

Quality Management System for Defence Aeronautical Industry

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ABSTRACT

Indian defence aeronautical industry, while becoming a global business, demands a large effort to monitor quality management system (QMS) and to ensure quality of aeronautical products. An effort is being made to look for an effective QMS for aeronautical industry in India, which will also meet the requirements of the regulatory authority.

The essential features of an effective QMS are described and compared with the presently available QMS standards for defence aeronautical industry such as QCSR: 2002 (DGAQA, India), Def Stan (MoD, UK), ISO, AQAPs (NATO) and Society of Automotive Engineers (SAE) aerospace standards (AS). Evolution, relevance and review of the existing standards, to meet the requirements of the industry as well as regulatory authority, have been made to bring out the special features and differences. The study leads to the most acceptable standard of SAE-AS-9100 (Rev B).

With suitable modifications to include regulatory requirement of assistance for government quality assurance in the standard, when complied with, it will fully meet the QMS requirements of the Indian defence aeronautical supply organisations as well as the requirements of the regulatory authority. Minor reorientation of the regulatory functions and inclusion of the QMS in the defence aeronautical supply orders are also suggested.

Keywords: Quality management system, defence aeronautical requirements, QMS, aerospace standards, aerospace industry, aeronautical industry, regulatory authority, defence standards

NOMENCLATURE

| | | | |
|----------|---------------------------------------------------------------------------------------------------|-------------|---------------------------------------------------------------------|
| AQAPs | Allied quality assurance publications | DGAQA | Directorate General, Aeronautical Quality Assurance |
| AS | Aerospace standard | DTD&P (Air) | Directorate of Technical Development & Production (Airborne Stores) |
| BS | British standard | IS/ISO | Indian standards / International Organisation for Standardisation |
| GQA | Government quality assurance | QMS | Quality management system |
| DDPMAS | Procedure document on design, development and production of military aircraft and airborne stores | QA | Quality assurance |
| Def Stan | Defence standards, UK | QAR | Quality assurance representative |

| | |
|--------------|--------------------------------------------------|
| QCSR | Quality control system requirements for industry |
| SAE | Society of Automotive Engineers |
| AG | Aerospace Group |
| Supply chain | Supplier → Organisation → Customer |

1. INTRODUCTION

India's military aircraft industry is acquiring dimensions, and is becoming a global business. Significant changes are happening within short intervals. The world is a far more complex and technologically-driven place now, than it was in the yesteryears. The quality management system plays a vital role in managing these changes. Efforts to monitor quality management system and to ensure quality of aeronautical products are enormous due to the technological sophistication, the rigours of stringent practices, and the spread of a large number of associated work-centres in the aviation sector. It poses a significant challenge to the quality assurance functions in general, and the role of regulatory authority, in particular. The fact, that airworthiness, quality, reliability, and safety will have to be the major selling points of aeronautical products, makes it a compulsory course to adopt, accept, and practice these.

It is in this context that an effort is being made to look for an effective quality management system for defence aeronautical industry in India, which will also meet the requirements of the regulatory authority.

2. QMS REQUIREMENTS

The essential requirements for an effective quality management system for aeronautical industry in India, is with the exclusive purpose of building quality and obtaining assurance of that quality.

2.1 QMS Based on Principles

QMS is at the core of an organisation's activities. Emphasis is on the top management to define quality policy, provide evidence of its commitment, and

implementation of QMS. Customer requirements are determined and fulfilled by the organisation. It is the responsibility of the top management to identify the competence of the personnel for each job and provide suitable training. It is the responsibility of the top management to evaluate actions taken and address their outcomes. Organisation's quality management takes necessary action for continual improvement of the effectiveness of QMS. Management draws a clear distinction between the preventive action and the corrective action. Monitoring customer satisfaction is like presenting the balance sheet. Early methods of counting defects and complaints will not suffice. A proactive approach by the organisation is required to maintain consistent quality of supplies and services. The organisation is responsible for controlling product quality and offering for acceptance to the customer only the product that conforms to the contract requirements.

