Review Article

Suggested Indian Test schedule, to consolidate the process of type certification of oxygen mask, a vital component of integrated life support system for fighters

Wg Cdr Pankaj Tyagi* Dr Parvati Gopal# GP Capt G S Nayar$
Air Cmde A K Sengupta@ GP Capt Ranjit Kumar+

The MIL SPEC requirements to test an oxygen mask, for fighter crew were studied. Elaborate and expensive infrastructure arrangements required to conduct such tests have been brought out in this paper. Suggestions and justifications have been made to have an Indian Test Schedule with specific tests that could be conducted at the existing facilities, with slight modifications, thus creating an in house capability to type certify an oxygen mask for fighers, which is a vital component of integrated life support system (ILSS). A different approach, from the conventional mindset to test equipment against foreign test schedules, would be able to save foreign exchange and dependence on foreign labs, while maintaining high level of confidence required for such an equipment.

Keywords : Type certification process; test schedules, pressure demand breathing, oxygen mask, integrated life support system (ILSS).

The process of Type Certification, to introduce an item for in-flight use, is a parallel development to the indigenisation process. It aims at the assessment of the quality of the product being offered, by the manufacturing firm against the laid down specification. The responsibility for this, is shared by both the state and the industry, so that the best possible product goes in to the aircraft, as no room for compromise on the specifications exists in the aviation world. The ultimate aim of the process of type certification is to maintain a very high level of confidence of the user. Any failure in this process can ultimately affect the viability of the whole project, which in aviation carries a heavy cost, apart from the setback it can cause to the national prestige.

The whole process is highly technical, involving

* *Classified Specialist (Aviation Medicine), IAM, IAF, Vimanapura PO Bangalore-560 017*
# *Scientist 'E', IAM, IAF, Vimanpura, Bangalore - 560 017*
$ *Sr Adv (Av Med), IAM, IAF, Vimanapura, Bangalore-560 017*
@ *Commandant, IAM, IAF, VImanapura, Bangalore-560 017*
+ *Sr Adv (Av Med), DEBEL, Bangalore.*

Suggested Indian test schedule: Pankaj Tyagi et

number of specialists in diverse fields and need a number of Labs with a wide range of test facilities. Not only has each component, to pass the relevant tests, the product also needs to integrate with the aircraft system and prove itself to function at optimum level under various environmental and aviation stresses. In the advanced countries of the west the test facilities and certification process have evolved over the years, along with the increasing capabilities in R & D work to design and develop better products. Equal contribution, in consolidation of this process was made by the Military, by giving clear cut specifications to the defence ancillary industry, which responded to them by offering high quality product in time.

The Indian aviation industry, for the first time, is poised to venture into the type certification process of the components of the Integrated Life Support System (ILSS) for a fighter aircraft which includes Oxygen Concentrator, Partial Pressure of Oxygen Sensor, Oxygen Regulator, Anti - G valve, Helmet and an Oxygen mask. There is a need to have Indian Defence standards or the Military specifications like those of US, UK, France or Germany, as at present only the internationally available Mil-Specs, Def - standards are used as reference documents for the Indian process of Type Certification, on case to case basis. Naturally, the test and the methodology and to an extent the process of type certification is based on these reference documents. As a consequence the facility to conduct the specified tests have to be same as those existing in these advanced countries. This is as expensive a proposition as that of developing a new product. If the appropriate Test Facilities are not developed or upgraded as the product takes shape in stages and finally to perform as part of a subsystem, not only does the quality control becomes difficult and expensive but also, the valuable inputs to the manufacturer at different stages of development are thus denied. This adds to the cost in term of money and delays in terms of time, which crucial for military hardware.

In the field of Life Support System it important for us to take a different approach the whole process of type certification, upgrad our existing facilities to the extent possible i minimum time and most importantly lay dow Indian Mill-Standards & Specifications, to cove our national projects.

In this study we focused on the simplest bu a vital component of ILSS, the Oxygen Mask The USAF Military Specification MIL-M-8716 for pressure breathing oxygen mask, MBU - 12 P was analysed with the aim to identify the US requirements to type certify the Mask and to giv suggestions to do the same by indigenous means

United states Air Force Requirments

For Oxygen Mask MBU - 12/P to be introduced in flight, it has to meet successfully the requirements as laid down in MIL-SPEC-M 87163 approved by Department of Air Force [1, 2] The custodian of this document and its preparing activity is by Air Force 11, while the reviewer is Air Force 99. There is thus an early involvement of US AF, in the process of laying down the expectations from a new Mask.

