ENGINEERING LETTER | 15

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PRACTICAL LIMITS OF SPARK-RESISTANT CONSTRUCTION

INTRODUCTION

Fan applications with airstreams of explosive or flammable particles or gases require spark-resistant system components for the safe handling of such airstreams. This includes components such as ductwork, dampers, filter devices, heating or cooling coils, and fans. This Engineering Letter presents practical considerations and methods of providing fans with varying types of Spark-Resistant Construction (SRC).

THE AMCA STANDARD

The Air Movement and Control Association (AMCA) established a standard set of Classifications for Spark-Resistant Construction. For reference, that Standard is shown here in its entirety.

AMCA STANDARD 99-0401-86
Classification for Spark-Resistant Construction

Fan applications may involve the handling of potentially explosive or flammable particles, fumes, or vapors. Such applications require careful consideration of *all* system components to ensure the safe handling of such gas streams. This AMCA Standard deals only with the fan unit installed in that system. The Standard contains guidelines which are to be used by both the manufacturer and user as a means of establishing *general* methods of construction. The exact method of construction and choice of alloys is the responsibility of the manufacturer; however, the customer must accept both the type and design with full recognition of the potential hazard and the degree of protection required.

TYPE	CONSTRUCTION
A	All parts of the fan in contact with the air or gas being handled shall be made of nonferrous material. Steps must also be taken to assure that the impeller, bearings, and shaft are adequately attached and/or restrained to prevent a lateral or axial shift in these components.
B	The fan shall have a nonferrous impeller and nonferrous ring about the opening through which the shaft passes. Ferrous hubs, shafts, and hardware are allowed, provided construction is such that a shift of impeller or shaft will not permit two ferrous parts of the fan to rub or strike. Steps must also be taken to assure that the impeller, bearings, and shaft are adequately attached and/or restrained to prevent a lateral or axial shift in these components.
C	The fan shall be so constructed that a shift of the impeller or shaft will not permit two ferrous parts of the fan to rub or strike.

Notes

1. No bearings, drive components, or electrical devices shall be placed in the air or gas stream unless they are constructed or enclosed in such a manner that failure of that component cannot ignite the surrounding gas stream.
2. The user shall electrically ground all fan parts.
3. For this Standard, nonferrous material shall be any material with less than 5% iron or any other material with demonstrated ability to be spark resistant.
4. The use of aluminum or aluminum alloys in the presence of steel which has been allowed to rust requires special consideration. Research by the U.S. Bureau of Mines and others has shown that aluminum impellers rubbing on rusty steel may cause high-intensity sparking.

The use of the above Standard in no way implies a guarantee of safety for any level of spark resistance. “Spark-resistant construction also does not protect against ignition of explosive gases caused by catastrophic failure or from any airstream material that may be present in a system.”

This Standard applies to: Centrifugal Fans; Axial and Propeller Fans; Power Roof Ventilators.

This Standard applies to ferrous and nonferrous metals. The potential questions which may be associated with fans constructed of FRP, PVC, or any other plastic compound were not addressed.

THE LIMITATIONS OF SRC

The AMCA standard provides the system designer with a uniform way to specify the system requirements and provides fan manufacturers with general guidelines. The fan manufacturer must still develop unique designs to deal with the physical and practical limitations of fan equipment when developing construction methods to comply with AMCA.

A major limitation is the practical availability of truly "nonferrous" alloys that really can be used in fan construction. There are certain alloys or noble metals than are truly nonferrous, alloys that contain no iron, but for the most part they are extremely expensive and/or difficult to obtain in forms and strengths necessary for fan construction.

For most purposes, the fan manufacturer uses more readily available alloys that are considered nominally nonferrous and which have strength and work properties suited to fan construction. The New York Blower Company's list of usable alloys is shown in Figure 1.

Alloy	% FE (iron)
Aluminum 5052*	0.45
Aluminum 6061*	0.70
Brass CDA 360	0.00
Bronze CDA 958	4.75
Copper CDA 110 or 122	0.00
Monel 400 Shafting	2.50

Note: Alternate alloys may be substituted; not to exceed 5% iron content. Hardware, such as setscrews or keys, may have an iron content greater than 5% provided they are recessed and relatively inaccessible.