To achieve maximum effectiveness, the organisation must follow recognised international practices and maintain a system for the management of quality. The principles of quality management as well as the quality system elements are laid down in national and international standards. Consequently, the customer expects the organisation to utilise all the necessary elements of the quality system applicable to the specific products. Quality management is a coordinated activity to direct and control an organisation with regard to quality. Quality management includes the establishment of the elements such as quality policy, quality objective, quality planning, quality control, quality assurance, and quality improvement—each appropriate to the product being offered. Quality assurance has two facets—internal quality assurance and external quality assurance. While the industry takes care of the elements of the QMS including internal quality assurance, the regulatory authority functions to provide confidence to the user by external quality assurance.

3. AEROSPACE SECTOR-SPECIFIC REQUIREMENTS

Aeronautical equipment such as aircraft demands utmost safety and reliability during service use, and hence, the normal requirements may not suffice.

Therefore, certain additional industry-specific requirements are mandatory. These include, requirements in the areas of reliability, maintainability, and safety; airworthiness requirements, such as design verification and validation, etc. Emphasis needs to be given in areas such as configuration management, accountability for quality controls, first article inspection, measurement of key characteristics, etc.

3.1 Evidence for the Effectiveness of the System

Scope for continuous monitoring of the quality management system and taking steps to prevent/rectify occasional aberrations due to human error must be available.

3.2 Evidence that the Quality Requirements of the Product is Ensured

The complete visibility of the organisation's quality activities supported by objective evidence enables the government quality assurance (GQA) to accept the product for the user. Process of transformation from design to production, ie, a sequential record of production, without losing any of the features and characteristics, properly documented with records, is the evidence of meeting the quality requirements during production. Unflinching integrity of the human resources is the only thing, which cannot be documented.

3.3 Provide Confidence, in Addition to Satisfaction, to the Customer

Internal quality assurance function of providing confidence to the user is the prime function of the organisation's quality management. The time and costs involved in the development of modern and complex aeronautical systems demand that the customer or the regulatory authority is given the right to have the fullest view of the design as well as the production activities to gain confidence in the resultant systems. Aeronautical equipment, having complex systems of even mature and qualified design, are less verifiable through inspection, and that inspection or final acceptance tests often cannot assess some of the technical

characteristics such as reliability. Therefore, effective control of quality should start as early as possible in the design, development, and manufacturing cycles.

4. GOVERNMENT QUALITY ASSURANCE/REGULATORY REQUIREMENTS

Objective of the government quality assurance is to provide an external/third party assurance of compliance by the organisation, with the requirements of the contract. The involvement of government quality assurance is intended for application in defence contracts, for quality of products/services, which can be verified for conformity to the satisfaction of the customer, prior to the delivery of the product or services, and for furnishing of objective evidence. Government quality assurance plan also takes care of the identified risks. Risk management is the process of analysis, evaluation, and control of risks to reduce the probability of occurrence of an unwanted event and its impact during production and use of military equipment. The risk factors (risk analysis, evaluation, and control) and guidance for government quality assurance are enumerated¹ in AQAP 170. Role of government quality assurance /quality assurance representative² (QAR) as in AQAP 170/Def Stan 05-91 is meant for risk perception, ensuring adequacy of qualification tests, acceptance standards commensurate with the customer requirements, approval status extensions, etc.

The need for a third party certification also arises because an individual customer is not equipped for conducting all the tests that are necessary, or the cost of verification is very high, or he cannot afford destructive testing. These requirements of certification, including safety and environmental regulations, affect the customer and the organisation.

Endorsement for products, services, and the existing quality management system in the organisation from unbiased and independent agencies, is a marketing technique for commercial products. An effective quality management system certified/approved by government quality assurance should be a promoting factor for the supply of aeronautical products too.

5. REVIEW OF CURRENT QMS STANDARDS

The evolution and relevance of the current international quality management system standards may be reviewed so that one may choose the best model for achieving the above requirements. Standardisation, significant improvements in quality and safety, and reduction in cost, are also aimed while selecting the QMS.

