	22.16	13.22	4.83
118.00	28.40	25.48	22.95	32.73	21.18	28.20	4.75	24.53	15.99	21.78	11.13	4.50
119.00	29.83	28.01	21.34	31.22	22.05	30.66	4.43	23.26	15.31	20.04	15.00	4.40
120.00	29.62	29.84	22.51	33.55	23.27	30.29	3.61	23.68	15.21	21.71	14.78	4.64

Table B.2.A

TIME	HEAD	CHST	ABD	UBAC	TEMPERATURE C		DTPIART. DAT		R-TH	RCLF	FOOT	RECT	AMB
					LBAC	ARM	HRST	F-TH	FCLF				
0.00	35.20	35.55	34.45	35.73	33.78	35.60	34.55	33.28	31.98	34.38	33.05	37.72	3.93
3.00	35.93	36.13	34.88	36.13	34.30	36.03	35.30	33.68	34.42	34.80	32.83	37.99	3.95
6.00	35.65	36.20	34.93	36.18	34.45	36.35	35.65	33.60	33.88	34.48	32.19	37.66	3.90
9.00	34.05	35.95	34.70	35.95	34.48	36.18	35.45	32.63	32.93	33.38	31.08	37.72	4.03
12.00	27.83	34.73	34.43	34.77	33.70	34.93	35.33	30.90	31.67	32.43	31.30	37.55	4.13
15.00	29.43	33.63	33.77	34.00	33.07	33.80	34.20	29.30	30.77	31.23	30.83	37.73	4.20
18.00	29.00	32.97	33.40	33.40	32.53	33.00	32.97	28.27	30.10	30.47	30.47	37.76	4.17
21.00	24.50	31.55	32.40	32.50	31.70	32.20	32.70	26.15	28.35	29.60	29.45	37.66	4.30
24.00	24.50	31.00	32.00	32.10	31.60	31.80	32.20	25.40	27.85	29.10	29.10	29.32	4.20
27.00	24.95	30.60	31.75	31.65	31.30	31.30	31.70	24.70	27.35	28.60	28.75	37.63	4.25
30.00	24.50	30.70	31.57	31.57	31.17	31.37	31.37	24.93	27.83	27.50	27.63	37.93	3.77
33.00	24.70	30.53	31.33	31.53	31.00	30.97	31.03	24.57	27.53	27.17	27.37	37.40	3.80
36.00	24.90	30.33	31.13	31.30	30.87	30.70	30.93	24.20	27.13	26.77	27.07	37.38	3.80
39.00	28.95	30.13	31.78	31.07	30.90	31.10	30.63	23.87	27.65	26.47	27.60	37.50	3.78
42.00	29.25	29.90	31.65	31.23	30.98	31.08	30.48	23.67	27.45	26.33	27.30	37.47	3.90
45.00	30.05	29.87	31.52	31.13	30.90	31.00	30.07	23.37	27.20	26.10	27.18	37.42	3.88
48.00	27.00	30.15	31.60	31.20	30.83	30.77	30.67	22.25	27.53	25.25	27.00	37.82	4.17
51.00	26.20	30.20	31.40	31.20	30.57	30.60	30.53	22.20	27.33	25.00	26.60	37.78	4.13
54.00	26.10	30.35	31.23	31.25	30.33	29.40	30.30	22.00	27.07	24.90	26.47	37.46	4.13
57.00	24.30	30.25	31.07	31.10	30.13	29.40	30.35	21.70	26.90	24.65	26.20	37.56	4.13
60.00	23.90	30.30	31.10	31.15	29.93	29.30	30.25	21.55	26.63	24.60	26.00	37.26	4.13
63.00	23.30	30.20	30.90	31.15	29.63	29.35	30.25	21.35	26.50	24.50	25.93	37.22	4.13
66.00	23.30	30.20	30.80	31.15	29.43	29.30	30.30	21.40	26.43	24.60	25.83	37.17	4.10
69.00	0.00	30.55	30.77	31.70	29.40	29.25	30.55	17.70	26.37	24.50	25.53	37.07	4.13
72.00	27.00	30.50	30.73	31.80	29.20	29.30	30.55	17.60	26.00	24.50	25.20	36.96	4.13
75.00	27.20	30.55	30.63	31.90	29.13	29.13	30.55	17.60	26.00	24.50	25.10	36.94	4.13
78.00	26.60	30.75	30.67	31.60	29.10	29.40	30.50	17.80	25.70	24.35	24.87	36.94	4.13
81.00	25.25	30.75	30.67	31.45	29.07	29.50	30.50	18.10	25.47	24.25	24.80	36.91	4.20
84.00	24.80	30.85	30.70	31.55	29.00	29.95	30.40	21.95	25.40	24.15	24.53	36.89	4.00
87.00	24.65	30.75	30.60	31.70	29.00	30.10	30.55	18.30	25.20	24.10	24.50	36.84	4.03
90.00	24.70	30.65	30.63	31.60	28.90	29.85	30.45	22.25	25.10	24.00	24.27	36.81	4.07
93.00	24.65	30.30	30.47	31.65	28.97	29.60	30.50	18.70	24.95	23.90	23.90	36.79	4.07
96.00	24.15	30.35	30.43	31.60	29.00	29.50	30.55	18.90	24.75	23.80	23.50	36.77	4.03
99.00	24.25	30.35	29.85	31.55	28.87	29.35	30.60	18.70	24.50	23.75	23.20	37.05	4.07
102.00	23.85	30.15	29.80	31.40	28.83	29.15	30.20	22.15	24.20	23.55	23.95	36.71	4.03
105.00	23.90	30.15	29.70	31.35	28.77	29.00	29.80	18.60	24.00	23.15	23.80	37.04	4.03
108.00	0.00	28.50	29.40	31.55	28.73	29.20	29.70	18.70	24.10	23.40	22.87	37.41	4.15
111.00	0.00	0.00	30.27	34.10	29.33	32.30	30.30	0.00	0.00	29.70	24.90	37.09	3.10
114.00	33.10	0.00	30.77	34.50	29.93	32.90	30.75	25.10	0.00	30.60	23.40	37.05	3.10
117.00	33.40	0.00	31.07	34.90	30.40	33.40	31.00	0.00	0.00	31.00	23.60	37.04	3.10

(Table B.2.A, continued)

120.00	33.90	33.70	31.57	35.40	30.80	33.70	31.30	0.00	25.30	31.60	27.20	24.00	37.03	3.00
123.00	33.90	34.00	31.90	0.00	30.70	0.00	0.00	29.00	0.00	32.00	0.00	0.00	36.46	2.70

Table B.2.B

TIME	HEAD	CHBT	RATE OF HEAT LOSS (WATTS)			DTPART. DAT		F-TH	FCLF	R-TH	RCLF	FOOT
	ABD	UBAC	LBAC	ARM	MRST							
0.00	5.32	1.95	2.85	3.44	1.88			2.39	2.34	3.67	3.05	4.60
3.00	3.47	2.55	2.43	3.87	3.26			1.96	2.78	2.90	3.97	7.91
6.00	12.69	6.74	4.78	4.99	3.90			10.97	9.55	14.36	11.16	17.19
9.00	23.73	9.03	8.51	11.03	4.97			13.64	14.04	18.62	14.43	24.57
12.00	0.00	0.00	10.71	0.00	7.81			26.27	15.64	26.48	17.26	22.35
15.00	32.85	0.00	17.35	0.00	11.43			23.69	18.79	25.90	18.86	22.44
18.00	28.80	0.00	17.92	0.00	13.05			23.29	18.44	25.31	18.78	22.37
21.00	15.55	0.00	16.39	0.00	12.90			22.12	18.14	24.95	18.80	21.55
24.00	21.02	0.00	14.29	0.00	13.99			22.16	18.14	24.39	18.22	20.85
27.00	14.47	0.00	15.16	20.44	13.82			21.72	18.63	24.30	18.13	21.11
30.00	30.16	0.00	15.37	21.90	13.90			21.88	17.85	26.43	17.90	23.03
33.00	28.13	0.00	15.37	27.81	13.55			21.25	18.41	26.14	17.38	22.09
36.00	28.85	0.00	16.78	30.69	13.33			20.79	17.89	25.51	17.08	22.41
39.00	29.66	0.00	14.53	27.25	12.92			19.34	17.42	25.04	16.83	23.09
42.00	21.60	0.00	14.24	32.44	12.16			18.02	16.54	25.22	16.89	22.65
45.00	16.70	0.00	16.01	25.90	10.98			17.25	16.89	25.64	17.22	22.69
48.00	26.90	0.00	17.17	29.17	12.26			16.96	16.54	25.22	17.34	22.35
51.00	24.17	0.00	16.90	29.76	13.33			17.03	17.03	26.21	17.34	22.11
54.00	23.49	0.00	17.56	27.70	11.18			18.06	16.39	27.44	16.90	22.11
57.00	18.70	0.00	17.10	27.43	13.58			19.07	16.39	27.44	16.90	22.11
60.00	18.55	0.00	17.30	33.51	13.51			16.41	14.81	25.17	14.77	20.02
63.00	25.65	0.00	17.30	25.80	14.06			18.51	15.98	26.30	16.47	21.69
66.00	18.31	0.00	14.96	28.51	13.17			17.86	15.89	25.11	16.55	21.06
69.00	23.09	0.00	15.51	28.19	12.71			15.94	15.30	25.27	15.74	20.95
72.00	23.69	0.00	16.01	22.60	12.29			15.37	15.65	24.60	16.19	21.04
75.00	24.51	0.00	15.30	26.88	10.39			16.33	16.06	24.56	16.07	21.26
78.00	26.45	0.00	13.38	20.04	13.15			19.72	16.21	24.35	15.07	20.96
81.00	30.62	0.00	15.51	26.94	13.15			20.81	16.21	24.35	15.07	20.96
84.00	28.39	0.00	15.26	21.83	12.02			21.38	18.35	26.20	15.87	20.56
87.00	28.95	0.00	15.92	22.60	11.50			16.17	18.93	26.28	16.78	21.16
90.00	30.70	0.00	15.93	25.47	11.07			21.45	16.67	26.86	16.08	21.09
93.00	30.96	0.00	16.68	27.92	11.39			21.82	16.67	26.84	15.93	20.50
96.00	35.23	0.00	16.02	29.28	11.79			22.14	17.94	27.36	15.98	19.51
99.00	29.64	0.00	16.47	28.24	10.94			17.73	20.23	25.84	16.23	19.93
102.00	29.06	0.00	16.51	27.16	11.02			22.77	17.56	30.62	16.08	18.34
105.00	28.92	0.00	16.22	26.13	12.04			25.92	16.76	30.85	16.03	20.16
108.00	16.17	0.00	13.42	23.14	9.36			19.24	15.31	18.91	15.28	20.13
111.00	12.51	0.00	9.57	14.53	5.64			10.10	9.26	8.87	10.36	10.40
114.00	9.98	0.00	7.90	11.14	3.99			6.49	6.30	6.72	7.66	13.88
117.00	6.40	0.00	4.72	9.83	3.18			6.31	5.73	6.64	6.36	14.56

(Table B.2.B, continued)

120.00	3.72	4.69	8.93	0.00	4.77	8.03	2.18	6.09	4.23	3.97	5.47	12.21
123.00	3.97	0.00	11.89	0.00	3.76	4.15	3.94	5.52	2.84	4.22	4.55	5.15

Table B.3.A

TIME	HEAD	CHST	ABD	UBAC	TEMPERATURE C		LRST	DTP2ARI. DAT		R-TH	RCLF	FOOT	RECT	AMB
					LBAC	ARM		F-TH	FCLF					
0.00	34.43	35.00	34.53	36.03	34.37	36.03	34.93	33.60	35.50	33.47	33.50	33.93	37.11	4.97
3.00	33.77	34.87	34.60	36.33	34.73	35.90	35.30	33.77	35.47	33.43	33.53	33.90	37.14	4.93
6.00	33.17	35.03	34.57	36.10	34.77	35.67	34.67	33.43	34.93	32.93	33.10	33.87	37.16	4.93
9.00	31.53	33.37	33.47	35.43	33.97	34.67	33.40	31.63	33.53	31.30	34.70	32.80	37.18	4.93
12.00	30.83	31.73	32.73	35.23	33.47	34.30	32.90	30.77	33.00	30.43	30.93	32.07	37.14	4.90
15.00	30.13	30.53	32.27	35.13	33.13	34.13	32.67	30.27	32.77	29.97	30.53	31.60	37.26	4.93
18.00	29.77	30.60	32.10	35.20	33.13	33.83	32.60	29.87	32.47	29.60	30.43	31.33	37.24	4.90
21.00	29.60	30.37	31.77	35.00	33.13	33.43	31.97	29.00	31.73	29.03	29.70	30.87	37.22	4.87
24.00	28.90	29.77	31.30	34.80	32.93	33.10	30.83	28.33	31.27	28.53	29.13	30.60	37.25	4.87
27.00	29.10	29.47	30.87	34.50	32.80	32.77	30.90	28.03	31.17	28.13	29.00	30.43	37.25	4.87
30.00	29.23	29.37	30.60	34.47	32.73	32.70	30.43	27.67	31.10	27.77	28.87	30.40	37.27	4.87
33.00	31.00	29.25	30.47	34.33	32.73	32.53	31.05	27.77	30.75	27.60	28.87	30.30	37.29	4.87
36.00	30.80	28.87	30.23	34.17	32.43	32.43	30.33	27.80	30.65	27.30	28.90	30.40	37.26	4.83
39.00	30.60	28.53	29.93	34.20	32.37	32.13	31.15	27.10	30.80	27.37	28.90	29.97	37.29	4.80
42.00	30.50	28.40	29.63	34.10	32.30	32.03	30.35	26.90	30.50	26.93	28.37	29.73	37.29	4.87
45.00	28.43	28.30	29.37	33.90	32.13	31.87	30.55	26.65	30.10	26.97	28.10	29.53	37.28	4.80
48.00	28.23	28.00	29.23	33.63	31.97	31.77	30.35	26.35	29.87	26.55	27.77	29.37	37.23	4.77
51.00	28.39	27.50	29.00	33.57	31.80	31.83	30.05	26.25	29.70	26.25	27.53	29.27	37.20	4.77
54.00	32.00	27.85	28.67	33.50	31.43	31.80	30.00	26.00	29.33	26.10	27.27	28.90	37.17	4.77
57.00	29.05	26.83	28.47	33.43	31.37	31.53	29.55	25.75	28.97	25.63	26.97	28.57	37.13	4.77
60.00	29.10	27.40	28.40	33.43	31.37	31.43	29.55	25.90	29.20	25.80	27.10	28.73	37.17	4.77
63.00	28.95	27.55	28.23	33.33	31.23	31.30	29.50	25.55	28.80	25.40	26.77	28.40	37.12	4.77
66.00	26.50	26.70	27.97	33.20	30.90	31.10	29.10	25.45	28.60	25.27	26.43	28.13	37.07	4.80
69.00	26.50	26.77	27.73	33.03	30.63	30.93	28.90	25.20	28.40	25.07	26.23	27.83	37.02	4.77
72.00	26.60	25.90	27.57	33.07	30.47	30.60	28.90	25.09	28.23	24.83	25.90	27.57	36.98	4.77
75.00	26.70	26.65	27.37	32.87	30.30	30.73	28.95	24.75	28.03	24.43	24.95	27.50	36.94	4.73
78.00	26.80	26.70	27.17	32.57	30.13	30.70	28.80	24.70	28.00	24.43	24.95	27.47	36.96	4.73
81.00	26.70	26.59	26.90	32.53	30.17	30.80	28.35	24.85	27.85	24.33	25.33	27.37	36.92	4.77
84.00	26.80	26.40	26.90	32.53	30.03	30.57	25.50	24.70	27.95	24.30	25.17	27.20	36.91	4.77
87.00	26.90	26.15	26.87	32.53	30.07	30.23	25.70	24.35	28.00	24.07	24.97	27.03	36.79	4.77
90.00	27.10	26.15	26.77	32.43	30.03	30.07	24.80	24.05	28.10	23.93	24.83	26.93	36.86	4.73
93.00	27.20	26.00	26.53	32.40	29.93	29.77	24.80	23.90	28.05	23.87	24.60	26.83	36.81	4.73
96.00	27.00	25.45	26.40	32.33	29.87	29.63	24.60	23.80	28.25	23.83	24.53	26.77	36.81	4.73
99.00	26.70	25.40	26.37	32.27	29.90	29.47	24.50	23.80	28.27	23.67	24.37	26.53	36.76	4.70
102.00	26.50	25.70	26.23	32.20	29.83	29.40	24.40	23.60	28.27	23.53	24.07	26.23	36.69	4.67
105.00	26.80	25.50	26.13	32.17	29.73	29.20	24.60	23.45	28.27	23.33	23.80	25.93	36.72	4.73
108.00	26.30	27.20	26.00	32.10	29.63	29.13	24.50	23.50	28.43	23.33	23.70	25.87	36.72	4.70
111.00	26.50	27.10	25.97	32.20	29.57	29.07	24.30	23.35	28.67	23.17	23.57	25.73	36.68	4.70
114.00	26.80	27.10	25.83	32.27	29.40	28.90	24.30	23.40	28.70	23.07	23.33	25.70	36.66	4.67
117.00	26.90	25.15	25.83	32.30	29.40	28.93	24.20	23.50	28.67	22.97	23.10	25.40	36.66	4.67

(Table B.3.A, continued)

120.00	27.10	25.40	25.73	32.07	29.33	28.47	24.30	23.35	28.80	22.77	22.87	25.10	36.64	4.70
123.00	26.80	25.33	25.63	31.87	29.30	28.63	23.80	23.65	29.13	22.67	23.00	25.20	36.61	4.73
126.00	26.90	25.20	25.53	31.73	29.20	28.63	23.90	23.50	29.20	22.60	22.83	25.03	36.62	4.73
129.00	27.20	25.17	25.50	31.57	29.13	28.37	24.10	23.35	29.20	22.60	22.63	24.93	36.61	4.73
132.00	27.10	24.90	25.47	31.53	29.07	28.27	23.70	23.10	29.10	22.47	22.50	24.83	36.58	4.73
135.00	27.40	25.00	25.37	31.43	29.00	28.13	23.90	23.00	29.03	22.40	22.30	24.63	36.57	4.73
138.00	27.20	24.90	25.37	31.27	28.87	28.03	0.00	22.90	29.40	22.40	22.23	24.63	36.55	4.73
141.00	0.00	23.30	26.15	30.40	27.90	27.90	23.70	22.80	30.25	22.00	22.15	25.95	36.48	4.65
144.00	0.00	23.30	26.00	30.25	27.90	27.65	24.10	22.80	30.45	22.10	22.80	25.60	36.43	4.60
147.00	0.00	23.30	25.95	30.10	27.85	27.70	24.40	22.90	30.50	22.35	22.60	25.20	36.43	4.60
150.00	0.00	23.20	25.85	30.05	27.85	27.55	24.40	22.90	30.45	22.55	22.20	25.20	36.44	4.60
153.00	0.00	0.00	26.60	31.10	29.50	28.40	25.00	24.60	30.70	23.00	0.00	0.00	35.90	4.00
156.00	0.00	0.00	26.40	30.50	29.10	28.40	25.30	24.70	31.00	23.50	0.00	0.00	35.90	4.00
159.00	26.30	0.00	26.30	30.90	29.40	28.50	24.90	24.80	30.80	23.70	0.00	0.00	36.00	4.00
162.00	26.40	0.00	26.00	30.60	29.00	28.70	0.00	24.90	31.00	24.00	0.00	0.00	36.00	3.90
165.00	26.30	0.00	25.60	30.20	28.90	28.60	24.00	25.10	31.30	24.30	0.00	0.00	36.10	3.90
168.00	26.10	0.00	25.90	30.30	29.20	29.30	24.80	25.70	31.90	0.00	0.00	0.00	36.20	4.00

Table B.3.B

TIME	HEAD	CHBT	RATE OF HEAT LOSS (WATTS)				DTP2ARI.DAT		FCLF	R-TH	RCLF	FOOT
			ABD	UBAC	LSAC	ARM	WBST	F-TH				
0.00	12.26	4.88	4.43	2.61	3.87	8.09	6.65	4.33	4.01	3.45	3.44	2.87
3.00	17.27	4.54	5.99	2.43	5.04	10.00	3.51	3.99	4.70	3.16	2.25	2.64
6.00	30.51	8.23	12.07	11.49	11.61	22.22	12.88	16.48	13.27	22.46	10.50	9.44
9.00	26.67	14.23	17.78	13.54	14.95	34.13	14.69	24.20	21.14	25.96	16.97	12.63
12.00	13.48	13.48	17.48	11.72	14.97	34.07	11.38	23.46	17.02	29.56	13.23	12.84
15.00	13.28	16.78	16.78	10.62	15.42	32.16	13.37	23.45	18.88	26.51	12.91	13.65
18.00	31.82	11.91	18.00	12.36	14.94	31.82	11.80	19.56	17.60	26.63	13.12	14.40
21.00	29.37	9.98	19.46	11.98	13.64	38.19	14.64	22.66	18.55	24.29	16.71	15.46
24.00	37.27	9.64	20.79	14.62	15.31	36.13	19.39	22.39	23.05	23.90	16.44	16.70
27.00	31.07	8.41	20.99	16.70	15.60	34.77	19.13	18.83	19.51	20.20	13.51	16.54
30.00	29.51	8.27	20.65	19.92	13.63	35.07	18.47	20.10	19.74	20.77	14.95	15.80
33.00	38.49	9.28	20.35	12.75	14.69	30.70	14.35	15.26	18.41	20.69	13.03	14.76
36.00	36.94	6.97	19.59	13.85	17.16	33.27	18.46	17.89	20.52	23.70	14.98	16.38
39.00	40.28	13.86	19.61	14.77	13.32	37.51	17.16	21.88	23.25	24.43	13.63	15.97
42.00	41.51	9.87	20.32	14.58	13.33	39.75	19.41	21.36	21.43	18.47	15.84	17.94
45.00	37.47	18.38	20.20	16.76	13.91	36.16	12.65	21.14	22.81	20.97	15.78	16.62
48.00	39.43	11.98	19.47	19.09	14.30	38.27	17.53	21.41	22.65	18.86	14.85	16.65
51.00	32.92	22.63	18.15	14.07	15.29	39.79	17.39	21.61	21.87	22.13	15.95	17.72
54.00	34.61	15.96	19.37	13.14	15.63	36.61	16.39	21.15	22.50	22.84	15.23	16.80
57.00	36.42	20.58	18.83	13.39	13.37	39.55	18.20	20.76	22.34	22.14	14.96	16.45
60.00	35.21	19.64	19.29	13.38	12.72	36.78	21.76	20.15	22.07	21.25	15.23	16.45
63.00	32.68	16.34	19.02	15.13	13.09	37.52	14.77	20.54	21.22	21.46	14.85	16.09
66.00	34.47	22.00	18.19	12.99	15.55	37.26	16.09	20.96	22.82	22.58	15.45	17.50
69.00	36.18	20.26	19.38	12.38	17.10	33.52	19.88	20.77	21.98	22.78	14.08	15.68
72.00	25.07	20.02	19.21	12.46	13.40	36.76	14.71	20.07	20.67	19.76	13.84	13.92
75.00	31.67	13.25	18.33	16.52	14.29	37.79	13.27	19.66	21.57	19.10	14.23	15.34
78.00	34.24	14.44	16.22	15.14	14.69	38.97	16.02	20.96	19.28	21.77	13.83	17.04
81.00	29.45	19.45	18.64	13.79	12.99	35.24	17.42	21.30	21.80	21.71	13.44	15.08
84.00	31.13	16.58	18.07	15.85	16.79	38.36	16.85	22.70	23.69	23.05	15.67	17.79
87.00	19.54	15.25	18.04	14.24	13.96	38.45	15.96	22.18	23.59	21.21	15.35	17.04
90.00	28.24	17.60	18.72	15.93	15.87	35.32	17.57	22.38	24.58	24.04	15.95	17.37
93.00	28.90	19.35	18.83	16.27	16.19	36.72	16.59	22.07	24.86	21.88	14.95	17.56
96.00	27.56	22.57	19.99	18.33	15.05	32.66	20.15	22.28	22.92	18.45	12.90	14.97
99.00	30.38	16.40	18.88	19.99	16.01	36.94	13.87	22.54	24.49	22.96	15.59	17.26
102.00	30.57	15.82	18.28	16.74	15.33	36.41	13.83	22.40	24.96	22.65	15.94	17.17
105.00	26.52	16.08	18.63	17.06	15.02	35.47	13.13	22.43	25.17	22.77	15.60	16.91
108.00	31.03	15.71	17.51	13.38	14.63	38.14	12.95	22.32	25.50	22.87	15.36	17.21
111.00	29.58	14.96	18.70	13.04	14.52	35.34	13.09	22.25	26.01	22.39	15.18	16.80
114.00	28.93	18.56	18.29	12.74	15.94	35.31	12.94	22.44	25.35	22.67	14.96	17.40
117.00	28.38	14.38	18.28	14.74	14.43	33.85	13.24	22.66	25.97	22.87	14.97	16.54

(Table B.3.B, continued)

120.00	29.59	14.48	17.63	14.56	15.23	35.16	12.47	22.76	27.00	22.35	15.09	16.45
123.00	29.87	16.57	19.20	18.72	15.04	36.40	11.80	24.87	25.77	22.07	14.96	17.48
126.00	27.82	16.31	18.87	17.41	15.42	35.09	16.02	24.45	25.27	22.29	15.39	16.33
129.00	29.50	15.10	18.98	18.24	14.81	35.77	13.29	24.51	25.54	22.50	15.55	16.12
132.00	28.87	15.30	18.19	18.07	15.27	35.36	14.01	24.35	25.57	22.54	15.38	15.88
135.00	27.78	16.63	18.95	17.85	16.12	34.26	13.67	24.36	25.37	22.94	15.14	16.16
138.00	15.55	15.38	17.97	18.70	17.93	29.93	12.22	22.76	23.24	22.35	13.35	14.94
141.00	20.91	15.49	21.60	25.87	19.28	37.21	16.44	26.76	26.29	23.83	16.19	16.07
144.00	17.93	16.52	21.00	19.76	14.98	42.64	13.94	26.81	25.35	23.72	17.19	18.12
147.00	15.96	17.31	20.76	20.33	16.21	35.90	11.80	27.09	25.53	25.22	17.22	16.54
150.00	16.64	16.36	20.82	21.32	17.31	40.35	9.63	27.24	25.66	25.35	16.90	17.64
153.00	24.77	11.67	15.10	22.42	21.93	39.16	5.61	22.74	18.91	27.86	16.59	17.87
156.00	23.65	12.07	16.03	24.65	23.08	40.03	6.56	22.92	19.06	29.60	17.75	19.12
159.00	24.20	9.43	13.95	13.83	17.18	42.26	5.68	22.59	18.43	28.53	16.59	17.87
162.00	24.85	10.16	16.06	23.88	21.89	40.84	6.32	23.37	19.47	29.85	17.38	18.71
165.00	24.41	12.46	16.95	23.71	23.39	42.10	10.20	23.66	19.97	30.85	18.48	19.91
168.00	20.45	6.96	10.85	17.35	15.01	31.88	0.00	15.44	16.11	17.58	12.13	13.06

Table B.4.A

TIME	HEAD	CHST	ABD	UBAC	TEMPERATURE C		LRBT	DTF3ARI. DAT		R-TH	RCLF	FOOT	RECT	AMB
0.00	22.37	33.50	33.03	32.23	LBAC	ARM	30.10	F-TH	FCLF	30.70	31.07	11.80	37.19	3.80
2.00	21.77	33.17	32.30	32.77	32.07	0.00	29.25	30.23	33.00	30.00	30.73	11.70	37.21	3.80
4.00	20.40	32.30	32.47	32.75	31.83	0.00	28.10	29.80	32.70	29.30	30.37	15.15	37.24	3.80
6.00	20.00	32.10	32.50	32.75	31.27	0.00	30.00	29.47	32.60	28.80	30.20	13.75	37.25	3.80
8.00	19.83	31.93	32.27	32.40	31.20	0.00	30.40	29.00	32.37	29.07	29.93	14.20	37.25	3.80
10.00	19.77	31.47	32.20	32.00	30.73	35.40	30.40	28.77	32.17	27.85	29.50	13.95	37.25	3.77
12.00	19.73	31.37	32.00	31.70	30.97	19.40	30.05	28.57	31.90	27.50	29.07	13.20	37.25	3.77
14.00	19.23	31.30	31.53	31.45	30.80	18.40	29.40	28.37	31.87	27.00	28.80	12.95	37.25	3.77
16.00	19.20	30.73	31.50	31.30	30.47	0.00	29.05	28.00	31.60	26.75	28.47	11.30	37.25	3.77
18.00	19.65	30.53	31.43	31.00	30.40	0.00	28.45	27.73	31.50	26.60	28.37	11.20	37.24	3.77
20.00	19.60	30.40	31.43	31.25	30.40	0.00	28.10	27.53	31.33	26.25	28.03	11.10	37.22	3.77
22.00	19.55	30.17	31.33	31.30	30.57	0.00	27.65	27.40	31.23	26.10	27.80	10.90	37.20	3.73
24.00	19.45	30.07	31.03	31.10	30.57	0.00	27.30	27.10	30.97	25.85	27.63	10.80	37.17	3.80
26.00	19.15	29.83	31.00	31.20	30.37	0.00	27.00	26.87	30.80	25.65	27.43	10.70	37.15	3.80
28.00	19.15	29.77	30.90	31.25	30.20	0.00	26.60	26.57	30.63	25.35	27.17	10.60	37.15	3.80
30.00	19.15	29.50	30.80	31.45	30.07	0.00	26.15	26.40	30.53	25.15	27.03	10.50	37.15	3.80
32.00	0.00	29.33	30.73	31.35	30.10	0.00	26.30	26.37	30.50	24.90	26.90	10.40	37.12	3.80
34.00	19.15	29.40	30.53	31.45	30.10	0.00	26.30	26.20	30.40	24.65	26.73	10.40	37.11	3.80
36.00	18.90	29.23	30.43	31.45	30.10	0.00	26.30	26.10	30.33	24.60	26.47	10.20	37.09	3.80
38.00	18.70	28.85	30.55	28.90	29.80	0.00	26.40	25.80	29.50	24.50	25.80	10.10	36.90	3.25
40.00	18.40	29.23	30.07	31.55	30.10	0.00	25.75	25.97	30.27	24.30	26.40	10.10	37.02	3.80
42.00	18.40	29.13	29.83	31.65	30.10	0.00	25.55	25.90	30.37	24.20	26.30	10.10	36.99	3.80
44.00	16.40	29.13	29.70	31.50	29.97	0.00	25.70	25.90	30.53	24.35	26.33	10.20	36.97	3.77
46.00	16.20	29.30	29.67	31.30	29.87	0.00	25.85	26.20	30.93	24.60	26.50	10.20	36.94	3.77
48.00	16.20	30.15	29.00	32.10	29.90	0.00	25.70	26.00	31.10	23.40	25.85	0.00	36.84	4.30
50.00	16.20	30.00	28.70	32.80	29.95	0.00	25.70	26.05	30.90	23.20	25.65	0.00	36.81	4.40
52.00	16.60	30.00	28.65	33.30	30.15	0.00	0.00	26.00	30.85	23.10	25.55	0.00	36.81	4.40
54.00	17.10	30.10	28.65	33.50	30.10	0.00	24.90	26.10	30.45	23.20	25.75	0.00	36.80	4.70
56.00	16.60	30.10	28.60	33.60	29.90	0.00	0.00	25.85	30.45	23.00	25.60	0.00	36.78	4.60
58.00	16.80	30.15	28.75	33.70	30.00	0.00	0.00	25.80	30.30	22.90	25.35	0.00	36.76	4.60
60.00	16.70	30.05	28.45	33.70	30.00	0.00	25.50	25.75	30.25	22.90	25.25	0.00	36.75	4.55
62.00	17.20	29.85	28.55	33.70	30.30	0.00	25.50	25.95	30.35	22.80	25.05	0.00	36.74	4.60
64.00	17.30	29.90	28.50	33.70	30.30	0.00	25.60	25.90	30.25	22.90	25.05	0.00	36.73	4.55
66.00	17.00	29.90	28.50	33.70	30.30	0.00	25.50	25.85	30.15	23.00	24.95	0.00	36.69	4.50
68.00	17.00	29.85	28.40	33.70	30.35	0.00	25.10	25.80	30.10	22.80	24.90	0.00	36.65	4.60
70.00	16.90	29.85	28.30	33.80	30.30	0.00	0.00	25.75	30.15	22.80	24.95	0.00	36.62	4.55
72.00	16.70	29.90	28.20	33.90	30.40	0.00	0.00	25.60	29.95	22.80	24.90	0.00	36.59	4.50
74.00	16.60	29.85	28.10	33.90	30.30	0.00	0.00	25.60	29.80	22.80	24.75	0.00	36.56	4.50
76.00	16.40	29.85	28.05	34.00	30.30	0.00	0.00	25.55	29.80	22.80	24.70	0.00	36.54	4.50
78.00	16.30	29.85	28.05	33.90	30.20	0.00	0.00	25.50	29.65	22.80	24.55	0.00	36.53	4.50

(Table B.4.A, continued)

80.00	16.30	29.75	28.10	33.90	30.25	0.00	0.00	25.40	29.65	22.80	24.50	0.00	36.53	4.50
82.00	16.30	29.70	28.15	33.90	30.30	0.00	0.00	25.30	29.65	22.70	24.40	0.00	36.51	4.50
84.00	16.30	29.70	28.10	33.80	30.30	0.00	0.00	25.25	29.60	22.60	24.25	0.00	36.51	4.50
86.00	16.40	29.75	28.05	33.70	30.15	0.00	0.00	25.20	29.70	22.60	24.00	0.00	36.51	4.50
88.00	18.00	29.03	28.05	31.05	29.97	0.00	0.00	25.20	29.65	22.80	23.95	0.00	36.66	3.93
90.00	18.05	29.00	27.95	31.15	30.10	0.00	0.00	25.20	29.60	22.80	24.15	0.00	36.66	3.97
92.00	18.00	28.87	27.90	30.85	30.13	0.00	0.00	25.25	29.55	22.70	24.00	0.00	36.67	3.87
94.00	18.05	28.90	27.75	31.00	30.00	0.00	0.00	25.20	29.60	22.30	23.75	9.30	36.67	4.00
96.00	18.15	28.80	27.70	31.00	29.83	0.00	0.00	25.20	29.70	22.30	23.70	9.10	36.69	4.00
98.00	16.20	29.65	27.60	33.90	29.80	0.00	0.00	25.20	29.85	22.10	23.85	0.00	36.54	4.45
100.00	16.20	29.65	27.50	33.90	29.75	0.00	0.00	25.25	29.85	22.10	23.70	0.00	36.53	4.30
102.00	16.40	29.85	27.45	34.00	29.70	0.00	0.00	25.25	29.90	22.00	23.55	0.00	36.51	4.45
104.00	16.30	30.00	27.35	34.00	29.60	0.00	0.00	25.20	29.85	21.90	23.45	0.00	36.49	4.50
106.00	18.15	29.03	27.25	30.33	29.63	0.00	0.00	25.10	29.75	21.80	23.70	8.90	36.69	3.93
108.00	17.65	28.90	27.15	30.33	29.53	0.00	0.00	25.10	29.85	21.80	25.30	8.90	36.63	3.97
110.00	17.60	28.30	27.05	30.33	29.40	0.00	0.00	25.15	29.75	21.60	25.00	9.00	36.64	4.00
112.00	17.95	28.67	27.10	31.40	29.53	0.00	0.00	25.20	29.85	21.40	24.90	8.90	36.68	4.00
114.00	17.85	28.53	27.00	31.25	29.47	0.00	0.00	25.30	29.90	21.50	24.80	8.80	36.68	4.00
116.00	18.00	28.60	26.95	30.67	29.60	0.00	0.00	25.35	29.95	21.60	24.60	8.90	36.69	4.00
118.00	18.15	28.63	26.95	30.90	29.73	0.00	0.00	25.45	30.05	21.70	24.70	8.70	36.71	3.93
120.00	18.20	28.57	27.00	31.03	29.80	0.00	0.00	25.40	29.95	21.60	24.70	8.90	36.72	3.97
122.00	18.25	28.60	27.10	31.17	29.73	0.00	0.00	25.40	30.00	21.60	25.00	8.70	36.72	3.90
124.00	18.30	28.63	26.95	31.07	29.73	0.00	0.00	25.45	30.10	21.70	24.50	8.60	36.71	3.97
126.00	17.70	28.67	26.95	30.80	29.60	0.00	0.00	25.50	30.00	21.70	24.80	8.60	36.72	3.97
130.00	17.60	28.70	26.80	30.57	29.43	0.00	0.00	25.55	30.20	21.80	24.40	8.60	36.72	3.93
132.00	17.70	28.60	26.65	30.40	29.30	0.00	0.00	25.60	30.35	21.60	24.20	8.60	36.72	3.93
134.00	17.65	28.60	26.70	30.50	29.37	0.00	0.00	25.60	30.35	21.60	24.00	8.40	36.71	3.93
136.00	17.95	28.53	26.60	30.70	29.40	0.00	0.00	25.65	30.45	21.70	24.00	8.50	36.69	3.93
138.00	18.15	28.40	26.50	30.67	29.43	0.00	0.00	25.65	30.35	21.60	24.00	8.50	36.66	3.90
140.00	18.90	27.95	26.70	31.45	29.70	0.00	0.00	25.40	31.20	0.00	23.90	8.40	36.97	3.65
142.00	19.00	28.10	26.70	31.60	29.55	0.00	0.00	25.40	31.10	0.00	23.80	8.40	36.97	3.75
144.00	18.80	27.90	26.70	31.80	29.65	0.00	0.00	25.50	31.20	0.00	23.60	8.40	36.96	3.75
146.00	18.70	27.80	26.70	31.95	29.75	0.00	0.00	25.60	31.60	0.00	23.70	8.40	36.94	3.75
148.00	18.80	27.50	26.70	31.80	29.75	0.00	0.00	25.80	31.90	0.00	23.80	8.20	36.94	3.75
150.00	19.30	27.50	26.70	31.55	29.55	0.00	0.00	26.00	32.20	0.00	24.40	8.20	36.93	3.70
152.00	0.00	27.60	26.70	31.45	29.50	0.00	0.00	26.20	32.00	0.00	24.80	8.30	36.92	3.75
154.00	19.90	27.40	26.70	31.50	29.50	0.00	0.00	26.30	32.00	0.00	24.70	8.30	36.92	3.60
156.00	19.50	27.50	26.70	31.50	29.50	0.00	0.00	26.40	32.10	0.00	24.90	8.30	36.92	3.65
158.00	19.40	27.30	26.70	31.35	29.40	0.00	0.00	26.50	32.30	0.00	25.20	8.30	36.92	3.55
160.00	0.00	27.10	26.60	31.35	29.25	0.00	0.00	26.50	32.40	0.00	26.40	8.40	36.92	3.70
162.00	18.80	27.50	26.60	31.25	29.25	0.00	0.00	26.60	32.10	0.00	26.30	8.40	36.93	3.65
164.00	18.70	27.55	26.60	31.20	29.25	0.00	0.00	26.60	32.10	0.00	26.80	8.30	36.92	3.45
166.00	18.20	27.45	26.50	31.20	29.25	0.00	0.00	26.70	32.40	0.00	27.20	8.30	36.94	3.50
168.00	18.10	27.65	26.50	31.15	29.30	0.00	0.00	26.60	32.60	0.00	27.70	8.40	36.96	3.60
170.00	18.20	27.65	26.40	31.15	29.05	0.00	0.00	25.60	32.60	0.00	27.90	8.70	36.89	2.70
172.00	18.00	27.00	0.00	28.50	28.50	0.00	0.00	25.60	0.00	0.00				

(Table B.4.A, continued)

174.00	17.70	27.30	0.00	28.60	28.60	0.00	0.00	0.00	25.60	0.00	0.00	27.80	8.60	36.88	2.70
176.00	17.40	27.30	0.00	28.60	28.70	0.00	0.00	0.00	25.60	0.00	0.00	28.20	8.60	36.89	2.70

Table B.4.B

TIME	HEAD	CHST	RATE OF HEAT LOSS (WATTS)					DTP3ARI DAT			R-TH	RCLF	FOOT
			ABD	UBAC	LBAC	ARM	MRBT	F-TH	FCLF				
0.00	79.40	20.03	22.49	21.55	16.12	37.26	18.21	30.90	15.71	26.14	12.32	31.48	
2.00	79.43	20.26	31.43	32.16	20.07	33.98	15.64	31.92	17.33	29.57	13.79	34.32	
4.00	81.78	24.57	23.78	28.34	19.85	35.30	32.38	29.59	17.72	29.78	13.55	33.10	
6.00	78.72	22.95	24.43	29.53	29.04	39.55	26.90	29.74	16.49	25.71	13.94	33.64	
8.00	74.42	18.88	24.70	30.88	20.43	37.52	18.88	33.17	18.60	28.35	14.18	34.59	
10.00	69.18	26.74	25.84	23.13	20.62	31.57	21.11	28.58	17.57	24.11	13.80	33.50	
12.00	66.59	25.58	27.34	16.44	29.13	33.13	21.21	28.55	18.46	27.39	13.67	33.77	
14.00	72.88	23.92	27.09	31.97	19.41	35.04	32.68	28.77	17.51	27.78	13.48	33.10	
16.00	70.64	21.46	25.51	31.97	19.05	34.78	22.33	32.23	19.03	27.08	13.61	26.69	
18.00	71.06	25.31	24.82	30.51	21.70	32.34	23.85	31.36	18.90	26.03	13.61	33.64	
20.00	66.76	21.85	24.07	29.60	13.50	28.26	38.51	30.23	18.04	32.69	13.29	32.69	
22.00	70.12	24.47	24.64	28.87	17.33	35.95	18.68	31.04	17.30	23.46	11.91	25.24	
24.00	66.97	23.90	23.96	26.13	25.28	35.93	15.02	31.15	18.86	25.79	12.91	26.65	
26.00	71.22	22.77	23.74	27.95	14.53	36.63	19.08	30.96	20.24	30.09	13.16	26.85	
28.00	74.03	24.52	24.26	29.41	15.48	35.37	14.51	30.09	20.29	25.35	12.85	20.01	
30.00	67.01	22.74	23.48	28.14	16.29	32.45	20.40	30.36	20.59	27.73	13.23	16.56	
32.00	65.38	17.32	20.95	13.52	15.35	33.63	14.11	30.66	19.63	26.66	12.91	32.02	
34.00	83.41	21.45	23.93	0.00	16.63	33.07	14.41	31.33	20.88	25.72	12.84	32.29	
36.00	83.06	24.45	23.92	0.00	16.87	37.66	14.51	30.23	19.14	24.68	8.69	19.86	
38.00	79.72	20.40	26.02	15.53	11.32	37.95	15.63	28.98	18.06	22.74	11.71	28.91	
40.00	85.96	19.12	23.19	30.51	15.86	36.45	13.30	31.44	20.72	26.81	12.78	31.88	
42.00	86.80	17.59	21.98	25.03	15.36	36.50	8.73	29.09	17.61	24.76	12.12	16.29	
44.00	84.98	14.28	20.38	20.65	17.44	34.12	5.89	27.86	17.63	23.56	11.65	16.70	
46.00	0.00	13.08	18.51	17.90	13.76	29.90	4.16	24.93	15.11	20.69	11.19	16.29	
48.00	62.54	14.16	21.07	0.00	9.63	31.80	56.10	30.36	17.51	22.38	21.58	32.56	
50.00	66.15	16.24	20.99	0.00	8.28	36.21	0.00	33.76	19.20	25.81	16.81	16.01	
52.00	61.88	18.54	19.43	0.00	7.65	33.85	0.00	28.00	17.72	20.17	16.81	25.26	
54.00	64.45	18.21	20.74	0.00	8.37	30.73	0.00	31.89	19.47	25.31	20.82	31.21	
56.00	69.06	21.16	21.56	0.00	18.54	32.93	0.00	31.57	19.86	26.21	20.32	19.96	
58.00	68.13	15.26	16.30	0.00	7.92	31.67	0.00	31.21	19.48	25.76	20.32	19.96	
60.00	63.52	20.67	19.93	0.00	8.37	31.16	0.00	29.55	17.37	32.11	18.82	14.19	
62.00	62.83	17.39	18.02	0.00	7.74	28.29	0.00	29.37	18.40	24.19	19.32	14.26	
64.00	64.42	13.62	19.26	0.00	18.18	30.34	0.00	30.93	18.73	24.57	19.70	28.24	
66.00	66.22	14.93	19.92	0.00	16.74	30.73	0.00	30.66	19.17	24.47	19.82	29.72	
68.00	64.32	14.93	19.83	0.00	8.19	29.18	0.00	29.93	18.74	23.91	18.06	27.02	
70.00	62.83	15.09	19.58	0.00	8.37	29.46	0.00	29.92	19.63	23.91	19.32	28.91	
72.00	65.83	15.26	20.00	0.00	18.90	33.81	0.00	31.30	19.25	23.72	18.57	27.83	
74.00	66.28	14.93	20.00	0.00	10.35	33.24	0.00	31.30	19.51	23.43	18.44	27.70	
76.00	69.74	15.09	20.40	0.00	9.81	33.65	0.00	30.29	19.57	23.43	18.32	27.43	
78.00	63.30	15.42	20.74	0.00	10.98	33.93	0.00	30.20	19.64	23.53	18.44	27.70	

(Table B.4.B, continued)

80.00	67.55	15.75	21.07	0.00	9.99	33.96	0.00	30.28	20.03	22.96	18.06	27.02
82.00	66.13	16.08	21.15	0.00	8.55	34.64	0.00	29.72	19.52	22.40	18.19	27.43
84.00	65.47	16.24	21.15	0.00	8.73	33.12	0.00	29.54	19.14	23.05	17.44	26.21
86.00	64.66	16.57	20.91	0.00	19.80	31.72	0.00	29.36	18.32	20.19	13.92	10.48
88.00	63.68	12.88	23.41	18.82	21.79	34.08	7.21	28.63	18.44	22.03	9.40	21.21
90.00	63.11	17.58	22.25	9.14	19.23	29.85	29.92	27.89	19.99	24.04	10.55	27.02
92.00	61.42	21.27	22.85	8.77	17.70	35.30	45.66	27.87	19.51	23.27	11.81	27.02
94.00	60.09	19.79	22.02	9.50	12.59	34.44	42.20	28.05	16.92	21.30	9.75	15.67
96.00	62.87	17.45	22.99	16.63	16.32	33.12	43.76	28.24	19.03	26.11	11.98	21.33
98.00	63.35	15.42	21.46	0.00	7.38	27.52	0.00	29.80	18.32	26.14	18.82	14.33
100.00	59.79	17.55	21.88	0.00	19.80	32.64	79.90	28.33	18.38	24.23	18.44	27.83
102.00	62.92	14.76	22.13	0.00	15.12	31.98	50.30	29.35	18.58	25.27	18.82	14.40
104.00	66.33	17.06	21.47	0.00	9.18	32.00	0.00	29.53	18.58	26.06	18.57	14.46
106.00	70.50	18.03	23.73	20.05	14.03	35.65	11.77	28.28	18.46	23.76	12.20	15.54
108.00	72.60	18.55	23.67	19.94	18.95	37.79	15.43	28.35	17.75	23.69	11.90	23.91
110.00	70.40	17.20	24.12	19.49	22.12	38.44	16.95	28.42	17.04	25.15	11.12	23.42
112.00	69.77	18.97	23.08	11.69	20.59	34.44	12.69	27.80	18.62	25.15	11.16	19.20
114.00	68.82	21.05	23.52	7.16	22.51	36.99	53.27	28.05	19.50	25.16	11.94	15.54
116.00	70.87	19.35	23.22	10.78	18.41	33.72	55.38	27.92	18.13	23.45	12.16	17.09
118.00	72.22	18.80	23.34	6.77	19.04	35.40	11.98	27.86	18.71	22.75	14.11	34.72
120.00	67.61	19.46	23.23	5.01	12.03	37.28	48.67	27.59	18.35	22.93	12.62	16.89
122.00	66.92	18.12	23.57	13.48	18.95	35.22	50.32	28.29	19.01	23.18	11.52	32.29
124.00	69.20	20.38	23.46	15.44	17.87	36.89	48.17	28.55	18.78	24.34	10.99	23.22
126.00	64.69	19.47	23.33	16.40	13.24	34.14	49.40	28.03	18.64	23.44	11.86	0.00
128.00	73.61	21.16	24.29	17.30	14.62	35.35	32.14	28.09	20.58	24.53	4.09	0.00
130.00	72.85	17.50	23.68	17.36	24.78	35.23	50.55	28.47	20.79	25.27	3.43	0.00
132.00	71.26	17.61	23.83	16.84	17.08	36.62	51.82	28.84	20.79	25.27	3.43	0.00
134.00	71.16	19.54	23.35	8.04	13.74	33.83	47.57	28.90	18.78	23.88	13.68	0.00
136.00	68.66	18.08	22.34	12.34	21.95	36.01	49.07	28.10	20.05	24.97	3.83	17.92
138.00	70.02	19.21	23.75	15.12	12.38	38.10	50.82	28.39	17.33	24.37	11.00	23.22
140.00	83.91	18.81	22.73	14.62	22.43	33.58	10.35	28.58	19.30	25.83	4.88	15.96
142.00	82.56	20.36	22.90	25.40	21.54	35.12	7.11	28.11	22.78	26.80	4.09	13.44
144.00	83.17	21.66	21.70	10.60	22.74	40.23	16.95	28.39	23.89	27.28	3.83	13.72
146.00	83.81	21.76	22.39	0.00	22.28	38.53	14.95	29.26	24.48	27.47	4.09	13.72
148.00	84.21	22.19	22.31	13.52	19.81	32.31	10.66	29.55	24.88	27.95	4.49	13.58
150.00	76.33	23.98	22.73	21.96	22.63	36.13	8.32	29.45	22.86	27.38	4.49	1.82
152.00	73.76	21.22	22.91	22.29	23.64	38.84	19.79	29.07	23.77	27.48	4.35	12.04
154.00	82.68	22.09	22.57	28.68	22.72	37.00	34.65	29.45	24.48	27.48	4.22	14.28
156.00	82.75	23.81	23.17	0.00	23.19	39.27	22.33	29.93	25.07	27.58	4.88	14.42
158.00	88.08	23.54	23.43	30.33	22.83	40.84	21.82	30.50	25.34	27.96	5.28	15.26
160.00	88.10	25.54	25.92	31.42	24.26	42.94	25.48	31.08	23.91	27.96	5.54	13.72
162.00	83.21	19.47	24.63	18.82	21.36	36.45	16.54	30.31	24.17	28.15	5.54	15.82
164.00	86.53	21.05	24.81	0.00	23.81	38.69	18.17	30.60	24.68	28.15	5.28	13.72
166.00	89.47	25.02	25.50	9.50	22.81	41.13	20.91	30.51	24.55	27.86	6.60	16.94
168.00	88.26	21.91	25.24	9.80	19.98	37.71	11.98	30.60	22.30	25.55	6.60	17.22
170.00	82.42	20.19	24.97	19.08	24.16	38.66	34.08	30.80	23.12	27.48	5.28	14.42
172.00	97.91	23.47	32.27	1.10	23.02	47.46	17.86	27.00	19.66	26.42	5.01	0.00

(Table B.4.B, continued)

174.00	87.68	21.74	33.99	0.00	26.31	42.06	12.38	27.96	24.41	29.51	4.75	0.00
176.00	85.83	12.60	31.92	0.00	28.87	37.51	8.22	27.96	23.62	29.31	4.49	0.00

APPENDIX C

DETERMINATION OF THE VISCOSITY (μ), THERMAL CONDUCTIVITY (k), AND OTHER PROPERTIES FOR A 95% HELIUM - 5% OXYGEN GAS MIXTURE

To facilitate the selection of correlations for predicting the properties of this binary mixture of nonpolar helium and oxygen, the behavior of the mixture was investigated by evaluating the component gases to see if they could be treated as perfect gases. To this end, the compressibility factor (Z) of each component was determined from Nelson-Obert generalized compressibility charts [53] with a reduced pressure, P_r , and reduced temperature, T_r , as defined in Equations C.1 and C.2, respectively.

$$P_r = \frac{P}{P_c} \quad (C.1)$$

where: P = Ambient pressure in ATA

P_c = Critical pressure in ATA

$$T_r = \frac{T}{T_c} \quad (C.2)$$

where: T = Ambient temperature in $^{\circ}\text{K}$

T_c = Critical temperature in $^{\circ}\text{K}$

The estimated compressibility factors (Z) as well as the critical and reduced values are listed for each component in Table C.1. The compressibility factors of both helium and oxygen were found to be approximately one (Table C.1), which indicates that these real gases can be assumed to behave

Table C.1

Critical and Reduced Properties, and Compressibility Factor Values
for a 95% Helium - 5% Oxygen Mixture at 295.30 °K and 20.89 ATA

<u>Helium</u>	<u>Oxygen</u>
$T_c = 5.3 \text{ °K}$	$T_c = 154.8 \text{ °K}$
$P_c = 2.26 \text{ ATA}$	$P_c = 50.1 \text{ ATA}$
$Tr = 55.72$	$Tr = 1.91$
$Pr = 9.24$	$Pr = 0.42$
$Z \approx 1.00$	$Z \approx 0.99$

ideally at the mixture's temperature and pressure. To evaluate the behavior of the mixture, Dalton's Law [53] is applied in terms of compressibility factors for a mixture of ideal gases (Eq. C.3).

$$Z_m = \sum_{i=1}^n y_i Z_i \quad (C.3)$$

where: Z_m = Mixture compressibility

y_i = Mole fraction for component i

Z_i = Compressibility factor for pure component i

n = Number of components in mixture

Equation C.4 is reproduced from Obert [53] and expresses the relationship between a mole fraction and a volume fraction.

$$y_i = \frac{n_i}{n} = \frac{V_i}{V} \quad (C.4)$$

where: y_i = Mole fraction of component i

n_i = Number of moles of component i

n = Number of moles of mixture

V_i = Partial volume of component i

V = Volume of mixture

$$\frac{V_i}{V} \cdot 100 = \text{Percent by volume of component } i$$

For a 95% helium - 5% oxygen mixture, Equation C.4 indicates that the mole fractions are 0.95 for helium and 0.05 for oxygen. With these mole fractions and the compressibility factors (Table C.1) for helium and oxygen, Equation C.3 yields a mixture compressibility factor (Z_m) of 1.004. This result confirms that the mixture may also be treated as ideal.

Examination of a generalized compressibility chart [53], shows that, as the pressure becomes small relative to its critical pressure, the compressibility factor for any value of reduced temperature (T_r) approaches one. This implies that any nonpolar real gas will act ideally if its pressure is low relative to its critical pressure. Analogously, property correlations for low pressure mixtures of nonpolar, real gases may be assumed to yield reasonable values for mixtures at any pressure when the mixture behaves ideally. This conclusion permitted us to select correlations for viscosity (μ) and thermal conductivity (k) which were recommended by Reid and Sherwood [43] for low pressure mixtures of nonpolar real gases.

Viscosity (μ)

Reid and Sherwood [43] suggest that Equation C.5 be used to predict the viscosity (μ_m) of a low pressure binary mixture with the Wilke estimate (ϕ_{ij} , Eq. C.6) for the ϕ_{12} and ϕ_{21} terms.

$$\mu_m = \frac{\mu_1}{1 + \phi_{12} (y_2/y_1)} + \frac{\mu_2}{1 + \phi_{21} (y_1/y_2)} \quad (\text{C.5})$$

where: μ_m = Mixture viscosity

μ_1, μ_2 = Viscosity of pure components

y_1, y_2 = Mole fractions

$$\phi_{ij} = \frac{\left[1 + \left(\frac{\mu_i}{\mu_j} \right)^{0.5} \left(\frac{M_j}{M_i} \right)^{0.25} \right]^2}{\sqrt{8} \cdot \left[1 + \left(\frac{M_i}{M_j} \right) \right]^{0.5}} \quad (\text{C.6})$$

where: ϕ_{ij} = ϕ_{12} and ϕ_{21} for Equation C.5

μ_i, μ_j = Viscosity of pure components i and j

M_i, M_j = Molecular weight of pure components i and j

Table C.2 displays the property values which were substituted into Equations C.5 and C.6 to estimate the mixture viscosity. As indicated in Table C.2, the temperature of the mixture is specified as 295.3 °K (22.15 °C).

