CMVA Certification Program
Category 1 – Data Collection
Performance Objectives

Basis

These performance objectives define what an individual certified at Category 1 should be able to do, on the job. They are based directly on the ISO standard 18436-2:2014(E) and were prepared by members of CMVA's Training and Certification Committee.
Titles are from the ISO standard Annex A Table A.1 and are reprinted by permission. The full text of the standard is available to CMVA members under licence on www.cmva.com by clicking on the Members Only tab.
The major (but not exclusive) focus of each category is as shown in the title. Vocabulary is part of the required knowledge at each category.
The noted percentages are derived roughly from the ISO standard, which indicates the number of hours during a 30 hour course to spend on each topic.

Examination and Certification

Anyone who has mastered the indicated performance should be able to pass the associated test.
In general, there will be approximately the same percentage of exam questions on each topic as the study time suggested in the ISO standard. Each exam consists of 50 multiple choice or true/false questions, and the exam is different each time it is given.

Exam questions are straightforward. Don't look for hidden meanings. If you think a question is tricky or badly worded or unfair, note that fact on the test; it may be taken into consideration in the marking and the question will certainly be reviewed before the test is given again.
Terms in <angle brackets> are codes for the evaluation of questions after the exams are written. Ignore them.
Certification at the Category 1 level also requires the completion of a data collection practicum.

Number of Hours Allowed To Write the Exam

Category	1	2	3	4
# of questions	60	100	100	60
# of hours allowed	2	3	4	5

1. Principles of Vibration 20% - about 10 questions per exam

Throughout this section, be prepared to use both English (mils, inches per second) and metric (micrometres [μm], millimeters per second) units, as appropriate.

Definitions, Relationships

Define vibration, periodic vibration, and sine wave.
Define period and frequency. Define "1X". Define amplitude. Define overall, RMS, peak, and peak-to-peak readings.
Define time domain, time waveform, spectrum, frequency domain, and orders.
Define displacement, velocity, and acceleration, and relate them to the appropriate units, both English and metric. Identify the most typical uses for acceleration, velocity, and displacement readings both in components and frequency range of interest.
Define cycles per minute (CPM), kilocycles per minutes (KCPM), Hertz (Hz), revolutions per minutes (RPM), inches per second (in/s), millimeters per second (mm/s), centimeters per second (cm/s), mils, and micrometers.
Define natural frequency, resonance and critical speed in physical terms.

Relate real-world events to conventional patterns

Observe a periodically vibrating item such as a pendulum or spring-mass system, identify its period and frequency, and indicate its peak velocity, acceleration and displacement.

Draw the vibrating item's displacement waveform, velocity waveform, and acceleration waveform, and label the curves with the above information.

Draw the vibrating item's spectrum.

Illustrate with reference to the time waveform the use of the true peak (zero to peak) amplitude convention for obtaining overall vibration velocity and acceleration measurements.

Illustrate with reference to the time waveform the use of the peak to peak amplitude convention for overall vibration for both seismic (housing) vibration displacement measurements and shaft-relative displacement measurements.

Illustrate the use of the root mean square (RMS), peak and peak-to-peak amplitude conventions in vibration spectra (displacement, velocity and acceleration).

Recognize that some instruments take an RMS reading and multiply it by the square root of 2 to get an estimate of peak reading (often called pseudo-peak), and identify the limitations of this approach.

Calculations

Convert from Hertz (Hz) to cycles per minute (CPM), and from CPM to Hz, and be able to relate either of them to revolutions per minute (RPM) if appropriate.

Convert from in/s to mm/s and back.
Convert from cm/s to mm/s or in/s and back.
Convert from mils to micrometers and back.

For single frequency components, calculate the root mean square (RMS) from the peak reading, and the peak reading from the RMS reading.

Calculate period from frequency and frequency from period, and read them from graphs.

2. Data Acquisition 25% - about 12 questions per exam

Safety

Pay due care and attention to the safety of yourself and others. Your safety is your responsibility.

