Q. In a meeting with Hydro management on May 29, 2015, Liberty noted that there was no evidence provided on the quality of Hydro QA/QC oversight of vendor maintenance on the DC motors. Please provide documentation on Hydro's oversight of such activities and explain why it believes this oversight is appropriate.

A. Hydro utilizes external expert motor repair shops [ ] through publicly tendered motor maintenance contracts. Hydro's oversight of the contractors includes the requirements of its motor repair contractors to follow *ANSI/EASA Standard AR100 Recommended Practice for the Repair of Rotating Electrical Apparatus* for quality assurance purposes. Within that standard, Section 4, attached as PR-PUB-NLH-183 Attachment 1, deals with the post repair testing protocol. The motor is not returned to Hydro unless the motor has passed this quality testing. Successful motor test results accompany the motor when returned to Hydro.

Since the incident on January 11, 2013 and Hydro's subsequent investigation, Hydro further performs its own in-house quality control testing. This return to service testing of the DC lube oil pump motor specifically consists of verifying oil pressure, voltage of the armature, field voltage, current of the armature, field current, and motor speed, as well as a 25-minute running function test in addition to the pre-incident return to service tests as outlined in Hydro's response to PR-PUB-NLH-181. Hydro believes its oversight to be appropriate pre- January 11, 2013 in that Hydro specifically utilized an expert motor repair shop to perform the work to ANSI/EASA Standard AR100, including quality control testing in shop before releasing the motor back to Hydro. [ ] However, given the January 11, 2013 experience and investigation, following the incident Hydro has enhanced its own internal quality control return to service testing. In addition, the existing DC lube oil pump return to service testing protocol was reviewed following the January 2013 investigation and the updated oil pressure verification was added similar to the change made in the weekly testing protocol.

Section 4
Testing

4.1 SAFETY CONSIDERATIONS

See Appendix for safety considerations.

4.2 INSULATION CONDITION INSPECTION AND TESTS

Tests should be performed to indicate the suitability of the insulation for continued operation. Insulation resistance tests should be performed with acceptable results before the high-potential tests. Other tests, indicated below, may also be applied. All test results should be retained. Trends in results are often better condition indicators than the absolute values (Reference: IEEE Stds. 95).

4.2.1 Insulation Resistance Test

Test voltage should be applied for one minute. (Reference: IEEE Stds. 43, Sec. 5.4 and 12.2.)

GUIDELINES FOR DC VOLTAGES TO BE APPLIED DURING INSULATION RESISTANCE TEST

Winding Rated Voltage (V)[a]	Insulation Resistance Test Direct Voltage (V)
<1000	500
1000 - 2500	500 - 1000
2501 - 5000	1000 - 2500
5001 - 12,000	2500 - 5000
>12,000	5000 - 10,000

[a] Rated line-to-line voltage for three-phase AC machines, line-to-ground for single-phase machines, and rated direct voltage for DC machines or field windings.

Reference: IEEE Stds. 43, Table 1.

4.2.2 Polarization Index (P.I.) Test

The polarization index (P.I.) test should be performed at the same voltage as the test in Paragraph 4.2.1 for ten minutes. The recommended minimum value of polarization index for windings rated Class B and higher is 2.0 (References: IEEE Stds. 43, Sec. 9.2; and IEEE Stds. 432, App. A2).

If the one minute insulation resistance is above 5000 megohms, the calculated polarization index (P.I.) may not be meaningful. In such cases, the P.I. may be disregarded as a measure of winding condition (Reference: IEEE 43, Sec. 5.4 and 12.2).

4.2.3 Insulation Power Factor Tests

Insulation power factor, dissipation factor, and tip-up tests may be performed on large machines. Interpretation of results is by comparison with

RECOMMENDED MINIMUM INSULATION RESISTANCE VALUES AT 40° C (All Values in MΩ)

Minimum Insulation Resistance	Test Specimen
$IR_{1min} = kV + 1$	For most windings made before about 1970, all field windings, and others not described below.
$IR_{1min} = 100$	For most DC armature and AC windings built after about 1970 (form-wound coils).
$IR_{1min} = 5$	For most machines with random-wound stator coils and form-wound coils rated below 1 kV.

Notes:

1 IR_{1min} is the recommended insulation resistance, in megohms, at 40° C of the entire machine winding.

2 kV is the rated machine terminal-to-terminal voltage, in rms kV.