Table C.2

Properties Substituted into Equations C.5 and C.6 for a
95% Helium - 5% Oxygen Mixture at 295.3 °K and 307.0 PSIA

	<u>Helium</u>	<u>Oxygen</u>
Subscript #	1	2
Mole Fraction	0.95	0.05
Molecular Weight	4.003	32.00
Viscosity (LB/FT·SEC) [†]	1.326×10^{-5}	1.3944×10^{-5}

This temperature represents a mean film temperature selected from the RHL1AR1 data file by taking the average of the highest and lowest film temperatures for all of the regions. Substituting from Table C.2 into Equation C.6 for ϕ_{12} and ϕ_{21} yields 2.3226 and 0.3055, respectively. Equation C.5 produces a mixture viscosity of 1.3865×10^{-5} LB/FT·SEC when the ϕ_{ij} values and property values from Table C.2 are substituted.

Thermal Conductivity (k)

From information and recommendations presented by Reid and Sherwood [43], we decided to utilize the binary form of the Wassiljewa equation (Eq. C.7) with the A_{ij} terms which are determined from the Lindsay and Bromley formulation (Eq. C.8).

[†]These values were interpolated from data presented in the U.S. Navy Diving Gas Manual [42].

$$k_m = \frac{k_1}{1 + A_{12}(y_2/y_1)} + \frac{k_2}{1 + A_{21}(y_1/y_2)} \quad (C.7)$$

where: k_m = Thermal conductivity of the mixture
 k_1, k_2 = Thermal conductivity of the pure components 1 and 2
 y_1, y_2 = Mole fraction of components 1 and 2
 A_{12}, A_{21} Determined by Equation C.8

$$A_{ij} = 0.25 \left[1 + \left\{ \left(\frac{\mu_i}{\mu_j} \right) \left(\frac{M_j}{M_i} \right)^{0.75} \left[\frac{\left(1 + \frac{S_i}{T} \right)}{\left(1 + \frac{S_j}{T} \right)} \right]^{0.5} \right\}^2 \right] \cdot \frac{\left(1 + \frac{S_{ij}}{T} \right)}{\left(1 + \frac{S_i}{T} \right)} \quad (C.8)$$

where: A_{ij} = A_{12}, A_{21} for Equation C.7

μ_i, μ_j = Pure component viscosities

M_i, M_j = Pure component molecular weights

T = Absolute temperature of mixture

S_i, S_j = $1.5 T_{bi}$ unless component i is He, H_2 , or Ne;
 then $S_i = 79^\circ K$

T_{bi} = Normal boiling point of component i ($^\circ K$)

$S_{ij} = S_{ji} = C_s(S_i S_j)^{0.5}$

C_s ≈ 1 unless one of the components is very polar, then
 $C_s \approx 0.733$

These equations are valid for nonpolar, real gases and thus reasonable estimates for ideal gases.

Table C.3 displays the values that are necessary to solve for the mixture's thermal conductivity. Substituting the values from Table C.3 into Equation C.8 yields values for A_{12} and A_{21} of 2.3689 and 0.52399, respectively. A mixture thermal conductivity of 2.189×10^{-5} BTU/SEC·FT $^\circ F$ is obtained when these values and the properties from Table C.3 are substituted into Equation C.7.

Table C.3

Properties for Equations C.7 and C.8 for a
95% Helium - 5% Oxygen Mixture at 295.3 °K and 307.0 PSIA

	<u>Helium</u>	<u>Oxygen</u>
Subscript #	1	2
Mole Fraction	0.95	0.05
Molecular Weight	4.003	32.000
Thermal Conductivity (BTU/FT·SEC°F) [†]	2.417×10^{-5}	4.386×10^{-6}
Viscosity (LB/FT·SEC) [†]	1.326×10^{-5}	1.3944×10^{-5}
Normal Boiling Point (°K)	4.3	90.0
S (°K)	79.0	135.0
S _{ij} (°K)	103.27	

Other Properties

As previously mentioned, the specific heat, C_p , and the density, ρ , were interpolated from data in reference 42. The interpolations yielded values of 0.94215 BTU/LB°F and 0.2878 LB/FT³ for the specific heat and density, respectively. The volume coefficient of expansion was determined with the ideal gas formulation of the reciprocal of the absolute film temperature. The characteristic length in the Grashof and Nusselt numbers was set equal to the region's length for vertical cylinders and to the region's diameter for horizontal cylinders and spheres. Table C.4 summarizes the properties described above and presents them in SI units.

[†]These values were interpolated from data presented in the U.S. Navy Diving Gas Manual [42].

Table C.4

Properties Necessary to Determine Grashof, Prandtl, and Nusselt Numbers
for a 95% Helium - 5% Oxygen Mixture at 22.15 °C and 200 MSW

Specific Heat (C_p)	$3.945 \times 10^3 \text{ J/KG}^\circ\text{K}$
Density (ρ)	4.610 KG/M^3
Viscosity (μ)	$2.063 \times 10^{-5} \text{ KG/M} \cdot \text{SEC}$
Thermal Conductivity (k)	$1.364 \times 10^{-1} \text{ W/M}^\circ\text{K}$

APPENDIX D

INTERACTIVE PROGRAM DOCUMENTATION

The interactive program and associated documentation have been developed on a Digital Equipment Corporation's (DEC) PDP 11/60 computer which executes the RSX-11M operating system. The program was written in DEC's FORTRAN IV-PLUS language [54,55], and the PLXY-11M Software [50] was used in generating all associated plots. To implement this code on another computer or operating system will require the availability of a FORTRAN compiler with compatible plotting software and personnel capable of understanding and modifying the interactive program's code. Such personnel should be able to resolve any differences which might exist between DEC's FORTRAN IV-PLUS version and the new system's version of the FORTRAN language. Any differences encountered should be limited to the 'OPEN' and 'CLOSE' statements used to access input and output files and to the subroutine calls used in accessing the plotting software.

The information presented in this interactive model program has been developed and verified with accepted principles of engineering analysis. These developments may be found in the Chapters I-VII of this document. The constants specified for the garment ensemble are taken from the Navy's

prototype Diver Thermal Protection (DTP) garment. The references to corrected predicted overall heat transfer coefficient (OHTC) indicate that these values are corrected by use of an empirically derived biasing factor. The development of these factors is found in Chapter VII. The references to uncorrected OHTC indicate that the empirical biasing factors have not been applied to the predicted values.

Program Source Code

This interactive diver heat loss program has been written in DEC's FORTRAN IV-PLUS language and utilizes DEC's PLXY-11M plotting software for producing data plots. A flow chart of the program is included as Appendix E, and the actual FORTRAN source code listing is presented in Appendix F. The source code has been internally documented by use of comment statements. In the DEC FORTRAN IV-PLUS language, comments are specified in two manners: the placement of a "C" in column 1 indicates a comment line and the presence of an exclamation point ('!') in columns 7 thru 72 indicates that what follows is a comment. Both of these methods have been used within the program code to allow blocking of information. An experienced research engineer, knowledgeable in FORTRAN programming, should be able to understand and modify the program code with the assistance of the documentation that follows. Any modifications to the program source code without prior written approval of the authors is the sole responsibility of the user.

Creation of an Executable Task

As implied previously, this documentation assumes that the interactive program is to be assembled on a DEC computer which executes an RSX-11M operating system that includes a FORTRAN IV-PLUS compiler. Translation of the source program is performed with the FORTRAN IV-PLUS compiler (F4P) by the command line:

```
MCR>F4P HLMOD.OBJ,HLMOD.LST=HLMOD.FTN †
```

This command specifies an object file, HLMOD.OBJ; a listing file, HLMOD.LST; and the source code file, HLMOD.FTN. Further information on the F4P command and the operation of this compiler is available in reference 55.

The translation step completed, an executable task can now be created. This step is accomplished by using the Task Builder (TKB), a program for linking object files and resolving symbol references. The command used to invoke the TKB task follows.

```
MCR>TKB
TKB>HLMOD.TSK,=HLMOD.OBJ,[1,1]PLTUSL/LB
TKB>/
ENTER OPTIONS:
TKB>MAXBUF=292
TKB>ACTFIL=5
TKB>//
```

The MAXBUF option is specified to allow input and output file record lengths greater than 132 characters (bytes). The ACTFIL=5 option allows five files to be open simultaneously. This is necessary when creating plots to compare

†Each command line is terminated by striking RETURN.

experimental and predicted data. The input file, HLMOD.OBJ, created by the F4P step, is converted into a runnable task, HLMOD.TSK, with all the necessary system supplied subroutines linked into the Main module. The second input file, [1,1]PLTUSL/LB, is the system library containing the object modules for the PLXY-11M plotting subroutines. Further documentation on TKB can be found in references 55 and 56.

The file, HLMOD.TSK, can now be run to estimate supplementary heating requirements for the resting diver. To initiate execution, the RUN task is employed by the command:

```
MCR>RUN HLMOD.TSK
```

This command loads the interactive heat loss program into memory and initiates its processing.

Running the Interactive Model Program

The diver heat loss program was written for two different modes of execution: production and research. In the production mode, predicted regional heat flux and supplementary heating are calculated from data supplied about the diver's posture, the body region of interest, the number of finite difference nodes per region, a design mean skin temperature, and the ambient depth and temperature. The values of predicted overall heat transfer coefficient (OHTC) are always corrected by applying the empirically derived biasing factors before calculating the predicted regional heat flux and supplementary heating. The research mode duplicates the production mode but also allows the comparison of predicted and experimental temperatures, heat

fluxes, and overall heat transfer coefficients. The comparisons are performed by using either corrected or uncorrected predicted values. In this mode, the predicted values of regional skin temperature are calculated by using a mean skin temperature derived from the experimental segmental skin temperatures. The experimental data used for comparison is always stored in a direct access data file [54] which is organized as described in Appendix A of this document.

The first question asked on the interactive terminal is:

1 ARE YOU A RESEARCH USER ? (Y,N,X) .

If you respond with a 'Y' (yes), then the program will execute the research mode, while if you enter 'N' (no), the production mode will be executed. The 'X' (exit) response is provided to allow the user to terminate execution. When the user responds to this question, the program stores the answer in the variable REU. Thus REU will contain either 'Y', 'N', or 'X'.

Since the production mode questions are a partial subset of the research mode questions, both sets will be presented at the same time with REU=Y used to designate the research mode and REU=N to indicate the production mode. Each question will be numbered, and the flow through the questions will be indicated by logic statements. For example, if a group of questions is processed in only the production mode, you will then be instructed to go to

the next question asked by the research mode or both modes. The logic statement would appear as:

```
IF REU=N GO TO 9
```

where the trailing number indicates the next appropriate question. The single difference in the logic for a research mode only question would be REU=Y instead of REU=N. Questions not covered by a logic statement are applicable to both modes.

The layout (column and line spacing) of the questions presented below closely matches that which appears on an interactive video terminal during execution of the program. This correspondence was preserved to make the questions appear as realistic as possible and thus give the unfamiliar user an idea of what to expect when running the program. The only difference in the appearance of this document and the video terminal is that the first line of each question has been displaced to allow the inclusion of the documentation's question number.

Question Flow

To present the question flow completely, the first question is repeated:

1 ARE YOU A RESEARCH USER ? (Y,N,X) †

As indicated previously, a 'Y' (yes) response causes the program to execute the research mode, while an 'N' (no) response causes the production

†The response to each question is terminated by striking RETURN.

mode to be executed. An 'X' (exit) response causes the program to terminate and returns the user to the operating system's control. If the user wishes to do additional computing, the program must be initiated by issuing the RUN HLMOD.TSK instruction again.

IF REU=N GO TO 4

2 DO YOU WISH TO CORRECT PREDICTED 'U' VALUES ? (Y/N)

A 'Y' (yes) response sets REU=S, which indicates that the research mode is being executed and that all overall heat transfer coefficient values, U, are to be corrected by applying the biasing factors (See Chapter VII for details.). An 'N' (no) response indicates that the U values are to be left uncorrected. This response leaves REU set equal to 'Y' (yes) which implies execution of the research mode with uncorrected overall heat transfer coefficient values.

3 DO YOU WISH DEBUG PRINTS: ? (Y/N):

A 'Y' (yes) response will activate certain print statements used to output information useful in diagnosing possible program errors. An 'N' (no) reply causes these debugging prints to remain inactive.

4 ENTER DEPTH IN (M)SW, (F)SW OR (P)SIG BY (M#,F#,P#): [F]

The expected response is the ambient depth of immersion expressed in meters of seawater (MSW), feet of seawater (FSW), or pounds per square inch gage (PSIG). The units are indicated by an M, F, or P which precedes the

number (i.e., M200.0 indicates 200 MSW). The depth specified must be ≤ 76.2 MSW, ≤ 250 FSW, or ≤ 111.37 PSIG to remain within the range of tabulated thermal conductivity values. Since the model was developed by using data from air compensated dry suits, this maximum depth was chosen to match the normal limit specified by the U.S. Navy for air diving [46].

The '[F]' (floating point) notation appearing at the end of question 4 and '[I]' (integer) notation appearing at the end of question 10 are examples of the designations used to indicate the type of number, real or integer, that is expected as a response. The '[F]' and '[I]', respectively, indicate that the expected response is a real or integer number. These notations appear on questions where a numeric response is required that is not specified in the list of possible choices.

The 'R' and 'X' responses of questions 5 thru 8 perform similar functions in each question. The 'R' response causes the program to re-initialize all of the displayed data to the initial program's assigned values. The values presented in each question are the program's assigned values used in the interactive model. This option is provided to allow the user to test special values and then return to the program's assigned data without terminating and rerunning the interactive program. An 'X' response is entered when no changes are desired or when all modifications are completed. The program then proceeds to the next question.

5 SEA LEVEL GARMENT ENSEMBLE PROPERTIES

1-SPECIFIC THERMAL RESISTANCE OF UNDERGARMENT: (CLO/CM) 2.27
 2-UNIT THICKNESS OF UNDERGARMENT: (CM) 1.63
 3-THICKNESS OF OUTER GARMENT: (CM) 0.1587
 4-THERMAL CONDUCTIVITY OF OUTER GARMENT: (W/M*C) 0.1731
 ENTER (1-4) TO ALTER, (R) TO REINITIALIZE, (X) FOR NO CHANGE:

Question five asks the user to verify the assumed sea level garment ensemble properties. If a selection is made, the program collects the new value and then re-displays the question.

The region names and ID numbers indicated in questions 6 thru 8 correspond to the numbered regions appearing in Figure 1 (Chapter I). Additionally, whenever a change is indicated in response to these questions, the program will collect the indicated value and then re-display the complete question.

6 REGIONAL UNDERGARMENT THICKNESS (CM)

ID #	REGION	MULTIPLIER	UNIT THICKNESS	ACTUAL THICKNESS
1	HEAD	1.00 *	1.63	= 1.6300
2	TORSO	1.00 *	1.63	= 1.6300
3	ABDOMEN	1.00 *	1.63	= 1.6300
4	THIGH	1.00 *	1.63	= 1.6300
5	CALF	1.00 *	1.63	= 1.6300
6	FOOT	2.00 *	1.63	= 3.2600
7	UP ARM	1.00 *	1.63	= 1.6300
8	LOW ARM	1.00 *	1.63	= 1.6300
9	HAND	1.00 *	1.63	= 1.6300

ENTER (1-9) TO ALTER, (R) TO REINITIALIZE, (X) FOR NO CHANGE:

This question allows the user to change the assumed regional undergarment thicknesses by entering a new multiplier for each of the nine regions. The unit thickness appearing above is entry 2 of question five (UNIT THICKNESS OF UNDERGARMENT: (CM)) and is the nominal value associated with the Navy's DTP garment.

7 ALLOWABLE REGIONAL HEAT FLUX (W/M**2)

ID #	REGION	ALLOWABLE HEAT FLUX
1	HEAD	23.30
2	TORSO	60.00
3	ABDOMEN	49.70
4	THIGH	42.40
5	CALF	85.00
6	FOOT	97.00
7	UP ARM	98.90
8	LOW ARM	125.25
9	HAND	265.86

ENTER (1-9) TO ALTER, (R) TO REINITIALIZE, (X) FOR NO CHANGE:

Here the user is given the opportunity to verify and modify the assumed regional allowable heat fluxes. To modify a specific region, enter the appropriate number. The program will prompt for a new value and then re-display the table.

8 REGIONAL BIASING FACTORS (DIMENSIONLESS)

ID #	REGION	BIASING FACTOR
1	HEAD	2.63
2	TORSO	2.63
3	ABDOMEN	2.27
4	THIGH	3.50
5	CALF	3.21
6	FOOT	12.70
7	UP ARM	2.29
8	LOW ARM	2.19
9	HAND	3.49

ENTER (1-9) TO ALTER, (R) TO REINITIALIZE, (X) FOR NO CHANGE:

This question allows the operator to modify our empirical regional biasing factors. To change a region's value, enter the corresponding ID #. The program will prompt for a new value and then re-display the question. The derivation of these biasing factors may be found in Chapter VII.

9 WRITE OUTPUT FILE WHERE: (T=SCREEN,F=DMPDAT.LST)

Both the production and research modes automatically create a detailed output file which is enhanced when the debug option has been activated. This statement asks where to print the output file. The 'T' response, which indicates the 'SCREEN', refers to the terminal at which the program is running. The 'F' answer, which refers to 'DMPDAT.LST', indicates the name of the file which is created on the user's default system device [55,57].

10 ENTER # NODES: [I]

This question allows you to change the number of finite difference nodes from one node to any reasonable number per region. This ability is of little value when comparing predicted and experimental data unless the experimental values are recorded at multiple sites per region. We suggest that the # NODES be specified as one until more detailed segmental temperature and heat flux data is available. This option has been included in the code to allow the operator to investigate the effects of small changes in pressure on the garment ensemble's overall thermal resistance. The upper limit on the number of nodes is left to the user's discretion. The number can be no greater than 9999 (limit of computer variable), but practicality and the lengths of the regions suggest a number approximately equal to 100.

IF REU=N GO TO 14

11 DO YOU WISH TO COMPARE T,Q,U VALUES WITH EXP'T DATA: (Y/N)

The answer to this question determines whether the research mode compares experimental and predicted values. A 'Y' (yes) response instructs the computer to compare experimental and predicted values, while an 'N' (no) response indicates that no comparison is to be performed. These responses are stored in the variable QCOMP. This variable is introduced to facilitate subsequent logic since it controls the processing of certain questions (See question 12.). When a comparison is performed, the design mean skin temperature is automatically set equal to the experimental mean skin temperature which is determined from Hody's equation (Eq. 8) with the segmental experimental temperatures. (See Chapters II and IV.) The ambient temperature is set equal to the experimental value. Thus, it is unnecessary to collect a design mean skin temperature (question 14) or an ambient temperature (question 15). If a negative response is entered for this question, the program automatically jumps to question 14. (Note: If plots of the experimental and predicted data (question 18) are to be produced, a 'Y' (yes) response must be tendered here.)

IF QCOMP=N GO TO 14

12 ENTER TOTAL SURFACE AREA OF EXP'T SUBJECT (M**2): [F]

The comparison of predicted and experimental values is performed in terms of a heat flux (W/M^2). However, the experimental data is stored as a rate of heat loss and therefore, must be divided by the segmental surface area for conversion to a heat flux before being compared. The segmental surface area

is found by multiplying the subject's total surface area by the corresponding Hody segmental surface fraction (Table 1 of Chapter I). In our case, the experimental values represent the average of at least three subject's data which was recorded in various unit systems. These values were converted to a common base system, rates of heat loss in watts, before being averaged.

13 ENTER EXPERIMENTAL DATA FILE NAME:

Enter the name of the direct access file containing the experimental data to be compared. This direct access file must be organized and formatted as specified in Appendix A.

After processing questions 12 and 13, it is known that QCOMP equals a 'Y' (yes); therefore, the program must skip questions 14 and 15 and proceed directly to question 16 (as indicated above in question 11).

IF QCOMP=Y GO TO 16

14 ENTER DESIGN MEAN SKIN TEMPERATURE (C): [F]

Enter the mean skin temperature value that is to be used as the design goal for indicating thermal safety. The value entered here must be ≤ 32 °C and ≥ 26 °C to remain within the mean skin temperature range defined for the regional skin temperature prediction model. (See Chapter IV for details.) This question is skipped if a comparison is performed. Instead, the Hody mean skin temperature calculated from the segmental experimental skin temperatures is used.

15 ENTER AMBIENT TEMPERATURE ≥ 1.0 (C): [F]

Enter the ambient temperature to be used as the design value. The ambient temperature must be ≥ 1.0 °C to remain within the temperature limits defined for the boundary layer fluid properties. (See Chapter VI.) When a comparison is performed, question 15 is skipped, and instead, the experimental ambient temperature is used.

16 SELECT BODY REGION (1-9) OR (0) FOR ALL REGIONS: [I]

A response of one through nine corresponds to regions 1 to 9 of the model man (Fig. 1), respectively, and specifies that calculations will be performed for that region only. An answer of zero instructs the program to perform the heat loss calculations for all regions without recalling any of these questions.

17 SELECT POSTURE OF SUBJECT (0-SIT,1-STAND,2-PRONE): [I]

This is the last question asked by both modes. The program is designed to accommodate a sitting, standing, or prone, resting subject. The response given here designates which posture is to be assumed for the calculations.

At this point, all necessary information has been collected, and the program proceeds by calculating and outputting the predicted regional heat flux and required supplementary heating within the constraints of the parameters specified above. If the program is executing in the production mode (REU=N), then all predicted values of overall heat transfer coefficient (OHTC) are corrected by applying experimentally derived biasing factors. (See Chapter VII.) If the research mode is being executed, then the predicted OHTC

values are either left uncorrected ($REU=Y$) or corrected by using the experimentally derived biasing factors ($REU=S$). If a comparison of predicted and experimental data is being conducted, the program calculates the experimental comparison variables and then asks if plots are desired. (See Figures D.1-D.5 for examples of the computer generated plots.) If no comparative plots are to be generated, the program returns to question 1.

IF QCOMP=N GO TO 1

18 DO YOU WISH TO PLOT T'S, Q'S, AND U'S? (Y/N)

If a 'Y' (yes) is entered, the program proceeds by asking questions which concern the plot scales and then produces three regional plots which compare dimensional, predicted and experimental values as a function of time. The three plots generated are for regional skin temperature (T in $^{\circ}C$), heat flux (Q in W/M^2), and overall heat transfer coefficient (U in $W/M^2^{\circ}C$). An 'N' (no) response indicates no dimensional plots are to be produced, and the program proceeds to question 21. The tendered response is stored in variable PLD.

IF PLD=N GO TO 21

The scale factors which are displayed for verification and possible change in questions 19, 20, 22, and 23 are all real numbers. Thus any new value which may be entered must also be real.

19 Y-AXIS SCALE FACTORS

	LY	SY	IY
T C	5.00	20.00	4.00
Q W/M2	5.00	0.00	50.00
U W/M2*C	4.00	0.00	4.00

SELECT: (1=T,2=Q,3=U,X=NO MORE CHANGES)

This question gives the user the opportunity to alter the assumed y-axis scale factors of length (LY), starting value (SY), and increment (IY) used for the dimensional T, Q, and U plots. If a number between one and three (corresponding to skin temperature ($^{\circ}\text{C}$), heat flux (W/M^2), and overall heat transfer coefficient ($\text{W/M}^2\text{C}$), respectively) is entered, the program will prompt for the indicated scale factors and then re-display the question. An 'X' (exit) is entered when no changes are desired or when all changes are completed.

20 X-AXIS (TIME) SCALE FACTORS

	LX	SX	IX
T,Q,U MIN	7.00	0.00	20.00

CHANGE X-AXIS? (Y/N)

This question allows the operator to modify the x-axis (time-axis) scale factors. There is only one set of x-axis scale factors for the dimensional skin temperature, heat flux, and overall heat transfer coefficient figures. This is done because all of the plots are generated from the same set of experimental temperature and rate of heat loss data. If a 'Y' (yes) is tendered, the program will prompt the entry (separated by commas) of the time-axis scale factors of length (LX), starting value (SX), and increment (IX) in the units of minutes. An 'N' (no) response will cause the program to continue using the assumed values.

The y-axis scales shown in question 19 and the x-axis scale of question 20 were used to develop the plots displayed in Figures D.1-D.3. The listings of data in Tables D.5-D.7 are produced as the corresponding plot is generated and are stored in the output files discussed below. Each tabulation lists all the data plotted in the respective figure.

The program proceeds to generate the intermediate vector files used by the DEC PLXY-11M plotting routines [50] and the corresponding output files. The three intermediate vector and output files produced are named COMPAR.VEC;N and COMPAR.OUT;M, respectively, where N and M are version numbers assigned by the operating system. The temperatures are plotted and outputted in COMPAR.VEC;N and COMPAR.OUT;M, followed by the heat fluxes in COMPAR.VEC;N+1 and COMPAR.OUT;M+1, and then the overall heat transfer coefficients in COMPAR.VEC;N+2 and COMPAR.OUT;M+2. The vector files must then be manually converted to interpretable graphs by running the PLTCTL.TSK program. Details on this program are contained in reference 50. The interpretable graphs and their corresponding output files may be directed to a hard copy printer using the RSX-11M tasks PIP or PRI detailed in reference 52.

21 DO YOU WISH TO PLOT NORMALIZED T'S AND BIOT #'S ? (Y/N)

If a 'Y' (yes) is entered, the program proceeds by asking questions which concern the plot scales and then produces regional plots which compare non-dimensional predicted and experimental values as a function of time. The two plots generated for each region are for regional normalized skin temperature (TN) and Biot number (BI). An 'N' (no) response indicates no dimensionless plots are to be produced, and the program returns to question 1. The tendered response is stored in variable PLN.

IF PLN=N GO TO 1

22 Y-AXIS SCALE FACTORS
NON-DIMENSIONAL T'S & U'S

	LY	SY	IY
TN	4.00	0.50	0.25
BI	4.00	0.00	10.00

SELECT: (1=TN,2=BI,X=NO MORE CHANGES)

This question gives the user the opportunity to alter the assumed y-axis scale factors used for the non-dimensional TN and BI plots. If either 1 or 2 (corresponding to normalized skin temperature (TN) and Biot number (BI), respectively) is entered, the program will prompt for the indicated scale factors and will then re-display the question. An 'X' (exit) is entered when no changes are desired or when all changes are completed.

23 X-AXIS (TIME) SCALE FACTORS

	LX	SX	IX
TN,BI MIN	7.00	0.00	20.00

CHANGE X-AXIS? (Y/N)

This question allows the operator to modify the x-axis (time-axis) scale factors. There is only one set of x-axis scale factors for the non-dimensional normalized skin temperature and Biot number graphs. This was done because all of the plots were generated from the same set of experimental temperature and rate of heat loss data. If a 'Y' (yes) is tendered, the program will prompt the entry (separated by commas) of the time-axis scale factors of length (LX), starting value (SX), and increment (IX) in units of minutes. An 'N' (no) response will cause the program to continue using the assumed values.

The y-axis scales shown in question 22 and the x-axis scale of question 23 were used to develop the plots displayed in Figures D.4 and D.5. The listings of data in Tables D.8 and D.9 are produced as the corresponding plot is generated. Each tabulation lists all the data plotted in the respective figure.

The program proceeds to generate the intermediate vector files used by the DEC PLXY-11M plotting routines [50] and the corresponding data output files. The two intermediate vector and output files produced are named COMPARN.VEC;N and COMPARN.0'T;M, respectively, where the trailing N and M are version numbers assigned by the operating system. The normalized temperatures are plotted and outputted in COMPARN.VEC;N and COMPARN.OUT;M, followed by the Biot numbers in COMPARN.VEC;N+1 and COMPARN.OUT;M+1. The vector files must then be manually converted to interpretable graphs by running the PLTCTL.TSK program. Details on this program are contained in reference 50. The interpretable graphs and their corresponding output files may be directed to to a hard copy printer using the RSX-11M tasks PIP and PRI which are detailed in reference 52.

As previously indicated, the dimensional plots of temperature, heat flux, and overall heat transfer coefficient and the non-dimensional plots of normalized temperature and Biot number are generated collectively for any specified region. These groupings were chosen rather than allowing selective plotting of a specific parameter since the overall heat transfer coefficients (U) and Biot numbers (BI) are functions of the regional temperature and heat flux. This dependence of the U's and BI's indicated the desirability of the other plots to verify the integrity of the computational routines. This arrangement allows plots of specific regional parameters to be produced by printing only the desired graph, yet retain the advantages offered by verification.

Example Production and Research Runs

The question numbers of the previous section will be used to denote the question corresponding to the indicated response. For the production mode example, design conditions of ambient temperature, depth, and design mean skin temperature were chosen to be representative of the model's design goals. The experimental data used in the research mode example is considered representative of the calibrated data available. The question flow, Table D.1, and output, Table D.2, correspond to the production mode example. The question flow, Table D.3, and outputs, Tables D.4-D.9, and Figures D.1-D.5 represent the research mode example. Further discussion of these outputs follows the figures.

Table D.1

Production Mode Question Flow

Question #	Response
1	N
2	NA†
3	NA
4	F10.0
5	X
6	X
7	X
8	X
9	F
10	1
11	NA
12	NA
13	NA
14	30.0
15	5.0
16	3
17	2
18	NA
19	NA
20	NA
21	NA
22	NA
23	NA

Table D.2

Sample Production Mode Output

BODY REGION:	3
POSTURE: 0=SIT,1=STAND,2=PRONE	2
DESIGN MEAN SKIN TEMPERATURE:	30.00 C
REFERENCE DEPTH:	10.00 FSW
AMBIENT TEMPERATURE:	5.00 C
PREDICTED TEMPERATURE FOR REGION 3:	30.31 C
CORRECTED PREDICTED OHTC FOR REGION 3:	3.96 W/M**2*C
PREDICTED UNIT HEAT FLUX FOR REGION 3:	100.25 W/M**2
ALLOWABLE UNIT HEAT FLUX FOR REGION 3:	49.70 W/M**2
REQUIRED SUPPLEMENTARY HEAT FLUX:	50.55 W/M**2
PREDICTED RATE OF HEAT LOSS FOR REGION 3:	33.35 WATTS
ALLOWABLE RATE OF HEAT LOSS FOR REGION 3:	16.54 WATTS
REQUIRED SUPPLEMENTARY HEATING:	16.82 WATTS

†NA indicates Not Appropriate, used to indicate an unasked question.

Table D.3

Research Mode Question Flow

Question #	Response
1	Y
2	N
3	N
4	F10.0
5	X
6	X
7	X
8	X
9	F
10	1
11	Y
12	1.91
13	DTPIART.DAT [†]
14	NA
15	NA
16	3
17	2
18	Y
19	X ^{††}
20	N
21	Y
22	X
23	N

[†]This file specification corresponds to the experimental data. The format used in this direct access file is explained in Appendix A.

^{††}To produce Figures D.3 and D.8, the scale factors for the U's in question 19 must be changed to LY = 4.0, SY = 0.0, IY = 2.0 from LY = 4.0, SY = 0.0, IY = 4.0.

Table D.4

Sample Research Mode Output

EXPERIMENTAL TIME: 0.00

BODY REGION:	3
POSTURE: 0=SIT,1=STAND,2=PRONE	2
DESIGN MEAN SKIN TEMPERATURE:	34.03 C
REFERENCE DEPTH:	10.00 FSW
AMBIENT TEMPERATURE:	3.93 C
PREDICTED TEMPERATURE FOR REGION 3:	34.34 C
UNCORRECTED PREDICTED OHTC FOR REGION 3:	1.75 W/M**2*C
PREDICTED UNIT HEAT FLUX FOR REGION 3:	53.23 W/M**2
ALLOWABLE UNIT HEAT FLUX FOR REGION 3:	49.70 W/M**2
REQUIRED SUPPLEMENTARY HEAT FLUX:	3.53 W/M**2
PREDICTED RATE OF HEAT LOSS FOR REGION 3:	17.71 WATTS
ALLOWABLE RATE OF HEAT LOSS FOR REGION 3:	16.54 WATTS
REQUIRED SUPPLEMENTARY HEATING:	1.17 WATTS
WGT'ED EXP'T TEMP'S, SITES 3, 5;† FOR REGION 3:	34.11 C
WGT'ED EXP'T OHTC'S, SITES 3, 5;† FOR REGION 3:	0.50 W/M**2*C
WGT'ED EXP'T HEAT FLUX, SITES 3, 5;† FOR REGION 3:	15.14 W/M**2

EXPERIMENTAL TIME: 3.00

BODY REGION:	3
POSTURE: 0=SIT,1=STAND,2=PRONE	2
DESIGN MEAN SKIN TEMPERATURE:	34.59 C
REFERENCE DEPTH:	10.00 FSW
AMBIENT TEMPERATURE:	3.95 C
PREDICTED TEMPERATURE FOR REGION 3:	34.90 C
UNCORRECTED PREDICTED OHTC FOR REGION 3:	1.75 W/M**2*C
PREDICTED UNIT HEAT FLUX FOR REGION 3:	54.21 W/M**2
ALLOWABLE UNIT HEAT FLUX FOR REGION 3:	49.70 W/M**2
REQUIRED SUPPLEMENTARY HEAT FLUX:	4.51 W/M**2
PREDICTED RATE OF HEAT LOSS FOR REGION 3:	18.04 WATTS
ALLOWABLE RATE OF HEAT LOSS FOR REGION 3:	16.54 WATTS
REQUIRED SUPPLEMENTARY HEATING:	1.50 WATTS
WGT'ED EXP'T TEMP'S, SITES 3, 5;† FOR REGION 3:	34.58 C
WGT'ED EXP'T OHTC'S, SITES 3, 5;† FOR REGION 3:	0.34 W/M**2*C
WGT'ED EXP'T HEAT FLUX, SITES 3, 5;† FOR REGION 3:	10.23 W/M**2

†Sensor sites (3,5) refer to the experimental segments of Figure 2 and Table 1.

Figure D.1. Plots of Experimental (T-EXPT) and Predicted (T-PRED) Temperatures ($^{\circ}\text{C}$) for the Abdomen.

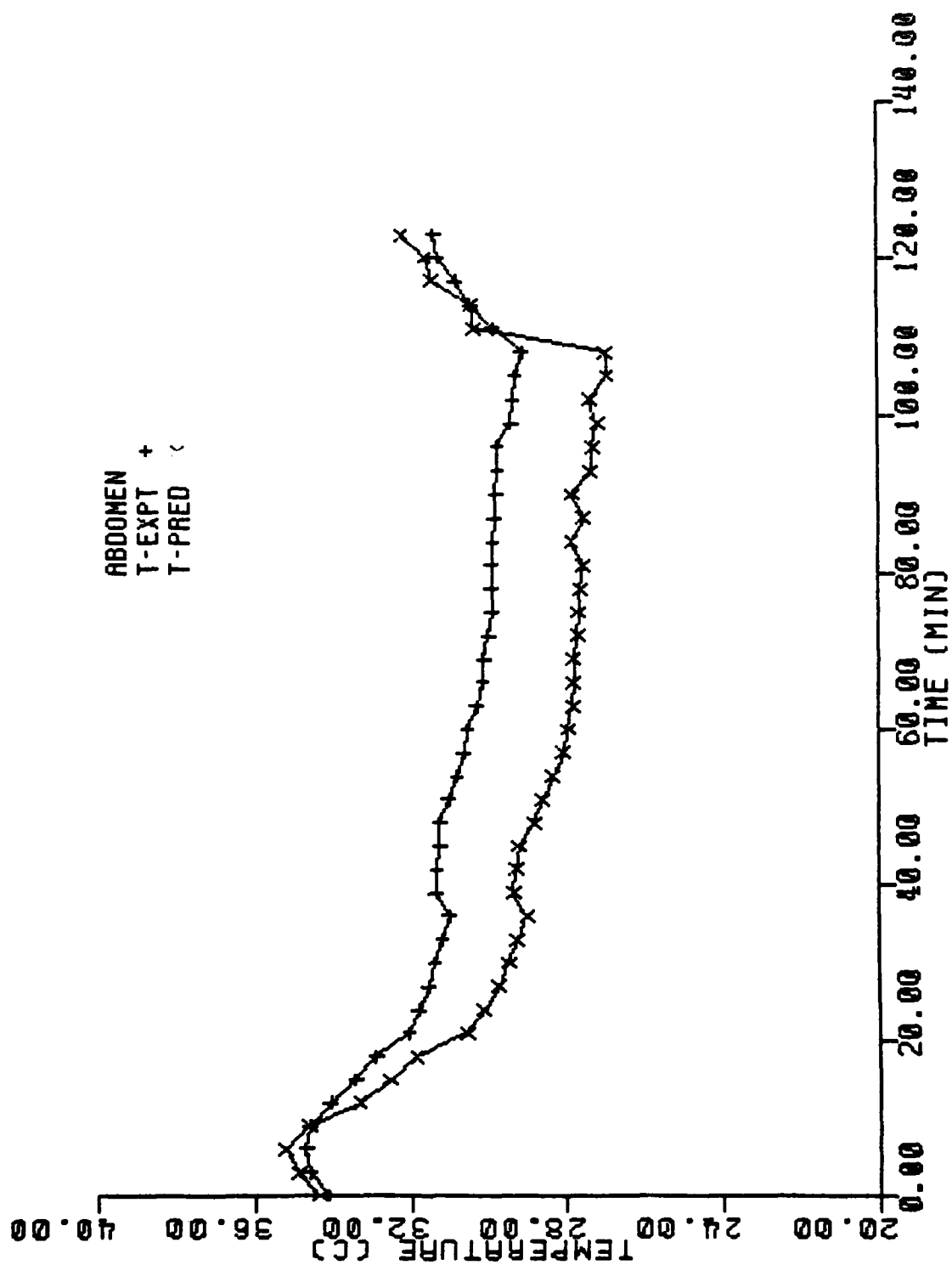


Figure D.1

Table D.5

Experimental (T-EXPT) and Predicted (T-PRED) Temperature Values (°C) as a Function of Time as Plotted in Figure D.1.

ABDOMEN

LY: 5.00 SY: 20.00 IY: 4.00

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	T-EXPT	T-PRED
0.00	34.11	34.34
3.00	34.58	34.90
6.00	34.68	35.20
9.00	34.59	34.61
12.00	34.05	33.31
15.00	33.41	32.52
18.00	32.87	31.83
21.00	32.04	30.53
24.00	31.79	30.12
27.00	31.52	29.73
30.00	31.36	29.49
33.00	31.16	29.25
36.00	31.00	29.00
39.00	31.33	29.34
42.00	31.31	29.26
45.00	31.20	29.17
48.00	31.20	28.80
51.00	30.97	28.59
54.00	30.77	28.32
57.00	30.59	28.06
60.00	30.50	27.95
63.00	30.25	27.81
66.00	30.10	27.78
69.00	30.07	27.77
72.00	29.94	27.67
75.00	29.86	27.65
78.00	29.86	27.60
81.00	29.85	27.50
84.00	29.83	27.83
87.00	29.78	27.50
90.00	29.74	27.79
93.00	29.70	27.31
96.00	29.69	27.27
99.00	29.35	27.13
102.00	29.30	27.35
105.00	29.22	26.89
108.00	29.06	26.91
111.00	29.79	30.28
114.00	30.34	30.31
117.00	30.73	31.32
120.00	31.17	31.50
123.00	31.28	32.10

Figure D.2. Plots of Experimental (Q-EXPT) and Uncorrected Predicted (Q-PRED) Heat Flux (W/M^2) for the Abdomen.

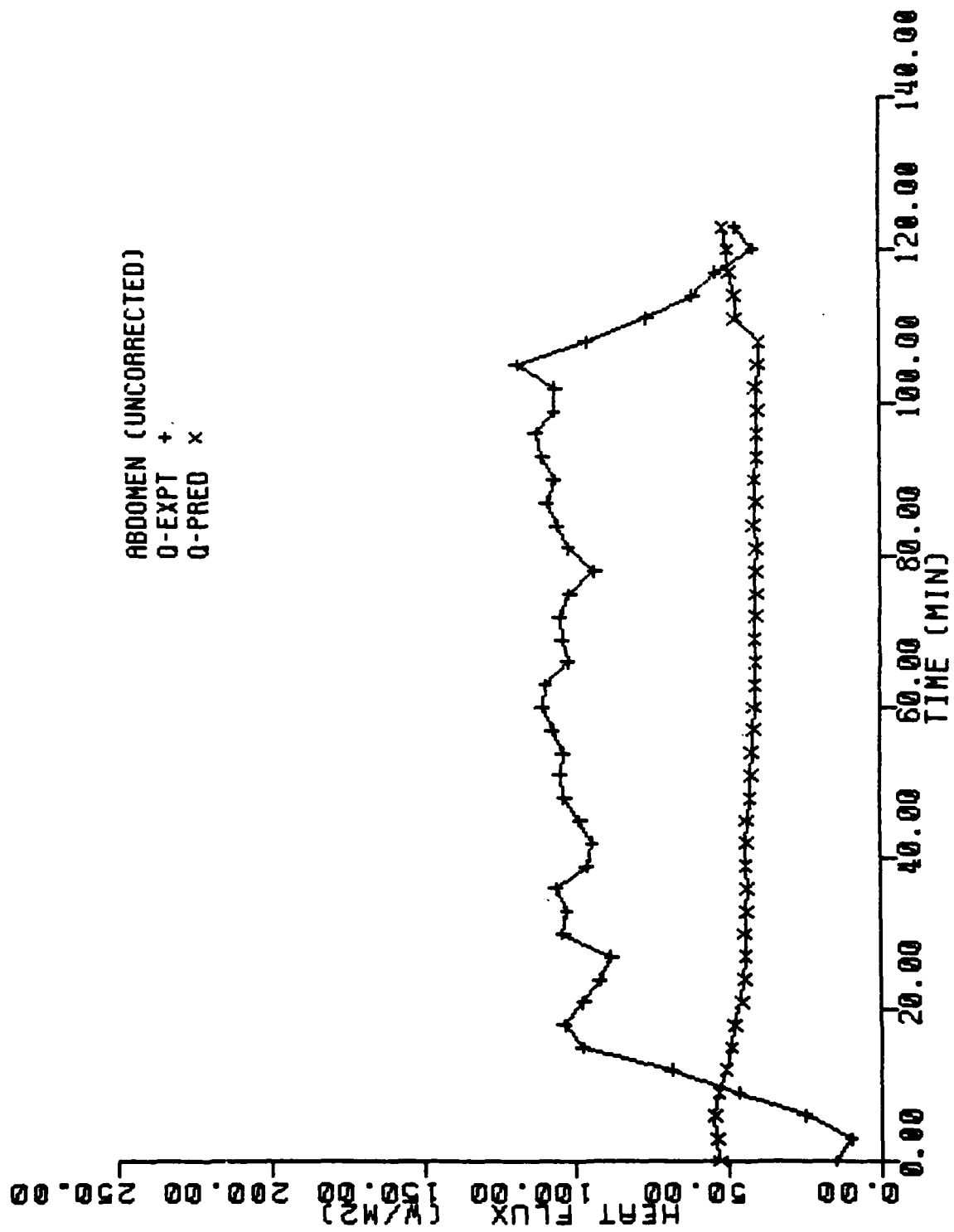


Figure D.2

Table D.6

Experimental (Q-EXPT) and Uncorrected Predicted (Q-PRED)
Heat Flux Values (W/M^2) as a Function of Time as Plotted
in Figure D.2.

ABDOMEN (UNCORRECTED)

LY: 5.00 SY: 0.00 IY: 50.00

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$
TIME Q-EXPT Q-PRED

0.00	15.14	53.23
3.00	10.23	54.21
6.00	25.58	54.85
9.00	46.88	53.56
12.00	68.93	51.02
15.00	97.95	49.46
18.00	103.87	48.26
21.00	97.71	45.70
24.00	92.36	45.11
27.00	88.23	44.31
30.00	104.17	44.63
33.00	102.86	44.15
36.00	106.27	43.71
39.00	96.51	44.35
42.00	94.45	44.03
45.00	98.43	43.89
48.00	103.46	42.75
51.00	104.77	42.44
54.00	104.05	41.97
57.00	107.14	41.49
60.00	110.64	41.29
63.00	109.53	41.04
66.00	102.29	41.03
69.00	104.05	40.96
72.00	104.65	40.73
75.00	101.63	40.75
78.00	93.55	40.67
81.00	102.05	40.38
84.00	105.58	41.28
87.00	108.81	40.64
90.00	106.54	41.11
93.00	110.13	40.24
96.00	112.22	40.23
99.00	106.15	39.91
102.00	105.88	40.37
105.00	118.15	39.55
108.00	95.47	39.39
111.00	75.90	47.11
114.00	60.94	47.15
117.00	53.52	48.99
120.00	40.99	49.46
123.00	46.82	50.99

Figure D.3. Plots of Experimental (U-EXPT) and Uncorrected Predicted (U-PRED) Overall Heat Transfer Coefficient (OHTC in $W/M^2\text{ }^\circ C$) for the Abdomen.

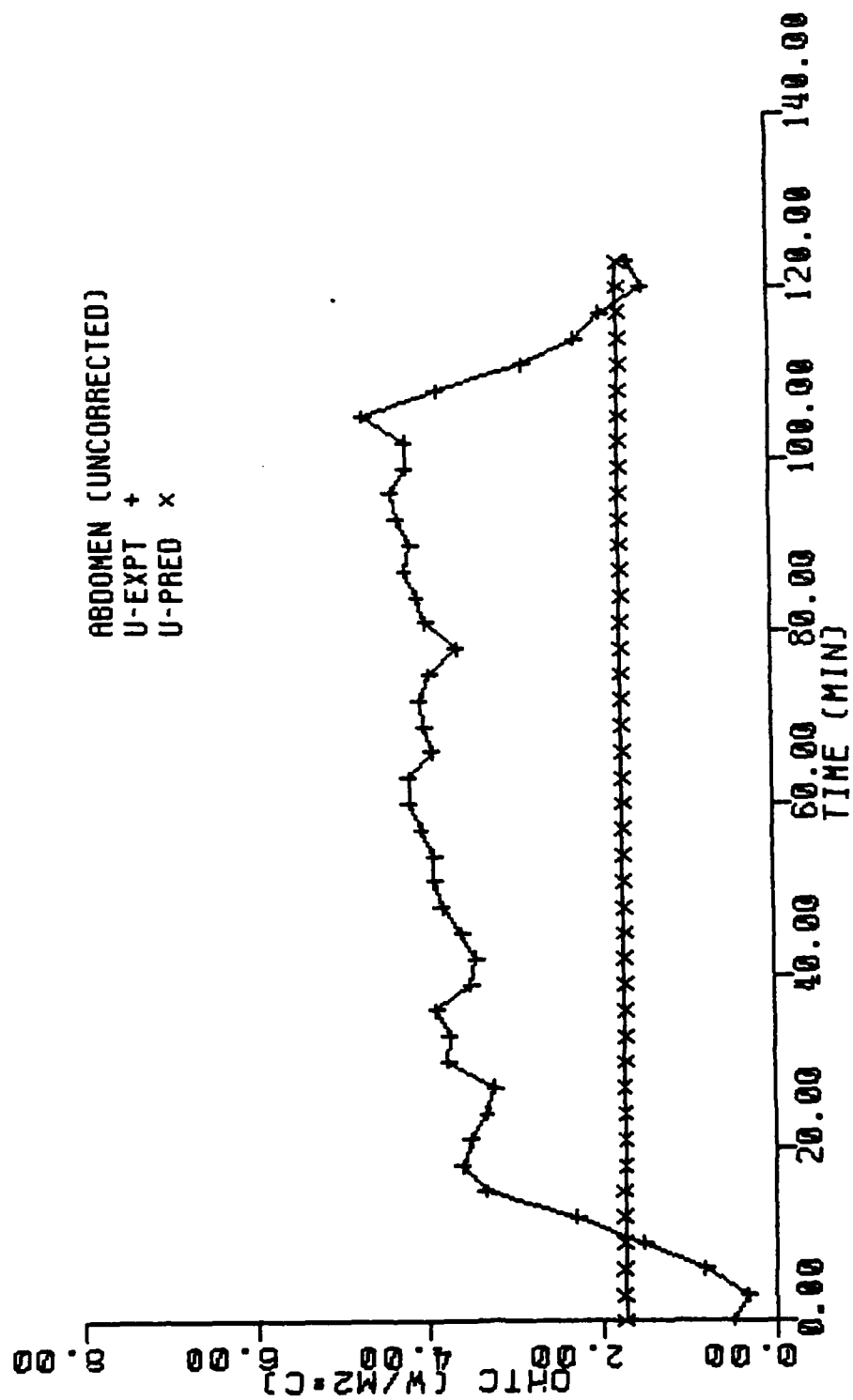


Figure D.3

Table D.7

Experimental (U-EXPT) and Uncorrected Predicted (U-PRED) Overall Heat Transfer Coefficient Values ($W/M^2\text{°C}$) as a Function of Time as Plotted in Figure D.3.

ABDOMEN (UNCORRECTED)

LY: 4.00 SY: 0.00 IY: 2.00

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	U-EXPT	U-PRED
0.00	0.50	1.75
3.00	0.34	1.75
6.00	0.83	1.75
9.00	1.53	1.75
12.00	2.30	1.75
15.00	3.36	1.75
18.00	3.62	1.74
21.00	3.52	1.74
24.00	3.34	1.74
27.00	3.24	1.74
30.00	3.77	1.74
33.00	3.76	1.74
36.00	3.91	1.73
39.00	3.50	1.74
42.00	3.44	1.74
45.00	3.60	1.74
48.00	3.83	1.74
51.00	3.90	1.74
54.00	3.91	1.73
57.00	4.05	1.73
60.00	4.19	1.73
63.00	4.19	1.73
66.00	3.92	1.73
69.00	4.00	1.73
72.00	4.05	1.73
75.00	3.94	1.73
78.00	3.62	1.73
81.00	3.97	1.73
84.00	4.08	1.73
87.00	4.21	1.73
90.00	4.14	1.73
93.00	4.29	1.73
96.00	4.35	1.73
99.00	4.19	1.73
102.00	4.18	1.73
105.00	4.67	1.73
108.00	3.82	1.73
111.00	2.83	1.73
114.00	2.23	1.73
117.00	1.93	1.74
120.00	1.45	1.74
123.00	1.62	1.73

Figure D.4. Plots of Experimental Normalized (TN-EXPT) and Predicted Normalized (TN-PRED) Temperatures for the Abdomen.

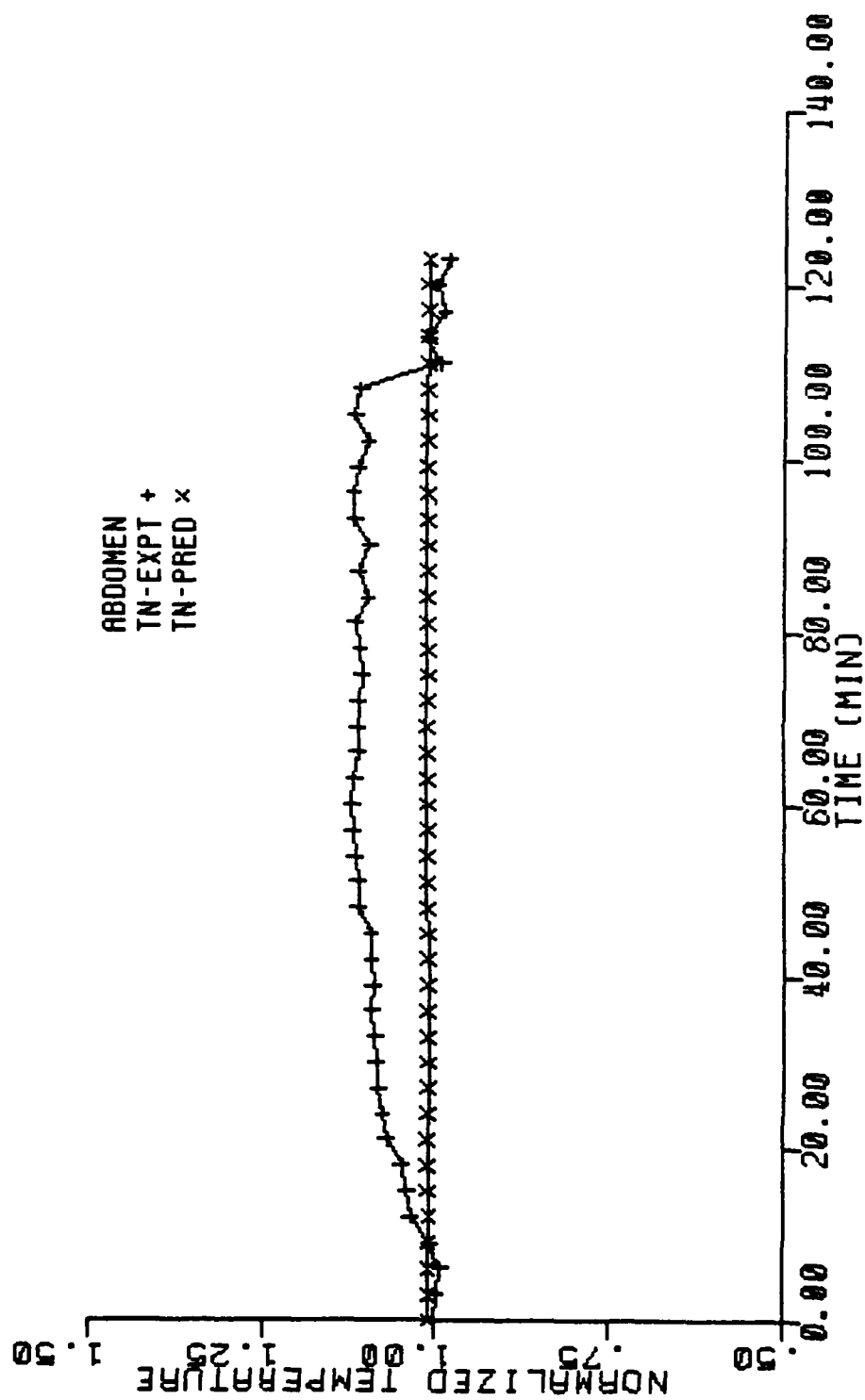


Figure D.4

Table D.8

Experimental (TN-EXPT) and Predicted (TN-PRED) Normalized Temperature Values (Dimensionless) as a Function of Time as Plotted in Figure D.4.

ABDOMEN

LY: 4.00 SY: 0.50 IY: 0.25

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	TN-EXPT	TN-PRED
0.00	1.00	1.01
3.00	1.00	1.01
6.00	0.99	1.01
9.00	1.01	1.01
12.00	1.04	1.01
15.00	1.04	1.01
18.00	1.05	1.01
21.00	1.07	1.01
24.00	1.08	1.01
27.00	1.08	1.01
30.00	1.09	1.01
33.00	1.09	1.01
36.00	1.09	1.01
39.00	1.09	1.01
42.00	1.09	1.01
45.00	1.09	1.01
48.00	1.11	1.01
51.00	1.11	1.01
54.00	1.12	1.01
57.00	1.12	1.01
60.00	1.12	1.01
63.00	1.12	1.01
66.00	1.11	1.01
69.00	1.11	1.01
72.00	1.11	1.01
75.00	1.11	1.01
78.00	1.11	1.01
81.00	1.12	1.01
84.00	1.10	1.01
87.00	1.11	1.01
90.00	1.10	1.01
93.00	1.12	1.01
96.00	1.12	1.01
99.00	1.11	1.01
102.00	1.10	1.01
105.00	1.12	1.01
108.00	1.11	1.01
111.00	0.99	1.01
114.00	1.01	1.01
117.00	0.99	1.01
120.00	1.00	1.01
123.00	0.98	1.01

Figure D.5. Plots of Experimental Biot (BI-EXPT) and Uncorrected Predicted Biot (BI-PRED) Numbers for the Abdomen.

