

## **NDE DURING MANUFACTURE AND MAINTENANCE OF AIRCRFTS AND HELICOPTERS**

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### **ABSTRACT**

Indian aviation Industry is poised for growth by the increase in Government Defense Spending & Make in India initiatives. This has encouraged global aerospace companies in entering India and existing Indian Aerospace companies in deepening their expertise and capabilities

NDE contributes reliability & safety, through implementing design stipulated acceptable norms , during Manufacturing process, prevention of service failures by in service inspection and Failure Investigation of failed components for further improvement. Also NDE has a vital role in life extension of Aircrafts & Helicopters.

This paper attempts in covering Aerospace NDE topics related to personnel certification , approvals of various Government regulatory bodies, National and International accreditation like, NABL NADCAP, approval of materials and equipment. Process control, Calibration, MRO ( Maintenance Repair & Overhaul) of Aircraft / Helicopter, and failure analysis of Aircraft / Helicopter components.

Keywords:

Aerospace NDE NADCAP Aircraft Helicopter MRO In service Inspection.

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From a small beginning in 1940, The growth of Indian Aeronautical industry is phenomenal, presently it has engaged in all aspects of Aircraft and Helicopter design , production and service.

NDT is employed right from raw material stage thro various processes and finishing, but does not end here, while the components are in service, NDT methods are employed to detect initiation and propagation of defects so that measures can be taken to prevent further damage.

Whenever a component/assembly fails suitable NDT methods are employed to ascertain the cause , and remedial measures are taken so that further repetition of the failure does not occur in the remaining components/assemblies.

## **Personnel Certification**

The Aerospace Industries association approved NAS 410 (NATIONAL AEROSPACE STANDARDS ) as an Industry standard in 1996. With effect from Dec 31<sup>st</sup> 1997 it replaced MIL STD 410 E. NAS 410 Level I, Level II & Level III training & Certification are to be carried out by personnel who are certified to NAS 410 Level III in the particular method Technique and product.

NAS 410 certification is a mandatory requirement for exporting flight hardware to overseas customers ( Eg : M/S Rolls-Royce UK, M/S Airbus France, M/S Honeywell USA etc ) and mandatory requirement of DGCA ( Director General of Civil Aviation ) for issuing Certificate of Competency ( COC ) in NDT methods

## **Approvals of various Government regulatory bodies**

### **DGCA Approval in NDT**

Personnel carrying NDT on civil aircrafts, shall obtain Certificate of Competency ( COC ) from DGCA ( Director General of Civil Aviation ) for issuing . Civil aviation requirements (CAR) is detailed in section 2 – airworthiness series 'L',part xiv 20th January 1992. Rev. 2, 23<sup>rd</sup> May 2006. This part of the CAR specifies the requirements pertaining to age, knowledge, qualification, skill and medical standards for issue and renewal of Certificate of Competency. Renewal is once in six months by paying fees of Rs 2500.

### **DGAQA Approval in NDT**

For NDT of Military Aircrafts , the personnel shall be approved by Director General of Aircraft Quality Assurance , a Government regulatory body.

## **International Accreditation**

NADCAP (National Aerospace Defence Contractors Accreditation Programme) is an industry managed programme. Accreditations are performed by Performance Review Institute (PRI),based in USA, a 3rd party registrar associated with the Society of Automotive Engineers (SAE).

Foundry and Forge division of Hindustan Aeronautics Ltd ( Bangalore Complex) is the First organization in the country to obtain NADCAP approval in 2005 & in the area of Nondestructive Testing methods viz Radiography, Penetrant & Magnetic particle testing. Subsequently other process like Heat treatment, chemical process etc were approved and other divisions of HAL got NADCAP approval in various special process.

As on today ( November 2015) around 30 companies in India have NADCAP approval in RT, PT MT and UT of composites, but none have approval for UT of Metallic materials, because there is no customer requirement at present.

The reasons for seeking accreditation is that our customers are making accreditation mandatory for doing business with them. It is expected the NADCAP approval tag will open more opportunities in the global aerospace market. The other reason is that the various standards will ensure that consensus-based best practices are implemented for increasing quality of our processes. ISO 9000 & AS9100 only prescribe general requirements for business management. NADCAP goes much further to ensure the quality of a specific area of our processes, based on detailed and proven methodologies.

