Original Article

Semi-closed capsular ejection revisited: Is it too late to modify an old aircraft?

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ABSTRACT

In the 1AF, MiG 21T-77 is the only tighter aircraft that has a semi-closed ejection. The Original Equipment Manufacturer (OEM) laid down 94.0 cm as the maximum acceptable sitting height compatible with the aircraft, since the canopy slides over a metallic plate that may come in contact with the pilot's helmet when simulating the ejection sequence in encapsulation trials on ground and could be expected during actual ejection, as well. Therefore this study was carried out to re-define the sitting height limitations for aircrew to fly this aircraft. This was done specially in view of the new Light Weight Integrated Helmets (LWIH) currently in use by the fleet; and was thought to add more to the sitting height of the aircrew vis-a-vis the old ZSH-3 Helmet. Sitting height measurements of 11 subjects were taken with three different helmet types: LWIH of two different makes and ZSH-3. This was followed by cockpit and encapsulation trials, simulating the ejection sequence on ground. Trials were also conducted for an aircrew who had recently made a successful ejection from the aircraft. Encapsulation trials were repeated after removal of seat headrest cushion when it was noticed that this was contributing to worsening of posture and jeopardizing safe encapsulation for aircrew with borderline sitting heights. The results of this study are discussed in detail. It was concluded that minor variations in sitting height on account of different helmets do not appear to worsen safe encapsulation on ground. Replacing the existing thick seat headrest cushion with a thinner one appears to be a logical modification to improve aircrew-aircraft compatibility. Aircrew with borderline sitting heights should be made aware of dynamics of the ejection process that ensures safe encapsulation during actual ejection.

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In the Indian Air Force (I AF), the MiG 21 T-77 is the only fighter aircraft that has a semi-closed ejection facility. When the ejection handle is pressed without jettisoning the canopy, the 'R' gun fires operating the restraint mechanism. Next, the main gun fires and the seat-man combination travels upwards on the guide rails. The rear part of the canopy (grip locks) gets engaged to trunnions on the seat and the canopy slides down over a curved metallic plate above the pilot's head after which the front end of the canopy locks with the lower front part of the seat. This semi-closed capsule clears the tail of the aircraft and starts descending due to gravity. After a time-delay, the 'F' guns fire leading to separation of the canopy from the seat, followed by automatic deployment of the main parachute and seat-man separation for a safe touch down [1,2]. Ind J Aerospace Med 51(1), 2007

Budding fighter pilots in the IAF have been trained on this aircraft for many years now. Anthropometric compatibility with the cockpit, especially sitting height considerations have been a problem area for many young pilots. Every six months this has meant planning for cockpit and encapsulation trials for those with borderline Sitting Height (SH) and for some young trainees invariably, unfitness to fly the aircraft. Similarly, some MiG 21 pilots who were earlier trained on this aircraft were found unfit to fly the same after a gap of few

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years, possibly due to gain in weight contributing to an increase in SH. Investigation of a fatal aircraft accident about 14 years ago had revealed the criticality of limiting the maximum permissible SH to eject safely from this aircraft. The Russian manufacturers had recommended a maximum SH of 94.0 cm, but that was when the parachute-KP27 oxygen bottle assembly in the seat pan had a combined thickness of 225 mm. With the introduction of a 15 mm thick Personal Survival Pack (PSP), the total thickness of this assembly became 240 mm. The maximum permissible SH was accordingly reduced to 92.5 cm. This continues to be the upper limit [3].

This restriction of SH could never be sacrosanct, since a number of aircrew in the ± 1.0 cm range could be declared fit or unfit only after laborious cockpit trials at a fighter training base. With the introduction of the Light Weight Integrated Helmet (LWIH) for the MiG fleet, there were reports of an additional increase in SH of the fully kitted aircrew. This study was carried out to ascertain anthropometric changes on account of the new LWIH and to comprehensively review the aircrew aircraft compatibility issues in this aircraft.

