

Prepared E A Smallhorn	<b>CORD GROUP LTD.</b>	Doc. No. S420010
Approved PLPotter	Title <b>THERMAL COMFORT MANIKIN</b>  <b>SPECIFICATIONS</b>	Page <b>1 of 6</b>
Revision 01		Date 13 MAR 06

## 1. MANIKIN

### 1.1. SHELL:

#### 1.1.1. Structure

- Low mass, removable copper shells, mounted on a thermal plastic skeleton.
- A removable ring shall be provided in the neck to facilitate handling and storage of the manikin.
- 

#### 1.1.2. Shape

- Based on SAE, pre-ASPECT data provided by UMTRI (University of Michigan Transportation Research Institute)
- Representative of a mid-sized male
- Surface area, less section dividers:  $1.8 \text{ m}^2 \pm 10\%$ .
- Joint designs ensure that a minimum of heated/calculated skin surface area is lost to the joint mechanism.

#### 1.1.3. Sections

Shell divided into 26 measurable sections:

- |                             |                         |
|-----------------------------|-------------------------|
| 1. Head - Front             | 14. Right Hand          |
| 2. Head - Back              | 15. Abdomen             |
| 3. Chest                    | 16. Buttocks            |
| 4. Back                     | 17. Left Calf - Front   |
| 5. Left Forearm - Front     | 18. Left Calf - Back    |
| 6. Left Forearm - Back      | 19. Left Thigh - Front  |
| 7. Left Upper Arm - Front   | 20. Left Thigh - Back   |
| 8. Left Upper Arm - Back    | 21. Right Calf - Front  |
| 9. Right Forearm - Front    | 22. Right Calf - Back   |
| 10. Right Forearm - Back    | 23. Right Thigh - Front |
| 11. Right Upper Arm - Front | 24. Right Thigh - Back  |
| 12. Right Upper Arm - Back  | 25. Left Foot           |
| 13. Left Hand               | 26. Right Foot          |

- Thermal breaks separate each section.
- Lift points provided on each side of torso and back of neck for holding the manikin securely during dressing, positioning for a test and storage. Lift brackets provided.
- Service cable connections at sides of neck.
- Walls of the shell sections: copper, 0.030" wall thickness
- Manikin weight: 80 kg (176 lbs) adjustable  $\pm 15 \text{ kg}$  (33 lbs)
- Surface Emissivity:  $>0.9$
- Surface Colour: Customer specified.

### 1.2. JOINTS:

- Provide a thermal break between the sections they join.
- Easily removable for maintenance
- Connector systems that allow for complete separation without cutting wires.

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- Designed with inherent friction brakes such that the manikin limbs will remain in any position.

### 1.2.1. JOINT ROTATIONS

JOINT	ROTATION AXES	MIN. TRAVEL RANGE
Neck	none	NA
Shoulder	forward/backward	360°
Shoulder	out to side	45°
Elbow	forward/backward	0° (down) to ±90°
Wrist	Rotation about lower arm	Palms in to ±60°
Waist	No rotation	NA
Hip	forward/backward	0° (down) to ±90°
Knee	forward/backward	0° (down) to ±90°
Ankle	Rotation about lower leg	toes front to ±60°

### 1.3. HEATERS:

- Create a uniform power density over the surface area of all sections.
- Total manikin power: 650 W/cm<sup>2</sup>
- Sectional power density: 500 W/cm<sup>2</sup> on head, hands and feet; 300 W/cm<sup>2</sup> on all other sections.

### 1.4. SENSORS:

- Ribbon type RTD's (600 to 800 ohms at 20°C) connected in series and distributed over each section shell
- Mounted on the inside of the copper shell in a distributed pattern using aluminum tape
- Accurate to ±0.2°C.
- Up to 37 optional Heat Flow Transducers producing millivolt output distributed over the shell.
- Three additional millivolt sensor channels available through external connectors.
- Four RTD type (600 to 800 ohms at 20°C) external environment temperature sensors readable individually by the data acquisition system.

### 1.5. WIRING/CABLING:

- Pigtail for power, temperature and heat flux measurements:
  - left side of neck
  - 1 m (3.28 ft) pigtail with a "Y" and two connectors. (Ref system drawing) This gives a capability to disconnect and reconnect the cable when the manikin is moved into the vehicle during tests.
- Pigtail for environmental sensors (4):
  - left side of neck
  - 2 m (6.56 ft) pigtail with a junction to four 1m (3.28 ft) pigtails with sensors and the ends
- Three connectors for spare (millivolt) measurements: right side of neck
- Two 10 m (32.8 ft) long main cables with connectors.

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### 1.6. ELECTRICAL:

- All section heaters on the manikin are through ground fault interruptible circuits.
- All sections of the manikin grounded through the controller unit.
- The power inputs:
  - 120VAC/60Hz; and
  - 220VAC/50Hz.

## 2. CONTROL SYSTEM SOFTWARE:

### 2.1. ALGORITHM:

- Designed to maintain constant sectional temperature or power.