Frequency of NADCAP audit can vary for each special processes. The normal accreditation cycle is 12 months, which can be extended to 18 months interval in subsequent audits. 2 years on Merit scheme.

### **National Accreditation for NDT Laboratory**

NABL ( National Accreditation Board for Laboratories) is the sole accreditation body in India that provides third party assessment and has been authorized by Government of India.

Laboratory accreditation according to the standard ISO/IEC 17025 also covers the quality management elements of ISO 9000. So laboratory accreditation, which is based on ISO/IEC 17025 is a measure of both technical competence and quality management

NABL accreditation is not a one-time phenomenon. Once the laboratory gets accredited for some specific tests or calibration parameters, accreditation to a laboratory shall be valid for a period of 2 years and NABL shall conduct periodical surveillance of the laboratory on annual basis.

### **Materials and equipment for Aerospace NDT**

Stationary/ Mobile X-Ray equipment up to 320 kV having dual focus ( fine and coarse) with beryllium window and portable equipment of 160 kV for MRO are generally used. Gamma radiation is not used in aerospace NDT. Some overseas customer mandates Auto processor only. Industrial X-ray films to meet requirements of ASTM –E-1815 / EN 584-1

X ray film viewers to be calibrated with light meter as per ASTM E 1742 to indicate up to which density it can be used. State of art like Digital radiography ( Direct digital radiography and computed radiography are in use. Medical CT scan equipment is used for composite inspection during manufacture of composite parts for Helicopters and Aircrafts.

Visible penetrant shall not be used for flight hardware. Only QPL-AMS- 2644 approved Fluorescent penetrant shall be used . When using post emulsified penetrant, emulsifier shall be from the same family/brand. However different brand developer can be used with different brand penetrants . Refer AMS 2644 and QPL-AMS-S 2644 for list of approved Fluorescent penetrant. Photo fluorometer for comparing the brightness of the Fluorescent penetrant and refractometer for checking the emulsifier concentration and TAM panel for the process

performance checks to be used. Maximum Number of process control checks and calibration of the instruments are in Penetrant Inspection.

Conventional Ultrasonic testing like Pulse echo contact and immersion technique with A and C scan presentation are used during manufacturing Inspection of wrought material, and Pulse echo contact technique with A scan is used for MRO.

Apart from the conventional Ultrasonic , advanced Ultrasonic technique PAUT ( Phased array Ultrasonic technique) is in practice from 2004 for military aircrafts as a customer requirement. Most of the UT reference blocks with traceability are presently imported.

Magnetic Particle stationary equipments with suitable amperage, fluorescent magnetic particle in carrier liquid as per AMS 2641 and wet continuous method is used. Dry powder and residual methods shall not be used. Portable Electric magnetic yoke is used in MRO. Adequacy of the magnetization shall be checked by Gauss meter as per AMS 1444 and residual magnetism in the components shall not exceed 3 gauss, which is checked by Residual field indicator.

Eddy current crack detectors are used in MRO with special customized probes . In Manufacturing shops Eddy current conductivity meters are used for conductivity measurements ( IACS /Mega Siemens per meter ) after heat treatment and for alloy sorting, material mix up etc. Primary NIST traceable conductivity standards are presently imported.

Efforts in indigenising special purpose MPI equipment for testing of rolled rings, which saved foreign exchange is worth mentioning here.

As per one of HAL customer's (M/s. Rolls Royce UK) specification , Steel rings required MPI by induction method to detect surface and subsurface discontinuities at various stages (before and after machining). A detailed specification and technique of magnetization was made by the author. In 2003 NDE Technologist from M/s. Rolls Royce, UK conducted exhaustive experiments on this equipment with standard specifications, Simulated defect samples, and actual component and gave approval for the satisfactory performance of the equipment in fully meeting their requirements.

