Considering the Mechanical Aspects of ATEX

By Niilo Nykanen, R+W America

Many engineers and technologists have been aware of electrical ignition sources in hazardous, explosive industrial atmospheres for the last quarter century; this applies to standard design practices both in Europe and North America. During the late 1990s and early 2000s, ATEX 95 Equipment Directive94/9/EC was implemented in the newly formed European Union to standardize new machine building practices and the maintenance of existing equipment. The ATEX directive is essentially the culmination of best practices utilized in many European nations to avoid accidental ignition of explosive atmospheres during industrial processes. The directive transcends pre-existing national directives and allows for expedited equipment delivery across the EU. ATEX equipment is also becoming a standard design practice across North America. As global trade increases and NEMA manufactures of explosion-proof equipment cross paths with IEC manufacturers of ATEX products, parallels have been made to cross-reference items made in the EU and North America for certain applications. This often prompts equipment users to revisit older product design standards in order to help balance the requirements. Shaft couplings provide one example.

For the past 30 years or more, designers have paid due diligence to the electrical aspect of hazardous atmosphere equipment design, but have often ignored the mechanical side. In recent years, the mechanical aspects of ATEX design have increasingly come to light. Not only do electrical power transmission products, but also mechanical power transmission products need to comply with the ATEX directive. Many electrical engineers and designers forget that both the electrical and mechanical components of the completed assemblies should not be capable of providing an ignition source in a volatile, combustible atmosphere. If an electrical component such as a motor fails and the windings burn up, or the connections melt down, the standard practice for many years has been to isolate these areas with thick material and gasketing.

More recently this consideration has been applied to mechanical parts that transmit power which may fail. Many North American manufacturers have specified that only non-sparking components in mechanical power transmission couplings may be used, such as aluminum or stainless steel. Although both aluminum and stainless steel can produce sparks in the correct conditions (i.e. a high-speed rotating aluminum part hitting an oxidized steel piece at a glancing angle), they are generally much less prone to produce sparks than carbon steels, especially at high speeds. Another design consideration machine builders need to keep in mind when specifying moving components into potentially hazardous atmospheres is how the parts might strike each other if they fail or are installed incorrectly. A simple example is a glancing blow, much like striking a flint against steel in an antiquated attempt to light a fire. Parts that strike each other in a perpendicular

R+W EK-ATEX couplings are backlash- free, and the conductive elastomer element is very easily press fit into position (all photos courtesy of R+W).

manner are much less likely to spark in the same manner as a hammer that hits mild steel on an anvil. Eliminating or reducing the potential sparking from mechanical contact or friction (metal to metal or metal to some other type of sparking material) is critical when designing product that may go into an ATEX application. Although this principle is probably a bit newer in the mechanical design world, electrical designers have steered away from anything such as open motor frames and hot surfaces for many years. The bottom line is that any electrical or mechanical device which could be an ignition source for a fire or explosion should not be used in hazardous atmospheres.

When making a coupling selection for a hazardous environment, designers should pay close attention to the possible failure modes and use proper risk assessment principles. Whenever possible, in an explosive atmosphere—driving and driven components, couplings, line shafts, etc., should be designed in such a manner that sparking materials cannot deliver glancing blows to each other in a failure mode. At a speed of 4.5 meters-per-second, a 2 kilo-Newton blow can be a very effective ignition source between steel parts. This means that a rotating steel object as small as 100 mm in diameter, moving at 850 or more rpm with a mass of 200 or greater grams, could produce a significant ignition source if it happened to crash and stop very quickly:

$$F(N) = 1/2 * m\,(\text{kg}) * v\,(m/s)^\wedge 2/s\,(m),$$
$$2\,kN = 1/2 * .2\,\text{kg} * 4.5\,m/s^\wedge 2/.001\,m,$$
$$850\,\text{rpm} = 100\,\text{mm DIA @ } 4.5\,m/s \text{ rim speed.}$$

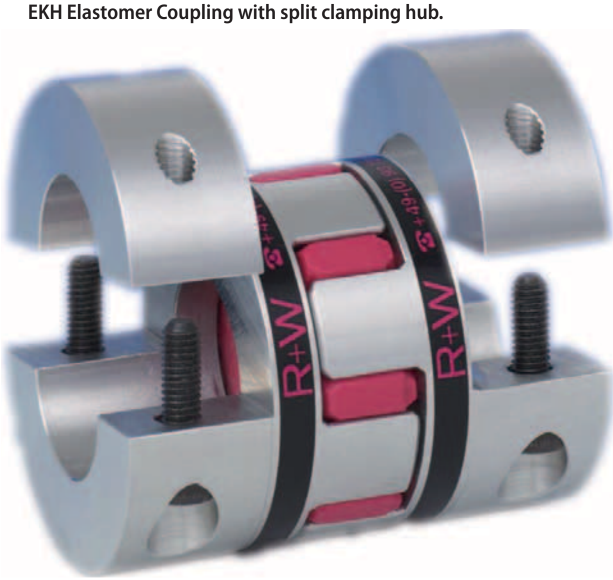
A system designer conducting a failure mode effects analysis (FMEA) must also realize that in some cases a coupling could fail in such a way that the driver and driven hub could lose contact with each other. It is possible that a driven shaft rotating at high speed under its own inertia could produce a static charge. This is due to the fact that most motor and drive line shafts ride in lubricated bearings. Oil and grease do not typically conduct electricity very well. Many electrical transformers are oil filled for this reason. Shafts in electric motors, especially the brushless types, tend to build a static charge for various reasons to include asymmetry in the magnetic circuit of rotating electrical machines. These static charges build up as small areas of high potential around the shaft bearings and periodically discharge. This causes microscopic pitting in the bearings and can be a leading cause of bearing failure. Manufacturers often include a grounding brush in ATEX and other NEMA hazardous location motor designs. If a coupling between a driven shaft and motor shaft fails catastrophically and allows the driven shaft to spin freely, arcing could occur in the bearings and air gaps between the remnants of the coupling.