The whole procedure of Type Certification is grouped in the following five parts :

Part - I

Defining Scope, Applicable documents & Requirements

The scope is defined to cover the

Table -1
Performance

Tensile bonding strength	To be greater than the tensile strength of the silicone rubber
Mask leakage	Not to exceed 100 milliters per minute
Combination valve installation, inlet performance (low suction)	The total leakage shall be 15 ml/mt.
Combination valve installation, inlet performance (high suction)	The total leakage shall be 150 ml/mt. or less
Combination valve installation, exhalation performance	A pressure of 20mm of Hg in the facepiece and a pressure between 15 and 19.9 mm of Hg in the inlet tubing to open exhalation portion of the valve.
Combination valve installation, exhalation resistance	Not to be greater than 4.67mm of Hg with a flow of 100 lit/mt.
Combination valve installation, inhalation resistance	Not to exceed 2.80mm of Hg at a flow of 50 liters and 5.60mm of mercury at a flow of 100 lt/mt.
Subjective use	Silicon rubber not to produce any objectionable odour, shall not be tacky, shall not have any property that cause discomfort or affect wearability. No freeze up of combination valve is acceptable.
Silicon Rubber Tear Resistance	Silicon rubber shall have a minimum Tear Resistance of 150 psi.
Hardness	Shore A Durometer hardness of the silicon rubber for the face piece shall be 45° 5.
Low Temperature brittle point	Minimum brittle point of silicon rubber shall be - 40° C.
Toxicity	Material used in Mask and combination valve shall not contain any chemical or material that have toxic properties even when cleaned with a mild dish washing solution.
Delivery tube leakage	No leak accepted up to internal pressure of 5 psi.
Delivery tube collapse	Corrugated portion shall not collapse up to a suction of 5 inches of Hg for 3 sec while the tube is restrained to specific length.
Delivery tube strength	Shall not tear or separate when specific stretch force is applied.
Microphone bracket-dielectric Strength	Microphone bracket shall withstand without flashover or breakdown, the application of 250 volts alternating potential of commercial line frequency.

Salt For Test	Microphone bracket shall meet the salt for requiremen
Colour	Colour of hardshell, webbing and all silicon rubber sho be green matching specified colour number.

requirements specific to one type of pressure breathing Mask designated as MBU-12/P. The applicable documents available to the manufacturer, include 11 related Federal Specification, 7 Military Specifications, 2 Federal Standards and 8 Military Standards. Copies of 16 Government Drawings specific to the mask are also made available to the manufacturer. The documents are listed in the Defence index of Specifications and Standards (DISS). American Society of Testing Materials (ASTM) also provides the Test document for tear resistance of vulcanised rubber. The Intended use of the oxygen mask is, specified as a dispensing gaseous oxygen from pressure demand regulators to aircrew members engaged in high altitude flying. The document draws the attention of the manufacturers, to have the products that they propose to offer to the Federal Government, tested for Qualification, to be awarded the contract. The whole process is transparent and the bids are open to all.

This above procedure highlights the importance of institutionalising the Standards, the Tests and the free availability of necessary documents to the manufacturer. India need to strengthen this area.

Part -II

Design and Construction

This part covers the main and subsidiary drawings, in accordance of which the mask and its components will be constructed. The weight of the mask is specified here which is not to be exceeded. The components included in the mask assembly are also listed in this section.

Part -III

Performance & workmanship

This part defines the limits of performance and quality of workmanship expec from a mask. The specific ranges of resu expected from mask MBU-12/P are given Table-1.

Part-IV

Qualification Testing Methods

This part defines the methods which ha to be followed to conduct the tests as listed Table 1, which would qualify the product, in t case the mask.