* Iron content in most aluminum alloys is actually a random contamination and not a predicted element of the alloy.

Figure 1 - Spark-Resistant Alloys used by nyb

Aluminum is the most frequently used alloy due to its low cost. However, as pointed out in the AMCA Standard, when aluminum is in close proximity to steel, **careful maintenance programs are necessary to prevent rust, because aluminum rubbing against rusty steel can cause high-intensity sparking.** In applications where such maintenance is not possible, an SRC method that places steel in the airstream is not recommended.

Regardless of which classification is chosen, airborne foreign or "tramp" particles could either strike each other, or strike one of the components of the fan, causing a spark. Protection against such occurrence cannot be built into the fan itself.

SRC does not eliminate the potential for spark generation. Fans with any type of SRC are only intended to minimize the potential that any two or more fan components might generate sparks within the airstream by rubbing or striking during operation. No type of SRC can be guaranteed to eliminate the possibility of generating a spark, nor would any SRC type preclude sparks resulting from any foreign influence such as airborne materials striking each other.

The AMCA Standard requires construction that will not permit a wheel and/or shaft to shift due to some malfunction during operation. If two components are allowed to shift and rub against each other for any length of time, either sparks or frictional heat could become a hazard in an explosive or flammable gas stream. Normally, standard procedures of fastening the wheel to the shaft and locking the shaft in the bearings are sufficient. However, the degree of hazard in these situations dictates that extraordinary precautions to more securely prevent such shifting are in order, so further methods of attachment or restraint are required.

The following types of SRC are furnished by The New York Blower Company. These types meet the AMCA Standard, but go a step further by explaining the specific construction methods used to achieve SRC.

NEW YORK BLOWER SRC STANDARDS

AIRSTREAM-TYPE SRC - (AMCA Standard 99-0401-86, Type A) to include all airstream parts constructed of a spark-resistant† alloy. Bearing stop blocks and/or an aluminum shaft sleeve shall be provided to prevent contact of the shaft with the housing at the shaft opening. Shaft set collars shall be provided to prevent axial movement of the shaft through the bearings. The fan wheel shall be secured to the shaft in such a manner that it cannot shift axially on the shaft.

WHEEL-TYPE SRC - (AMCA Standard 99-0401-86, Type B) to include the wheel constructed of a spark-resistant† alloy, and a buffer around the housing shaft opening. Bearing stop blocks and/or an aluminum shaft sleeve (in lieu of buffer) shall be provided to prevent contact of the shaft with the housing at the shaft opening. Shaft set collars shall be provided to prevent axial movement of the shaft through the bearings. The fan wheel shall be secured to the shaft in such a manner that it cannot shift axially on the shaft.

BUFFER-TYPE SRC - (AMCA Standard 99-0401-86, Type C) to include buffers constructed of a spark-resistant† alloy attached to the housing interior adjacent to the wheel front and back. Fan designs which incorporate a conical inlet venturi within the confines of the housing shall utilize a spun-aluminum venturi in lieu of a separate buffer on the inlet side. A buffer will also be located at the housing shaft opening.

† The term "spark-resistant alloy" may include, but is not limited to, those alloys shown in Figure 1.

WHAT THE NYB SRC TYPES OFFER AND HOW THEY ARE ACCOMPLISHED

One or more of these SRC types are offered on most New York Blower fans as indicated in the specific literature describing those fans.

Of these types, a fan furnished with AIRSTREAM-TYPE SRC should provide the greatest degree of spark resistance. In the event that two or more fan components in the airstream rub or strike together, a properly maintained fan should be able to continue in operation for some reasonable period of time, without producing a spark. However, the severity of a hazard that calls for AIRSTREAM-TYPE SRC dictates that the fan should be closely monitored and shut down immediately upon such an occurrence. If allowed to operate, the rubbing or striking of these fan components will generate frictional heat, quickly deteriorate, and eventually catastrophically fail. **Good safety practice cannot be ignored!**

A fan furnished with WHEEL-TYPE SRC differs from AIRSTREAM-TYPE SRC in that only the wheel itself is constructed of a spark-resistant alloy. A spark-resistant buffer is added around the housing opening through which the shaft passes as shown in Figure 2. The remainder of the fan components are furnished in their standard material, usually mild steel.