Reference: IEEE Stds. 43, Table 3.

results of tests on similar machines. No standard interpretation of results has been established (Reference: IEEE Stds. 432, Sec. 8.1).

4.2.4 Step Voltage Test

Step voltage tests are useful if performed at regular maintenance intervals. Changes in results may indicate insulation degradation (Reference: IEEE Stds. 95).

4.2.5 Turn-To-Turn Test

Accepted methods of testing turn-to-turn insulation vary widely. No single standard procedure applies, although several standards touch on the subject (IEEE Stds. 432, 522, and 792; and NEMA Stds. MG 1, 12.5).

4.2.6 Surge Comparison Testing

The surge comparison test is most often applied to winding circuits using a test voltage of twice the circuit rating plus 1000 volts.

4.2.7 Interlaminar Insulation Test

Defects in laminated cores can be detected by loop or core tests (Reference: IEEE Stds. 432, Sec. 9.1, App. A4).

4.2.8 Bearing Insulation Test

Bearing insulation should be tested with a 500V megohmmeter. Insulation resistance should be 1 megohm or greater.

4.3 RECOMMENDED WINDING TESTS

Windings should be tested to ensure that there are no grounds, short circuits, open circuits, incorrect connections or high resistance connections.

4.3.1 Stator and Wound-Rotor Windings

One or more of the following tests should be performed:

(1) Insulation resistance test.
(2) Winding resistance test.
(3) Growler test.
(4) Phase-balance test.
(5) Surge comparison test.
(6) Polarity test.
(7) Ball rotation test (low voltage energization).

4.3.2 Squirrel Cage Windings

One or both of these tests should be performed:

(1) Growler test.
(2) Single-phase test.

4.3.3 Armature Windings

One or more of the following tests should be performed:

(1) Insulation resistance test.
(2) Growler test.
(3) Surge comparison test.
(4) Bar-to-bar resistance or voltage drop test.

4.3.4 Shunt, Series, Interpole, Compensating and Synchronous Rotor Windings

One or more of the following tests should be performed:

(1) Insulation resistance test.
(2) Winding resistance test.
(3) Surge comparison test.
(4) Voltage drop test (DC or AC voltage), coils in series.
The variation in DC voltage drops should not be greater than 5% between coils of same field circuit.
10% variation in AC test results is acceptable if the DC test is within limit.

4.3.5 Interconnection of Windings

Shunt, series, interpole, compensating, and synchronous rotor windings should be tested to ensure that the polarities and connections are correct. Terminal and lead markings should comply with Subsection 1.5.

4.4 HIGH-POTENTIAL TESTS

High-potential tests should be performed on windings and certain accessories of electrical machines at a specified voltage. To avoid excessive stressing of the insulation, repeated application of the high-potential test voltage is not recommended.

Machines to be tested must be clean and dry. Inspection and insulation resistance tests with acceptable results should be performed before the high-potential tests. Insulation resistance tests should be repeated at the completion of the high-potential tests.

When a high-potential test is conducted on an assembled brushless exciter and synchronous machine field winding, the brushless circuit components (diodes, thyristors, etc.) should be short-circuited (not grounded) during the test.

High-potential tests should be successively applied between each winding or electric circuit under test and the frame (or core) of the machine. All other windings or electric circuits not under test should be connected to the frame (or core).

Capacitors of capacitor-type motors must be left connected to the winding in the normal manner for machine operation (running or starting).

Electrical machines may be tested using AC or DC high-potential test equipment. A DC instead of an AC voltage may be used for high-potential tests. In such cases, the DC test voltage should be 1.7 times the specified AC voltage. A failure under test can be less damaging to the winding if a DC voltage is used.

AC high-potential testing should be performed by applying specified voltage at 50-60 Hz continuously for one minute.

DC high-potential testing should be performed by applying specified voltage for a duration of one minute after test voltage is reached. The DC potential should be increased gradually to the desired test voltage in order to limit the charging current.

Caution: After completion of a DC high-potential test, the winding must be grounded to the frame (or core) until the charge has decayed to zero. (References: IEEE Stds. 4 and 95; and NEMA Stds. MG 1, 3.1.1.)

4.4.1 Windings

4.4.1.1 New Windings

High-potential tests should be applied as specified in Table 4-1 for AC voltage and Table 4-2 for DC voltage. To avoid excessive stressing of the insulation, repeated application of the high-potential test voltage is not recommended. Immediately after rewind, when equipment is installed or assembled and a high-potential test of the entire assembly is required, it is recommended that the test voltage not exceed 80% of the original test voltage. The tests should be applied once only at the specified voltage. (Reference: NEMA Stds. MG 1, 12.3.)

