Microenvironmental Protection in Military Flying

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STUDIES on thermal stress, pertaining to low altitude tropical operation of military aircraft during summer months, have established that in most cases tolerance levels are reached during flight with duration ranging between 40 min and 90min, depending on the actual thermal environment in the aircraft. Limitations of air cycle system of cooling which is currently being used in military aircraft during high ambient temperatures are well known. It is also well established that the total heat accumulation corresponding to the tolerance levels ranges between 160 K cal to 200 K cal for acclimatised Indian subjects. It can therefore be concluded that a microenvironmental protection system with a refrigeration capacity of 200 K cal should be able to dissipate the heat accumulation in flyers and provide thermal comfort for the total duration of the sortie.

Blockley's studies have shown that the functional efficiency of subjects gets affected when one approaches a level of 65% of the heat accumulation corresponding to tolerance. Earlier attempts in microenvironmental and other protection carried out at the Institute of Aviation Medicine, Indian Air Force aimed at providing refrigeration to a level where the aircrew could be kept in a thermal state compatible with functional efficiency. The aircrew are not allowed to cross the 100 Kcal level during any part of the sortie. This could be achieved by a series of measures, viz., (a) Prior body cooling in a cold environment for a specific duration, (b) Cooling by an aircooling trolley and an air ventilated suit, (c) Short burst cooling by means of dry oxygen using an air ventilated suit.

First two methods of cooling are provided during a stage before the aircrew are physiologically strained by the thermal stress. Aircrew have often expressed their preference to get refrigeration during flight. Short burst cooling provides cooling during a stage where the subject is physiologically strained. However, the total amount of refrigeration provided during this stage is very much limited yet it gives the subject a fine subjective feeling which steps up his functional efficiency during the short interval during and after the burst.

Liquid cooled suits (L C S) because of the higher specific heat of the liquid in circulation is to be considered as a more effective way of refrigeration than air ventilated suits. Results of laboratory trials in hot cockpit with a LCS system with 200 K cals of refrigeration capacity are given in the table below.

Thermal protection offered by the LCS system for 1 hour exposure 50°C DB and 32.5°C WB

Subject	Rise in heart rate beats/min	Heat accumulation Kcal/m²
EMI	4	25.7
DYR	0	11.3
MBD	2	24.4
CAV	10	22.5
RKS	0	27.0
MKV	0	6.8
Mean	2.7	19.6
SD	3.9	8.4

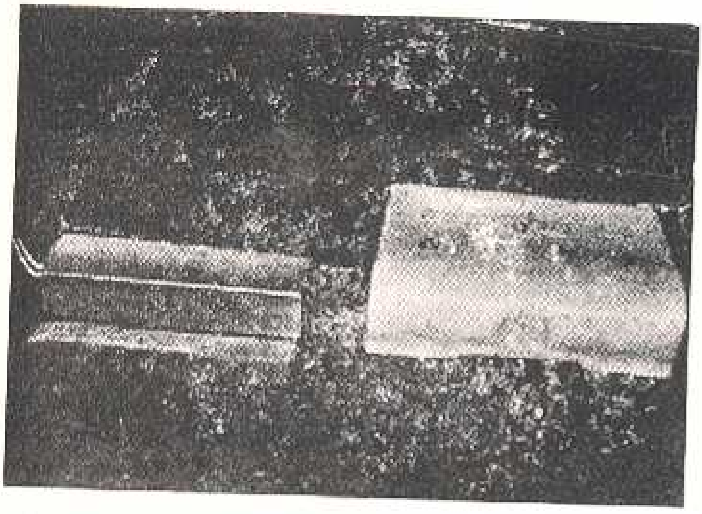

Fig. 1 — Stainless Steel Container for refrigerant Ice Pack and Fibreglass Shell for Survival aids.

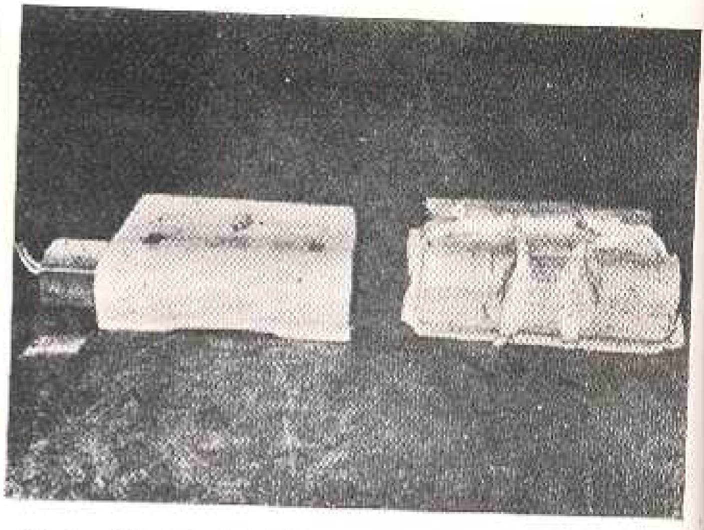

Fig. 2 — Fitment of refrigerant Ice Pack and Survival aids in Fibreglass shell.