SLE Torque Limiter with clamping hubs and elastomer insert.

Many mechanical power transmission products already have ATEX certification. As with any other product, just because an industrial power transmission part is certified by an approved body does not necessarily mean that it is the best part for the design of a system. For example, there are many ATEX-certified, flexible disk-style couplings on the market that are widely used in the petrochemical industry. This is due primarily to the disc coupling having been the original type described in the API (American Petroleum Institute) 671 guidelines for special purpose couplings. There are some specific high-speed compressor applications in this industry with a critical reliance upon specific features of the disc pack coupling. These couplings certainly do offer excellent properties for fatigue resistance, high- speed balance, and prevention of static build-up, due to their all-metal construction. This does not mean that this design is free of all negative properties.

The EKZ Intermediate Spacer is precision molded and wear resistant.

Machine builders must be aware that when using this style of coupling for ATEX applications, it is possible in the event of a disk, hub and/or, spacer failure, that fasteners and broken pieces of disks could impact each other at various angles. In a worst case scenario a piece of the coupling could flail into a guard or other surrounding metal component(s). If the application is high-speed and/or high-inertia, spark(s) could fly in any direction. Fortunately, the designers of these couplings have put years of consideration into special bolting designs and safety catches for spacers which generally work well in failure mode. This design can become quite complex and costly, oftentimes requiring a customer to assemble many components on site. Since this type of coupling is often mistakenly assumed to be the only option for equipment built in accordance with API guidelines, many system designers use it without considering that alternatives, such as approved elastomer jaw couplings, may be better suited to their actual requirements.



EKH Elastomer Coupling with split clamping hub.

Many ATEX-certified elastomer jaw coupling designs have advanced greatly over the past few decades in terms of their balance, torque density, ease of installation and reliability over long maintenance intervals. Electrically conductive elements are used in order to eliminate the potential for electrostatic charges to arc from one hub to the next. One advantage that an elastomeric jaw-style coupling has over a disk coupling is that in the event the element fails, it might throw a few pieces of rubber or plastic in the surrounding area (versus metal) which typically would not constitute a significant ignition source. In the case of higher quality machined jaw couplings, very seldom does a whole spider element completely disintegrate at once. The jaws are designed with an inward, opening curvature to positively contain most of the large pieces of the elastomeric element in the event of a failure. If the entire element were lost at once, the jaws would impact each other straight on from a very close distance, much like the dowel bolts in a much more complex disk pack coupling. Once the jaws are impacted the motor can continue to turn the load until an operator or maintenance worker recognizes a problem. A jaw coupling with a failed elastomeric also maintains electrical continuity between the driver and driven hubs. Guarding design in ATEX applications with an elastomeric jaw coupling can be a bit more simplified as well, compared to other couplings. Because there is no metal disk or element that could potentially be thrown in failure mode, the guard can be more suited to simply protect personnel from coming into contact with rotating parts, rather than creating a re-enforced guard to catch pieces of flying metal.

R+W EK-ATEX couplings are backlash-free, and the conductive elastomer element is very easily press fit into position. Due to a proprietary, secondary molding process, the surfaces of the legs of the elastomer element exhibit a very smooth and straight fit with the precision machined curved jaws, resulting in good electrical conductivity versus many other spider couplings on the market. This smooth even fit also means that there is very consistent compression on the entire elastomer when the machine is running. The result is a less likely chance of failure due to uneven compression compared to elastomeric spiders that are simply pulled from their initial molds and installed. The single elastomeric element not only compensates for a bit of angular shaft misalignment, like a single disk-style coupling, but also for axial and lateral/parallel misalignment. Spacer designs facilitate larger amounts of misalignment and offer easy installation over a wide range of distances between shaft ends, which is also typically useful in API-compliant pump package designs. Split clamping hubs ensure a backlash-free frictional connection, addressing keyway wear and/or eliminating keyways completely, and typically require a fraction of the time for installation and removal.

Catastrophic failures due to unforeseen torque overloads do happen in the field. These failures can be induced from resonant vibrations in the final assembly and can be difficult to predict unless a complex array of electronic sensors is in place throughout the machine. One design advantage of the R+W ATEX coupling is that it is also offered with an optional torque limiting feature, certified and approved for use in explosive atmospheres. This means that in the event of a mechanical overload, the coupling itself actually disengages rather than causing a catastrophic failure. A mechanical ring on the coupling is designed to move slightly in the event of disengagement. This movement can be used to trigger an electrical signal to alert operators to the problem. In many instances, systems are designed so that disengagement will shut a system down so maintenance personnel can repair the cause of the overload before it causes excess damage to equipment.

In conclusion, when designing a mechanical power transmission system for an ATEX environment, one must be very diligent in the proper selection of parts. Just because a part has a certified marking does not necessarily mean it will always be suitable for application in each of these areas and environments every time. In order to prevent any electro-static discharge, all moving parts should maintain electrical conductivity between each other. All motor and machine frames must be chassis-grounded, with special attention being paid to any fluid flow processes. Possible failure modes must also be considered to minimize the opportunity for sparks to be generated should the unexpected occur. When choosing ATEX parts it should also be noted to find out from a prospective vendor how long they have been producing hazardous location product, when they were certified, and by what agency. Always choose wisely and get multiple opinions from different vendors and agencies when designing your system. **PTE**

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