4.4.1.2 Reconditioned Windings

High-potential tests for reconditioned windings should be performed at 65% of the new winding test value.

4.4.1.3 Windings Not Reconditioned

Machines with windings not reconditioned should have an insulation resistance test instead of a high-potential test.

4.4.2 Accessories

4.4.2.1 New Accessories

Accessories such as surge capacitors, lightning arresters, current transformers, etc., which have leads connected to the machine terminals should be disconnected during the test, with the leads connected together and to the frame or core. These accessories should have been subjected to the high-potential test applicable to the class of machine at their point of manufacture. Capacitors of capacitor-type motors must be left connected to the winding in the normal manner for machine operation (running or starting).

Component devices and their circuits, such as space heaters and temperature sensing devices in contact with the winding (thermostats, thermocouples, thermistors, resistance temperature detectors, etc.), connected other than in the line circuit, should be connected to the frame or core during machine winding high-potential tests. Each of these component device circuits, with leads connected together, should then be tested by applying a voltage between the circuit and the frame or core. The high-potential tests should be applied as specified in Table 4-3 for AC voltage and Table 4-4 for DC voltage. During each device circuit test, all other machine windings and components should be connected together and to the frame or core. (Reference: NEMA Stds. MG 1, 3.1.8.)

4.4.2.2 Accessories of Machines with Reconditioned Windings

The high-potential test for accessory circuits of reconditioned machines should be performed at 65% of the new device test value.

4.4.2.3 Accessories of Machines with Windings Not Reconditioned

Accessory circuits of machines which have not had their windings reconditioned should have an insulation resistance test instead of a high-potential test.

4.5 NO-LOAD TESTS

4.5.1 Speed

For AC motors, no-load running tests should be made at rated voltage and rated frequency. The speed should be measured and compared with nameplate speed.

Shunt-wound and compound-wound DC motors should be run with rated voltage applied to the armature, and rated current applied to the shunt field. The speed should be measured and compared with nameplate speed.

Series-wound motors should be separately excited when tested due to danger of runaway.

DC generators should be driven at rated speed with rated current applied to the shunt field. The output voltage should be measured and compared with rated voltage.

4.5.2 Current

No-load current should be recorded.

4.5.3 Cooling System

The cooling system should be verified as being operational.

4.5.4 Sound Level

Tests may be made for sound level as an indication of fault or as an irritation to those in the machine ambient (Reference: NEMA Stds. MG 1, Part 9).

4.5.5 Bearing Temperature

Ambient and bearing housing temperatures may be measured periodically until temperatures are stabilized.

4.5.6 Vibration Tests

The vibration tests should be in accordance with NEMA Stds. MG 1, 7 for standard machines, as arranged with the customer, or as necessary to check the operating characteristics of the machine. When there are special requirements, i.e., lower than standard levels of vibration for a machine, NEMA Stds. MG 1, 7 for special machines is recommended.

The unfiltered vibration limits for resiliently mounted standard machines (having no special vibration requirements), based on rotational speed, are shown in Table 4-5. Vibration levels for speeds above 1200 rpm are based on the peak velocity of 0.15 inch per second (3.8 mm/s). Vibration levels for speeds below about 1200 rpm are based on the peak velocity equivalent of 0.0025 inch (0.0635 mm) peak-to-peak displacement. For machines with rigid mounting, multiply the limiting values by 0.8.

Note: International standards specify vibration velocity as rms in mm/s. To obtain an approximate metric rms equivalent, multiply the peak vibration in in/s by 18 (Reference: NEMA Stds. MG 1, 7.8).

4.6 TESTS WITH LOAD

Tests with load may be made as arranged with the customer or as necessary to check the operating characteristics of the machine (References: IEEE Stds. 112 and 115 and NEMA Stds. MG-1).

4.7 INSTRUMENT CALIBRATION

Each instrument and transducers, if applicable, required for test results should be calibrated at least annually against standards traceable to the National Institute of Standards and Technology (NIST) or equivalent standards laboratories (References: ANSI/NCSL Z540-1-1994 and ISO 10012).