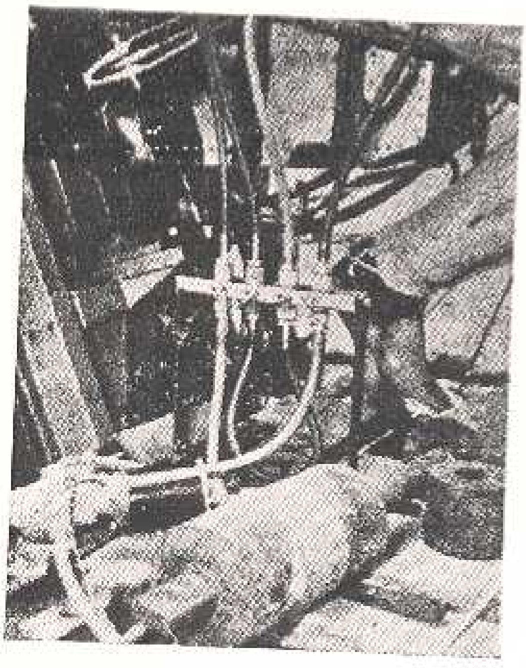

Fig. 3 — Quick release connections of LCS to refrigerant Pack and Pump.

Fig. 4 — Miniature DC Pump for liquid circulation through LCS.

It can be seen that the heart rate changes and heat accumulation in one hour of heat exposure at 50°C DB and 32.5°C WB with the LCS are very marginal. This shows the efficacy of this mode of cooling.

Refrigerant Pack for Inflight Use

The refrigerant system presently developed for inflight use consists of the following :

(a) Fibreglass container for survival aids,
(b) Refrigerant ice pack in stainless steel,
(c) A set of quick release connectors,
(d) A miniature DC pump with DC motor operating on 24 volts,
(e) Mounting for the quick release connectors and pump in the aircraft.

Fibreglass Container.

Rigid fibreglass containers for survival aids are replacing the old canvas type of compressible survival packs. Because of the incompressible nature, these packs do not give dynamic overshoot of acceleration and are therefore more safe to use in ejection seats. The shell currently developed can be used in supersonic fighters and jet trainer and has been tested for a static loading corresponding to 30 g and dynamic loading of 18-20g during ejection trials using an ejection test rig. The fibreglass shell has the same dimensions as the currently used survival packs and has got a compartment in the front running across the full length with a volume of approximately two litre, survival aids other than water can be packed in the usual manner in the space behind the compartment. Sleeping bag can be packed so as to occupy a uniform layer underneath the compartment.

Refrigerant Ice Pack.

A stainless steel container with coated copper tubes running inside the steel container with the ends welded to the sides, is fabricated to fit into the fibreglass pack (Fig. 1 & 2). Water can be filled into the container through an opening provided in the container which may be later on closed with a nut. Water can be drained out through the same opening whenever required. A steel container with water is kept in a deep freeze for sufficiently long time so that the entire water is converted into ice. Approximately 1.75kg of ice is formed and provides the refrigeration for the liquid supply to the LCS which is pumped through the copper tubes. The fibreglass shell, the thermocole insulation provided on the sides of the compartment, and the survival aids including the sleeping bag provides adequate insulation for the refrigerant pack, (Fig. 2). The water in the refrigerant pack (approx. 1.75 litres) is considered adequate for survival use whenever required. While transferring the steel container from the deep freeze to the survival pack in the aircraft they have to be taken in a properly insulated bag. The liquid circulated for cooling is 1:1 mixture of water with glycol. This liquid circulating through the copper tubes and getting cooled will not freeze at 0°C.

Quick Release Connectors.

The connections of the LCS to the refrigerant pack, LCS to the pump and the refrigerant pack to the pump are all carried out using self sealing quick release connectors so that during ejection separation of the ejection seat from the aircraft, the survival pack from the ejection seat, and the survival pack from the subject are all achieved clean (Fig. 3). These connectors have been tested on the ground by pulling up the ejection seat by a winch system and later in ejection trials using an ejection test rig. During the ejection trials, velocities were recorded and the velocity values were compared with control ejection values. No discernible change in velocities are produced during the quick release disconnections.

Pump for Liquid Circulation.

A miniature DC pump (Fig. 4) is required with capability of circulating approximately 1 litre of liquid per minute. The pump has to be operated by a 24 volt DC motor. Fuel pumps presently being used in trainer aircraft have been found to serve the purpose as evidenced during trials. A similar pump was indigenously developed and was found to serve the purpose.

Conclusion

The liquid cooled system in the present form gives approximately 200 K cals of refrigeration and can keep aircrew in a thermal state close to comfort during summer operations in our country. The system in its present form can be incorporated for inflight use and as evidenced by ejection trials will not pose any problems during ejection.