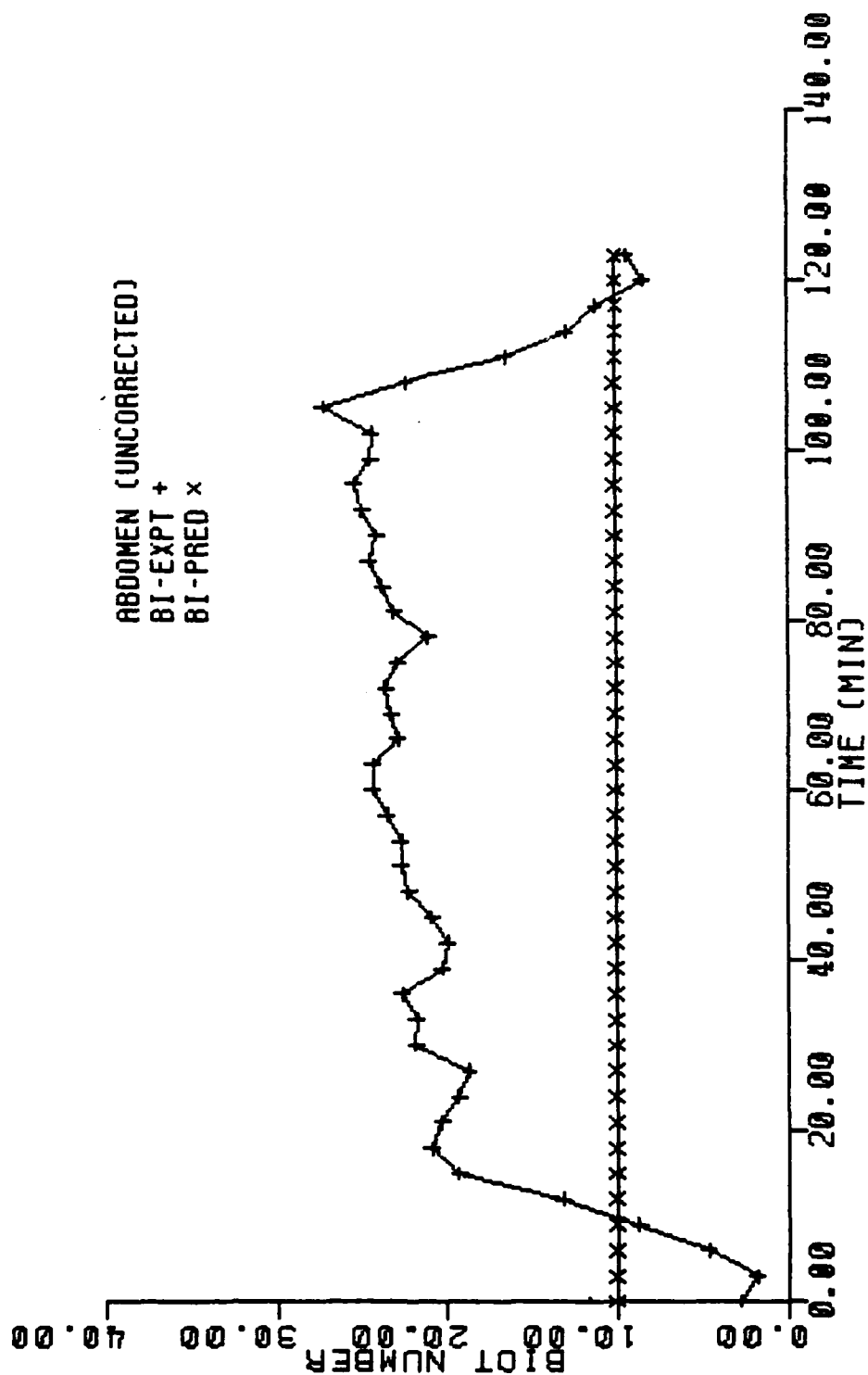


Figure D.5

Table D.9

Experimental (BI-EXPT) and Uncorrected Predicted (BI-PRED)
Biot Number Values (Dimensionless) as a Function of Time as
Plotted in Figure D.5.

ABDOMEN (UNCORRECTED)

LY: 4.00 SY: 0.00 IY: 10.00

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	BI-EXPT	BI-PRED
0.00	2.89	10.11
3.00	1.94	10.11
6.00	4.80	10.11
9.00	8.86	10.11
12.00	13.29	10.11
15.00	19.39	10.11
18.00	20.94	10.11
21.00	20.39	10.11
24.00	19.37	10.10
27.00	18.75	10.10
30.00	21.87	10.09
33.00	21.79	10.09
36.00	22.66	10.09
39.00	20.28	10.09
42.00	19.96	10.09
45.00	20.88	10.09
48.00	22.18	10.10
51.00	22.62	10.10
54.00	22.66	10.10
57.00	23.47	10.10
60.00	24.32	10.10
63.00	24.31	10.10
66.00	22.77	10.10
69.00	23.23	10.10
72.00	23.52	10.10
75.00	22.88	10.10
78.00	21.03	10.10
81.00	23.05	10.10
84.00	23.68	10.09
87.00	24.46	10.09
90.00	24.03	10.09
93.00	24.90	10.09
96.00	25.30	10.09
99.00	24.37	10.09
102.00	24.32	10.09
105.00	27.17	10.09
108.00	22.24	10.09
111.00	16.47	10.07
114.00	12.96	10.07
117.00	11.22	10.08
120.00	8.41	10.07
123.00	9.41	10.06

Both the production and research runs assume that the diver was in a prone position, and the data calculated in both cases was for the abdomen, region 3 (Fig. 1). The prone posture was chosen since the wet experimental data was recorded from mostly prone divers. The abdomen was used since it is one of the principal regions for which the experimental data was considered reliable. Thus, this region should provide an accurate basis for comparison of our predicted values with the experimental ones.

Table D.2 is the only output generated by the production mode, and Table D.4 is the comparable research mode output. Comparison of Tables D.2 and D.4 reveals that the parameters printed are basically the same except that Table D.2 refers to the overall heat transfer coefficient (OHTC) as corrected, where Table D.4 refers to it as uncorrected; Table D.4 also includes the experimental data and the time at which the data was recorded. Only the first two of fifty-six time increments taken from the experimental study DTP1ART are shown in Table D.4. Figures D.1-D.3 are the regional dimensional skin temperature, heat flux, and overall heat transfer coefficient plots, respectively, produced to display the comparison between dimensional experimental and predicted data. The data actually plotted in Figures D.1-D.3 is listed in Tables D.5-D.7, respectively. Figures D.4 and D.5 are the regional non-dimensional normalized skin temperature and Biot number plots, respectively, which are produced to display the comparison between dimensionless experimental and predicted data. The data actually plotted in Figures D.4 and D.5 is listed in Tables D.8 and D.9, respectively. Figures D.1-D.5 and Tables D.5-D.9 can be produced only when a comparison of temperatures, heat fluxes, and overall heat transfer coefficients is indicated by a 'Y' (yes) response to question 11. These plots have no counterpart in the production mode.

The assumed scale factors displayed in questions 19, 20, 22, and 23 were chosen to allow direct comparisons between regions and across studies. The assumed y-axis scales will handle all of the non-anomalous data taken from the three wet, air breathing studies which were used in verifying this diver heat loss program. The assumed x-axis scales, as noted, accommodate two of the experimental studies and will handle the other study if the axis length (LX) is increased.

The examples shown here are two of the primary reports produced by the program, but they are not the only variations possible. By selectively answering certain questions negatively instead of affirmatively and vice versa, the operator may cause different forms of output to be generated. For example, if the response to question 2 is a 'Y' (yes) in the research mode question flow (Table D.3) sample, then the overall heat transfer coefficients are corrected by applying the biasing factors and Figures D.6-D.10 and Tables D.10-D.15 are produced instead of Figures D.1-D.5 and Tables D.4-D.9, respectively. If questions 18 or 21 were answered with 'N' (no), then no dimensional or non-dimensional plots, respectively, would be produced. In both modes if the number of nodes (question 10) is entered as a value greater than one, then the output files would show the results of the computations for each node.

Table D.10

Sample Research Mode Output With Corrected Overall Heat Transfer Coefficients

EXPERIMENTAL TIME: 0.00

BODY REGION:	3
POSTURE: 0=SIT,1=STAND,2=PRONE	2
DESIGN MEAN SKIN TEMPERATURE:	34.03 C
REFERENCE DEPTH:	10.00 FSW
AMBIENT TEMPERATURE:	3.93 C
PREDICTED TEMPERATURE FOR REGION 3:	34.34 C
CORRECTED PREDICTED OHTC FOR REGION 3:	3.97 W/M**2*C
PREDICTED UNIT HEAT FLUX FOR REGION 3:	120.83 W/M**2
ALLOWABLE UNIT HEAT FLUX FOR REGION 3:	49.70 W/M**2
REQUIRED SUPPLEMENTARY HEAT FLUX:	71.13 W/M**2
PREDICTED RATE OF HEAT LOSS FOR REGION 3:	40.20 WATTS
ALLOWABLE RATE OF HEAT LOSS FOR REGION 3:	16.54 WATTS
REQUIRED SUPPLEMENTARY HEATING:	23.66 WATTS
WGT'ED EXP'T TEMP'S, SITES 3, 5;† FOR REGION 3:	34.11 C
WGT'ED EXP'T OHTC'S, SITES 3, 5;† FOR REGION 3:	0.50 W/M**2*C
WGT'ED EXP'T HEAT FLUX, SITES 3, 5;† FOR REGION 3:	15.14 W/M**2

EXPERIMENTAL TIME: 3.00

BODY REGION:	3
POSTURE: 0=SIT,1=STAND,2=PRONE	2
DESIGN MEAN SKIN TEMPERATURE:	34.59 C
REFERENCE DEPTH:	10.00 FSW
AMBIENT TEMPERATURE:	3.95 C
PREDICTED TEMPERATURE FOR REGION 3:	34.90 C
CORRECTED PREDICTED OHTC FOR REGION 3:	3.98 W/M**2*C
PREDICTED UNIT HEAT FLUX FOR REGION 3:	123.06 W/M**2
ALLOWABLE UNIT HEAT FLUX FOR REGION 3:	49.70 W/M**2
REQUIRED SUPPLEMENTARY HEAT FLUX:	73.36 W/M**2
PREDICTED RATE OF HEAT LOSS FOR REGION 3:	40.94 WATTS
ALLOWABLE RATE OF HEAT LOSS FOR REGION 3:	16.54 WATTS
REQUIRED SUPPLEMENTARY HEATING:	24.41 WATTS
WGT'ED EXP'T TEMP'S, SITES 3, 5;† FOR REGION 3:	34.58 C
WGT'ED EXP'T OHTC'S, SITES 3, 5;† FOR REGION 3:	0.34 W/M**2*C
WGT'ED EXP'T HEAT FLUX, SITES 3, 5;† FOR REGION 3:	10.23 W/M**2

†Sensor sites (3,5) refer to the experimental segments of Figure 2 and Table 1.

Figure D.6. Plots of Experimental (T-EXPT) and Predicted (T-PRED) Temperatures ($^{\circ}\text{C}$) for the Abdomen.

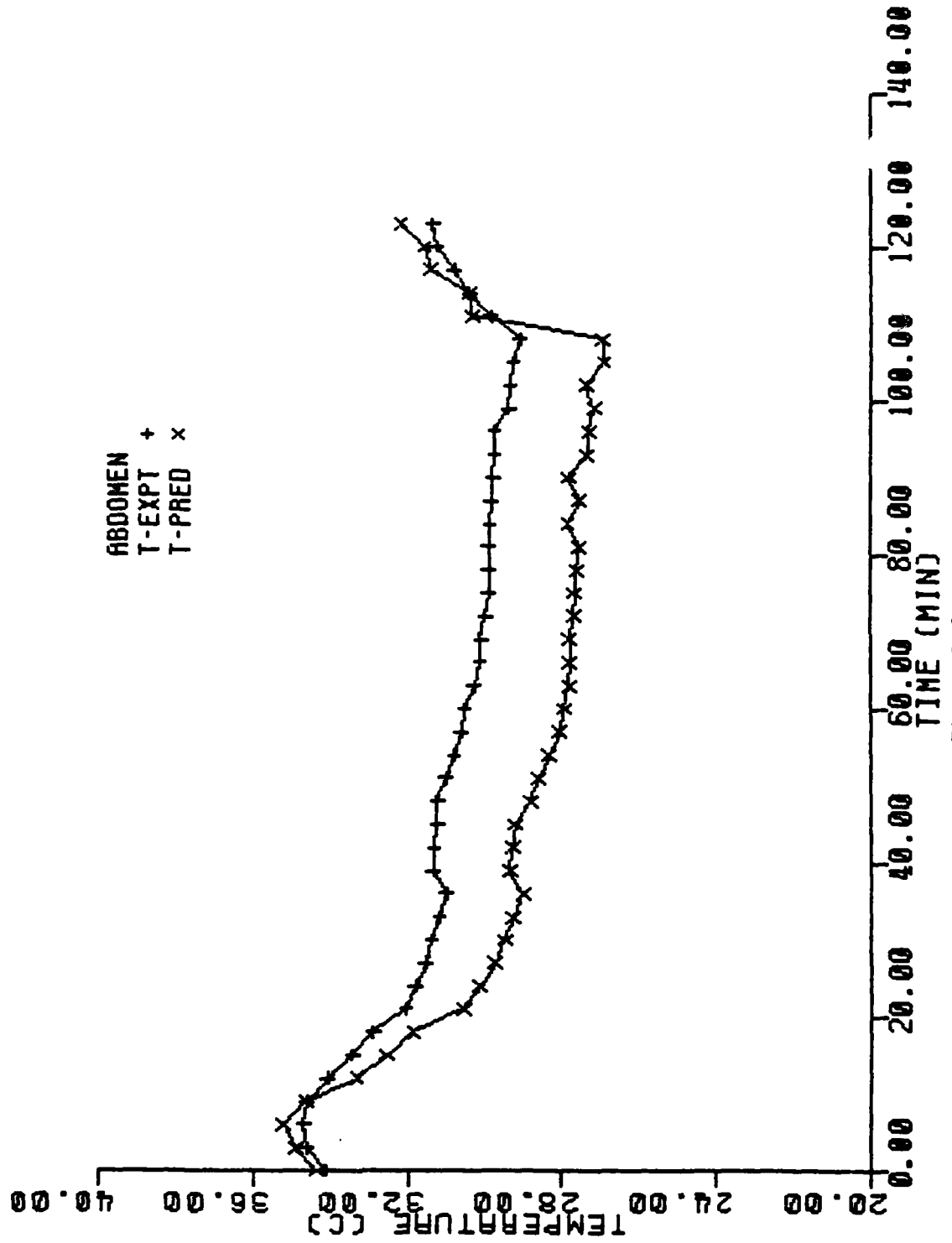


Figure D.6

Table D.11

Experimental (T-EXPT) and Predicted (T-PRED) Temperature Values (°C) as a Function of Time as Plotted in Figure D.6.

ABDOMEN

LY: 5.00 SY: 20.00 IY: 4.00

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	T-EXPT	T-PRED
0.00	34.11	34.34
3.00	34.58	34.90
6.00	34.68	35.20
9.00	34.59	34.61
12.00	34.05	33.31
15.00	33.41	32.52
18.00	32.87	31.83
21.00	32.04	30.53
24.00	31.79	30.12
27.00	31.52	29.73
30.00	31.36	29.49
33.00	31.16	29.25
36.00	31.00	29.00
39.00	31.33	29.34
42.00	31.31	29.26
45.00	31.20	29.17
48.00	31.20	28.80
51.00	30.97	28.59
54.00	30.77	28.32
57.00	30.59	28.06
60.00	30.50	27.95
63.00	30.25	27.81
66.00	30.10	27.78
69.00	30.07	27.77
72.00	29.94	27.67
75.00	29.86	27.65
78.00	29.86	27.60
81.00	29.85	27.50
84.00	29.83	27.83
87.00	29.78	27.50
90.00	29.74	27.79
93.00	29.70	27.31
96.00	29.69	27.27
99.00	29.35	27.13
102.00	29.30	27.35
105.00	29.22	26.89
108.00	29.06	26.91
111.00	29.79	30.28
114.00	30.34	30.31
117.00	30.73	31.32
120.00	31.17	31.50
123.00	31.28	32.10

Figure D.7. Plots of Experimental (Q-EXPT) and Corrected Predicted (Q-PRED) Heat Flux (W/M^2) for the Abdomen.

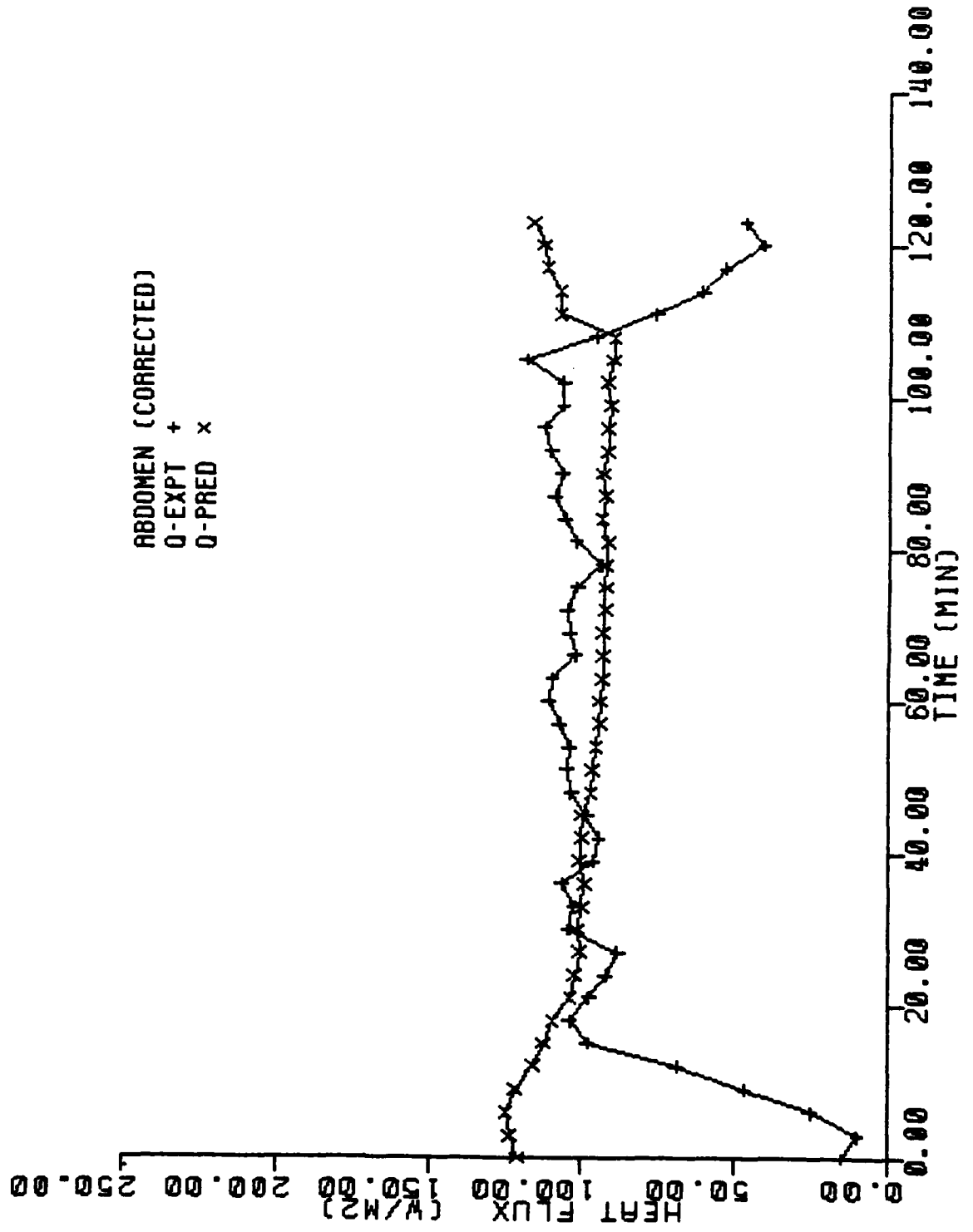


Figure D.7

Table D.12

Experimental (Q-EXPT) and Corrected Predicted (Q-PRED)
Heat Flux Values (W/M^2) as a Function of Time as Plotted
in Figure D.7.

ABDOMEN (CORRECTED)

LY: 5.00 SY: 0.00 IY: 50.00

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	Q-EXPT	Q-PRED
0.00	15.14	120.83
3.00	10.23	123.06
6.00	25.58	124.52
9.00	46.88	121.58
12.00	68.93	115.81
15.00	97.95	112.28
18.00	103.87	109.56
21.00	97.71	103.73
24.00	92.36	102.39
27.00	88.23	100.58
30.00	104.17	101.32
33.00	102.86	100.23
36.00	106.27	99.23
39.00	96.51	100.68
42.00	94.45	99.94
45.00	98.43	99.63
48.00	103.46	97.05
51.00	104.77	96.34
54.00	104.05	95.26
57.00	107.14	94.18
60.00	110.64	93.74
63.00	109.53	93.17
66.00	102.29	93.15
69.00	104.05	92.99
72.00	104.65	92.47
75.00	101.63	92.51
78.00	93.55	92.32
81.00	102.05	91.66
84.00	105.58	93.71
87.00	108.81	92.26
90.00	106.54	93.31
93.00	110.13	91.34
96.00	112.22	91.33
99.00	106.15	90.60
102.00	105.88	91.64
105.00	118.15	89.78
108.00	95.47	89.41
111.00	75.90	106.94
114.00	60.94	107.03
117.00	53.52	111.20
120.00	40.99	112.28
123.00	46.82	115.76

Figure D.8. Plots of Experimental (U-EXPT) and Corrected Predicted (U-PRED) Overall Heat Transfer Coefficient (OHTC in $\text{W}/\text{M}^2\text{C}$) for the Abdomen.

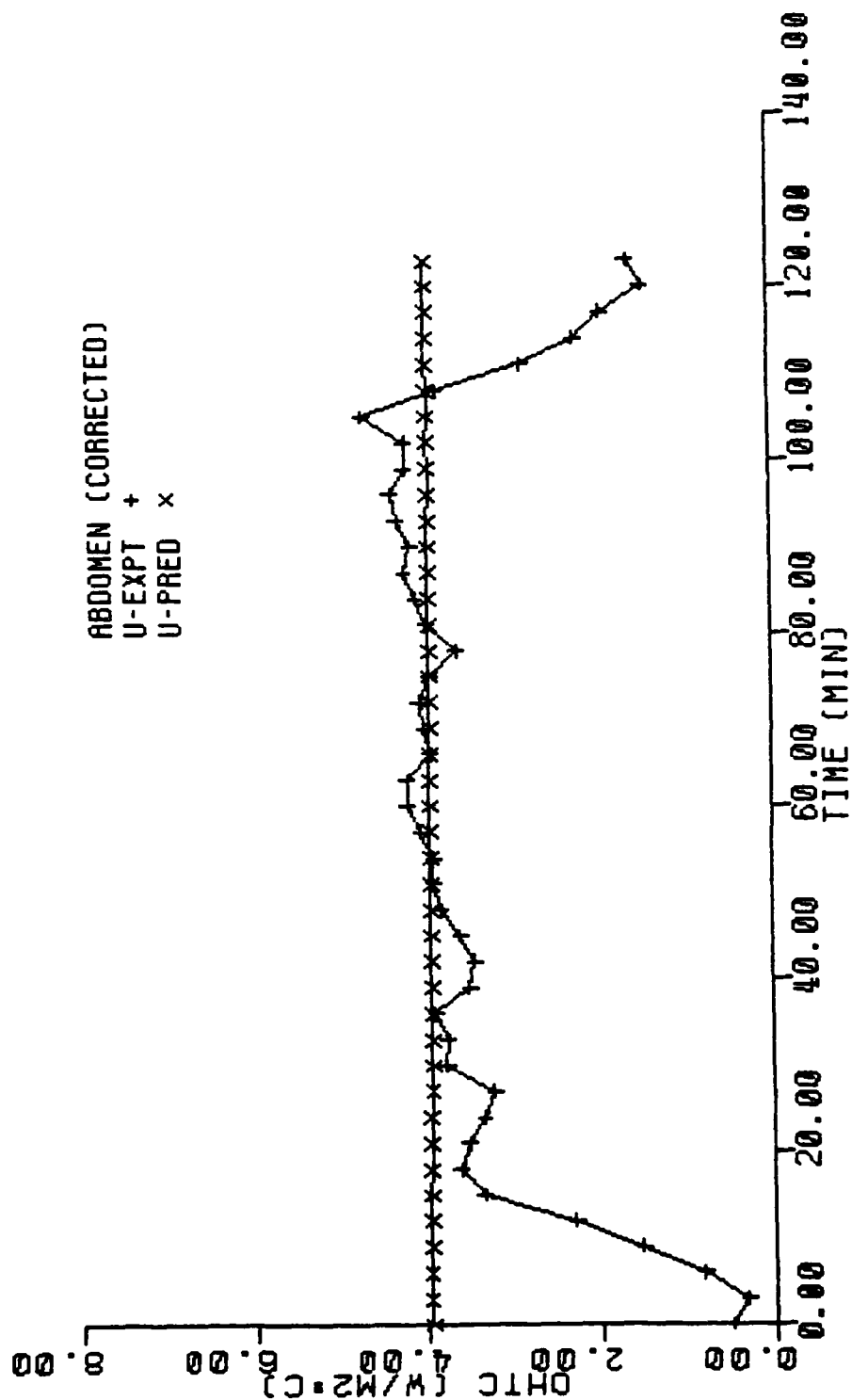


Figure D.8

Table D.13

Experimental (U-EXPT) and Corrected Predicted (U-PRED) Overall Heat Transfer Coefficient Values ($W/M^2\text{°C}$) as a Function of Time as Plotted in Figure D.8.

ABDOMEN (CORRECTED)

LY: 4.00 SY: 0.00 IY: 2.00

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	U-EXPT	U-PRED
0.00	0.50	3.97
3.00	0.34	3.98
6.00	0.83	3.98
9.00	1.53	3.98
12.00	2.30	3.97
15.00	3.36	3.97
18.00	3.62	3.96
21.00	3.52	3.95
24.00	3.34	3.95
27.00	3.24	3.95
30.00	3.77	3.94
33.00	3.76	3.94
36.00	3.91	3.94
39.00	3.50	3.94
42.00	3.44	3.94
45.00	3.60	3.94
48.00	3.83	3.94
51.00	3.90	3.94
54.00	3.91	3.94
57.00	4.05	3.94
60.00	4.19	3.94
63.00	4.19	3.93
66.00	3.92	3.93
69.00	4.00	3.93
72.00	4.05	3.93
75.00	3.94	3.93
78.00	3.62	3.93
81.00	3.97	3.93
84.00	4.08	3.93
87.00	4.21	3.93
90.00	4.14	3.93
93.00	4.29	3.93
96.00	4.35	3.93
99.00	4.19	3.93
102.00	4.18	3.93
105.00	4.67	3.93
108.00	3.82	3.93
111.00	2.83	3.93
114.00	2.23	3.93
117.00	1.93	3.94
120.00	1.45	3.94
123.00	1.62	3.94

Figure D.9. Plots of Experimental Normalized (TN-EXPT) and Predicted Normalized (TN-PRED) Temperatures for the Abdomen.

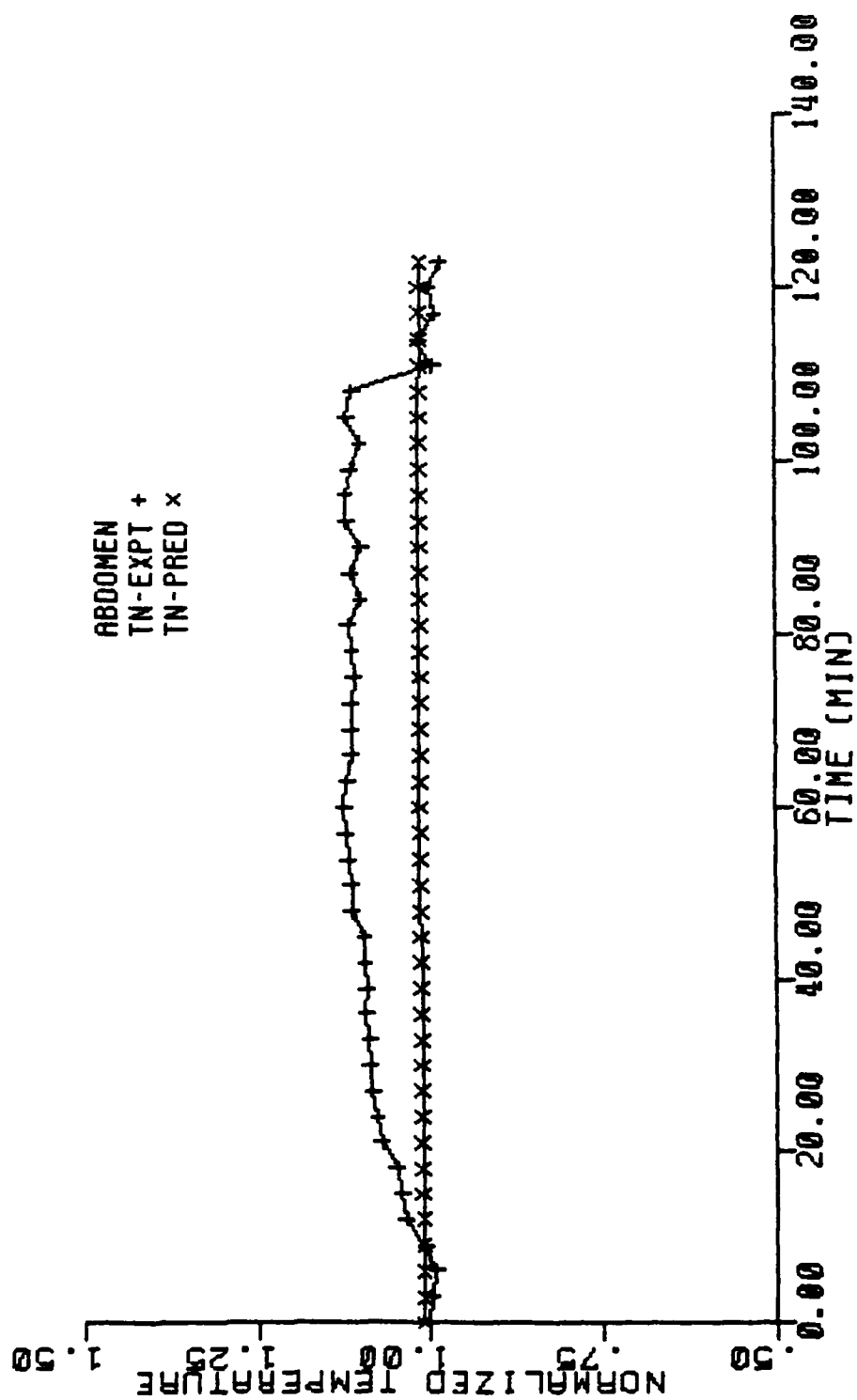


Figure D.9

Table D.14

Experimental (TN-EXPT) and Predicted (TN-PRED) Normalized Temperature Values (Dimensionless) as a Function of Time as Plotted in Figure D.9.

ABDOMEN

LY: 4.00 SY: 0.50 IY: 0.25

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	TN-EXPT	TN-PRED
0.00	1.00	1.01
3.00	1.00	1.01
6.00	0.99	1.01
9.00	1.01	1.01
12.00	1.04	1.01
15.00	1.04	1.01
18.00	1.05	1.01
21.00	1.07	1.01
24.00	1.08	1.01
27.00	1.08	1.01
30.00	1.09	1.01
33.00	1.09	1.01
36.00	1.09	1.01
39.00	1.09	1.01
42.00	1.09	1.01
45.00	1.09	1.01
48.00	1.11	1.01
51.00	1.11	1.01
54.00	1.12	1.01
57.00	1.12	1.01
60.00	1.12	1.01
63.00	1.12	1.01
66.00	1.11	1.01
69.00	1.11	1.01
72.00	1.11	1.01
75.00	1.11	1.01
78.00	1.11	1.01
81.00	1.12	1.01
84.00	1.10	1.01
87.00	1.11	1.01
90.00	1.10	1.01
93.00	1.12	1.01
96.00	1.12	1.01
99.00	1.11	1.01
102.00	1.10	1.01
105.00	1.12	1.01
108.00	1.11	1.01
111.00	0.99	1.01
114.00	1.01	1.01
117.00	0.99	1.01
120.00	1.00	1.01
123.00	0.98	1.01

Figure D.10. Plots of Experimental Biot (BI-EXPT) and Corrected Predicted Biot (BI-PRED) Numbers for the Abdomen.

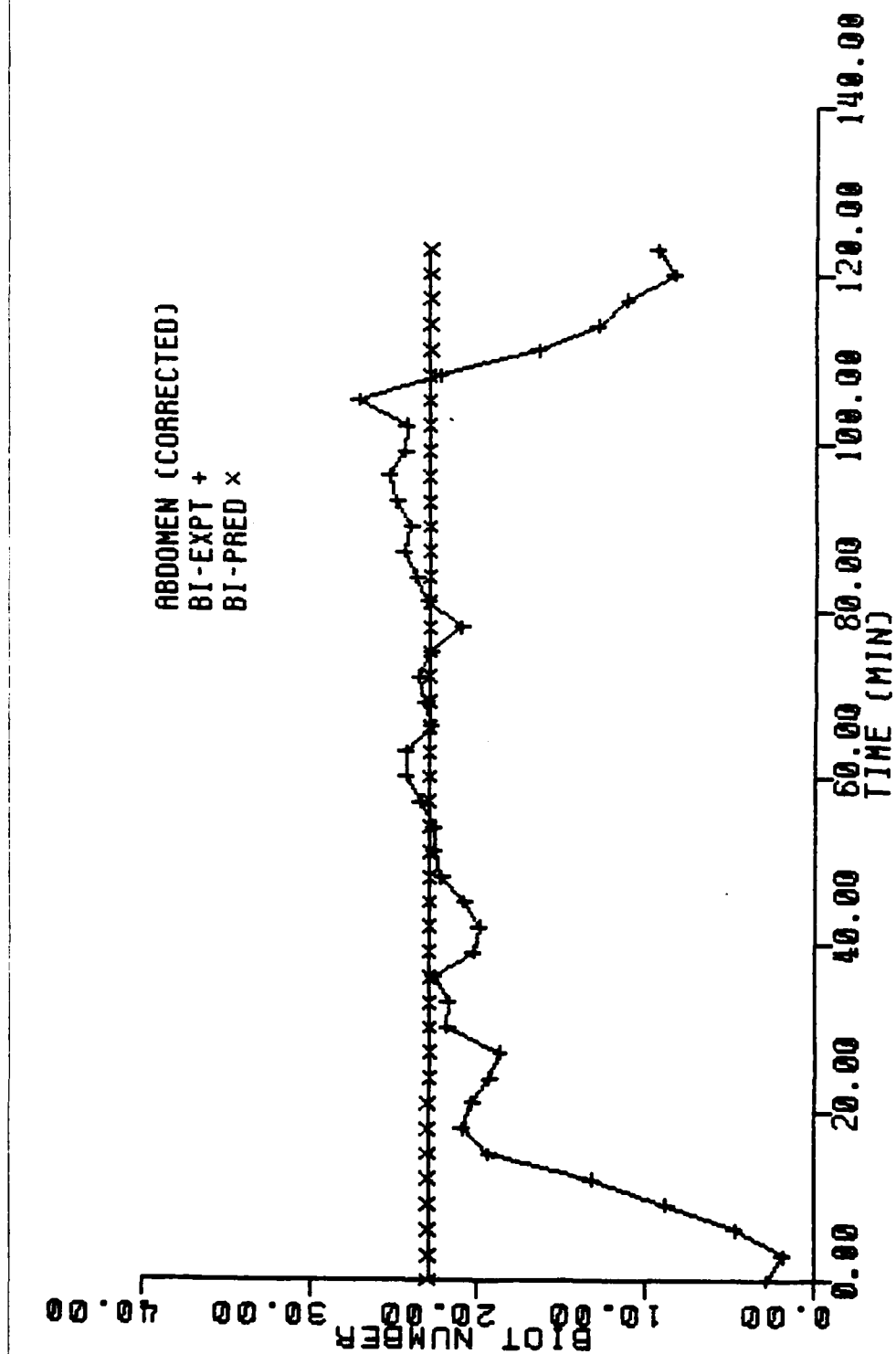


Figure D.10

Table D.15

Experimental (BI-EXPT) and Corrected Predicted (BI-PRED)
Biot Number Values (Dimensionless) as a Function of Time as
Plotted in Figure D.10.

ABDOMEN (CORRECTED)

LY: 4.00 SY: 0.00 IY: 10.00

* INDICATES POINT NOT PLOTTED; ITS VALUE IS ≤ 0 OR $< SY$

TIME	BI-EXPT	BI-PRED
0.00	2.89	22.94
3.00	1.94	22.94
6.00	4.80	22.94
9.00	8.86	22.94
12.00	13.29	22.94
15.00	19.39	22.94
18.00	20.94	22.94
21.00	20.39	22.94
24.00	19.37	22.93
27.00	18.75	22.93
30.00	21.87	22.91
33.00	21.79	22.91
36.00	22.66	22.91
39.00	20.28	22.91
42.00	19.96	22.91
45.00	20.88	22.91
48.00	22.18	22.93
51.00	22.62	22.92
54.00	22.66	22.92
57.00	23.47	22.92
60.00	24.32	22.92
63.00	24.31	22.92
66.00	22.77	22.92
69.00	23.23	22.92
72.00	23.52	22.92
75.00	22.88	22.92
78.00	21.03	22.92
81.00	23.05	22.92
84.00	23.68	22.91
87.00	24.46	22.91
90.00	24.03	22.92
93.00	24.90	22.91
96.00	25.30	22.91
99.00	24.37	22.91
102.00	24.32	22.91
105.00	27.17	22.91
108.00	22.24	22.91
111.00	16.47	22.87
114.00	12.96	22.87
117.00	11.22	22.87
120.00	8.41	22.87
123.00	9.41	22.84



APPENDIX E

INTERACTIVE PROGRAM FLOW CHART

Main Program

Define body dimensions, properties of air, temperature prediction coefficients, suit properties, allowable regional heat flux, correlation between 12 segment Body map and 9 region model, plotting variables, and various dependent variables.

- 1[†] Determine if operator is a research or production user.
(REU=Y-Research, N-Production, X-Terminate program)

IF REU=X STOP

IF REU=N GO TO 4

- 2 Determine if corrected or uncorrected overall heat coefficients are desired.
(If corrected set REU equal to S otherwise do not alter.)

- 3 Determine if debug prints are desired.

- 4 Input ambient depth and units as M,F,P#
(RDU=M-MSW, F-FSW, P-PSIG; RD=Numerical value).

- 5 Verify current sea level garment ensemble properties, collect new values, or re-initialize properties to the program assigned values. (See Function REINIT.)

[†]Numeric labels correspond to the question numbers (1-23) of Appendix D.

6 Verify current regional undergarment thicknesses (in CM), collect new multipliers, or re-initialize multipliers to the program assigned values. (See Function REINIT.)

7 Verify current allowable regional heat fluxes (W/M^2), collect new value, or re-initialize heat fluxes to the program assigned values. (See Function REINIT.)

8 Verify current regional biasing factors (dimensionless), collect new values, or re-initialize biasing factors to the program assigned values. (See Function REINIT.)

9 Input where to write output file.
(T-Screen, F-DMPDAT.LST)

10 Input number of finite difference nodes (NN).

IF REU=N GO TO 14

11 Determine if a comparison of predicted and experimental data is to be performed.
(QCOMP=Y-Perform comparison, N-No comparison)

IF QCOMP=N GO TO 14

12 Input total surface area of the experimental subject (TAR).

13 Input the name of the direct access file containing the experimental data.
(See Appendix A.)

Open direct access data file specified in question 13.

IF QCOMP=Y GO TO 16

14 Input design mean skin temperature (TDMS).

15 Input ambient temperature (TA).

16 Determine region or regions for which to perform calculations (BR).

17 Determine the subject's posture.
(ATT=0-Sitting, 1-Standing, 2-Prone)

Do to Z for each region specified:

Open output file specified in question 9.

IF QCOMP=N GO TO C

Do to X for each experimental time:

Determine TDMS by using Hody's mean skin temperature, Equation 8 of Chapter IV, and TA from the experimental data.

C[†] IF BR≠1 or BR≠9 or (BR≠4 and ATT≠0) GO TO D
(Note: BR=1 and BR=9 imply spheres and are treated as single node regions for all postures. BR=4 and ATT=0 indicate a horizontal cylinder, the thigh, while the subject is sitting. For this case the thigh is treated as a single node region.)

SET J=1

GO TO E

D Do to W J=1 to number of nodes (NN):

E Calculate the nodal overall heat transfer coefficient for the garment ensemble (See function subroutine OHTC.) by:

U = OHTC(J)

IF REU = Y GO TO F

Note: REU = S indicates the research mode with corrected U's,
REU = Y indicates the research mode with uncorrected U's,
REU = N indicates the production mode which always corrects U's.

[†]Alphabetic symbols are used to label all statements except for those which correspond to the questions (1-23) of Appendix D.

$$U = U * BF(BR)$$

BF(BR) = Array containing the empirically derived basing factors.
(See Chapter VII.)

F Sum nodal U values and increment occurrence counter by:

$$US = US + U$$

$$UN = UN + 1.0$$

Calculate the predicted rate of heat loss per unit of nodal surface area (W/M^2) by:

$$QR = U(T1 - TA)$$

T1 = predicted regional skin temperature.

Add the rate of heat loss (watts) from this node to the nodal rate of heat loss sum by:

$$Q(BR) = Q(BR) + (QR * SAM(BR)/NN)$$

Q(BR) = Variable containing running sum for region BR,

SAM = Array containing the regional surface areas of the 9 body regions
(Fig. 1 of Chapter I),

SAM(BR) = Variable containing surface area of region BR,

NN = Number of nodes per region
(question 10).

If BR=1 or BR=9 or (BR=4 and ATT=0) GO TO G

W Continue - to next node.

G Determine regional heat flux (W/M^2) by:

$$Q(BR) = \frac{Q(BR)}{SAM(BR)}$$

Determine regional overall heat transfer coefficient by:

$$U = US/UN$$

Determine regional allowable rate of heat loss (watts) by:

$$QA(BR) = QALL(BR) * SAM(BR)$$

$QALL(BR)$ = Variable containing allowable heat flux (W/M^2) for region BR.

Determine regional predicted heat loss (watts) by:

$$QP(BR) = Q(BR) * SAM(BR)$$

Determine required regional supplementary rate of heat loss (watts) by:

$$QSUPP(BR) = QP(BR) - QA(BR)$$

Determine required regional supplementary heat flux (W/M^2) by:

$$QSUP = Q(BR) - QALL(BR)$$

IF QCOMP=N GO TO X

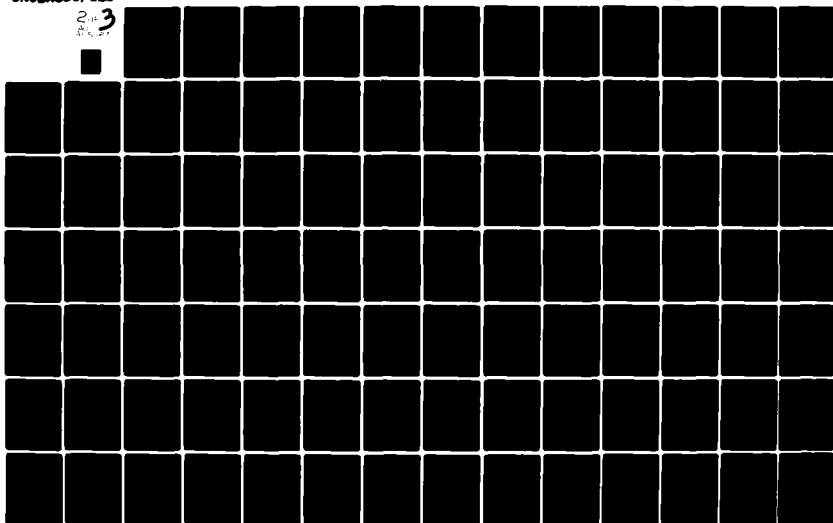
AD-A115 167

DUKE UNIV MEDICAL CENTER DURHAM N C F & HALL LAB FOR--ETC F/8 6/17
THE DEVELOPMENT OF PREDICTIVE ENGINEERING FORMULATIONS FOR DIVE--ETC(U)
1988 C E JOHNSON, J D COLLINS N00014-79-C-0379

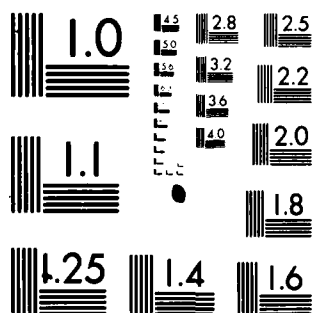
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213



15 16



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

Fill appropriate portions of array P for this experimental time with the regional predicted skin temperature (T1), heat flux (Q(BR)), and overall heat transfer coefficient averaged across all nodes (U), also the design mean skin (TDMS) and ambient (TA) temperatures. Array P is used to preserve values for the possibility of later plotting.

The layout of the plotting array P is as described below.

P(I,1) = Experimental time
 P(I,2) = Experimental temperature (TEXPT)
 P(I,3) = Predicted temperature (T1)
 P(I,4) = Experimental heat flux (QEXPT)
 P(I,5) = Predicted heat flux (Q(BR))
 P(I,6) = Experimental overall heat transfer coefficient (UEXPT)
 P(I,7) = Predicted overall heat transfer coefficient (U)
 P(I,8) = Design mean skin temperature (TDMS)
 P(I,9) = Ambient temperature (TA)

Subscript I is incremented by one each time a new time record[†] is processed (i.e., I=1 indicates time = 0.0, I=2 indicates time = 3.0, I=3 indicates time = 6.0; assuming a time increment of 3.0 minutes).

Initialize summing variables as zero:

TEXPT = 0.0
 SWGT = 0.0
 QEXPT = 0.0
 SWGTQ = 0.0
 UEXPT = 0.0
 SWGTU = 0.0

[†]See Foreword for the connotation of time record.

Do to J L=1,2:

SET M=COR(BR,L)

COR = The array containing the correspondence between the 9 region[†] model man and the 12 segment^{††} Hody man. Each row of array COR corresponds to a body region of the model man.

For BR=3, the abdomen,
COR(3,1) = 3-Hody's abdomen,
COR(3,2) = 5-Hody's lower back.

For BR=6, the feet,
COR(6,1) = 12-Hody's feet,
COR(6,2) = -1.

The -1 indicates that the correspondence is one to one.

IF M=-1 GO TO J

IF EXP(M+13)=0 GO TO H

EXP(M+13) = Experimental temperature for Hody segment M.

Add weighted temperature for segment M into regional sum and increment occurrence counter by:

TEXPT = TEXPT + (EXP(M+13) * WGT(M))

SWGT = SWGT + WGT(M)

WGT(M) = Variable containing the Hody surface area fraction for Hody segment M.

[†]All references to a region indicate one of the 9 regions of the developed model man (Fig. 1 of Chapter I).

^{††}All references to a segment indicate one of the 12 segments used to record the experimental data (Fig. 2 of Chapter I).

H IF EXP(M+1)=0 GO TO I

EXP(M+1) = Experimental rate of heat loss
for Hody segment M.

Add rate of heat loss for segment M into
regional sum and increment occurrence
counter by:

$$QEXPT = QEXPT + EXP(M+1)$$

$$SWGTO = SWGTO + WGT(M)$$

I IF EXP(M+1)=0 OR EXP(M+13)=0 GO TO J

Add overall heat transfer coefficient term
into regional sum and increment occurrence
counter by:

$$UEXPT = UEXPT + \left(\frac{EXP(M+1)}{EXP(M+13) - TA} \right)$$

$$SWGTO = SWGTO + WGT(M)$$

J Continue - to next value of L.

IF SWGT=0 GO TO K

$$TEXPT = \frac{QEXPT}{SWGT}$$

K IF SWGTO=0 GO TO M

$$QEXPT = \frac{QEXPT}{SWGTO * TAR}$$

M IF SWGTU=0 GO TO N

$$U_{EXPT} = \left(\frac{U_{EXPT}}{SWGTU * TAR} \right)$$

N Fill the appropriate portions of array P for this experimental time (P(I,1)) with the regional experimental skin temperature (TEXT in P(I,2)), surface heat flux (QEXPT in P(I,4)), and overall heat transfer coefficient (UEXPT in P(I,6)) for possible later plotting. (See the previous description of array P for details.)

X Continue - to next experimental time.

IF QCOMP=N GO TO Z

18 Determine if plots comparing dimensional experimental and predicted skin temperatures, heat fluxes, or overall heat transfer coefficients are desired.
(PLD= Y-Produce plots, N-No plots)

IF PLD=N GO TO 21

19 Verify assumed y-axis scale factors for the three different dimensional plots or enter new values.

20 Verify assumed x-axis scale factors (one set of scale factors for all three dimensional plots) or enter new values.

Produce three dimensional plots comparing predicted and experimental values of regional skin temperature, heat flux, and overall heat transfer coefficient with the scales defined in questions 19 and 20.

- 21 Determine if plots comparing dimensionless predicted and experimental values of regional normalized skin temperature and Biot number are desired.
(PLN=Y-Produce plots, N-No plots)
- 22 Verify assumed y-axis scale factors for both of the non-dimensional plots or enter new values.
- 23 Verify assumed x-axis scale factors (one set of scale factors for both dimensionless plots) or enter new values.

Produce two dimensionless plots comparing predicted and experimental values of regional normalized skin temperature and Biot number using the scales defined in questions 22 and 23.

Z Close output file specified in question 9.

Continue

GO TO 1

STOP

Function REINIT(I)

Declare values passed to subroutine.

Define default values for the sea level garment ensemble properties (I=1), regional undergarment thicknesses (I=2), allowable regional heat fluxes (I=3), and the regional biasing factors (I=4).

```
IF I=1 GO TO A
IF I=2 GO TO B
IF I=3 GO TO C
IF I=4 GO TO D
```

RETURN

A Push assumed default values of the sea level garment ensemble properties into the appropriate variables which destroys their current contents.

RETURN

B Push assumed default values of the regional undergarment multipliers into the appropriate array variable which destroys their current contents.

RETURN

C Push assumed default values of the allowable regional heat fluxes into the appropriate array variables which destroys their current contents.

RETURN

D Push assumed default values of the regional
biasing factors into the appropriate array
variables which destroys their current
contents.

RETURN

Function OHTC(SN)

Declare variables passed to subroutine.

Calculate depth of regional datum below shoulder level (RDS), depth of start of nodal element below the regional datum (SEP), and the depth of the mid-point of the nodal element below the shoulder reference (RED).

Calculate decimal percent change in undergarment thickness due to the hydrostatic pressure of RED centimeters of seawater (CSW) at the mid-point of the nodal element (DPCT).

Calculate suit entrapped gas temperature (MT). Estimate (MT) by averaging regional skin and ambient temperatures.

Calculate thermal conductivity ratio (CR) of air at sea level and the entrapped gas at depth. See function TC.

Calculate specific thermal resistance of undergarment at depth due to change in thermal conductivity of entrapped gas (SRUGA) by:

$$SRUGA = SRO * CR$$

SRO = Specific thermal resistance (CLO/CM) of undergarment at sea level.

Correct undergarment specific thermal resistance (SRUGA) for effects of hydrostatic suit squeeze (SRUGHA) at a depth of RED (CSW) below the shoulder reference by:

$$SRUGHA = SRUGA (1 - (DR * DPCT))$$

DR = decimal percent change in specific thermal resistance at sea level per decimal percent change in undergarment thickness. (See Chapter V.)

Convert specific thermal resistance (SRUGHA) in CLO/CM to a thermal resistance in $M^2\text{C}/W$ (RUGHAJ).

Note: 1 CLO = $0.18 M^2\text{HR}^\circ\text{C}/\text{KCAL}$ or
1 CLO = $0.155 M^2\text{C}/W$

Calculate radius (R1 in meters) from center line of region to skin surface by region diameter divided by 2.

Calculate radius (R2 in meters) from region center line to undergarment/outer garment interface by:

$$R2 = R1 + (WUGO * TWUGO(BR) * (1 - DPCT))$$

WUGO = Unit undergarment thickness at sea level,

TWUGO = Array containing the regional multipliers indicating the number of layers of unit thickness material per region. Variable BR indicates region of interest.

Calculate radius (R3 in meters) from region center line to outer garment/outer boundary layer interface by R2 plus thickness of outer garment (assumed incompressible).

Calculate undergarment thermal resistance (RUG); corrected for curvature of region and biased to the skin surface area by:

$$RUG = \frac{R1 * RUGHAJ * \ln (R2/R1)}{R2 - R1}$$

(Note: $\ln$ indicates the logarithm to the base e.)

Calculate resistance of outer garment corrected for curvature of region and biased to the skin surface area by:

$$ROG = \frac{R1 * \ln (R3/R2)}{COG}$$

COG = thermal conductivity of outer garment.

Calculate regional temperature of outer garment/outer boundary layer interface (T3 in °C) by Secant Method with function subroutine F(T).

Calculate regional convective heat transfer coefficient for outer boundary layer (CHTC) (See function subroutine CHTC.) at temperature T3.

Calculate regional outer boundary layer resistance (ROBL) biased to the skin surface area by:

$$ROBL = \frac{R1}{R3 * CHTC * T3}$$

Calculate overall heat transfer coefficient
of garment ensemble (OHTC) biased to skin
surface area by:

$$\text{OHTC} = \frac{1.0}{R_{UG} + R_{OG} + R_{OBL}}$$

RETURN

Function F(T)

Note: This function is used by the Secant Method to evaluate if a new estimate (T3) of the temperature of the outer garment's outer surface is correct. If T3 is estimated correctly the value of F, below, will be approximately zero. T3 is the variable name used in the calling module. The call to this function appears as F(T3).

Declare passed variables.

Calculate by using the temperature of the outer garment/outer boundary layer interface (T), which is passed from subroutine OHTC, a value of the energy balance F by:

$$F = \frac{T1 - TA}{RUG + ROG + CHTC(T3, R3)} - \frac{T1 - T}{RUG + ROG}$$

T1 = Regional skin temperature passed from the calling module in common,
 RUG = Resistance of undergarment passed from calling module in common,
 ROG = Resistance of outer garment passed from calling module in common,
 CHTC(T3, R3) = Calls Function CHTC to determine convective heat transfer coefficient at radius R3 and temperature T3.

RETURN

Function CHTC(T3,R3)

Declare passed variables.

Determine for the specified subject posture (ATT) whether the region is a vertical or horizontal cylinder, or a sphere.

If a vertical cylinder, set the characteristic length (CL in meters) to the length of the cylindrical region by:

$$CL = B(BR,3)$$

B(BR,3) = Variable containing length of region BR.

GO TO A

If a horizontal cylinder set the characteristic length (CL in meters) to the diameter of the cylindrical region by:

$$CL = 2.0 * R3$$

R3 = Radius to outer surface of the garment ensemble.

GO TO A

If a sphere, set the characteristic length (CL in meters) to the diameter of the spherical region by:

$$CL = 2.0 * R3$$

A Grashof/Prandtl number product routine:

Calculate film temperature (TF in °C) by:

$$TF = \frac{T3 + TA}{2.0}$$

T3 = Temperature of outer garment/outer boundary layer interface passed from Function OHTC.

TA = Ambient temperature passed from Main program.

Calculate a value for property grouping

ALPHA ($\frac{g\beta\rho^2C_p}{\mu k}$) for water by:

$$\log (ALPHA) = 9.80714 (\log (TF))^{0.12733}$$

$$ALPHA = 10^{\log (ALPHA)}$$

(Equation fits tabularized data for water over temperature range of 4.44 to 21.11 °C, taken from Holman [40].)

Note: Our FORTRAN will not exponentiate a negative number to a non-interger power, thus TF must be ≥ 1.0 since log of a number less than 1.0 is negative.

Calculate Grashof/Prandtl number product (GRPR) by:

$$GRPR = ALPHA * CL^3 * (T3 - TA)$$

T3 = Outside surface temperature,
TA = Ambient temperature.

Branch to equations for determination of Nusselt number for a vertical or horizontal cylinder, or sphere. The development of these empirical equations can be found in Chapter V.

If vertical cylinder, by:

$$\log (\text{NU}) = 9.1934 - 2.4128 (\log (\text{GRPR})) + 0.1817 (\log (\text{GRPR}))^2$$

GO TO B

If horizontal cylinder, by:

$$\log (\text{Nu}) = 0.2486 (\log (\text{GRPR})) - 0.4483$$

GO TO B

If sphere, by:

$$\log (\text{NU}) = 0.46486 (\log (\text{GRPR})) - 1.9726$$

B Computing CHTC from $\log (\text{NU})$:

Calculate thermal conductivity of water boundary layer (CF in W/M°C) by:

$$\text{CF} = 0.56662 + 1.7977 \times 10^{-3} * \text{TF}$$

(Equation fits tabularized data for water over temperature range of 0 to 21.11 °C, taken from Holman [40].)

Calculate convective heat transfer coefficient
CHTC by:

$$\text{CHTC} = \frac{\text{CF} * 10^{\log(\text{Nu})}}{\text{CL}}$$

RETURN

Function TR(TDMS,BR)

This subroutine calculates the regional (Fig. 1 of Chapter I) experimental skin temperature from the experimental data recorded from Hody's 12 segments (Fig. 2 of Chapter I).

Declare passed variables.

Initialize summation variables TR and SWGT to zero.

Do to A L=1,2:

SET J=COR(BR,L)

COR = The array containing the correspondence between the 9 region model man (Fig. 1 of Chapter I) and the 12 segment Hody man (Fig. 2 of Chapter I). Each row of array COR corresponds to a body region of the model man.

For BR=3, the abdomen,
COR(3,1) = 3-Hody's abdomen,
COR(3,2) = 5-Hody's lower back.

For BR=6, the feet,
COR(6,1) = 12-Hody's feet,
COR(6,2) = -1.

The -1 indicates that the correspondence is one to one.