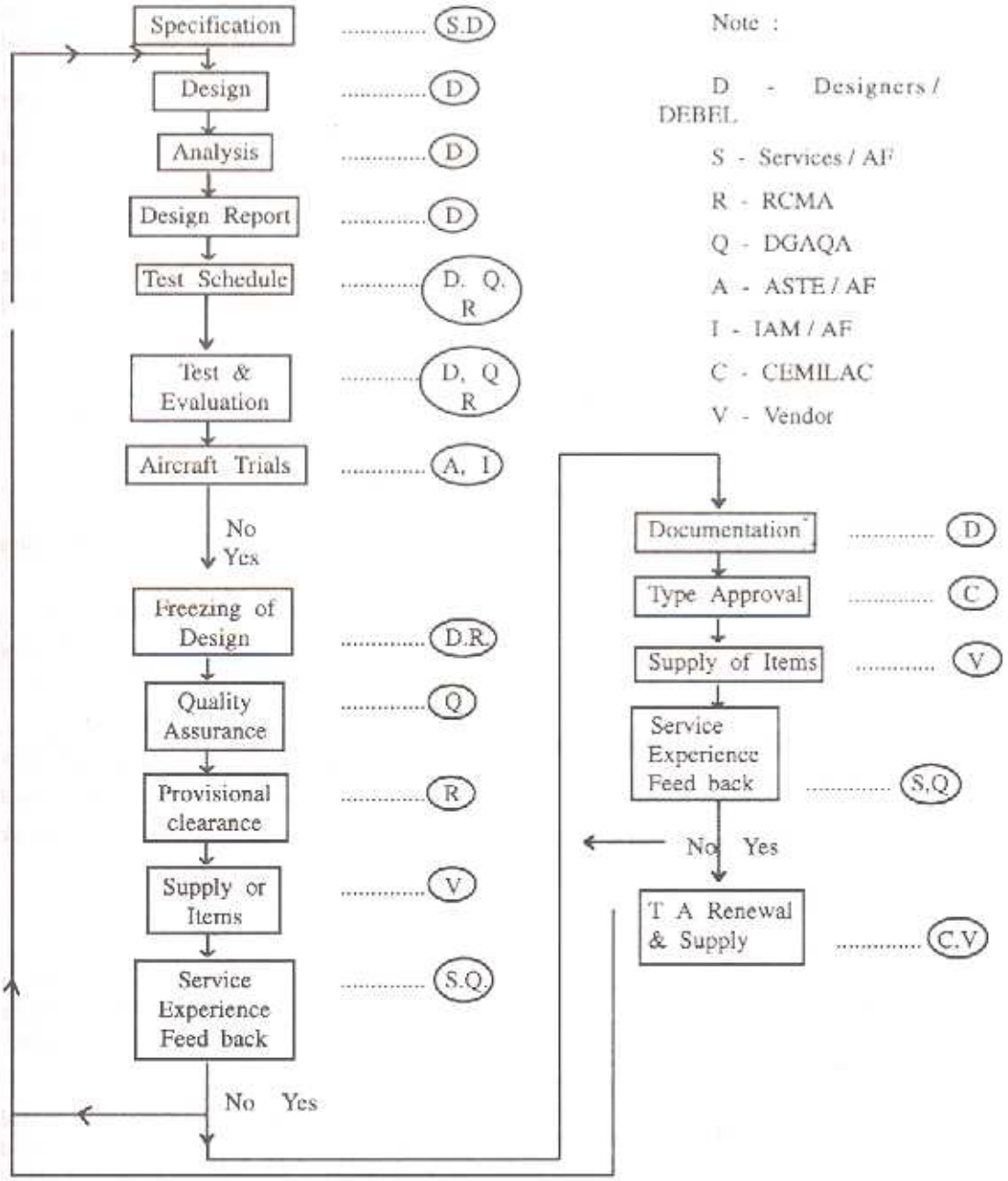
Part-V

Quality Assurance Provisions

A very important area which assures consistent quality of the product to be suppli to the Federal Government is covered in this pa This is an area which needs further strengtheni in India. The inspection requirement, as follow in USA is split in two levels :

(a) Qualification Inspection : The test samp for this consists of one mask of each si and test sheet of silicon material. The t report is required to include the results all the tests and a detailed statement compliance or noncompliance with ea requirement of the Mil -Specs, identified the applicable paragraph number. Tl

CERTIFICATION OF FLYING CLOTHING
ACTIVITIES & AGENCIES



(Fig.1)

requirement brings out the importance of covering all that needs to be covered while formulating the specification, as the specifications become the basis of all qualification requirements of the future.

(b) Quality conformance inspection : This consists of individual Tests which each and every mask is required to undergo. For the purpose of MBU-12P mask five such Tests have been identified. Sampling plans and tests identify three ways of sampling the masks provided by the manufacturer and also lays down the Reject Criteria.

Infrastructure required

The infrastructure required to conduct the tests as per US requirements is in the form of well developed labs with all modern simulators and auxiliary instrumentations. Such labs in US are financially viable due to it having the largest aviation industrial base in the world, in terms of volume of equipment needing the tests as well as the financial support available to R & D agencies.