Material and Methods

The study was carried out at a large fighter base of the IAF that conducts MiG operational flying training. The following aspects were studied:-

(a) Anthropometric measurements. SH measurements were done for 11 subjects including four aircrew, using portable anthropometric arm. Care was taken to ensure that the subjects adopted proper posture. Wooden planks of varying thickness were used below the feet to get the thighs parallel to the ground. Vertical lines were marked on the wall behind the subjects, using a spirit level, to ensure that the portable anthropometric arm was held truly vertical. The LWIH comes with Velcro detachable foam padding of varyingthickness of 10 to 20 mm on the top inner portion and similar padding in the front and rear linings. For purposes of standardization, no additional padding over the inner top of LWIH was used for any subject. Subjects could however choose to use or discard the padding in the front or rear of the helmet lining. No subject complained of any discomfort due to this during the trials. One of the co-authors, a Qualified Flying Instructor (QF1), was satisfied with the helmet fitment of each subject. SH measurements were made for each subject in underwear and in full flying clothing without helmet. This was followed by measurement of SH in flying clothing with LWIH of two makes (LWIH 1 and LWIH 2) and ZSH-3 helmet with visors in fully down and fully up positions.

(b) Overhead clearances in the cockpit. This specifically meant clearance between the metallic plate and the crown of the helmet for aircrew of varying sitting heights. Bars of moldable clay (plasticine) were stuck to the crown of the helmet, which got compressed by the curved metallic plateon lowering of the canopy. The compressed plasticine bars were measured by Vernier callipersto ascertains clearance. Plasticine bars were placed at two places on the helmets. One was placed just below the tip of the metallic plate and the second over the vertex of the helmet. The point where the canopy was actually pressing on the metallic plate was more to the rear of the helmet and the normal downward curve of the helmet under that point permitted a much larger gap at that point. For the purpose of standardization, measurement was done from vertex of helmet to a point on metallic plate where canopy was in contact with it.

(c) Encapsulation trials. Encapsulation trials were conducted in the Ejection Seat Bay at the base. These were conducted on personnel with full flying clothing. For each subject these were conducted with all three types of available helmets. Parachute-PSP-Oxygen bottle assembly thickness of240 mm was ensured. The seat was kept in the lowest position. Encapsulation for some subjects was redone on different seats to allow checking for individual differences in seat and canopy combinations. For encapsulation trials the tradesmen holding the rear part of the canopy were instructed to apply only a forward pressure onto the seat trunnions. Downward movement was carried out by tradesmen holding front end of the canopy only. The aircrew were not cleared if the rear part of the canopy lifted off the seat trunnions during the procedure. This was observed to be an objective criterion for failing the encapsulation trial. In case the canopy did not lift off, only if aircrew complained of intolerable pressure during encapsulation, was the test abandoned and aircrew considered unfit.

(d) Case Study. Encapsulation trials were conducted for a pilot who had recently ejected successfully.

Results

The mean, maximum and minimum increase in sitting height of the kitted subjects with various helmets in visor up and down positions is given in Table 1.

The evaluation reveals that the mean increase in sitting height is lesser in both LWIH as compared to the ZSH 3 helmet. LWIH 1 helmet contributed to least mean increase in sitting height followed by LWIH 2; the greatest increase being due to ZSH 3 helmets. The individual sitting height of the subjects in various configurations are given in Table 2 and the difference in sitting height with different helmets in Table 3. Although there does not seem to be any specific design for G loading of the LWIH it is expected that with the onset of ejection both visors would come down. It was seen that both visors do come down with mild jerk in Gz axis. Thus the critical parameter is the increase in SH with visor down.

While conducting the cockpit clearance as well as encapsulation trials it was observed that the aircrew require an over-the-nose vision that permits them to see the base of the pitot head and adjacent portion of the nose of the aircraft. This is considered essential for take-off, approach and landing. Normally, however, the pilots adjust their sitting position to cater to an overhead clearance of approximately 5 cm. The permissible range of travel for the seat is about 80 (± 10) mm. Pilots with high sitting height chose the lowest position and short pilots raised the seat appropriately. For the purpose of this trial, the seat position in the cockpit were fixed by the subjects depending on adequacy of over-the-nose vision as advised by the qualified pilot on type.

The overhead cockpit clearances for subjects with varying sitting height are given at Table 4. Subject with SH of 92.1 cm had adequate (> 5.0

Table 1: Increase in sitting height with various helmets

Helme	Mean increase (cm)	Max increase (cm)	Min increase
LWIH 1 Helmet with visor up	3.4	4.5	2.0
LWIH 1 Helmet with visor down	2.28	3.7	1.4
LWIH 2 Helmet with visor up	4.25	5.2	3.6
LWIH 2 Helmet with visor down	2.86	3.7	2.3
ZSH 3 Helmet with visor up	4.05	5.0	3.2
ZSH 3 Helmet with visor down	2.96	4.1	2.2

