Analyzing the Heat Loss of Motorsports Racing Suits

Reannan Riedy & Meredith McQuerry, Ph.D., Florida State University

Keywords: Thermal comfort, heat loss, auto-racing, thermal manikin

Background: From street racing to multi-million-dollar NASCAR events, motor racing has evolved significantly and gained a massive fan base over the course of its existence. This sport captures and intrigues its audience with the speed, risk, and long hours that its drivers must endure. Drivers compete at high speeds for, on average, 3-4 hours in a cockpit that can reach temperatures of 50ºC, depending on the design of the car. As engineers have worked to create a faster car, the comfort of the driver is often sacrificed (Carlson et al., 2014). Significant testing has been done in order to determine the overall physiological strain a driver goes through during competition (Carlson et al., 2014) or the effect of the car's physical environment and modifications (Walker et al., 2001), but very little research has been done on the effect that the driver's racing PPE has on the driver's thermal comfort.

SFI Grade	TPP Rating	
	Cal/cm^2	W-sec/cm^2
1	≥ 6	≥ 25.1
3	≥ 14	≥ 58.6
5	≥ 19	≥ 79.6
10	≥ 38	≥ 159.1
15	≥ 60	≥ 251.2
20	≥ 80	≥ 335.0
25	≥ 100	≥ 418.7
30	≥ 120	≥ 502.4

Figure 1. The SFI rating scale, which is determined by a racing suit's TPP rating (*SFI Specification 3.2A*, 2020).

Racing organizations such as NASCAR, Sports Car Club of America (SCCA), and International Motor Sports Association (IMSA) require that a racing suit meet at least one of several certification levels determined by The SFI Foundation, Inc. (SFI) or the Federation Internationale De L'Automobile (FIA). Racing organizations accept SFI 3.2A/1 combined with a fire resistant base layer, SFI 3.2A/5 or higher, FIA Standard 1986, or FIA Standard 8856-2000 (*General Competition Rules*, 2022; *SFI Specification 3.2A*, 2020).

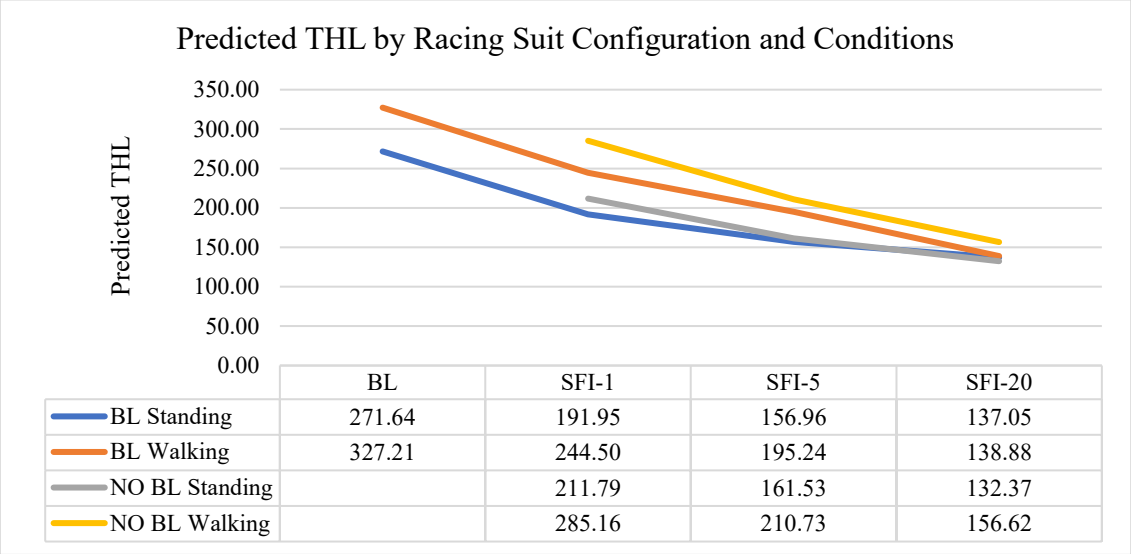
While motorsports PPE must go through intense testing for thermal protection, its comfort and breathability is rarely considered. Several studies regarding the physiological impact of the activity have been published, yet there continues to be a lack of information in the body of research regarding the impact of the PPE ensemble, specifically, on thermal comfort and heat stress. Therefore, the purpose of this research was to determine the impact of racing PPE on the thermal comfort of race car drivers by utilizing a thermal manikin to observe the Total Heat Loss (THL) of standard racing suits.

