EXHIBIT O

TECHNICAL ASSOCIATES
BOARD OF CERTIFICATION

TABofC

2359 PERIMETER POINTE PARKWAY, SUITE 270 CHARLOTTE, NC 28208 PHONE: 704-333-9011 FAX: 704-333-1728

Vibration Analyst Classifications:

Category I:

Scope of Certification:
Personnel classified to Category I are able to perform a range of pre-defined, generally simple single-channel, machinery vibration condition monitoring activities in accordance with established procedures. All activities shall be performed under supervision.

a) know the basic principles of vibration and recognize the different units of measurement;

b) be able to collect reliable data ensuring appropriate standards of repeatability;

c) be able to identify errors in collected data;

d) be able to retrieve pre-defined measurement settings for use with vibration analysis equipment and transfer data from analysis system to a computer-based system;

e) be able to compare overall or single-value vibration measurements against pre-established alert settings;

f) be able to identify deviations from the norm for single-value vibration values and trends;

g) report on visual observations of equipment condition.

Education: Candidates do not need to provide evidence of formal education to establish eligibility for certification.

Training: Candidates seeking full certification are **required** to complete 30 hours of training based on the requirements in ISO 18436-2:2014.

Experience: Candidates seeking full certification are **required** to have a minimum of six (6) months experience in the field of machinery vibration condition monitoring and diagnostics.

Category I: Body of Knowledge/Training Topics:

Subject:	**Principles of Vibration** • Basic Motion • Period, frequency • Amplitude (Peak, Peak-to-Peak, RMS) • Parameters (displacement, velocity, acceleration) • Units, unit conversions • Time and frequency domains • Natural frequency, resonance, critical speeds
	Data Acquisition • Instrumentation • Transducers • Sensor mounting, mounted natural frequency • Test procedures • Computer database upload/download • Recognition of poor data
	Signal Processing • FFT application
	Condition Monitoring • Fault condition recognition
	Fault Analysis • General fault recognition
	Corrective Action • Basic maintenance action
	Equipment Knowledge • Electric motors, generators and drives • Pumps, fans • Compressors • Rolling mills, paper machines, other process equipment • Machine tools • Structures, piping • Gearboxes
	Acceptance Testing • Test procedure

Category II:

Scope of Certification:
Personnel classified to Category II are able to perform industrial machinery vibration measurements and basic vibration analysis using single-channel instruments, with or without phase trigger signals, according to established and recognized procedures. They require all the knowledge, experience and skills expected of Category I, and in addition they shall at least:

a) be able to define the measurement activities to be undertaken by a Category I individual in the course of routine data collection;

b) be aware of and capable of using the basic principles of signal analysis and, as such, can define acquisition and analysis settings to collect data appropriate to the machine(s) monitored;

c) be able to perform basic (single-channel) impact tests to determine natural frequencies;

d) be able to interpret and evaluate test results from routine analysis and acceptance tests in accordance with specifications and standards;

e) be able to diagnose common fault indications and recommend basic corrective actions commensurate with their area of machinery experience including carrying out single-plane balancing of rigid rotors with or without phase;

f) be able to provide technical guidance to and instruct Category I personnel.

Education: Candidates do not need to provide evidence of formal education to establish eligibility for certification.

Training: Candidates seeking full certification are **required** to complete 38 hours of training over Category I, based on the requirements in ISO 18436-2:2014.

Experience: Candidates seeking full certification are **required** to have a minimum of eighteen (18) months experience in the field of machinery vibration condition monitoring and diagnostics.

Category II: Body of Knowledge/Training Topics:

Subject:	
	Principles of Vibration • Basic motion • Period, frequency • Amplitude (Peak, Peak-to-Peak, RMS) • Parameters (displacement, velocity, acceleration) • Units, unit conversions • Time and frequency domains • Phase • Natural frequency, resonance, critical speeds
	Data Acquisition • Instrumentation • Transducers • Sensor mounting, mounted natural frequency • F_{max}, acquisition time • Proximity sensor conventions • Triggering • Test planning • Test procedures • Data formats • Recognition of poor data
	Signal Processing • Analog recording, digital sampling • FFT application • Time Windows (uniform, Hanning, flat-top) • Filters (low pass, high pass, band pass, tracking) • Anti-aliasing • Bandwidth, resolution • Noise reduction • Averaging (linear, synchronous time, exponential) • Dynamic range
	Condition Monitoring • Equipment evaluation and prioritization • Monitoring program design • Baseline assessments, trending • Route planning • Fault condition recognition
	Fault Analysis • Spectrum analysis harmonics and sidebands • Time waveform analysis • Phase analysis • Shaft centerline analysis • Enveloping • Mass unbalance • Misalignment • Mechanical looseness • Bearing defects (rolling element, journal)

