

PHYSIOLOGICAL EVALUATION OF CONSTANT-WEAR OVER-WATER FLIGHT SUIT

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Any type of constant-wear over-water flight suit (OWFS) should offer adequate thermal protection in accidental cold water immersion, but it should cause minimal heat stress during normal flight operations. This study aimed to determine physiological strain caused by OWFS made of 3-layer taslanized Oxford Gore-Tex* (GT) and Cotton Ventile (CV) materials 1) during aerobatic and 2) in climatic chamber simulations under elevated ambient temperature.

Three healthy fighter pilots (32-36 a) volunteered for the measurements during aerobatics. Two of the pilots and four medically screened male subjects (19-49 a) participated in the simulations. Each subject tested both OWFS wearing a standard flight garment (SFG) during every trial. In the trials with GT-OWFS also a Nomex flight overall was worn over the suit.

The test flights were conducted in winter and in summer. The sorties consisted series of aerobatic maneuvers at low altitudes of 300 - 3000 m above ground. The normal acceleration varied from -1G to +7G with high +G duration lasting some 15 to 20 sec; total flight time varied from 36 to 45 min. The pilots wore the OWFS with SFG about 7 h during the day and carried out two test flights (a.m. and p.m.), one as pilot, the other as co-pilot. Rectal temperature (T_r) and heart rate (HR) were recorded continuously during the flights. The simulations in the climatic chamber consisted of a 90-min sitting and a 45-min bicycle ergometer work (50 W) period at 30°C T_o and 40 % rh, preceding 30-min bedrest in a neutral climate. Continuous monitoring included ECG, HR, T_r , and skin temperatures (T_{sk}) at nine sites. Sweat production was determined from the changes in body weight corrected for fluid intake and accounting for the amount of sweat absorbed into the clothing.

During aerobatics HR fluctuated rapidly independent of the worn OWFS. The HR peaks were between 130 and 160 min^{-1} during high-G maneuvers. The mean T_r increase was 0.8°C in GT and 0.4°C in CV, respectively. The increases were more pronounced in pilots than in co-pilots. During the simulations, individual differences in HR response were great depending on the $\dot{V}O_{2\text{max}}$ of the subjects. Mean HR was 73 min^{-1} for GT and 65 min^{-1} for CV at the end of the sitting period, and respectively 137 min^{-1} for GT and 133 min^{-1} for CV at the end of work. The mean increases in T_r , T_{sk} , and mean body temperature were 0.3, 1.1, and 0.4°C for GT during sitting and 0.3, 1.2, and 0.4°C for CV, respectively. The further mean increases in the temperatures during bicycle work were 0.7, 1.7, and 0.8°C for GT and 0.7, 1.4, and 0.8°C for CV. The mean rates of body heat storage (S) during sitting were 11.5 Wm^{-2} for GT and 16.0 Wm^{-2} for CV. No differences occurred in mean rates of S between the OWFS during the work; it was 40.7 Wm^{-2} for both OWFS. Average sweat production was 1135 g for GT and 996 g for CV.

The results indicate considerable heat stress in pilots clad in OWFS with SFG during the aerobatics and in simulations under elevated ambient temperature. There was no significant difference in physiological strain caused by the OWFS made of GT or CV materials during the simulations. However, during aerobatic maneuvers the OWFS made of GT and used together with Nomex flight overall and SFG was too insulative. In order to minimize heat stress during operational flights further study is required to evaluate new materials for OWFS; particular attention should be paid to underwear, and to the role of design, fit, and ventilation characteristics of constant-wear OWFS on the function of the total flight clothing system.