Brüel & Kjær Vibro
A member of the NSK Group

Safety and reliability assessment specification

VCM-3 – VIBRO Condition Monitoring 3

Safety and reliability assessment specification **VCM-3**, C108080.002 / V01, en, date of issue: 11.11.2021

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The purpose of this technical information is to inform about the reliability figures for VCM-3 – VIBRO Condition Monitoring 3 range of products. The technical information introduces the concept of system availability, system reliability and system maintainability as related to the Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR). A summary of the reliability figures for VCM-3 is provided in tabular form as well as an explanation of each of the reliability concepts.

1 Introduction

When considering a condition monitoring system such as VCM-3 the availability parameter is the most important performance criterion as it combines the "Reliability" and "Maintainability" properties of the system into one single figure.

- **Availability**
  "the probability that the system is operating properly when it is requested for use." That is, Availability is the probability that a system has not failed or undergoing a repair action when it needs to be used. Availability is normally specified as a percentage, e.g. 94.5% (0.945), allowing for a calculation of system downtime per year.
- **Reliability**
  "the probability that a device will perform its intended function during a specified period of time under stated conditions." The most common reliability parameter is the mean-time-between-failure (MTBF), which can also be specified as the failure rate or the number of failures during a given period. In this note two MTBF values are calculated. One based upon theoretical data and one based upon field data from the installed base of systems.
- **Maintainability**
  "the probability of performing a successful repair action within a given time." In other words, maintainability measures the ease and speed with which a system can be restored to operational status after a failure occurs. Maintainability is often characterized as a mean-time-to-repair (MTTR) specified in hours.

2 Availability for VCM-3

The table below contains a summary of the reliability figures calculated for VCM-3. System availability is calculated using the following formula:

Mission Profile	MTBF (hours)	MTTR (hours)	Availability[1]	Average Yearly Downtime
Based on theoretical data, Offshore Wind	640,900	73	0,999886 (99.99%)	60 minutes
Based on theoretical data, Onshore Wind	661,800	73	0,999890 (99.99%)	58 minutes
Based on theoretical data, Factory Floor	1,960,000	73	0,999963 (100.00%)	20 minutes
Based on field data	25,185,146	73	0,999997 (100.00%)	2 minutes

Table 2-1) Availability for VCM-3

[1] ***Availability*** *= MTBF/(MTBF+MTTR)*

3 Theoretical Mean Time Between Failure

This technical information uses the FIDES Guide 2009 (Edition A September 2010) (www.fides-reliability.org) to calculate the theoretical reliability numbers for the electronic components of the VCM-3 devices. The guide bases the calculation on the electronic characteristics of the device and in which environment the device is being used (mission profile).
It is important to state that the MTBF value is a statistical value which can only be used on a large population, not as a single value to predict the lifetime of a single component telling when to exchange the component to avoid a failure. That is, if you have an MTBF of 50000 hours for a particular unit then if you have 50000 units running at the same time, in theory one unit will fail each hour. So rather than telling you when you should exchange a unit, the MTBF tell you how many spare units should be used to support a population of a certain number of installed units.
Below we state the calculated reliability for three selected mission profiles. Details of the mission profiles can be found at the end of this document.

Mission Profile	MTBF (hours)	MTTR (hours)
Offshore Wind	640,900	73
Onshore Wind	661,800	76
Factory Floor	1,960,000	224

4 Field Data Mean Time Between Failure

To give a practical view on the reliability of the VCM-3 products, BKV has collected field data on delivered devices.

Product	FieldUnits	Repairs	Parts per million
VCM-3	9,079	3	324

We have chosen to calculate the reliability numbers based on the above information

- **OperationFactor:** compensating for the fact that the unit may be switched off during service visits to the machine. (Conservative estimate)
- **Repairs:** the number of units received for repair during the introduced in 2017.
- **HoursInOperation:** the yearly number of hours in operation for each unit, assuming continuous operation.
- **PopulationHours:** the yearly number of operational hours for the deployed population. Note that this is using a conservative estimate of the number of hours (one year) the units have been running, since we do not have exact numbers of actual operational hours.
    - **PopulationHours** = FieldUnits * HoursInOperation * OperationFactor
      = 9,079*8,760*0.95
      = 75,555,438 hours/year
    - **MTBF** = **PopulationHours / Repairs** = 75,555,438 / 3 = 25,185,146 hours

5 Hardware Maintainability – MTTR

Mean Time To Repair (MTTR) for hardware expresses the probability that an item will be restored to an operational state within a given period of time, when the maintenance is performed in accordance with prescribed procedures and resources.

The MTTR figure for the VCM-3 is based upon the assumption that a faulty device is exchanged with a new, and a conservative assumption that no spare units are available on-site. Three days is assumed to get a spare unit on-site and one hour to replace the unit (72 + 1) hours).
Time for regular service visits are not included as this is not necessary, the unit requires no regular hardware maintenance such as calibration.
Assumed MTTR to be used in the availability calculation:

MTTR = 72 + 1 = 73 hours.

VCM-3 life profiles														
		Temperature and humidity			Temperature cycling				Mechanical	Chemical				Induced
Phase name	Calendar time (hours)	On/Off	Ambient temperature (°C)	Relative humidity (%)	ΔT (°C)	Number of cycles (/year)	Cycle duration (hours)	Maximum Temperature during cycling (°C)	Random vibrations (Grms)	Saline pollution	Environmental pollution	Application pollution	Protection level	Π application
Onshore Wind	8 760	On	45	70	15	365	24	60	0.5	Weak	Weak	Weak	Non hermetic	1
Offshore Wind	8 760	On	45	95	20	365	24	60	0.5	Strong	Weak	Weak	Hermetic	1
Factory floor	8 760	On	45	50	10	365	24	60	0.5	Weak	Strong	Moderate	Non hermetic	1

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