Type certification system for flying clothing in India

The procedure of type certification flying clothing items, as practiced in India is briefly given in the Fig 1. [3]

Suggested Indian Test Schedule of an oxygen mask for fighter aircraft

Let us now consider a way to assess a given oxygen mask to meet the requirement of modern day fighter flying with a ceiling altitude of 50,000 feet on the following basis :

Experience and the infrastructure availabl our country : IAM has been conducting evaluation of different types of Oxygen M since mid sixties and has over a period of t developed a test protocol that has stood the of time as evidenced, in the manner the AE masks were introduced in service. Full use of Altitude Simulator was made in this proto Modifications to upgrade existing test rigs to computerise the data acquistions and results (to bring in repeatability and indepenc scrutiny) and methods to do underwater tests h already been suggested to the Human Engineer Panel. Following protocol is used by IAM. [4

(a) Static Tests

General External Examination

Inspiratory Valve overload test

Leakage Tests :

Test for mask tube & Inspiratory va leakage

Test for Leakage from Composite mask

Test for outward Leakage through inspirato valve

Inspiratory valve opening pressure test

Anti-suffocation valve opening pressure te

Back pressure through Expiratory valve te

Test for compensatory characteristics of ma

(b) Dynamic Tests

Subjective comfort test on ground, varying rates of ascent & descent to specif altitudes and during explosive decompression.

Oxygen concentration studies during norm breathing, while talking & on force hyperventilation on ground and during simulate flight conditions in an altitude chamber

Operational requirements from IAF's point of view : The US MIL-SPECS take into consideration world wide climatic range, for operational deployment and for logistics support. This information is then extrapolated into the ENVIRONMENTAL TEST SCHEDULES and in the methods of conducting these tests. Since India's geographical features covers all the ranges from desert, sea, snowbound areas to tropical jungles, it is prudent for us to follow the same test ranges and methodology as specified by USA, for the purpose of type certification of mask and other ILSS items. For this reason, no change is recommended in the existing Environmental Test Schedule but the methodology needs to be dove tailed into the existing Environmental Test Facilities. The list of such tests are given in Table-2, not all of these are required for the oxygen mask. To this end the Hot Cockpit, Human Centrifuge and Small Altitude Chambers available at the Instrument Test Lab at IAM have to meet the requirements specific to the selected tests.

Table - 2
Environmental Tests for determining natural and induced environments on equipment used in military applications

Low pressure (Altitude)
High Temperature
Low Temperature
Temperature Shock
Solar Radiation (Sunshine)
Rain
Humidity
Fungus
Salt fog
Sand & Dust
Explosive Atmosphere
Leakage (immersion)
Acceleration
Vibration
Acoustic Noise
Shock
Temperature, Humidity, Vibration, Altitude
Icing/Freezing Rain

Suggested Additional Tests in the Indian protocol

In addition to the Tests conducted by IAM's protocol, which cover the assessment of physiological requirements exceptionally well, the following tests are suggested to cover the operational requirements. [6]

The anchoring mechanism e.g. Chain & toggle tests
Dynamic Pressure holding test for Occipital bladder + Mask combination
PPG + Mask combination
Visual Field Mapping
Underwater Performance
Rubber Tear resistance
Hardness Test
Low temperature brittle point Test
Toxicity Test
Delivery Tube leakage, collapse & strength Tests
Microphone bracket dielectric Test
Salt Fog Test
Colour Specifications as per ISI standards
Icing/Freezing Rain Test
Acceleration Tests
Fungus Test
High & Low Temperature Tests
Solar Radiation Tests

Importance of field trials for India

Since whole range of environmental conditions are available within the existing deployment locations of our armed forces, in different climatic seasons, any drawback that may exist in the infrastructure can be overcome by conducting extensive field trials. These trials should be conducted not only to assess subjective and objective performance but also to note the effect of actual field conditions on the shelf life of the equipment/item being introduced. This area needs specific projects to identify the field trials requirements in conjunction with the approved Indian Test Schedules.

These studies will also evolve for the user, the tests required to assess the serviceability state of ILSS components in the field. The periodic maintenance schedule will also come out of these tests and trials. The reasonable life of the equipment or component would also be formulated on the basis of the inputs from the Qualification tests and Field Trials.

Conclusion

This study has attempted to define an indigenous approach to Type Certify an Oxygen Mask for fighter flying. Similar approach needs to be taken to cover other components of ILSS. A clear demarcation is required in the developing agency and the testing agency, if highest quality is to be maintained.

References

1. MIL -M - 87163A (USAF)
2. MIL - STD - 810D
3. CEMILAC Doc 15.12.97
4. Kumar Ranjit. Report on Defective indigenous oxygen mask Mk 1, IAM Test Report 74/87.
5. Kumar Ranjit. Evaluation of a New Oronasal Mask with anti Suffocation value for IAF Squadron service. IAM Departmental Project No. 89.
6. Ernsting J. Operational and physiological requirements for aircraft oxygen systems. AGARD report no. 697, 1984, p1-1 to 1-10, Paris, Advisory Group for Aerospace Research and Development.