

SUBJECT:

Shaft Bonding (Grounding) in Hazardous (Classified) Locations

SUMMARY:

Per the recently revised IEEE Standard 841-2021, shaft bonding (grounding) devices are now acceptable options for 841-compliant motors. In hazardous (Class I, Division 2 or Zone 2) environments, shaft bonded 841-compliant motors are permitted when the application has been properly reviewed for acceptability. One method to determine whether shaft bonding is permissible for a given application is to calculate the maximum shaft voltage discharge energy and compare it with the minimum ignition energy of the hazardous gases that may be present. These calculations are described, and a spreadsheet is provided for performing them, in IEEE Std 1349-2021. Shaft bonding is expected to be permissible in applications involving most gases, except for hydrogen and acetylene.

BACKGROUND:

Many chemical processing applications, particularly oil and gas processing, involve the presence of potentially explosive gases. NFPA 70 *National Electrical Code (NEC)* classifies such environments, in NEC 500.5(B), as Class I, Division 1 or Zone 1 (consistent hazard), and Class I, Division 2 or Zone 2 (potential or intermittent hazard). In these applications, adjustable speed drives (ASDs) are often used to control electric motors, both to allow precise speed/torque control and to save on energy costs. ASDs, however, are known to produce a capacitive voltage on the shaft, which can discharge through the bearings, causing electrical discharge machining (EDM) damage and premature bearing failure.

EDM damage can effectively be mitigated by electrically bonding the motor shaft to the frame, with a shaft bonding ring or other shaft bonding device. (These devices are commonly called shaft grounding devices, but this bulletin will use the more accurate term shaft bonding.)

NEC considers shaft bonding devices to be sparking devices. It is assumed that their use in classified areas comes with a risk of explosion. Prior to NEC-2017, shaft bonding was forbidden in Class I, Division 1 and Class I, Division 2 environments, except inside of explosionproof enclosures.

Underwriters Laboratory (UL) developed an approved set of procedures for installing AEGIS® Shaft Grounding Rings inside of explosionproof (XP) motors, out of the flame path. There are dozens of motor repair companies in the US with UL approval for this installation. Additionally, several major motor manufacturers offer lines of XP motors with shaft bonding rings factory-installed.

XP motors are typically only used in Class I, Div. 1 environments. XP motors could be used in Class I, Div. 2 environments, but more often, IEEE Std 841-compliant motors are used. The IEEE Std 841 did not previously allow shaft bonding except in "IEEE 841 Std Features" motors.

RECENT DEVELOPMENTS:

Since the 2017 edition, NEC has relaxed the rules for shaft bonding in Class I Div. 2 locations. NEC-2020 Section 501.125(B)(5) states:

A sliding contact shaft bonding device used for the purpose of maintaining the rotor at ground potential shall be permitted where the potential discharge energy is determined to be nonincendive for the application. The shaft bonding device shall be permitted to be installed on the inside or the outside of the motor.

The 2018 Canadian Electrical Code (CEC) also reflected this change, in Subrule 18-150(4):

18-150-(4) Machines referred to in Subrule 2) e) that contain a sliding contact shaft bonding device suitable for non-hazardous locations shall be permitted for use, provided that

- a) the device is used for the purpose of maintaining the rotor at ground potential;*
- b) the potential discharge energy is determined to be non-incendive for the application; and*
- c) the potential discharge energy calculation is documented and authenticated by the person assuming responsibility for the calculation.*

The incendivity calculations assess whether the maximum possible shaft voltage discharge energy is less than the minimum ignition energy (MIE) of any hazardous gases present. The calculations are outlined in UL 1836-2014, *Outline of Investigation for Electric Motors and Generators for Use in Class I, Division 2, Class I, Zone 2, Class II, Division 2 and Zone 22 Hazardous (Classified) Locations*. MIE values for gases can be found in NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*.

With these changes in the NEC and CE, the next revision of IEEE Std 841, IEEE-841-2021, allowed shaft bonding in 841-compliant motors (in Section 14.3.k).

Later in 2021, IEEE's Petroleum and Chemical Industry Committee also released an updated standard, IEEE Std 1349-2021, for electric machines in Zone 2 and Class I, Div. 2 hazardous locations. This standard includes, in Appendix G.3, explanations and diagrams of the incendivity calculations. The standard's Working Group also released a spreadsheet designed to facilitate these calculations.

It takes as input parameters like drive common mode voltage, various motor dimensions and capacitances, and bearing information. These data can be measured, calculated, or obtained from the manufacturer, and then plugged in to calculate the maximum discharge energy. The discharge energy can then be compared with the MIE of the relevant gas(es). In practice, shaft bonding is likely to be found safe in the presence of most combustible gases, except for acetylene and hydrogen gas.

KEY TAKEAWAYS:

- AEGIS® shaft bonding rings can be installed by UL-approved procedures in explosionproof motors for use in Class I environments, typically Div. 1.
- Per IEEE Std 841-2021, 841-compliant motors can now be equipped with shaft bonding devices. Provided the incendivity calculations show the discharge energy is nonincendive for the application, per NEC-2020, such motors may be used in Zone 2 and Class I, Div. 2 environments.
- The incendivity calculations are described in IEEE Std 1349-2021, Appendix G.3. It is available for purchase at <https://standards.ieee.org/ieee/1349/10559/>
- The incendivity calculation spreadsheet, IEEE 1349-2021 Discharge Energy Calculator.xlsx, can be downloaded at the same page, under Additional Resources. Most users will use the built-in formulas on the Induction Machine tab.
- The calculations require values for several drive, motor, and bearing properties. The calculations may be performed by, or in collaboration with, the motor manufacturer, and also use information from the drive manufacturer.