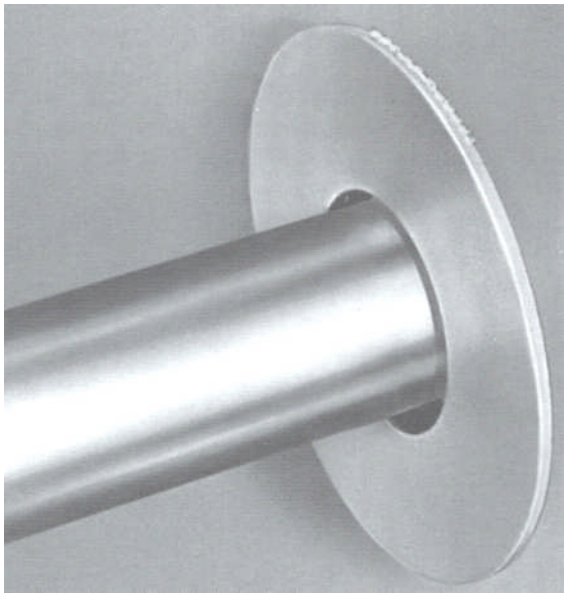

Figure 2 – Spark Resistant Buffer

Fans furnished with WHEEL-TYPE SRC should not continue in operation for any length of time with the wheel rubbing any component or with the shaft striking the buffer. Practically speaking, it is not possible to predict a "safe" length of time, because there may be other ferrous components within the fan airstream which could be torn or jarred loose by the rubbing or striking of the wheel or shaft, and such loose ferrous objects could create a spark. Also, the buffer cannot support the weight or withstand the forces of the rotating shaft for any prolonged period of time.

The AIRSTREAM-TYPE and WHEEL-TYPE SRC specifications go further to minimize the potential for sparking by taking extraordinary precautions to minimize the potential for abnormal movement or shift of the fan's airstream components. While the standard bearing mounting bolts will resist vertical or axial movement, the addition of bearing stop blocks will resist horizontal movement and effectively secure the bearings in place. The addition of shaft set collars as shown in Figure 3 will further resist shaft movement through the bearings. These combined features virtually eliminate the possibility of any movement in the shaft and bearing assembly.

There are many ways to secure the fan wheel to the shaft, but standard setscrews and keys are not enough for the more severe applications. Figure 4 details one alternative which includes a bolted aluminum wheel retaining plate on the end of the shaft. Other methods might include countersinking the shaft to accept a setscrew, sweat-fitting, or tapered bores to prevent the wheel from slipping on the shaft axially. The precise method will vary by fan size and type.

The BUFFER-TYPE SRC specifications utilize standard, usually mild steel, airstream component parts and employ spark-resistant plates or buffers to stop the wheel or shaft from coming into direct contact with other airstream components. A fan design which requires an inlet cone is usually furnished with an aluminum cone to act as the buffer on one side, as shown in Figure 5. Other designs might utilize a spark-resistant band or plate.

