Pol J Aviat Med Psychol 2014; 20(2): 37-42
DOI: 10.13174/pjamp.20.02.2014.4

TECHNICAL NOTE

PILOT'S PANEL AS A TECHNICAL TEACHING AID IN AVIATION MEDICINE

Mirosław DEREŃ, Marcin PIOTROWSKI, Paweł POMASKI, Andrzej JAROSZ
Military Institute of Aviation Medicine, Warsaw, Poland

Source of support: Own sources

Author's address: M. Dereń, Military Institute of Aviation Medicine, Scientific and Didactic Centre, 54/56 Krasińskiego Street, 01-755 Warsaw, Poland, mderen@wiml.waw.pl

Introduction: Technical protection measures for airborne personnel in reduced pressure conditions are always prone to damage or failure. In such cases, the level of training and the ability to cope with the conditions of altitude hypoxia potentially presenting direct threat to human life are of key importance for safety and operational efficacy of pilots. Training in simulated conditions may increase the safety of trainees, albeit not guarantee it. Therefore, training methods should be continuously improved, especially in the field of safety and reliability of operation of flight simulators as well as the reliability of procedures.

Methods: In order to increase their awareness under the influence of hypoxic conditions, a switching module was designed to facilitate the change in the source of gas provided for respiration to trainees exposed to reduced atmospheric pressure in a low-pressure chamber. The article describes the design and operation of the pilot's panel module installed in each training station within the low-pressure chamber.

Conclusions: The solution met the technical assumptions. The functionality of the manual switching module will be maintained in the future automatic gas-switching system within the respiratory installation.

Keywords: pilots, hipoxia, low-pressure chamber, aviation medicine

Figure: 9 • **References:** 2 • **Full-text PDF:** http://www.pjamp.com • **Copyright** © 2014 Polish Aviation Medicine Society, ul. Krasińskiego 54/56, 01-755 Warsaw, license WIML • **Indexation:** Index Copernicus, Polish Ministry of Science and Higher Education

INTRODUCTION

The crews of modern combat aircraft face new challenges associated with dynamic changes of flight conditions and operation of complex pilot equipment. Correct performance of flight tasks in changing conditions requires the crews to guarantee high level of psychophysical efficiency. Therefore, in order to make effective and safe use of modern aircraft, the airborne personnel must undergo a highly specialized and comprehensive training. The training should lead to increase efficiency of performance of airborne tasks and, most importantly, to increase tolerance of the airborne personnel to the physical flight-related factors.

Due to these requirements, specific for airborne work, appropriate training regimen was imposed onto airborne personnel and paratroopers. Apart from theoretical preparation involving up-to-date knowledge in aviation medicine, airborne personnel and paratroopers underwent a practical training of coping with potential threats that may occur at high altitudes.

The acquired and fixed awareness of psychophysical consequences of danger situations allows to counteract rationally the adverse consequences thereof.

Altitude hypoxia is a condition involving internal disorders resulting from the deficiency of oxygen in cells due to reduced partial pressure of oxygen in the atmosphere [1]. Hypoxia may result in reduced abilities of critical assessment, perception, attention, gradual increase in the respiratory and heart rate, increased muscular agitation or even cramps of smooth or striated muscles.

The ability of airborne personnel to identify symptoms of hypoxia increases the likelihood of preventing its consequences in cases of emergency, e.g. oxygen apparatus failure.

Trainings in low-pressure chambers (LPC) allow the airborne personnel to e.g. identify their own, individual signs and symptoms of hypoxia in a controlled and safe situation. Individuals are able to experience how their bodies react to hypoxia (reactions vary depending on age, physical fitness and individual traits).

Symptoms of hypoxia are classified into objective, i.e. observed by the supervisor of the altitude exposure, and subjective, i.e. perceived by the trainees themselves. For airborne personnel members, the most important symptoms are those that can be experienced and identified by themselves and, subsequently, compared with the symptoms identified during the LPC simulation training. The subjective symptoms include e.g. the perception of the lack of air, anxiety, headache, dizziness, fatigue, disturbed vision, euphoria. LPC training allows not only paying passive attention to one's own perception, but also to evaluate other phenomena that enable the assessment of hypoxia, e.g. color vision and contrast sensitivity disturbances.

