

Helicopter Vibration Health Monitoring (VHM)

Guidance Material for Operators Utilising VHM in Rotor and Rotor Drive Systems of Helicopters

CAP 753



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Revision History

1. Edition 1 June 2006

In the early 1990s Vibration Health Monitoring (VHM) systems were introduced to almost all large helicopters operating in the North Sea in support of the oil and gas industry. UK and Norwegian operators took this action voluntarily. Later, in June 1999, the UK Civil Aviation Authority (CAA), having recognised the potential safety benefit of these systems, issued Additional Airworthiness Directive (AAD) 001-05-99. This made the installation and use of VHM mandatory for UK registered helicopters issued with a Certificate of Airworthiness in the Transport Category (Passenger), and having a maximum approved passenger seating configuration of more than nine. Supporting information, providing general guidance and describing an acceptable means of compliance with AAD 001-05-99, was published in CAP 693 - Acceptable Means of Compliance Helicopter Health Monitoring.

The primary objectives of AAD 001-05-99 and CAP 693 were to define the necessary scope of helicopter VHM and ensure that the VHM systems were operated correctly. CAP 693 does not however, give detailed guidance for VHM system design to achieve effective health monitoring. The purpose of CAP 753 is to provide additional guidance for Operators utilising VHM in rotor and rotor drive systems of helicopters. This covers both VHM system design and operation.

The Operator is advised to use this guidance in satisfying himself that the VHM system meets acceptable standards and continues to meet these standards in operation. Based upon the Operator's assessment the CAA will seek a compliance statement from the Operator as evidence that the VHM meets the objective of the Air Navigation Order (ANO). Systems previously accepted under the CAA AAD or other provisions will not need any additional statements of compliance, unless they are modified or operated in a different manner.

Amendment 2012/01 to Edition 1 - August 2012

Updated in response to an AAIB recommendation to include a process where operators receive detailed component condition reports in a timely manner to allow effective feedback as to the operation of the Vibration Health Monitoring system.

Amendment 2017/01 to Edition 1 - February 2018

Updated to reflect the issue of CAA SAFETY DIRECTIVE Number: [SD-2015/002 Offshore Helicopter Operations](#) – Vibration Health Monitoring and EASA Certification Memorandum [CM-DASA-001 Issue 01](#), Vibration Health Monitoring: Prioritisation of Maintenance Alerts and the publication of the [HeliOffshore HUMS Best Practice Guidance](#). The document format has also been revised.

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Glossary

AAD	Additional Airworthiness Directive
AC	Advisory Circular
ANO	Air Navigation Order
BCAR	British Civil Airworthiness Requirements
CAP	Civil Aviation Publication
CAA	Civil Aviation Authority
CBIT	Continuous Built In Test
COTS	Commercial Off The Shelf
CS	Certification Standard
CSI	Controlled Service Introduction
EASA	European Aviation Safety Agency
EMC	Electromagnetic Compatibility
FAA	Federal Aviation Administration
FAR	Federal Aviation Requirements
GG	Gas Generator
IBIT	Initiated Built In Test
ICA	Instructions for Continued Airworthiness
JAR	Joint Aviation Requirements
LRU	Line Rectification Unit
MEL	Minimum Equipment List
PT	Power Turbine
SO(n)	Shaft Order (n-1 harmonic)
STC	Supplemental Type Certificate
TCH	Type Certificate Holder
VHM	Vibration Health

Chapter 1

Introduction

Background

- 1.1 Vibration Health Monitoring (VHM) has been used on the majority of UK large public transport rotorcraft, operating in the North Sea, since the early 1990s. The purpose of embodying VHM at this time was to reduce the likelihood of rotor, rotor drive system and engine failures that could prevent continued safe flight and safe landing. Since this time the accident rate attributable to such failures for this category of helicopter has reduced significantly, and the Civil Aviation Authority (CAA) believes that VHM played and continues to play a major role in this achievement.
- 1.2 In order to ensure that acceptable minimum standards were achieved and maintained, regarding the use and operation of VHM, the CAA issued AAD 001-05-99 which became effective on 1 June 1999. This made the installation and use of VHM mandatory for UK registered helicopters, issued with a Certificate of Airworthiness in the Transport Category (Passenger), and having a maximum approved seating configuration of more than nine.
- 1.3 In September 2003 the European Aviation Safety Agency (EASA) was formed. EASA reviewed the need for helicopter VHM requirements and the appropriate applicability of such requirements across Europe. The conclusion from this review was that National Aviation Authorities should introduce national operational VHM requirements for demanding operations, such as that of the North Sea, where they considered this to be necessary. The CAA subsequently introduced equipment and procedure requirements into the Air Navigation Order (ANO).
- 1.4 Mindful of the likelihood of future VHM operational regulations and recognising the need for updated requirements for VHM design, the UK CAA decided that CAP 693 (Acceptable Means of Compliance – Helicopter Health Monitoring CAA AAD 001-05-99) needed to be replaced with a new document addressing these

minimum standard issues. Accordingly this CAP 753 provides additional guidance for Operators utilising VHM in rotor and rotor drive systems of helicopters; this covers both VHM system design and operation.