Instrument

Take good care of your instrument, paying attention to transducers, cables, batteries, and recommendations in its User's Manual.
Recognize and trouble-shoot accelerometer or cable problems by properly using the instrument's built-in check features.
Check the calibration of your instrument with its sensors periodically, as recommended in its manual, and whenever you have reason to suspect the quality of data it is generating (such as if the accelerometer was dropped). If it is not within specs, have it calibrated before collecting more data.

Sensors

Describe different types of vibration sensors and the parameter(s) they measure (accelerometer, velocity transducer, eddy probe, displacement).
Be able to identify common vibration sensors (e.g. and relate them to the type of measurement required.
Identify the physical limitations of different sensors, including frequency response and temperature limitations.
Determine when sensors need power.

Sensor Mounting; Mounted Natural frequency

Define different sensor mounting techniques and their uses. Consider handheld (probe, stinger), magnet, adhesive, wax, and stud. Name potential problems associated with different mountings.
Use the correct sensor mounting technique for the frequency range required.

Data Collecting Technique

Presence in the Plant

Make sure the appropriate people know you are collecting data at this time, as defined by plant policy (e.g. work permit, hot work permit, conversation, etc.)

Personal Observations

In addition to collecting vibration data with your instrument, make systematic observations of the machine and its environment using eyes, ears, nose and touch. Record anything that might be affecting the machine, such as speed, load, temperature, fluid, size of wood chips, position of louvers, etc. (if and only if these items change from time to time).

Observe and record potential problems. If a potentially serious problem arises (e.g. unusual loud noise, major oil leak), interrupt data collection and report it.

Collecting Vibration Data

Identify and use the proper sensor orientation for radial (horizontal and vertical) and axial readings on both vertical and horizontal units.

Acquire valid repeatable data in the correct direction at the correct test point on the correct machine, using the correct transducer and the correct frequency range, for the appropriate length of time.

Use a measurement point that provides best possible transmission of the vibration signal – e.g. solid steel between housing and bearing – and use the identical test point each time. Mark the points.

Place the accelerometer on the test point carefully, without banging it.

For hand-held readings, hold the probe firmly enough to get the reading to steady out, and keep holding it the same way until data collection on that test point is complete. Use the same technique for every reading, and make sure other data collectors at your site also use the same technique. If different people can take data 2 or 3 times in a row, and get the same result, your technique is good.

For other mounting types, make sure mounting surface on machine is clean and dry and appropriate.

Observe reading and compare to previous reading on same test point (if instrument allows) as data is being collected. If there are serious discrepancies, check further: instrument, cable, sensor in good shape, test point right, technique right, what else is going on that might cause the difference? is the unit running? – i.e. try not to go back to the office and then have to wonder about all these things.

For variable speed machines, sample speed automatically if the route is set up to do this and the appropriate speed signal (one pulse per revolution) is available, or enter speed manually as a variable or a note from a local display where appropriate.

Obtain accurate speed using strobe light when appropriate.

Collect data from any permanently mounted transducer (including continuous monitoring systems), based on the capabilities of the instrument you are using.

Computer Interaction

Take good care of your computer, paying attention to data backup (including off-site), file management, virus checking, proper storage of disks and CD's, etc.

Load the appropriate route from the computer into the instrument.

Transfer the acquired data into the computer and verify that it is appropriate and recoverable, before erasing it from the instrument.

Ensure that the database has only good data; delete any data that is shown to be erroneous.

Ensure that alarms are recorded in the database.

Data Quality

Be able to suggest bad data due to hand motion, clipped signal, improper frequency range, insufficient settling time, conflicting information, bad mounting, inappropriate scale, machine not running, vibration picked up from another machine, or instrument problems (e.g. accelerometer overload or bounce (looseness).)

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Evaluate route data and determine that it is most likely valid.

Read a spectrum and determine (on the basis of a comparison of known runspeed and frequencies apparent in the plot) that this spectrum could not have been taken on "this" machine.