IF J=-1 GO TO A

Add weighted predicted temperature for segment J into regional sum and increment occurrence counter by:

$$TR = TR + PRED(J,TDMS) * WGT(J)$$

$$SWG T = SWGT + WGT(J)$$

PRED = Function subroutine for determining predicted skin temperature for any of Hody's 12 segments,
(See Function PRED(REG,TDMS) for details.)
WGT = Array containing surface area fractions for Hody's 12 segments.

A Continue - to next L value.

Determine weighted average TR by:

$$TR = \frac{TR}{SWG T}$$

RETURN

Function PRED(REG,TSKM)

This function calculates a value for one of Hody's 12 segments by using an empirically verified Kerslake type model. This function is called by Function TR.

Declare passed variables.

Calculate the predicted temperature for the segment specified in REG by:

$$\text{PRED} = \text{TSKM} + (\text{KA}(\text{REG}) * \text{KR})$$

TSKM = Design mean skin temperature,
KA(REG) = Coefficient for the Hody segment specified by REG,
KR = Constant used in the temperature prediction equations developed to predict the skin temperatures at the 12 Hody segments.

The KA(REG) and KR values were derived from linearized experimental data taken from 4 resting subjects in helium oxygen at 20 °C and 200 MSW. The equation for PRED is based on a Kerslake type model. The development of this equation is found in Chapter IV.

RETURN

Function TC(TDC,Z)

Computes the thermal conductivity of air (TC) at a temperature of TDC °C and a pressure of Z MSW from a table of data extracted from the U.S. Navy Diving Gas Manual [42]. A method of two-dimensional linear interpolation described by Carnahan, Luther, and Wilkes, Applied Numerical Methods, p. 63 [49] is used. The table of air data covers a temperature range of -1.11 to 54.44 °C and a pressure range of 14.7 to 200.0 PSIA.

RETURN

Subroutine PLOTD(IR,PSYM,BR)

This subroutine must be called three different times to generate the three graphs of temperature, heat flux, and conductance.

Declare variables passed to subroutine.

The array P as filled in the Main program is passed to this subroutine via a common block statement. Each row corresponds to a specific time. For the Kth row the array is filled as follows.

P(K,1) = Experimental time
P(K,2) = Experimental temperature (TEXPT)
P(K,3) = Predicted temperature (T1)
P(K,4) = Experimental heat flux (QEXPT)
P(K,5) = Predicted heat flux (Q(BR))
P(K,6) = Experimental overall heat
transfer coefficient (UEXPT)
P(K,7) = Predicted overall heat transfer
coefficient (U)
P(K,8) = Design mean skin temperature
(TDMS)
P(K,9) = Ambient temperature (TA)

The passed variable IR indicates the offset into array P at which to find the experimental and predicted pairs of temperatures, heat fluxes, and overall heat transfer coefficients.

Call subroutine SYMBOL to write body region name on plot.
(The subroutines SYMBOL, PLOT, LINE, and others used in this subprogram, which are not outlined in this flow chart, are specialized plotting subroutines detailed in reference 50.)

Call subroutine PLOT to reset plot pointer
to origin.

Do to Z J=1,2:
(J=1-Experimental curve generated,
2-Predicted curve generated)

Do to Y K=1,NREC:

Fill the array XP with the experimental
times to be plotted (Skip times where the
data is less than or equal to zero.) by:

$$XP(K) = P(K,1)$$

Fill the array YP with the dimensional
experimental (J=1) or predicted (J=2) data
of regional skin temperature (IR=1), heat
flux (IR=3), or overall heat transfer
coefficient (IR=5) depending on the current
values of the variables J and IR by:

$$YP(K) = P(K,IR+J)$$

Y Continue - to next time record.

IF J#1 GO TO A

Write output file containing both
experimental and predicted data points
plotted. (Since both the experimental and
predicted values are already in array P,
they are both printed at once.)

A Call subroutine LINE to write curve defined by the ordered pairs contained in XP and YP with the plotting symbol defined in PSYM(J).

Call subroutine SYMBOL to write curve label (i.e., T-EXPT or T-PRED, Q-EXPT or Q-PRED, U-EXPT or U-PRED) contained in array variable LABEL(J) passed in common from the Main program.

Call subroutine SYMBOL to write curve plotting symbol (i.e., '+' - experimental, 'x' - predicted) defined in PSYM(J).

Z Continue to next curve.

RETURN

Subroutine PLOTN(IR,PSYM,BR,RMD)

This subroutine must be called two different times to generate the two graphs of normalized temperature and Biot number.

Declare variables passed to subroutine.

The array P as filled in the Main program is passed to this subroutine via a common block statement. Each row corresponds to a specific time. For the Kth row the array is filled as follows.

P(K,1) = Experimental time
P(K,2) = Experimental temperature (TEXPT)
P(K,3) = Predicted temperature (T1)
P(K,4) = Experimental heat flux (QEXPT)
P(K,5) = Predicted heat flux (Q(BR))
P(K,6) = Experimental overall heat
transfer coefficient (UEXPT)
P(K,7) = Predicted overall heat transfer
coefficient (U)
P(K,8) = Design mean skin temperature
(TDMS)
P(K,9) = Ambient temperature (TA)

The passed variable IR indicates the offset into array P at which to find the experimental and predicted pairs of temperatures, heat fluxes, and overall heat transfer coefficients.

Call subroutine SYMBOL to write body region name on plot.
(The subroutines SYMBOL, PLOT, LINE, and others used in this subprogram, which are not outlined in this flow chart, are specialized plotting subroutines detailed in reference 50.)

Call subroutine PLOT to reset plot pointer to origin.

Determine depth of the mid-point of the region BR below sea level (RMD) by taking into account the posture of the subject. This depth is used to calculate the thermal conductivity of air for use in the Biot number computations.

Do to Z J=1,2:
(J=1-Experimental curve generated,
2-Predicted curve generated)

Do to Y K=1,NREC:

Fill the array XP with the experimental times to be plotted (Skip times where the data is less than or equal to zero.) by:

$$XP(K) = PD(K,1) = P(K,1)$$

Calculate and fill array YP with the dimensionless experimental (J=1) or predicted (J=2) data of regional normalized skin temperature (IR=1) or Biot number (IR=5), depending on the current values of the variables J and IR. Use the following equations to determine the normalized skin temperature and Biot number.

Calculate the regional normalized skin temperature (TN) by:

$$YP(K) = PD(K,J+1) = \frac{P(K,IR+J) - P(K,9)}{P(K,8) - P(K,9)}$$

P(K,IR+J) = Experimental (J=1) or predicted (J=2) regional skin temperature,
 P(K,9) = Experimental ambient temperature,
 P(K,8) = Hody mean skin temperature determined from the 12 experimental temperatures,
 IR = 1.

Calculate the regional Biot numbers (BI) by:

$$YP(K) = PD(K,J+1) = \frac{P(K,IR+J) * (B(BR,2)/2.0)}{TC(TM,RMD)}$$

P(K,IR+J) = Experimental (J=1) or predicted (J=2) overall heat transfer coefficient for region BR,
 TC(TM,RMD) = Estimate of thermal conductivity of the suit entrapped gas. Estimate is based on a mean entrapped gas temperature (TM) at a depth equivalent to the mid-point of the region (RMD),
 TM = The average of the regional predicted skin (T1) and the ambient (TA) temperatures,
 RDM = Depth of the mid-point of the region below sea level,
 B(BR,2) = Diameter of region BR,
 IR = 5.

Y Continue - to next time record.

Call subroutine LINE to write curve defined by the ordered pairs contained in XP and YP with the plotting symbol defined in PSYM(J).

Call subroutine SYMBOL to write curve label
(i.e., TN-EXPT or TN-PRED, BI-EXPT or
BI-PRED) contained in array variable
LABEL(J) passed in common from the Main
program.

Call subroutine SYMBOL to write curve
plotting symbol (i.e., '+' - experimental,
'x' - predicted) defined in PSYM(J).

Z Continue - to next curve.

Write output file containing both
experimental and predicted data points
plotted. Both loops of Z must be completed
since only then will both the experimental
and predicted values be available. (Array
PD is used to store the experimental and
predicted values.)

RETURN

✓
APPENDIX F
INTERACTIVE PROGRAM LISTING

```

REAL KA, KR, COG, Q(10), EXP(29), SCALY(3,3), SCALYN(2,3)
1, LX, SX, IX, LY, SY, IY, LYS, XP(125), YP(125)
2, BF(9), QA(9), QP(9), QSUPP(9), SAM(9), GALL(9)
REAL*8 LABEL(3), BREG(10)
INTEGER FLAG1, FLAG2, COR, BR, ATT, SYM(2)
BYTE RDU, GCOMP, FILE(30), WG, PLD, PLN, DUM, REU, NST
1, PRTL(11), PRT, OUT, PU(2)
COMMON /PREDD/KA(12), KR
1, /BODY/B(9,3), COR(9,2), WGT(12)
2, /TRNOSQ/C(6,7)
3, /SUIT/WUGO, DR, SRO, WOG, COG, TWUGO(9)
4, /DEBUG/FLAG2, LO
5, /OHTCD/RUGHA, RUG, ROG, ROBL, R1, R2, R3, T1, T3, FLAG1
6, Q1A, Q13
7, /PROB/BR, ATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS
8, RDU
9, /PLOT/P(125,9), LX, SX, IX, LY, SY, IY, LYS, LABEL, NREC
1, BREG, XP, YP, PD(125,3), LCL, CH, REU, PRT(13)
2, /MISC/GALL, BF

```

```

C*****
C   NOTE: ALL VALUES FOR ARRAYS ENTERED VIA DATA STATEMENTS
C   ARE ENTERED IN COLUMN MAJOR ORDER!!
C*****

```

```

C
C   ARRAY B - CONTAINS REGIONAL BODY DIMENSIONS
C   !
C   *NOTE* ALL VALUES ARE IN METERS
C   - 1ST COLUMN CONTAINS IDENTIFICATION OF SHAPE
C     -1 IMPLIES SPHERE
C     0 IMPLIES CYLINDER
C     +# IMPLIES CONIC = DIAMETER OF TOP OF CONE
C   - 2ND # IS DIAMETER OF SPHERE, CYLINDER OR
C     BOTTOM OF CONE
C   - 3RD # IS THE HEIGHT OF REGION

```

```

! DIMENSIONAL NUMBERS ENTERED FOR MODEL MAN
! *NOTE* ALL CYLINDERS AND CONES ARE CONNECTED END
! TO END.
! ID# - REGION = SHAPE / ENTERED #'S /
! 1 - HEAD = SPHERE / -1.0,0.206,0.206 /
! 2 - TORSO = CYLINDER / 0.0,0.30,0.353 /
! 3 - ABDOMEN = CYLINDER / 0.0,0.30,0.353 /
! 4 - THIGH = CYLINDER / 0.0,0.15,0.383 /
! 5 - CALF = CYLINDER / 0.0,0.12,0.328 /
! 6 - FOOT = CYLINDER / 0.0,0.15,0.104 /
! 7 - UPPER ARM = CYLINDER / 0.0,0.096,0.223 /
! 8 - LOWER ARM = CYLINDER / 0.0,0.07,0.267 /
! 9 - HAND = SPHERE / -1.0,0.123,0.123 /

```

```

C   ARRAY COR (9,2) CONTAINS THE CORRESPONDENCE BETWEEN
C   OUR 9 REGION MODEL ID #'S AND THE 12 SEGMENT
C   HODY/ZUMRICK MEASUREMENT SYSTEM ID #'S.
C   THE ROW NUMBERS OF THE ARRAY CORRESPOND TO THE

```

! BODY REGION ID'S FOR OUR 9 REGION MAN.
! FOR EXAMPLE: 9 REGION MODEL, REGION TORSO(2)
! CORRESPONDS TO THE 12 SEGMENT MODEL, SEGMENTS
! CHEST(2) AND UPPER BACK (4).

! ROW#	9 REGION MODEL NAME	12 SEGMENT MODEL CORRESPONDING SEGMENTS NAME(ID#) ID #'S ARE IN ARRAY COR(9,2)
! 1	HEAD	HEAD(1), (-1)
! 2	TORSO	CHEST(2), UPPER BACK(4)
! 3	ABDOMEN	ABDOMEN(3), LOWER BACK(5)
! 4	THIGH	FRONT THIGH(8), REAR THIGH(10)
! 5	CALF	FRONT CALF(9), REAR CALF(11)
! 6	FOOT	FOOT(12), (-1)
! 7	UPPER ARM	ARM(6), (-1)
! 8	LOWER ARM	ARM(6), (-1)
! 9	HAND	WRIST(7), (-1)

! NOTE (-1) INDICATES THAT ONLY
! ONE CORRESPONDING SEGMENT IS
! AVAILABLE FROM 12 SEGMENT MODEL

C ARRAY SAM(9) CONTAINS THE REGIONAL SURFACE AREAS OF OUR
! MODEL MAN IN METERS SQUARED (M**2)
DATA B/-1. 0, 0. 0, 0. 0, 0. 0, 0. 0, 0. 0, 0. 0, 0. 0, 0. 0, -1. 0
1, 0. 206, 0. 30, 0. 30, 0. 15, 0. 12, 0. 15, 0. 096, 0. 07, 0. 123
2, 0. 206, 0. 353, 0. 353, 0. 383, 0. 328, 0. 104, 0. 223, 0. 267, 0. 123/
3, COR/1, 2, 3, 8, 9, 12, 6, 6, 7, -1, 4, 5, 10, 11, -1, -1, -1, -1/
4, SAM/0. 1333, 0. 3327, 0. 3327, 0. 3610, 0. 2474, 0. 1334
5, 0. 1490, 0. 1174, 0. 0950/

C
C ARRAY C - CONTAINS THERMAL CONDUCTIVITY DATA FOR AIR
! - AS F(TEMP, PRES)
! - PRESSURES - 14. 7, 30. 0, 50. 0, 100. 0 PSIA
! - TEMPERATURES - 30. 0, 50. 0, 70. 0, 90. 0, 110. 0,
! 130. 0 F

! **NOTE**
! CONDUCTIVITIES HAVE UNITS BTU/SEC FT F
! AND VALUES MUST BE MULTIPLIED BY 1. 0E-6
! DATA TAKEN FROM:
! - U. S. NAVY DIVING GAS MANUAL,
! - NAVSHIPS 0994-003-7010, 1971
! - PAGE T-4 (AIR DATA)

DATA C/0. 0, 14. 7, 30. 0, 50. 0, 100. 0, 200. 0
2, 30. 0, 3. 93, 3. 93, 3. 93, 3. 98, 4. 03
3, 50. 0, 4. 06, 4. 07, 4. 08, 4. 11, 4. 16
4, 70. 0, 4. 19, 4. 20, 4. 21, 4. 24, 4. 29
5, 90. 0, 4. 32, 4. 33, 4. 34, 4. 37, 4. 42
6, 110. 0, 4. 45, 4. 46, 4. 47, 4. 49, 4. 54
7, 130. 0, 4. 58, 4. 59, 4. 59, 4. 62, 4. 66/

C
C ARRAY KA CONTAINS CONSTANTS, A(i)'S, NEEDED FOR THE

! SEGMENTAL TEMPERATURE PREDICTIONS EQUATIONS. THESE
! CONSTANTS WERE DERIVED FROM KERSLAKE'S MODEL. SEE
! TEXT FOR DETAILS.

- C VARIABLE KR IS CONTANT R NEEDED FOR SEGMENTAL
! TEMPERATURE PREDICTIONS.
! THE KR CONSTANT WAS DERIVED FROM A KERSLAKE TYPE MODEL
! SEE TEXT FOR DETAILS OF DERIVATION
! DATA KA/0.36, 0.27, 0.30, 0.52, -0.08, 0.22, -0.64, -0.04,
! -0.16, -0.06, -0.55, -0.86/
! 1, KR/2.946/
- C
C ARRAY GALL (9) CONTAINS THE REGIONAL ALLOWABLE HEAT
! FLUXES(W/M**2) ADAPTED FROM THE DATA OF BURRISS,
! PRINCIPLE INVESTIGATOR, 'STUDY OF THE THERMAL PROCESSES
! FOR MAN IN SPACE', NASA CONTRACT REPORT CR-216.
- C
C ARRAY BF(9) CONTAINS THE REGIONAL BIASING FACTORS USED
! TO MAKE PREDICTED OVERALL HEAT TRANSFER COEFFICIENTS
! AGREE MORE FAVORABLY WITH THE EXPERIMENTAL VALUES.
! PRED OHTC * BF(i) = CORRECTED PRED OHTC
! DATA GALL/23.3, 60.0, 49.7, 42.4, 85.0, 97.0, 98.9, 125.25
! 1, 265.86/
! 2, BF/2.63, 2.63, 2.27, 3.50, 3.21, 12.70, 2.29, 2.19, 3.49/
- C
C DEFINITION OF SUIT THERMAL PROPERTIES AND DIMENSIONS
! WUGO = WIDTH (THICKNESS) OF UNDER GARMENT AT SEA
! LEVEL (CM).
! SRO = SPECIFIC RESISTANCE OF UNDER GARMENT
! AT SEA LEVEL (CLO/CM)
! DR = DECIMAL % CHANGE IN SRO PER DECIMAL % CHANGE
! IN UNDERGARMENT THICKNESS
! (CLO/CM/CLO/CM/CM/CM) (IE: DIMENSIONLESS)
! EXPERIMENTALLY DETERMINED. SEE TEXT FOR
! DETAILS.
! WOG = WIDTH OF OUTER GARMENT (CM) => 1/16 INCH
! COG = THERMAL CONDUCTIVITY OF OUTER GARMENT MATERIAL
! WATTS/M*C)
- C
C TWUGO = ARRAY CONTAINING THE # OF THICKNESSES OF
! UNDERGARMENT MATERIAL FOR EACH REGION.
! EACH LAYER IS 'WUGO' THICK.
- C
C WGT - CONTAINS SURFACE AREA WEIGHTS FOR THE 12 SEGMENT
! BODY MODEL.
! DATA WUGO, SRO, DR, WOG, COG/1.63, 2.27, 0.1175, 0.15875
! 1, 0.17307/

2, TWUGO/1. 0, 1. 0, 1. 0, 1. 0, 1. 0, 2. 0, 1. 0, 1. 0, 1. 0/
 3, WGT/0. 070, 0. 085, 0. 085, 0. 090, 0. 090, 0. 140, 0. 050, 0. 095
 4, 0. 065, 0. 095, 0. 065, 0. 070/

C

C

BREG - ARRAY CONTAIN BODY REGION NAMES FOR PRINT
 ORDERED ACCORDING TO REGION ID #

DATA BREG/'HEAD', 'TORSO', 'ABDOMEN', 'THIGH', 'CALF',
 1'FOOT', 'UP ARM', 'LOW ARM', 'HAND', 'TIME'/

C

C*****

! PLOTTING AND COMPARISON VARIABLES

! SCALY = ARRAY CONTAINS Y AXIS SCALES FOR T, G, AND U
 ! PLOTS

! CONTENTS OF ARRAY SCALY(3, 3)

COLUMN/	1	2	3	
! ROW				
! 1	! 5. 0	! 20. 0	! 4. 0	TEMPERATURES
! 2	! 5. 0	! 0. 0	! 50. 0	HEAT FLUXES
! 3	! 4. 0	! 0. 0	! 4. 0	TRANSFER COEF.

! COLUMN 1 CONTAINS LENGTH OF Y-AXIS

! COLUMN 2 CONTAINS STARTING Y-AXIS VALUE

! COLUMN 3 CONTAINS Y-AXIS INCREMENT

(IE: Y-AXIS UNITS/INCH(CM))

! SCALYN = ARRAY CONTAINS Y AXIS SCALES FOR
 ! NORMALIZED TEMPERATURE AND BIOT # PLOTS
 ! CONTENTS OF ARRAY SCALYN(2, 3)

COLUMN/	1	2	3	
! ROW				
! 1	! 4. 0	! 0. 5	! 0. 25	NORMALIZED TEMPERATURES
! 2	! 4. 0	! 0. 0	! 10. 0	BIOT NUMBERS

! COLUMN 1 CONTAINS LENGTH OF Y-AXIS

! COLUMN 2 CONTAINS STARTING Y-AXIS VALUE

! COLUMN 3 CONTAINS Y-AXIS INCREMENT

(IE: Y-AXIS UNITS/INCH(CM))

! LX = LENGTH OF X-AXIS

! SX = STARTING VALUE FOR X-AXIS

! IX = INCREMENT FOR X-AXIS

! LY = LENGTH OF Y-AXIS

! SY = STARTING VALUE FOR Y-AXIS

! IY = INCREMENT FOR Y-AXIS

! LYS = LENGTH Y-AXIS SAVED

! XP = ARRAY FOR X-AXIS VALUES FOR PLOTTING

! YP = ARRAY FOR Y-AXIS VALUES FOR PLOTTING

! LABEL = ARRAY FOR LEGEND NAMES FOR PLOTS

! P = ARRAY FOR SAVING X AND Y VALUES FOR PLOTTING

! FILE = ARRAY FOR NAME OF FILE CONTAINING EXPERIMENTAL
 ! DATA FOR COMPARISON

! TAR = TOTAL AREA OF EXPERIMENTAL SUBJECT

!GEXPT = SUM OF EXPERIMENTAL Q'S FOR SIMPLE SUM
 !UEXPT = SUM OF EXPERIMENTAL U'S
 !TEXPT = SUM OF EXPERIMENTAL T'S
 !PLD = INDICATES WHETHER DIMENSIONAL PLOTS
 ARE WANTED OR NOT
 !PLN = INDICATES WHETHER NON-DIMENSIONAL PLOTS
 ARE WANTED OR NOT
 !IR = 0, 4, 6. 0= NO LINEARIZED EXPT. PLOTS
 4= PLOT LINEARIZED EXPT. Q'S
 6= PLOT LINEARIZED EXPT. U'S
 !SWGTT = SUM OF HODY WEIGHTS FOR CONVERSION
 FROM HODY'S 12 SEGMENTS TO THE MODEL'S 9
 REGION FORM.
 !SWGTT = SUM OF HODY WEIGHTS FOR CONVERSION
 OF SEGMENTAL EXPERIMENTAL TEMPERATURES
 FROM HODY'S 12 SEGMENTS TO THE MODEL'S 9
 REGION FORM.
 !SWGTTG = SUM OF HODY WEIGHTS FOR CONVERSION
 OF SEGMENTAL EXPERIMENTAL HEAT FLOWS
 FROM HODY'S 12 SEGMENTS TO THE MODEL'S 9
 REGION FORM.
 !SWGTTU = SUM OF HODY WEIGHTS FOR CONVERSION
 OF SEGMENTAL EXPERIMENTAL OVERALL HEAT
 TRANSFER COEFFICIENTS
 FROM HODY'S 12 SEGMENTS TO THE MODEL'S 9
 REGION FORM.
 !LFN = LENGTH OF EXPT. FILE NAME. (NO. OF CHARACTERS)
 !TS = TIME START FOR LINEARIZATION
 !TE = TIME END FOR LINEARIZATION
 !NREC = NUMBER OF EXPT. RECORDS (TIMES) AVAILABLE FOR
 COMPARISON
 !QCOMP = Y OR N, INDICATES DESIRE FOR COMPARISON OF
 EXPERIMENTAL VALUE WITH PREDICTIONS.

!EXP IS THE ARRAY USED TO READ IN EXPERIMENTAL DATA
 VALUES FOR COMPARISON
 !ARRAY Q CONTAINS THE 9 COMPUTED REGIONAL HEAT FLUXES
 !ARRAY GP CONTAINS THE 9 COMPUTED REGIONAL HEAT FLOWS
 !ARRAY GA CONTAINS THE 9 ASSUMED REGIONAL ALLOWABLE
 HEAT FLOWS
 !ARRAY QSUPP CONTAINS THE 9 COMPUTED REQUIRED
 REGIONAL HEAT FLOWS

C-----
 C ARRAY SCALY IS ENTERED INTO THE COMPUTER VIA A DATA
 STATEMENT IN COLUMN MAJOR ORDER AS:
 ! LYT, LYQ, LYU, SYT, SYQ, SYU, IYT, IYQ, IYU
 ! WHERE: LYX => LENGTH OF Y-AXIS
 ! SYX => STARTING VALUE FOR Y-AXIS
 ! IYX => INCREMENTING VALUE FOR Y-AXIS
 ! (X IN THE ABOVE IMPLIES T'S, Q'S, OR
 ! U'S)

C ARRAY SCALN IS ENTERED INTO THE COMPUTER VIA A DATA
 ! STATEMENT IN COLUMN MAJOR ORDER AS:
 ! LYTN, LYBI, SYTN, SYBI, IYTN, IYBN
 ! WHERE: LYXX => LENGTH OF Y-AXIS
 ! SYXX => STARTING VALUE FOR Y-AXIS
 ! IYXX => INCREMENTING VALUE FOR Y-AXIS
 ! (XX IN THE ABOVE IMPLIES TN'S OR BI'S)

C VARIABLES LX, SX, IX ARE ENTERED INTO THE PROGRAM VIA
 ! A DATA STATEMENT AS:
 ! LX, SX, IX
 ! WHERE: LX => LENGTH OF X-AXIS
 ! SX => STARTING VALUE FOR X-AXIS
 ! IX => INCREMENTING VALUE FOR X-AXIS

C SYM IS A VECTOR CONTAINING THE INTEGERS CORRESPONDING
 ! TO THE SYMBOLS TO BE USED FOR THE EXPERIMENTAL AND
 ! PREDICTED VALUES RESPECTIVELY.
 DATA SCALY/5. 0, 5. 0, 4. 0, 20. 0, 0. 0, 0. 0, 4. 0, 50. 0, 4. 0/
 1, SCALYN/4. 0, 4. 0, 0. 5, 0. 0, 0. 25, 10. 0/
 2, LX, SX, IX/7. 0, 0. 0, 20. 0/
 3, SYM/3, 4/

C*****
 C THE FOLLOWING VARIABLES ARE USED AS TEMPORARY VARIABLES
 ! AND HAVE NO PERMANENT MEANING
 ! DUM, I, J, L, M, N

C*****
 ! THIS SYSTEM LEVEL SUBROUTINE CALL IS USED TO ATTACH THE
 ! TERMINAL TO THIS TASK. THIS PREVENTS RETURNS USED TO
 ! TERMINATE RESPONSES FROM BEING INTERPRETED BY THE
 ! OPERATING SYSTEMS MONITOR CONTROL ROUTINE.
 CALL WTG10 ("1420, "5)

C-----
 C MAIN VARIABLES DEFINED IN MODULE MAIN
 ! FLAG2 = DEBUG PRINT FLAG (-1=>YES, 0=>NO)
 ! BR = BODY REGION ID (0-9)
 ! RD = REFERENCE DEPTH => DEPTH BELOW SEA LEVEL
 ! OF SHOULDER LINE (FSW, MSW, PSI)
 ! RDU = INDICATOR OF UNITS OF
 ! (F=FSW, M=MSW, P=PSI)
 ! NN = # OF NODE TO DIVIDE EACH REGION INTO
 ! FOR FINITE DIFFERENCE CALCULATIONS
 ! OUT = VARIABLE CONTAINING DESIRED LOCATION
 ! FOR OUTPUT PRINTS (T=TERMINAL,
 ! F=DR: DMPDAT. LST)
 ! TDMS = TEMPERATURE - MEAN SKIN - AT WHICH TO PERFORM
 ! CALCULATIONS (DESIGN MEAN SKIN TEMPERATURE)
 ! TA = TEMPERATURE - AMBIENT - AT WHICH TO PERFORM
 ! CALCULATIONS
 ! T1 = TEMPERATURE OF THE SKIN SURFACE
 ! ATT = ATTITUDE OF SUBJECT (DIVER)

```

      (0=SITTING, 1=STANDING, 2=LAY HORIZONTAL)
!ITOT  = FLAG VARIABLE INDICATING WHETHER OR NOT
!      DOING ALL REGIONS OR A SINGLE REGION
!      ( -1=>ALL REGIONS, 0=>SINGLE REGION)
!LO    = VARIABLE CONTAINING LOGICAL UNIT #
!      AT WHICH TO PRINT OUTPUT PRINTS
!      (5=>TERMINAL, 3=>DR:DMPDAT.LST)
!U     = VARIABLE CONTAINING RESULTS OF CALCULATION
!      OF OVERALL HEAT TRANSFER COEFFICIENT
!      FOR SPECIFIED NODE OF SELECTED REGION
!US    = VARIABLE CONTAINING RUNNING SUM OF NODAL
!      U'S
!UN    = VARIABLE CONTAINING THE COUNT OF THE
!      NUMBER OF NODES IN THE SUM (US)
!GR    = VARIABLE CONTAINING HEAT LOSS CALCULATED FOR
!      EACH NODE
!GSUP  = REQUIRED SUPPLEMENTARY HEAT FLUX FOR
!      THE REGION OF INTEREST

```

```

C-----
!THE FOLLOWING VARIABLE FOUND IN MODULE MAIN ARE
!DEFINED IN OTHER MODULES (SUBROUTINES, FUNCTIONS)
!DZ, DZV, FLAG1, ROBL, ROG, RUG, RUGHA, R1, R2, R3, T3

```

```

C-----
!INTEGER VARIABLE 'IB' AND ARRAY 'PRTL' ARE BOTH USED
!BY THE OUTPUT PRINTING ROUTINES.
!THESE VARIABLES HAVE BEEN ASSIGNED TO ALLOW MORE
!EFFICIENT USE OF THE FORTRAN CODE

```

```

C-----
DATA PRTL/' ','C','O','R','R','E','C','T','E','D',' ' /
1, IB/'--'/
30  WRITE (5,31)
31  FORMAT ('$ARE YOU A RESEARCH USER ? (Y,N,X) ')
C    THESE VARIABLE ARE BEING PRE-DEFINED FOR THE
C    PRODUCTION MODE.  ALL OF THESE VARIABLE CAN BE
C    DYNAMICALLY MODIFIED IN THE RESEARCH MODE.
    REU='N'
    BR=0
    FLAG2=0
    FLAG1=0
    IR=0
    NN=1
    OUT='T'
    GCOMP='N'
    READ (5,32) REU
32  FORMAT (1A1)
    IF (REU.NE. 'Y'. AND. REU.NE. 'N'. AND. REU.NE. 'X')
      1 GO TO 30
    IF (REU.EQ. 'N') GO TO 44
    IF (REU.EQ. 'X') GO TO 15
    WRITE (5,39)
39  FORMAT ('$DO YOU WISH TO CORRECT PREDICTED '
1, ''U'' VALUES ? (Y/N) ')
    READ (5,32) DUM

```

```

IF (DUM.EQ. 'Y') REU='S'
40 WRITE (5,41)
41 FORMAT ('$DO YOU WISH DEBUG PRINTS: ? (Y/N): ')
READ (5,32) DUM
FLAG2=-1
IF (DUM.EQ. 'Y') GO TO 44
FLAG2=0
44 WRITE (5,6)
6 FORMAT ('$ENTER DEPTH IN (M)SW, (F)SW OR (P)SIG BY '
1, '(M#,F#,P#): [F]', T70)
READ (5,7) RDU, RD
7 FORMAT (1A1, F10.2)
50 WRITE (5,51) (IB, M=1, 39), SRO, WUGO, WOG, COG
51 FORMAT (' ', 39A2, /, ' SEA LEVEL GARMENT ENSEMBLE '
1, 'PROPERTIES', /
2, '01-SPECIFIC THERMAL RESISTANCE OF UNDERGARMENT: '
3, '(CLO/CM)'
4, T58, F8.2, /, ' 2-UNIT THICKNESS OF UNDERGARMENT: '
5, '(CM)'
6, T58, F8.2, /, ' 3-THICKNESS OF OUTER '
7, 'GARMENT: (CM)', T58, F8.4, /, ' 4-THERMAL CONDUCTIVITY'
8, ' OF OUTER GARMENT: (W/M*C)'
9, T58, F8.4, /, '$ENTER (1-4) TO ALTER, (R) '
1, 'TO REINITIALIZE, (X) FOR NO '
2, 'CHANGE: ')
READ (5,32) IT
IF (IT.EQ. 'X') GO TO 58
IF (IT.EQ. 'R') FL4=REINIT(1)
IF (IT.EQ. 'R') GO TO 50
DECODE (1, 53, IT) IT
53 FORMAT (I1)
GO TO (54, 55, 56, 57) IT
GO TO 50
54 WRITE (5,541)
541 FORMAT ('$ ENTER 1 - SPECIFIC THERMAL RESISTANCE '
1, 'OF UNDERGARMENT (CLO/CM): [F] ')
READ (5,542) SRO
542 FORMAT (F10.2)
GO TO 50
55 WRITE (5,551)
551 FORMAT ('$ ENTER 2 - UNIT THICKNESS OF UNDERGARMENT'
1, '(CM): [F] ')
READ (5,552) WUGO
552 FORMAT (F10.3)
GO TO 50
56 WRITE (5,561)
561 FORMAT ('$ ENTER THICKNESS OF OUTER GARMENT (CM): [F] ')
READ (5,562) WOG
562 FORMAT (F10.5)
GO TO 50
57 WRITE (5,571)
571 FORMAT ('$ ENTER THERMAL CONDUCTIVITY OF OUTER GARMENT '
1, '(W/M*C): [F] ')

```

```

572      READ (5,572) COG
      FORMAT (F10.5)
      GO TO 50
58      WRITE (5,580) (IB,M=1,39), (M,BREG(M),TWUGO(M),WUGO
1, (TWUGO(M)*WUGO),M=1,9)
580      FORMAT (' ',39A2,/, ' REGIONAL UNDERGARMENT THICKNESS'
1, ' (CM)',/, '0',T37, 'UNIT',T47, 'ACTUAL',/
2, ' ',T4, 'ID #',T12, 'REGION',T23, 'MULTIPLIER',T35
3, 'THICKNESS',T46, 'THICKNESS',/
4,9(5X,I1,5X,1A8,5X,F6.2, ' * ',F6.2, ' = ',F8.4,/),/
5, '$ENTER (1-9) TO ALTER, (R) TO '
6, 'REINITIALIZE, (X) FOR NO CHANGE: ')
      READ (5,32) IT
      IF (IT.EQ. 'X') GO TO 59
      IF (IT.EQ. 'R') FL4=REINIT(2)
      IF (IT.EQ. 'R') GO TO 58
      DECODE (1,53,IT) IT
      WRITE (5,584) IT,BREG(IT)
584      FORMAT ('$ENTER NEW MULTIPLIER FOR ',I1, '- ',1A8
1, ': [F] ')
      READ (5,585) TWUGO(IT)
585      FORMAT (F6.2)
      GO TO 58
59      WRITE (5,590) (IB,M=1,39), (M,BREG(M),GALL(M),M=1,9)
590      FORMAT (' ',39A2,/, ' ALLOWABLE REGIONAL HEAT FLUX'
1, ' (W/M**2)',/, '0',T32, 'ALLOWABLE',/, ' ',T4, 'ID #'
2,T12, 'REGION',T32, 'HEAT FLUX',/
3,9(' ',5X,I1,5X,1A8,10X,F10.2,/),/
4, '$ENTER (1-9) TO ALTER, (R) TO '
1, 'REINITIALIZE, (X) FOR NO CHANGE: ')
      READ (5,32) IT
      IF (IT.EQ. 'X') GO TO 60
      IF (IT.EQ. 'R') FL4=REINIT(3)
      IF (IT.EQ. 'R') GO TO 59
      DECODE (1,53,IT) IT
      WRITE (5,591) IT
591      FORMAT ('$ENTER ALLOWABLE HEAT FLUX FOR REGION '
1,I1, ' (W/M**2): [F] ')
      READ (5,592) GALL(IT)
592      FORMAT (F10.3)
      GO TO 59
60      WRITE (5,600) (IB,M=1,39), (M,BREG(M),BF(M),M=1,9)
600      FORMAT (' ',39A2,/, ' REGIONAL BIASING FACTORS'
1, ' (DIMENSIONLESS)',/
2, '0',T4, 'ID #'
3,T12, 'REGION',T31, 'BIASING FACTOR',/
4,9(' ',5X,I1,5X,1A8,10X,F10.2,/),/
5, '$ENTER (1-9) TO ALTER, (R) TO '
6, 'REINITIALIZE, (X) FOR NO CHANGE: ')
      READ (5,32) IT
      IF (IT.EQ. 'X') GO TO 609
      IF (IT.EQ. 'R') FL4=REINIT(4)
      IF (IT.EQ. 'R') GO TO 60

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        DECODE (1,53,IT) IT
        WRITE (5,601) IT
601      FORMAT ('$ENTER BIASING FACTOR FOR REGION '
              1, I1, ' (DIMENSIONLESS): [F] ')
        READ (5,602) BF(IT)
602      FORMAT (F10.3)
        GO TO 60
609      WRITE (5,111)
111      FORMAT ('$WRITE OUTPUT FILE WHERE: '
              1, '(T=SCREEN, F=DMPDAT.LST) ')
        READ (5,32) OUT
        WRITE (5,10)
10       FORMAT ('$ENTER # NODES: [I] ')
        READ (5,11) NN
11       FORMAT (I4)
        IF (REV.EQ. 'N') GO TO 43
        WRITE (5,16)
16       FORMAT ('$DO YOU WISH TO COMPARE T, Q, U VALUES WITH '
              1, 'EXP'T DATA: (Y/N) ')
        READ (5,161) QCOMP, CH
161      FORMAT (1A1, : F10.2)
        IF (QCOMP.NE. 'Y') GO TO 43
162      NREC=0
        WRITE (5,1621)
1621     FORMAT ('$ENTER TOTAL SURFACE AREA OF EXP'T '
              1, 'SUBJECT IN M**2: [F] ')
        READ (5,1622) TAR
1622     FORMAT (F10.2)
        IF (TAR.LE.0.0) GO TO 162
163      WRITE (5,1630)
1630     FORMAT ('$ENTER EXPERIMENTAL DATA FILE NAME: ')
        READ (5,1631) LFN, (FILE(L), L=1, LFN)
1631     FORMAT (G, <LFN>A1)
        FILE(LFN+1)="0" !WRITE NULL
        OPEN (UNIT=2, TYPE='OLD', ACCESS='DIRECT',
              1NAME=FILE, FORM='FORMATTED',
              2CARRIAGECONTROL='FORTRAN', READONLY,
              3RECORDSIZE=200, ERR=163)
        READ (2'1,164) NREC
164      FORMAT (I4)
        GO TO 114
43       WRITE (5,431) (IB, M=1,39)
431      FORMAT (' ',39A2,/, '$ENTER DESIGN MEAN SKIN '
              1, 'TEMPERATURE (C): [F]', T65)
        READ (5,433) TDMS
433      FORMAT (F10.3)
4330     WRITE (5,432)
432      FORMAT ('$ENTER AMBIENT TEMPERATURE >= 1.0 C: [F]', T65)
        READ (5,433) TA
        IF (TA.LT.1.0) GO TO 4330
114      WRITE (5,8)
8        FORMAT ('$SELECT BODY REGION (1-9) OR (0) FOR ALL '
              1, 'REGIONS: [I]', T65)

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      READ (5,81) BR
81      FORMAT (I10)
      WRITE (5,82)
82      FORMAT ('$SELECT POSTURE OF SUBJECT (0-SIT,1-STAND, '
      1,'2-PRONE): [I]',T65)
      READ (5,81) ATT
      ITOT=0
      IF (BR.EQ.0) ITOT=-1
      PRT(1)=' '
      PV=2
      IF (REV.EQ.'S'.OR.REV.EQ.'N') GO TO 821
      PRT(2)='U'
      PRT(3)='N'
      PV=4
821     DO 822 M=2,11
      PRT(PV)=PRTL(M)
822     PV=PV+1
      PV=PV-1
      IF (ITOT.EQ.0) GO TO 113
      DO 14 BR=1,9
113     LO=5
      IF (OUT.EQ.'T') GO TO 1130
      LO=3
      OPEN (UNIT=LO,NAME='SY:DMPDAT.LST')
1130     WRITE (LO,11301)
11301    FORMAT ('O')
      IF (GCOMP.NE.'Y') GO TO 1134
      DO 150 I=1,NREC
      READ (2'I+1,1131) EXP
1131     FORMAT (13F8.2,15F6.2,F6.1)
      TA=EXP(27)
      IF (TA.GT.0.0) GO TO 11311
      DO 11310 J=2,7
      P(I,J)=-1.0
11310    CONTINUE
11311    TDMS=0.0
      SWGT=0.0
      DO 1132 M=14,25
C   DROP VALUE & WEIGHT FROM SUM IF 'T' VALUE <= 0.0
      IF (EXP(M).LE.0.0) GO TO 1132
      TDMS=TDMS+(WGT(M-13)*EXP(M))
      SWGT=SWGT+WGT(M-13)
1132     CONTINUE
      IF (SWGT.EQ.0.0) GO TO 11321
      TDMS=TDMS/SWGT
11321    P(I,1)=EXP(1)
      WRITE (LO,1133) EXP(1)
1133     FORMAT (' EXPERIMENTAL TIME: ',F8.2)
1134     LY=' MSW'
      IF (RDU.EQ.'F') LY=' FSW'
      IF (RDU.EQ.'P') LY=' PSI'
      T1=TR(TDMS,BR)
      WRITE (LO,115) BR,ATT,TDMS,RD,LY,TA,BR,T1

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115  FORMAT ('OBODY REGION: ', T56, I10, /
      1, ' POSTURE: 0=SIT, 1=STAND, 2=PRONE ', T56, I10, /
      2, ' DESIGN MEAN SKIN TEMPERATURE: ', T54, F10.2, ' C', /
      3, ' REFERENCE DEPTH: ', T52, F10.2, 1A4, /
      4, ' AMBIENT TEMPERATURE: ', T54, F10.2, ' C', //
      5, ' PREDICTED TEMPERATURE FOR REGION ', I1, ': ', T54
      6, F10.2, ' C')
      IF (NN.EQ.1) GO TO 116
      WRITE (LO, 1151) NN
1151  FORMAT (' NUMBER OF NODES: ', T56, I10)
116   Q(BR)=0.0
      US=0.0
      UN=0.0
      !NOTE: HEAD(1) AND HAND(9) ARE SPHERES AND ARE THUS
      !       MODELED AS HAVING ONE NODE ONLY FOR ALL
      !       ATTITUDES, 0=SIT, 1=STAND, 2=LAY HORT.
      !       THIGH(4) IS A HORIZONTAL CYLINDER FOR
      !       ATT = 0(SIT) AND THUS HAS ONLY ONE NODE
      !       WHEN ATT=1(STAND), 2(LAY HORT) THIGH(4)
      !       MATCHS ALL THE OTHER CYLINDERS IN
      !       ATTITUDE
      IF (BR. NE. 1. AND. BR. NE. 9. AND. (BR. NE. 4. OR. ATT. NE. 0))
      1 GO TO 1161
      J=1
      GO TO 118
      -----
      !NOTE:
      !       P(I,1)=TIME
      !       P(I,2)=T EXPERIMENTAL
      !       P(I,3)=T PREDICTED
      !       P(I,4)=Q EXPERIMENTAL
      !       P(I,5)=Q PREDICTED
      !       P(I,6)=U EXPERIMENTAL
      !       P(I,7)=U PREDICTED
      !       P(I,8)=TDMS
      !       P(I,9)=TA
      -----
1161  DO 13 J=1, NN
      IF (NN.EQ.1) GO TO 118
      IF (J.EQ.1) WRITE (LO, 11611)
11611  FORMAT ('O')
      WRITE (LO, 1162) BR, J
1162  FORMAT (' REGION ', I1, ' NODE ', I4)
118   U=OHTC(J)
      !CHECK TO SEE IF CONVECTIVE HEAT TRANSFER COEFFICIENT
      ! WAS SUCCESSFULLY DETERMINED. FLAG3=0.0 => SUCCESS
      ! FLAG3=1.0 AND FLAG3=2.0 => FAILURE (SEE SUBROUTINE
      ! CHTC FOR DIFFERENCE BETWEEN FLAG3=1.0 AND 2.0)
      IF (FLAG3.GT.0.0) GO TO 148
      !CHECK TO SEE IF OHTC WAS SUCCESSFULLY DETERMINED.
      ! FLAG1 >= -1 SUCCESS, FLAG1 < -1 FAILURE.
      ! (SEE SUBROUTINE OHTC FOR MEANING OF VARIOUS
      ! VALUES OF FLAG1)

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IF (FLAG1.GE.-1) GO TO 1191
IF (FLAG1.NE.-3) GO TO 11801
WRITE (LO,1180) T3,TA
1180 FORMAT (' ESTIMATE OF OUTSIDE SURF. TEMP., ',F5.2
1, ' LESS THAN AMBIENT TEMP., ',F5.2)
GO TO 11803
11801 WRITE (LO,11802) NTOL
11802 FORMAT (' MAXIMUM # OF ITERATIONS (NTOL='
1, I4, ') ALLOWED FOR ESTIMATING', /
2, ' THE OUTSIDE SURFACE TEMPERATURE OF THE '
3, ' ENSEMBLE BY THE SECANT METHOD EXCEEDED')
11803 WRITE (LO,11804)
11804 FORMAT (20X, ' RUN TERMINATED !')
GO TO 148
C IF DOING PRODUCTION MODE RUN (REV=N) THEN MUST APPLY
!BIASING FACTOR BF(BR) TO THE NODAL U VALUE .
!NOTE: ONLY ON NODE IS DEFINED PER REGION IN THE
!PRODUCTION MODE.
1181 IF (REV.EQ. 'N'. OR. REV.EQ. 'S') U=U*BF(BR)
US=US+U
UN=UN+1.0
QR=U*(T1-TA) !WATT/M2
Q(BR)=Q(BR)+(QR*SAM(BR)/FLOAT(NN)) !WATTS
IF (FLAG2.EQ.0) GO TO 119
WRITE (LO,1182) RUG,ROG,ROBL,R1,R2,R3,T1,T3
1, FLAG1,F(T3),CHTC(T3,R3),US,UN,QR,Q(BR)
1182 FORMAT (' RUG,ROG,ROBL',1P,3G15.7, /
1, ' R1,R2,R3',3G15.7, /
2, ' T1,T3',2G15.7,OP, /
3, ' FLAG1,F(T3),CHTC(T3,R3)',17,1P,2G15.7, /
4, ' US,UN',2G15.7, /
5, ' QR,Q(BR)',2G15.7)
C -----
C Q(BR)=Q(BR)+(QR*SAM(BR)/FLOAT(NN)) !WATTS
C NOTE: MULTIPLYING NODAL HEAT FLUX 'QR' BY
C REGIONAL SURFACE AREA 'SAM(BR)' DIVIDED BY THE
C NUMBER OF NODES 'FLOAT(NN)' FORCES THE EXTRA AREA
C CONTRIBUTED BY A CYLINDER BOTTOM AND
C A CYLINDER TOP, REGIONS 6 AND 7
C RESPECTIVELY, TO BE INCLUDED IN THE
C LATTERAL SURFACE AREA. THIS IS
C CONSISTANT WITH THE AREA ASSUMED
C FOR HEAT LOSS IN THE DEVELOPMENT
C OF THE OHTC.
C -----
119 IF (NN.EQ.1) GO TO 126
WRITE (LO,125) (PRT(L),L=1,PV),J,U,J,QR
125 FORMAT (<PV>A1,'PREDICTED OHTC FOR NODE '
1, I4, ': ',T47,F10.2, ' W/M**2*C', /
2, ' PREDICTED HEAT FLUX FOR NODE '
3, I4, ': ',T49,F10.2, ' W/M**2', /)
126 IF (BR.EQ.1. OR. BR.EQ.9. OR. (BR.EQ.4. AND. ATT.EQ.0))
1 GO TO 142

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13      CONTINUE
142     Q(BR)=G(BR)/SAM(BR)          !W/M**2
      U=US/UN
      WRITE (LO,144) (PRT(L),L=1,PV),BR,U,BR,Q(BR),BR,GALL(BR)
144     FORMAT (<PV>A1,'PREDICTED OHTC FOR REGION ',I1,' ',T47
      1,F10.2,' W/M**2*C',/
      2,' PREDICTED UNIT HEAT FLUX FOR REGION ',I1
      3,' ',T49,F10.2,' W/M**2',/, ' ALLOWABLE UNIT HEAT FLUX '
      4,' FOR REGION ',I1,' ',T49,F10.2,' W/M**2')
      GA(BR)=GALL(BR)*SAM(BR)
      GP(BR)=Q(BR)*SAM(BR)
      QSUPP(BR)=GP(BR)-GA(BR)
      QSUP=G(BR)-GALL(BR)
      WRITE (LO,131) QSUP,BR,GP(BR),BR,GA(BR),QSUPP(BR)
131     FORMAT (' REQUIRED SUPPLEMENTARY HEAT FLUX:',T49,F10.2
      1,' W/M**2',/
      2,' PREDICTED RATE OF HEAT LOSS FOR REGION ',I1,' '
      3,T50,F10.2,' WATTS',/, ' ALLOWABLE RATE OF HEAT LOSS '
      4,' FOR REGION ',I1,' ',T50,F10.2,' WATTS',/
      5,' REQUIRED SUPPLEMENTARY HEATING:',T50,F10.2
      6,' WATTS')
      IF (QCOMP.NE.'Y') GO TO 148
      P(I,3)=T1
      P(I,5)=Q(BR)                  !WATTS/M2
      P(I,7)=US/UN                  !WATTS/M2*C
      P(I,8)=TDMS                   !T DES. MEAN SKIN
      P(I,9)=TA                     !T AMBIENT
      TEXPT=0.0
      UEXPT=0.0
      GEXPT=0.0
      SWGTT=0.0
      SWGTG=0.0
      SWGTU=0.0
      DO 1437 L=1,2
      M=COR(BR,L)
      IF (M.EQ.-1) GO TO 1437
C   DROP VALUE & WEIGHT FROM SUM IF 'T' VALUE <= 0.0
      IF (EXP(M+13).LE.0.0) GO TO 1435
      TEXPT=TEXPT+(WGT(M)*EXP(M+13))
      SWGTT=SWGTT+WGT(M)
C   DROP VALUE & WEIGHT FROM SUM IF 'Q' VALUE <= 0.0
1435  IF (EXP(M+1).LE.0.0) GO TO 1436
      GEXPT=GEXPT+EXP(M+1)          !WATTS
      SWGTG=SWGTT+WGT(M)
C   DROP VALUE & WEIGHT FROM SUM IF 'Q' VALUE <= 0.0
1436  IF (EXP(M+1).LE.0.0.OR.EXP(M+13).LE.0.0) GO TO 1437
      UEXPT=UEXPT+(EXP(M+1)/(EXP(M+13)-TA))
      SWGTU=SWGTT+WGT(M)
1437  CONTINUE
      IF (SWGTT.EQ.0.0) GO TO 1438
      TEXPT=TEXPT/SWGTT
1438  IF (SWGTT.LE.0.0) GO TO 1439
      GEXPT=GEXPT/(TAR*SWGTT) !W/M2

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1439 IF (SWG TU. EQ. 0. 0) GO TO 1440
      UEXPT=UEXPT/(SWG TU*TAR)
1440 P(I, 2)=TEXPT
      P(I, 4)=GEXPT
      P(I, 6)=UEXPT
      M=2
      PU(1)=', '
      PU(2)=', '
      IF (COR(BR, 2). EQ. -1) M=1
      IF (M. EQ. 1) PU(1)=', '
      WRITE (LO, 1441) (COR(BR, L), PU(L), L=1, M), BR, TEXPT
      1, (COR(BR, L), PU(L), L=1, M), BR, UEXPT
      2, (COR(BR, L), PU(L), L=1, M), BR, GEXPT
1441 FORMAT (' WGT''ED EXP''T TEMP, SITE(S) '
      1, <M>(I2, A1), ' REGION ', I1, ': ', T54
      2, F10. 2, ' C', /
      3, ' WGT''ED EXP''T QHTC, SITE(S) '
      4, <M>(I2, A1), ' REGION ', I1, ': ', T47
      5, F10. 2, ' W/M**2*C', /
      6, ' WGT''ED EXP''T HEAT FLUX, SITE(S) '
      7, <M>(I2, A1), ' REGION ', I1, ': ', T49
      8, F10. 2, ' W/M**2')
148 WRITE (LO, 149) (IB, M=1, 32)
149 FORMAT (' ', 32A2)
      IF (GCOMP. NE. 'Y') GO TO 360
150 CONTINUE
      IF (ITOT. EQ. -1. AND. BR. GT. 1) GO TO 152
      PRT(1)='('
      LCL=2
      IF (REV. EQ. 'S') GO TO 1501
      PRT(2)='U'
      PRT(3)='N'
      LCL=4
1501 DO 1502 M=2, 10
      PRT(LCL)=PRTL(M)
1502 LCL=LCL+1
      PRT(LCL)=')'
      WRITE (5, 151)
151 FORMAT ('$DO YOU WISH TO PLOT T''S, Q''S, AND U''S? '
      1, '(Y/N) ')
      READ (5, 32) PLD
      IF (PLD. NE. 'Y') GO TO 249
1510 LABEL(1)='T C'
      LABEL(2)='Q W/M2'
      LABEL(3)='U W/M2*C'
      WRITE (5, 1511) (LABEL(M), (SCALY(M, N), N=1, 3), M=1, 3)
1511 FORMAT (' ', 10X, 'Y-AXIS SCALE FACTORS', /
      1, 10X, 7X, 'LY', 10X, 7X, 'SY', 10X, 7X, 'IY', /
      2, 3(1X, A8, 1X, 3(F10. 2, 9X), /), /
      3, '$SELECT: (1=T, 2=Q, 3=U, X=NO MORE CHANGES) ')
      READ (5, 32) IT
      IF (IT. EQ. 'X') GO TO 1517
      DECODE (1, 1514, IT) L

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1514  FORMAT (I1)
      IF (L.LE.0.OR.L.GE.4) GO TO 1517
      WRITE (5,1515) LABEL(L)
1515  FORMAT ('$ENTER',A8,' LY,SY,IY SEPARATED BY COMMAS: '
           1' [F] ')
      READ (5,1516) (SCALY(L,M),M=1,3)
1516  FORMAT (3F10.3)
      GO TO 1510
1517  WRITE (5,1518) LX,SX,IX
1518  FORMAT (' ',10X,'X-AXIS (TIME) SCALE FACTORS',//
           1,10X,7X,'LX',10X,7X,'SX',10X,7X,'IX',/
           2,(1X,'T,G,U MIN',3(F10.2,9X),),/,/
           3,'$CHANGE X-AXIS? (Y/N) ')
      READ (5,32) IT
      IF (IT.NE.'Y') GO TO 152
      WRITE (5,1519)
1519  FORMAT ('$ENTER LX,SX,IX SEPARATED BY COMMAS: [F] ')
      READ (5,1516) LX,SX,IX
      GO TO 1517
152   IF (PLD.NE.'Y') GO TO 249
      DO 200 K=1,3
      CALL NEWDEV (,'DR:COMPAR.VEC',14)
      CALL PLOTST (4,'IN',1)
      CALL PLOT (1.0,1.0,-3)
      CALL AXIS (0.0,0.0,'TIME (MIN)',-10,LX,0.0,SX,IX)
      GO TO (190,170,180) K
190   LY=SCALY(K,1)
      SY=SCALY(K,2)
      IY=SCALY(K,3)
      LYS=LY
      CALL AXIS (0.0,0.0,'TEMPERATURE (C)',+15,LY,90.0,SY,IY)
      LABEL(1)='T-EXPT '
      LABEL(2)='T-PRED '
      OPEN (UNIT=6,NAME='DR:COMPAR.OUT')
      WRITE (6,191) BREG(BR),LY,SY,IY
191   FORMAT (' ',7X,1A8,/, ' ',7X,'LY:',F7.2,5X,'SY:'
           1,F7.2,5X,'IY:'
           2,F7.2,/, ' ',7X,'* INDICATES POINT NOT PLOTTED;'
           3,' ITS VALUE IS <= 0 OR < SY',/
           4,12X,' TIME ',12X,' T-EXPT ',10X
           5,' T-PRED ',/)
      CALL PLOTD(1,SYM,BR)
      CALL PLOTND
      CLOSE (UNIT=6)
      GO TO 200
170   LY=SCALY(K,1)
      SY=SCALY(K,2)
      IY=SCALY(K,3)
      LYS=LY
      CALL AXIS (0.0,0.0,'HEAT FLUX (W/M2) ',+19,LY
           1,90.0,SY,IY)
      LABEL(1)='G-EXPT '
      LABEL(2)='G-PRED '

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OPEN (UNIT=6, NAME='DR: COMPAR. OUT')
WRITE (6, 171) BREQ(BR), (PRT(M), M=1, LCL), LY, SY, IY
171  FORMAT (' ', 7X, 1AB, <LCL>A1, /, ' ', 7X, 'LY: ', F7. 2, 5X, 'SY: '
      1, F7. 2, 5X, 'IY: '
      2, F7. 2, /, ' ', 7X, '* INDICATES POINT NOT PLOTTED; '
      3, ' ITS VALUE IS <= 0 OR < SY', /
      4, 12X, ' TIME ', 12X, ' G-EXPT ', 10X
      5, ' G-PRED ', /)
CALL PLOTD(3, SYM, BR)
CALL PLOTND
CLOSE (UNIT=6)
GO TO 200
180  LY=SCALY(K, 1)
      SY=SCALY(K, 2)
      IY=SCALY(K, 3)
      LYS=LY
      CALL AXIS (0. 0, 0. 0, 'DHTC (W/M2*C)', +13, LY, 90. 0, SY, IY)
      LABEL(1)='U-EXPT '
      LABEL(2)='U-PRED '
      OPEN (UNIT=6, NAME='DR: COMPAR. OUT')
      WRITE (6, 181) BREQ(BR), (PRT(M), M=1, LCL), LY, SY, IY
181  FORMAT (' ', 7X, 1AB, <LCL>A1, /, ' ', 7X, 'LY: ', F7. 2, 5X, 'SY: '
      1, F7. 2, 5X, 'IY: '
      2, F7. 2, /, ' ', 7X, '* INDICATES POINT NOT PLOTTED; '
      3, ' ITS VALUE IS <= 0 OR < SY', /
      4, 12X, ' TIME ', 14X, ' U-EXPT ', 10X
      5, ' U-PRED ', /)
      CALL PLOTD(5, SYM, BR)
      CALL PLOTND
      CLOSE (UNIT=6)
200  CONTINUE
249  IF (ITOT.EQ. -1. AND. BR.GT. 1) GO TO 320
      WRITE (5, 300)
300  FORMAT ('$DO YOU WISH TO PLOT NORMALIZED T''S AND'
      1, ' BIOT #' 'S ? (Y/N) ')
      READ (5, 32) PLN
      IF (PLN.NE. 'Y') GO TO 360
310  LABEL(1)='TN'
      LABEL(2)='BI'
      WRITE (5, 311) (LABEL(M), (SCALYN(M, N), N=1, 3), M=1, 2)
311  FORMAT (' ', 10X, 'Y-AXIS SCALE FACTORS', /
      1, ' ', 8X, 'NON-DIMENSIONAL T''S & U''S', //
      2, 10X, 7X, 'LY', 10X, 7X, 'SY', 10X, 7X, 'IY', /
      3, 2(1X, AB, 1X, 3(F10. 2, 9X), /), /
      4, '$SELECT: (1=TN, 2=BI, X=NO MORE CHANGES) ')
      READ (5, 32) IT
      IF (IT.EQ. 'X') GO TO 317
      DECODE (1, 314, IT) L
314  FORMAT (I1)
      IF (L.LE. 0. OR. L.GE. 4) GO TO 317
      WRITE (5, 315) LABEL(L)
315  FORMAT ('$ENTER', AB, ' LY, SY, IY SEPARATED BY COMMAS: '
      1, ' [F] ')

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316      READ (5,316) (SCALYN(L,M),M=1,3)
      FORMAT (3F10.3)
      GO TO 310
317      WRITE (5,318) LX,SX,IX
318      FORMAT (' ',10X,'X-AXIS (TIME) SCALE FACTORS',//
1,10X,7X,'LX',10X,7X,'SX',10X,7X,'IX',/
2,(1X,'TN,BI MIN',3(F10.2,9X),/),/
3,'$CHANGE X-AXIS? (Y/N) ')
      READ (5,32) IT
      IF (IT.NE.'Y') GO TO 320
      WRITE (5,319)
319      FORMAT ('$ENTER LX,SX,IX SEPARATED BY COMMAS: [R] ')
      READ (5,316) LX,SX,IX
      GO TO 317
320      IF (PLN.NE.'Y') GO TO 360
      DO 350 K=1,2
      CALL NEWDEV (,'DRO: COMPARN. VEC',15)
      CALL PLOTST (4,'IN',1)
      CALL PLOT (1.0,1.0,-3)
      CALL AXIS (0.0,0.0,'TIME (MIN)',-10,LX,0.0,SX,IX)
      GO TO (330,340) K
330      LY=SCALYN(K,1)
      SY=SCALYN(K,2)
      IY=SCALYN(K,3)
      LYS=LY
      CALL AXIS (0.0,0.0,'NORMALIZED TEMPERATURE',+22,LY
1,90.0,SY,IY)
      LABEL(1)='TN-EXPT '
      LABEL(2)='TN-PRED '
      OPEN (UNIT=6,NAME='DR: COMPARN. OUT')
      WRITE (6,331) BREQ(BR),LY,SY,IY
331      FORMAT (' ',7X,1A8,/, ' ',7X,'LY:',F7.2,5X,'SY:'
1,F7.2,5X,'IY:'
2,F7.2,/, ' ',7X,'* INDICATES POINT NOT PLOTTED;'
3,' ITS VALUE IS <= 0 OR < SY',/
4,12X,' TIME ',13X,' TN-EXPT ',10X
5,' TN-PRED ',/)
      CALL PLOTN(1,SYM)
      CALL PLOTND
      CLOSE (UNIT=6)
      GO TO 350
340      LY=SCALYN(K,1)
      SY=SCALYN(K,2)
      IY=SCALYN(K,3)
      LYS=LY
      CALL AXIS (0.0,0.0,'BIOT NUMBER',+11,LY
1,90.0,SY,IY)
      LABEL(1)='BI-EXPT '
      LABEL(2)='BI-PRED '
      OPEN (UNIT=6,NAME='DR: COMPARN. OUT')
      WRITE (6,341) BREQ(BR),(PRT(M),M=1,LCL),LY,SY,IY
341      FORMAT (' ',7X,1A8,<LCL>A1,/, ' ',7X,'LY:',F7.2,5X,'SY:'
1,F7.2,5X,'IY:'

```

```

2,F7.2,/,',',7X,'* INDICATES POINT NOT PLOTTED; '
3,' ITS VALUE IS <= 0 OR < SY',/
4,12X,' TIME ',13X,' BI-EXPT ',10X
5,' BI-PRED ',/)
CALL PLOTN(5,SYM)
CALL PLOTND
CLOSE (UNIT=6)
350 CONTINUE
360 IF (LO.EQ.5) GO TO 361
    CLOSE (UNIT=LO)
361 IF (ITOT.EQ.0) GO TO 15
14 CONTINUE
15 CLOSE (UNIT=2,DISPOSE='SAVE')
    IF (REV.EQ.'X') GO TO 362
    GO TO 30
C*****
!THIS CALL TO A SYSTEM LEVEL SUBROUTINE IS
!USED TO DE-ATTACH THE TERMINAL. SEE
!COMMENT AT TOP OF CODE ABOUT INITIAL
!CALL TO 'WTGIO'
362 CALL WTGIO ("2000,"5)
C*****
STOP
END

```

```
FUNCTION REINIT(I)
REAL A(5),B(5),C(9),D(9),E(9),F(9),G(9),H(9)
COMMON /SUIT/A,C
1, /MISC/E,G
DATA B/1. 63, 0. 1175, 2. 27, 0. 15875, 0. 17307/
1, D/1. 0, 1. 0, 1. 0, 1. 0, 1. 0, 2. 0, 1. 0, 1. 0, 1. 0/
2, F/23. 3, 60. 0, 49. 7, 42. 4, 85. 0, 97. 0, 98. 9, 125. 25
3, 265. 86/
4, H/2. 56, 2. 56, 2. 22, 3. 45, 3. 13, 12. 50, 2. 27, 2. 17, 3. 45/
GO TO (10, 20, 30, 40) I
10 DO 11 J=1, 5
   A(J)=B(J)
11 CONTINUE
   GO TO 100
20 DO 21 J=1, 9
   C(J)=D(J)
21 CONTINUE
   GO TO 100
30 DO 31 J=1, 9
   E(J)=F(J)
31 CONTINUE
   GO TO 100
40 DO 41 J=1, 9
   G(J)=H(J)
41 CONTINUE
100 REINIT=I
   RETURN
   END
```

REAL FUNCTION OHTC(SN)

C-----

! THIS FUNCTION SYNTHESIZES THE PRESSURE AND TEMPERATURE
! DATA AND PRODUCES A VALUE FOR THE OVERALL HEAT TRANSFER
! COEFFICIENT IN WATTS/SEC*C*(M**2) FOR THE GARMENT
! ENSEMBLE.

