

RAPID DECOMPRESSION IN A SUPERSONIC TRAINER AIRCRAFT (A CASE REPORT)

By

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Introduction

A sudden loss of cabin pressurization in a pressurized aircraft may have serious consequences. One such case of sudden failure of cabin pressure in a supersonic trainer aircraft occurred recently at one of the fighter bases of the I.A.F. Eventhough the consequences of this accident were not serious in terms of injury to the pilots, the case has been discussed with a view to bring out the various aspects of such an episode.

Flight History

Two pilots experienced on the type of aircraft were carrying out an instrument profile sortie. The exercise was to climb upto 8 kms., engage reheat to achieve supersonic speeds and climb to 13 kms., do an I.A.F. pattern turn at 13 kms. and descend to base. The front cockpit pilot engaged reheat at 8 kms. at a speed of 850 km./hr. and starting climbing. At 11 kms. the speed 1.1 Mach and by 11.4 kms. it had increased to 1.15 Mach. At about this time both pilots heard a big explosion and saw that the front cockpit canopy of this tandem trainer had disintegrated and debris from canopy flew about like missiles striking the front seat pilot on his visor and bonedome. There was no misting. The R.T. Communication was very badly disrupted and both

the pilots felt as if they were talking into an empty void. One of them felt a sudden chilling effect. Both pilots switched on to 100% oxygen and made a rapid descent to 2 kms. The speed was reduced to 650 km./hr. Now they could hear one another. They made an uneventful landing. Just prior to the decompression the captain of the aircraft in the rear cockpit had read the cabin differential pressure at 0.26 kms./cm.² and the ambient altitude at about 11.4 kms. There was no loss of consciousness or giddiness in either pilot. There was no history of joint pains, sudden retro sternal chest pain, cough or dyspnoea. No tingling sensations in the skin, or any hyperaesthesia or anaesthesia of the skin were reported.

Flying Clothing Worn by the Two Pilots

Both pilots were wearing light weight flying overalls over their anti G suit, inner leather helmet and bone dome. The captain was wearing a fibre glass type bone dome while the front seat pilot was donning a light aluminium alloy bone dome. Both were having fully serviceable KM-32 masks. Both had their visors in the down position at the time of decompression.

Complete clinical examination of pilots after landing was carried out. No abnormalities were detected except small

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abrasions on the forehead of the front seat pilot.

Management

There were no symptoms or clinical manifestations of Decompression Sickness. However in view of the fact that the cabin had reached an altitude of 11.4 kms., both pilots were advised not to leave camp for 24 hours; not to fly for 48 hours and to report any untoward symptoms immediately to the Sqn. M.O. Both pilots were given a complete medical check in the evening of the day of the accident. No clinical abnormalities were detected. At the end of 48 hours their condition was reviewed clinically and as both pilots were asymptomatic they were cleared for flying.

Observations

The Cockpit: The aircraft was a high performance tandem trainer. The cockpits are separated by a glass partition. The canopies are also separate. The cabin pressurization however is from a common source. The decompression occurred as a result of shattering of the front canopy. It appeared that the canopy had been ripped off its framework by a giant force. The wind shield was undamaged. The glass partition between the two cockpits was completely lost on the right side while on the left side, a little bit was still left behind. The rear canopy remained intact. The instruments in both cockpits remained functional through out. A few small pieces of the shattered plexiglass of the front canopy were found on the floor of both cockpits. The instrument flying cockpit hood was torn into pieces on its superior surface. It was in use at the time of the accident.

Cabin Pressurization

In this aircraft cabin pressurization starts from an ambient altitude of 2 kms.

and builds up to a maximum pressure differential of 0.3 kg./cm.² at a height of 10 kms. after which it is maintained at this pressure differential. Being pressurized by a common unit and duct, if one cockpit loses its pressurization the other also automatically gets depressurized. In this particular case just prior to the accident, the captain of the aircraft read the cabin to ambient pressure differential at 0.26 kg./cm.² (3.3 PSI). After decompression, the cabin reached an altitude of 11.4 kms. (37,400 ft.), where the atmospheric pressure is about 160 mm. Hg (3.2 PSI). It is important to take note of the cabin attitude after decompression at supersonic speeds as the cabin pressure drops below the ambient because of the venturi effect created by the supersonic slip stream flowing over the exposed cockpit. This effect would act as a suction, lowering the cabin pressure to a level somewhat below that of the ambient.

From the pressurization pattern it was seen that the ambient altitude corresponding to a pressure differential of 0.26 kg./sq. cm. (3.3 PSI) is 9 km., where the pressure is 3.9 PSI. Therefore it may be concluded that the cabin pressure was 3.3+3.9 (7.2 PSI) corresponding to an altitude of 18,000 ft. Hence during the rapid decompression the cabin altitude changed from 18,000 ft. to 37,400 ft.

Physical Aspects of the Decompression

Both pilots heard a loud bang. This was due to the sudden decompression and is a well-known and established effect. However, both say that there was no misting possibly because the cabin air was dry or perhaps that in the sudden shock of having undergone a decompression the pilots failed to notice misting which took place but which was whipped away by the slip stream.