In case of aircraft crew training, demonstration of the altitude hypoxia is carried out in conditions corresponding to the altitude of 7 500 m asl (ca. 280 mmHg) and is provided to each trainee [2].

In case of paratroopers performing tasks at altitudes of more than 4000 m asl (HALO/HAHO jumps), the LPC simulation profile corresponds to the altitude of 10 000 m asl (ca. 180 mm Hg).

Various flight conditions are simulated within the LPC depending on particular tasks carried out

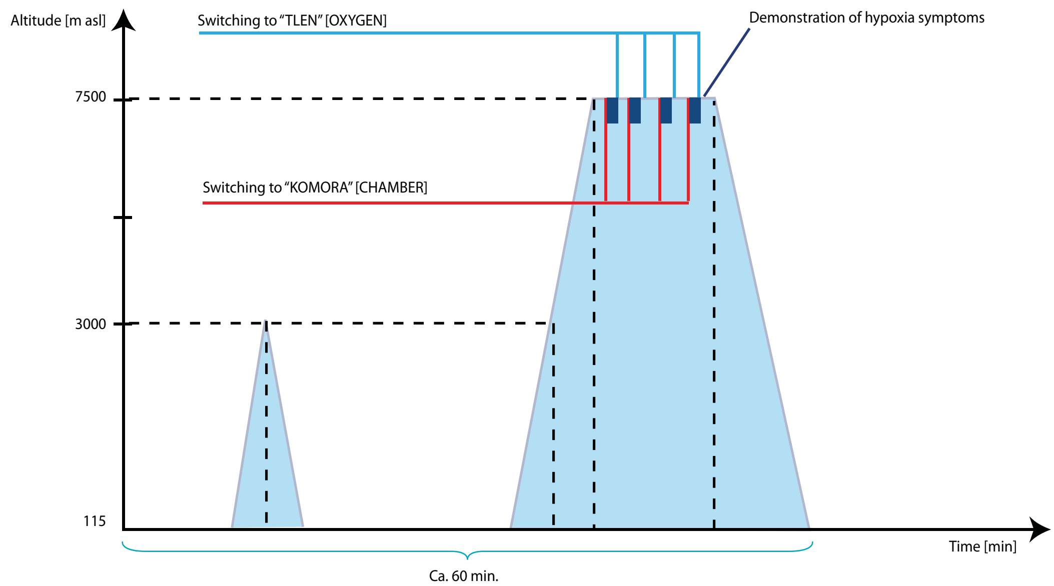

Fig. 1. An example low-pressure chamber exposure profile.

by the airborne personnel. An example simulation profile is presented in Fig. 1.

The exemplary training involves:

a) assessment of barofunction (the efficiency of pressure equilibration in the anatomical body cavities);
b) determination of nitrogen desaturation half-time (respiration with 100% oxygen – altitude and time depending on the profile);
c) demonstration of altitude hypoxia symptoms (4-minute cycles of breathing the chamber air);

The training including hypoxia-related phenomena requires a change in the trainee's respiration conditions consisting in a change in the source of gas (oxygen or air) provided to the pilot's mask. The source of oxygen is the chamber's oxygen system fitted with inhaler ports.

Formerly, during demonstration of altitude hypoxia the air was drawn in from the internal space of the chamber. The change in the gas source (oxygen to air) required the mask being disconnected from the inhaler port (Fig. 2. and 3.), and left unconnected (training phase: Fig. 1 here: "Switch to CHAMBER". The change from the air to the oxygen required the mask being reconnected to the inhaler port (training phase: Fig. 1. here: "Switch to OXYGEN").

METHODS

Before pilot panels were installed in low-pressure chamber, gas sources had been switched by a trainee or the instructor within the chamber using connector (Fig.3.) of the mask and the LPC oxygen system. Switching was time-consuming and tedious (connectors have non-ergonomical shapes and their springs require using much strength). In case of stress due to e.g. fainting of a trainee, the switching was burdened with a risk of delay in oxygen delivery.

Therefore, design and execution of pilot's panel was the first step taken on to introduce a technical solution facilitating fast switching of the source of gas provided for respiration to a trainee within the low-pressure chamber. A pilot's panel was designed and developed at the Military Institute of Aviation Medicine (Fig. 4.). The pilot's panel maintaining a fixed connection of the pilot's mask and the chamber's oxygen system enables convenient switching of the source of gas provided to the mask.

