MODERN OXYGEN AND ANTI-G PROTECTION FOR THE PILOT OF ADVANCED FIGHTER AIRCRAFT SAAB JAS 39

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A new oxygen and anti-g regulation system has been designed by INTERTECHNIQUE - EROS under SAAB specifications.

It meets the following requirements :

1) Providing High Altitude breathing protection and decompression protection.

2) Providing improved Anti-G protection thanks to the use of a high performance anti-g valve and in addition, manually selectable, Assisted Positive Pressure Breathing (APPB). That is pressure breathing as a function of g-loads.

3) Using a gaseous oxygen supply for the regulator and for the g-valve.

4) Providing an electronic warning monitor for the breathing function and eventually in the future for the anti-g function.

Therefore, the JAS39 regulation system is using the most advanced pneumatic technology for its basic functions, but it also uses electronics only for surveillance purposes.

The use of pneumatic and electronic technology provides the highest level of performance and safety.

This paper will outline the new design features and the regulation part of this system.

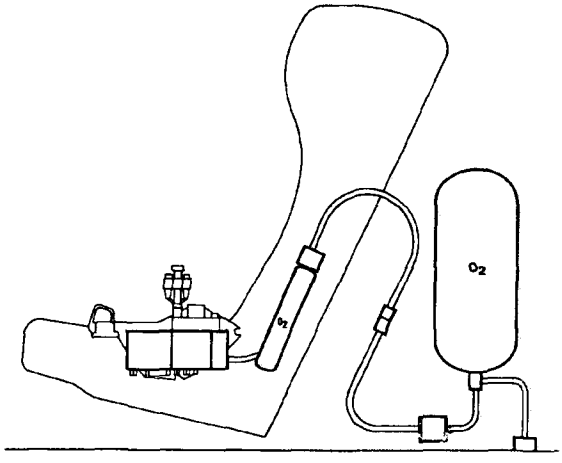

Fig. 1 Oxygen and Anti-g system with supply

DESCRIPTION

This system includes the following major elements (see figure 1) :

- an aircraft gaseous high pressure oxygen supply,
- a pressure reducer,
- an emergency oxygen source (seat mounted),
- an oxygen regulator,
- an anti-g valve,
- a connection module with P.E.C (Personal Equipment Connector) allowing connections of pneumatic and electrical lines between : regulator, anti-g valve, supply line and pilot equipment (see figures 2, 3 and 4). The telephone line is duplicated for redundance.

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MASS	
Emergency oxygen unit	1.055 kg
REGULATION PART Oxygen regulator : 0.560 Connection box : 0.465 Anti-g valve : 0.290 Mounting plate ; 0,455 Junction plate (PEC) : 0.380	2.150 Kg
Total (seat mounted)	3.205 kg

Figure 2 - Mass

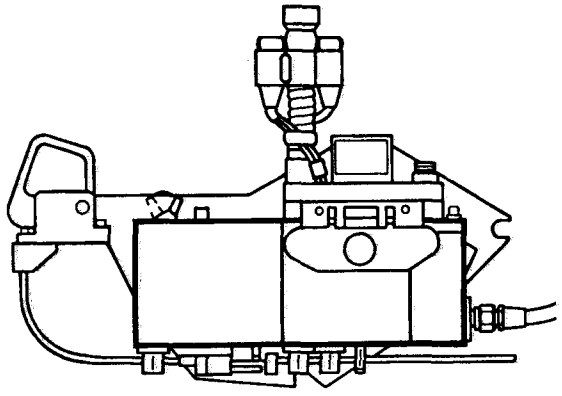

Figure 3 - Oxygen and anti-g regulation system - Seat mounted

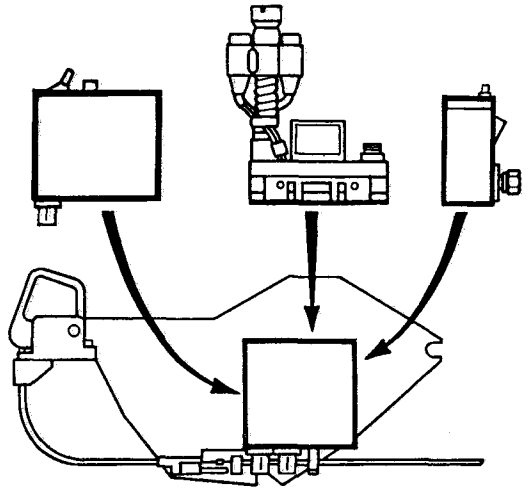

Figure 4 - Disassembly

THE OXYGEN REGULATOR

The oxygen regulator performs the following basic functions :