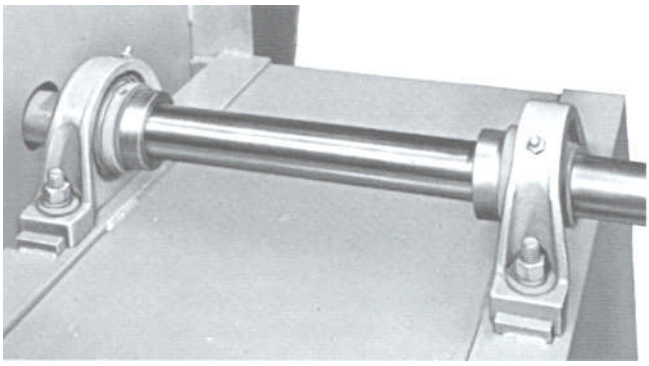

Figure 3 – Bearing Stop Blocks/Shaft Set Collars

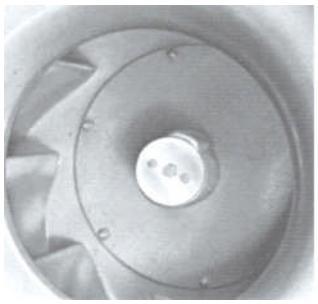

Figure 4 - Wheel Retaining Plate

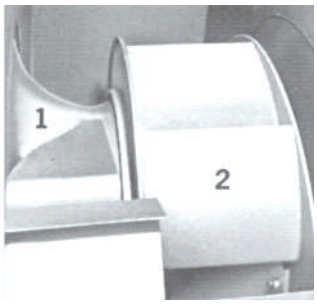

Figure 5 - Aluminum Inlet Cone (1), Steel Wheel (2)

The BUFFER-TYPE SRC is intended to provide a low cost alternative for non-critical applications. **The user or specifier must exercise caution in selecting this type so that the safety of the installation is not compromised for the sake of initial cost.**

Generally, aluminum wheel construction is utilized for AIRSTREAM-TYPE AND WHEEL-TYPE SRC. Because the material strength characteristics of aluminum decrease sharply at elevated temperatures, it is not recommended for handling anything other than nonabrasive airstreams at less than 200°F. In cases beyond these limits, BUFFER-TYPE SRC may be the only readily available alternative.

As with the WHEEL-TYPE SRC, fans furnished with BUFFER-TYPE SRC **should not continue to operate for any length of time with the wheel or shaft rubbing the buffers.** High speed fans will tend to wear away buffers more rapidly than slower speed fans, and thus **BUFFER-TYPE SRC should be used with caution on high speed fans. The greater wheel tip speeds and shaft surface speeds, combined with their corresponding weights and forces, reduce the amount of time available to react.**

When a high speed fan application requires spark resistance but AIRSTREAM- and WHEEL-TYPE SRC are not practical, The New York Blower Company will work with the system designer to provide special spark-resistant features on a case by case basis.

Periodic inspection of the fan, and particularly the airstream, is recommended. The build-up of foreign material or rust, the potential deterioration due to abrasion or corrosion, or the accidental shifting of any fan part could lead to further hazards of potential ignition or explosion.

The centrifugal fan arrangements most compatible with the intended use of SRC are those in which the wheel is overhung on the shaft and the bearings are outside the airstream. Such arrangements include Arrangements 1, 8, 9, and 10 as described in AMCA Standard 99-2404-78.

One item mentioned in the AMCA Standard for SRC is that the user must electrically ground all fan parts. This is necessary so that any electrical charge or static electricity that might build up in operation can be safely conducted away. Though there is probably sufficient electrical conductivity through most bearings to transmit any static charge to the bearing pedestal, brush type contacts on the pedestal may be a good added precaution. The pedestal can then be suitably grounded to the support structure. Steps should be taken by the user to ensure electrical conductivity to the connecting ductwork.

AXIAL FANS AND SRC

Propeller Fans, Duct Fans, Vaneaxial Fans, and Tubular Centrifugal Fans have the common difficulty of placing the bearings, and sometimes the drive components, either directly in the airstream or in an inner tube construction that is located within the airstream as shown in Figure 6.

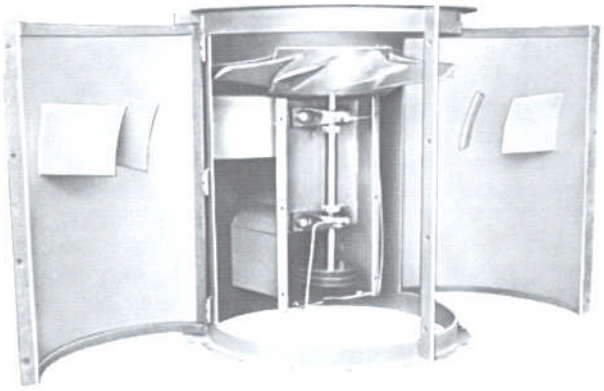

Figure 6 – Tubeaxial Fan

The New York Blower Company offers WHEEL- and BUFFER- TYPE SRC on its Duct, Tubeaxial, Vaneaxial, and Tubular AcoustaFoil fan lines.