Both pilots were at the time of the accident concentrating on flying. None was talking and hence neither had difficulty in passing out the gases contained in their lungs.

Injuries to the Pilots

The front cockpit pilot suffered from a mild abrasion of his right maxillary region. This was due to small pieces chipped off from the visor in the down position, by the impact of flying pieces of the shattered canopy. Some pieces also struck the frontal region of his bone dome producing a small dent as well as a distortion of the anterior rim of the bone dome. It may be emphasized that the pilot was definitely saved by the bone dome and the visor in the 'down position' from grievous injury. The rear cockpit pilot did not suffer from any external injury. The partition between the two cockpits was shattered by the impact of flying canopy debris from the front canopy. This established a direct connection between the two cockpits. However it may be said that decompression of the rear cockpit occurred slower than the front one.

Time for Decompression

The time for decompression of either cockpit could be calculated using Fleigner's equation:

$$t = \frac{Vc \times 0.22}{A} \times \sqrt{\frac{Pc - Pa}{Pa}}$$

t = Time taken for decompression to occur in seconds.

Vc = Volume of the cabin in cubic feet.

A = Area of leak orifice in square inches.

Pc = Cabin pressure.

Pa = Ambient pressure.

The volumes of the front and the rear cockpit in this aircraft are approximately equal. The cockpit volume was calculated and found to be 63.3 cubic feet.

Area of orifice was taken as the area over which the canopy framework rests and for the front cockpit it was calculated to be 1140 sq. inches. However due to a partially jagged leak orifice the effective area for leakage of cockpit air was approximately taken as 70% of 1140 sq. inches (998 sq. inches).

The decompression in the rear cockpit occurred through the broken glass partition in between the two cockpits. The total area of this partition is 12.5 inches \times 15 inches but the total effective area for escape of the cabin air was taken to 80% of 12.5 \times 15 sq. inches.

Based on these observations:

t for front cockpit

$$t = \frac{0.22 \times 63.3}{998} \times \frac{7.2 - 3.2}{3.2}$$

$$= 0.016 \text{ sec.}$$

t for rear cockpit in seconds

$$t = \frac{0.22 \times 63.3}{150} \times \frac{7.2 - 3.2}{3.2}$$

$$= 0.104 \text{ sec.}$$

Pressurization: Safe or Unsafe

The cabin altitude just prior to the Rapid Decompression was about 18,000 (7.2 PSI). The atmospheric pressure at the final altitude was 3.2 PSI (37,400 ft.).

For ensuring absolute safety in an explosive decompression Violette² has suggested that the pressure ratio P_c/P_a should not exceed a maximum permissible value worked out on the basis of decompression co-efficient V/A where V is in cubic metres and A in sq. metres. A curve is given by him where maximum permissible pressure ratios are plotted against various values of decompression co-efficient.

In the case of rapid decompression of the front cockpit the decompression coefficient is 2.8 and maximum permissible pressure ratio is 2.4 which is more than the pressure ratio of 2.4 experienced in the decompression. For the rear cockpit V/A is 19.0 and maximum pressure ratio is 3.2, the actual pressure ratio being 2.3. Thus the decompressions were safe.

Decompression Sickness

The critical altitude for the appearance of decompression sickness is about 25,000 ft. Both pilots were exposed to an altitude of 37,400 ft. However either pilot was asymptomatic as far as the various symptoms of decompression sickness are concerned because they descended to safe altitude rapidly, the time of stay at 37,400 ft. was less than 2 minutes. However, after landing the pilots were kept under strict observation for 24 hours for appearance of delayed symptoms of decompression sickness and were kept off flying for 48 hours as re-exposure to decompression within this time increases the susceptibility of an individual to decompression sickness.

References

1. Fryer, D. I.: Failure of the Pressure Cabin—Text Book of Aviation Physiology. Ed. J. A. Gillies, 1965.
2. Violette, F.: Theses. Faculty des Sciences de l'Universite' de Paris, 1955.

Hypoxia

Hypoxia is another possible effect of rapid decompression. In the case under discussion, however, the altitude reached was 37,400 ft. and hence pressure breathing was not resorted to. However the front cockpit pilot gave himself bursts of pressure breathing at 200 mm. of water pressure as a safety measure. This was considered unnecessary. The aircraft is equipped with a dilutor demand automatic pressure breathing regulator and thus both pilots automatically received 100% O_2 on being decompressed. Both had switched on to 100% oxygen after the emergency and continued this until after landing safely. Hypoxia therefore did not occur at any stage.

Blast Effects

The aircraft was flying at a speed of 1.15 Mach at the time of decompression. The true air speed of flight was 1040 kph. High air speeds give rise to large values of 'Q' forces which are hazardous. The injury threshold is laid down as a blast force of 4.7 PSI corresponding to 450 knots at sea level. Taking the lower value of air density at flight altitude in this case into consideration, the equivalent air speed was only 375 knots which was less than the injury threshold. Further, the pilots were well protected by the wind shield. Clinical examination did not reveal any petechial haemorrhages at the shoulder, the front of the face and the trunk to suggest exposure to 'Q' forces. There were no avulsion sprains of the upper limbs. Hence the pilots did not suffer any wind blast or wind shear effects.