Table 2: Sitting height measurement with different helmets

	StHt (cm)	St Ht FC (cm)	LWIH 1 Visor Down	LWIH1 Visor Up	LWIH 2 Visor Down	LWIH 2 Visor Up	ZSH-3 Visor Down	ZSH-3 Visor Up
Subject 1	87.7	88.4	91.1	92.2	91.0	92.5	92.5	93.4
Subject 2	88.0	88.0	91.7	92.5	91.6	93.2	91.5	92.8
Subject 3	88.7	88.7	90.9	91.9	92.4	93.5	91.2	92.3
Subject 4	88.9	89.1	91.1	92.5	91.5	93.3	91.8	92.8
Subject 5	89.5	89.5	92.3	93.3	92.7	93.9	92.7	93.7
Subject 6	90.3	90.3	91.8	92.8	92.7	94.3	93.4	94.5
Subject 7	91.3	91.4	94	95.3	94.8	95.5	94.9	95.6
Subject 8	91.4	91.8	93.2	93.8	94.6	96.1	94.1	95.4
Subject 9	92.3	92.1	94.2	95.9	94.5	95.9	94.3	95.3
Subject 10	92.8	92.7	94.6	96.1	95.0	96.3	94.9	96.2
Subject 11	93.5	93.6	95.8	96.7	96.3	97.9	96.9	98.2
Average	90.4	89.92	92.79	93.91	93.37	94.76	93.47	94.56
Max	93.5	93.6	95.8	96.7	96.3	97.9	96.9	98.2
Min	87.7	88.0	90.9	91.9	91.0	92.5	91.2	92.3

Note: St Ht: Sitting Height
St Ht FC: Fully Kitted Sitting Height

Table 3: Increase in sitting height with different helmets

	St Ht (cm)	St Ht FC (cm)	LWIH 1 Visor Down	LWIH1 Visor Up	LWIH 2 Visor Down	LWIH 2 Visor Up	ZSH-3 Visor Down	ZSH-3 Visor Up
Subject 1	87.7	88.4	2.7	3.8	2.6	4.1	4.1	5
Subject 2	88	88	3.7	4.5	3.6	5.2	3.5	4.8
Subject 3	88.7	88.7	2.2	3.2	3.7	4.8	2.5	3.6
Subject 4	88.9	89.1	2	3.4	2.4	4.2	2.7	3.7
Subject 5	89.5	89.5	2.8	3.8	3.2	4.4	3.2	4.2
Subject 6	90.3	90.3	1.5	2.5	2.4	4	3.1	4.2
Subject 7	91.3	91.4	2.6	3.9	3.4	4.1	3.5	4.2
Subject 8	91.4	91.8	1.4	2	2.8	4.3	2.3	3.6
Subject 9	92.3	92.1	2.1	3.8	2.4	3.8	2.2	3.2
Subject 10	92.8	92.7	1.9	3.4	2.3	3.6	2.2	3.5
Subject 11	93.5	93.6	2.2	3.1	2.7	4.3	3.3	4.6
Average	90.4	90.51	2.28	3.4	2.86	4.25	2.96	4.05
Max	93.5	93.6	3.7	4.5	3.7	5.2	4.1	5.0
Min	87.7	88.0	1.4	2.0	2.3	3.6	2.2	3.2

Note: St Ht: Sitting Height
St Ht FC: Fully Kitted Sitting Height

Table4: Cockpit clearance with different helmets

	Ac SI No	Seat raised* (cm)	PSP (mm)	St Ht (cm)	St Ht FC (cm)	Lw'iHl Tip" (cm)	LW1H1 Crown" (cm)	LW1I12 Tip (cm)	LWIH 2 Crown (cm)	ZSH-3 (cm)	ZSH-3 Crown (cm)
Subject 1	1 C528	2.3	240	87.7	88.4	4.6	6.1	3.9	5	4.7	5.9
Subject 2	1 C 528	2.2	240	88	88	5.1	6	4.4	5.4	5.1	6.1
Subject 3	1 C 528	4.2	240	88.7	88.7	5.9	6.8	5.2	6.4	5.2	6.4
Subject 3	1 C 528	Lowest	240	88.7	88.7	>9.0	>10.0	>9.0	>I0.0	>9.()	>10.0
Subject 4	2 CI 105	3.5	240	88.9	89.1	3.9	5.8	0.6	5.9	3.1	6.1
Subject 5	1 C528	1.3	240	89.5	89.5	4.8	5.7	3.9	4.3	4.3	5.1
Subject 6	2 CI 105	3	240	90.3	90.3	3.2	5.8	2.6	4.9	3	5.9
Subject 7	1 C 528	3.3	240	91.3	91.4	3.5	3.8	2.7	3	2.9	3.3
Subject 7	1 C 528	Lowest	240	91.3	91.4	>5	>5	5.1	6.2	5.1	6.4
Subject 8	1 C 528	5.5	240	91.4	91.8	3.2	3.8	2.3	3	2.4	3.2
Subject 8	1 C 528	Lowest	240	91.4	91.8	6.6	8.6	>5.0	>7.0	>5.3	>7.5
Subject 9	2 CI 105	1.7	240	92.3	92.1	3.5	6	3.4	5.3	3.1	5.8
Subject 10	2 CI 105	1.5	240	92.8	92.7	2.4	4.5	2.5	5	2.6	5.3
Subject 11	2 CI 105	0.5	240	93.5	93.6	2.3	4.2	2	4.1	2	4.3