- 1.5 It should be noted that the EASA have issued CS 29.1465 Vibration health monitoring. This specification defines the design standard for VHM.
- 1.6 Following the introduction of European Air Operations Regulations (CR(EU) No 965/2012) for Commercial Air Transport (CAT) operations, the mandate for VHM addressed by the ANO was no longer applicable to helicopters such as those used offshore. To ensure continuity until revised European regulations providing the equivalent VHM requirements have been adopted, the CAA issued Safety Directive Number: [SD-2015/002 'Offshore Helicopter Operations –VHM'](#) mandating all UK Operators to have a VHM system installed. The revised European regulations providing the equivalent VHM requirements are SPA.HOFO.155, which come into effect on 1st January 2019.

Terminology

Alarm: An Alert that, following additional processing or investigation, has resulted in a maintenance action being required.

Alert: An indication produced by the VHM system that requires further processing or investigation by the operator to determine if corrective maintenance action is required

Applicant: A person or organisation applying for approval of a VHM system in accordance with the ANO. For the purpose of this document Applicants will simply be referred to as the Operator and the Design Organisation.

Operator: This will be a UK AOC or PAOC helicopter Operator.

Design Organisation: This will be a Design Organisation who seeks the Operator's approval of installation of a VHM system and/or evaluation of its performance in accordance with Chapter 2 of this CAP.

Close Monitoring: This may be required when a VHM component or indicator requires focussed and increased monitoring, e.g. in the event that an indicator value exceeds a "maintenance action" threshold or shows other signs which warrant increased attention. The close monitoring procedure typically reduces the maximum period between successive indicator downloads to no more than 10 hours. Note that close monitoring is not intended to be a long-term solution, but a period of heightened monitoring, diagnostic

support and assessment to ensure that determinations of serviceability are made using all the data available.

Commercial Off-the-Shelf (COTS): This term defines equipment hardware and software that is not qualified to aircraft standards.

Controlled Service Introduction (CSI): A period in-service where capabilities and functions that could not yet be verified prior to entry into service (including support functions) are evaluated.

Coverage: The percentage of components in the engines, rotor and rotor drive systems that have VHM Indicators to provide advance warning of incipient failures that could prevent continued safe flight and landing.

Critical Component: There are a number of definitions of “critical” in different CS requirements. For the purpose of this CAP it is defined as “any component, individual failure of which would prevent continued safe flight and landing”.

Data Download Process: The process for downloading VHM data from the aircraft to the Ground Station. Typically, but not necessarily, a memory card, or portable device shall be specified which allows the required VHM data to be downloaded for analysis after every flight.

Data Management: Management of VHM data addresses integrity of data transfer from the helicopter to Ground Station, between Ground Stations (possibly at different bases), database integrity, data assessment and recovery methods.

Design Organisation: A European organisation which is approved to Part 21 Subpart J by EASA, or a US organisation approved to the equivalent FAR regulation by the FAA.

False Alert: This is an Alert that after further processing or investigation has been determined to not require any further action.

False Alarm: An Alert that after further processing or investigation has resulted in unnecessary maintenance action

Ground Station: A Ground Station is the means of access to VHM data, including Alerts, for immediate post-flight fault diagnosis by the responsible maintenance staff. It should also be capable of accessing other historical and relevant health monitoring data from other aircraft in the fleet, for the purpose of comparison, to assist in the analysis of exceedance and fault diagnosis. A Ground Station may have the ability to link interactively to Ground Stations at other line stations, the Operator’s main base and third-party engineering support over an Internet or Intranet connection or by a direct dial-up modem. While initial VHM systems used a specific computer as a Ground Station a ‘virtual’ Ground Station using means of access to a central server may also be acceptable. However, it

would need to be substantiated that integrity of data could be maintained to an appropriate standard.

Integrity Level: The level of accuracy and reliability that the VHM system should achieve. The integrity level necessary for each VHM Application is dependent on the criticality of the functions being performed.

Line Replaceable Units: Elements of the system that can be readily replaced during line maintenance.

Sensors: The hardware that measures vibration. Sensors need to provide a reliable signal of appropriate and defined performance in a typical helicopter operating environment. Sensors may have CBIT/IBIT capabilities sufficient to determine the correct functioning of the component.

Signal Sampling Rate: The frequency at which the signal is recorded. This should be sufficient for the required bandwidth and to address anti-aliasing.

Vibration Health Monitoring (VHM): Use of data generated by processing vibration signals to detect incipient failure or degradation of mechanical integrity.

VHM Application: The use of a VHM Indicator for a specific component failure, for example, shaft order one (SO1) vibration monitoring of tail rotor drive shaft balance.

VHM Indicator: A VHM Indicator is the result of processing sampled data by applying an algorithm to achieve a single value, which relates to the health of particular component failure modes.

Primary VHM Indicators will be those which can be monitored directly for the purposes of generating Alerts. Secondary VHM Indicators are those which can be used in the diagnostic process after an Alert is generated but themselves are unsuitable for direct Alert generation.

A VHM Indicator may itself be further processed with other VHM Indicators to give a further indicator.

NOTE: Indications of VHM data abnormality may also be used in the future, if and when this technology becomes sufficiently mature.

VHM Indicator Generation Rate: The rate at which each VHM Indicator value is acquired. This is usually a function of the data recording/processing speed, the number of VHM Indicators being recorded and the quantity of data required for each sample.

VHM System: Typically comprises vibration sensors and associated wiring, data acquisition and processing hardware, the means of downloading data from the helicopter, the Ground Station and all associated instructions for operation of the system.