5.1 Quality Control System Requirements

DGAQA as the regulatory authority for military aviation in India, has contributed to the quality of the products under development and production projects through sustained efforts. Quality control system requirements for Industry³(QCSR:1973) was the basic document, which laid down the requirements to be met by the aeronautical supply organisations to obtain the approval of regulatory authority (DTD&P(Air)/DGAQA). This document was prepared⁴ based on Def Stan 05-21/Issue dated 1 January 1973, the original of which was published in 1960 as AQAP-1. Joint Services Specification⁵, JSS:0254-01 on QCSR for Industry was prepared and issued by the Directorate of Standardisation in April 1983, virtually adopting the requirements specified in Def-Stan 05-21 and QCSR:1973.

5.2 UK Defence Standards & ISO Standards

The UK Defence Standards had undergone revision subsequently in 1979 and British standard, BS 5750, came into existence. BS 5750 was substantially and comprehensively revised first in 1981 and again in 1987 with the advent of quality management systems brought out by the International Organisation for Standardisation (ISO). BS 5750 (Part 1) of 1987 was revised⁶ to be in line with the IS/ISO 9001:1994.

Defence standards on quality management systems have been further updated⁷⁻⁹ to Def Stan 05-91, 05-92, 05-93, and 05-94, incorporating the elements¹⁰ of ISO 9001:1994, ISO-9002: 1994, ISO 9003:1994¹¹ and ISO 9004:1994¹², respectively and retaining the role of (government) quality assurance representative.

5.3 Allied Quality Assurance Publications

In accordance with the standardisation agreements among the NATO group of nations, STANAG 4107 'Mutual acceptance of government quality assurance and use of AQAPs' and STANAG 4108, the existing allied quality assurance publications (AQAPs) on quality management systems were revised¹³ to AQAP-100, 110, 119, 120, 130, 131, 150, 159, 160, 169, 170, etc after adopting/merging the requirements specified in ISO 9000: 1994 series of standards and retaining the role of government quality assurance. Most of these standards are meant for contractual requirements and the rest are for guidance. Contractual AQAPs require the organisation to provide objective evidence of the establishment and maintenance of quality management system necessary to give sufficient confidence to the regulatory authority, that the product meets the contract requirements.

One important distinguishing feature of the Def Stan and AQAPs against ISO 9001: 1994 is that the government quality assurance requirements are retained in Def Stan and AQAPs while bringing the quality system elements in line with the ISO standard, which does not take cognisance of the role of government quality assurance. Additional requirements/features in the NATO AQAPs (refer Chapter III of AQAP 110 and STANAG 4159 and STANAG 4427) are:

- (a) Configuration management (CM) system comprising
 - Configuration identification
 - Configuration control
 - Configuration status accounting, and
 - Configuration audit
- (b) Assistance for government quality assurance/QAR with accommodation and facilities required for the proper accomplishment of the work.
- (c) NATO supplementary requirements are added to various clauses in AQAPs. One such requirement, for example, is 'criteria for acceptance and rejection shall be documented' (as per AQAP 110 Clause 4.10).

It may also be noted that the organisation's application format for concessions / deviations permits, as per AQAP 170, includes effect/variation in cost due to the deviation, to be charged or credited to government, which is not available as per the procedure of DDPMAS¹⁴ being followed at present in India.

AQAPs have also indicated methods and tools to improve GQA based on the principle that the production organisation must manage the quality system, and that, the organisation must provide assurance of that quality to the degree required in the contract.

5.4 SAE-AS-9100

International Aerospace Quality Group (IAQG), which included representation from the aerospace industry leaders in the US, Asia/Pacific, and Europe; users and regulatory bodies like Federal Aviation Authority, under the aegis of Society of Automotive Engineers (SAE) prepared an international standard¹⁵

known as SAE-AS-9100 for quality management system requirements for the aerospace industry. In addition to the requirements of ISO 9001:1994, the standard brought out additional aerospace sector-specific requirements and recognised the role of regulatory authority in the aeronautical industry.

ISO 9000: 1994 series of standards have been further revised in 2000 and superseded by ISO 9001:2000¹⁶ and ISO 9004:2000¹⁷, with the vocabulary updated from ISO 8402 to ISO 9000:2000¹⁸.