Table 4-1. HIGH-POTENTIAL TEST USING AC

NEW WINDINGS

<table>
<tr><th>DESCRIPTION OF MACHINE</th><th colspan="2">EFFECTIVE AC HIGH-POTENTIAL TEST VOLTAGE</th></tr>
<tr><th>AC INDUCTION MACHINES AND NONEXCITED SYNCHRONOUS MACHINES</th><th>STATOR WINDING</th><th>ROTOR WINDING</th></tr>
<tr><td>Motors rated 0.5 hp and less, generators rated 373 watts (or equivalent) and less, and for operation on circuits:
a) 250 volts or less</td><td>1000 volts</td><td rowspan="3">1000 volts + 2 times the secondary voltage</td></tr>
<tr><td>b) Above 250 volts</td><td rowspan="3">1000 volts + 2 times the rated voltage of the machine</td></tr>
<tr><td>Motors rated greater than 0.5 hp, generators rated greater than 373 watts (or equivalent), and for:
a) Non-reversing duty</td></tr>
<tr><td>b) Reversing duty</td><td>1000 volts + 4 times the secondary voltage</td></tr>
</table>

<table>
<tr><th>AC SYNCHRONOUS MACHINES WITH SLIP RINGS</th><th>STATOR WINDING</th><th>FIELD WINDING</th></tr>
<tr><td rowspan="2">MOTORS</td><td rowspan="2">1000 volts + 2 times the rated voltage of the motor</td><td>Starting Method 1*
10 times the rated excitation voltage but not less than 2500 volts nor more than 5000 volts</td></tr>
<tr><td>Starting Method 2*
2 times the IR drop across the resistor but not less than 2500 volts</td></tr>
<tr><td>GENERATORS
a) With stator (armature) or field windings rated 35 volts or less</td><td colspan="2">500 volts</td></tr>
<tr><td>b) With output less than 250 watts and rated voltage 250 volts or less</td><td colspan="2">1000 volts</td></tr>
<tr><td>c) With rated excitation voltage 500 volts DC or less</td><td rowspan="2">1000 volts + 2 times the rated voltage of the generator</td><td>10 times the rated excitation voltage but not less than 1500 volts</td></tr>
<tr><td>d) With rated excitation voltage above 500 volts DC</td><td>4000 volts + 2 times the rated excitation voltage</td></tr>
</table>

* Starting Method 1: For a motor to be started with its field short-circuited or closed through an exciting armature.

Starting Method 2: For a motor to be started with a resistor in series with the field winding. The IR drop is taken as the product of the resistance and the current that would circulate in the field winding if short-circuited on itself at the specified starting voltage (Reference: NEMA Stds. MG 1, 21.22.3).

Table 4-1. HIGH-POTENTIAL TEST USING AC

NEW WINDINGS—continued

<table>
<tr><th>DESCRIPTION OF MACHINE</th><th colspan="2">EFFECTIVE AC HIGH-POTENTIAL TEST VOLTAGE</th></tr>
<tr><th>AC BRUSHLESS SYNCHRONOUS MACHINES AND EXCITERS</th><th>MAIN STATOR WINDING</th><th>MAIN FIELD WINDING AND EXCITER ARMATURE</th></tr>
<tr><td>Armature (stator) or field windings rated 35 volts or less</td><td colspan="2">500 volts</td></tr>
<tr><td>With rated output less than 250 watts and 250 volts or less</td><td colspan="2">1000 volts</td></tr>
<tr><td>With rated main excitation voltage 350 volts DC or less</td><td rowspan="2">1000 volts + 2 times the rated voltage of the machine</td><td>10 times the rated excitation voltage but not less than 1500 volts*</td></tr>
<tr><td>With rated main excitation voltage greater than 350 volts DC</td><td>2800 volts + 2 times the rated excitation voltage*</td></tr>
<tr><th>BRUSHLESS EXCITERS</th><th>EXCITER STATOR (FIELDS)</th><td rowspan="4">Alternatively, the brushless exciter rotor (armature) shall be permitted to be tested at 1000 volts plus 2 times the rated nonrectified alternating current voltage but in no case less than 1500 volts.*</td></tr>
<tr><td>a) With exciter field excitation voltage not greater than 350 volts DC</td><td>10 times the rated excitation voltage but not less than 1500 volts</td></tr>
<tr><td>b) With exciter field excitation voltage greater than 350 volts DC</td><td>2800 volts + 2 times the rated excitation voltage</td></tr>
<tr><td>c) With AC-excited stators (fields)</td><td>1000 volts + 2 times the AC-rated voltage of the stator</td></tr>
</table>