By putting full efforts towards making a specification & devising suitable techniques of magnetization and giving constant technical input to the Indian equipment manufacturer, and finally getting the approval of technologist from M/s. Rolls Royce, UK , has resulted in savings of foreign exchange of around Rs. 95 lakhs. ( Foreign Manufacturers quoted around Rs 1.2 crores for this equipment)

## PROCESS CONTROL, CALIBRATION

Efficiency and consistency of ND inspection system has to be ensured by periodical control checks as detailed below. records to be maintained with dates and shall be kept for review by auditor.

When the NDT facility is handling more than one project , for process control checks and calibration, the frequency mentioned which is least among the customer s to be followed. For numerical values the highest value among the customers to be followed. The values should be logged in and the Register to be maintained up to date for customer and other third party audits.

Details of Calibration of Instruments / Equipments to be given in the procedures and Calibration Format shall contain , Instruments details, Frequency of Calibration, reference of document which details the requirements and Proposed Place for calibration viz, OEM / Authorized OEM dealers/ NPL / NABL accredited Laboratories / Firms carrying calibration with traceability. Current Calibration Certificates to be verified and signed by Level III and to be kept on file.

#### LIST OF NDT DOCUMENTS

For all the NDT methods practiced and for Training & certification of NDT personnel detailed procedures are to be written Level II / Level III . Procedure shall give cross reference to customer specification/ National ,International standards.. All procedures shall be approved by NAS 410 Level III.

Procedures Specific in nature for example, detailed step by step operation of the Instrument / Equipment, acceptable values, reporting format etc to be prepared.

For Repeatability & Reliability of test results NDT data cards are prepared & issued as X Ray, UT, MT technique, specific to the part shall be prepared .

#### **NDT Acceptance grades for Aerospace castings / forgings / weldments**

NDT acceptance grades for castings / forgings / weldments/composite parts shall be specified / referenced in any of the following documents .

1. Engineering drawing
2. Test sheet
3. Data card
4. Purchase order of the Customer

The following is general guide line , and customers requirement shall be followed.

Refer AMS 2175( Castings, Classification & inspection of ) for Castings:

Refer AMS-STD-2154 / AMS 2630 ( Ultrasonic inspection of wrought metals & wrought metal products ) for Forgings .

Refer MIL-STD-1907 (Military standard - Inspection, Liquid Penetrant ,Magnetic particle soundness requirements for castings, wrought products and weldment )

## **MRO ( Maintenance Repair & Overhaul) of Aircraft / Helicopter,**

The process of implementing a damage detection and characterization strategy for engineering structures is referred to as Structural Health Monitoring (SHM).

Generally Damage tolerance analysis is performed by the designers on each primary structural elements and components prone to cracking.

NDE engineers study the location, orientation and nature of possible discontinuities and recommend suitable NDT methods with appropriate techniques and issue them as service Instructions ( SI's) to fleet operators for implementation during maintenance.

### **Failure analysis of Aircraft / Helicopter components.**

The purpose of failure analysis is to prevent further failures. Failures occur when a component, sub assembly of a system fails to perform to the desired expectations for which it was designed. . For an item to be classified as a failure it need not be completely broken.

Lot of case studies can be cited in this aspect, where based on Failure analysis, defective parts are replaced by new one in preventing service related failure, and in many instances NDE has given feed back information to design, in Improving the product quality.

### **Special techniques for clearance of Aircraft on Ground (AOG)**

Consequent to the failure of the eye end fitting (Rod end of tracking link assembly of Helicopter), there was a urgent need to develop a insitu NDT technique to detect crack initiation in the remaining Helicopters which were AOG ( Aircraft on Ground).

After exhaustive study and trials, Insitu ultrasonic technique of eye end fitting by micro miniature angle beam probe was developed and proved before DGAQA. Based on this technique clearance was given by the regulating authorities for flying Helicopters which were grounded (AOG). Many such cases can be cited where special NDT techniques are prepared and used for clearance of AOG ( Aircraft on Ground).

### **Conclusion**

From the above mentioned details, it can be summarized, NDE plays pivotal role in final acceptance of aerospace components during manufacturing Inspection , and Insitu and Overhaul Inspection during service, validating the components for further service and removing the defective components, and thereby prevents service failures.

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