5.5 Quality Control System Requirements for Industry (2002)

After the above aspects were brought to the notice of the Regulatory Authority for Military Aviation in India, ie, DGAQA, the document¹⁹ 'Quality Control System Requirements for Industry' (QCSR:1973) underwent a revision, adopting/merging most of the features of ISO 9001:1994 and adding a few of the aerospace sector-specific requirements from

Table 1. Chronological evolution of quality system standards (1945-2004)

| 1945 | 1960 | 1970 | 1975 | 1980 | 1986 | 1994 | 2000 | 2004 |
|------------|----------------|---------|------------------|----------------|-------------------------|------------------------------|---------------------|---------------------|
| | | | | | | SAE-AS-9100 | SAE-AS-9100 (Rev A) | SAE-AS-9100 (Rev B) |
| | | BS 4891 | | BS 5750 | JSS 0254-01 | | | |
| | | | | | BS 5750 Pt 2 =ISO 9003 | ISO 8402= IS 13999 | IS/ ISO 9001 | |
| | | | | | BS 5750 Pt 1 =ISO 9002 | ISO 9000= IS 14000 | IS/ ISO 9004 | |
| | | | | | BS 5750 Pt 0 = ISO 9000 | ISO 9001= IS 14001 | | |
| | | | | | ISO 9004 | ISO 9002= IS 14002 | | |
| | | | | | | ISO 9003= IS 14003 | | |
| | | | | | | IS/ISO 9004 | | |
| | | | QCSR DTD&P (Air) | | | QCSR (DGAQA) Revised in 2002 | | |
| | UK | | | UK | | UK | | |
| | Def Stan 05-21 | | | Def Stan 05-30 | | Def Stan | | |
| | Def Stan 05-22 | | | =BS 5750 Pt 6 | | 5-91, | | |
| | | | | Def Stan 05-25 | | 5-92, | | |
| | | | | =BS 5750 Pt 5 | | 5-93, | | |
| | | | | Def Stan 05-22 | | 5-94 | | |
| | | | | =BS 5750 Pt 4 | | | | |
| | | | | Def Stan 05-29 | | | | |
| | | | | =BS 5750 Pt 3 | | | | |
| | | | | Def Stan 5-24 | | | | |
| | | | | =BS 5750 Pt 2 | | | | |
| | | | | Def Stan 5-21 | | | | |
| | | | | = BS 5750 Pt 1 | | | | |
| NATO AQAP1 | | | | | | NATO AQAP 100 | | |
| | | | | | | 110,119,120130,131,1 | | |
| | | | | | | 50,159,160,169,170 | | |

the aerospace standard SAE-AS-9100. This document was issued in 2002 superseding the QCSR:1973.

Def Stan is under revision to align with ISO 9001:2000 and so also the AQAPs. Chronological details of development of these standards on parallel paths are depicted in Table 1.

5.6 SAE-AS-9100 (Rev B)

SAE-AS-9100 was further revised in 2000 as AS 9100 Revision²⁰ A [SAE-AS-9100 (Rev A)] for being effective until 15 December 2003 and AS 9100 Revision B [SAE-AS-9100 (Rev B)] from January 2004 onwards. The revisions were in line with ISO 9001:2000. Aerospace industry required participation of regulatory authority in the preparation of these standards, which had further helped to include specific regulatory requirements in the standard. Thus, AS 9100 (Rev B) continued to recognise the role of regulatory authorities in the establishment of quality system requirements for aeronautical industry/manufacturers. (The QMS requirements for aerospace standard for maintenance/repair stations of aeronautical equipment is AS 9100). AS 9100 (Rev B) specifies requirements for a QMS that can be used for contractual purposes, as it focuses on the effectiveness of the QMS in meeting customer requirements.

In addition to the requirements listed in ISO 9001:2000, AS 9100 (Rev B) also includes aerospace sector-specific requirements, which were felt to be necessary to assure quality of aerospace products. These include requirements in the areas of reliability, maintainability, and safety. These are:

- First article inspection
- Measurement of key characteristics, etc
- Design verification/validation, and testing processes
- Approval and review of supplier performance
- Verification of purchased product
- Configuration management throughout the product's life cycle
- Control of production process changes

- Control of production equipment, tools, and numerical control machine programmes
- Control of work performed outside the organisation's facilities
- Accountability of quality control
- Review of disposition of nonconforming product
- Right of entry/access for regulatory authority
- Use of customer designated/approved sources
- Control of acceptance authority media
- Protection against foreign object damage, etc.