! THE GARMENT ASSUMED IS THE NAVY'S DIVER THERMAL
! PROTECTION ENSEMBLE

! THE UNDERGARMENT IS MODELED AS DESCRIBED IN THE TEXT.

! THE OUTER GARMENT IS MODELED AS A SOLID SLAB OF
! NEOPRENE OF THICKNESS EQUAL TO OUTER GARMENT THICKNESS.

! THE HEAT TRANSFER COEFFICIENT FOR THE OUTER BOUNDARY
! LAYER IS DETERMINED FROM EQUATIONS DERIVED FROM
! EXPERIMENTAL DATA. (SEE TEXT FOR DETAILS)

C-----

C OHTC

VARIABLES DEFINED IN MODULE OHTC

RDS	= REGIONAL DATUM START=> REGION DEPTH BELOW SHOULDER REFERENCE (RDS=0.0 IF LAYING HORIZONTAL)
CR	= CONDUCTIVITY RATIO=> RATIO OF THERMAL CONDUCTIVITIES OF AIR AT (0 MSW, 21.1 C) AND THE SUIT ENTRAPPED GAS AT AMBIENT DEPTH AND PRESSURE.
DPCT	= DECIMAL % CHANGE IN THINSULATE THICKNESS AS A FUNCTION OF HYDROSTATIC PRESSURE (DEPTH BELOW SHOULDERS)
DZ	= NODAL DISTANCE INCREMENT. DISTANCE BETWEEN NODES IN FINITE DIFFERENCE SOLUTION FOR EACH REGION. EACH CYLINDRICAL REGION IS DIVIDED INTO NODES ALONG IT'S LENGTH ONLY. SPHERES ARE TREATED AS HAVING A SINGLE NODE AT ALL TIMES.
DZV	= NODAL DEPTH INCREMENT. DEPTH CHANGE CAUSED BY EACH NODE WHEN REGION IS VERTICAL. WHEN THE REGION IS HORIZONTAL THE NODES STEP OUTWARD IN THE HORIZONTAL DIRECTION. WHEN THE REGION IS VERTICAL THE NODES STEP DOWNWARD IN THE VERTICAL PLANE.
EDS	= ELEMENT DISTANCE FROM SEA LEVEL, ELEMENT IMPLIES DIFFERENTIAL ELEMENT OF FINITE DIFFERENCE EQUATIONS. IE: DEPTH BELOW SEA LEVEL TO THE ELEMENT OF INTEREST)
SEP	= START OF NODAL ELEMENT POSITION, DISTANCE FROM THE STARTING END OF THE REGION TO THE START OF THE NODAL ELEMENT.
SEPV	= STARTING DEPTH OF THE NODAL ELEMENT FROM BEGINNING DEPTH OF THE REGION
MT	= MEAN TEMPERATURE BETW. AMBIENT AND THE SKIN SURFACE. ESTIMATED TEMPERATURE OF THE GAS ENTRAPPED IN THE UNDERGARMENT.
RDM	= REFERENCE DEPTH (RD) CONVERTED TO METERS OF SEA WATER. (RD => DEPTH FROM SEA LEVEL TO

SHOULDERS)

RED = REGIONAL ELEMENT DEPTH, DEPTH BELOW SHOULDERS TO MID-POINT OF THE ELEMENT OF INTEREST.
(NOTE: IF SUBJECT LAYING HORIZONTAL (ATT=2) THEN RED=0.0)

ROBL = THERMAL RESISTANCE DUE TO THE PRESENCE OF THE BOUNDARY LAYER ON THE OUTSIDE SURFACE OF THE OUTER GARMENT

ROG = THERMAL RESISTANCE DUE TO THE PRESENCE OF THE OUTER GARMENT

RUG = THERMAL RESISTANCE DUE TO THE PRESENCE OF THE UNDER GARMENT

SRUGA = SPECIFIC THERMAL RESISTANCE OF THE UNDERGARMENT DUE TO THE ENTRAPPED GAS AT THE AMBIENT TEMPERATURE AND PRESSURE ONLY.

SRUGHA = SPECIFIC THERMAL RESISTANCE OF THE UNDERGARMENT DUE TO BOTH HYDROSTATIC SQUEEZE AND THE AMBIENT GAS AT DEPTH

RUGHA = THERMAL RESISTANCE OF THE UNDER GARMENT DUE TO BOTH HYDROSTATIC SQUEEZE AND THE AMBIENT GAS AT DEPTH (IN UNITS OF CLO'S)

RUGHAJ = THERMAL RESISTANCE OF THE UNDER GARMENT, RUGHA, CONVERTED FROM CLO'S TO $\text{SEC} \cdot \text{C} \cdot \text{M}^2 / \text{J}$ OR $\text{C} \cdot \text{M}^2 / \text{WATT}$

R1 = RADIUS FROM CENTER OF CYLINDER/SPHERE TO EDGE OF THE CYLINDER/SPHERE (M)

R2 = RADIUS FROM CENTER OF CYLINDER/SPHERE TO OUTSIDE EDGE OF THE UNDERGARMENT (M)

R3 = RADIUS FROM CENTER OF CYLINDER/SPHERE TO OUTSIDE EDGE OF OUTER GARMENT (M)

TR2 = THICKNESS OF THE UNDERGARMENT, WUGO, AT DEPTH THICKNESS REDUCED DUE TO HYDROSTATIC SQUEEZE

T3 = TEMPERATURE OF THE OUTER SURFACE OF THE OF THE OUTER GARMENT

NOTE FLAG1, FTOL, TTOL, NTOL, AND REAL FUNCTION F ARE ALL INVOLVED IN FINDING THE OUTSIDE SURFACE TEMPERATURE, T3, OF THE OUTER GARMENT USING THE SECANT METHOD OF FINDING THE REAL ROOTS OF THE FUNCTION F.

FLAG1 = FLAG INDICATING RESULTS OF THE SECANT METHOD FOR FINDING THE OUTSIDE SURFACE TEMP. OF THE OUTER GARMENT

- = -3 => ESTIMATE OF OUTSIDE SURFACE TEMP. > OR = AMBIENT TEMPERATURE
- = -2 => MAX ALLOWED NUMBER OF ITERATIONS ,NTOL, EXCEEDED.
- = -1 => VALUE OF FUNCTION F AT NEW TEMP. EQUALS VALUE OF F AT OLD TEMP.
- = 1 => COMPUTED CHANGE IN TEMPERATURE LESS THAN OR EQUAL TO MINIMUM ALLOWED TEMPERATURE SPECIFIED (TTOL).
- = 2 => NEW VALUE OF FUNCTION F LESS THAN OR EQUAL TO MINIMUM ALLOWED VALUE ,FTOL.

FTOL = MINIMUM ALLOWED VALUE OF THE FUNCTION F

```

TTOL  = MINIMUM ALLOWED VALUE FOR THE TEMPERATURE STEP
        AT EACH ITERATION
NTOL  = MAXIMUM ALLOWED NUMBER OF STEPS THE SECANT
        PROCEDURE CAN TAKE
TN1   = NEW ESTIMATE OF THE TEMPERATURE
TNO   = OLD ESTIMATE OF THE TEMPERATURE
DT    = DIFFERENCE BETW. OLD AND NEW TEMPERATURE
        ESTIMATES
B     = ARRAY CONTAINING BODY DIMENSIONS FOR THE 9
        REGION MODEL MAN.
COR   = ARRAY CONTAINING THE CORRESPONDENCE BETWEEN
        THE 9 REGION AND 12 SEGMENT MODELS
WGT   = ARRAY CONTAINING THE 12 SEGMENTAL BODY
        SURFACE AREA WEIGHTS.
*NOTE* THE FOLLOWING VARIABLES USED IN THIS MODULE
WERE DEFINED IN MODULE - MAIN
        ATT, BR, COG, DR, FLAG2, LO, NN, RD, RDU, SRO, TA,
        TDMS, WOG, WUGO, TWUGO

```

```

*NOTE* THE FOLLOWING VARIABLES USED IN THIS MODULE
ARE TEMPORARY VARIABLE AND HAVE NO PERMANENT MEANING
I, N

```

```

INTEGER ATT, BR, SN, FLAG2, FLAG1, COR

```

```

REAL MT

```

```

BYTE RDU

```

```

COMMON /BODY/B(9,3),COR(9,2),WGT(12)

```

```

1, /DEBUG/FLAG2, LO

```

```

2, /OHTCD/RUGHA, RUG, ROG, ROBL, R1, R2, R3, T1, T3, FLAG1

```

```

3, Q1A, Q13

```

```

4, /PROB/BR, ATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS

```

```

5, RDU

```

```

6, /SUIT/WUGO, DR, SRO, WOG, COG, TWUGO(9)

```

```

-----
!NTOL, FTOL, TTOL ARE TOLERANCE LIMITS USED IN FINDING
!T3 BY THE SECANT METHOD SUCH THAT F(T3)~0:

```

```

!NTOL=> MAXIMUM NUMBER OF ITERATIONS ALLOWED

```

```

!FTOL=> ZERO TOLERANCE. IF F(T3) IS <= FTOL

```

```

! THEN F(T3)~0

```

```

!TTOL=> ZERO TOLERANCE FOR THE DIFFERENCE BETWEEN
!T3(NEW) AND T3(OLD).

```

```

! IF (T3(NEW)-T3(OLD)) <= TTOL THEN DIFFERENCE IS
! ASSUMED ~ 0

```

```

DATA NTOL, FTOL, TTOL/300, 1.0E-7, 1.0E-3/

```

```

-----
RDS=0.0

```

```

RED=0.0

```

```

DPCT=0.0

```

```

IF (ATT.EQ.2) GO TO 13 !2=PRONE

```

```

! ATT=0 OR ATT=1 (SIT, STAND)

```

```

IF (BR.GT.1) GO TO 10

```

```

RDS=B(BR,2)*(-1.0)

```

```

GO TO 13

```

```

10

```

```

IF (BR.EQ.2) GO TO 13

```

```

N=2
11 IF (BR. GE. 7. AND. BR. LE. 9) N=7
   IF (BR. EQ. 7) GO TO 13
   DO 12 I=N, BR-1
   IF (I. EQ. 4. AND. ATT. EQ. 0) GO TO 110
   RDS=RDS+B(I, 3)
   GO TO 12
110 RDS=RDS+(B(I, 2)/2. 0)
12. CONTINUE
   IF (BR. NE. 4. OR. ATT. NE. 0) GO TO 13
   !BR=4 AND ATT=0
   RDS=RDS-(B(BR, 2)/2. 0)
13 IF (BR. NE. 1. AND. BR. NE. 9) GO TO 131
   !BR=1 OR BR=9
   DZ=B(BR, 2)
   SEP=0. 0
   SEPV=0. 0
   DZV=B(BR, 2)
   IF (ATT. EQ. 2) DZV=0. 0
   GO TO 14
131 DZ=B(BR, 3)/FLOAT(NN)
   SEP=DZ*FLOAT(SN-1)
   DZV=B(BR, 3)/FLOAT(NN)
   IF (ATT. EQ. 2) DZV=0. 0
   IF (ATT. EQ. 0. AND. BR. EQ. 4) DZV=B(BR, 2)
   SEPV=DZV*FLOAT(SN-1)
   IF (ATT. EQ. 2) SEPV=0. 0
   IF (ATT. EQ. 0. AND. BR. EQ. 4) SEPV=0. 0
14 RDM=RD
   IF (RDU. NE. 'P') GO TO 15
   RDM=RD/1. 461 !1. 461 PSI/MSW
15 IF (RDU. NE. 'F') GO TO 16
   RDM=RD*0. 3048 !0. 3048 MSW/FSW
16 IF (ATT. EQ. 2) GO TO 20
   RED=RDS+SEPV+DZV/2. 0
   IF (BR. EQ. 1) GO TO 20
   IF (RED. GT. 0. 1711) GO TO 17
   DPCT=2. 358E-2*RED*100. 0
   GO TO 20
   !DPCT=>DECIMAL PERCENT CHANGE IN THICKNESS
   !**NOTE** THE MULTIPLICATION OF RED BY 100. 0 IS TO
   ! CONVERT THE UNITS FROM METERS TO CENTIMETERS
17 DPCT=0. 343+(3. 784E-3*RED*100. 0)-
   1(1. 345E-5*((RED*100. 0)**2))
   !TR=ESTIMATED REGIONAL TEMP. (12 POINT MODEL CONVERTED
   ! TO 9 POINT MODEL)
20 MT=(T1+TA)/2. 0
   EDS=RDM+RED
   CR=TC(21. 1, 0)/TC(MT, EDS) !CONDUCTIVITY RATIO
21 SRUGA=(SR0*CR)
   SRUGHA=SRUGA*(1. 0-DR*DPCT)
   RUGHA=(SRUGHA*WUGO*TWUGO(BR))*(1. 0-DPCT) !CLO'S
   !

```

```

! ** NOTE **
! RUGHA IS IN CLO'S
! RUGHAJ IS RUGHA CONVERTED TO (SEC*C*M2/J)=(C*M2/WATT)
!
RUGHAJ=RUGHA*0.15477      !0.15477 M2*C/WATT/CLO
IF (FLAG2.EQ.0) GO TO 30
WRITE (LD,22) DZ,DZV,SEP,SEPV,RDM,RED,DPCT
1, T1,MT,EDS,TC(21.1,0),TC(MT,EDS),CR
2, SRUGA,SRUGHA,RUGHA,RUGHAJ
22 FORMAT (' DZ,DZV',1P,2G15.7, /
1, ' SEP,SEPV',2G15.7, /
2, ' RDM,RED,DPCT',3G15.7, /
3, ' T1,MT,EDS',3G15.7, /
4, ' TC(21.1,0),TC(MT,EDS)',2G15.7,/, ' CR',G15.7
5, ' SRUGA,SRUGHA',2G15.7, /
6, ' RUGHA',G15.7, 'CLO RUGHAJ',G15.7
7, 'M2*C/WATT')
30 R1=B(BR,2)/2.0          !M
TR2=(WUGO*TWUGO(BR)*(1.0-DPCT))/100.0 !M
R2=R1+TR2                 !M
R3=R2+(WOG/100.0)         !M
RUG=R1*RUGHAJ*LOG(R2/R1)/TR2 !M2*C/WATT
ROG=R1*LOG(R3/R2)/COG     !M2*C/WATT
!*****
! USING SECANT METHOD TO FIND TEMPERATURE OF OUTSIDE
! SURFACE OF OUTER GARMENT (T3).
! ASSUME (T1+TA)/2.0 <= T3 <= TA
!*****
!*****
! TA+(TA*0.01) USED AS INITIAL END POINT, TO AVOID
! DETERMINATION OF 'GRPR' PRODUCT WHEN THE WALL
! TEMPERATURE = AMBIENT TEMPERATURE
TNO=TA+(TA*0.01)
!*****
TN1=(T1+TA)/2.0
IF (TN1.LE.TA) GO TO 430
N=1
DT=TN1-TNO
40 N=N+1
IF (N.GT.NTOL) GO TO 45
FO=F(TNO)
F1=F(TN1)
IF (FLAG3.GT.0.0) RETURN
IF (ABS(F1).LE.FTOL) GO TO 41
IF ((F1-FO).EQ.0.0) GO TO 44
DT=F1*DT/(FO-F1)
TNO=TN1
TN1=TN1+DT
IF (TN1.LE.TA) GO TO 430
IF (ABS(DT).LE.TTOL) GO TO 42
GO TO 40
41 FLAG1=2          !FTOL SATISFIED

```

```
GO TO 43
42  FLAG1=1          !TTOL SATISFIED
43  T3=TN1
   IF (T3.GE.TA) GO TO 431
430  FLAG1=-3
   GO TO 44
431  ROBL=R1/(R3*CHTC(T3,R3))
   OHTC=1.0/(RUG+ROG+ROBL)
   GO TO 46
44  FLAG1=-1          !F(TN1)-F(TN0) < 0
   GO TO 46
45  FLAG1=-2          !NTOL EXCEEDED
46  IF (FLAG2.EQ.0) GO TO 47
   TMP=F(TN1)
   WRITE (LO,461) T3,DT,TN1,TMP,Q1A,Q13
461  FORMAT ('  T3,DT,TN1',1P,3G15.7, /
1, '  F(TN1),Q1A,Q13',3G15.7)
47  RETURN
   END
```

REAL FUNCTION F(T)

C-----
 C F(T) VARIABLES DEFINE IN MODULE F(T)
 !THIS MODULE IS A FUNCTION SUBROUTINE DEFINING
 !THE FUNCTION TO BE SOLVED SUCH THAT $F(T) \approx 0$.
 !THE FUNCTION RELATES THE HEAT LOSS THRU THE
 !COMPLETE ENSEMBLE TO THAT THRU THE UNDER GARMENT
 !AND THE OUTER GARMENT. THE UNKNOWN IN THIS
 !EQUATION IS THE TEMPERATURE AT THE OUTSIDE
 !SURFACE OF THE OUTER GARMENT.
 !THE VALUE OF T3 PASSED AS T IS SUBSTITUTED INTO THE
 !EQUATION FOR F(T) AND THE CALCULATED VALUE IS
 !PASSED BACK FOR USE IN THE SECANT METHOD OF ESTIMATING
 !T3

C-----
 C VARIABLES NEEDED FOR CALCULATION OF F(T)
 !C = FUNCTION SUBROUTINE FOR CALCULATING THE
 ! COEFFICIENT OF HEAT TRANSFER THRU THE FREE
 ! CONVECTION BOUNDARY LAYER
 !IBR = BODY REGION OF INTEREST, BR, PASSED TO THE
 ! SUBROUTINE
 !ROG = THERMAL RESISTANCE OF OUTER GARMENT
 !RUG = THERMAL RESISTANCE OF UNDER GARMENT
 !T = ARGUMENT PASSED TO FUNCTION, ESTIMATE
 ! OF T3 TEMPERATURE OF OUTSIDE SURFACE OF
 ! THE OUTER GARMENT
 !TA = TEMPERATURE - AMBIENT
 !T1 = TEMPERATURE OF THE CYLINDER/SPHERE SURFACE
 !T3 = TEMPERATURE OF THE OUTSIDE SURFACE OF THE
 ! OUTER GARMENT
 !R1 = RADIUS TO REGION SURFACE/INNER GARMENT
 ! INTERFACE
 !R3 = RADIUS TO OUTER GARMENT/FLUID BOUNDARY LAYER
 ! INTERFACE

C-----
 C *NOTE* THE FOLOWING VARIABLE ARE DEFINED IN PREVIOUS MODULES
 !DZ, DZV, FLAG1, IATT, NN, RD, RDU, RUGHA, R1, R2, R3, TDMS

C-----
 BYTE RDU
 INTEGER FLAG1
 COMMON /OHTCD/RUGHA, RUG, ROG, ROBL, R1, R2, R3, T1, T3, FLAG1
 1, Q1A, Q13
 2, /PROB/IBR, IATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS
 3, RDU
 HC=CHTC(T, R3)
 IF (FLAG3.GT.0.0) RETURN
 Q1A=(T1-TA)/(RUG+ROG+(R1/(R3*HC)))
 Q13=(T1-T)/(RUG+ROG)
 F=Q1A-Q13
 RETURN
 END

REAL FUNCTION CHTC(T3,R3)

C-----
 ! THIS FUNCTION COMPUTES THE CONVECTIVE HEAT TRANSFER
 ! COEFFICIENT FOR THE OUTER BOUNDARY LAYER IN
 ! WATTS/SEC*C*(M**2). THE EQUATIONS USED WERE
 ! DERIVED FROM EXPERIMENTAL DATA. (SEE TEXT FOR DETAILS)

C-----
 INTEGER BR, COR, ATT, FLAG2, LO
 REAL LNU, LGRPR
 BYTE RDU
 COMMON /BODY/B(9,3), COR(9,2), WGT(12)
 1/PROB/BR, ATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS
 2, RDU
 3, /DEBUG/FLAG2, LO

C-----
 ! ** NOTE **
 ! ALL REFERENCES TO LOG IMPLY LOG BASE 10 (LOG10)

C-----
 C
 ! COEFFICIENTS FOR DETERMINATION OF THE GRASHOF AND
 ! PRANDTL NUMBER PRODUCT.
 ! USING:

GRPR = (ALPHA)*(T WALL - T AMBIENT)*(L**3)

! WHERE:

LOG (ALPHA) = BETA1*(LOG (T FILM))**BETA2

ALPHA = G*BETA*RHO**2*CP/MU*K

T FILM = (T WALL + T AMBIENT) / 2.0

GRPR = GRASHOF# * PRANDTL#

! THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
 ! EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.

C
 ! COEFFICIENTS FOR DETERMINATION OF THE THERMAL
 ! CONDUCTIVITY OF WATER AS A FUNCTION OF TEMPERATURE IN
 ! DEGREES C.

! THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
 ! EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.

! K = CFO + CF1*T

DATA BETA1, BETA2/9.80714, 0.12733/

1, CFO, CF1/0.56662, 1.7977E-3/

C-----
 ! COEFFICIENTS FOR DETERMINATION OF LOG (NU) AS A
 ! FUNCTION OF LOG (GRPR) FOR VERTICAL CYLINDERS
 ! LOG(NU) = VCO + VC1*(LOG(GRPR)) + VC2*((LOG(GRPR))**2)
 ! THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
 ! EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.

C
 ! COEFFICIENTS FOR DETERMINATION OF LOG (NU) AS A
 ! FUNCTION OF LOG (GRPR) FOR SPHERES
 ! LOG(NU) = SO*LOG(GRPR) + S1
 ! THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
 ! EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.

C COEFFICIENTS FOR DETERMINATION OF LOG (NU) AS A
 !FUNCTION OF LOG (GRPR) FOR HORIZONTAL CYLINDERS
 !LOG(NU) = HCO*LOG(GRPR) + HC1
 !THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
 !EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.
 DATA VCO, VC1, VC2/9. 1934, -2. 4128, 0. 1817/
 1, S0, S1/0. 46486, -1. 9726/
 2, HCO, HC1/0. 2486, -0. 4483/

C-----
 C CHTC VARIABLES DEFINED IN MODULE CHTC
 !ALPHA = G*BETA*RHO**2*CP/MU*K
 !BETA = LOG (ALPHA)
 !BETA1 = COEFFICIENT SEE ABOVE
 !BETA2 = COEFFICIENT SEE ABOVE
 !CF = THERMAL CONDUCTIVITY OF WATER AT TEMPERATURE
 !CFO = COEFFICIENT SEE ABOVE
 !CF1 = COEFFICIENT SEE ABOVE
 !CL = CHARACTERISTIC LENGTH FOR FREE CONVECTION
 ! FOR VERTICAL CYLINDERS = LENGTH OF CYLINDER
 ! FOR HORIZONTAL CYLINDERS = DIAMETER OF
 ! CYLINDER
 ! FOR SPHERES = DIAMETER
 !GR = GRASHOF NUMBER, PRANDTL NUMBER PRODUCT
 !HCO = COEFFICIENT SEE ABOVE
 !HC1 = COEFFICIENT SEE ABOVE
 !LGRPR = LOG (GRPR)
 !LNU = LOG (NU)
 ! NU = NUSSELT NUMBER
 !S0 = COEFFICIENT SEE ABOVE
 !S1 = COEFFICIENT SEE ABOVE
 !TF = TEMPERATURE OF FILM
 ! (T SURFACE + T AMBIENT GAS)/2.0
 !VCO = COEFFICIENT SEE ABOVE
 !VC1 = COEFFICIENT SEE ABOVE
 !VC2 = COEFFICIENT SEE ABOVE
 !B = ARRAY CONTAINING BODY REGION DIMENSIONS
 !FLAG3 = INTEGER VARIABLE USED TO INDICATE SUCCESS OR
 ! FAILURE OF THIS SUBROUTINE.
 ! = 0.0 CHTC DETERMINED SUCCESSFULLY
 ! = 1.0 CHTC NOT DETERMINED, ESTIMATED FILM
 ! TEMPERATURE LESS THAN 1.0
 ! = 2.0 CHTC NOT DETERMINED, GRASHOF*PRANDTL
 ! PRODUCT IS EQUAL TO ZERO.

C-----
 C *NOTE* THE FOLLOWING VARIABLES WERE DEFINED IN PREVIOUS
 !MODULES:
 !BR, TA, T3

C-----
 C *NOTE* ARRAYS COR AND WGT ARE PASSED TO THIS MODULE IN
 !LABELED COMMON BUT ARE NOT USED IN THIS MODULE.

C-----
 FLAG3=0.0

```

      GO TO (1,2) ATT
C      ATT=0 SITTING
      GO TO (11,10,10,12,10,10,10,10,11) BR
C      ATT=1 STANDING
1      GO TO (11,10,10,10,10,10,10,10,11) BR
C      ATT=2 PRONE
2      GO TO (11,12,12,12,12,12,12,12,11) BR
C      VERTICAL CYLINDERS
10     CL=B(BR,3)      !M
      ASSIGN 105 TO LRET
      GO TO 20
105    LNU=VCO+(VC1*LGRPR)+(VC2*(LGRPR**2.0))
      GO TO 15
C      SPHERE
11     CL=2.0*R3      !M
      ASSIGN 115 TO LRET
      GO TO 20
115    LNU=(S0*LGRPR)+S1
      GO TO 15
C      HORIZONTAL CYLINDER
12     CL=2.0*R3      !M
      ASSIGN 125 TO LRET
      GO TO 20
125    LNU=(HCO*LGRPR)+HC1
15     CF=CF0+(CF1*TF)      !W/M*C
      CHTC=(10.0**LNU)*CF/CL !W/M2*C
      RETURN
20     TF=(T3+TA)/2.0
      IF (TF.LT.1.0) GO TO 21
      BETA=BETA1*(LOG10(TF)**BETA2)
      ALPHA=(10.0**BETA)
      GRPR=ALPHA*(CL**3.0)*(T3-TA)
      IF (GRPR.LE.0.0) GO TO 23
      LGRPR=LOG10(GRPR)
      GO TO LRET
21     WRITE (LO,22)
      IF (LO.NE.5) WRITE (5,22)
22     FORMAT (' SYSTEM WILL NOT EXPONENTIATE A NEGATIVE ',/
1, ' BASE BY A REAL EXPONENT',/
2,20X, 'RUN TERMINATED !')
      FLAG3=1.0
      RETURN
23     WRITE (LO,24)
      IF (LO.NE.5) WRITE (5,24)
24     FORMAT (' THE LOGARITHM OF ZERO '
1, ' IS UNDEFINED',/
2,20X, ' RUN TERMINATED !')
      FLAG3=2.0
25     RETURN
      END

```

REAL FUNCTION TR(TDMS, BR)

C-----
 ! THIS FUNCTION COMPUTES THE PREDICTED REGIONAL
 ! TEMPERATURES FOR THE 9 REGION MODEL.
 ! THE PREDICTIVE EQUATIONS USED WERE DERIVED FOR
 ! THE 12 SEGMENT HODY MODEL WITH EXPERIMENTAL
 ! DATA. (SEE TEXT FOR DETAILS)
 ! THE PREDICTIONS FOR THE 12 SEGMENTS WERE
 ! COMBINED BY A WEIGHTED SUM USING THE HODY
 ! WEIGHTS CORRESPONDING TO THE SUMMED SEGMENTS.
 ! THE CORRESPONDENCE BETWEEN THE 9 REGION AND 12 SEGMENT
 ! MODELS IS SHOWN IN ARRAY COR, BELOW. FOR MORE DETAIL
 ! SEE MODULE MAIN

ROW#	9 REGION	12 SEGMENT MODEL
=>BR	MODEL NAME	CORRESPONDING SEGMENTS NAME(ID#)
		ID #'S ARE IN ARRAY COR(9,2)
1	HEAD	HEAD(1), (-1)
2	TORSO	CHEAT(2), UPPER BACK(4)
3	ABDOMEN	ABDOMEN(3), LOWER BACK(5)
4	THIGH	FRONT THIGH(8), REAR THIGH(10)
5	CALF	FRONT CALF(9), REAR CALF(11)
6	FOOT	FOOT(12), (-1)
7	UPPER ARM	ARM(6), (-1)
8	LOWER ARM	ARM(6), (-1)
9	HAND	WRIST(7), (-1)
		NOTE (-1) INDICATES THAT ONLY ONE CORRESPONDING SEGMENT IS AVAILABLE FROM 12 SEGMENT MODEL

C-----
 C TR

TDMS	= DESIGN MEAN SKIN TEMPERATURE. MEAN SKIN TEMPERATURE AT WHICH TO COMPUTE THE PREDICTED REGIONAL TEMPERATURES.
BR	= BODY REGION OF INTEREST. ONE OF THE 9 REGION MODEL REGIONS.
COR	= ARRAY CONTAINING CORRESPONDENCE BETWEEN 9 REGION AND 12 SEGMENT MAPS
SWGT	= SUM OF WEIGHTS CORRESPONDING TO THE 12 SEGMENTS SUMMED.
PRED	= FUNCTION SUBROUTINE WHICH CALCULATES THE 12 SEGMENTAL PREDICTED TEMPERATURES AT A GIVEN MEAN SKIN TEMPERATURE, TDMS AND SEGMENT J
WGOT	= ARRAY CONTAINING THE 12 HODY SURFACE WEIGHTS
NOTE: ARRAY B IS PASSED TO THIS MODULE IN LABELED COMMON BUT THIS ARRAY IS UNUSED IN THIS MODULE.	
NOTE: VARIABLES I AND J ARE TEMPORARY VARIABLES USED AS DO LOOP INDICES AND COUNTERS.	
NOTE: VARIABLES I AND J ARE TEMPORARY VARIABLES USED	

AS DO LOOP INDICIES AND COUNTERS.

INTEGER COR, BR
COMMON /BODY/B(9,3), COR(9,2), WGT(12)
TR=0.0
SWGT=0.0
!NOTE: THERE IS NO CHECKING FOR 0.0 VALUES
! IN THE SUM SINCE THE PREDICTED VALUES
! CAN NOT BE ZERO UNLESS TDMS=0.0.
! TDMS CAN NOT BE ZERO BY ACCIDENT IT
! MUST BE SPECIFIED AS ZERO IF THAT
! IS THE DESIRED VALUE.
DO 10 I=1,2
J=COR(BR,I)
IF (J.EQ.-1) GO TO 10
SWGT=SWGT+WGT(J)
TR=TR+(PRED(J,TDMS)*WGT(J))
CONTINUE
TR=TR/SWGT
RETURN
END

10

REAL FUNCTION PRED(REG, TSKM)

C-----
 !FUNCTION PRED DETERMINES THE PREDICTED 12 SEGMENTAL
 !TEMPERATURES FROM EQUATIONS DERIVED USING
 !EXPERIMENTAL DATA AND BASED ON A KERSLAKE
 !TYPE MODEL. (SEE TEXT FOR DETAILS)

C-----
 C PRED VARIABLES REQUIRED AND LOCALLY DEFINED
 !REG = SEGMENT FOR WHICH TO PREDICT
 ! SKIN TEMPERATURE
 !TSKM = MEAN SKIN TEMPERATURE TO USE AS
 ! INDEPENDENT ARGUMENT IN THE EQUATIONS.
 ! USUALLY THE DESIGN MEAN SKIN TEMPERATURE.
 !KA = ARRAY CONTAINING THE COEFFICIENTS FOR
 ! THE PREDICTIVE EQUATIONS
 !KR = CONSTANT USED IN THE PREDICTIVE EQUATIONS

C-----
 REAL KA, KR
 INTEGER REG
 COMMON /PREDD/KA(12), KR
 PRED=TSKM+(KA(REG)*KR)
 RETURN
 END

REAL FUNCTION TC(TDC,Z)

C-----

THE FUNCTION SUBROUTINE TC(TDC,Z) DETERMINES THE THERMAL CONDUCTIVITY OF AIR CORRESPONDING TO THE VALUES OF TEMPERATURE, T C, AND PRESSURE, Z MSW PASSED. THE VALUE IS DETERMINED BY A METHOD OF TWO DIMENSIONAL LINEAR INTERPOLATION ADAPTED FROM CARNAHAN, LUTHER, AND WILKES, "APPLIED NUMERICAL METHODS", P 63, PRB 1.28, JOHN WILEY & SONS, INC., 1969
 ARRAY C - CONTAINS THERMAL CONDUCTIVITY DATA FOR AIR AT
 - PRESSURES - 14.7, 30.0, 50.0, 100.0, 200.0 PSIA
 - TEMPERATURES - 30.0, 50.0, 70.0, 90.0, 110.0, 130.0 F

NOTE

CONDUCTIVITIES HAVE UNITS BTU/SEC FT F
 AND VALUES MUST BE MULTIPLIED BY 1.0E-06

DATA TAKEN FROM:

- U. S. NAVY DIVING GAS MANUAL,
- NAVSHIPS 0994-003-7010, 1971
- PAGE T-4 (AIR DATA)

LAYOUT OF ARRAY C

	30.0	50.0	70.0	90.0	110.0	130.0	F
14.7	3.93	4.06	4.19	4.32	4.45	4.58	
30.0	3.93	4.07	4.20	4.33	4.46	4.59	
50.0	3.95	4.08	4.21	4.34	4.47	4.59	
100.0	3.98	4.11	4.24	4.37	4.49	4.62	
200.0	4.03	4.16	4.29	4.42	4.54	4.66	
Psia							

C*NOTE* IF THE VALUE OF 'C' RETURNED TO CALLING MODULE IS NEGATIVE THEN THE VALUE OF 'T' OR 'Z' WAS OUT OF RANGE FOR THE TABLE STORED IN ARRAY C.

C-----

C TC

VARIABLES REQUIRED AND LOCALLY DEFINED

TDC = TEMPERATURE OF INTEREST IN DEGREES C
 Z = DEPTH BELOW SURFACE IN METERS OF SEAWATER
 A = COMPONENT OF EQUATION FOR TC
 (SINGLE TERM COMPUTED SEPARATELY)
 B = COMPONENT OF EQUATION FOR TC
 (SINGLE TERM COMPUTED SEPARATELY)
 LO = LOGICAL UNIT NUMBER AT WHICH TO PRINT INFORMATION.
 P = ABSOLUTE PRESSURE => DEPTH IN METERS OF SEAWATER, Z, CONVERTED TO PSIA
 T = TEMPERATURE DEGREES F => TEMPERATURE DEGREES C, TDC, CONVERTED TO DEGREES F

NOTE: VARIABLES I, II, IJ AND J ARE TEMPORARY VARIABLES USED AS DO LOOP INDICES AND COUNTERS.

BYTE IQ
 INTEGER FLAG2

```

COMMON /DEBUG/FLAG2,LD
2, /TRNOSQ/C(6,7)
C   CONVERT Z METERS OF SEA WATER TO PSI ABSOLUTE
P=((64.15*100.0*Z)/(2.54*(12.0**3)))+14.7
C   REDUCE P TO 1 SIGNIFICANT DIGIT AFTER DECIMAL PT
P=((AINT((P+0.05)*10.0))/10.0)
C   CONVERT DEGREES C TO F
T=((TDC+273.15)*1.8)-459.67)
IF (P.LT.C(2,1).OR.T.LT.C(1,2)
1.OR.P.GT.C(6,1).OR.T.GT.C(1,7)) GO TO 20
DO 10 I=2,6
IF (C(I,1).LT.P) GO TO 10
II=I
IF (C(I,1).NE.P) II=II-1
GO TO 12
10  CONTINUE
GO TO 20
12  DO 13 J=2,7
IF (C(1,J).LT.T) GO TO 13
IJ=J
IF (C(1,J).NE.T) IJ=IJ-1
GO TO 15
13  CONTINUE
GO TO 20
15  B=(T-C(1,IJ))/(C(1,IJ+1)-C(1,IJ))
IF (T.EQ.C(1,IJ)) B=0.0
A=(P-C(II,1))/(C(II+1,1)-C(II,1))
IF (P.EQ.C(II,1)) A=0.0
TC=((1.0-A)*(1.0-B)*C(II,IJ))+(A*(1.0-B)*C(II+1,IJ))
1+(B*(1.0-A)*C(II,IJ+1))+(A*B*C(II+1,IJ+1))
C   CORRECT TC TO BE IN WATTS/M*C
C   1.0E-6 IS APPLIED TO YIELD CORRECT VALUES
TC=TC*(1.0E-6)*6230.551
C   6230.551 J/M*C/BTU/FT*F
C
RETURN
20  TC=0.0
WRITE(LD,11) T,P
11  FORMAT (' ',10X,'T=',F10.2,' OR P=',F10.2
1,' OUT OF RANGE OF TABLE')
RETURN
END

```

SUBROUTINE PLOTD(IR,PSYM,BR)

C-----
 !PLOTD IS A SUBROUTINE FOR PLOTTING T'S, Q'S, AND U'S
 !BOTH PREDICTED AND EXPERIMENTAL VERSUS TIME.

C-----
 C PLOTD VARIABLES REQUIRED AND LOCALLY DEFINED
 !IR = OFFSET INTO ARRAY P AT WHICH TO PICK
 UP BOTH THE PREDICTED AND EXPERIMENTAL DATA.
 P(ROW,IR+1) = EXPERIMENTAL
 P(ROW,IR+2) = PREDICTED
 !PSYM = ARRAY (PSYM(2)) CONTAINING THE INTEGER
 NUMBERS INDICATING THE SYMBOLS TO BE USED FOR
 THE EXPERIMENTAL AND PREDICTED CURVES
 RESPECTIVELY. (SEE DIGITAL EQUIPMENT CORP.
 MANUAL PLXY-11M, USER'S GUIDE FOR DETAILS)
 !BR = BODY REGION WHICH THE EXPERIMENTAL AND
 PREDICTED VALUE CORRESPOND TO.
 !LYS = Y-AXIS LEVEL FOR LABELS. INITIALLY SET
 AT LY
 !NREC = NUMBER OF TIME RECORDS TO PLOT
 (IE: 1 TO NREC)
 !DE = BYTE VARIABLE CONTAINING EITHER '*'
 OR ' ' (SPACE). IT IS USED TO FLAG
 THE EXPERIMENTAL DATA POINTS NOT
 PLOTTED BECAUSE THEY ARE EITHER <= 0 OR
 < SY. SY IS THE STARTING VALUE
 FOR THE Y-AXIS.
 !DP = BYTE VARIABLE CONTAINING EITHER '*'
 OR ' ' (SPACE). THIS VARIABLE IS USED
 IN THE SAME MANNER AS VARIABLE DE
 EXCEPT THAT DP IS USED FOR THE PREDICTED
 VALUES.
 !BREG = ARRAY CONTAINING NAMES OF BODY REGIONS
 ARRANGED TO CORRESPOND TO BR
 !LABEL = ARRAY CONTAINING LABEL TEXT FOR THE PLOTS
 !P = ARRAY CONTAINING THE DATA TO BE PLOTTED

NOTE: VARIABLES E,F,G,J,K AND L ARE TEMPORARY
 VARIABLES USED FOR DUMMY ARGUMENTS,
 DO LOOP INDICES AND COUNTERS.

NOTE: THE FOLLOWING VARIABLE ARE DEFINED IN
 A MANNER NECESSARY TO SATISFY THE DEC
 PLXY-11M SUBROUTINE'S SPECIFICATIONS
 !IX = X-AXIS INCREMENT => # UNITS PER PLOT UNIT
 !IY = Y-AXIS INCREMENT => # UNITS PER PLOT UNIT
 !LX = X-AXIS LENGTH IN PLOT UNITS
 !LY = Y-AXIS LENGTH IN PLOT UNITS
 !SX = X-AXIS STARTING VALUE
 !SY = Y-AXIS STARTING VALUE
 !XP = ARRAY USED TO PASS X-AXIS VALUES TO
 PLXY-11M SUBROUTINE LINE
 !YP = ARRAY USED TO PASS Y-AXIS VALUES TO

PLXY-11M SUBROUTINE LINE

```

REAL LX, SX, IX, LY, SY, IY, LYS, XP(125), YP(125)
REAL*8 LABEL(3), BREG(10)
INTEGER PSYM(2), BR
BYTE DE, DP, REU, RT
COMMON /PLOT/ F, .25, 9, LX, SX, IX, LY, SY, IY, LYS, LABEL, NREC
1, BREG, XP, YP, PD(125, 3), LCL, CH, REU, PRT(13)
SL=3.0
IF (CH.GT.0.0) SL=CH
CALL SYMBOL (LX-SL, LYS-0.20, 0.1169, BREG(BR), 0.0, +8)
IF (IR.EQ.1) GO TO 10
CALL SYMBOL (999., 999., 0.1169, PRT, 0.0, +LCL)
10 CALL PLOT (0.0, 0.0, +3)
LYS=LYS-0.20
DO 13 J=1, 2
L=0
DO 12 K=1, NREC
IF (J.GT.1) GO TO 115
DE=' '
C CHECKING EXP'T VALUE TO BE IN RANGE OF PLOT
IF (P(K, IR+1).LE.0. OR. P(K, IR+1).LT.SY) DE='*'
DP=' '
C CHECKING PRED VALUES TO BE IN RANGE OF PLOT
IF (P(K, IR+2).LE.0. OR. P(K, IR+2).LT.SY) DP='*'
WRITE (6, 11) P(K, 1), P(K, IR+1), DE, P(K, IR+2), DP
11 FORMAT (10X, F8.2, 10X, F10.2, 1A1, 9X, F10.2, 1A1)
115 IF (P(K, J+IR).LE.0. OR. P(K, J+IR).LT.SY) GO TO 12
L=L+1
XP(L)=P(K, 1)
YP(L)=P(K, J+IR)
12 CONTINUE
XP(L+1)=SX
XP(L+2)=IX
YP(L+1)=SY
YP(L+2)=IY
CALL PLOT (0.0, 0.0, +3)
CALL LINE (XP, YP, L, 1, +1, PSYM(J))
CALL SYMBOL (LX-SL, LYS-0.20, 0.1169, LABEL(J), 0.0, +8)
CALL WHERE (E, F, G)
CALL SYMBOL (E, F+(0.1169/2.0), 0.1169, PSYM(J), 0.0, -1)
CALL WHERE (E, LYS, G)
LYS=LYS-(0.1169/2.0)
13 CONTINUE
RETURN
END

```

SUBROUTINE PLOTN(IR,PSYM)

C-----

!PLOTN IS A SUBROUTINE FOR PLOTTING NORMALIZED
!TEMPERATURES AND BIOT NUMBERS
!BOTH PREDICTED AND EXPERIMENTAL VERSUS TIME.

C-----

C PLOTN

VARIABLES REQUIRED AND LOCALLY DEFINED

!IR = OFFSET INTO ARRAY P AT WHICH TO PICK
UP BOTH THE PREDICTED AND EXPERIMENTAL DATA.
P(ROW,IR+1) = EXPERIMENTAL
P(ROW,IR+2) = PREDICTED

!PSYM = ARRAY (PSYM(2)) CONTAINING THE INTEGER
NUMBERS INDICATING THE SYMBOLS TO BE USED FOR
THE EXPERIMENTAL AND PREDICTED CURVES
RESPECTIVELY. (SEE DIGITAL EQUIPMENT CORP.
MANUAL PLXY-11M, USER'S GUIDE FOR DETAILS)

!BR = BODY REGION WHICH THE EXPERIMENTAL AND
PREDICTED VALUE CORRESPOND TO.

!RMD = DEPTH IN MSW TO THE MIDDLE OF THE REGION.

!LYS = Y-AXIS LEVEL FOR LABELS. INITIALLY SET
AT LY

!NREC = NUMBER OF TIME RECORDS TO PLOT
(IE: 1 TO NREC)

!DE = BYTE VARIABLE CONTAINING EITHER '*'
OR ' ' (SPACE). IT IS USED TO FLAG
THE EXPERIMENTAL DATA POINTS NOT
PLOTTED BECAUSE THEY ARE EITHER ≤ 0 OR
 $< SY$. SY IS THE STARTING VALUE
FOR THE Y-AXIS.

!DP = BYTE VARIABLE CONTAINING EITHER '*'
OR ' ' (SPACE). THIS VARIABLE IS USED
IN THE SAME MANNER AS VARIABLE DE
EXCEPT THAT DP IS USED FOR THE PREDICTED
VALUES.

!BREG = ARRAY CONTAINING NAMES OF BODY REGIONS
ARRANGED TO CORRESPOND TO BR

!LABEL = ARRAY CONTAINING LABEL TEXT FOR THE PLOTS

!P = ARRAY CONTAINING THE DATA TO BE PLOTTED

NOTE: VARIABLES E,F,G,J,K AND L ARE TEMPORARY
VARIABLES USED FOR DUMMY ARGUMENTS,
DO LOOP INDICES AND COUNTERS.

NOTE: THE FOLLOWING VARIABLE ARE DEFINED IN
A MANNER NECESSARY TO SATISFY THE DEC
PLXY-11M SUBROUTINE'S SPECIFICATIONS

!IX = X-AXIS INCREMENT => # UNITS PER PLOT UNIT
!IY = Y-AXIS INCREMENT => # UNITS PER PLOT UNIT
!LX = X-AXIS LENGTH IN PLOT UNITS
!LY = Y-AXIS LENGTH IN PLOT UNITS
!SX = X-AXIS STARTING VALUE
!SY = Y-AXIS STARTING VALUE
!XP = ARRAY USED TO PASS X-AXIS VALUES TO

```

      PLXY-11M SUBROUTINE LINE
      YP      = ARRAY USED TO PASS Y-AXIS VALUES TO
      PLXY-11M SUBROUTINE LINE

```

```

REAL LX, SX, IX, LY, SY, IY, LYS, XP(125), YP(125)
REAL*8 LABEL(3), BREG(10)
INTEGER PSYM(2), BR, ATT, COR
BYTE DE, DP, RDU, REU, PRT
COMMON /BODY/B(9,3), COR(9,2), WGT(12)
1, /PROB/BR, ATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS
2, RDU
3, /PLOT/P(125,9), LX, SX, IX, LY, SY, IY, LYS, LABEL, NREC
4, BREG, XP, YP, PD(125,3), LCL, CH, REU, PRT(13)
SL=3.0
IF (CH.GT.0.0) SL=CH
CALL SYMBOL (LX-SL, LYS-0.20, 0.1169, BREG(BR), 0.0, +8)
IF (IR.EQ.1) GO TO 10
CALL SYMBOL (999., 999., 0.1169, PRT, 0.0, +LCL)
10 CALL PLOT (0.0, 0.0, +3)
LYS=LYS-0.20
IF (ATT.EQ.2) RMD=RDM
IF (ATT.EQ.1) RMD=RDM+RDS+(B(BR,3)/2.0)
IF (ATT.NE.0) GO TO 5
RMD=RDM+RDS
IF (BR.EQ.4) RMD=RMD+(B(BR,2)/2.0)
IF (BR.NE.4) RMD=RMD+(B(BR,3)/2.0)
5 DO 13 J=1,2
L=0
DO 12 K=1, NREC
C CHECKING EXP'T VALUE TO BE IN RANGE OF PLOT
IF (P(K,1+IR).LE.0.0.OR.P(K,1+IR).LT.SY) GO TO 12
L=L+1
XP(L)=P(K,1)
PD(L,1)=XP(L)
IF (IR.NE.1) GO TO 11
YP(L)=(P(K,J+IR)-P(K,9))/(P(K,8)-P(K,9))
PD(L,J+1)=YP(L)
GO TO 12
11 IF (IR.NE.5) GO TO 12
TM=(P(K,J+1)+P(K,9))/2.0
YP(L)=(P(K,J+IR)*(B(BR,2))/2.0)/TC(TM, RMD)
PD(L,J+1)=YP(L)
12 CONTINUE
XP(L+1)=SX
XP(L+2)=IX
YP(L+1)=SY
YP(L+2)=IY
CALL PLOT (0.0, 0.0, +3)
CALL LINE (XP, YP, L, 1, +1, PSYM(J))
CALL SYMBOL (LX-SL, LYS-0.20, 0.1169, LABEL(J), 0.0, +8)
CALL WHERE (E, F, G)
CALL SYMBOL (E, F+(0.1169/2.0), 0.1169, PSYM(J), 0.0, -1)
CALL WHERE (E, LYS, G)

```

```
13      LYS=LYS-(0.1169/2.0)  
      CONTINUE  
14      WRITE (6,14) (PD(K,1),PD(K,2),PD(K,3),K=1,L)  
      FORMAT (10X,F8.2,10X,F10.2,10X,F10.2)  
      RETURN  
      END
```

↓
APPENDIX G
SAMPLE CALCULATION

To illustrate the computations performed by the interactive model program, an example will be calculated by hand and compared to the corresponding program output (Table G.1). Table G.2 is a question flow of the form introduced in the documentation section (Appendix D) which shows the responses to the program's queries necessary to generate the example program output (Table G.1).

