

Atheris: A Revolutionary Anti-G Suit System

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Thermal Manikin Testing



- Copper manikin testing was performed to provide quantitative comparison to legacy state-of-the-art equipment
- Both versions included the IPG
- All other variables (undergarments, boots, etc.) were held constant
- Each ensemble was integrated to the manikin in as flight-like and comparative condition as possible
- Manikin skin temperature maintained at 34 deg C
- Exterior conditions are held constant and tightly controlled
 - Dry: 20 deg C, 40%RH, 0.4 m/s wind speed
 - Evaporative: 34 deg C, 40%RH, 0.4 m/s wind speed
- Heat loss measured to calculate dry heat resistance and evaporative resistance



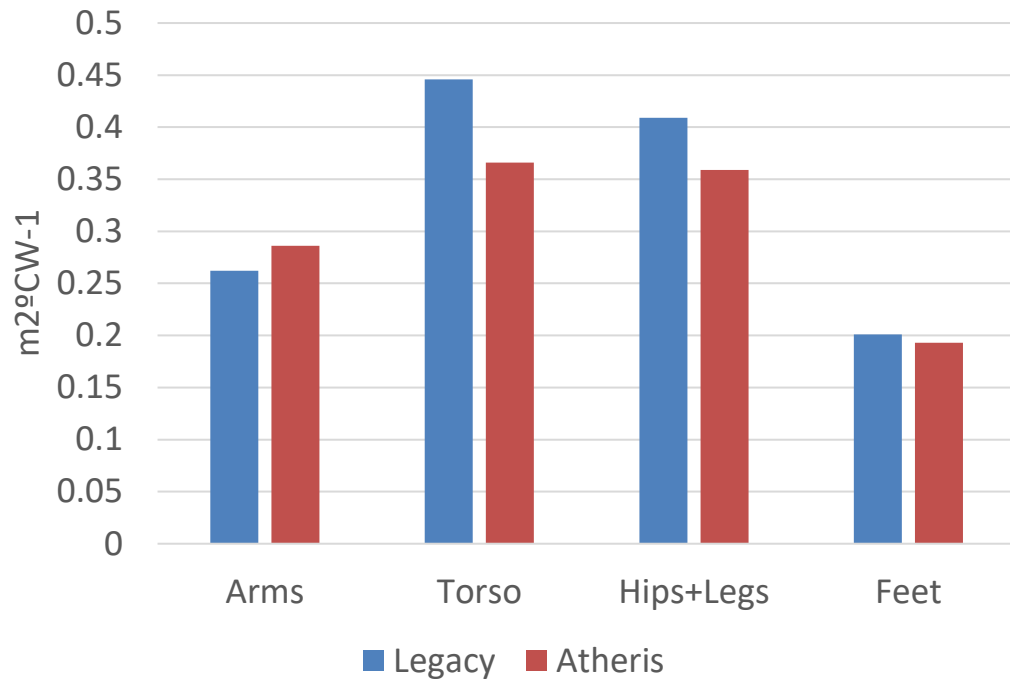
Thermal Manikin "Newton"