<table>
<tr><th>DC MOTORS AND GENERATORS</th><th>FIELD WINDING</th><th>ARMATURE WINDING</th></tr>
<tr><td>With armature or field windings rated 35 volts or less</td><td colspan="2">500 volts</td></tr>
<tr><td>Motors rated 0.5 hp and less, generators rated less than 250 watts, and for operation on circuits:
a) 240 volts or less</td><td colspan="2">1000 volts</td></tr>
<tr><td>b) Above 240 volts</td><td colspan="2" rowspan="2">1000 volts + 2 times the rated voltage of the machine</td></tr>
<tr><td>Motors rated greater than 0.5 hp and generators rated 250 watts and larger</td></tr>
</table>

<table>
<tr><th>UNIVERSAL MOTORS RATED 250 VOLTS OR LESS</th><th>FIELD WINDING</th><th>ARMATURE WINDING</th></tr>
<tr><td>Rated 0.5 hp and less, except motors marked for portable tools</td><td colspan="2">1000 volts</td></tr>
<tr><td>Rated greater than 0.5 hp, and all motors marked for portable tools</td><td colspan="2">1000 volts + 2 times the rated voltage of the motor</td></tr>
</table>

* The brushless circuit components (diodes, thyristors, etc.) should be short-circuited (not grounded) during the test.

References: NEMA Stds. MG 1, 12.3, 15.48, 20.17, 21.22.4, 21.22.5, 23.20 and 24.49.

Table 4-2. HIGH-POTENTIAL TEST USING DC

NEW WINDINGS

<table>
<tr><th>DESCRIPTION OF MACHINE</th><th colspan="2">DC HIGH-POTENTIAL TEST VOLTAGE</th></tr>
<tr><th>AC INDUCTION MACHINES AND NONEXCITED SYNCHRONOUS MACHINES</th><th>STATOR WINDING</th><th>ROTOR WINDING</th></tr>
<tr><td>Motors rated 0.5 hp and less, generators rated 373 watts (or equivalent) and less, and for operation on circuits:
a) 250 volts or less</td><td>1700 volts</td><td rowspan="3">1700 volts + 3.4 times the secondary voltage</td></tr>
<tr><td>b) Above 250 volts</td><td rowspan="3">1700 volts + 3.4 times the rated voltage of the machine</td></tr>
<tr><td>Motors rated greater than 0.5 hp, generators rated greater than 373 watts (or equivalent), and for:
a) Non-reversing duty</td></tr>
<tr><td>b) Reversing duty</td><td>1700 volts + 6.8 times the secondary voltage</td></tr>
</table>

<table>
<tr><th>AC SYNCHRONOUS MACHINES WITH SLIP RINGS</th><th>STATOR WINDING</th><th>FIELD WINDING</th></tr>
<tr><td rowspan="2">MOTORS</td><td rowspan="2">1700 volts + 3.4 times the rated voltage of the motor</td><td>Starting Method 1*
17 times the rated excitation voltage but not less than 4250 volts nor more than 8500 volts</td></tr>
<tr><td>Starting Method 2*
3.4 times the IR drop across the resistor but not less than 4250 volts</td></tr>
<tr><td>GENERATORS
a) With stator (armature) or field windings rated 35 volts or less</td><td colspan="2">850 volts</td></tr>
<tr><td>b) With output less than 250 watts and rated voltage 250 volts or less</td><td colspan="2">1700 volts</td></tr>
<tr><td>c) With rated excitation voltage 500 volts DC or less</td><td rowspan="2">1700 volts + 3.4 times the rated voltage of the generator</td><td>17 times the rated excitation voltage but not less than 2550 volts</td></tr>
<tr><td>d) With rated excitation voltage above 500 volts DC</td><td>6800 volts + 3.4 times the rated excitation voltage</td></tr>
</table>

* Starting Method 1: For a motor to be started with its field short-circuited or closed through an exciting armature.

Starting Method 2: For a motor to be started with a resistor in series with the field winding. The IR drop is taken as the product of the resistance and the current that would circulate in the field winding if short-circuited on itself at the specified starting voltage (Reference: NEMA Stds. MG 1, 21.22.3).

Caution: After completion of a DC high-potential test, the winding must be grounded to the frame (or core) until the charge has decayed to zero. (References: IEEE Stds. 4 and 95; and NEMA Stds. MG 1, 3.1.)