The example output is generated in the research mode, yet Table G.1 is the output of a simple production mode run (See Table D.2.) with the addition of the program generated debug information. This mimicking of the production mode from the research mode is done to activate the debug prints which contain the results of the intermediate computations necessary for comparison.

The answers to questions 4 thru 8, 10, and 14 thru 17 of Table G.2 display the information necessary to define the example problem. These responses indicate that the modeled diver is lying prone (question 17) in a wet environment at a depth of 10.0 FSW (question 4) and at a temperature of 5.0 °C (question 15). The ensemble being worn is the U.S. Navy's prototype

Table G.1

A Production Mode Output Enhanced With Debug Information

BODY REGION: 3
 POSTURE: 0=SIT,1=STAND,2=PRONE 2
 DESIGN MEAN SKIN TEMPERATURE: 30.00 C
 REFERENCE DEPTH: 10.00 FSW
 AMBIENT TEMPERATURE: 5.00 C

PREDICTED TEMPERATURE FOR REGION 3: 30.31 C

DZ,DZV 0.3530000 0.0000000
 SEP,SEPV 0.0000000 0.0000000
 I RDM,RED,DPCT 3.048000 0.0000000 0.0000000
 N T1,MT,EDS 30.30807 17.65403 3.048000
 F TC(21.1,0),TC(MT,EDS) 2.6105195E-02 2.5872320E-02
 D O CR 1.009001 SRUGA,SRUGHA 2.290432 2.290432
 E R RUGHA 3.733404 CLO RUGHAJ 0.5778190 M2*C/WATT
 B M T3,DT,TN1 5.719394 -1.0215981E-04 5.719394
 U A F(TN1),Q1A,Q13 3.8146973E-06 44.16370 44.16370
 G T RUG,ROG,ROBL 0.5485279 8.2342243E-03 1.6289219E-02
 I R1,R2,R3 0.1500000 0.1663000 0.1678875
 O T1,T3 30.30807 5.719394
 N FLAG1,F(T3),CHTC(T3,R3) 1 3.8146973E-06 54.84949
 US,UN 3.961251 1.000000
 QR,Q(BR) 100.2516 33.35371

CORRECTED PREDICTED OHTC FOR REGION 3: 3.96 W/M**2*C
 PREDICTED UNIT HEAT FLUX FOR REGION 3: 100.25 W/M**2
 ALLOWABLE UNIT HEAT FLUX FOR REGION 3: 49.70 W/M**2
 REQUIRED SUPPLEMENTARY HEAT FLUX: 50.55 W/M**2
 PREDICTED RATE OF HEAT LOSS FOR REGION 3: 33.35 WATTS
 ALLOWABLE RATE OF HEAT LOSS FOR REGION 3: 16.54 WATTS
 REQUIRED SUPPLEMENTARY HEATING: 16.82 WATTS

Table G.2
Question Flow for Generation of Table G.1

Question #	Response
1	Y
2	Y
3	Y
4	F10.0
5	X
6	X
7	X
8	X
9	F
10	1
11	N
12	NA
13	NA
14	30.0
15	5.0
16	3
17	2
18	NA
19	NA
20	NA
21	NA
22	NA
23	NA

diver thermal protection garment (questions 5 and 6). The calculations are to be performed only for the abdomen (question 16) and are assuming one node per region (question 10). The diver's mean skin temperature (question 14) is to be maintained at a steady value of 30.0 °C, and the values of allowable heat flux (question 7) and biasing factor (question 8) to be used are those assigned by the program.

The following array listings contain the information necessary to perform the example calculations. The arrays are displayed in the order of their use in the example calculations. Each array, which contains either regional or segmental data, is displayed with the region or segment ID numbers and names. Regional data corresponds to the nine regions of the model man (Fig. 1 of Chapter I) and segment data corresponds to the twelve Hody segments (Fig. 2 of Chapter I).

Array COR(9,2)

Region ID #	Region Name	Corresponding Segments	
		S1	S2
1	HEAD	1	-1
2	TORSO	2	4
3	ABDOMEN	3	5
4	THIGH	8	10
5	CALF	9	11
6	FOOT	12	-1
7	UPPER ARM	6	-1
8	LOWER ARM	6	-1
9	HAND	7	-1

Array COR indicates the correspondence between model regions and Hody segments. Note: A segment of -1 indicates that there is a one to one correspondence between a model region and a Hody segment.

Array KA(12)

Segment ID #	Segment Name	Predictive Skin Temperature Correlation Coefficient
1	HEAD	0.36
2	CHEST	0.27
3	ABDOMEN	0.30
4	UPPER BACK	0.52
5	LOWER BACK	-0.08
6	ARM	0.22
7	WRIST	-0.64
8	FRONT THIGH	-0.04
9	FRONT CALF	-0.16
10	REAR THIGH	-0.06
11	REAR CALF	-0.55
12	FOOT	-0.86

Array KA contains the twelve segmental coefficients needed to use the predictive skin temperature correlation. The development of this correlation is described in Chapter IV.

Constant KR

Along with the twelve segment coefficients, the predictive skin temperature correlation requires a fixed constant KR.

$$KR = 2.946$$

This constant is also described in Chapter IV.

Array WGT(12)

<u>Segment ID #</u>	<u>Segment Name</u>	<u>Hody Skin Surface Area Fraction</u>
1	HEAD	0.070
2	CHEST	0.085
3	ABDOMEN	0.085
4	UPPER BACK	0.090
5	LOWER BACK	0.090
6	ARM	0.140
7	WRIST	0.050
8	FRONT THIGH	0.095
9	FRONT CALF	0.065
10	REAR THIGH	0.095
11	REAR CALF	0.065
12	FOOT	0.070

Array WGT contains the twelve Hody surface area fractions corresponding to the 12 segments (Fig. 2 of Chapter I).

Array C(6,7)

	<u>Temperature (°F)</u>					
<u>Pressure (PSIA)</u>	30.00	50.00	70.00	90.00	110.00	130.00
14.70	3.93	4.06	4.19	4.32	4.45	4.58
30.00	3.93	4.07	4.20	4.33	4.46	4.59
50.00	3.95	4.08	4.21	4.34	4.47	4.59
100.00	3.98	4.11	4.24	4.37	4.49	4.62
200.00	4.03	4.16	4.29	4.42	4.54	4.66

Array C contains values of the thermal conductivity of air multiplied by 10^6 as a function of temperature (°F) and absolute pressure (PSIA).

Garment Ensemble Constants

WUGO: 1.63 (CM)
 SRO: 2.27 (CLO/CM)
 DR: 0.1175
 WOG: 0.15875 (CM)
 COG: 0.17307 (W/M°C)

WUGO = Unit thickness of undergarment at sea level

SRO = Specific thermal resistance of undergarment at sea level

DR = Ratio of the decimal percent change in specific thermal resistance (SRO) to the decimal percent change in thickness of the undergarment. This is the slope of a line which describes the change in the undergarment specific thermal resistance with a change in the undergarment thickness due to a hydrostatic pressure differential between the inside and the outside of the ensemble. (See Fig. 68 of Chapter V.)

WOG = Width of the outer garment. This value is constant over all temperatures and pressures due to the impermeability and incompressibility of the outer garment material.

COG = Thermal conductivity of outer garment. This value is constant over all gases due to the impermeability of outer garment material.

Array TWUGO(9)

Region ID #	Region Name	Number of Layers of Undergarment WUGO Thick
1	HEAD	1.0
2	TORSO	1.0
3	ABDOMEN	1.0
4	THIGH	1.0
5	CALF	1.0
6	FOOT	2.0
7	UPPER ARM	1.0
8	LOWER ARM	1.0
9	HAND	1.0

Array TWUGO defines the number of layers of unit thickness undergarment material covering each region.

Array B(9,3)

<u>Region ID #</u>	<u>Region Name</u>	<u>Shape Indicator</u>	<u>Major Diameter</u>	<u>Characteristic Length</u>
1	HEAD	-1.000	0.206	0.206
2	TORSO	0.000	0.300	0.353
3	ABDOMEN	0.000	0.300	0.353
4	THIGH	0.000	0.150	0.383
5	CALF	0.000	0.120	0.328
6	FOOT	0.000	0.150	0.104
7	UPPER ARM	0.000	0.096	0.223
8	LOWER ARM	0.000	0.070	0.267
9	HAND	-1.000	0.123	0.123

Array B contains the body dimensions of the nine region model man (Fig. 1 of Chapter I).

Shape indicator: -1.0 = sphere

0.0 = cylinder

Major diameter: For sphere and cylinder - the diameter

Characteristic Length: For sphere - same as major diameter
For cylinder - the length of cylinder

Array BF(9)

<u>Region ID #</u>	<u>Region Name</u>	<u>Empirically Derived Biasing Factor</u>
1	HEAD	2.63
2	TORSO	2.63
3	ABDOMEN	2.27
4	THIGH	3.50
5	CALF	3.21
6	FOOT	12.70
7	UPPER ARM	2.29
8	LOWER ARM	2.19
9	HAND	3.49

Array BF defines the empirically derived biasing factors used to correct the predicted overall heat transfer coefficients (OHTC). The derivation of these biasing factors may be found in Chapter VII.

Array SAM(9)

<u>Region ID #</u>	<u>Region Name</u>	<u>Regional Surface Area (M²)</u>
1	HEAD	0.1333
2	TORSO	0.3327
3	ABDOMEN	0.3327
4	THIGH	0.3610
5	CALF	0.2474
6	FOOT	0.1334
7	UPPER ARM	0.1490
8	LOWER ARM	0.1174
9	HAND	0.0950

Array SAM contains the nine regional surface areas computed from the dimensions described in Array B.

Array QALL(9)

<u>Region ID #</u>	<u>Region Name</u>	<u>Allowable Heat Flux (W/M²)</u>
1	HEAD	23.30
2	TORSO	60.00
3	ABDOMEN	49.70
4	THIGH	42.40
5	CALF	85.00
6	FOOT	97.00
7	UPPER ARM	98.90
8	LOWER ARM	125.25
9	HAND	265.86

Array QALL contains the allowable regional heat fluxes necessary to remove the waste heat produced by a resting seated subject. These were extracted from data by Burriss et al. [33,34].

The computations which appear on the following pages were performed to check the computational accuracy of the interactive model program's algorithm, as well as to provide a sample to illustrate the calculation of the predicted heat loss values. To facilitate this checking of the program's algorithm, the hand calculations maintain more significant figures than would be expected from the accuracy of the experimental data from which the diver heat loss model was developed.

Begin Sample Computations

In the Main module:

Calculate regional skin temperature (T1).

Given: Design mean skin temperature (TDMS) = 30.0°C
Body region (BR) = 3 (Abdomen)

$$T1 = TR(TDMS, BR)$$

From Function TR:

From Array COR for BR = 3:

$$COR(3,1) = 3 \text{ (Hody's site 3)} = S1$$

$$COR(3,2) = 5 \text{ (Hody's site 5)} = S2$$

$$TR(TDMS, 3) = \frac{PRED(S1, TDMS) \cdot WGT(S1) + PRED(S2, TDMS) \cdot WGT(S2)}{WGT(S1) + WGT(S2)}$$

From Function PRED:

$$PRED(S, TDMS) = TDMS + KA(S) \cdot KR$$

$$PRED(S1, TDMS) = 30.0 + KA(3) \cdot KR$$

$$KR = 2.946$$

From Array KA for site 3:

$$KA(3) = 0.30$$

$$PRED(S1, TDMS) = 30.0 + (0.30)(2.946) = 30.88 \text{ }^{\circ}\text{C}$$

$$PRED(S2, TDMS) = 30.0 + KA(5) \cdot KR$$

$$KR = 2.946$$

From Array KA for site 5:

$$KA(5) = -0.08$$

$$PRED(S2, TDMS) = 30.0 - (0.08)(2.946) = 29.76 \text{ }^{\circ}\text{C}$$

From Array WGT for sites 3 and 5:

$$WGT(3) = 0.085$$

$$WGT(5) = 0.090$$

$$TR(TDMS, 3) = \frac{(30.88 \cdot 0.085) + (29.76 \cdot 0.090)}{(0.085 + 0.090)}$$

$$T1 = 30.308 \text{ }^{\circ}\text{C}$$

In this example, calculations are shown for a single node per region; if multiple nodes were desired, the following would be executed once for each node.

Begin multiple node loop:

Calculate the overall heat transfer coefficient (OHTC).

Using: Subroutine OHTC

Given: Design mean skin temperature (TDMS) = 30.0 °C
 Body region (BR) = 3 (Abdomen)
 Diver's posture (ATT) = 2 (Prone)
 Depth below sea level of shoulders (RD) = 10.00 FSW
 Ambient temperature (TA) = 5.0 °C
 Regional skin temperature (T1) = 30.308 °C

$$\text{OHTC} = \frac{1.0}{\text{RUG} + \text{ROG} + \text{ROBL}}$$

RUG = Unit thermal resistance of the undergarment as a function of the ambient temperature and depth, and the hydrostatic pressure differential due to the region's depth below the shoulders.

ROG = Unit thermal resistance of the outer garment. The outer garment is assumed to be unaffected by the suit entrapped gas (impermeable) and the hydrostatic pressure difference (incompressible).

ROBL = Unit thermal resistance of the outer fluid boundary layer. This is predicted by using empirically derived equations fitted to experimental data.

Determine RUG:

$$\text{RUG} = \frac{\text{RUGHAJ} \cdot \text{R1} \cdot \ln^{\dagger} (\text{R2/R1}) \cdot 100.0}{\text{WUGO} \cdot \text{TWUGO}(\text{BR}) \cdot (1.0 - \text{DPCT})}$$

Determine unit thermal resistance of a flat undergarment sample at depth (RUGHAJ).

Determine the thermal conductivity ratio (CR).

CR is the ratio of the thermal conductivity of air at sea level and standard temperature, and the thermal conductivity of the suit entrapped gas at ambient depth and temperature.

$$\text{CR} = \frac{k(\text{air, sea level, } 21.1 \text{ }^{\circ}\text{C})}{k(\text{entrapped gas, ambient pressure, ambient temperature})}$$

[†]ln implies logarithm to the base e.

When the suit entrapped gas is air,

$$CR = \frac{TC(21.1, 0 \text{ MSW})}{TC(MT, EDS)}$$

EDS = Element (node) depth below sea level = RDM + RED

RDM = Reference depth (RD) converted to MSW
For RD given as 10.0 FSW,

$$RDM = 10.00 \text{ FSW} \cdot 0.3048 \frac{\text{MSW}}{\text{FSW}}$$

$$RDM = 3.048 \text{ MSW}$$

RED = Regional element (node) depth below the shoulder reference.
This depth is computed to the mid-point of the nodal element
and indicates the hydrostatic pressure differential.

For a diver posture (ATT) = 2 (Prone),

RED = 0.0, since all regions are at the same depth below sea level.

$$EDS = 3.048 + 0.0$$

$$EDS = 3.048 \text{ MSW}$$

MT = Mean temperature of the suit entrapped gas

$$MT = (T_1 + T_A)/2.0$$

$$MT = (30.308 + 5.0)/2.0$$

$$MT = 17.65 \text{ }^{\circ}\text{C}$$

$$CR = \frac{TC(21.1, 0)}{TC(17.65, 3.048)}$$

From Function TC(TDC, Z):

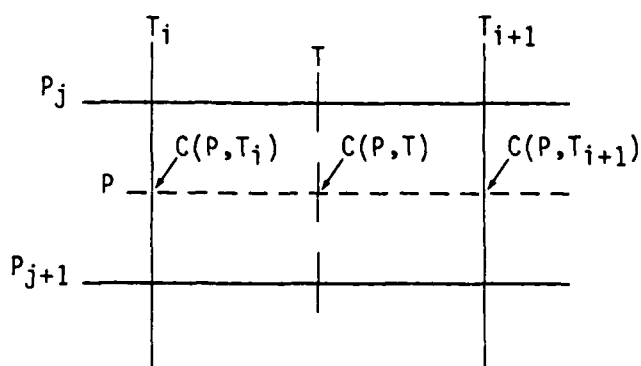
Convert TDC ($^{\circ}\text{C}$) to T ($^{\circ}\text{F}$),

$$T \text{ (}^{\circ}\text{F)} = ((TDC + 273.15) \cdot 1.8) - 459.67$$

Convert Z (MSW) to P (PSIA),

$$P \text{ (PSIA)} = (Z \cdot 100.0 \cdot 64.15)/(2.54 \cdot 12.0^3) + 14.7$$

Using a method of two-dimensional linear interpolation (Adapted from Carnahan, Luther, and Wilkes, Applied Numerical Methods, p. 63, Problem 1.28 [49], Function TC estimates the value of the thermal conductivity of air from Array C. This method is outlined on the next page.



$$C(P, T) = C(P, T_i) + (C(P, T_{i+1}) - C(P, T_i)) \cdot \beta$$

$$C(P, T_i) = C(P_j, T_i) + (C(P_{j+1}, T_i) - C(P_j, T_i)) \cdot \alpha$$

$$C(P, T_{i+1}) = C(P_j, T_{i+1}) + (C(P_{j+1}, T_{i+1}) - C(P_j, T_{i+1})) \cdot \alpha$$

$$\text{where: } \beta = (T - T_i) / (T_{i+1} - T_i)$$

$$\alpha = (P - P_j) / (P_{j+1} - P_j)$$

Determine TC(21.1, 0).

$$\begin{aligned} TDC &= 21.1 \text{ } ^\circ\text{C} \quad , \quad Z = 0 \text{ MSW} \\ T &= 69.98 \text{ } ^\circ\text{F} \quad , \quad P = 14.7 \text{ PSIA} \end{aligned}$$

$$C(P, T) = 4.1899 \times 10^{-6} \text{ BTU/SEC } ^\circ\text{F}$$

Convert $C(P, T)$ in BTU/SEC $^\circ\text{F}$ to $\text{W/M}^\circ\text{C}$

$$C(P, T) = 4.1899 \times 10^{-6} \cdot 6230.551 \frac{\text{W/M}^\circ\text{C}}{\text{BTU/SEC} \cdot ^\circ\text{F}}$$

$$TC(21.1, 0) = 2.6105 \times 10^{-2} \text{ W/M}^\circ\text{C}$$

Determine TC(17.65, 3.048).

$$\begin{aligned} TDC &= 17.65 \text{ } ^\circ\text{C} \quad , \quad Z = 3.048 \text{ MSW} \\ T &= 63.77 \text{ } ^\circ\text{F} \quad , \quad P = 19.155 \text{ PSIA} \end{aligned}$$

$$C(P, T) = 4.1524 \times 10^{-6} \text{ BTU/SEC} \cdot ^\circ\text{F}$$

Convert $C(P, T)$ in BTU/SEC $^\circ\text{F}$ to $\text{W/M}^\circ\text{C}$

$$C(P, T) = 4.1524 \times 10^{-6} \cdot 6230.551 \frac{\text{W/M}^\circ\text{C}}{\text{BTU/SEC} \cdot ^\circ\text{F}}$$

$$TC(17.65, 3.048) = 2.5872 \times 10^{-2} \text{ W/M}^\circ\text{C}$$

$$CR = \frac{TC(21.1,0)}{TC(17.65,3.048)}$$

$$CR = \frac{2.6105 \times 10^{-2}}{2.5872 \times 10^{-2}}$$

$$CR = 1.009006$$

Determine specific thermal resistance of the undergarment in the ambient environment (SRUGA).

The specific thermal resistance of the undergarment material at sea level in air (SRO) is adjusted for the effects of the suit entrapped gas at ambient conditions through multiplication by the conductivity ratio (CR).

$$\begin{aligned} SRUGA &= SRO \cdot CR \\ SRUGA &= 2.27 \text{ CLO/CM} \cdot 1.00901 \\ SRUGA &= 2.29044 \text{ CLO/CM} \end{aligned}$$

Determine the decimal percent change in undergarment thickness (DPCT) due to hydrostatic pressure (RED in CM).

For $RED \leq 0.1711 \text{ CM}$:

$$DPCT = RED \cdot 100.0 \cdot 2.358 \times 10^{-2}$$

For $RED > 0.1711 \text{ CMS}$:

$$DPCT = 0.343 + (RED \cdot 100.0 \cdot 3.784 \times 10^{-3}) - ((RED \cdot 100.0)^2 \cdot 1.345 \times 10^{-5})$$

As previously stated for a prone diver, $RED = 0.0$ since all regions are at the same depth below sea level.

$$\begin{aligned} DPCT &= 0.0 \cdot 100.0 \cdot 2.358 \times 10^{-2} \\ DPCT &= 0.0 \end{aligned}$$

Determine the specific thermal resistance of the undergarment at ambient conditions corrected for the effects of hydrostatic pressure (SRUGHA).

SRUGHA is formed by multiplying the specific thermal resistance of the undergarment (SRUGA) by one minus the decimal percent change in specific thermal resistance due to a change in undergarment thickness ($DPCT \cdot DR$).

$$\begin{aligned} SRUGHA &= SRUGA \cdot (1.0 - DPCT \cdot DR) \\ SRUGHA &= 2.29044 \cdot (1.0 - 0.0 \cdot 0.1175) \\ SRUGHA &= 2.29044 \text{ CLO/CM} \end{aligned}$$

Determine the unit thermal resistance (RUGHA).

The specific thermal resistance (SRUGHA) is converted to a unit thermal resistance (RUGHA) by multiplying by the actual thickness of the undergarment.

$$RUGHA = SRUGHA \cdot (WUGO \cdot TWUGO(BR))(1.0 - DPCT)$$

From Array TWUGO:

$$TWUGO(3) = 1.0$$

$$WUGO = 1.63 \text{ CM}$$

$$DPCT = 0.0$$

$$RUGHA = 2.29044 \cdot (1.63 \cdot 1.0)(1.0 - 0.0)$$

$$RUGHA = 3.7334 \text{ CLO}$$

Convert undergarment resistance in CLO (RUGHA) to $M^2\text{°C/W}$ (RUGHAJ).

$$RUGHAJ = RUGHA \cdot 0.15477 \frac{M^2\text{°C/W}}{CLO}$$

$$RUGHAJ = 0.57782 \text{ M}^2\text{°C/W}$$

Determine radius from center line of region to skin surface (R1).

$$R1 = B(BR,2)/2.0 = B(3,2)/2.0$$

From Array B:

$$B(3,2) = 0.300 \text{ M}$$

$$R1 = 0.300/2.0$$

$$R1 = 0.15 \text{ M}$$

Determine radius from center line to outer surface of undergarment (R2).

$$R2 = R1 + (WUGO \cdot TWUGO(BR) \cdot (1.0 - DPCT)/100.0)$$

From Array TWUGO:

$$TWUGO(3) = 1.0$$

$$R2 = 0.15 + (1.63 \cdot 1.0 \cdot (1.0 - 0.0)/100.0)$$

$$R2 = 0.1663 \text{ M}$$

Determine radius from center line to outer surface of outer garment (R3).

$$R3 = R2 + 0.06/100.0$$

$$R3 = 0.15875/100.0)$$

Determine the unit thermal resistance of the undergarment on a cylindrical surface (RUG) by converting the unit resistance on a flat surface (RUGHAI).

$$RUG = \frac{RUGHAI \cdot R1 \cdot \ln(R2/R1) \cdot 100.0}{WUGO \cdot TWUGO(BR) \cdot (1.0 - DPCT)}$$

$$RUG = \frac{0.57782 \cdot 0.15 \cdot \ln(0.1663/0.15) \cdot 100.0}{1.63 \cdot 1.0 \cdot (1.0 - 0.0)}$$

$$RUG = 0.548529 \text{ M}^2\text{C/W}$$

Determine ROG:

$$ROG = \frac{R1 \cdot \ln(R3/R2)}{COG}$$

$$ROG = \frac{0.15 \cdot \ln(0.1678875/0.1663)}{0.17307}$$

$$ROG = 8.23429 \times 10^{-3} \text{ M}^2\text{C/W}$$

Determine ROBL for water boundary layer:

$$ROBL(T3) = \frac{R1}{R3 \cdot CHTC(T3, R3)}$$

Determine the temperature of outside surface of the outer garment (T3) by application of the Secant Method for finding the roots of the equation displayed below and coded as Function F(T).

$$F(T3) = \frac{T1 - TA}{RUG + ROG + ROBL(T3)} - \frac{T1 - T3}{RUG + ROG}$$

Repeated solutions of the above with the Secant algorithm to select the new estimates of T3 yielded $F(T3) = 0$ when $T3 = 5.7194 \text{ }^\circ\text{C}$.

Determine the convective heat transfer coefficient ($CHTC(T3, R3)$).

Given: Diver posture (ATT) = 2 (Prone)
 Body region (BR) = 3 (Abdomen)
 Temperature of outer surface (T3) = 5.7194 °C
 Ambient temperature (TA) = 5.0 °C
 Radius to outer edge of garment (R3) = 0.1678875 M

Determine the Grashof Prandtl number product (GrPr).

$$\text{GrPr} = \alpha \cdot \text{CL}^3 \cdot (T_3 - T_A)$$

$$\text{Determine } \alpha = \frac{g\beta\rho^2C_p}{\mu k}$$

$$\log^\dagger \alpha = 9.80714 (\log T_f)^{0.12733}$$

This equation fits data taken from Holman [40] over a range of temperatures from 4.44 °C to 21.11 °C for α in units of $1/(M^3\text{°C})$.

Determine film temperature (T_f).

$$\begin{aligned} T_f &= (T_3 + T_A)/2.0 \\ T_f &= (5.7194 + 5.0)/2.0 \\ T_f &= 5.3597 \text{ °C} \end{aligned}$$

$$\begin{aligned} \log \alpha &= 9.80714 (\log T_f)^{0.12733} \\ \log \alpha &= 9.80714 (\log 5.3597)^{0.12733} \\ \log \alpha &= 9.4205 \end{aligned}$$

$$\begin{aligned} \alpha &= 10^{\log \alpha} = 10^{9.4205} \\ \alpha &= 2.6333 \times 10^{+9} \text{ } 1/(M^3\text{°C}) \end{aligned}$$

Determine characteristic length (CL).

For diver posture (ATT) = 2, body region (BR) = 3 is classified as a horizontal cylinder. For a horizontal cylinder the characteristic length (CL) is defined to be the overall diameter of the cylinder which includes the garment ensemble.

$$\begin{aligned} \text{CL} &= 2.0 \cdot R_3 \\ \text{CL} &= 2.0 \cdot 0.1678875 \\ \text{CL} &= 0.3357750 \end{aligned}$$

$$\begin{aligned} \text{GrPr} &= \alpha \cdot \text{CL}^3 \cdot (T_3 - T_A) \\ \text{GrPr} &= 2.6333 \times 10^{+9} (0.335775)^3 \cdot (5.7194 - 5.0) \\ \text{GrPr} &= 7.17160 \times 10^{+7} \end{aligned}$$

[†]log implies logarithm to the base 10.

Determine Nusselt number.

Given: Horizontal cylinder (BR = 3 and ATT = 2)

For a horizontal cylinder,
 $\log Nu = 0.2486 (\log GrPr) - 0.4483$

This equation fits experimental data taken during a series of respiratory heat loss studies performed by the Navy Experimental Diving Unit. (See Chapter II.)

$$\log Nu = 0.2486 (\log 7.1716 \times 10^7) - 0.4483$$

$$\log Nu = 1.5046$$

$$Nu = 10^{\log Nu} = 10^{1.5046}$$

$$Nu = 31.9595$$

Determine convective heat transfer coefficient (h).

$$h = \frac{Nu \cdot k}{CL}$$

Determine thermal conductivity (k).

$$k = 1.7977 \times 10^{-3} (T_f) + 0.56662$$

This equation fits data taken from Holman [40] over a range of temperatures from 0 °C to 21.11 °C for k in units of W/M°C.

$$k = 1.7977 \times 10^{-3} (5.3597) + 0.56662$$

$$k = 0.57626 \text{ W/M}^\circ\text{C}$$

$$h = \frac{31.9595 \cdot 0.57626}{0.3357750}$$

$$h = 54.8492$$

$$CHTC(T3, R3) = h = 54.8492$$

$$ROBL(T3) = \frac{R1}{R3 \cdot CHTC(T3, R3)}$$

$$ROBL(T3) = \frac{0.15}{(0.1678875)(54.8492)}$$

$$ROBL(T3) = 1.629 \times 10^{-2} \text{ M}^2\text{C/W}$$

$$HTC = \frac{1.0}{RUG + ROG + ROBL}$$

$$OHTC = \frac{1.0}{0.548529 + 8.23429 \times 10^{-3} + 1.629 \times 10^{-2}}$$

$$OHTC = 1.74504 \text{ W/M}^2\text{°C}$$

Return to Main program.

Since this is a production mode run, the regional/nodal OHTC's are corrected by applying empirically derived biasing factors.

Determine corrected value of overall heat transfer coefficient (U).

$$U = OHTC \cdot BF(BR)$$

From Array BF for region 3:

$$BF(3) = 2.27$$

$$U = OHTC \cdot BF(3)$$

$$U = 1.74504 \cdot 2.27$$

$$U = 3.96124 \text{ W/M}^2\text{°C}$$

To allow for multiple nodes per region add the most recent nodal U into a regional sum (US) and increment a nodal counter (UN).

$$US = US + U$$

$$US = 3.96124$$

$$UN = UN + 1.0$$

$$UN = 1.0$$

Determine a nodal heat flux (QR).

$$QR = U \cdot (T1 - TA)$$

$$QR = 3.96124 \cdot (30.308 - 5.0)$$

$$QR = 100.2511 \text{ W/M}^2$$

Determine a nodal heat loss (Q).

$$Q = QR \cdot SAM(BR)/NN$$

From Array SAM for region 3:

$$SAM(3) = 0.3327 \text{ M}^2$$

In this example $NN = 1$ since there is only one node per region. In a multi-node case NN would contain the number of nodes per region.

$$Q = 100.2511 \cdot 0.3327/1.0$$

$$Q = 33.3535 \text{ W}$$

Determine the total regional rate of heat loss $Q(BR)$ as of this node.

$$\begin{aligned}Q(BR) &= Q(BR) + Q \\Q(BR) &= 0.0 + 33.3535 \\Q(BR) &= 33.3535\end{aligned}$$

The array Q is used to store the regional rate of heat loss to allow a complete regional rate of heat loss record to be kept if all nine regions are being done at once. (A '0' (zero) response to question 16 of Table G.2.)

At this point all computations for a particular node have been completed. Thus if multiple nodes per region are being done, the calculations for the overall heat transfer coefficient (OHTC) must be repeated for the next node.

Begin new nodal loop.

When all nodes are calculated:

Determine the average regional overall heat transfer coefficient (U).

$$U = US/UN$$

$$U = 3.96124/1.0$$

$$U = 3.96124 \text{ W/M}^2\text{°C}$$

Corrected Predicted OHTC for Region 3: $3.96124 \text{ W/M}^2\text{°C}$

Determine regional heat flux Q(BR).

$$Q(BR) = Q(BR)/SAM(BR)$$

$$Q(BR) = 33.3535/0.3327$$

$$Q(BR) = 100.2510 \text{ W/M}^2$$

Predicted Unit Heat Flux for Region 3: 100.2510 W/M^2

From Array QALL for region 3:

$$QALL(3) = 49.70 \text{ W/M}^2$$

Allowable Unit Heat Flux for Region 3: 49.70 W/M^2

Determine supplementary heat flux (QSUPP(BR)).

$$QSUPP(BR) = Q(BR) - QALL(BR)$$

$$QSUPP(BR) = 100.2510 - 49.70$$

$$QSUPP(BR) = 50.5510 \text{ W/M}^2$$

Required Supplementary Heat Flux: 50.551 W/M^2

Determine regional rate of heat loss (QP).

$$QP = Q(BR) \cdot SAM(BR)$$

$$QP = 100.2510 \cdot 0.3327$$

$$QP = 33.3535 \text{ W}$$

Predicted Heat Loss for Region 3: 33.3535 W

Determine regional rate of allowable heat loss (QA).

$$QA = QALL(BR) \cdot SAM(BR)$$

$$QA = 49.70 \cdot 0.3327$$

$$QA = 16.535 \text{ W}$$

Allowable Heat Loss for Region 3: 16.535 W

Determine supplementary heating requirement (QSUP).

$$QSUP = QP - QA$$

$$QSUP = 33.3535 - 16.535$$

$$QSUP = 16.8185 \text{ W}$$

Required Supplementary Heating: 16.8185 W

At this point the calculations are complete. If another case were desired, one must define a new set of constraints by selecting the appropriate answers to the questions of Table G.1.

Comparison of the hand computed variables with the corresponding variables of Table G.1 indicates that the computer solution and the hand calculation agree to within at least three significant digits. This indicates the accuracy of the computer solution. The items in Table G.1 that do not appear in the hand calculations are either pertinent only with non-prone subjects or pertain solely to the execution of the Secant algorithm.

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REFERENCES

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ADDENDUM: MIXED BREATHING GAS INTERACTIVE MODEL PROGRAM

to

Technical Report

THE DEVELOPMENT OF PREDICTIVE ENGINEERING FORMULATIONS FOR DIVER HEATING

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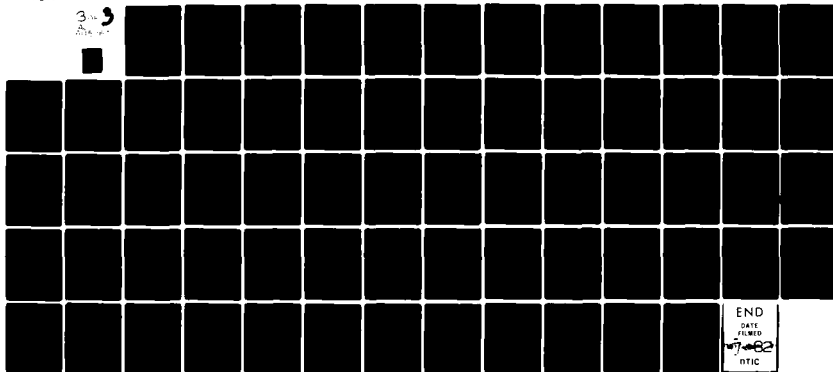
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

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MIXED BREATHING GAS INTERACTIVE MODEL PROGRAM DESCRIPTION

This addendum to The Development of Predictive Engineering Formulations for Diver Heating discusses the modification of the air diving program to permit the estimation of supplementary heating requirements when mixed breathing gas is employed with a pressure compensated dry suit. We will discuss only the specific changes to the numerical model code that were necessary to perform mixed gas related calculations. The remainder of the numerical code is exactly as previously presented in the main report. We also will present a listing of the twelve modules constituting the mixed breathing gas executable program titled MGMOD.TSK, a revised flow chart of the real function subroutine thermal conductivity (TC) which was adapted to accommodate both nitrogen-oxygen and helium-oxygen mixtures, a flow chart of the new function subroutines TCMG and INTERP associated with TC, and a description of the overlay structure required to build this program under DEC's RSX-11M operating system. Although this numerical code was developed for a binary mixture of nonpolar gases, the predictive program and subroutines could be easily adapted to accommodate tertiary mixtures of nitrogen, helium, and oxygen, whose use is being explored experimentally for very deep diving.

Our present mixed gas program is limited to the 1 to 69 ATA pressure range and the -1 to 54 °C temperature range by the data arrays compiled within the real function subroutine INTERP. It is our opinion that gas mixture predictive correlations for pressure and temperature should be experimentally validated prior to assuming accurate prediction of properties beyond the ranges cited.

There is currently no available mixed gas experimental data analogous to that which was collected during the Diver Thermal Protection series and which was used in our major report; however, we consider that MGMOD.TSK will predict supplementary heating requirements for resting divers who are breathing mixed gas with an accuracy comparable to that obtained with HLMOD.TSK. We express this opinion because the only change to the major program logic is the consideration of the effect of mixed gas permeating the open cell insulative undergarment. We note on page 142 of the report that the tests of Nuckols [1] indicated that the insulative properties of diver undergarment materials can be attributed primarily to their ability to entrap gas. Nuckols found in a normal environment that the thermal resistance of a porous material was proportional to the gas thermal conductivity with which it was permeated. The laws of physics permitted us to extrapolate these findings to the ambient conditions of diving with either pressurized air or mixed gas.

Referring to the listing of the Main module MHLMOD.FTN, the first variation from the original program HLMOD.FTN is the introduction of two variables in the main program labeled COMMON/TRNOSQ/ statement. YG is a real variable which is used to quantify the mole fraction of the inert gas component of a binary breathing mixture. IG is a byte data type variable employed to identify the inert gas component of a mixture or air. Inert gases considered in this program are nitrogen and helium, and the symbols used in the program are 'N' and 'H', respectively. 'A' is used to designate air. The

second modification to the Main module is the introduction of two additional interactive questions seen on page 388 of the program listing. Referring to Appendix E, Interactive Program Flow Chart, these two questions would be labeled 4a and 4b, respectively, and would be interjected between questions labeled 4 and 5 on page 270.

4a Select breathing gas:
(A)ir or oxygen mixed with (H)elium
or (N)itrogen.

4b Enter mole fraction of inert component.

Similarly, questions 4a and 4b would be inserted immediately before question 5 on page 220 of Appendix D, Interactive Program Documentation. There are no other changes to the Main module. Further modifications which are necessary to apply the model for mixed gas breathing are contained within the associated subroutine modules. We suggest that the reader refer to the module listing of MHLMOD.FTN and the cited subroutine modules in order to understand the program logic that now will be described. The program listing begins on page 381.

We see on page 393 of the program listing that statement label 118 determines the regional overall heat transfer coefficient U by means of the Function OHTC. Reviewing the real function subroutine OHTC, we see that it is necessary to compute the conductivity ratio CR defined as

$$CR = TCAR/TC(MT,EDS) \quad (1)$$

in order to correct the undergarment reference specific thermal resistance for the effects of entrapped gas at the ambient temperature and pressure. The variable MT is the estimated temperature of the gas entrapped in the undergarment and EDS is the depth below sea level of the differential element of a body region that is being considered. (See Fig. 72, page 155, for

illustration of such a differential element.) The expression TC(MT,EDS) calls the real function subroutine TC. TCAR is the reference value for the thermal conductivity of air at 21.1 °C and 0.0 meters depth. This reference value of undergarment thermal conductivity is used whether the breathing gas is air or a binary mixture.

The called function subroutine TC also accesses the variables YG and IG as specified in the labeled COMMON/TRNOSQ/ statement. Using IG, the function subroutine TC determines whether the ambient gas is air or a mixture. If IG is 'A', the routine proceeds exactly as explained in the main report and calculates the thermal conductivity of air at the ambient conditions. However, if IG is either 'N' or 'H', the subroutine calls the real function subroutine TCMG. The statement labeled 100 of the TC routine accesses the thermal conductivity-mixed gas function TCMG which calculates the mixture thermal conductivity as a function of the inert gas mole fraction, temperature, and pressure.

The values of ambient temperature (°F) and pressure (PSIA) are passed to TCMG by the function call of statement 100 as discussed above. The assigned values of YG and IG are again transferred by means of a block COMMON statement. The real function subroutine INTERP is called from within Function TCMG to calculate the values of thermal conductivity and viscosity for component gases or the mixture. Real function INTERP interpolates pure gas property data excerpted from the U.S. Navy Diving Gas Manual [2] as a function of temperature and pressure. Data of thermal conductivity and viscosity for nitrogen, helium, and oxygen are stored in INTERP. The interpolation algorithm is again that of Carnahan, Luther, and Wilkes [3]; see page 295 of the report. Using the interpolated pure component values now stored in Array TP, Function TCMG computes the mixed gas thermal conductivity by the Mason-Saxena form of Wassiljewa's equation as is recommended by

reference 4. This computed value of thermal conductivity for a mixed gas at ambient conditions is returned to Function OHTC where it is used to calculate the conductivity ratio CR, Equation 1. The remainder of the OHTC function subroutine performs as previously described in the main report and computes the value of U for the Main module.

The U.S. Navy Diving Gas Manual [2] tabulates the thermal conductivity of helium-oxygen gas mixtures as a function of temperature only at 1 ATA. The same is true for the absolute viscosity of helium-oxygen mixtures, but this principal reference contains no tabulations of thermal conductivity or absolute viscosity for nitrogen-oxygen mixtures. Appendix C of the U.S. Navy Diving Gas Manual implies that the limited data that is tabulated for thermal conductivity of helium-oxygen mixtures at low pressure were determined experimentally by Srivastava and Barua [5] and that the low pressure absolute viscosity of these mixtures were estimated by the Wilke technique. A description of Wilke's correlation may be found in reference 6. The U.S. Navy Diving Gas Manual does tabulate, from a number of reliable references, the thermal conductivity and absolute viscosity of nitrogen, helium, and oxygen as a function of temperature and pressure. The availability of this pure gas data permits reasonably accurate estimation of mixture values of thermal conductivity by means of the Wassiljewa equation that was discussed in Appendix C of our major report. Following the recommendation of Reid, Prausnitz, and Sherwood [4], we employ the Mason-Saxena form of Wassiljewa's equation. This form is similar to that previously presented as Equation C.7 except that the ϕ_{ij} terms, defined below, have been substituted for the A_{ij}

terms in Equation C.7. The equation for a binary mixture of inert gas and oxygen is:

$$k_m = \frac{k_1}{1 + 1.065 \phi_{12} (y_2/y_1)} + \frac{k_2}{1 + 1.065 \phi_{21} (y_1/y_2)} \quad (2)$$

where: k_m = Thermal conductivity of the binary mixture

k_1, k_2 = Thermal conductivity of the pure components

y_1, y_2 = Mole fraction of pure components

Subscript 1 identifies the inert gas component of the mixture and subscript 2, the oxygen component.

The ϕ_{ij} terms of Equation 2 are represented as:

$$\phi_{12} = \frac{\left[1 + \left(\frac{\mu_1}{\mu_2} \right)^{1/2} \left(\frac{M_2}{M_1} \right)^{1/4} \right]^2}{\left[8 \left(1 + \left(\frac{M_1}{M_2} \right) \right) \right]^{1/2}} \quad (6)$$

where: μ_1, μ_2 = Absolute viscosity of pure components

M_1, M_2 = Molecular weight of pure components

By reciprocity, ϕ_{21} may be determined with ϕ_{12} and associated pure component properties.

$$\phi_{21} = \left(\frac{\mu_2}{\mu_1} \right) \left(\frac{M_1}{M_2} \right) \phi_{12} \quad (4)$$

The Mason-Saxena form of Wassiljewa's equation may be extended easily to the case of a tri-mixture of breathing gases, such as helium, nitrogen, and oxygen, by evaluating the general form of the equation:

$$k_m = \sum_{i=1}^3 \frac{k_i}{1 + \sum_{\substack{j=1 \\ j \neq i}}^3 1.065 \phi_{ij} (y_j/y_i)} \quad (5)$$

where:

$$\phi_{ij} = \frac{\left[1 + \left(\frac{\mu_i}{\mu_j} \right)^{1/2} \left(\frac{M_j}{M_i} \right)^{1/4} \right]^2}{\left[8 \left(1 + \left(\frac{M_i}{M_j} \right) \right) \right]^{1/2}} \quad (6)$$

When the indices i and j have been assigned specific values, a reciprocity relationship may be used to determine ϕ_{ji} in terms of ϕ_{ij} :

$$\phi_{ji} = \left(\frac{\mu_j}{\mu_i} \right) \left(\frac{M_i}{M_j} \right) \phi_{ij} \quad (7)$$

To test the accuracy of our numerical algorithm of the Mason-Saxena form of Wassiljewa's equation, it was only possible to compare estimated and tabulated gas mixture thermal conductivity values at 1 ATA and a specific temperature. This was because of the discussed limitations of reference 2. A test comparison for a 95% helium - 5% oxygen mixture at 1 ATA and 21 °C (70 °F) revealed less than a 2% difference when the tabulated value was used as the comparative base. This small percent deviation is comparable

to the range of accuracy, for the computational Equation 5, cited both by Reid and Sherwood [6] and Reid, Prausnitz, and Sherwood [4]. Also, our computed thermal conductivity values for a binary mixture of helium and oxygen at elevated pressures compared quite favorably with values computed by Equation C.7.

PROGRAM LISTING.

```

MHLMOD (Main Module)
REAL KA, KR, COG, Q(10), EXP(29), SCALY(3,3), SCALYN(2,3)
1, LX, SX, IX, LY, SY, IY, LYS, XP(125), YP(125)
2, BF(9), QA(9), QP(9), QSUPP(9), SAM(9), GALL(9)
REAL*8 LABEL(3), BREG(10)
INTEGER FLAG1, FLAG2, COR, BR, ATT, SYM(2)
BYTE RDU, GCOMP, FILE(30), WG, PLD, PLN, DUM, REV, NST
1, PRTL(11), PRT, OUT, PU(2)
COMMON /PREDD/KA(12), KR
1, /BODY/B(9,3), COR(9,2), WGT(12)
2, /TRNOSQ/YG, IG
3, /SUIT/WUGO, DR, SRO, WOG, COG, TWUGO(9)
4, /DEBUG/FLAG2, LD
5, /OHTCD/RUGHA, RUG, RDG, ROBL, R1, R2, R3, T1, T3, FLAG1
6, Q1A, Q13
7, /PROB/BR, ATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS
8, RDU
9, /PLOT/P(125,9), LX, SX, IX, LY, SY, IY, LYS, LABEL, NREC
1, BREG, XP, YP, PD(125,3), LCL, CH, REV, PRT(13)
2, /MISC/GALL, BF

```

```

C*****
C   NOTE: ALL VALUES FOR ARRAYS ENTERED VIA DATA STATEMENTS
C   ARE ENTERED IN COLUMN MAJOR ORDER!!
C*****

```

```

C
C   ARRAY B - CONTAINS REGIONAL BODY DIMENSIONS
C   !
C   !   *NOTE* ALL VALUES ARE IN METERS
C   !
C   !   - 1ST COLUMN CONTAINS IDENTIFICATION OF SHAPE
C   !       -1 IMPLIES SPHERE
C   !       0 IMPLIES CYLINDER
C   !       +* IMPLIES CONIC = DIAMETER OF TOP OF CONE
C   !   - 2ND # IS DIAMETER OF SPHERE, CYLINDER OR
C   !       BOTTOM OF CONE
C   !   - 3RD # IS THE HEIGHT OF REGION
C   !

```

```

! DIMENSIONAL NUMBERS ENTERED FOR MODEL MAN
! *NOTE* ALL CYLINDERS AND CONES ARE CONNECTED END
! TO END.

```

```

! ID# - REGION = SHAPE / ENTERED #'S /
! 1 - HEAD = SPHERE / -1.0,0.206,0.206 /
! 2 - TORSO = CYLINDER / 0.0,0.30,0.353 /
! 3 - ABDOMEN = CYLINDER / 0.0,0.30,0.353 /
! 4 - THIGH = CYLINDER / 0.0,0.15,0.383 /
! 5 - CALF = CYLINDER / 0.0,0.12,0.328 /
! 6 - FOOT = CYLINDER / 0.0,0.15,0.104 /
! 7 - UPPER ARM = CYLINDER / 0.0,0.096,0.223 /
! 8 - LOWER ARM = CYLINDER / 0.0,0.07,0.267 /
! 9 - HAND = SPHERE / -1.0,0.123,0.123 /
!

```

```

C   ARRAY COR (9,2) CONTAINS THE CORRESPONDENCE BETWEEN
C   ! OUR 9 REGION MODEL ID #'S AND THE 12 SEGMENT
C   ! BODY/ZUMRICK MEASUREMENT SYSTEM ID #'S.
C   ! THE ROW NUMBERS OF THE ARRAY CORRESPOND TO THE

```

! BODY REGION ID'S FOR OUR 9 REGION MAN.
 ! FOR EXAMPLE: 9 REGION MODEL, REGION TORSO(2)
 ! CORRESPONDS TO THE 12 SEGMENT MODEL, SEGMENTS
 ! CHEST(2) AND UPPER BACK (4).

ROW#	9 REGION MODEL NAME	12 SEGMENT MODEL CORRESPONDING SEGMENTS NAME(ID#) ID #'S ARE IN ARRAY COR(9,2)
1	HEAD	HEAD(1), (-1)
2	TORSO	CHEST(2), UPPER BACK(4)
3	ABDOMEN	ABDOMEN(3), LOWER BACK(5)
4	THIGH	FRONT THIGH(8), REAR THIGH(10)
5	CALF	FRONT CALF(9), REAR CALF(11)
6	FOOT	FOOT(12), (-1)
7	UPPER ARM	ARM(6), (-1)
8	LOWER ARM	ARM(6), (-1)
9	HAND	WRIST(7), (-1)

! NOTE (-1) INDICATES THAT ONLY
 ! ONE CORRESPONDING SEGMENT IS
 ! AVAILABLE FROM 12 SEGMENT MODEL

C ! ARRAY SAM(9) CONTAINS THE REGIONAL SURFACE AREAS OF OUR
 ! MODEL MAN IN METERS SQUARED (M**2)
 DATA B/-1. 0, 0. 0, 0. 0, 0. 0, 0. 0, 0. 0, 0. 0, 0. 0, 0. 0, -1. 0
 1, 0. 206, 0. 30, 0. 30, 0. 15, 0. 12, 0. 15, 0. 096, 0. 07, 0. 123
 2, 0. 206, 0. 353, 0. 353, 0. 383, 0. 328, 0. 104, 0. 223, 0. 267, 0. 123/
 3, COR/1, 2, 3, 8, 9, 12, 6, 6, 7, -1, 4, 5, 10, 11, -1, -1, -1, -1/
 4, SAM/0. 1333, 0. 3327, 0. 3327, 0. 3610, 0. 2474, 0. 1334
 5, 0. 1490, 0. 1174, 0. 0950/

C !
 C ! ARRAY KA CONTAINS CONSTANTS, A(i)'S, NEEDED FOR THE
 ! SEGMENTAL TEMPERATURE PREDICTIONS. THESE
 ! CONSTANTS WERE DERIVED FROM KERSLAKE'S MODEL. SEE
 ! TEXT FOR DETAILS.

C !
 C ! VARIABLE KR IS CONTANT R NEEDED FOR SEGMENTAL
 ! TEMPERATURE PREDICTIONS.
 ! THE KR CONSTANT WAS DERIVED FROM A KERSLAKE TYPE MODEL
 ! SEE TEXT FOR DETAILS OF DERIVATION
 DATA KA/0. 36, 0. 27, 0. 30, 0. 52, -0. 08, 0. 22, -0. 64, -0. 04,
 1-0. 16, -0. 06, -0. 55, -0. 86/
 1, KR/2. 946/

C !
 C ! ARRAY GALL (9) CONTAINS THE REGIONAL ALLOWABLE HEAT
 ! FLUXES(W/M**2) ADAPTED FROM THE DATA OF BURRISS,
 ! PRINCIPLE INVESTIGATOR, 'STUDY OF THE THERMAL PROCESSES
 ! FOR MAN IN SPACE', NASA CONTRACT REPORT CR-216.

C !
 C ! ARRAY BF(9) CONTAINS THE REGIONAL BIASING FACTORS USED
 ! TO MAKE PREDICTED OVERALL HEAT TRANSFER COEFFICIENTS

!AGREE MORE FAVORABLY WITH THE EXPERIMENTAL VALUES.
 ! PRED OHTC * BF(1) = CORRECTED PRED OHTC
 DATA GALL/23. 3. 60. 0, 49. 7, 42. 4, 85. 0, 97. 0, 98. 9, 125. 25
 1, 265. 86/
 2, BF/2. 63, 2. 63, 2. 27, 3. 50, 3. 21, 12. 70, 2. 29, 2. 19, 3. 49/

C

C DEFINITION OF SUIT THERMAL PROPERTIES AND DIMENSIONS

!WUGO = WIDTH (THICKNESS) OF UNDER GARMENT AT SEA
 LEVEL (CM).
 !SRO = SPECIFIC RESISTANCE OF UNDER GARMENT
 AT SEA LEVEL (CLO/CM)
 !DR = DECIMAL % CHANGE IN SRO PER DECIMAL % CHANGE
 IN UNDERGARMENT THICKNESS
 (CLO/CM/CLO/CM/CM/CM) (IE: DIMENSIONLESS)
 EXPERIMENTALLY DETERMINED. SEE TEXT FOR
 DETAILS.
 !WOG = WIDTH OF OUTER GARMENT (CM) => 1/16 INCH
 !COG = THERMAL CONDUCTIVITY OF OUTER GARMENT MATERIAL
 WATTS/M*C)

C

!TWUGO = ARRAY CONTAINING THE # OF THICKNESSES OF
 UNDERGARMENT MATERIAL FOR EACH REGION.
 EACH LAYER IS 'WUGO' THICK.

C

!WGT - CONTAINS SURFACE AREA WEIGHTS FOR THE 12 SEGMENT
 BODY MODEL.

DATA WUGO, SRO, DR, WOG, COG/1. 63, 2. 27, 0. 1175, 0. 15875
 1, 0. 17307/
 2, TWUGO/1. 0, 1. 0, 1. 0, 1. 0, 1. 0, 2. 0, 1. 0, 1. 0, 1. 0/
 3, WGT/0. 070, 0. 085, 0. 085, 0. 090, 0. 090, 0. 140, 0. 050, 0. 095
 4, 0. 065, 0. 095, 0. 065, 0. 070/

C

!BREG - ARRAY CONTAIN BODY REGION NAMES FOR PRINT
 ORDERED ACCORDING TO REGION ID #

DATA BREG/'HEAD', 'TORSO', 'ABDOMEN', 'THIGH', 'CALF',
 1 'FOOT', 'UP ARM', 'LOW ARM', 'HAND', 'TIME'/

C

C*****

!PLOTING AND COMPARISON VARIABLES

!SCALY = ARRAY CONTAINS Y AXIS SCALES FOR T, Q, AND U
 PLOTS

! CONTENTS OF ARRAY SCALY(3,3)

! COLUMN/	1	2	3	
! ROW				
! 1	! 5. 0	20. 0	4. 0	TEMPERATURES
! 2	! 5. 0	0. 0	50. 0	HEAT FLUXES
! 3	! 4. 0	0. 0	4. 0	TRANSFER COEF.

! COLUMN 1 CONTAINS LENGTH OF Y-AXIS
 ! COLUMN 2 CONTAINS STARTING Y-AXIS VALUE
 ! COLUMN 3 CONTAINS Y-AXIS INCREMENT
 ! (IE: Y-AXIS UNITS/INCH(CM))

 ! SCALYN = ARRAY CONTAINS Y AXIS SCALES FOR
 ! NORMALIZED TEMPERATURE AND BIOT # PLOTS
 ! CONTENTS OF ARRAY SCALYN(2,3)

COLUMN/	1	2	3	
ROW				
1	4.0	0.5	0.25	NORMALIZED TEMPERATURES
2	4.0	0.0	10.0	BIOT NUMBERS

! COLUMN 1 CONTAINS LENGTH OF Y-AXIS
 ! COLUMN 2 CONTAINS STARTING Y-AXIS VALUE
 ! COLUMN 3 CONTAINS Y-AXIS INCREMENT
 ! (IE: Y-AXIS UNITS/INCH(CM))

 ! LX = LENGTH OF X-AXIS
 ! SX = STARTING VALUE FOR X-AXIS
 ! IX = INCREMENT FOR X-AXIS
 ! LY = LENGTH OF Y-AXIS
 ! SY = STARTING VALUE FOR Y-AXIS
 ! IY = INCREMENT FOR Y-AXIS
 ! LYS = LENGTH Y-AXIS SAVED
 ! XP = ARRAY FOR X-AXIS VALUES FOR PLOTTING
 ! YP = ARRAY FOR Y-AXIS VALUES FOR PLOTTING
 ! LABEL = ARRAY FOR LEGEND NAMES FOR PLOTS
 ! P = ARRAY FOR SAVING X AND Y VALUES FOR PLOTTING
 ! FILE = ARRAY FOR NAME OF FILE CONTAINING EXPERIMENTAL
 ! DATA FOR COMPARISON
 ! TAR = TOTAL AREA OF EXPERIMENTAL SUBJECT
 ! GEXPT = SUM OF EXPERIMENTAL G'S FOR SIMPLE SUM
 ! UEXPT = SUM OF EXPERIMENTAL U'S
 ! TEXPT = SUM OF EXPERIMENTAL T'S
 ! PLD = INDICATES WHETHER DIMENSIONAL PLOTS
 ! ARE WANTED OR NOT
 ! PLN = INDICATES WHETHER NON-DIMENSIONAL PLOTS
 ! ARE WANTED OR NOT
 ! IR = 0, 4, 6. 0= NO LINEARIZED EXPT. PLOTS
 ! 4= PLOT LINEARIZED EXPT. G'S
 ! 6= PLOT LINEARIZED EXPT. U'S
 ! SWGT = SUM OF HODY WEIGHTS FOR CONVERSION
 ! FROM HODY'S 12 SEGMENTS TO THE MODEL'S 9
 ! REGION FORM.
 ! SWGTT = SUM OF HODY WEIGHTS FOR CONVERSION
 ! OF SEGMENTAL EXPERIMENTAL TEMPERATURES
 ! FROM HODY'S 12 SEGMENTS TO THE MODEL'S 9
 ! REGION FORM.
 ! SWGTG = SUM OF HODY WEIGHTS FOR CONVERSION
 ! OF SEGMENTAL EXPERIMENTAL HEAT FLOWS
 ! FROM HODY'S 12 SEGMENTS TO THE MODEL'S 9
 ! REGION FORM.

