

## **The Effects of Heat Stress on Air Force Employees Conducting Fuel Cell Maintenance Activities on Air Force Jets**

### **Introduction:**

The degree to which metabolic responses occur in reaction to hot environments differs per individual; however, when any human body is exposed to heat and the internal (core) body temperature rises, the body must rid itself of the excess heat. It does this automatically by increasing cardiac output and expanding larger blood vessels to accommodate the increased flow.<sup>1</sup> This heat-stress-induced increase in the body's metabolism is potentially a confounding variable in the association between jet fuel constituent metabolism and performance and health measures:

Of the 324 persons who completed the study, a total of 140 employees, not including those at Dyess AFB, were monitored for core body temperature as well as other measures of metabolic activity including skin and ear temperatures, heart rate, and gross motor activity.

These measurements of heat stress and heat strain are being compared to some of the many heat stress guidelines that have been developed to protect people against heat-related illnesses. The objective of any heat stress index is to prevent a person's core body temperature from rising excessively; the World Health Organization concluded, "It is inadvisable for deep body (core) temperature to exceed 38 °C (100.4 °F) in prolonged daily exposure to heavy work."<sup>2</sup> NIOSH guidelines also use a maximum core body temperature of 38 °C as the basis for their environmental criteria.<sup>3</sup> The American Conference of Governmental Industrial Hygienists (ACGIH) offers additional physiological guidelines, as well. For individuals with normal cardiac performance, sustained heart rate should not exceed 180 beats per minute *minus age*; the core temperature of unacclimatized workers should not exceed 38 °C (100.4 °F), while the core temperature of those workers who are accustomed to the work environment (acclimatized) should not exceed 38.5 °C (101.3 °F). Finally, a worker should not experience profuse and prolonged sweating or symptoms of sudden and severe fatigue, nausea, dizziness, or lightheadedness, or lose more than 1.5% of body weight over the shift.<sup>4</sup>

### **Methods:**

With the development of new technology, measuring core body temperature has only very recently become a viable option for research and industrial applications. During this study, NIOSH researchers used the CorTemp Wireless Core Body Temperature Monitoring System™ to monitor up to six employees daily. The CorTemp Temperature Sensor is swallowed and provides continuous monitoring of core body temperatures until the sensor is passed from the body, about 72 hours after being swallowed. The sensor has a temperature-sensitive crystal that vibrates in direct proportion to the temperature of the surrounding body tissues. This vibration creates an electromagnetic flux that continuously transmits harmlessly through the body tissues. A recorder receives this signal and translates it into digital temperature information that is then displayed on the unit and simultaneously stored to memory.

Heart rate, gross motor activity, skin temperature, and ear temperature monitoring were also conducted using the Mini-Mitter Mini-Logger Series 2000®. Employees wore an aural (ear)

temperature probe, a skin temperature probe, Polar chest-band heart rate monitor, and an activity sensor on the wrist.

Environmental factors most nearly correlated with core body temperature and other physiological responses to heat were also monitored using two wet bulb globe temperature (WBGT) instruments. One was placed inside the hangar with the fuel cell maintenance employees, and a second was placed outside to monitor outdoor environmental conditions every day during the study.

**Status:**

Currently, analyses are being conducted on the environmental and physiological measurements that were collected in order to assess the extent of heat stress and strain experienced by each employee. Analyses will also help identify variables that will in turn help other study researchers identify the potential and extent of heat stress confounding.

**Findings:**

Analyses are currently ongoing.

**Discussion/Conclusions:**

Site-specific NIOSH reports will be completed and forwarded to management and employee representatives at each Air Force base included in the study. These reports will include sampling results for groups of employees only (no individual data will be provided), and will provide recommendations for abating heat stress conditions and heat strain, if applicable.

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**National Institute for Occupational Safety and Health (NIOSH)**  
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4. ACGIH. 2001 TLVs<sup>®</sup> and BEIs<sup>®</sup>: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 2001.

**UNITED STATES AIR FORCE  
AFIOH**

**JP-8 Final Risk Assessment**

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