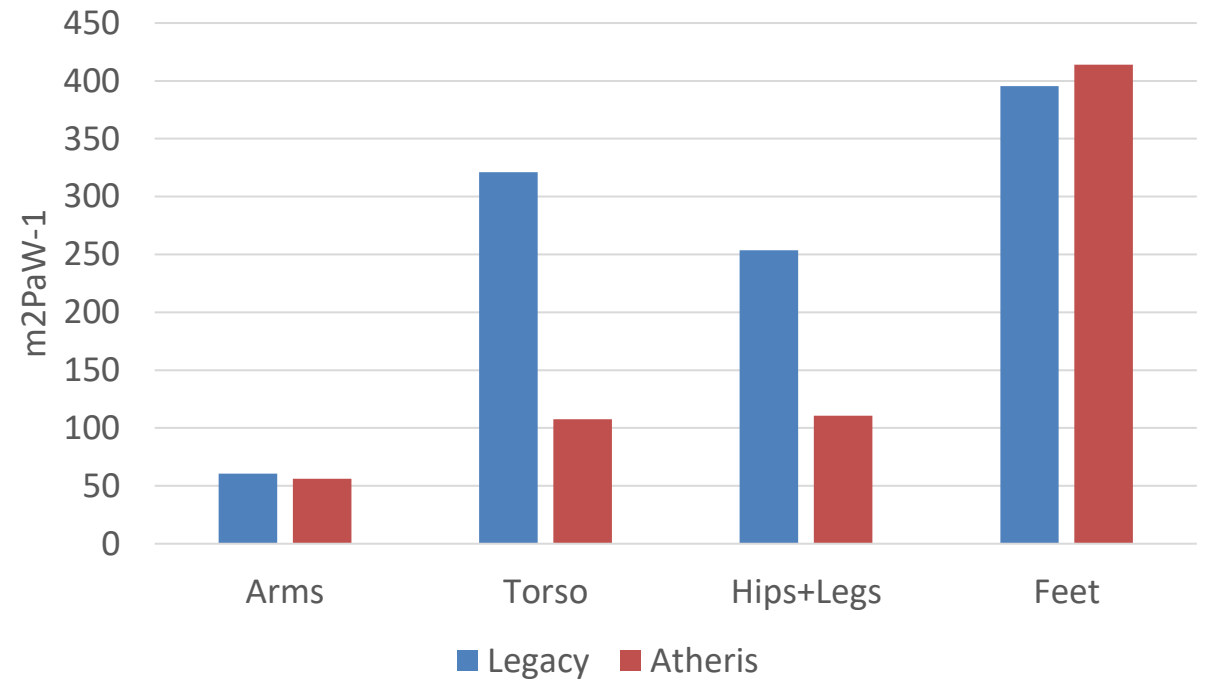
Thermal Manikin Results



Mean Heat Resistance



Mean Vapor Resistance



Thermal Manikin Results



- Data showed quantitatively that the Atheris suit provides ~20% reduction in overall thermal burden:

Zone	Skin Area (m2)	Mean Heat Resistance m2°CW-1		Percentage Difference
		Legacy	Atheris	
Arms	0.293	0.262	0.286	9.2%
Torso	0.433	0.446	0.366	-17.9%
Hips+Legs	0.731	0.409	0.359	-12.2%
Feet	0.119	0.201	0.193	-4.0%

Zone	Skin Area (m2)	Mean Vapor Resistance m2PaW-1		Percentage Difference
		Legacy	Atheris	
Arms	0.293	60.7	56.1	-7.6%
Torso	0.433	321	107.5	-66.5%
Hips+Legs	0.731	253.7	110.7	-56.4%
Feet	0.119	395.5	414.1	4.7%

- Note:
 - Tests were done entirely passively – no airflow through the suit
 - Active air flow through both the lower and upper portions of the Atheris suit would further improve thermal comfort and evaporative heat loss



Atheris integrated to the copper manikin



Thermal Manikin Details



- The manikin has 32 independent zones in which heat input or temperature can be controlled and measured
- Measurements are described extensively in ISO15831:2004, in ISO 9920 and in ASTM 2370 and 1291.
- Measurements performed in triplicate.

$$\text{Dry heat resistance} = \frac{T_{skin} - T_{ambient}}{\text{Dry heat loss}} \left[\frac{\text{Kelvin}}{\text{Watt per square meter}} = m^2 \cdot K \cdot W^{-1} \right]$$

$$\text{Vapour resistance} = \frac{P_{H_2O \text{ skin}} - P_{H_2O \text{ ambient}}}{\text{Evaporative heat loss}} \left[\frac{\text{Pascal}}{\text{watt per square meter}} = m^2 \cdot Pa \cdot W^{-1} \right]$$

$$\text{Evaporative heat loss} = \text{Total measured heat loss} - \text{Dry heat loss}$$

$$\text{Dry heat loss} = \frac{T_{skin} - T_{ambient}}{\text{Dry heat resistance}}$$