### 2.2. FEATURES

The software shall have the following features:

- Windows interface
- Menu driven hardware parameter set up
- Menu driven system calibration
  - Incorporates an offset and gain value for each temperature and heat flux sensor
- Scientific quality real time on-screen graphics capability including:
  - zoom in/out to full screen size
  - Y-axis maximum redefinition by mouse pick
  - Background grid pattern
  - Real time trending of 1 through 16 traces (up to 6 simultaneously) with selectable X-axis time references
- Data export facility for transferring data to commercially available software such as Excel spreadsheets
- PID tuning feature including:
  - A graph showing body section temperature vs time
  - Auxiliary panel to the graph allowing editing/tuning of PID constants
  - Second trace showing heater on/off status and control effort versus time
  - Save changes to template file feature

### 2.3. OPERATING SYSTEM

- Microsoft Windows NT 4, Windows 95, 98, 2000 & XP.

### 2.4. DATA ACQUISITION DEVELOPMENT ENVIRONMENT:

- National Instruments Lab Windows

### 2.5. PROGRAMMING LANGUAGE: "C"

### 2.6. FUNCTIONS:

- |                         |                                         |
|-------------------------|-----------------------------------------|
| • system initialization | • data display (real time or from file) |
| • diagnostics           | • data logging                          |
| • data acquisition      | • user interfacing                      |
| • data processing       | • log file export to third party format |
| • heater control        | • system calibration                    |

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## 2.7. TEST IDENTIFICATION PARAMETERS

- Vehicle Description
- Test Title
- Test Type
- Test Number
- Date of Test
- Time of Test
- Garment Description
- Sectional insulation level
- Manikin Location/Position Description
- Environment Description
- Ambient Temperature
- Ambient Humidity
- Air Flow Description
- Speed
- Blower Disposition

## 2.8. TEST OPERATING PARAMETERS

- Operating Modes:
  - Constant Temperature
  - Constant Heat flux
- Sectional Skin Temperature Set Points
- Sectional Heat Flux Set Points

## 2.9. MEASURED PARAMETERS

- Sectional Area-Mean Skin Temperatures [°C]
- Individual Environment Temperatures [°C]
- Sectional Area-Mean Heater Power [W]
- Local Heat Fluxes [W/m<sup>2</sup>]

## 2.10. COMPUTED PARAMETERS

- Average Environment Temperatures [°C]
- Sectional Area-Mean Heat Flux [W/m<sup>2</sup>]

## 2.11. DISPLAYED PARAMETERS

- Input Data
- Elapsed time
- Start time
- Sectional Area-Mean Skin Temperatures [°C]
- Individual Environment Temperatures [°C]
- Average Environment Temperatures [°C]
- Sectional Area-Mean Heat Flux [W/m<sup>2</sup>]
- Local Heat Fluxes [W/m<sup>2</sup>]

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**2.12. LOGGED PARAMETERS:**

- Time
- Test Inputs
- Individual environment temperatures (4 points)
- Area-Mean environment temperature (Average of 4 points)
- Area-Mean sectional skin temperatures
- Area-Mean sectional powers
- Area-Mean sectional heat flux
- Overall skin temperature
- Overall power
- Overall Area-Mean Heat Flux

**3. CONTROL SYSTEM HARDWARE:**

- The system shall be capable of measurements at a minimum of 12-bit resolution or equivalent on all channels.
- Selectable skin temperature range: 20 to 40°C (68 to 104°F)
- Maximum selectable heat flux: 300 w/m<sup>2</sup> ,500 w/m<sup>2</sup> for head, hands & feet
- System measurement accuracy: ±0.2°C (±0.9°F) on temperature channels and ±1% on heater power and HFT channels.
- The measurement subsystem is based on standard data acquisition equipment thus providing:
  - Readily available maintenance and calibration support
  - Traceability to national calibration standards
  - Expandability
  - Complete manufacturer's documentation

**4. SYSTEM PERFORMANCE:**

- Settling times:
- Local HFT sites: 1 minute or less
- Sectional heat flux: 1 minute or less
- Sectional temperature: 1 minute or less

**5. SYSTEM OPERATING CONDITIONS:**

**5.1. MANIKIN**

- Ambient temperature range: -20 to 60°C (- 4 to 140°F)
- "Accurate" internal temperature range: 20 to 40°C (68 to 104°F)
- "No damage" internal temperature range: -20 to 65°C (- 4 to 149°F)
- Thermal cut-out temperature: 65°C (149°F)
- Ambient humidity: 0 to 95% RH Non-condensing

**5.2. CONTROL UNIT**

- Ambient temperature range: 10 to 40°C (50 to 104°F)
- Ambient humidity: 0 to 95% RH Non-condensing

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**5.3. SYSTEM STORAGE CONDITIONS:**

**5.4. MANIKIN**

- Storage temperature range: -20 to 60°C (- 4 to 140°F)

**5.5. CONTROL UNIT**

- Storage temperature range: -20 to 60°C (- 4 to 140°F)

**6. HANDLING**

- A C-bracket allows the manikin to be hung vertically from the neck ring for dressing and installing in vehicles within one minute or less.
- An alternative bracket allows manikin to be lifted horizontally from torso strong points.

**7. STORAGE AND SHIPPING:**

- The manikin fits in a custom foam-filled packing crate.
- The cables and control unit pack in the same foam-filled crate.

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