Note: * Seat raised above lowest position in cm.

\# Clearance between tip of metallic plate and helmet top

@ Clearance between vertex (crown) of helmet and metallic plate (at the point of its contact with canopy)

cm) overhead clearance with all three helmets in visor down position. This was despite seat being raised by 1.7 cm from the lowest position, for adequate over the nose vision. Subject 10, with SH of 92.8 cm, had adequate overhead clearance with all except'the LWIH1, where the clearance was 4.5 cm. Again, this was with seat raised 1.5 cm above lowest position.lt was observed that for the same subject there were noticeable differences in seat height adjustment to ensure adequacy of over-the-nose vision amongst different aircraft. This necessitated adopting differing seat positions for the same subject in different aircraft.

Details of encapsulation trials for all subjects are given in Table 4. The subject with sitting height of 92.1 cm cleared the encapsulation trials with all three helmets. However, the subjects with sitting height of 90.3 cm and 91.4 cm could not clear the encapsulation trial with any helmet, as they felt sex ere pressure during the lowering of the canopy. Encapsulation trials for these subjects were repeated on a different seat-canopy combination to rule out individual seat variations. They did not clear the trials on either seat canopy combination. This suggested that even though there was no extra enhancement of sitting height due to the new LWIHs as compared to the ZSH 3, some subjects within existing acceptable sitting height criteria could not be encapsulated on ground with any helmet.

During the cockpit and encapsulation trials il was noticed that the seat headrest cushion was not permitting the helmeted head of the pilot to be held straight. Measurements done on several available seats revealed that the cushion was 7 to 9 cm thick. Due to its shape, this thick headrest cushion created a forward displacement of the helmeted head by about 9 to 10 cm. This rexene-covered sponge cushion was actually responsible for noticeable flexion of the pilot's neck on adoption of the ejection posture. More importantly, this forward displacement of the helmeted head resulted in the tip of the curved metallic plate coming in contact with the crown of the helmet during canopy closure. During encapsulation trial for the aircrew with sitting height of 91.4 cm, the curved metallic plate exerted severe unbearable pressure on the crown (vertex) of the helmet. This pressure was greatest when the canopy was lowered about midway from the horizontal position to its final locking point.

A close inspection of the curved metallic plate revealed that its curve corroborated well with the normal curved surface of the helmets. However, because of the thick headrest cushion these curves were not matching. This misalignment of the curved metallic plate with the upper surface of the helmet was responsible for diminished availability of space for the seated pilot during encapsulation. It was therefore decided to examine the clearances and encapsulation after removal of the seat headrest cushion (Figs 1 -4).

On removal of the headrest cushion it was observed that the helmeted head of the pilot could rest in the curved hollow of the headrest more conveniently. This permitted avoidance of flexion of the cervical spine while sitting and adopting the ejection posture. More crucial was the fact that now the curvature of the curved metallic plate matched the contour of upper surface of the helmet. This created enhanced availability of vertical space for the seated pilot during encapsulation.

On removal of the seat headrest cushion, the encapsulation trials of the aircrew with sitting height of 91.4 cm were successfully completed with all three types of helmets. The increased vertical space

Fig 1: Seat with headrest cushion

Note: 1. Tip of metallic plate pressing vertex of helmet.
2. Flexion of neck in ejection posture.

Fig 2: Seat without headrest cushion

Note: 1. Curvature of metallic plate follows that of helmet.
2. Better cervical spine position in ejection

Fig 3: Commencing encapsulation of seat with headrest cushion

Note: 1. Tip of metallic plate pressing vertex of helmet.
2. Flexion of neck in ejection posture.