BUFFER-TYPE SRC on these fans requires bearings and drive components to be isolated from the airstream. To accomplish this, the fans are furnished with shaft seals and all airstream junctions are continuously welded and/or gasketed with suitable material. To prevent a shift of the impeller and/or shaft, a ceramic-felt shaft seal with retaining plates constructed of copper is used. For Tubeaxial and Vaneaxial fans, an aluminum wheel is also required. On the Duct Fan, a partial aluminum wheel is used.

WHEEL-TYPE SRC utilizes all of the modifications of BUFFER-TYPE SRC. The addition of a wheel retainer, set collars, and bearing stop blocks help prevent a lateral or axial shift of the wheel, bearings, and shaft.

FIBERGLASS-REINFORCED PLASTIC AND SRC

Centrifugal fans made of FRP material present an excellent degree of spark resistance as FRP materials are nonsparking. However, FRP is also a nonconductor so the possibility of building and retaining a static charge is greater and must be accounted for. Adding graphite to the final resin finish will provide the necessary conductivity to alleviate this situation. The special construction features of FRP fans may also call for other considerations in dealing with hazardous fumes. See Engineering Letter 20.

WHERE TO AVOID ATTEMPTING SRC

The basic requirement that bearings should not be placed in hazardous airstreams eliminates several centrifugal fan arrangements from consideration. Single-width or double-width fans in either Arrangement 3 or Arrangement 7, where the fan bearings are located in the inlet, should not be furnished for such service. See Figure 7.

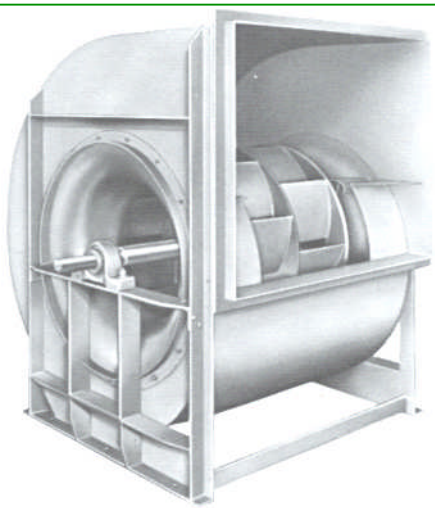

Figure 7 - Arrangement 3 Double-Width Fan

CONCLUSION

Moving explosive or flammable gas streams through fans requires the utmost care in system design and equipment selection. The system designer must weigh the total system from all angles to minimize risk, particularly when the system components and/or fans are in environments that are located in areas where people are likely to be working or passing.

The explosiveness of the gas mixture, the people factor, and the potential for foreign or “tramp” elements to enter the system, are all necessary concerns in determining to what degree special-material construction should be used. Vibration detectors to warn of impending malfunction of bearings or rotating assemblies are a good preventive measure to forestall the actual rubbing or impact of two parts in any mechanical equipment, and should certainly be considered in “severe risk” situations. The extraordinary measures to pre-vent wheel and shaft movement offered in **nyb**’s AIRSTREAM-TYPE SRC and WHEEL-TYPE SRC are features to help minimize the potential of allowing two parts to strike.

The three classifications of spark-resistant construction in AMCA’s Standard and the specific construction methods offered by New York Blower provide only degrees of resistance to sparking. They have been used, and are continuing in use, as deterrents to possible sparking and ignition in hazardous systems. Care must be taken to recognize that there are no absolute guarantees.

Therefore, in particularly hazardous applications, the location of the fan and perhaps the entire system should be a major consideration. In some cases, protective enclosures around the fan or other mechanical parts in the system may be another protective step to lessen the danger in the event that a spark might occur in spite of the precautions taken. The system designer is in the best position to weigh the alternatives and specify the required fan equipment.