!SWGTU = SUM OF HODY WEIGHTS FOR CONVERSION
 OF SEGMENTAL EXPERIMENTAL OVERALL HEAT
 TRANSFER COEFFICIENTS
 FROM HODY'S 12 SEGMENTS TO THE MODEL'S 9
 REGION FORM.
 !LFN = LENGTH OF EXPT. FILE NAME. (NO. OF CHARACTERS)
 !TS = TIME START FOR LINEARIZATION
 !TE = TIME END FOR LINEARIZATION
 !NREC = NUMBER OF EXPT. RECORDS (TIMES) AVAILABLE FOR
 COMPARISON
 !QCOMP = Y OR N, INDICATES DESIRE FOR COMPARISON OF
 EXPERIMENTAL VALUE WITH PREDICTIONS.
 !EXP IS THE ARRAY USED TO READ IN EXPERIMENTAL DATA
 VALUES FOR COMPARISON
 !ARRAY Q CONTAINS THE 9 COMPUTED REGIONAL HEAT FLUXES
 !ARRAY QP CONTAINS THE 9 COMPUTED REGIONAL HEAT FLOWS
 !ARRAY QA CONTAINS THE 9 ASSUMED REGIONAL ALLOWABLE
 HEAT FLOWS
 !ARRAY QSUPP CONTAINS THE 9 COMPUTED REQUIRED
 REGIONAL HEAT FLOWS

C-----
 C ARRAY SCALY IS ENTERED INTO THE COMPUTER VIA A DATA
 STATEMENT IN COLUMN MAJOR ORDER AS:
 ! LYT,LYQ,LYU,SYT,SYQ,SYU,IYT,IYQ,IYU
 WHERE: LYX => LENGTH OF Y-AXIS
 SYX => STARTING VALUE FOR Y-AXIS
 IYX => INCREMENTING VALUE FOR Y-AXIS
 (X IN THE ABOVE IMPLIES T'S, Q'S, OR
 U'S)
 C
 C ARRAY SCALN IS ENTERED INTO THE COMPUTER VIA A DATA
 STATEMENT IN COLUMN MAJOR ORDER AS:
 ! LYTN,LYBI,SYTN,SYBI,IYTN,IYBN
 WHERE: LYXX => LENGTH OF Y-AXIS
 SYXX => STARTING VALUE FOR Y-AXIS
 IYXX => INCREMENTING VALUE FOR Y-AXIS
 (XX IN THE ABOVE IMPLIES TN'S OR BI'S)
 C
 C VARIABLES LX, SX, IX ARE ENTERED INTO THE PROGRAM VIA
 A DATA STATEMENT AS:
 ! LX, SX, IX
 WHERE: LX => LENGTH OF X-AXIS
 SX => STARTING VALUE FOR X-AXIS
 IX => INCREMENTING VALUE FOR X-AXIS
 C
 C SYM IS A VECTOR CONTAINING THE INTEGERS CORRESPONDING
 TO THE SYMBOLS TO BE USED FOR THE EXPERIMENTAL AND
 PREDICTED VALUES RESPECTIVELY.
 DATA SCALY/5.0,5.0,4.0,20.0,0.0,0.0,4.0,50.0,4.0/

1, SCALYN/4. 0, 4. 0, 0. 5, 0. 0, 0. 25, 10. 0/
 2, LX, SX, IX/7. 0, 0. 0, 20. 0/
 3, SYM/3, 4/

C*****

C THE FOLLOWING VARIABLES ARE USED AS TEMPORARY VARIABLES
 !AND HAVE NO PERMANENT MEANING
 !DUM, I, J, L, M, N

C*****

!THIS SYSTEM LEVEL SUBROUTINE CALL IS USED TO ATTACH THE
 !TERMINAL TO THIS TASK. THIS PREVENTS RETURNS USED TO
 !TERMINATE RESPONSES FROM BEING INTERPRETED BY THE
 !OPERATING SYSTEMS MONITOR CONTROL ROUTINE.
 CALL WTQIO ("1420,"5)

C-----

C MAIN	VARIABLES DEFINED IN MODULE MAIN
!FLAG2	= DEBUG PRINT FLAG (-1=>YES, 0=>NO)
!BR	= BODY REGION ID (0-9)
!RD	= REFERENCE DEPTH => DEPTH BELOW SEA LEVEL OF SHOULDER LINE (FSW,MSW,PSI)
!RDU	= INDICATOR OF UNITS OF (F=FSW, M=MSW, P=PSI)
!NN	= # OF NODE TO DEVIDE EACH REGION INTO FOR FINITE DIFFERENCE CALCULATIONS
!OUT	= VARIABLE CONTAINING DESIRED LOCATION FOR OUTPUT PRINTS (T=TERMINAL, F=DR:DMPDAT.LST)
!TDMS	= TEMPERATURE - MEAN SKIN - AT WHICH TO PERFORM CALCULATIONS (DESIGN MEAN SKIN TEMPERATURE)
!TA	= TEMPERATURE - AMBIENT - AT WHICH TO PERFORM CALCULATIONS
!T1	= TEMPERATURE OF THE SKIN SURFACE
!ATT	= ATTITUDE OF SUBJECT (DIVER) (0=SITTING, 1=STANDING, 2=LAY HORIZONTAL)
!ITOT	= FLAG VARIABLE INDICATING WHETHER OR NOT DOING ALL REGIONS OR A SINGLE REGION (-1=>ALL REGIONS, 0=>SINGLE REGION)
!LO	= VARIABLE CONTAINING LOGICAL UNIT # AT WHICH TO PRINT OUTPUT PRINTS (5=>TERMINAL, 3=>DR:DMPDAT.LST)
!U	= VARIABLE CONTAINING RESULTS OF CALCULATION OF OVERALL HEAT TRANSFER COEFFICIENT FOR SPECIFIED NODE OF SELECTED REGION
!US	= VARIABLE CONTAINING RUNNING SUM OF NODAL U'S
!UN	= VARIABLE CONTAINING THE COUNT OF THE NUMBER OF NODES IN THE SUM (US)
!GR	= VARIABLE CONTAINING HEAT LOSS CALCULATED FOR EACH NODE
!GSUP	= REQUIRED SUPPLEMENTARY HEAT FLUX FOR THE REGION OF INTEREST

C-----

!THE FOLLOWING VARIABLE FOUND IN MODULE MAIN ARE

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      !DEFINED IN OTHER MODULES (SUBROUTINES, FUNCTIONS)
      !DZ, DZV, FLAG1, ROBL, ROG, RUG, RUGHA, R1, R2, R3, T3
C-----
      !INTEGER VARIABLE 'IB' AND ARRAY 'PRTL' ARE BOTH USED
      !BY THE OUTPUT PRINTING ROUTINES.
      !THESE VARIABLES HAVE BEEN ASSIGNED TO ALLOW MORE
      !EFFICIENT USE OF THE FORTRAN CODE
C-----
      DATA PRTL/' ','C','O','R','R','E','C','T','E','D',' ','/'
      1, IB/'--'/
30      WRITE (5,31)
31      FORMAT ('$ARE YOU A RESEARCH USER ? (Y,N,X) ')
C      THESE VARIABLE ARE BEING PRE-DEFINED FOR THE
C      PRODUCTION MODE. ALL OF THESE VARIABLE CAN BE
C      DYNAMICALLY MODIFIED IN THE RESEARCH MODE.
      REU='N'
      BR=0
      FLAG2=0
      FLAG1=0
      IR=0
      NN=1
      OUT='T'
      GCOMP='N'
      READ (5,32) REU
32      FORMAT (1A1)
      IF (REU.NE. 'Y'. AND. REU.NE. 'N'. AND. REU.NE. 'X')
      1 GO TO 30
      IF (REU.EQ. 'N') GO TO 44
      IF (REU.EQ. 'X') GO TO 15
      WRITE (5,39)
39      FORMAT ('$DO YOU WISH TO CORRECT PREDICTED '
      1, ''U'' VALUES ? (Y/N) ')
      READ (5,32) DUM
      IF (DUM.EQ. 'Y') REU='S'
40      WRITE (5,41)
41      FORMAT ('$DO YOU WISH DEBUG PRINTS: ? (Y/N): ')
      READ (5,32) DUM
      FLAG2=-1
      IF (DUM.EQ. 'Y') GO TO 44
      FLAG2=0
44      WRITE (5,6)
6      FORMAT ('$ENTER DEPTH IN (M)SW, (F)SW OR (P)SIG BY '
      1, '(M#,F#,P#): [F]', T70)
      READ (5,7) RDU, RD
7      FORMAT (1A1, F10.2)
71      WRITE (5,72)
72      FORMAT (' SELECT BREATHING GAS: ', /
      1, '$(A)IR OR OXYGEN MIXED WITH (H)ELIUM OR (N)ITROGEN'
      2, ' (A,H,N): ', T70)
      READ (5,32) IQ
      IF (IQ.EQ. 'A') GO TO 50
      WRITE (5,73) IQ
73      FORMAT ('$ ENTER MOLE FRACTION OF INERT ', 1A1

```

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1, ' COMPONENT:  [F]', T70)
READ (5, 74) YG
74  FORMAT (F6. 3)
50  WRITE (5, 51) (IB, M=1, 39), SRO, WUGO, WOG, COG
51  FORMAT ( ' ', 39A2, /, ' SEA LEVEL GARMENT ENSEMBLE '
1, ' PROPERTIES', /
2, ' 01-SPECIFIC THERMAL RESISTANCE OF UNDERGARMENT: '
3, ' (CLO/CM)'
4, T58, FB. 2, /, ' 2-UNIT THICKNESS OF UNDERGARMENT: '
5, ' (CM)'
6, T58, FB. 2, /, ' 3-THICKNESS OF OUTER '
7, ' GARMENT: (CM)', T58, FB. 4, /, ' 4-THERMAL CONDUCTIVITY'
8, ' OF OUTER GARMENT: (W/M*C)'
9, T58, FB. 4, /, '$ENTER (1-4) TO ALTER, (R) '
1, ' TO REINITIALIZE, (X) FOR NO '
2, ' CHANGE: '
READ (5, 32) IT
IF (IT.EQ. 'X') GO TO 58
IF (IT.EQ. 'R') FL4=REINIT(1)
IF (IT.EQ. 'R') GO TO 50
DECODE (1, 53, IT) IT
53  FORMAT (I1)
GO TO (54, 55, 56, 57) IT
GO TO 50
54  WRITE (5, 541)
541  FORMAT ( '$ ENTER 1 - SPECIFIC THERMAL RESISTANCE '
1, ' OF UNDERGARMENT (CLO/CM): [F] ' )
READ (5, 542) SRO
542  FORMAT (F10. 2)
GO TO 50
55  WRITE (5, 551)
551  FORMAT ( '$ ENTER 2 - UNIT THICKNESS OF UNDERGARMENT '
1, ' (CM): [F] ' )
READ (5, 552) WUGO
552  FORMAT (F10. 3)
GO TO 50
56  WRITE (5, 561)
561  FORMAT ( '$ ENTER THICKNESS OF OUTER GARMENT (CM): [F] ' )
READ (5, 562) WOG
562  FORMAT (F10. 5)
GO TO 50
57  WRITE (5, 571)
571  FORMAT ( '$ ENTER THERMAL CONDUCTIVITY OF OUTER GARMENT '
1, ' (W/M*C): [F] ' )
READ (5, 572) COG
572  FORMAT (F10. 5)
GO TO 50
58  WRITE (5, 580) (IB, M=1, 39), (M, BREQ(M), TWUGO(M), WUGO
1, (TWUGO(M)*WUGO), M=1, 9)
580  FORMAT ( ' ', 39A2, /, ' REGIONAL UNDERGARMENT THICKNESS'
1, ' (CM)', /, ' 0', T37, ' UNIT', T47, ' ACTUAL', /
2, ' ', T4, ' ID #', T12, ' REGION', T23, ' MULTIPLIER', T35
3, ' THICKNESS', T46, ' THICKNESS', /

```

```

4,9(5X,I1,5X,1A8,5X,F6.2,' * ',F6.2,' = ',F8.4,/),/
5,'$ENTER (1-9) TO ALTER, (R) TO '
6,'REINITIALIZE, (X) FOR NO CHANGE: '
READ (5,32) IT
IF (IT.EQ. 'X') GO TO 59
IF (IT.EQ. 'R') FL4=REINIT(2)
IF (IT.EQ. 'R') GO TO 58
DECODE (1,53,IT) IT
WRITE (5,584) IT,BREG(IT)
584 FORMAT ('$ENTER NEW MULTIPLIER FOR ',I1,'-',1A8
1,': [F] ')
READ (5,585) TWUGO(IT)
585 FORMAT (F6.2)
GO TO 58
59 WRITE (5,590) (IB,M=1,39),(M,BREG(M),GALL(M),M=1,9)
590 FORMAT (' ',39A2,/, ' ALLOWABLE REGIONAL HEAT FLUX'
1, ' (W/M**2)',/, '0',T32, 'ALLOWABLE',/, ' ',T4, 'ID #'
2,T12, 'REGION',T32, 'HEAT FLUX',/
3,9(' ',5X,I1,5X,1A8,10X,F10.2,/),/
4,'$ENTER (1-9) TO ALTER, (R) TO '
1,'REINITIALIZE, (X) FOR NO CHANGE: '
READ (5,32) IT
IF (IT.EQ. 'X') GO TO 60
IF (IT.EQ. 'R') FL4=REINIT(3)
IF (IT.EQ. 'R') GO TO 59
DECODE (1,53,IT) IT
WRITE (5,591) IT
591 FORMAT ('$ENTER ALLOWABLE HEAT FLUX FOR REGION '
1,I1,' (W/M**2): [F] ')
READ (5,592) GALL(IT)
592 FORMAT (F10.3)
GO TO 59
60 WRITE (5,600) (IB,M=1,39),(M,BREG(M),BF(M),M=1,9)
600 FORMAT (' ',39A2,/, ' REGIONAL BIASING FACTORS'
1, ' (DIMENSIONLESS)',/
2, '0',T4, 'ID #'
3,T12, 'REGION',T31, 'BIASING FACTOR',/
4,9(' ',5X,I1,5X,1A8,10X,F10.2,/),/
5,'$ENTER (1-9) TO ALTER, (R) TO '
6,'REINITIALIZE, (X) FOR NO CHANGE: '
READ (5,32) IT
IF (IT.EQ. 'X') GO TO 609
IF (IT.EQ. 'R') FL4=REINIT(4)
IF (IT.EQ. 'R') GO TO 60
DECODE (1,53,IT) IT
WRITE (5,601) IT
601 FORMAT ('$ENTER BIASING FACTOR FOR REGION '
1,I1,' (DIMENSIONLESS): [F] ')
READ (5,602) BF(IT)
602 FORMAT (F10.3)
GO TO 60
609 WRITE (5,111)
111 FORMAT ('$WRITE OUTPUT FILE WHERE: '

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1, '(T=SCREEN, F=DMPDAT. LST)  '
READ (5, 32) OUT
WRITE (5, 10)
10  FORMAT ('*ENTER # NODES: [I]  ')
    READ (5, 11) NN
11  FORMAT (1I4)
    IF (REV. EQ. 'N') GO TO 43
    WRITE (5, 16)
16  FORMAT ('*DO YOU WISH TO COMPARE T, G, U VALUES WITH '
1, 'EXP'T DATA: (Y/N)  ')
    READ (5, 161) GCOMP, CH
161  FORMAT (1A1, :F10.2)
    IF (GCOMP. NE. 'Y') GO TO 43
162  NREC=0
    WRITE (5, 1621)
1621 FORMAT ('*ENTER TOTAL SURFACE AREA OF EXP'T'
1, 'SUBJECT IN M**2: [F]  ')
    READ (5, 1622) TAR
1622 FORMAT (F10.2)
    IF (TAR. LE. 0.0) GO TO 162
163  WRITE (5, 1630)
1630 FORMAT ('*ENTER EXPERIMENTAL DATA FILE NAME:  ')
    READ (5, 1631) LFN, (FILE(L), L=1, LFN)
1631 FORMAT (G, <LFN>A1)
    FILE(LFN+1)='0'          !WRITE NULL
    OPEN (UNIT=2, TYPE='OLD', ACCESS='DIRECT',
1NAME=FILE, FORM='FORMATTED',
2CARRIAGECONTROL='FORTRAN', READONLY,
3RECORDSIZE=200, ERR=163)
    READ (2'1, 164) NREC
164  FORMAT (I4)
    GO TO 114
43  WRITE (5, 431) (IB, M=1, 39)
431  FORMAT (' ', 39A2, /, '*ENTER DESIGN MEAN SKIN '
1, 'TEMPERATURE (C): [F]', T65)
    READ (5, 433) TDMS
433  FORMAT (F10.3)
4330 WRITE (5, 432)
432  FORMAT ('*ENTER AMBIENT TEMPERATURE >= 1.0 C: [F]', T65)
    READ (5, 433) TA
    IF (TA. LT. 1.0) GO TO 4330
114  WRITE (5, 8)
8  FORMAT ('*SELECT BODY REGION (1-9) OR (0) FOR ALL '
1, 'REGIONS: [I]', T65)
    READ (5, 81) BR
81  FORMAT (I10)
    WRITE (5, 82)
82  FORMAT ('*SELECT POSTURE OF SUBJECT (0-SIT, 1-STAND, '
1, '2-PRONE): [I]', T65)
    READ (5, 81) ATT
    ITOT=0
    IF (BR. EQ. 0) ITOT=-1
    PRT(1)=' '

```

```

PV=2
IF (REV.EQ. 'S'. OR. REV.EQ. 'N') GO TO 821
PRT(2)='U'
PRT(3)='N'
PV=4
821 DO 822 M=2, 11
PRT(PV)=PRTL(M)
822 PV=PV+1
PV=PV-1
IF (ITOT.EQ. 0) GO TO 113
DO 14 BR=1, 9
113 LO=5
IF (OUT.EQ. 'T') GO TO 1130
LO=3
OPEN (UNIT=LO, NAME='SY: DMPD47. LST')
1130 WRITE (LO, 11301)
11301 FORMAT ('O')
IF (GCOMP.NE. 'Y') GO TO 1134
DO 150 I=1, NREC
READ (2'I+1, 1131) EXP
1131 FORMAT (13F8.2, 15F6.2, F4.1)
TA=EXP(27)
IF (TA.GT. 0.0) GO TO 11311
DO 11310 J=2, 7
P(I, J)=-1.0
11310 CONTINUE
11311 TDMS=0.0
SWGT=0.0
DO 1132 M=14, 25
C DROP VALUE & WEIGHT FROM SUM IF 'T' VALUE <= 0.0
IF (EXP(M).LE. 0.0) GO TO 1132
TDMS=TDMS+(WGT(M-13)*EXP(M))
SWGT=SWGT+WGT(M-13)
1132 CONTINUE
IF (SWGT.EQ. 0.0) GO TO 11321
TDMS=TDMS/SWGT
11321 P(I, 1)=EXP(1)
WRITE (LO, 1133) EXP(1)
1133 FORMAT (' EXPERIMENTAL TIME: ', F8.2)
1134 LY=' MSW'
IF (RDU.EQ. 'F') LY=' FSW'
IF (RDU.EQ. 'P') LY=' PSI'
T1=TR(TDMS, BR)
WRITE (LO, 115) BR, ATT, TDMS, RD, LY, TA, BR, T1
115 FORMAT ('OBODY REGION: ', T56, I10, /
1, ' POSTURE: 0=SIT, 1=STAND, 2=PRONE', T56, I10, /
2, ' DESIGN MEAN SKIN TEMPERATURE: ', T54, F10.2, ' C', /
3, ' REFERENCE DEPTH: ', T52, F10.2, 1A4, /
4, ' AMBIENT TEMPERATURE: ', T54, F10.2, ' C', /
5, ' PREDICTED TEMPERATURE FOR REGION ', I1, ': ', T54
6, F10.2, ' C')
IF (NN.EQ. 1) GO TO 116
WRITE (LO, 1151) NN

```

```

1151  FORMAT (' NUMBER OF NODES: ', T56, I10)
116    G(BR)=0.0
      US=0.0
      UN=0.0
      !NOTE: HEAD(1) AND HAND(9) ARE SPHERES AND ARE THUS
      !       MODELED AS HAVING ONE NODE ONLY FOR ALL
      !       ATTITUDES, 0=SIT, 1=STAND, 2=LAY HORT.
      !       THIGH(4) IS A HORTIZONTAL CYLINDER FOR
      !       ATT = 0(SIT) AND THUS HAS ONLY ONE NODE
      !       WHEN ATT=1(STAND), 2(LAY HORT) THIGH(4)
      !       MATCHS ALL THE OTHER CYLINDERS IN
      !       ATTITUDE
      IF (BR. NE. 1. AND. BR. NE. 9. AND. (BR. NE. 4. OR. ATT. NE. 0))
      1 GO TO 1161
      J=1
      GO TO 118
      -----
      !NOTE:
      !       P(I,1)=TIME
      !       P(I,2)=T EXPERIMENTAL
      !       P(I,3)=T PREDICTED
      !       P(I,4)=Q EXPERIMENTAL
      !       P(I,5)=Q PREDICTED
      !       P(I,6)=U EXPERIMENTAL
      !       P(I,7)=U PREDICTED
      !       P(I,8)=TDMS
      !       P(I,9)=TA
      -----
1161  DO 13 J=1, NN
      IF (NN. EQ. 1) GO TO 118
      IF (J. EQ. 1) WRITE (LO, 11611)
11611  FORMAT ('O')
      WRITE (LO, 1162) BR, J
1162  FORMAT (' REGION ', I1, ' NODE ', I4)
118    U=OHTC(J)
      !CHECK TO SEE IF CONVECTIVE HEAT TRANSFER COEFFICIENT
      ! WAS SUCCESSFULLY DETERMINED.  FLAG3=0.0 => SUCCESS
      ! FLAG3=1.0 AND FLAG3=2.0 => FAILURE (SEE SUBROUTINE
      ! CHTC FOR DIFFERENCE BETWEEN FLAG3=1.0 AND 2.0)
      IF (FLAG3. GT. 0.0) GO TO 148
      !CHECK TO SEE IF OHTC WAS SUCCESSFULLY DETERMINED.
      ! FLAG1 >= -1 SUCCESS, FLAG1 < -1 FAILURE.
      ! (SEE SUBROUTINE OHTC FOR MEANING OF VARIOUS
      ! VALUES OF FLAG1)
      IF (FLAG1. GE. -1) GO TO 1181
      IF (FLAG1. NE. -3) GO TO 11801
      WRITE (LO, 1180) T3, TA
1180  FORMAT (' ESTIMATE OF OUTSIDE SURF. TEMP., ', F5.2
      1, ' LESS THAN AMBIENT TEMP., ', F5.2)
      GO TO 11803
11801  WRITE (LO, 11802) NTOL
11802  FORMAT (' MAXIMUN # OF ITERATIONS (NTOL='
      1, I4, ') ALLOWED FOR ESTIMATING', /

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2, ' THE OUTSIDE SURFACE TEMPERATURE OF THE '
3, ' ENSEMBLE BY THE SECANT METHOD EXCEEDED' )
11803 WRITE (LO,11804)
11804 FORMAT (20X, ' RUN TERMINATED !' )
GO TO 148
C
IF DOING PRODUCTION MODE RUN (REU=N) THEN MUST APPLY
!BIASING FACTOR BF(BR) TO THE NODAL U VALUE .
!NOTE: ONLY ON NODE IS DEFINED PER REGION IN THE
!PRODUCTION MODE.
1181 IF (REU.EQ. 'N'. OR. REU.EQ. 'S') U=U*BF(BR)
US=US+U
UN=UN+1.0
QR=U*(T1-TA) !WATT/M2
Q(BR)=Q(BR)+(QR*SAM(BR)/FLOAT(NN)) !WATTS
IF (FLAG2.EQ.0) GO TO 119
WRITE (LO,1182) RUG,ROG,ROBL,R1,R2,R3,T1,T3
1,FLAG1,F(T3),CHTC(T3,R3),US,UN,QR,Q(BR)
1182 FORMAT (' RUG,ROG,ROBL',1P,3G15.7, /
1, ' R1,R2,R3',3G15.7, /
2, ' T1,T3',2G15.7,OP, /
3, ' FLAG1,F(T3),CHTC(T3,R3)',17,1P,2G15.7, /
4, ' US,UN',2G15.7, /
5, ' QR,Q(BR)',2G15.7)
C-----
C Q(BR)=Q(BR)+(QR*SAM(BR)/FLOAT(NN)) !WATTS
C NOTE: MULTIPLYING NODAL HEAT FLUX 'QR' BY
C REGIONAL SURFACE AREA 'SAM(BR)' DIVIDED BY THE
C NUMBER OF NODES 'FLOAT(NN)' FORCES THE EXTRA AREA
C CONTRIBUTED BY A CYLINDER BOTTOM AND
C A CYLINDER TOP, REGIONS 6 AND 7
C RESPECTIVELY, TO BE INCLUDED IN THE
C LATTERAL SURFACE AREA. THIS IS
C CONSISTANT WITH THE AREA ASSUMED
C FOR HEAT LOSS IN THE DEVELOPMENT
C OF THE OHTC.
C-----
119 IF (NN.EQ.1) GO TO 126
WRITE (LO,125) (PRT(L),L=1,PV),J,U,J,QR
125 FORMAT (<PV>A1, 'PREDICTED OHTC FOR NODE '
1,I4, ': ',T47,F10.2, ' W/M**2*C', /
2, ' PREDICTED HEAT FLUX FOR NODE '
3,I4, ': ',T49,F10.2, ' W/M**2', /)
126 IF (BR.EQ.1. OR. BR.EQ.9. OR. (BR.EQ.4. AND. ATT.EQ.0))
1 GO TO 142
13 CONTINUE
142 Q(BR)=Q(BR)/SAM(BR) !W/M**2
U=US/UN
WRITE (LO,144) (PRT(L),L=1,PV),BR,U,BR,Q(BR),BR,GALL(BR)
144 FORMAT (<PV>A1, 'PREDICTED OHTC FOR REGION ',I1, ': ',T47
1,F10.2, ' W/M**2*C', /
2, ' PREDICTED UNIT HEAT FLUX FOR REGION ',I1
3, ': ',T49,F10.2, ' W/M**2', /, ' ALLOWABLE UNIT HEAT FLUX '
4, 'FOR REGION ',I1, ': ',T49,F10.2, ' W/M**2')

```

```

GA(BR)=GALL(BR)*SAM(BR)
GP(BR)=G(BR)*SAM(BR)
QSUPP(BR)=GP(BR)-GA(BR)
GSUP=G(BR)-GALL(BR)
WRITE (LO, 131) GSUP, BR, GP(BR), BR, GA(BR), QSUPP(BR)
131  FORMAT (' REQUIRED SUPPLEMENTARY HEAT FLUX: ', T49, F10.2
      1, ' W/M**2', /
      2, ' PREDICTED RATE OF HEAT LOSS FOR REGION ', I1, ': '
      3, T50, F10.2, ' WATTS', /, ' ALLOWABLE RATE OF HEAT LOSS '
      4, ' FOR REGION ', I1, ': ', T50, F10.2, ' WATTS', /
      5, ' REQUIRED SUPPLEMENTARY HEATING: ', T50, F10.2
      6, ' WATTS')
      IF (GCOMP.NE. 'Y') GO TO 148
      P(I,3)=T1
      P(I,5)=G(BR)                !WATTS/M2
      P(I,7)=US/UN                !WATTS/M2*C
      P(I,8)=TDMS                !T DES. MEAN SKIN
      P(I,9)=TA                  !T AMBIENT
      TEXPT=0.0
      UEXPT=0.0
      GEXPT=0.0
      SWGTT=0.0
      SWGTG=0.0
      SWGTU=0.0
      DO 1437 L=1,2
      M=COR(BR,L)
      IF (M.EQ.-1) GO TO 1437
C   DROP VALUE & WEIGHT FROM SUM IF 'T' VALUE <= 0.0
      IF (EXP(M+13).LE.0.0) GO TO 1435
      TEXPT=TEXPT+(WGT(M)*EXP(M+13))
      SWGTT=SWGTT+WGT(M)
C   DROP VALUE & WEIGHT FROM SUM IF 'G' VALUE <= 0.0
1435  IF (EXP(M+1).LE.0.0) GO TO 1436
      GEXPT=GEXPT+EXP(M+1)        !WATTS
      SWGTG=SWGTG+WGT(M)
C   DROP VALUE & WEIGHT FROM SUM IF 'G' VALUE <= 0.0
1436  IF (EXP(M+1).LE.0.0.OR.EXP(M+13).LE.0.0) GO TO 1437
      UEXPT=UEXPT+(EXP(M+1)/(EXP(M+13)-TA))
      SWGTU=SWGTU+WGT(M)
1437  CONTINUE
      IF (SWGTT.EQ.0.0) GO TO 1438
      TEXPT=TEXPT/SWGTT
1438  IF (SWGTG.LE.0.0) GO TO 1439
      GEXPT=GEXPT/(TAR*SWGTG) !W/M2
1439  IF (SWGTU.EQ.0.0) GO TO 1440
      UEXPT=UEXPT/(SWGTU*TAR)
1440  P(I,2)=TEXPT
      P(I,4)=GEXPT
      P(I,6)=UEXPT
      M=2
      PU(1)=' ',
      PU(2)=' ',
      IF (COR(BR,2).EQ.-1) M=1

```

```

      IF (M.EQ.1) PU(1)='/'
      WRITE (LO,1441) (COR(BR,L),PU(L),L=1,M),BR,TEXPT
      1, (COR(BR,L),PU(L),L=1,M),BR,UEXPT
      2, (COR(BR,L),PU(L),L=1,M),BR,GEXPT
1441  FORMAT (' WGT''ED EXP''T TEMP, SITE(S) '
      1,<M>(I2,A1), ' REGION ',I1,' ',T54
      2,F10.2,' C',/
      3, ' WGT''ED EXP''T OHTC, SITE(S) '
      4,<M>(I2,A1), ' REGION ',I1,' ',T47
      5,F10.2,' W/M**2*C',/
      6, ' WGT''ED EXP''T HEAT FLUX, SITE(S) '
      7,<M>(I2,A1), ' REGION ',I1,' ',T49
      8,F10.2,' W/M**2')
148  WRITE (LO,149) (IB,M=1,32)
149  FORMAT (' ',32A2)
      IF (GCOMP.NE.'Y') GO TO 360
150  CONTINUE
      IF (ITOT.EQ.-1.AND.BR.GT.1) GO TO 152
      PRT(1)='('
      LCL=2
      IF (REU.EQ.'S') GO TO 1501
      PRT(2)='U'
      PRT(3)='N'
      LCL=4
1501  DO 1502 M=2,10
      PRT(LCL)=PRTL(M)
1502  LCL=LCL+1
      PRT(LCL)='')
      WRITE (5,151)
151  FORMAT ('$DO YOU WISH TO PLOT T''S, Q''S, AND U''S? '
      1,'(Y/N) ')
      READ (5,32) PLD
      IF (PLD.NE.'Y') GO TO 249
1510  LABEL(1)='T C'
      LABEL(2)='Q W/M2'
      LABEL(3)='U W/M2*C'
      WRITE (5,1511) (LABEL(M),(SCALY(M,N),N=1,3),M=1,3)
1511  FORMAT (' ',10X,'Y-AXIS SCALE FACTORS',//
      1,10X,7X,'LY',10X,7X,'SY',10X,7X,'IY',/
      2,3(1X,A8,1X,3(F10.2,9X)),//
      3,'$SELECT: (1=T,2=Q,3=U,X=NO MORE CHANGES) ')
      READ (5,32) IT
      IF (IT.EQ.'X') GO TO 1517
      DECODE (1,1514,IT) L
1514  FORMAT (I1)
      IF (L.LE.0.OR.L.GE.4) GO TO 1517
      WRITE (5,1515) LABEL(L)
1515  FORMAT ('$ENTER',A8,' LY,SY,IY SEPARATED BY COMMAS: '
      1'[F] ')
      READ (5,1516) (SCALY(L,M),M=1,3)
1516  FORMAT (3F10.3)
      GO TO 1510
1517  WRITE (5,1518) LX, SX, IX

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```

1518  FORMAT (' ',10X,'X-AXIS (TIME) SCALE FACTORS',//
        1,10X,7X,'LX',10X,7X,'SX',10X,7X,'IX',/
        2,(1X,'T,G,U MIN',3(F10.2,9X)),//
        3,'$CHANGE X-AXIS? (Y/N) ')
      READ (5,32) IT
      IF (IT.NE.'Y') GO TO 152
      WRITE (5,1519)
1519  FORMAT ('$ENTER LX,SX,IX SEPARATED BY COMMAS: [F] ')
      READ (5,1516) LX,SX,IX
      GO TO 1517
152   IF (PLD.NE.'Y') GO TO 249
      DO 200 K=1,3
      CALL NEWDEV (,'DRO: COMPAR. VEC',14)
      CALL PLOTST (4,'IN',1)
      CALL PLOT (1.0,1.0,-3)
      CALL AXIS (0.0,0.0,'TIME (MIN)',-10,LX,0.0,SX,IX)
      GO TO (190,170,180) K
190   LY=SCALY(K,1)
      SY=SCALY(K,2)
      IY=SCALY(K,3)
      LYS=LY
      CALL AXIS (0.0,0.0,'TEMPERATURE (C)',+15,LY,90.0,SY,IY)
      LABEL(1)='T-EXPT '
      LABEL(2)='T-PRED '
      OPEN (UNIT=6,NAME='DR: COMPAR. OUT')
      WRITE (6,191) BREG(BR),LY,SY,IY
191   FORMAT (' ',7X,1AB,/, ' ',7X,'LY:',F7.2,5X,'SY:'
        1,F7.2,5X,'IY:'
        2,F7.2,/, ' ',7X,'* INDICATES POINT NOT PLOTTED;'
        3,' ITS VALUE IS <= 0 OR < SY',/
        4,12X,' TIME ',12X,' T-EXPT ',10X
        5,' T-PRED ',/)
      CALL PLOTD(1,SYM,BR)
      CALL PLOTND
      CLOSE (UNIT=6)
      GO TO 200
170   LY=SCALY(K,1)
      SY=SCALY(K,2)
      IY=SCALY(K,3)
      LYS=LY
      CALL AXIS (0.0,0.0,'HEAT FLUX (W/M2) ',+19,LY
        1,90.0,SY,IY)
      LABEL(1)='Q-EXPT '
      LABEL(2)='Q-PRED '
      OPEN (UNIT=6,NAME='DR: COMPAR. OUT')
      WRITE (6,171) BREG(BR),(PRT(M),M=1,LCL),LY,SY,IY
171   FORMAT (' ',7X,1AB,<LCL>A1,/, ' ',7X,'LY:',F7.2,5X,'SY:'
        1,F7.2,5X,'IY:'
        2,F7.2,/, ' ',7X,'* INDICATES POINT NOT PLOTTED;'
        3,' ITS VALUE IS <= 0 OR < SY',/
        4,12X,' TIME ',12X,' Q-EXPT ',10X
        5,' Q-PRED ',/)
      CALL PLOTD(3,SYM,BR)

```

```

CALL PLOTND
CLOSE (UNIT=6)
GO TO 200
180 LY=SCALY(K,1)
SY=SCALY(K,2)
IY=SCALY(K,3)
LYS=LY
CALL AXIS (0.0,0.0,'OHTC (W/M2*C)',+13,LY,90.0,SY,IY)
LABEL(1)='U-EXPT '
LABEL(2)='U-PRED '
OPEN (UNIT=6,NAME='DR: COMPAR. OUT')
WRITE (6,181) BREQ(BR), (PRT(M),M=1,LCL),LY,SY,IY
181 FORMAT (' ',7X,1A8,<LCL>A1,/, ' ',7X,'LY: ',F7.2,5X,'SY: '
1,F7.2,5X,'IY: '
2,F7.2,/, ' ',7X,'* INDICATES POINT NOT PLOTTED; '
3,' ITS VALUE IS <= 0 OR < SY',/
4,12X,' TIME',14X,' U-EXPT ',10X
5,' U-PRED ',/)
CALL PLOTD(5,SYM,BR)
CALL PLOTND
CLOSE (UNIT=6)
200 CONTINUE
249 IF (ITOT.EQ.-1.AND.BR.GT.1) GO TO 320
WRITE (5,300)
300 FORMAT ('$DO YOU WISH TO PLOT NORMALIZED T''S AND'
1,' BIOT #'S ? (Y/N) ')
READ (5,32) PLN
IF (PLN.NE.'Y') GO TO 360
310 LABEL(1)='TN'
LABEL(2)='BI'
WRITE (5,311) (LABEL(M),(SCALYN(M,N),N=1,3),M=1,2)
311 FORMAT (' ',10X,'Y-AXIS SCALE FACTORS',/
1,' ',8X,'NON-DIMENSIONAL T''S & U''S',//
2,10X,7X,'LY',10X,7X,'SY',10X,7X,'IY',/
3,2(1X,A8,1X,3(F10.2,9X)),//
4,'$SELECT: (1=TN,2=BI,X=NO MORE CHANGES) ')
READ (5,32) IT
IF (IT.EQ.'X') GO TO 317
DECODE (1,314,IT) L
314 FORMAT (I1)
IF (L.LE.0.OR.L.GE.4) GO TO 317
WRITE (5,315) LABEL(L)
315 FORMAT ('$ENTER',A8,' LY,SY,IY SEPARATED BY COMMAS: '
1,' [F] ')
READ (5,316) (SCALYN(L,M),M=1,3)
316 FORMAT (3F10.3)
GO TO 310
317 WRITE (5,318) LX,SX,IX
318 FORMAT (' ',10X,'X-AXIS (TIME) SCALE FACTORS',//
1,10X,7X,'LX',10X,7X,'SX',10X,7X,'IX',/
2,(1X,'TN,BI MIN',3(F10.2,9X)),//
3,'$CHANGE X-AXIS? (Y/N) ')
READ (5,32) IT

```

```

IF (IT.NE. 'Y') GO TO 320
WRITE (5,319)
319  FORMAT ('$ENTER LX, SX, IX SEPARATED BY COMMAS: [R] ')
      READ (5,316) LX, SX, IX
      GO TO 317
320  IF (PLN.NE. 'Y') GO TO 360
      DO 350 K=1,2
      CALL NEWDEV (, 'DR: COMPARN. VEC', 15)
      CALL PLOTST (4, 'IN', 1)
      CALL PLOT (1.0, 1.0, -3)
      CALL AXIS (0.0, 0.0, 'TIME (MIN)', -10, LX, 0.0, SX, IX)
      GO TO (330,340) K
330  LY=SCALYN(K,1)
      SY=SCALYN(K,2)
      IY=SCALYN(K,3)
      LYS=LY
      CALL AXIS (0.0, 0.0, 'NORMALIZED TEMPERATURE', +22, LY
1,90.0, SY, IY)
      LABEL(1)='TN-EXPT '
      LABEL(2)='TN-PRED '
      OPEN (UNIT=6, NAME='DR: COMPARN. OUT')
      WRITE (6,331) BREG(BR), LY, SY, IY
331  FORMAT (' ', 7X, 1A8, '/', ' ', 7X, 'LY: ', F7.2, 5X, 'SY: '
1, F7.2, 5X, 'IY: '
2, F7.2, '/', ' ', 7X, '* INDICATES POINT NOT PLOTTED; '
3, ' ITS VALUE IS <= 0 OR < SY', /
4, 12X, ' TIME ', 13X, ' TN-EXPT ', 10X
5, ' TN-PRED ', /)
      CALL PLOTN(1, SYM)
      CALL PLOTND
      CLOSE (UNIT=6)
      GO TO 350
340  LY=SCALYN(K,1)
      SY=SCALYN(K,2)
      IY=SCALYN(K,3)
      LYS=LY
      CALL AXIS (0.0, 0.0, 'BIOT NUMBER', +11, LY
1,90.0, SY, IY)
      LABEL(1)='BI-EXPT '
      LABEL(2)='BI-PRED '
      OPEN (UNIT=6, NAME='DR: COMPARN. OUT')
      WRITE (6,341) BREG(BR), (PRT(M), M=1, LCL), LY, SY, IY
341  FORMAT (' ', 7X, 1A8, <LCL>A1, '/', ' ', 7X, 'LY: ', F7.2, 5X, 'SY: '
1, F7.2, 5X, 'IY: '
2, F7.2, '/', ' ', 7X, '* INDICATES POINT NOT PLOTTED; '
3, ' ITS VALUE IS <= 0 OR < SY', /
4, 12X, ' TIME ', 13X, ' BI-EXPT ', 10X
5, ' BI-PRED ', /)
      CALL PLOTN(5, SYM)
      CALL PLOTND
      CLOSE (UNIT=6)
350  CONTINUE
360  IF (LD.EQ.5) GO TO 361

```

```
      CLOSE (UNIT=LD)
361    IF (ITOT.EQ.0) GO TO 15
14     CONTINUE
15     CLOSE (UNIT=2,DISPOSE='SAVE')
      IF (REV.EQ.'X') GO TO 362
      GO TO 30
C*****
      !THIS CALL TO A SYSTEM LEVEL SUBROUTINE IS
      !USED TO DE-ATTACH THE TERMINAL.  SEE
      !COMMENT AT TOP OF CODE ABOUT INITIAL
      !CALL TO 'WTGIO'
362    CALL WTGIO ("2000,"5)
C*****
      STOP
      END
```

```
FUNCTION REINIT(I)
REAL A(5), B(5), C(9), D(9), E(9), F(9), G(9), H(9)
COMMON /SUIT/A, C
1, /MISC/E, G
DATA B/1. 63, 0. 1175, 2. 27, 0. 15875, 0. 17307/
1, D/1. 0, 1. 0, 1. 0, 1. 0, 1. 0, 2. 0, 1. 0, 1. 0, 1. 0/
2, F/23. 3, 60. 0, 49. 7, 42. 4, 85. 0, 97. 0, 98. 9, 125. 25
3, 265. 86/
4, H/2. 56, 2. 56, 2. 22, 3. 45, 3. 13, 12. 50, 2. 27, 2. 17, 3. 45/
GO TO (10, 20, 30, 40) I
10 DO 11 J=1, 5
   A(J)=B(J)
11 CONTINUE
   GO TO 100
20 DO 21 J=1, 9
   C(J)=D(J)
21 CONTINUE
   GO TO 100
30 DO 31 J=1, 9
   E(J)=F(J)
31 CONTINUE
   GO TO 100
40 DO 41 J=1, 9
   G(J)=H(J)
41 CONTINUE
100 REINIT=I
   RETURN
   END
```

REAL FUNCTION OHTC(SN)

C-----
 ! THIS FUNCTION SYNTHESIZES THE PRESSURE AND TEMPERATURE
 ! DATA AND PRODUCES A VALUE FOR THE OVERALL HEAT TRANSFER
 ! COEFFICIENT IN WATTS/SEC*C*(M**2) FOR THE GARMENT
 ! ENSEMBLE.
 ! THE GARMENT ASSUMED IS THE NAVY'S DIVER THERMAL
 ! PROTECTION ENSEMBLE
 ! THE UNDERGARMENT IS MODELED AS DESCRIBED IN THE TEXT.
 ! THE OUTER GARMENT IS MODELED AS A SOLID SLAB OF
 ! NEOPRENE OF THICKNESS EQUAL TO OUTER GARMENT THICKNESS.
 ! THE HEAT TRANSFER COEFFICIENT FOR THE OUTER BOUNDARY
 ! LAYER IS DETERMINED FROM EQUATIONS DERIVED FROM
 ! EXPERIMENTAL DATA. (SEE TEXT FOR DETAILS)

C-----
 C OHTC VARIABLES DEFINED IN MODULE OHTC
 ! RDS = REGIONAL DATUM START=> REGION DEPTH BELOW
 ! SHOULDER REFERENCE (RDS=0.0 IF LAYING
 ! HORIZONTAL)
 ! TCAR = THERMAL CONDUCTIVITY OF AIR AT REFERENCE
 ! TEMPERATURE OF 21.1 C AND A DEPTH OF
 ! ZERO METERS OF SEA WATER
 ! = 2.611E-2 WATTS/METER C
 ! CR = CONDUCTIVITY RATIO=> RATIO OF THERMAL
 ! CONDUCTIVITIES OF AIR AT 0 MSW, 21.1 C (TCAR)
 ! AND THE SUIT ENTRAPPED GAS AT AMBIENT DEPTH
 ! AND PRESSURE.
 ! DPCT = DECIMAL % CHANGE IN THINSULATE THICKNESS AS A
 ! FUNCTION OF HYDROSTATIC PRESSURE (DEPTH BELOW
 ! SHOULDERS)
 ! DZ = NODAL DISTANCE INCREMENT. DISTANCE BETWEEN
 ! NODES IN FINITE DIFFERENCE SOLUTION FOR
 ! EACH REGION. EACH CYLINDRICAL REGION
 ! IS DIVIDED INTO NODES ALLONG IT'S
 ! LENGTH ONLY. SPHERES ARE TREATED AS HAVING
 ! A SINGLE NODE AT ALL TIMES.
 ! DZV = NODAL DEPTH INCREMENT. DEPTH CHANGE
 ! CAUSED BY EACH NODE WHEN REGION IS
 ! VERTICAL. WHEN THE REGION IS
 ! HORIZONTAL THE NODES STEP OUTWARD
 ! IN THE HORIZONTAL DIRECTION.
 ! WHEN THE REGION IS VERTICAL THE NODES
 ! STEP DOWNWARD IN THE VERTICAL PLANE.
 ! EDS = ELEMENT DISTANCE FROM SEA LEVEL. ELEMENT
 ! IMPLIES DIFFERENTIAL ELEMENT OF FINITE
 ! DIFFERENCE EQUATIONS. IE: DEPTH BELOW SEA
 ! LEVEL TO THE ELEMENT OF INTEREST)
 ! SEP = START OF NODAL ELEMENT POSITION.
 ! DISTANCE FROM THE STARTING END OF THE REGION
 ! TO THE START OF THE NODAL ELEMENT.
 ! SEPV = STARTING DEPTH OF THE NODAL ELEMENT FROM
 ! BEGINNING DEPTH OF THE REGION
 ! MT = MEAN TEMPERATURE BETW. AMBIENT AND THE SKIN

SURFACE. ESTIMATED TEMPERATURE OF THE GAS ENTRAPPED IN THE UNDERGARMENT.

RDM = REFERENCE DEPTH (RD) CONVERTED TO METERS OF SEA WATER. (RD => DEPTH FROM SEA LEVEL TO SHOULDERS)

RED = REGIONAL ELEMENT DEPTH, DEPTH BELOW SHOULDERS TO MID-POINT OF THE ELEMENT OF INTEREST. (NOTE: IF SUBJECT LAYING HORIZONTAL (ATT=2) THEN RED=0.0)

ROBL = THERMAL RESISTANCE DUE TO THE PRESENCE OF THE BOUNDARY LAYER ON THE OUTSIDE SURFACE OF THE OUTER GARMENT

ROG = THERMAL RESISTANCE DUE TO THE PRESENCE OF THE OUTER GARMENT

RUG = THERMAL RESISTANCE DUE TO THE PRESENCE OF THE UNDER GARMENT

SRO = SPECIFIC RESISTANCE OF UNDER GARMENT AT SEA LEVEL (CLO/CM)

SRUGA = SPECIFIC THERMAL RESISTANCE OF THE UNDERGARMENT DUE TO THE ENTRAPPED GAS AT THE AMBIENT TEMPERATURE AND PRESSURE ONLY.

SRUGHA = SPECIFIC THERMAL RESISTANCE OF THE UNDERGARMENT DUE TO BOTH HYDROSTATIC SQUEEZE AND THE AMBIENT GAS AT DEPTH

RUGHA = THERMAL RESISTANCE OF THE UNDER GARMENT DUE TO BOTH HYDROSTATIC SQUEEZE AND THE AMBIENT GAS AT DEPTH (IN UNITS OF CLO'S)

RUGHAJ = THERMAL RESISTANCE OF THE UNDER GARMENT, RUGHA, CONVERTED FROM CLO'S TO SEC*C*M2/J OR C*M2/WATT

R1 = RADIUS FROM CENTER OF CYLINDER/SPHERE TO EDGE OF THE CYLINDER/SPHERE (M)

R2 = RADIUS FROM CENTER OF CYLINDER/SPHERE TO OUTSIDE EDGE OF THE UNDERGARMENT (M)

R3 = RADIUS FROM CENTER OF CYLINDER/SPHERE TO OUTSIDE EDGE OF OUTER GARMENT (M)

TR2 = THICKNESS OF THE UNDERGARMENT, WUGO, AT DEPTH THICKNESS REDUCED DUE TO HYDROSTATIC SQUEEZE

T3 = TEMPERATURE OF THE OUTER SURFACE OF THE OF THE OUTER GARMENT

NOTE FLAG1, FTOL, TTOL, NTOL, AND REAL FUNCTION F ARE ALL INVOLVED IN FINDING THE OUTSIDE SURFACE TEMPERATURE, T3, OF THE OUTER GARMENT USING THE SECANT METHOD OF FINDING THE REAL ROOTS OF THE FUNCTION F.

FLAG1 = FLAG INDICATING RESULTS OF THE SECANT METHOD FOR FINDING THE OUTSIDE SURFACE TEMP. OF THE OUTER GARMENT

= -3 => ESTIMATE OF OUTSIDE SURFACE TEMP. > OR = AMBIENT TEMPERATURE

= -2 => MAX ALLOWED NUMBER OF ITERATIONS, NTOL, EXCEEDED.

= -1 => VALUE OF FUNCTION F AT NEW TEMP. EQUALS VALUE OF F AT OLD TEMP.

```

      = 1 => COMPUTED CHANGE IN TEMPERATURE
              LESS THAN OR EQUAL TO MINIMUM ALLOWED
              TEMPERATURE SPECIFIED (TTOL).
      = 2 => NEW VALUE OF FUNCTION F LESS THAN OR
              EQUAL TO MINIMUM ALLOWED VALUE , FTOL.
! FTOL = MINIMUM ALLOWED VALUE OF THE FUNCTION F
! TTOL = MINIMUM ALLOWED VALUE FOR THE TEMPERATURE STEP
!       AT EACH ITERATION
! NTOL = MAXIMUM ALLOWED NUMBER OF STEPS THE SECANT
!       PROCEDURE CAN TAKE
! TN1  = NEW ESTIMATE OF THE TEMPERATURE
! TN0  = OLD ESTIMATE OF THE TEMPERATURE
! DT   = DIFFERENCE BETW. OLD AND NEW TEMPERATURE
!       ESTIMATES
! B    = ARRAY CONTAINING BODY DIMENSIONS FOR THE 9
!       REGION MODEL MAN.
! COR  = ARRAY CONTAINING THE CORRESPONDENCE BETWEEN
!       THE 9 REGION AND 12 SEGMENT MODELS
! WGT  = ARRAY CONTAINING THE 12 SEGMENTAL BODY
!       SURFACE AREA WEIGHTS.
! *NOTE* THE FOLLOWING VARIABLES USED IN THIS MODULE
! WERE DEFINED IN MODULE - MAIN
!         ATT, BR, COG, DR, FLAG2, LO, NN, RD, RDU, SRO, TA,
!         TDMS, WOG, WUGO, TWUGO

```

```

! *NOTE* THE FOLLOWING VARIABLES USED IN THIS MODULE
! ARE TEMPORARY VARIABLE AND HAVE NO PERMINANT MEANING
!       I, N

```

```

INTEGER ATT, BR, SN, FLAG2, FLAG1, COR

```

```

REAL MT

```

```

BYTE RDU

```

```

COMMON /BODY/B(9,3), COR(9,2), WGT(12)

```

```

1, /DEBUG/FLAG2, LO

```

```

2, /OHTCD/RUGHA, RUG, ROG, ROBL, R1, R2, R3, T1, T3, FLAG1

```

```

3, Q1A, Q13

```

```

4, /PROB/BR, ATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS

```

```

5, RDU

```

```

6, /SUIT/WUGO, DR, SRO, WOG, COG, TWUGO(9)

```

```

! NTOL, FTOL, TTOL ARE TOLERANCE LIMITS USED IN FINDING
! T3 BY THE SECANT METHOD SUCH THAT F(T3)~0:

```

```

! NTOL=> MAXIMUN NUMBER OF ITERATIONS ALLOWED

```

```

! FTOL=> ZERO TOLERANCE. IF F(T3) IS <= FTOL
!       THEN F(T3)~0

```

```

! TTOL=> ZERO TOLERANCE FOR THE DIFFERENCE BETWEEN
!       T3(NEW) AND T3(OLD).