Fig 4: Commencing Encapsulation of seat without headrest cushion

Note: 1. Curvature of metallic plate follows that of helmet.
2 Better cervical spine position in ejection posture.

available permitted encapsulation to be completed comfortably. The curved metallic plate did not touch the upper surface of the helmet throughout the process of encapsulation.

The trial was then repeated for a non-aircrew subject with SH of 92.7 cm. The subject completed the encapsulation comfortably. Again, the curved metallic plate did not touch the upper surface of the helmet. However, when the same process was repeated on yet another subject with sitting height of 93.5cm, the encapsulation could not be completed due to severe pressure felt on the head and neck. Details of subjects for whom encapsulation trials were conducted without seat headrest cushion are given in Table 6.

Case study of recent ejection on MiG 21 T-77

A young squadron leader had a successful ejection from MiG 21 T-77 aircraft after an engine seizure/ flame out while on circuit. The pilot chose to eject without first jettisoning the canopy, which was the correct action to save time. He therefore had a normal semi-closed ejection. The pilot was apparently unharmed as a result of the ejection. However, MRI spine later revealed minimal hairline fractures of the spine at T10 and Tl 1 levels. There was no head injury or cervical spine injury. Examination of the helmet did not reveal any indentation or scratch on the top surface where the metallic plate could have compressed the helmet. The pilot had a SH of 88.7 cm. He always adjusts the seat to about 1.5 cm below the top-most position, since he still gets adequate clearance over the helmet. On the day of the ejection also he had kept the seat at such a position.

An encapsulation trial was conducted for this pilot. With the seat in the lowest position, he comfortably cleared the encapsulation, although the

Table 5: Encapsulation trials with head rest cushion

	St Ht(cm)	St Ht FC (cm)	Seat position	LWIH I	LW1H2	ZSH-3
Subject 1	87.7	88.4	Lowest	Clear	Clear	Clear
Subject 2	88.0	88.0	Lowest	Clear	Clear	Clear
Subject 3	88.7	88.7	Lowest	Clear	Clear	Clear
Subject 3	88.7	88.7	4.2 cm	No	No	No
Subject 4	88.9	89.1	Lowest	Clear	Clear	Clear
Subject 5	89.5	89.5	Lowest	Clear	Clear	Clear
Subject 6	90.3	90.3	Lowest	No	No	No
Subject 7	91.3	91.4	Lowest	Clear	Clear	Clear
Subject 8	91.4	91.8	Lowest	No	No	No
Subject 9	92.3	92.1	Lowest	Clear	Clear	Clear
Subject 10	92.8	92.7	Lowest	No	No	No
Subject 11	93.5	93.6	Lowest	No	No	No

Note: St Ht: Sitting Height

St Ht FC: Fully Kitted Sitting

Table 6: Encapsulation trials without head rest cushion

	St Ht(cm)	StHtFC(cm)	LWIH1	LWIH2	ZSH-3
Subject 8	91.4	91.8	Clear	Clear	Clear
Subject 9	92.3	92.1	Clear	Clear	Clear
Subject 10	92.8	92.7	Clear	Clear	Clear
Subject 11	93.5	93.6	No	No	No

Note: St Ht: Sitting Height
St Ht FC: Fully Kitted Sitting Height

tip of the curved metallic plate did come in contact with the top surface of the helmet. However, when encapsulation was attempted with the seat at 2.0 cm below the top-most position (approximating his usual seat position), it could not be completed, since he complained of severe pressure on the head and neck. The seat was then lowered further (to about halfway of its travel i.e. 4.2 cm above the lowest position). The officer could not still complete encapsulation because of severe pressure on the head and neck.

Discussion

Our finding of the mean increase in SH being lesser in both LWIH as compared to the ZSH 3 helmet, is at variance with a smaller study on LWIH done earlier [4] and findings of change in sitting height with helmet during evaluation of trainee pilots for aircraft compatibility at No. 2 AMTC, IAF. This is possibly because we chose to remove the inner cushions of the LWIH helmets in all cases, in order to standardise the change in sitting heights, whereas the other studies had not done so.

There are noticeable individual differences in both cockpit clearances and encapsulation. This has been observed during earlier studies as well [5, 6]. These differences were not explainable by the changes in individual sitting heights as a result of wearing of different helmets. In fact the increase in SH due to helmets was more in Subject 7 (91.3 cm) who cleared the encapsulation trial as compared to the shorter Subject 6 (90.3 cm) who failed the trial (Table 3). An important observation was that these subjects with borderline sitting heights either cleared encapsulation trials with all three helmets or did not clear trials with any of the three helmets. It can be inferred that minor differences in increase in sitting height due to helmet do not contribute to clearing/ failing the encapsulation trial.