The main role of the panel is to allow switching between the alternate sources of oxygen or chamber air without tedious disconnection of gas tubing connectors. The gas source is switched using a manually-controlled three-way switching valve.

The panel was designed for placement on the left side of the pilot's chair within the LPC (Fig. 5.).

Fig. 2. LPC oxygen system fitting.

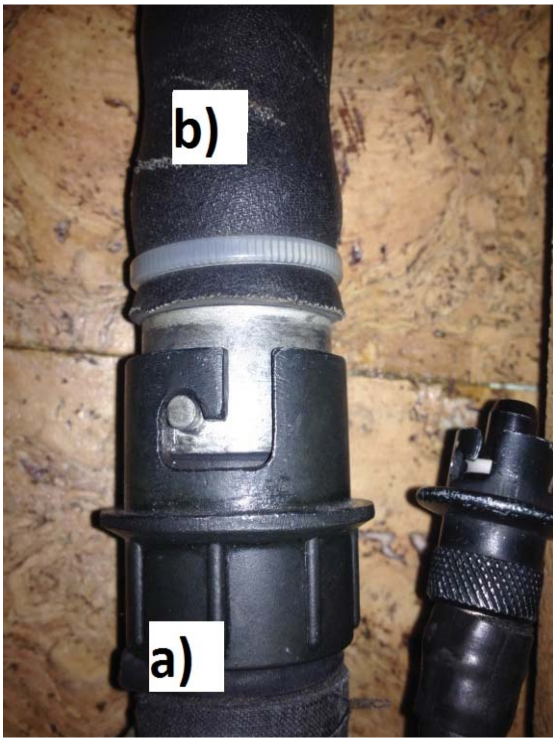

Fig. 3. Connection of the mask (a) and the LPC oxygen system (b).

Design

The main element of the pilot's panel (Fig. 4.) is a metal case allowing installation of the panel in the LPC pilot's chair. Inside the case, there is a three-way valve with a knob on the front side of the panel. The top side of the panel (Fig. 6.) also features a connection for bidirectional electrical communication as well as the guide bushing for the inhalation tubing connected to the three-way valve. The tubing ends with a pilot's mask connector. The bottom part of the panel case is open (Fig. 4.) allowing for free movements of the inhalation tubing connected to the pilot's mask. The back side of the panel features an open bushing for the inhalation tubing connecting the three-way valve with an inhaler installed within the LPC. A rating plate with panel ID number is placed on the back side of the case.

The dimensions of the panel (excluding fixation elements) are 250 x 200 x 85 mm.

The weight of the panel (with inhalation tubing connected) is 3.5 kg.

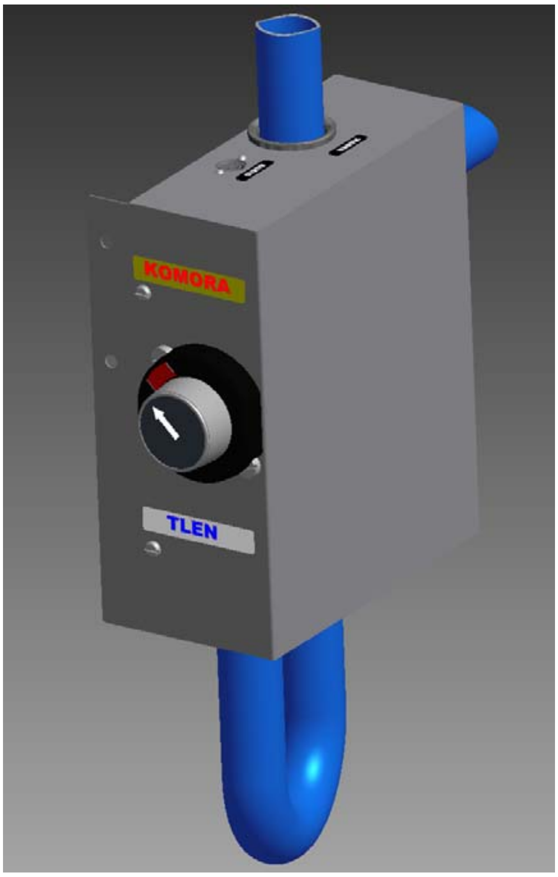

Fig. 4. Pilot's panel overview.
(symbols: KOMORA = CHAMBER, TLEN = OXYGEN)

Three-way valve

The panel features an AFRISO ARV 384 three-way valve in a switching setup. The valve body is fitted with three connector ports (Fig. 7.). Two ports are fitted with spiral inhalation tubing, one featuring the pilot's mask connector, the other connected to the inhaler. The third port for collection of air from the chamber is fitted with a metal mesh filter preventing the gas system from contamination.