- delivery of diluted or pure oxygen on demand,
- delivery of pure oxygen at positive pressures,
- continuous flow emergency by-pass manually activated,
- press-to-test for pre-flight check,
- anti-suffocation valve in case of complete loss of oxygen supply,
- flow indication and failure monitoring,
- etc ...

The demand stage of the regulator is a close loop system which meters the gas flow to the user as a function of his breathing demand, in terms of mask negative pressure.

A pressure sensitive element reads this negative pressure and opens the main flow valve accordingly. In order to minimize the user's breathing workload, , this demand stage is a pneumatic amplifier which uses supply gas energy to activate the main flow valve.

This is the "pilot valve" technology which has been considerably improved by INTERTECHNIQUE - EROS.

In addition, the regulator outlet flow generates an open loop servo effect which partially compensates the pressure resistance of the downstream breathing line to the user (hose and mask) (see figure 5).

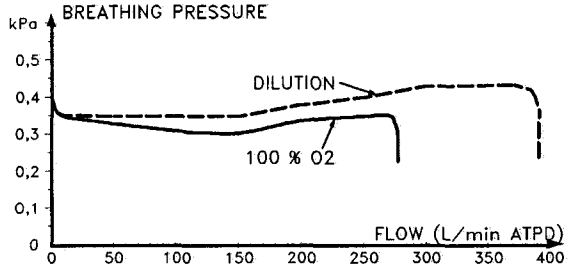

Figure 5 - Demand curve measured at ground level and at chest connector outlet

The maximum ambient flow delivered by the regulator increases with altitude as a result of cabin pressure decrease (see following curves on figure 6).

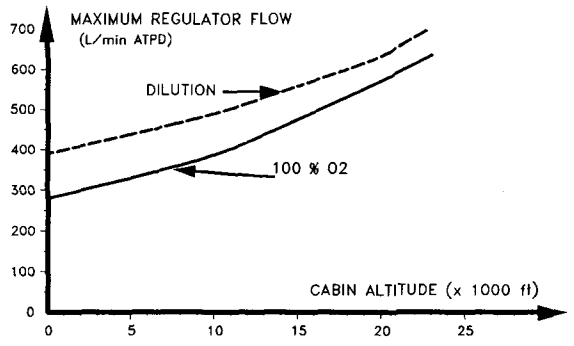

Figure 6 - Regulator flow versus cabin altitude

Thanks to the regulator high flow performance, the pilot can more easily practice the M1 manoeuvre for improving his g resistance. It also allows for pilot equipment (mask, chest bladder) to be more quickly and efficiently pressurized by the APPB at high g loads.

EMERGENCY FUNCTIONS

The different emergency cases covered by the system are :

- loss of oxygen main supply,
- regulator no flow failure,
- cockpit decompression,
- seat ejection,
- crash case.

The two first points are covered by what is described on figure 7.

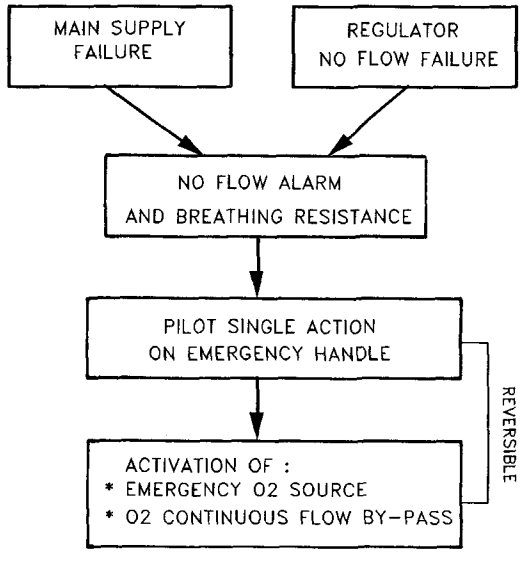

Figure 7 - Emergency functions

Cockpit decompression is covered by classic pressure breathing versus altitude.