It was noticed that the subjects with borderline sitting height who were more muscular and bulky failed the encapsulation as compared to the thinner subject who, although taller, had cleared the trial.

For the thinner subjects perhaps it is possible to adapt to the shape of the hollow seat back and thus effectively reduce some SH. Greater muscle bulk does not permit the stocky subjects to adjust with the curvature of the seat back and in them, therefore, there is no apparent reduction in sitting height.

Whether an individual clears the encapsulation trial successfully or not remains subjective to some extent. The pressure exerted upon the head by the canopy through the metallic plate cannot be quantified and therefore the assessors have to depend on the subject's opinion regarding the same.

The seat headrest is provided to prevent whiplash injuries to the neck during ejection or crash landing. Moreover, it would provide protection to the head and neck against ram air injuries, in the event of a canopy failure due to any reason. The cushion on the headrest would help to absorb the impact of the helmeted head in the event of its striking the headrest. Replacing the thick seat headrest cushion with a thinner one permits the curved metallic plate to be well aligned with the helmet top. In turn, this allows greater vertical space as well as better ejection posture for the seated pilot.

On removal of the seat headrest cushion, il would be possible to comfortably encapsulate subjects with sitting height of up to 92.7 (say 92.5) cm. This would be possible with a thinner seat headrest cushion of about 1.5 to 2.0 cm thickness, as well. Reduction in thickness of the cushion would permit aircrew within acceptable SH range to raise their seat position higher to have enhanced over-the-nose vision. Such a modification would also diminish any remote chances of head/ neck injury due to encapsulation of aircrew with borderline sitting height in actual ejection. It is hoped that these benefits would result in a substantial improvement in the perception of safety during ejection in the minds of all aircrew flying this aircraft.

The case study of the recent safe ejection in an aircrew and his subsequent encapsulation trials at various seat positions suggests that encapsulation during actual ejection may well be safely possible for aircrew who complain of intolerable pressure during the procedure on ground. During actual ejection, the seat is propelled upwards with an acceleration of approximately 15 to 20 G for short durations. This creates an inertial force of the same magnitude in the head-to-foot direction (the +Gz axis). With this force it can be expected that the dorsal spine would flex at the level of the manubrium sternii, the neck may also flex and the parachute is likely to get further compressed to a small extent. Further, during ejection, the included angle between the line of thrust of the seat and the spinal axis results in spinal compression coupled with severe flexion [7]. It is because of these reasons that clearances available for a safe encapsulation during actual ejection are likely to be more than during a simulation of encapsulation on ground.

Conclusion

The increase in SH of subjects wearing the LWIH was found to be less as compared to the old ZSH 3 helmets. Minor differences in addition to SH due to different types of helmets did not alter possibility-of clearing/ failing encapsulation trials. In the MiG 21 T-77 aircraft, there is appreciable \ariation in aircrew-aircraft compatibility for aircrew with borderline sitting height. This is due to aircraft factors that include variations in cockpit geometry and variable curvature of metallic plates on top of the seats. This variation is also due to human factors including differences in torso muscle mass. These differences are responsible for some aircrew (within acceptable SH limits) to fail the encapsulation trials.

There is a definite subjective element in quantifying tolerable pressure on the helmet during encapsulation on ground. The interpretation of results of the encapsulation trials cannot therefore be fully standardised.

The thick seat headrest cushion is responsible for a mismatch between the curvature of the curved metallic plate and the top surface of the helmet. This brings the tip of the plate into contact with the helmet during encapsulation and is the prime reason for aircrew with borderline sitting height to fail the encapsulation trial. Removal of the seat headrest cushion corrects the problem of mismatch between the curvature of the curved metallic plate and the top surface of the helmet and permits aircrew with sitting height up to 92.5 cm to be encapsulated comfortably. This will also permit aircrew to raise the seat higher for better over-the-nose vision, while ensuring safety during ejection. The authors are convinced that it is not too late to modify the seat head rest cushion of the MiG 21 T-77 aircraft.

Dynamics of encapsulation during actual ejection are very different from encapsulation on ground. Aircrew who are unable to tolerate downward pressure of the metallic plate on helmet during encapsulation on ground may nevertheless have safe encapsulation during actual ejection. This aspect needs to be highlighted to all aircrew and supervisors operating this aircraft.

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