Table 4-2. HIGH-POTENTIAL TEST USING DC

NEW WINDINGS—continued

DESCRIPTION OF MACHINE	DC HIGH-POTENTIAL TEST VOLTAGE	
AC BRUSHLESS SYNCHRONOUS MACHINES AND EXCITERS	**MAIN STATOR WINDING**	**MAIN FIELD WINDING AND EXCITER ARMATURE**
Armature (stator) or field windings rated 35 volts or less	850 volts	
With rated output less than 250 watts and 250 volts or less	1700 volts	
With rated main excitation voltage 350 volts DC or less	1700 volts + 3.4 times the rated voltage of the machine	17 times the rated excitation voltage but not less than 2550 volts*
With rated main excitation voltage greater than 350 volts DC		4750 volts + 3.4 times the rated excitation voltage*
BRUSHLESS EXCITERS	**EXCITER STATOR (FIELDS)**	Alternatively, the brushless exciter rotor (armature) shall be permitted to be tested at 1700 volts plus 3.4 times the rated nonrectified alternating current voltage but in no case less than 2550 volts.*
a) With exciter field excitation voltage not greater than 350 volts DC	17 times the rated excitation voltage but not less than 2550 volts	
b) With exciter field excitation voltage greater than 350 volts DC	4750 volts + 3.4 times the rated excitation voltage	
c) With AC-excited stators (fields)	1700 volts + 3.4 times the AC-rated voltage of the stator	

DC MOTORS AND GENERATORS	FIELD WINDING	ARMATURE WINDING
With armature or field windings rated 35 volts or less	850 volts	
Motors rated 0.5 hp and less, generators rated less than 250 watts, and for operation on circuits: a) 240 volts or less	1700 volts	
b) Above 240 volts	1700 volts + 3.4 times the rated voltage of the machine	
Motors rated greater than 0.5 hp and generators rated 250 watts and larger		

UNIVERSAL MOTORS RATED 250 VOLTS OR LESS	FIELD WINDING	ARMATURE WINDING
Rated 0.5 hp and less, except motors marked for portable tools	1700 volts	
Rated greater than 0.5 hp, and all motors marked for portable tools	1700 volts + 3.4 times the rated voltage of the motor	

* The brushless circuit components (diodes, thyristors, etc.) should be short-circuited (not grounded) during the test.
References: NEMA Stds. MG 1, 12.3, 15.48, 20.17, 21.22.4, 21.22.5, 23.20 and 24.49.

Caution: After completion of a DC high-potential test, the winding must be grounded to the frame (or core) until the charge has decayed to zero. (References: IEEE Stds. 4 and 95; and NEMA Stds. MG 1, 3.1.)

Table 4-3. HIGH-POTENTIAL TEST USING AC

NEW ACCESSORIES

Accessory*	Rated Voltage**	Effective AC High-Potential Test Voltage
Thermostats	600 volts	1000 volts + 2 times the rated voltage of the accessory or equal to the high-potential test voltage of the machine, whichever is lower.
Thermocouples Thermistors Resistance temperature dectectors (RTDs)	50 volts	
Space heaters	All	

* Accessories not connected in the line circuit.
** Unless otherwise stated.

Reference: NEMA Stds. MG 1, 3.1.8.

Table 4-4. HIGH-POTENTIAL TEST USING DC

NEW ACCESSORIES

Accessory*	Rated Voltage**	DC High-Potential Test Voltage
Thermostats	600 volts	1700 volts + 3.4 times the rated voltage of the accessory or equal to the high-potential test voltage of the machine, whichever is lower.
Thermocouples Thermistors Resistance temperature dectectors (RTDs)	50 volts	
Space heaters	All	

* Accessories not connected in the line circuit.
** Unless otherwise stated.

Reference: NEMA Stds. MG 1, 3.1.8.

Table 4-5. UNFILTERED VIBRATION LIMITS

RESILIENTLY MOUNTED MACHINES

RPM @ 60 Hz	Velocity in/s peak	Velocity mm/s	RPM @ 50 Hz	Velocity in/s peak	Velocity mm/s
3600	0.15	3.8	3000	0.15	3.8
1800	0.15	3.8	1500	0.15	3.8
1200	0.15	3.8	1000	0.13	3.3
900	0.12	3.0	750	0.10	2.5
720	0.09	2.3	600	0.08	2.0
600	0.08	2.0	500	0.07	1.7

Note: For machines with rigid mounting, multiply the limiting values by 0.8.

Reference: NEMA Stds. MG 1, 7.8.2, Table 7-1.