During the past three decades, a lot of changes have taken place in the concepts of quality and quality assurance, throughout the world. Major changes that have taken place during the above revisions of Def Stan, AQAPs and IS/ISO standards, can be summarised as follows:

- (a) The standards prior to 1979 gave importance to inspection and quality control, whereas subsequently, the major emphasis was changed to management of quality. There is wide acceptance, including among the defence services, that an effective system of management is the primary requirement for quality and reliability of a product. Quality management, as a philosophy, technology, and an efficient way of managing resources, has become a powerful concept for creating a focus on continuous improvement throughout an organisation.
- (b) The standards prior to 1979 had a product approach for quality control and quality assurance. It was thought that the desired results could be achieved more effectively with a process approach. IS/ISO standards have been revised to meet this principle. (advantages of a process approach are enumerated in IS/ISO 9001:2000).
- (c) Quality control is no longer considered as an activity restricted to the quality control department and its personnel only, but an activity encompassing all departments, personnel, and other resources

of the entire organisation. Hence, a system approach to the management of quality has been incorporated in the standards of the recent issues.

- (d) Various innovative ideologies preached by the quality gurus have found their way in to the quality standards of recent issues. At the same time, the freedom of choice of appropriate measures towards quality improvement, quality costing, training, areas of operation, and type of management, etc has been allowed.
- (e) Responsibility for quality considered earlier as limited to the operator/inspector/process/middle management, has now spread over the entire organisation, especially to the top management, and the organisation's quality management system and strategies. The management of quality is applicable to all functions and levels of an organisation, and balances control, assurance, and improvement of quality.
- (f) Organisations have realised that, in harmony with the changes in business and industrial processes, there is a continuous need for improvement in the skills and knowledge of personnel responsible for achieving quality.

6. CURRENT STATUS

Almost all the major supplier organisations, such as Divisions of Hindustan Aeronautics Limited, approved by the regulatory authority for quality assurance, have accreditation to ISO 9001:2000, in so far as the quality management system requirements are concerned.

To meet the needs of the modern-day quality management principles and strategies, and to align with the higher versions of SAE-AS 9100, the requirements of the QMS of the regulatory authority also may be upgraded. Contract review and servicing elements are also to be adequately covered in the regulatory requirements. JSS 0254-01 issued in 1983 by the Directorate of Standardisation also requires revision and improvement.

There is no definition of the specific terms used in the regulatory documents, and hence, it leads to avoidable and ambiguous interpretations and difference of opinions between the industry and the regulatory authority. Every key term is adequately defined with explanatory notes in IS/ISO 9000:2000, which has been adopted by SAE-AS-9100 (Rev B), to avoid such differences. Once contractually bound, all concerned can use the above ISO definitions of terms, without ambiguity.

If the financial control of the organisation really accounts for the cost of poor quality, it may work out to be a large share of the expenditure. Some of the aeronautical organisations give their products warranty for a very limited period of service-use, as in the case of commercial products. It needs to be appreciated that military hardware, especially aeronautical products, are different, with stringent requirements of quality, reliability, and safety.

Supply organisations after having accreditation for meeting the requirements of ISO 9001 are in a superior plateau and demonstrate a posture that they care less for the regulatory requirements. The aeronautical industry, which grows and wants to play its role globally, is ready to accept a better QMS. They would require only a few additional requirements specific to the aeronautical industry to be satisfied/added to its QMS. Updating to SAE-AS-9100 (Rev B) standard is a progressive step and encouraging task for the aeronautical industry.