Seat ejection involves automatic emergency oxygen, automatic decompression protection at High Altitude and automatic junction plate disconnect.

Crash case - oxygen supply is automatically closed in case of manual junction plate disconnect to reduce risk of fire at possible crash landing.

ANTI-G FUNCTION

The g-valve has been designed in order to meet two objectives : technically, to work with an oxygen supply and physiologically to provide the best protection to the high performance fighter aircraft pilot.

The use of oxygen supply for g-valves provides two major advantages : the oxygen pressure is stable and the oxygen is clean.

The considered g-valve is a pilot operated valve with high flow capacity and rapid response.

The high technology level of this g-valve can be demonstrated by the comparison of his g-sensing element weight 6 grams instead of 250 grams for well known existing g-valves. The weight of the complete g-valve is only 290 grams.

INTERTECHNIQUE - EROS has already 20 years experience on miniature g-valves and still develops further versions like the "hybrid" valve. This valve works with engine bleed air for the main flow and with MSOC gas product for the control side of the valve.

The demonstrated performance of our g-valves is equal or better than that of the best electronically controlled g-valves which are larger, heavier more complicated and expensive, and still at a prototype stage.

The following figure 8 shows the response of the anti-g valve under a 6 G per second ONSET, which is not the highest onset that the valve can match.

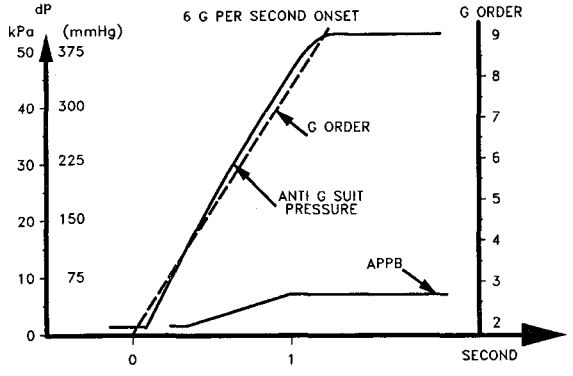

Figure 8 - APPB and g-suit pressure measured on two rigid capacities of 10 liters each.

This test was performed at ground level on 2 rigid 10 liter capacities. One can see that anti-g suit pressure starts with 50 milliseconds time delay then it overshoots slightly from 4 g up to 9 g. It also shows the APPB response starting at 4 g up to a maximum value at 9 g without significant time delay.

A real time delay of only 0.5 second can be expected with good g-pants and chest bladder.

Measurements made in similar conditions on a centrifuge with French personal garments have shown g-valve time delays of approximately 0.2 second.

Good performance of anti-g valve is also demonstrated by flight tests in Sweden.

INTERACTIVE G-VALVE OXYGEN REGULATOR

The SAAB JAS 39 is the first aircraft to be fitted in production with an interactive regulation g-valve system which was first developed by INTERTECHNIQUE - EROS.

The g-suit was then the 3rd part of the 3 piece partial pressure suit designed for high altitude protection (up to 65.000 ft) such as the French INTERTECHNIQUE - EROS VHA90 suit. The same type of partial pressure suit is well adapted to the use of APPB and provides excellent tolerance to high Gz loads and high G ONSET.

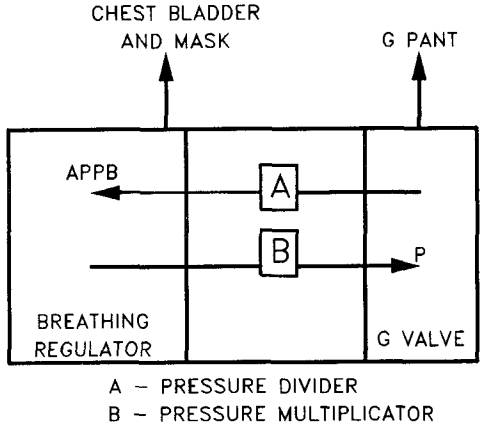

Figure 9 - Oxygen regulation and G-valve discussion (IN patent)

The INTERTECHNIQUE - EROS g-valve regulator interactive system works two ways as shown on figure 9 :

1) From the oxygen regulator to the g-valve : the g-valve is made sensitive to PPB and inflates the g-suit at the same pressure as PPB, that is the same pressure as in mask and pressure compensating vest.