The outer side of the panel features the valve knob (Fig. 8.) with an indicator ring and a disc. The knob is connected to the disc. After the knob is turned, a window within the disc reveals one of the indicator fields that provide information on the valve operation mode. Colored fields, white and red, are distributed on the indicator ring between the indicator disc and the front panel. Color LEDs are placed at the edges of the colored indicator fields: blue diodes on white fields and red diodes on red fields The valve knob features a graphical indicator in the form of an arrow pointing towards the indicator disc. After turning the knob into extreme positions, the arrow is points towards written messages indicating the current mode of operation: "TLEN" [OXYGEN] or "KOMORA" [CHAMBER].

Fig. 5. Installation of the pilot's panel.
(symbols: KOMORA = CHAMBER, TLEN = OXYGEN)

Fig. 6. Pilot's panel. Top view: 1 – open bushing; 2 – guide bushing; 3 – bidirectional communication connector; 4 – indicator ring; 5 – indicator disc; 6 – knob.

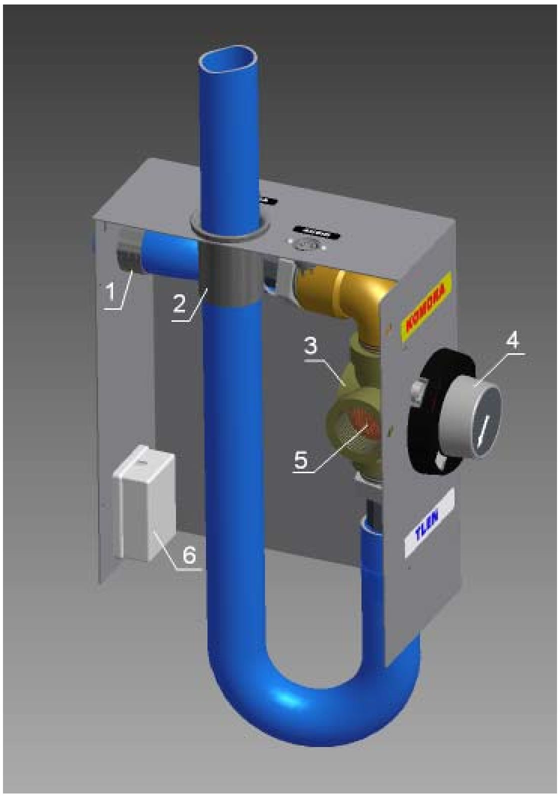

Fig. 7. The interior of the pilot's panel 1 – open bushing (inhaler tubing); 2 – guide bushing (mask tubing); 3 – three-way valve; 4 – knob; 5 – filter; 6 – block connector.

Inhalation tubing

The pilot's panel features flexible, spiral silicone tubing. The tubing is used to connect the three-way valve to the inhaler and a pilot's mask. The inhalation tubing connecting the three-way valve with the pilot's mask goes out of the panel via the guide bushing located on the top side of the panel, labeled "MASKA" [MASK]. Free-hanging under the top side of the panel, the inhalation tubing may be drawn out of the panel to a length facilitating connection to the pilot's mask and convenient use. The connector at the end of the inhalation tube fits the pilots' mask of the MiG-29 aircraft. The pilot's panel kit features a mask connector adapter (Fig. 9.) for the pilots' masks of the F-16 aircraft.

Electrical connections within the pilot's panel

The electrical circuit of the pilot's panel consists of the bidirectional communication path and valve operation indicator diode power pathway. The electrical system within the panel is wired using a spiral multicore cable.

Bidirectional communication socket is installed on the top side of the panel (Fig. 6.) and labeled as "AUDIO". The socket is used for connecting, either directly or via an additional adapter, the personal bidirectional communication system. The pilot's panel kit features two types of adapters for the "AUDIO" connector. They facilitate connection of personal bidirectional communication systems featuring connectors typical for MiG-29 or F-16 aircraft.