7. REGULATORY AUTHORITY'S QUALITY ASSURANCE FUNCTIONS

A study of the SAE-AS-9100 (Rev B) reveal that since elaborate details of the QMS are available in various associated literature, the job of surveillance/monitoring the effectiveness of the QMS will be far more meticulous and efficient than at present. There will be a rejuvenated enthusiasm on the part of government quality assurance to deal with and indulge in a far more superior and complete world standard. The current role of regulatory authority gets improved/modified to that of an accreditation agency in addition to government quality assurance. Accordingly, the functions of regulatory authority

may have to be modified/re-oriented to include the following:

- (a) Assessment/audit/revalidation of approval for implementing and maintaining an effective QMS in the supplier organisations and its continuous monitoring for effectiveness.
- (b) Measurement, analysis, and improvement of quality in association with the aeronautical industry.

DGAQA, the regulatory authority, doing external quality assurance, has a policy of utilising the inspection organisation of an approved firm to effect inspection and quality assurance at all stages of manufacture, repair, and overhaul of aircraft, aero-engines, and other aeronautical stores. This arrangement is known as²¹ approval of firm's inspection organisation (AFIO). There are several advantages gained by it. However, inspectors alone do not control quality. It is the system, which allows deviation to occur or prevents it. Methods are to be devised for improving the effectiveness of the existing system by suitably modifying the requirements of inspectors for approval, such as minimum qualification, training/experience in hardware/software, awareness, and commitment to the QMS/product quality, etc.

Approval of organisations, if done in accordance with SAE-AS-9100 (Rev B), would elevate the regulatory authority for quality assurance in military aviation in India to be on par with similar defence quality assurance organisations all over the world. This approval by Indian regulatory authority shall be acceptable to counterpart organisations in other countries with which reciprocal arrangement to carry out quality assurance functions exist. SAE AS 9104, which lays down the requirements for registration of aerospace QMS, could be a guideline. The establishment of common requirements, for use at all levels of the supply chain and the regulatory authority, should result in upgraded quality and safety, and decreased costs.

Self-certification, being followed in some organisations, is not intended in any of the QMS standards. Zero-defect operators when identified by the firm, are only for the internal quality assurance function of the firm.

To implement SAE-AS-9100 (Rev B) requirements, necessary competence has to be developed/built into the organisation. There is a commensurate need for government quality assurance personnel because effective performance of government quality assurance also demands a thorough knowledge of quality management, industrial practices and techniques, as well as technical knowledge associated with the product.

8. RECOMMENDATIONS

In the light of the above discussions, the following proposals/recommendations are made:

- (a) Aerospace Standard SAE-AS-9100 (Rev B), which lays down the requirements of QMS in the aerospace industry (with exclusions allowed within clause-product realisation), may be implemented as the QMS in the defence aeronautical industry in India, with the permission of SAE.
- (b) SAE-AS-9100 (Rev B) standard, with additional requirement of assistance for government quality assurance, may be considered as the basic document against which the regulatory authority grants accreditation/approval of aeronautical organisations.
- (c) Contract/purchase orders from the Services to supplier organisations may include the requirement of establishment and maintenance of a typical QMS such as SAE-AS-9100 (Rev B), so that it becomes mandatory for the industry to comply and qualify for defence aeronautical supplies.
- (d) The regulatory authority for quality assurance may verify compliance of QMS as per SAE-AS-9100 (Rev B) in their approved organisations engaged in aeronautical supplies to the Indian Defence Services, continuously monitor its effectiveness and take necessary action for further improvement.
- (e) The associated procedure of approval of firms inspection organisation, the system used for quality assurance by the regulatory authority, may be further improved, updated for effectiveness, and continued.

(f) JSS 0254-01 may be revised in line with or replaced by SAE-AS-9100 (Rev B).

9. CONCLUSIONS

If SAE-AS-9100 (Rev B) standard, which lays down the requirements of QMS in the aerospace industry is adopted as the QMS for the defence aeronautical industry in India, and accepted as the basic document against which approval of such organisations are being given by the regulatory authority, it will go a long way in making the Indian defence aeronautical industry globally competitive and in ensuring quality, reliability, and safety for their products.

ACKNOWLEDGEMENT

Guidance given by Shri A. Pratap Kumar, Dy Director General (South Zone) and Gp Capt R.K. Ayilliath, Chief Resident Inspector (Aircraft), both DGAQA, Bangalore, in the preparation of this paper is gratefully acknowledged.

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