   In other similar systems, the same g-valve can pressurize the g-suit at a different pressure ratio (3 to 4 times PPB), through a pressure multiplier.

   The connecting line is so designed that it prevents any return of information from the g-valve to the regulator.

2) From the g-valve to the regulator : a second line makes the regulator sensitive to g-valve outlet pressure through a pressure divider which generates the requested APPB gradient. A manually selectable control gives the pilot the choice of APPB or not.

BREATHING ELECTRONIC WARNING MONITOR

Flow detection (instead of blinker) and failure monitoring functions have been designed for pilot information on his breathing system.

The flow sensor is an original development (patented). It uses a 2 level flow detector so as to eliminate false alarms. The low level threshold is set approximately at 3 LPM and the upper level threshold is set at 30 LPM.

The pilot is informed on the status of his breathing system through the audio-visual alarm system of the aircraft.

The alarm is "ON" only in case the system flow stays more than 20 seconds either below the low level (NO-FLOW ALARM) or above the upper level (FULL-FLOW ALARM) (see figure 10).

The advantage is to be able to use the system with a standard face mask or with a partial pressure suit and benefit of the warning monitor. In both cases, up to now, all tests including flight tests have confirmed the viability of the concept.

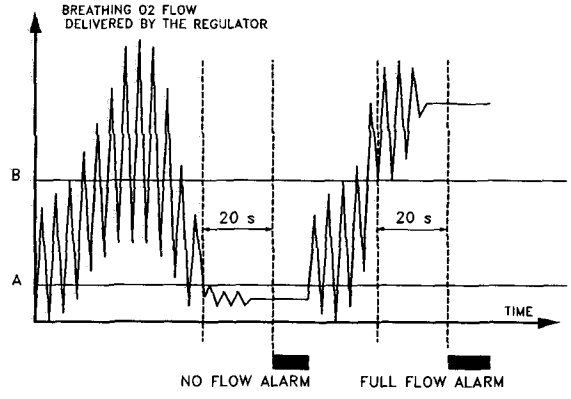

Figure 10 - Electronic survey - Breathing alarm system

ANTI-G ELECTRONIC SURVEILLANCE.

If we compare the consequences of hypoxic conditions and high g onset risks, time of usefull consciousness can be as long as one minute for hypoxia and is less than 5 seconds under high jolts. The breathing system works in the normal mode, has a warning monitor and an emergency system.

The anti-g system has only a single normal mode, even with the help of APPB. There is no emergency.

For these reasons there are two electronic warnings for the anti-g system when the following conditions appear :

- g-valve oxygen supply has decreased below 1.5 MPa.
- anti-g suit connection is disconnected.

On option, the following additional warning system is prossible (see figure 11).

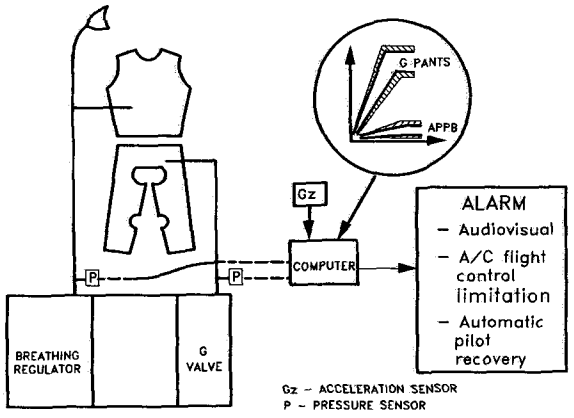

Figure 11 - Electronic survey - Anti-g failure alarm - (IN patent)

CONCLUSION

A new oxygen and anti-g system has been developed in order to meet the most stringent requirements for advanced fighter aircraft pilots in the field of high g protection set up by FMV and SAAB. (FMV = Defense Material Administration (DMA) of Sweden)

It only uses modern pneumatic technology for its vital parts and remains fully independent of the other aircraft systems, with the exception of its surveillance functions which uses electronics so as to be easily interconnected with the central surveillance system of the aircraft.

We wish to thank FMV and SAAB technicians for their active cooperation in the success of this design and for their confidence in our company.