	• Electric motor defects • Gearbox analysis • Resonance and critical speeds
	Corrective Action • Shaft alignment • Field balancing • Basic maintenance action
	Equipment Knowledge • Electric motors, generators and drives • Pumps, fans • Steam turbines, gas turbines • Compressors • Reciprocating machinery • Rolling mills, paper machines, other process equipment • Machine tools • Structures, piping • Gearboxes • Rolling element bearings • Journal bearings • Gearing • Coupling, belts
	Acceptance Testing • Test procedure • Specifications and standards • Reporting
	Equipment Testing and Diagnostics • Impact testing • Forced response testing
	Reference Standards • ISO standards • IEC standards • Relevant national standards and other specifications
	Reporting and Documentation • Condition monitoring reports • Vibration diagnostics reports
	Fault Severity Determination • Spectrum analysis • Time waveform analysis, orbit analysis • Levels: Overall, narrowband, component • Severity charts, graphs and formulas

Category III:

Scope of Certification:
Personnel classified to Category III require all the knowledge, experience and skills expected of personnel classified to Categories I and II, and in addition shall at least:

a) be able to design, direct and establish routine condition monitoring programs and non-routine investigations for the purpose of fault diagnosis;

b) be able to specify the appropriate vibration instrumentation hardware, software and processing for portable monitoring systems, permanently installed surveillance systems and equipment protection systems;

c) have an in-depth knowledge of the principles and techniques of machinery vibration analysis and be able to make initial diagnoses of suspected faults beyond the range of commonly encountered issues. This should include, but not be limited to, the use of frequency spectra, time waveforms and orbits, transfer functions, basic operating deflection shapes, and acceleration enveloping under both steady state and transient conditions with or without a phase trigger;

d) be able to manage such condition monitoring programs, evaluate the alarm settings, write working procedures and specify vibration acceptance testing procedures;

e) be able to initiate and validate machinery corrective actions including in situ two-plane rigid rotor balancing;

f) be able to recommend restrictions to machine operation;

g) be able to understand and direct, when necessary, alternative condition monitoring technologies to verify or investigate issues raised through routine data collection;

h) be able to provide technical guidance to and instruct Category I and II personnel, and, subject to agreement with the employer or client, deem them competent to carry out certain duties which would normally be outside the scope of those competencies.

It is the responsibility of the employer or client to ensure that Category III personnel have the necessary competency in the required management skills, e.g. creating budgets, preparing cost justifications and managing personnel development.

Education: It is recommended that candidates are familiar with current vibration analysis technology. Successful completion of two or more years of mechanical technology or engineering at an accredited college, university or technical school is recommended.

Training: Candidates seeking full certification are **required** to complete 38 hours of training over Category II, based on the requirements in ISO 18436-2:2014.

Experience: Candidates seeking full certification are **required** to have a minimum of thirty-six (36) months experience in the field of machinery vibration condition monitoring and diagnostics.

Prerequisite: Candidates seeking full certification are **required** to have current and valid certifications at ISO Category II.

Category III: Body of Knowledge/Training Topics:

Subject:	**Principles of Vibration** • Basic motion • Period, frequency • Amplitude (Peak, Peal-to-Peak, RMS) • Parameters (displacement, velocity, acceleration) • Units, unit conversions • Time and frequency domains • Vectors, modulation • Phase • Natural frequency, resonance, critical speeds • Force, response, damping, stiffness
	Data Acquisition • Instrumentation • Dynamic range, signal-to-noise ratio • Transducers • Sensor mounting, mounted natural frequency • F_{max}, acquisition time • Proximity sensor conventions • Triggering • Test planning • Test procedures • Data formats • Recognition of poor data
	Signal Processing • Analog recording, digital sampling • FFT computation • Time Windows (uniform, Hanning, flat-top) • Filters (low pass, high pass, band pass, tracking) • Anti-aliasing • Bandwidth, resolution • Noise reduction • Averaging (linear, synchronous time, exponential) • Dynamic range • Spectral maps
	Condition Monitoring • Computer database set-up, computer database maintenance • Monitoring program design • Alarms set-up (narrowband, envelope) • Baseline assessments, trending • Route planning • Alternative technologies (e.g. infrared thermographic testing, acoustic emission testing, ultrasonic testing, lubricant management, tribology and wear debris analysis, motor current analysis)

	Fault Analysis • Spectrum analysis harmonics and sidebands • Time waveform analysis • Phase analysis • Transient analysis • Orbit analysis • Shaft centerline analysis • Enveloping • Mass unbalance • Misalignment • Mechanical looseness • Rubs, instabilities • Bearing defects (rolling element, journal) • Electric motor defects • Flow induced vibration, aerodynamics and liquids • Gearbox analysis • Resonance and critical speeds • Turbomachinery
	Corrective Action • Shaft alignment • Field balancing • Replacement of machine parts • Flow control • Isolation and damping • Resonance control • Basic maintenance action
	Equipment Knowledge • Electric motors, generators and drives • Pumps, fans • Steam turbines, gas turbines • Compressors • Reciprocating machinery • Rolling mills, paper machines, other process equipment • Machine tools • Structures, piping • Gearboxes • Rolling element bearings • Journal bearings • Gearing • Couplings, belts
	Acceptance Testing • Specifications and standards • Reporting
	Equipment Testing and Diagnostics • Impact testing • Forced response testing • Transient analysis • Transfer functions