If data is suspected of being bad, retake the data and review for repeatability. If possible, correct the cause.

If quality data cannot be collected, record this fact and the reasons, and do not collect data on that point.

3. Signal Processing 6% *about 3 questions per exam*

Define FFT.

Calculate "1X" from speed, or determine from spectrum, in CPM and Hertz.

Know the basic concept of an FFT representing the amplitudes and frequencies of the frequency components of a time waveform.

Identify frequency from a spectrum.

Identify overall versus waveform versus spectrum Identify vertical and horizontal scales.

4. Condition Monitoring 6% *about 3 questions per exam*

Recognize basic measurement trends that indicate developing machine faults. Identify changes in readings and patterns that may indicate faults.

For machines that have exceptions, compare current readings to their history, to related readings on similar machines, and to records of process variables that may affect vibration, and inform designated person of the results.

Generate Exception Reports and send to people designated by supervisor, as per schedule. Typically, these reports would be comprised of a list of machines that exceed alert or alarm levels, complete with the test points that exceeded limits and the overall values of the readings in question.

5. Fault Analysis 6% *about 4 questions per exam*

Know that spectrum analysis is used, in conjunction with other data, to identify common machinery faults.

Recognize spectrums typical of mass unbalance, misalignment, mechanical looseness, or journal or rolling element bearing defects.

6. Corrective Action 6% *about 3 questions per exam*

Follow all safety and other plant procedures.
Generate a work order (for approval by Category 2 person or supervisor) for further analysis when exceptions are identified.
Generate a work order (for approval by Cat 2 person or supervisor) (or follow other clearly defined plant procedures) on identification of any of the following issues:

Safety Issues, e.g.

- poor access to test point
- potential for tripping the unit
- missing or loose guards
- possibility of steam burn, etc.
- leaks of oil, water, steam, H_2S, NH_3, etc.

Process, e.g.

- needed lubrication
- needed replacement of oil or air filters
- dirty fan blades
- improperly adjusted valves

Machine Mounting Problems, e.g.

- loose grout
- cracked or damaged machinery base
- loose bolts, etc.
- broken foundation

Piping Problems, e.g.

- broken clamps
- cracks in piping
- need for adjustment in pipe supports
- pipe strain

Needed Investigations, e.g.

- checking journal bearing clearances
- unusual noises
- hot spots

Work orders or similar plant procedures are important, because they ensure that everyone in the plant knows what is required. Properly executed and finished off, they constitute a machine history that is essential for efficient teamwork and effective analysis.
Shut-down work orders are especially likely to be written by data collectors, since they are things to do when the plant is shut down for some other reason. Even lubricating something on an ad hoc basis is done via work order, since it might mean that the existing lubrication schedule needs to be altered.

In many cases, operators have to issue permits for specific work to be done; this practice ensures that operators know when the data collector is in the plant collecting data. Since they are specific, you cannot do any other work on the same permit. Even if the plant does not require formal work permits, it is important to let operators know you are working around the machinery.

7. Equipment Knowledge 25% *about 12 questions per exam*

Define and understand basic operating principles of electric motors, generators and drives; fans, pumps, compressors (not recips); rolling mills, paper machines; machine tools and gearboxes.

Within each machine identify the forces that generate vibration, both normal and abnormal.

Understand the most basic principles of machine structures and piping, and their vibration.

Know that solid steel between the machine casing and bearing provides the best transmission of the vibration signal, and mark and use that transmission path for data collection.

Identify variations in operating conditions that can affect vibration.

Define unbalance and misalignment.

Recognize how machine RPM is related to the principal frequencies at which vibration due to unbalance and misalignment show up in the spectrum.

8. Acceptance Testing 6% 3 questions per exam

Be able to carry out a vibration test procedure as defined by others.

Take due care for the specifics of using a formal procedure, following directions exactly, and recording results accurately and according to the specifications in the procedure, in enough detail that you can testify about the test and its results at a later date.

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