Panel operation

The pilot's panel plays a dual purpose.

The first purpose is to switch the source of gas (gas mixture) delivered to the pilot's inhalation mask in reduced pressure conditions within the LPC.

Connecting the pilot's mask consists in:

– directly connecting the pilot's mask to the inhalation tubing connector (MiG-29 aircraft-type mask), or
– connecting the pilot's mask to the inhalation tubing connector via an adapter (F-16 aircraft-type mask) (Fig. 6.).
– selecting the appropriate valve operation mode using the knob.

During the exposure to reduced pressure, the subject (e.g. the pilot) breathes the oxygen delivered from the inhaler to the pilot's mask via the inhalation tubing and the three-way switching valve. The valve knob is set to "TLEN" [OXYGEN]. The indicator disc window reveals the white field of the indicator ring with blue light-emitting diodes. During the demonstration of altitude hypoxia, the pilot's mask is disconnected from the oxygen flow and switched to the air at reduced pressure within the low-pressure chamber. To this end, the instructor present within the chamber turns the valve knob clockwise by 90 degrees to the „KOMORA" [CHAMBER] position. The indicator disc covers the white field of the ring and the blue light-emitting diodes while revealing the red field and red-light emitting diodes. After the demonstration of altitude hypoxia or in emergency, the instructor reopens the oxygen flow by turning the valve knob counterclockwise by 90 degrees back to the "TLEN" [OXYGEN] position. The indicator disc covers the red field of the ring and red-light

Fig. 8. Indicator of the mode of operation of the three-way valve within the pilot's panel.

emitting diodes while revealing the white field and blue light-emitting diodes. The switch is made correctly when the knob is turned by 90 degrees and the light emitting diodes are revealed.

The other purpose of the panel is to facilitate a connection of two types of personal bidirectional communication kits to the bidirectional communication system of the LPC.

Connection of the communication system consists in:

- directly placing a personal bidirectional communication kit plug in the communication socket (AUDIO); or

Fig. 9. Mask connector adapter.

- placing a personal bidirectional communication kit plug in the communication socket (AUDIO) via an appropriate adapter.

CONCLUSIONS

The pilot's panel installed in the LPC meets its purpose and is an important step in the development of research, educational and training activities for airborne personnel of the Polish Armed Forces. The multipurpose character of bidirectional communication facilitates the use of communication elements used in civil aviation.

The design solution started development of the oxygen delivery system and pilot's mask gas supply system to a version controlled using an electrical circuit by an operator outside the LPC. Future expansion may include a use of computer-controlled actuator systems with current solutions being retained for cases requiring an emergency delivery of oxygen.

AUTHORS' DECLARATION:

Study Design: Mirosław Dereń, Marcin Piotrowski, Paweł Pomaski, Andrzej Jarosz; **Data Collection:** Mirosław Dereń, Marcin Piotrowski, Paweł Pomaski, Andrzej Jarosz; **Manuscript Preparation:** Mirosław Dereń, Marcin Piotrowski, Paweł Pomaski, Andrzej Jarosz; **Funds Collection:** Mirosław Dereń, Marcin Piotrowski, Paweł Pomaski, Andrzej Jarosz. The Authors declare that there is no conflict of interest.

REFERENCES

1. Golec L. Niedotlenienie wysokościowe: badania stopnia oporności (czas rezerwowy), badania w KNC, nadciśnienie oddechowe, programy badań [Altitude hypoxia: assessment of resistance (hypoxic reserve time), low pressure chamber tests, respiratory hypertension, testing programs] Warsaw: WIML; 1998.
2. Program Szkolenia Specjalistycznego w Zakresie Medycyny Lotniczej Personelu Latającego Sił Zbrojnych RP [Curriculum of Specialist Training in Aviation Medicine for the Airborne Personnel of Polish Armed Forces], Warsaw: WIML; 2008.

Cite this article as: Dereń M, Piotrowski M, Pomaski P, Jarosz A: Pilot's Panel as a Technical Teaching Aid in Aviation Medicine. Pol J Aviat Med Psychol 2014; 20(2): 37-42. DOI: 10.13174/pjamp.20.02.2014.4