```

```

!       IF (T3(NEW)-T3(OLD)) <= TTOL THEN DIFFERENCE IS
!       ASSUMED ~ 0

```

```

DATA NTOL, FTOL, TTOL/300, 1. 0E-7, 1. 0E-3/

```

```

! TCAR = THERMAL CONDUCTIVITY OF AIR AT REFERENCE
!       CONDITIONS OF 21.1 C AND 0 MSW. (W/M*C)

```

```

DATA TCAR/2. 611E-2/

```

```

!-----
RDS=0.0
RED=0.0
DPCT=0.0
IF (ATT.EQ.2) GO TO 13 !2=PRONE
! ATT=0 OR ATT=1 (SIT,STAND)
IF (BR.GT.1) GO TO 10
RDS=B(BR,2)*(-1.0)
GO TO 13
10 IF (BR.EQ.2) GO TO 13
N=2
11 IF (BR.GE.7.AND.BR.LE.9) N=7
IF (BR.EQ.7) GO TO 13
DO 12 I=N,BR-1
IF (I.EQ.4.AND.ATT.EQ.0) GO TO 110
RDS=RDS+B(I,3)
GO TO 12
110 RDS=RDS+(B(I,2)/2.0)
12 CONTINUE
IF (BR.NE.4.OR.ATT.NE.0) GO TO 13
!BR=4 AND ATT=0
RDS=RDS-(B(BR,2)/2.0)
13 IF (BR.NE.1.AND.BR.NE.9) GO TO 131
!BR=1 OR BR=9
DZ=B(BR,2)
SEP=0.0
SEPV=0.0
DZV=B(BR,2)
IF (ATT.EQ.2) DZV=0.0
GO TO 14
DZ=B(BR,3)/FLOAT(NN)
131 SEP=DZ*FLOAT(SN-1)
DZV=B(BR,3)/FLOAT(NN)
IF (ATT.EQ.2) DZV=0.0
IF (ATT.EQ.0.AND.BR.EQ.4) DZV=B(BR,2)
SEPV=DZV*FLOAT(SN-1)
IF (ATT.EQ.2) SEPV=0.0
IF (ATT.EQ.0.AND.BR.EQ.4) SEPV=0.0
14 RDM=RD
IF (RDU.NE.'P') GO TO 15
RDM=RD/1.461 !1.461 PSI/MSW
15 IF (RDU.NE.'F') GO TO 16
RDM=RD*0.3048 !0.3048 MSW/FSW
16 IF (ATT.EQ.2) GO TO 20
RED=RDS+SEPV+DZV/2.0
IF (BR.EQ.1) GO TO 20
IF (RED.GT.0.1711) GO TO 17
DPCT=2.358E-2*RED*100.0
GO TO 20
!DPCT=>DECIMAL PERCENT CHANGE IN THICKNESS
! **NOTE** THE MULTIPLICATION OF RED BY 100.0 IS TO
! CONVERT THE UNITS FROM METERS TO CENTIMETERS
17 DPCT=0.343+(3.784E-3*RED*100.0)-

```

```

1(1.345E-5*((RED*100.0)**2))
!TR=ESTIMATED REGIONAL TEMP. (12 POINT MODEL CONVERTED
!   TO 9 POINT MODEL)
20 MT=(T1+TA)/2.0
   EDS=RDM+RED
   CR=TCAR/TC(MT,EDS)      !CONDUCTIVITY RATIO
21 SRUGA=(SRO*CR)
   SRUGHA=SRUGA*(1.0-DR*DPCT)
   RUGHA=(SRUGHA*WUGO*TWUGO(BR))*(1.0-DPCT) !CLO'S
   !
   ! ** NOTE **
   !RUGHA IS IN CLO'S
   !RUGHAJ IS RUGHA CONVERTED TO (SEC*C*M2/J)=(C*M2/WATT)
   !
   RUGHAJ=RUGHA*0.15477      !0.15477 M2*C/WATT/CLO
   IF (FLAG2.EQ.0) GO TO 30
   WRITE (LO,22) DZ,DZV,SEP,SEPV,RDM,RED,DPCT
   1, T1, MT, EDS, TCAR, TC(MT,EDS), CR
   2, SRUGA, SRUGHA, RUGHA, RUGHAJ
22  FORMAT (' DZ,DZV',1P,2G15.7, /
   1, ' SEP,SEPV',2G15.7, /
   2, ' RDM,RED,DPCT',3G15.7, /
   3, ' T1,MT,EDS',3G15.7, /
   4, ' TCAR,TC(MT,EDS)',2G15.7,/, ' CR',G15.7
   5, ' SRUGA,SRUGHA',2G15.7, /
   6, ' RUGHA',G15.7, 'CLO RUGHAJ',G15.7
   7, 'M2*C/WATT')
30  R1=B(BR,2)/2.0          !M
   TR2=(WUGO*TWUGO(BR))*(1.0-DPCT))/100.0 !M
   R2=R1+TR2                !M
   R3=R2+(WOG/100.0)        !M
   RUG=R1*RUGHAJ*LOG(R2/R1)/TR2 !M2*C/WATT
   ROG=R1*LOG(R3/R2)/COG    !M2*C/WATT
   !*****
   ! USING SECANT METHOD TO FIND TEMPERATURE OF OUTSIDE
   ! SURFACE OF OUTER GARMENT (T3).
   ! ASSUME (T1+TA)/2.0 <= T3 <= TA
   !*****
   !*****
   ! TA+(TA*0.01) USED AS INITIAL END POINT, TO AVOID
   ! DETERMINATION OF 'GRPR' PRODUCT WHEN THE WALL
   ! TEMPERATURE = AMBIENT TEMPERATURE
   TNO=TA+(TA*0.01)
   !*****
   TN1=(T1+TA)/2.0
   IF (TN1.LE.TA) GO TO 430
   N=1
   DT=TN1-TNO
   N=N+1
   IF (N.GT.NTOL) GO TO 45
   FO=F(TNO)
   F1=F(TN1)

```

```

      IF (FLAG3.GT.0.0) RETURN
      IF (ABS(F1).LE.FTOL) GO TO 41
      IF ((F1-F0).EQ.0.0) GO TO 44
      DT=F1*DT/(F0-F1)
      TNO=TN1
      TN1=TN1+DT
      IF (TN1.LE.TA) GO TO 430
      IF (ABS(DT).LE.TTOL) GO TO 42
      GO TO 40
41      FLAG1=2              !FTOL SATISFIED
      GO TO 43
42      FLAG1=1              !TTOL SATISFIED
43      T3=TN1
      IF (T3.GE.TA) GO TO 431
430     FLAG1=-3
      GO TO 46
431     ROBL=R1/(R3*CHTC(T3,R3))
      OHTC=1.0/(RUG+ROG+ROBL)
      GO TO 46
44      FLAG1=-1              !F(TN1)-F(TNO) < 0
      GO TO 46
45      FLAG1=-2              !NTOL EXCEEDED
46      IF (FLAG2.EQ.0) GO TO 47
      TMP=F(TN1)
      WRITE (LO,461) T3,DT,TN1,TMP,Q1A,Q13
461     FORMAT ('  T3,DT,TN1',1P,3G15.7, /
1, '  F(TN1),Q1A,Q13',3G15.7)
47      RETURN
      END

```

REAL FUNCTION F(T)

```

C-----
C F(T)      VARIABLES DEFINE IN MODULE F(T)
!THIS MODULE IS A FUNCTION SUBROUTINE DEFINING
!THE FUNCTION TO BE SOLVED SUCH THAT F(T)~=0.
!THE FUNCTION RELATES THE HEAT LOSS THRU THE
!COMPLETE ENSEMBLE TO THAT THRU THE UNDER GARMENT
!AND THE OUTER GARMENT.  THE UNKNOWN IN THIS
!EQUATION IS THE TEMPERATURE AT THE OUTSIDE
!SURFACE OF THE OUTER GARMENT.
!THE VALUE OF T3 PASSED AS T IS SUBSTITUTED INTO THE
!EQUATION FOR F(T) AND THE CALCULATED VALUE IS
!PASSED BACK FOR USE IN THE SECANT METHOD OF ESTIMATING
!T3

```

```

C-----
C      VARIABLES NEEDED FOR CALCULATION OF F(T)
!C      = FUNCTION SUBROUTINE FOR CALCULATING THE
!      COEFFICIENT OF HEAT TRANSFER THRU THE FREE
!      CONVECTION BOUNDARY LAYER
!IBR      = BODY REGION OF INTEREST, BR, PASSED TO THE
!      SUBROUTINE
!ROG      = THERMAL RESISTANCE OF OUTER GARMENT
!RUG      = THERMAL RESISTANCE OF UNDER GARMENT
!T        = ARGUMENT PASSED TO FUNCTION, ESTIMATE
!      OF T3 TEMPERATURE OF OUTSIDE SURFACE OF
!      THE OUTER GARMENT
!TA        = TEMPERATURE - AMBIENT
!T1        = TEMPERATURE OF THE CYLINDER/SPHERE SURFACE
!T3        = TEMPERATURE OF THE OUTSIDE SURFACE OF THE
!      OUTER GARMENT
!R1        = RADIUS TO REGION SURFACE/INNER GARMENT
!      INTERFACE
!R3        = RADIUS TO OUTER GARMENT/FLUID BOUNDARY LAYER
!      INTERFACE

```

```

C-----
C *NOTE*  THE FOLOWING VARIABLE ARE DEFINED IN PREVIOUS MODULES
!DZ, DZV, FLAG1, IATT, NN, RD, RDU, RUGHA, R1, R2, R3, TDMS

```

```

C-----
      BYTE RDU
      INTEGER FLAG1
      COMMON /OHTCD/RUGHA, RUG, ROG, ROBL, R1, R2, R3, T1, T3, FLAG1
      1, Q1A, Q13
      2, /PROB/IBR, IATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS
      3, RDU
      HC=CHTC(T, R3)
      IF (FLAG3.GT.0.0) RETURN
      Q1A=(T1-TA)/(RUG+ROG+(R1/(R3*HC)))
      Q13=(T1-T)/(RUG+ROG)
      F=Q1A-Q13
      RETURN
      END

```

REAL FUNCTION CHTC(T3,R3)

! THIS FUNCTION COMPUTES THE CONVECTIVE HEAT TRANSFER
! COEFFICIENT FOR THE OUTER BOUNDARY LAYER IN
! WATTS/SEC*C*(M**2). THE EQUATIONS USED WERE
! DERIVED FROM EXPERIMENTAL DATA. (SEE TEXT FOR DETAILS)

INTEGER BR, COR, ATT, FLAG2, LD
REAL LNU, LGRPR
BYTE RDU
COMMON /BODY/B(9,3), COR(9,2), WGT(12)
1/PROB/BR, ATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS
2, RDU
3, /DEBUG/FLAG2, LD

! ** NOTE **
! ALL REFERENCES TO LOG IMPLY LOG BASE 10 (LOG10)

COEFFICIENTS FOR DETERMINATION OF THE GRASHOF AND
PRANDTL NUMBER PRODUCT.

! USING:

GRPR = (ALPHA)*(T WALL - T AMBIENT)*(L**3)

! WHERE:

LOG (ALPHA) = BETA1*(LOG (T FILM))**BETA2

ALPHA = G*BETA*RHO**2*CP/MU*K

T FILM = (T WALL + T AMBIENT) / 2.0

GRPR = GRASHOF# * PRANDTL#

! THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
! EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.

COEFFICIENTS FOR DETERMINATION OF THE THERMAL
CONDUCTIVITY OF WATER AS A FUNCTION OF TEMPERATURE IN
DEGREES C.

! THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
! EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.

! K = CF0 + CF1*T

DATA BETA1, BETA2/9.80714, 0.12733/

1, CF0, CF1/0.56662, 1.7977E-3/

! COEFFICIENTS FOR DETERMINATION OF LOG (NU) AS A
! FUNCTION OF LOG (GRPR) FOR VERTICAL CYLINDERS
! LOG(NU) = VC0 + VC1*(LOG(GRPR)) + VC2*((LOG(GRPR))**2)
! THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
! EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.

COEFFICIENTS FOR DETERMINATION OF LOG (NU) AS A
FUNCTION OF LOG (GRPR) FOR SPHERES
LOG(NU) = S0*LOG(GRPR) + S1
! THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
! EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.

!
 C COEFFICIENTS FOR DETERMINATION OF LOG (NU) AS A
 !FUNCTION OF LOG (GRPR) FOR HORIZONTAL CYLINDERS
 !LOG(NU) = HCO*LOG(GRPR) + HC1
 !THE COEFFICIENTS WERE FOUND BY FITTING THE EQUATION TO
 !EXPERIMENTAL DATA, SEE TEXT FOR DETAILS.
 DATA VCO,VC1,VC2/9. 1934, -2. 4128, 0. 1817/
 1, S0, S1/0. 46486, -1. 9726/
 2, HCO, HC1/0. 2486, -0. 4483/

C-----

C CHTC

VARIABLES DEFINED IN MODULE CHTC

!ALPHA = G*BETA*RHO**2*CP/MU*K
 !BETA = LOG (ALPHA)
 !BETA1 = COEFFICIENT SEE ABOVE
 !BETA2 = COEFFICIENT SEE ABOVE
 !CF = THERMAL CONDUCTIVITY OF WATER AT TEMPERATURE
 !CFO = COEFFICIENT SEE ABOVE
 !CF1 = COEFFICIENT SEE ABOVE
 !CL = CHARACTERISTIC LENGTH FOR FREE CONVECTION
 FOR VERTICAL CYLINDERS = LENGTH OF CYLINDER
 FOR HORIZONTAL CYLINDERS = DIAMETER OF
 CYLINDER
 FOR SPHERES = DIAMETER
 !GR = GRASHOF NUMBER, PRANDTL NUMBER PRODUCT
 !HCO = COEFFICIENT SEE ABOVE
 !HC1 = COEFFICIENT SEE ABOVE
 !LGRPR = LOG (GRPR)
 !LNU = LOG (NU)
 NU = NUSSELT NUMBER
 !S0 = COEFFICIENT SEE ABOVE
 !S1 = COEFFICIENT SEE ABOVE
 !TF = TEMPERATURE OF FILM
 = (T SURFACE + T AMBIENT GAS)/2.0
 !VCO = COEFFICIENT SEE ABOVE
 !VC1 = COEFFICIENT SEE ABOVE
 !VC2 = COEFFICIENT SEE ABOVE
 !B = ARRAY CONTAINING BODY REGION DIMENSIONS
 !FLAG3 = INTEGER VARIABLE USED TO INDICATE SUCCESS OR
 FAILURE OF THIS SUBROUTINE.
 = 0.0 CHTC DETERMINED SUCCESSFULLY
 = 1.0 CHTC NOT DETERMINED, ESTIMATED FILM
 TEMPERATURE LESS THAN 1.0
 = 2.0 CHTC NOT DETERMINED, GRASHOF*PRANDTL
 PRODUCT IS EQUAL TO ZERO.

C-----

C *NOTE* THE FOLLOWING VARIABLES WERE DEFINED IN PREVIOUS
 !MODULES:
 !BR, TA, T3

C-----

C *NOTE* ARRAYS COR AND WGT ARE PASSED TO THIS MODULE IN
 !LABELED COMMON BUT ARE NOT USED IN THIS MODULE.

C-----

FLAG3=0.0

```

      GO TO (1,2) ATT
C      ATT=0 SITTING
      GO TO (11,10,10,12,10,10,10,10,11) BR
C      ATT=1 STANDING
1      GO TO (11,10,10,10,10,10,10,10,11) BR
C      ATT=2 PRONE
2      GO TO (11,12,12,12,12,12,12,12,11) BR
C      VERTICAL CYLINDERS
10     CL=B(BR,3)      !M
      ASSIGN 105 TO LRET
      GO TO 20
105    LNU=VC0+(VC1*LGRPR)+(VC2*(LGRPR**2.0))
      GO TO 15
C      SPHERE
11     CL=2.0*R3      !M
      ASSIGN 115 TO LRET
      GO TO 20
115    LNU=(S0*LGRPR)+S1
      GO TO 15
C      HORIZONTAL CYLINDER
12     CL=2.0*R3      !M
      ASSIGN 125 TO LRET
      GO TO 20
125    LNU=(HCO*LGRPR)+HC1
15     CF=CF0+(CF1*TF)      !W/M*C
      CHTC=(10.0**LNU)*CF/CL  !W/M2*C
      RETURN
20     TF=(T3+TA)/2.0
      IF (TF.LT.1.0) GO TO 21
      BETA=BETA1*(LOG10(TF)**BETA2)
      ALPHA=(10.0**BETA)
      GRPR=ALPHA*(CL**3.0)*(T3-TA)
      IF (GRPR.LE.0.0) GO TO 23
      LGRPR=LOG10(GRPR)
      GO TO LRET
21     WRITE (LO,22)
      IF (LO.NE.5) WRITE (5,22)
22     FORMAT (' SYSTEM WILL NOT EXPONENTIATE A NEGATIVE ',/
1, ' BASE BY A REAL EXPONENT',/
2,20X, ' RUN TERMINATED !')
      FLAG3=1.0
      RETURN
23     WRITE (LO,24)
      IF (LO.NE.5) WRITE (5,24)
24     FORMAT (' THE LOGARITHM OF ZERO '
1, ' IS UNDEFINED',/
2,20X, ' RUN TERMINATED !')
      FLAG3=2.0
25     RETURN
      END

```

REAL FUNCTION TC(TDC,Z)

 C THE FUNCTION SUBROUTINE TC(TDC,Z) DETERMINES THE
 THERMAL CONDUCTIVITY OF AIR OR A SPECIFIED BREATHING
 GAS MIXTURE CORRESPONDING TO THE VALUES
 OF TEMPERATURE, T C, AND PRESSURE, Z MSW PASSED.
 THE AIR VALUE IS DETERMINED BY A METHOD OF TWO
 DIMENSIONAL LINEAR INTERPOLATION ADAPTED FROM
 CARNAHAN, LUTHER, AND WILKES, "APPLIED NUMERICAL
 METHODS", P 63, PRB 1.28, JOHN WILEY & SONS, INC., 1969
 THE MIXTURE THERMAL CONDUCTIVITY IS DETERMINED BY
 CALLING FUNCTION TCMG. (SEE TCMG FOR DETAILS)
 ARRAY C - CONTAINS THERMAL CONDUCTIVITY DATA FOR AIR AT
 - PRESSURES - 14.7, 30.0, 50.0, 100.0, 200.0 PSIA
 - TEMPERATURES - 30.0, 50.0, 70.0, 90.0, 110.0,
 130.0 F

NOTE

CONDUCTIVITIES HAVE UNITS BTU/SEC FT F
 AND VALUES MUST BE MULTIPLIED BY 1.0E-06

DATA TAKEN FROM:

- U. S. NAVY DIVING GAS MANUAL,
- NAVSHIPS 0994-003-7010, 1971
- PAGE T-4 (AIR DATA)

LAYOUT OF ARRAY C

	30.0	50.0	70.0	90.0	110.0	130.0	F
14.7	3.93	4.06	4.19	4.32	4.45	4.58	
30.0	3.93	4.07	4.20	4.33	4.46	4.59	
50.0	3.95	4.08	4.21	4.34	4.47	4.59	
100.0	3.98	4.11	4.24	4.37	4.49	4.62	
200.0	4.03	4.16	4.29	4.42	4.54	4.66	
Psia							

 C*NOTE* IF THE VALUE OF 'C' RETURNED TO CALLING MODULE IS
 NEGATIVE THEN THE VALUE OF 'T' OR 'Z' WAS OUT OF
 RANGE FOR THE TABLE STORED IN ARRAY C.

 C TC VARIABLES REQUIRED AND LOCALLY DEFINED
 TDC = TEMPERATURE OF INTEREST IN DEGREES C
 Z = DEPTH BELOW SURFACE IN METERS OF SEAWATER
 A = COMPONENT OF EQUATION FOR TC
 (SINGLE TERM COMPUTED SEPARATELY)
 B = COMPONENT OF EQUATION FOR TC
 (SINGLE TERM COMPUTED SEPARATELY)
 LO = LOGICAL UNIT NUMBER AT WHICH TO PRINT
 INFORMATION.
 P = ABSOLUTE PRESSURE => DEPTH IN METERS OF
 SEAWATER, Z, CONVERTED TO PSIA
 T = TEMPERATURE DEGREES F => TEMPERATURE
 DEGREES C, TDC, CONVERTED TO DEGREES F

NOTE: VARIABLES I, II, IJ AND J ARE TEMPORARY VARIABLES
 USED AS DO LOOP INDICES AND COUNTERS.

```

      !-----
      BYTE IG
      INTEGER FLAG2
      REAL C(6,7)
      COMMON /DEBUG/FLAG2,LO
      2, /TRNDSQ/YG, IG
      DATA C/0.0,14.7,30.0,50.0,100.0,200.0
      2,30.0,3.93,3.93,3.95,3.98,4.03
      3,50.0,4.06,4.07,4.08,4.11,4.16
      4,70.0,4.19,4.20,4.21,4.24,4.29
      5,90.0,4.32,4.33,4.34,4.37,4.42
      6,110.0,4.45,4.46,4.47,4.49,4.54
      7,130.0,4.58,4.59,4.59,4.62,4.66/
C      CONVERT Z METERS OF SEA WATER TO PSI ABSOLUTE
      P=((64.15*100.0*Z)/(2.54*(12.0**3)))+14.7
C      REDUCE P TO 1 SIGNIFICANT DIGIT AFTER DECIMAL PT
      P=((AINT((P+0.05)*10.0))/10.0)
C      CONVERT DEGREES C TO F
      T=((TDC+273.15)*1.8)-459.67
      IF (IG.NE.'A') GO TO 100
      IF (P.LT.C(2,1).OR.T.LT.C(1,2)
      1.OR.P.GT.C(6,1).OR.T.GT.C(1,7)) GO TO 20
      DO 10 I=2,6
      IF (C(1,1).LT.P) GO TO 10
      II=I
      IF (C(1,1).NE.P) II=II-1
      GO TO 12
10      CONTINUE
      GO TO 20
12      DO 13 J=2,7
      IF (C(1,J).LT.T) GO TO 13
      IJ=J
      IF (C(1,J).NE.T) IJ=IJ-1
      GO TO 15
13      CONTINUE
      GO TO 20
15      B=(T-C(1,IJ))/(C(1,IJ+1)-C(1,IJ))
      IF (T.EQ.C(1,IJ)) B=0.0
      A=(P-C(II,1))/(C(II+1,1)-C(II,1))
      IF (P.EQ.C(II,1)) A=0.0
      TC=((1.0-A)*(1.0-B)*C(II,IJ))+(A*(1.0-B)*C(II+1,IJ))
      1+(B*(1.0-A)*C(II,IJ+1))+(A*B*C(II+1,IJ+1))
C      CORRECT TC TO BE IN WATTS/M*C
C      1.0E-6 IS APPLIED TO YIELD CORRECT VALUES
      TC=TC*(1.0E-6)*6230.551
C      6230.551 J/M*C/BTU/FT*F
C
      RETURN
20      TC=0.0
      WRITE(LO,11) T,P
11      FORMAT (' ',10X,'T=',F10.2,' OR P=',F10.2
      1,' OUT OF RANGE OF TABLE')
      RETURN

```

```
100    TC=TCMG(T,P)  
      RETURN  
      END
```

```

      INTEGER FL1, FL2, FLAG2
      BYTE IG, ANS
      REAL INTERP, TP(2, 2), PHI(2), MW(3), KM, NUM,
      COMMON /DEBUG/FLAG2, LO
      2, /TRNOSQ/YG, IG
      DATA MW/28. 00, 4. 00, 32. 00/
      YQ=1. 00-YG
      IF (IG.EQ. 'N') FL1=1
      IF (IG.EQ. 'H') FL1=2
C  DETERMINE THERM. COND. AND VISCOSITY OF INERT
C  GAS COMPONENT OF THE MIXTURE.

```

```

DO 50 FL2=1,2
TP(1,FL2)=INTERP(T,P,FL1,FL2)
IF (TP(1,FL2).EQ.0.00) GO TO 1002
50 CONTINUE

```

C DETERMINE THERM. COND. AND VISCOSITY OF
C OXYGEN COMPONENT OF THE MIXTURE.

```

DO 60 FL2=1,2
TP(2,FL2)=INTERP(T,P,3,FL2)
IF (TP(2,FL2).EQ.0.0) GO TO 1002
60 CONTINUE

```

```

C
C
C  GAS PROPERTY ARRAY FOR THE COMPONENT GASES USED TO
C  COMPUTE THE BINARY BREATHING MIXTURE THERMAL
C  CONDUCTIVITY KM:

```

```

C                                     THERMAL                                ABSOLUTE
C                                     CONDUCTIVITY                            VISCOSITY
C                                     BTU/S*FT*F                             LBM/S*FT
C                                     *****
C                                     *
C      INERT GAS      TP(1,1)      *      TP(1,2)
C                                     *
C      OXYGEN         TP(2,1)      *      TP(2,2)
C                                     *****

```

C MASON-SAXENA FORM OF WASSILJEW'S EQUATION
C IS APPLIED TO THE COMPUTATION OF A BINARY

C BREATHING GAS MIXTURE. THIS TECHNIQUE
 C MAY ALSO BE DEVELOPED FOR USE WITH THE
 C COMPUTATION OF THERMAL CONDUCTIVITY OF
 C A TRI-MIXTURE OF BREATHING GASES.

C
 C FOR A BINARY GAS MIXTURE, INDEX 1 REFERS TO
 C INERT GAS IN THE PHI TERM CALCULATION
 C AND 2 REFERS TO OXYGEN PROPERTY TERMS.
 C THE TWO PHI TERMS ARE CONTAINED IN THE
 C ARRAY NAMED PHI. CALCULATE PHI TERMS:

C
 C
 63 NUM=(1.0+SQRT(TP(1,2)/TP(2,2))*((MW(3)/MW(FL1))**.25))**2
 DENOM=SQRT(8.0*(1.0+(MW(FL1)/MW(3))))
 PHI(1)=NUM/DENOM

C
 C PHI(2)=(TP(2,2)/TP(1,2))*(MW(FL1)/MW(3))*PHI(1)

C
 C THE THERMAL CONDUCTIVITY EXPRESSION (KM) OF A BINARY
 C GAS MIXTURE IS COMPRISED OF TWO TERMS WHICH ARE
 C DESIGNATED AS C1 AND C2. KM IS DETERMINED BY
 C SUMMING THE TWO TERMS C1 AND C2.

C
 C1=TP(1,1)/(1.0+(1.065*PHI(1))*(YO/YG))
 C2=TP(2,1)/(1.0+(1.065*PHI(2))*(YG/YO))
 KM=C1+C2
 TCMG=KM*6230.551

C THE COMPUTED GAS MIXTURE THERMAL CONDUCTIVITY
 C HAS BEEN CONVERTED FROM THE UNITS OF BTU/S*FT*F TO
 C WATTS/M*C OR J/S*M*C. 6230.551 J/S*M*C = 1 BTU/S*FT*F
 C THE SYMBOL TCMG HAS BEEN USED FOR RETURNING THE
 C GAS MIXTURE THERMAL CONDUCTIVITY TO THE REAL FUNCTION
 C SUBROUTINE TC

C
 1002 CONTINUE
 RETURN
 END

```

      REAL FUNCTION INTERP(T,P,FL1,FL2)
C   THIS FUNCTION SUBROUTINE INTERPOLATES COMPONENT GAS DATA
C   TABULATED AS A FUNCTION OF TEMPERATURE IN DEGREES F
C   AND PRESSURE IN PSIA.  DATA IS TABULATED FROM THE
C   U. S. NAVY GAS MANUAL.
      REAL TCN(10,7),TCH(10,7),TCO(10,7),MUN(10,7)
      1,MUH(10,7),MUD(10,7),MF(2),DA(10,7)
      INTEGER FL1,FL2,FLAG2
      COMMON /DEBUG/FLAG2,LO
      2,/TRNOSQ/YG,IG

C
C   UNITS ARE AS FOLLOWS:
C
C   THERMAL CONDUCTIVITY: BTU/SEC*FT*F
C
C   ABSOLUTE VISCOSITY: LBM/FT*SEC
C
C   THE RESULTS OF THIS PROGRAM SHOULD ALSO HANDLE TRI-MIXTURES OF
C   NITROGEN, HELIUM AND OXYGEN.
C
C   ARRAYS ARE ENTERED IN COLUMN MAJOR ORDER OF THE TABLES.
C
      DATA TCN/0.,14.7,30.,50.,100.,200.,300.,400.,500.,1000.
      1,30.0,3.834,3.84,3.86,3.89,3.95,4.01,4.08,4.14,4.48
      2,50.0,3.967,3.98,3.99,4.02,4.08,4.14,4.20,4.26,4.58
      3,70.0,4.100,4.11,4.12,4.15,4.21,4.26,4.32,4.38,4.68
      4,90.0,4.227,4.24,4.25,4.27,4.33,4.38,4.44,4.49,4.78
      5,110.0,4.348,4.36,4.37,4.39,4.45,4.50,4.55,4.60,4.88
      6,130.0,4.470,4.48,4.49,4.51,4.56,4.62,4.67,4.72,4.98/

C
      DATA TCH/0.,14.7,30.,50.,100.,200.,300.,400.,500.,1000.
      1,30.0,2.26,2.27,2.27,2.28,2.29,2.30,2.31,2.33,2.39
      2,50.0,3*2.32,2.33,2.34,2.36,2.37,2.38,2.45
      3,70.0,2.38,2.38,2.38,2.39,2.40,2.41,2.43,2.44,2.50
      4,90.0,2*2.43,2.44,2.44,2.45,2.47,2.48,2.49,2.55
      5,110.0,2.49,2.49,2.49,2.50,2.51,2.52,2.53,2.55,2.61
      6,130.0,3*2.54,2.55,2.56,2.57,2.59,2.60,2.66/

C
      DATA TCO/0.,14.7,30.,50.,100.,200.,300.,400.,500.,1000.
      1,30.0,3.918,3.93,3.94,3.97,4.03,4.09,4.15,4.21,4.54
      2,50.0,4.068,4.08,4.09,4.12,4.17,4.23,4.29,4.35,4.66
      3,70.0,4.214,4.22,4.23,4.26,4.32,4.37,4.43,4.48,4.79
      4,90.0,4.353,4.36,4.37,4.40,4.45,4.50,4.56,4.61,4.89
      5,110.0,4.483,4.49,4.50,4.53,4.58,4.63,4.68,4.73,4.99
      6,130.0,4.611,4.62,4.63,4.65,4.70,4.75,4.80,4.85,5.10/
C

```

```

DATA MUN/0. , 14. 7, 30. , 50. , 100. , 200. , 300. , 400. , 500. , 1000.
1, 30. 0, 1. 114, 1. 12, 1. 12, 1. 12, 1. 13, 1. 14, 1. 15, 1. 16, 1. 22
2, 50. 0, 1. 148, 1. 15, 1. 15, 2*1. 16, 1. 17, 1. 18, 1. 19, 1. 25
3, 70. 0, 1. 184, 3*1. 19, 1. 20, 1. 21, 1. 22, 1. 22, 1. 28
4, 90. 0, 1. 219, 2*1. 22, 2*1. 23, 1. 24, 1. 25, 1. 26, 1. 31
5, 110. 0, 1. 255, 3*1. 26, 1. 27, 1. 28, 1. 28, 1. 29, 1. 34
6, 130. 0, 1. 289, 2*1. 29, 2*1. 30, 1. 31, 1. 32, 1. 33, 1. 37/

```

C

```

DATA MUH/0. , 14. 7, 30. , 50. , 100. , 200. , 300. , 400. , 500. , 1000.
1, 30. 0, 9*1. 257
2, 50. 0, 9*1. 290
3, 70. 0, 9*1. 323
4, 90. 0, 9*1. 357
5, 110. 0, 9*1. 389
6, 130. 0, 9*1. 422/

```

C

```

DATA MUO/0. , 14. 7, 30. , 50. , 100. , 200. , 300. , 400. , 500. , 1000.
1, 30. 0, 1. 281, 1. 28, 1. 28, 1. 29, 1. 30, 1. 31, 1. 32, 1. 34, 1. 40
2, 50. 0, 1. 322, 1. 32, 1. 33, 1. 33, 1. 34, 1. 35, 1. 36, 1. 37, 1. 43
3, 70. 0, 1. 364, 3*1. 37, 1. 38, 1. 39, 1. 40, 1. 41, 1. 46
4, 90. 0, 1. 404, 3*1. 41, 1. 42, 1. 43, 1. 44, 1. 45, 1. 50
5, 110. 0, 1. 440, 1. 44, 1. 44, 1. 45, 1. 46, 1. 46, 1. 47, 1. 48, 1. 54
6, 130. 0, 1. 482, 2*1. 48, 1. 49, 1. 50, 2*1. 51, 1. 52, 1. 57/

```

C

```
DATA MF/1. E-05, 1. E-06/
```

C

C

C

```

C SYMBOL DA STANDS FOR THE WORKING DATA ARRAY INTO
C WHICH SPECIFIC ARRAYS OF DATA ARE TRANSFERRED FOR PURPOSE
C OF INTERPOLATION.

```

```

IF (FL1. EQ. 1. AND. FL2. EQ. 1) GO TO 30
IF (FL1. EQ. 1. AND. FL2. EQ. 2) GO TO 31
IF (FL1. EQ. 2. AND. FL2. EQ. 1) GO TO 32
IF (FL1. EQ. 2. AND. FL2. EQ. 2) GO TO 33
IF (FL1. EQ. 3. AND. FL2. EQ. 1) GO TO 34
IF (FL1. EQ. 3. AND. FL2. EQ. 2) GO TO 35

```

30

```

DO 40 J=1, 7
DO 40 I=1, 10
DA(I, J)=TCN(I, J)

```

40

```

CONTINUE
NM=1

```

31

```

SF=MF(2)
GO TO 61
DO 41 J=1, 7
DO 41 I=1, 10
DA(I, J)=MUN(I, J)

```

41

```

CONTINUE
NM=4

```

32

```

SF=MF(1)
GO TO 61
DO 42 J=1, 7
DO 42 I=1, 10
DA(I, J)=TCH(I, J)

```

```

42      CONTINUE
        NM=2
        SF=MF(1)
        GO TO 61
33      DO 43 J=1,7
        DO 43 I=1,10
        DA(I,J)=MUH(I,J)
43      CONTINUE
        NM=5
        SF=MF(1)
        GO TO 61
34      DO 44 J=1,7
        DO 44 I=1,10
        DA(I,J)=TCO(I,J)
44      CONTINUE
        NM=3
        SF=MF(2)
        GO TO 61
35      DO 45 J=1,7
        DO 45 I=1,10
        DA(I,J)=MUO(I,J)
45      CONTINUE
        NM=6
        SF=MF(1)
61      CONTINUE
63      IF (P.LT.DA(2,1).OR.T.LT.DA(1,2)
1. OR. P.GT.DA(10,1).OR.T.GT.DA(1,7)) GO TO 20
        DO 10 I=2,10
        IF (DA(I,1).LT.P) GO TO 10
        II=I
        IF (DA(I,1).NE.P) II=II-1
        GO TO 12
10      CONTINUE
        GO TO 20
12      DO 13 J=2,7
        IF (DA(1,J).LT.T) GO TO 13
        IJ=J
        IF (DA(1,J).NE.T) IJ=IJ-1
        GO TO 15
13      CONTINUE
        GO TO 20
15      B=(T-DA(1,IJ))/(DA(1,IJ+1)-DA(1,IJ))
        IF (T.EQ.DA(1,IJ)) B=0.0
        A=(P-DA(II,1))/(DA(II+1,1)-DA(II,1))
        IF (P.EQ.DA(II,1)) A=0.0
        INTERP=((1.0-A)*(1.0-B)*DA(II,IJ))+
1(A*(1.0-B)*DA(II+1,IJ))+
2(B*(1.0-A)*DA(II,IJ+1))+
3(A*B*DA(II+1,IJ+1))
        INTERP=INTERP*SF
        RETURN

```

C

C THIS IS SUBROUTINE BLOW-OUT STATEMENT.

```
C
20  INTERP=0.0
    WRITE (5,11)T,P,FL1,FL2
11  FORMAT(/, ' T= ',F10.2, ' OR P= ',F10.2
    1, ' OUT OF RANGE OF DATA ARRAY ASSOCIATED', /
    2, ' WITH FL1 ',I1, ' AND FL2 ',I1, '. ')
    RETURN
    END
```

REAL FUNCTION TR(TDMS, BR)

C-----
! THIS FUNCTION COMPUTES THE PREDICTED REGIONAL
! TEMPERATURES FOR THE 9 REGION MODEL.
! THE PREDICTIVE EQUATIONS USED WERE DERIVED FOR
! THE 12 SEGMENT HODY MODEL WITH EXPERIMENTAL
! DATA. (SEE TEXT FOR DETAILS)
! THE PREDICTIONS FOR THE 12 SEGMENTS WERE
! COMBINED BY A WEIGHTED SUM USING THE HODY
! WEIGHTS CORRESPONDING TO THE SUMMED SEGMENTS.
! THE CORRESPONDENCE BETWEEN THE 9 REGION AND 12 SEGMENT
! MODELS IS SHOWN IN ARRAY COR, BELOW. FOR MORE DETAIL
! SEE MODULE MAIN

ROW#	9 REGION	12 SEGMENT MODEL
=>BR	MODEL NAME	CORRESPONDING SEGMENTS NAME(ID#)
		ID #'S ARE IN ARRAY COR(9,2)
1	HEAD	HEAD(1), (-1)
2	TORSO	CHEAT(2), UPPER BACK(4)
3	ABDOMEN	ABDOMEN(3), LOWER BACK(5)
4	THIGH	FRONT THIGH(8), REAR THIGH(10)
5	CALF	FRONT CALF(9), REAR CALF(11)
6	FOOT	FOOT(12), (-1)
7	UPPER ARM	ARM(6), (-1)
8	LOWER ARM	ARM(6), (-1)
9	HAND	WRIST(7), (-1)
		NOTE (-1) INDICATES THAT ONLY ONE CORRESPONDING SEGMENT IS AVAILABLE FROM 12 SEGMENT MODEL

C-----
C TR

TDMS	VARIABLE REQUIRED AND LOCALLY DEFINED
	= DESIGN MEAN SKIN TEMPERATURE. MEAN SKIN TEMPERATURE AT WHICH TO COMPUTE THE PREDICTED REGIONAL TEMPERATURES.
BR	= BODY REGION OF INTEREST. ONE OF THE 9 REGION MODEL REGIONS.
COR	= ARRAY CONTAINING CORRESPONDENCE BETWEEN 9 REGION AND 12 SEGMENT MAPS
SWGT	= SUM OF WEIGHTS CORRESPONDING TO THE 12 SEGMENTS SUMMED.
PRED	= FUNCTION SUBROUTINE WHICH CALCULATES THE 12 SEGMENTAL PREDICTED TEMPERATURES AT A GIVEN MEAN SKIN TEMPERATURE, TDMS AND SEGMENT J
WGT	= ARRAY CONTAINING THE 12 HODY SURFACE WEIGHTS

NOTE: ARRAY B IS PASSED TO THIS MODULE IN LABELED
COMMON BUT THIS ARRAY IS UNUSED IN THIS MODULE.

NOTE: VARIABLES I AND J ARE TEMPORARY VARIABLES USED
AS DO LOOP INDICES AND COUNTERS.

NOTE: VARIABLES I AND J ARE TEMPORARY VARIABLES USED

! AS DO LOOP INDICIES AND COUNTERS.

INTEGER COR, BR

COMMON /BODY/B(9,3), COR(9,2), WGT(12)

TR=0.0

SWGT=0.0

!NOTE: THERE IS NO CHECKING FOR 0.0 VALUES
! IN THE SUM SINCE THE PREDICTED VALUES
! CAN NOT BE ZERO UNLESS TDMS=0.0.
! TDMS CAN NOT BE ZERO BY ACCIDENT IT
! MUST BE SPECIFIED AS ZERO IF THAT
! IS THE DESIRED VALUE.

DO 10 I=1,2

J=COR(BR, I)

IF (J.EQ.-1) GO TO 10

SWGT=SWGT+WGT(J)

TR=TR+(PRED(J, TDMS)*WGT(J))

CONTINUE

TR=TR/SWGT

RETURN

END

10

REAL FUNCTION PRED(REG,TSKM)

C-----
 !FUNCTION PRED DETERMINES THE PREDICTED 12 SEGMENTAL
 !TEMPERATURES FROM EQUATIONS DERIVED USING
 !EXPERIMENTAL DATA AND BASED ON A KERSLAKE
 !TYPE MODEL. (SEE TEXT FOR DETAILS)

C-----
 C PRED VARIABLES REQUIRED AND LOCALLY DEFINED
 !REG = SEGMENT FOR WHICH TO PREDICT
 ! SKIN TEMPERATURE
 !TSKM = MEAN SKIN TEMPERATURE TO USE AS
 ! INDEPENDENT ARGUMENT IN THE EQUATIONS.
 ! USUALLY THE DESIGN MEAN SKIN TEMPERATURE.
 !KA = ARRAY CONTAINING THE COEFFICIENTS FOR
 ! THE PREDICTIVE EQUATIONS
 !KR = CONSTANT USED IN THE PREDICTIVE EQUATIONS

C-----
 REAL KA,KR
 INTEGER REG
 COMMON /PREDD/KA(12),KR
 PRED=TSKM+(KA(REG)*KR)
 RETURN
 END

SUBROUTINE PLOTD(IR, PSYM, BR)

C-----
 !PLOTD IS A SUBROUTINE FOR PLOTTING T'S, G'S, AND U'S
 !BOTH PREDICTED AND EXPERIMENTAL VERSUS TIME.

C-----
 C PLOTD VARIABLES REQUIRED AND LOCALLY DEFINED
 !IR = OFFSET INTO ARRAY P AT WHICH TO PICK
 UP BOTH THE PREDICTED AND EXPERIMENTAL DATA.
 P(ROW, IR+1) = EXPERIMENTAL
 P(ROW, IR+2) = PREDICTED
 !PSYM = ARRAY (PSYM(2)) CONTAINING THE INTEGER
 NUMBERS INDICATING THE SYMBOLS TO BE USED FOR
 THE EXPERIMENTAL AND PREDICTED CURVES
 RESPECTIVELY. (SEE DIGITAL EQUIPMENT CORP.
 MANUAL PLXY-11M, USER'S GUIDE FOR DETAILS)
 !BR = BODY REGION WHICH THE EXPERIMENTAL AND
 PREDICTED VALUE CORRESPOND TO.
 !LYS = Y-AXIS LEVEL FOR LABELS. INITIALLY SET
 AT LY
 !NREC = NUMBER OF TIME RECORDS TO PLOT
 (IE: 1 TO NREC)
 !DE = BYTE VARIABLE CONTAINING EITHER '*'
 OR ' ' (SPACE). IT IS USED TO FLAG
 THE EXPERIMENTAL DATA POINTS NOT
 PLOTTED BECAUSE THEY ARE EITHER ≤ 0 OR
 $< SY$. SY IS THE STARTING VALUE
 FOR THE Y-AXIS.
 !DP = BYTE VARIABLE CONTAINING EITHER '*'
 OR ' ' (SPACE). THIS VARIABLE IS USED
 IN THE SAME MANNER AS VARIABLE DE
 EXCEPT THAT DP IS USED FOR THE PREDICTED
 VALUES.
 !BREG = ARRAY CONTAINING NAMES OF BODY REGIONS
 ARRANGED TO CORRESPOND TO BR
 !LABEL = ARRAY CONTAINING LABEL TEXT FOR THE PLOTS
 !P = ARRAY CONTAINING THE DATA TO BE PLOTTED

NOTE: VARIABLES E, F, G, J, K AND L ARE TEMPORARY
 VARIABLES USED FOR DUMMY ARGUMENTS,
 DO LOOP INDICES AND COUNTERS.

NOTE: THE FOLLOWING VARIABLE ARE DEFINED IN
 A MANNER NECESSARY TO SATISFY THE DEC
 PLXY-11M SUBROUTINE'S SPECIFICATIONS
 !IX = X-AXIS INCREMENT => # UNITS PER PLOT UNIT
 !IY = Y-AXIS INCREMENT => # UNITS PER PLOT UNIT
 !LX = X-AXIS LENGTH IN PLOT UNITS
 !LY = Y-AXIS LENGTH IN PLOT UNITS
 !SX = X-AXIS STARTING VALUE
 !SY = Y-AXIS STARTING VALUE
 !XP = ARRAY USED TO PASS X-AXIS VALUES TO
 PLXY-11M SUBROUTINE LINE
 !YP = ARRAY USED TO PASS Y-AXIS VALUES TO

PLXY-11M SUBROUTINE LINE

```

REAL LX, SX, IX, LY, SY, IY, LYS, XP(125), YP(125)
REAL*8 LABEL(3), BREG(10)
INTEGER PSYM(2), BR
BYTE DE, DP, REU, PRT
COMMON /PLOT/P(125,9), LX, SX, IX, LY, SY, IY, LYS, LABEL, NREC
1, BREG, XP, YP, PD(125,3), LCL, CH, REU, PRT(13)
SL=3.0
IF (CH.GT.0.0) SL=CH
CALL SYMBOL (LX-SL, LYS-0.20, 0.1169, BREG(BR), 0.0, +8)
IF (IR.EQ.1) GO TO 10
CALL SYMBOL (999., 999., 0.1169, PRT, 0.0, +LCL)
10 CALL PLOT (0.0, 0.0, +3)
LYS=LYS-0.20
DO 13 J=1, 2
L=0
DO 12 K=1, NREC
IF (J.GT.1) GO TO 115
DE=' '
C CHECKING EXP'T VALUE TO BE IN RANGE OF PLOT
IF (P(K, IR+1).LE.0.0R. P(K, IR+1).LT.SY) DE='*'
DP=' '
C CHECKING PRED VALUES TO BE IN RANGE OF PLOT
IF (P(K, IR+2).LE.0.0R. P(K, IR+2).LT.SY) DP='*'
WRITE (6, 11) P(K, 1), P(K, IR+1), DE, P(K, IR+2), DP
11 FORMAT (10X, F8.2, 10X, F10.2, 1A1, 9X, F10.2, 1A1)
115 IF (P(K, J+IR).LE.0.0R. P(K, J+IR).LT.SY) GO TO 12
L=L+1
XP(L)=P(K, 1)
YP(L)=P(K, J+IR)
12 CONTINUE
XP(L+1)=SX
XP(L+2)=IX
YP(L+1)=SY
YP(L+2)=IY
CALL PLOT (0.0, 0.0, +3)
CALL LINE (XP, YP, L, 1, +1, PSYM(J))
CALL SYMBOL (LX-SL, LYS-0.20, 0.1169, LABEL(J), 0.0, +8)
CALL WHERE (E, F, G)
CALL SYMBOL (E, F+(0.1169/2.0), 0.1169, PSYM(J), 0.0, -1)
CALL WHERE (E, LYS, G)
LYS=LYS-(0.1169/2.0)
13 CONTINUE
RETURN
END

```

SUBROUTINE PLOTN(IR,PSYM)

C-----
 ! PLOTN IS A SUBROUTINE FOR PLOTTING NORMALIZED
 ! TEMPERATURES AND BIOT NUMBERS
 ! BOTH PREDICTED AND EXPERIMENTAL VERSUS TIME.
 C-----

C PLOTN VARIABLES REQUIRED AND LOCALLY DEFINED
 ! IR = OFFSET INTO ARRAY P AT WHICH TO PICK
 ! UP BOTH THE PREDICTED AND EXPERIMENTAL DATA.
 ! P(ROW,IR+1) = EXPERIMENTAL
 ! P(ROW,IR+2) = PREDICTED
 ! PSYM = ARRAY (PSYM(2)) CONTAINING THE INTEGER
 ! NUMBERS INDICATING THE SYMBOLS TO BE USED FOR
 ! THE EXPERIMENTAL AND PREDICTED CURVES
 ! RESPECTIVELY. (SEE DIGITAL EQUIPMENT CORP.
 ! MANUAL PLXY-11M, USER'S GUIDE FOR DETAILS)
 ! BR = BODY REGION WHICH THE EXPERIMENTAL AND
 ! PREDICTED VALUE CORRESPOND TO.
 ! RMD = DEPTH IN MSW TO THE MIDDLE OF THE REGION.
 ! LYS = Y-AXIS LEVEL FOR LABELS. INITIALLY SET
 ! AT LY
 ! NREC = NUMBER OF TIME RECORDS TO PLOT
 ! (IE: 1 TO NREC)
 ! DE = BYTE VARIABLE CONTAINING EITHER '*'
 ! OR ' ' (SPACE). IT IS USED TO FLAG
 ! THE EXPERIMENTAL DATA POINTS NOT
 ! PLOTTED BECAUSE THEY ARE EITHER <= 0 OR
 ! < SY. SY IS THE STARTING VALUE
 ! FOR THE Y-AXIS.
 ! DP = BYTE VARIABLE CONTAINING EITHER '*'
 ! OR ' ' (SPACE). THIS VARIABLE IS USED
 ! IN THE SAME MANNER AS VARIABLE DE
 ! EXCEPT THAT DP IS USED FOR THE PREDICTED
 ! VALUES.
 ! BREG = ARRAY CONTAINING NAMES OF BODY REGIONS
 ! ARRANGED TO CORRESPOND TO BR
 ! LABEL = ARRAY CONTAINING LABEL TEXT FOR THE PLOTS
 ! P = ARRAY CONTAINING THE DATA TO BE PLOTTED
 C-----

NOTE: VARIABLES E,F,G,J,K AND L ARE TEMPORARY
 VARIABLES USED FOR DUMMY ARGUMENTS,
 DO LOOP INDICES AND COUNTERS.
 C-----

NOTE: THE FOLLOWING VARIABLE ARE DEFINED IN
 A MANNER NECESSARY TO SATISFY THE DEC
 PLXY-11M SUBROUTINE'S SPECIFICATIONS
 ! IX = X-AXIS INCREMENT => # UNITS PER PLOT UNIT
 ! IY = Y-AXIS INCREMENT => # UNITS PER PLOT UNIT
 ! LX = X-AXIS LENGTH IN PLOT UNITS
 ! LY = Y-AXIS LENGTH IN PLOT UNITS
 ! SX = X-AXIS STARTING VALUE
 ! SY = Y-AXIS STARTING VALUE
 ! XP = ARRAY USED TO PASS X-AXIS VALUES TO

```

      PLXY-11M SUBROUTINE LINE
      YP      = ARRAY USED TO PASS Y-AXIS VALUES TO
      PLXY-11M SUBROUTINE LINE

```

```

      REAL LX, SX, IX, LY, SY, IY, LYS, XP(125), YP(125)
      REAL*8 LABEL(3), BREG(10)
      INTEGER PSYM(2), BR, ATT, COR
      BYTE DE, DP, RDU, REU, PRT
      COMMON /BODY/B(9,3), COR(9,2), WGT(12)
      1, /PROB/BR, ATT, RD, RDM, TA, NN, TDMS, DZ, DZV, FLAG3, RDS
      2, RDU
      3, /PLOT/P(125,9), LX, SX, IX, LY, SY, IY, LYS, LABEL, NREC
      4, BREG, XP, YP, PD(125,3), LCL, CH, REU, PRT(13)
      SL=3.0
      IF (CH.GT.0.0) SL=CH
      CALL SYMBOL (LX-SL, LYS-0.20, 0.1169, BREG(BR), 0.0, +8)
      IF (IR.EQ.1) GO TO 10
      CALL SYMBOL (999., 999., 0.1169, PRT, 0.0, +LCL)
10    CALL PLOT (0.0, 0.0, +3)
      LYS=LYS-0.20
      IF (ATT.EQ.2) RMD=RDM
      IF (ATT.EQ.1) RMD=RDM+RDS+(B(BR,3)/2.0)
      IF (ATT.NE.0) GO TO 5
      RMD=RDM+RDS
      IF (BR.EQ.4) RMD=RMD+(B(BR,2)/2.0)
      IF (BR.NE.4) RMD=RMD+(B(BR,3)/2.0)
5    DO 13 J=1,2
      L=0
      DO 12 K=1, NREC
C    CHECKING EXP'T VALUE TO BE IN RANGE OF PLOT
      IF (P(K,1+IR).LE.0.0.OR.P(K,1+IR).LT.SY) GO TO 12
      L=L+1
      XP(L)=P(K,1)
      PD(L,1)=XP(L)
      IF (IR.NE.1) GO TO 11
      YP(L)=(P(K,J+IR)-P(K,9))/(P(K,8)-P(K,9))
      PD(L,J+1)=YP(L)
      GO TO 12
11    IF (IR.NE.5) GO TO 12
      TM=(P(K,J+1)+P(K,9))/2.0
      YP(L)=(P(K,J+IR)*(B(BR,2))/2.0)/TC(TM,RMD)
      PD(L,J+1)=YP(L)
12    CONTINUE
      XP(L+1)=SX
      XP(L+2)=IX
      YP(L+1)=SY
      YP(L+2)=IY
      CALL PLOT (0.0, 0.0, +3)
      CALL LINE (XP, YP, L, 1, +1, PSYM(J))
      CALL SYMBOL (LX-SL, LYS-0.20, 0.1169, LABEL(J), 0.0, +8)
      CALL WHERE (E, F, G)
      CALL SYMBOL (E, F+(0.1169/2.0), 0.1169, PSYM(J), 0.0, -1)
      CALL WHERE (E, LYS, G)

```

```
13      LYS=LYS-(0.1169/2.0)  
      CONTINUE  
14      WRITE (6,14) (PD(K,1),PD(K,2),PD(K,3),K=1,L)  
      FORMAT (10X,F8.2,10X,F10.2,10X,F10.2)  
      RETURN  
      END
```

FLOW CHARTS

Function TC(TDC,Z)

This function determines whether the breathing gas is air, a mixture of helium and oxygen, or a mixture of nitrogen and oxygen. If the breathing gas is air, its thermal conductivity is determined within this function. If the gas is either of the mixtures, the function TCMG is called to determine the mixture thermal conductivity.

Declare passed variables.

Convert TDC °C to T °F and convert Z MSW to P PSIA.

Branch to the appropriate statement for a breathing gas of air (IG = 'A'), or a mixture which contains nitrogen (IG = 'N') or helium (IG = 'H').

IF IG ≠ 'A' GO TO A

Compute the thermal conductivity of air (TC) at a temperature of T °F and a pressure of P PSIA from a table of data extracted from the U.S. Navy Diving Gas Manual [2]. A method of two-dimensional linear interpolation described by Carnahan, Luther, and Wilkes, Applied Numerical Methods, p. 63 [3] is used. The table of air data covers a temperature range of -1.11 to 54.44 °C and a pressure range of 14.7 to 200.0 PSIA (1.0 to 13.6 ATA).

RETURN

A Calculate the mixed gas thermal conductivity
(See Functions TCMG and INTERP.) by:

$$TC = TCMG(T,P)$$

RETURN

Function TCMG(T,P)

Declare passed (in common) variables YG as real and IG as byte.

Determine the mole fraction for oxygen (Y0) by:

$$Y0 = 1.00 - YG$$

YG = Inert gas (helium or nitrogen) mole fraction.

Determine the thermal conductivity and absolute viscosity of the pure components (helium and oxygen, or nitrogen and oxygen) by calling real function subroutine INTERP. Store these values in Array TP.

TP(1,1) = Inert gas thermal conductivity
(BTU/FT·SEC°F)
TP(1,2) = Inert gas absolute viscosity
(LBM/FT·SEC)
TP(2,1) = Oxygen thermal conductivity
(BTU/FT·SEC°F)
TP(2,2) = Oxygen absolute viscosity
(LBM/FT·SEC)

Determine the thermal conductivity of the breathing gas mixture (TCMG) by the Mason-Saxena form or Wassiljewa's equation as a function of temperature (T), pressure (P), thermo-physical property array (TP), molecular weight of the components (Array MW), and the mole fractions (YG and Y0). The units of TCMG are BTU/FT·SEC·°F.

Convert the units of TCMG to W/M°C.

RETURN

Real Function INTERP(T,P,FL1,FL2)

This function determines the thermal conductivity (FL2=1) or the absolute viscosity (FL2=2) of the pure gases nitrogen (FL1=1), helium (FL1=2), and oxygen (FL1=3) at a temperature of T °F and pressure of P PSIA. The thermal conductivity (BTU/FT·SEC°F) and absolute viscosity (LBM/FT·SEC) are determined from tables of data excerpted from the U.S. Navy Diving Gas Manual [2]. A method of two-dimensional linear interpolation described by Carnahan, Luther, and Wilkes, Applied Numerical Methods, p. 63 [3] is used. The tabulated data spans a temperature range of 30 °F (-1.11 °C) to 130 °F (54.44 °C) and a pressure range of 14.7 to 1000.0 PSIA (1.0 to 68.0 ATA).

Copy the appropriate pure component absolute viscosity (FL2=2) or thermal conductivity (FL2=1) data array into the working array DA.

Interpolate as described above for the value (INTERP) from the data of Array DA at a temperature of T °F and a pressure of P PSIA in English Engineering units.

RETURN

OVERLAY DESCRIPTION

As a result of adding the two additional subroutines for predicting the thermal conductivity of a mixed gas (TCMG and INTERP), the overall length of our predictive program has exceeded the maximum allowable program length of 32,000 words (two bytes per word) that is allowed by the RSX-11M operating system [7]. Therefore, to have the *mixed gas program* (MGMOD) task build successfully with the RSX-11M task builder program (TKB), an overlay structure [7] had to be defined.

An overlay structure defines which program modules (subroutines, functions, or main) are logically independent and, thus, may occupy the same memory space when the overlaid task is executed. The overlay description language (ODL) requires that each program module exist in an independent object file; thus, to facilitate the development of the overlay description, the mixed gas program (MGMOD) was divided into twelve independent modules. The modules are named:

MHLMOD	TCMG
REINIT	INTERP
OHTC	TR
FUNCTF	PRED
CHTC	PLOTD
TC	PLOTN

Each source code file ends with the FTN extension and each object file, which is the output from the F4P task [8], ends in the OBJ extension.

To create the overlayed executable task (MGMOD) the overlay structure that is desired must be described by using the Overlay Description Language (ODL) [7]. This overlay description must define all of the files that are needed to task build the program; the name of this overlay description file is expected to end with an extension of ODL. Table 1 displays the command sequence necessary to invoke the task builder program (TKB) when an overlay description file is used.

Table 1
Task Builder Program (TKB) Command File

```
MCR>TKB
TKB>MGMOD.TSK,=MGMOD.ODL/MP
ENTER OPTIONS:
TKB>MAXBUF=292
TKB>ACTFIL=5
TKB>//
```

The /MP switch (Table 1) is applied to the input file to denote it as an overlay description file. This switch also causes the TKB program to proceed to ENTER OPTIONS: without the need of the single slashed (/) line (See reference 7 for details.). The MAXBUF=292 option is to allow the executable task to read or write data files which have input or output record lengths of up to 292 bytes. This length was chosen to correspond with the length of our experimental data records. The ACTFIL=5 option allows five files to be open simultaneously. This is necessary when creating plots to compare experimental and predicted data.

The overlay description file (MGMOD.ODL) describes the manner in which to organize the various modules in the executable task. As indicated earlier,

for the modules to be overlayed, they must be logically independent; for the modules to be logically independent, they must not access one another in any way, neither directly nor indirectly. Thus, the overlay file describes which modules may overlay one another during execution because of their complete independence. The contents of MGMOD.ODL are in Table 2.

Table 2
Overlay Description File

```

.ROOT MHLMOD-PSUB-MAIN-SPC-*(OHTCC,PLOTC,TRC)
PSUB:  .FCTR [1,1]PLTUSL/LB
MAIN:  .FCTR [1,1]SYSLIB/LB:$SHORT
SPC:   .FCTR TC-TCMG-INTERP-REINIT
OHTCC: .FCTR OHTC-CHTC-FUNCTF
        .NAME NULL
PLOTC: .FCTR NULL-(PLC;D-PSUB,PLOTN-PSUB)
TRC:   .FCTR TR-PRED
        .END

```

The various commands (.ROOT, .FCTR, .NAME, and .END) in the overlay description file (Table 2) are described in the RSX-11M Task Builder Reference Manual [7] in the section entitled "Overlay Description Language (ODL)."

By using the TKB commands described in Table 1 with the overlay description file of Table 2, the twelve cited modules may be linked into an executable task (MGMOD.TSK) which does not exceed the RSX-11M operating system's restriction of a maximum task size of 32,000 words. The overlay described above was developed solely for the DEC RSX-11M operating system; application to another computer system will require modification of the overlay structure. It may be possible to eliminate the overlay structure if a computer's operating system allows all of the modules to be built into a single sequential program.

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