Figure 2. From left to right: Base layers, SFI-1 Suit, SFI-5 Suit, SFI-20 Suit. Each suit was tested with and without base layers.

Method: Three racing suit systems of varying SFI certification levels were purchased and analyzed in combination with the full systems ensemble including: base layers, racing gloves, and boots (Fig. 2). Using an ANDI sweating thermal manikin in an environmental chamber, thermal insulation and evaporative resistance measurements were collected according to ASTM F1291 and ASTM F2370, respectively. Each ensemble was tested under both static (standing) and dynamic (manikin walking) conditions. The predicted average THL of the three

racing suit systems, with and without thermal underwear, in both static and dynamic conditions, was analyzed according to appropriate statistical analysis procedures.

Results: For all configurations in both static and dynamic conditions, the results demonstrate a negative correlation between the certification level of the racing suit and the average predicted THL (Fig. 3). As per Figure 1, as TPP increases, average predicted THL decreases. The predicted average THL values of the SFI-1 suit tested with a base layer and the SFI-1 suit tested without a base layer were



	BL	SFI-1	SFI-5	SFI-20
BL Standing	271.64	191.95	156.96	137.05
BL Walking	327.21	244.50	195.24	138.88
NO BL Standing		211.79	161.53	132.37
NO BL Walking		285.16	210.73	156.62

Figure 3. Predicted THL by Racing Ensemble Configuration and Conditions.

significantly different when in static conditions. When comparing the SFI-5 suit configurations and the SFI-20 suit configurations under static conditions in the same way, the differences in THL values were not statistically significant. However, when comparing the predicted average THL of the varying suits tested with a base layer to their counterpart tested without a base layer under dynamic conditions, the differences were all statistically significant. Not surprisingly, the predicted average THL values of the suit configurations when worn with base layers were lower than the predicted average THL values of configurations worn without base layers, with the exception of the SFI-20 suit while in standing conditions.

Conclusions: It is worth noting that unlike firefighting PPE, racing suits do not have a minimum THL score ensuring wearer breathability and thermal comfort. Results from this research, however, demonstrate that the average predicted THL for a compliant racing ensemble (SFI-1 with base layers, SFI-5 and SFI-20 with or without base layers) is 172 W/m^2. More research must be done to better understand how the predicted manikin THL for racing ensembles effects the human body when performing under race day conditions, and to establish a minimum THL benchmark for racing ensembles. Future research should measure the physiological responses of drivers when wearing these suits.

References:

Carlson, L. A., Ferguson, D. P., & Kenefick, R. W. (2014). Physiological strain of stock car drivers during competitive racing. *Journal of Thermal Biology*, *44*(1), 20–26. https://doi.org/10.1016/J.JTHERBIO.2014.06.001

General Competition Rules. (2022). Sports Car Club of America, Inc. https://www.scca.com/pages/cars-and-rules

SFI Specification 3.2A. (2020, June 26). SFI Foundation, Inc. https://www.sfifoundation.com/wp-content/pdfs/specs/Spec_3.2A_062620.pdf

Walker, S. M., Dawson, B., & Ackland, T. R. (2001). Performance enhancement in rally car drivers via heat acclimation and race simulation. *Comparative Biochemistry and Physiology*, *Part A*(128), 701–707. https://doi.org/10.1016/S1095-6433(01)00276-8