	• Cross channel phase, coherence • Operating deflection shapes • Modal analysis
	Reference Standards • ISO standards • IEC standards • Relevant national standards and other specifications
	Reporting and Documentation • Condition monitoring reports • Vibration diagnostics reports
	Fault Severity Determination • Spectrum analysis • Time waveform analysis, orbit analysis • Levels: Overall, narrowband, component • Severity charts, graphs and formulas

Category IV:

Scope of Certification:
Personnel classified to Category IV require all the knowledge and skills expected of Category I, Category II and Category III personnel. In addition, they shall be able to direct and audit condition monitoring strategies.

Employers should recognize that a Category IV individual is likely to have a broad technical knowledge and experience of a range of machine situations and techniques, and an in-depth knowledge of a selection of them.

In addition, personnel classified to Category IV shall at least:

a) be able to apply vibration theory and techniques, including measurement and interpretation of multi-channel spectral results such as frequency response functions, phase and coherence;

b) be able to understand and perform signal analysis, including understanding of frequency and time domain processing, including orbits and their limitations;

c) be able to determine the natural frequencies, mode shapes and damping of systems, components and assemblies;

d) be able to determine and assess the operating deflection shapes of machines and connected structures and recommend means for correction;

e) be able to use generally recognized advanced techniques for vibration analysis, parameter identification and fault diagnosis;

f) be able to apply the basic principles of rotor bearing dynamics to vibration diagnosis;

g) understand and apply advanced two-plane influence coefficient or static and couple balancing theory;

h) be able to recommend corrective actions or design modifications, including component change or repair, isolation, damping, change of stiffness and change of mass;

i) be able to interpret and evaluate codes of practice and specifications published in international standards and other documents;

j) be able to recognize vibration caused by gas pulsation in machines, such as reciprocating machines and screw compressors, be able to measure the necessary parameters, and recommend means for correction;

k) be able to recommend corrective actions for resilient mounting and other hold down and foundation problems.

Education: It is recommended that candidates seeking certification are familiar with current vibration analysis technology. Successful completion of two or more years of mechanical technology or engineering at an accredited college, university or technical school is recommended.

Training: Candidates seeking full certification are **required** to complete 64 hours of training over Category III, based on the requirements in ISO 18436-2:2014.

Experience: Candidates seeking full certification are **required** to have a minimum of sixty (60) months experience in the field of machinery vibration condition monitoring and diagnostics.

Prerequisite: Candidates seeking full certification are **required** to have current and valid certifications at ISO Category III.

Category IV: Body of Knowledge/Training Topics:

Subject:	**Principles of Vibration** • Vectors, modulation • Phase • Natural frequency, resonance, critical speeds • Force, response, damping, stiffness • Instabilities, non-linear systems
	Data Acquisition • Instrumentation • Dynamic range, signal-to-noise ratio • Test planning • Test procedures
	Signal Processing • RMS and peak detection • Analog to digital conversion • Analog recording, digital sampling • FFT Computation • Filters (low pass, high pass, band pass, tracking) • Anti-aliasing • Bandwidth, resolution • Noise reduction • Averaging (linear, synchronous time, exponential) • Dynamic range • Signal-to-noise ratio • Spectral maps
	Condition Monitoring • Monitoring program design • Alternative technologies (e.g. infrared thermographic testing, acoustic emission testing, ultrasonic testing, lubricant management, tribology and wear debris analysis, motor current analysis)
	Fault Analysis • Spectrum analysis harmonics and sidebands • Time waveform analysis • Phase analysis • Transient analysis • Orbit analysis • Shaft centerline analysis • Enveloping • Rubs, instabilities • Electric motor defects • Flow induced vibration, aerodynamics and liquids • Resonance and critical speeds • Turbomachinery
	Corrective Action • Field balancing • Flow control

	• Isolation and damping • Resonance control
	Equipment Testing and Diagnostics • Impact testing • Forced response testing • Transient analysis • Transfer functions • Damping evaluation • Cross channel phase, coherence • Operating deflection shapes • Modal analysis • Torsional vibration
	Reference Standards • ISO standards • IEC standards • Relevant national standards and other specifications
	Reporting and Documentation • Vibration diagnostics reports
	Fault Severity Determination • Spectrum analysis • Time waveform analysis, orbit analysis • Severity charts, graphs and formulas
	Rotor and Bearing Dynamics • Rotor characteristics • Bearing characteristics • Rotor Balancing