

PRODUCT APPLICATION GUIDE

A technical bulletin for engineers, contractors and students in the air movement and control industry.

High Temperature Exhaust

“Many are never used; some are used just once; others are used all the time.” What are they? They’re high temperature exhaust fans.

High temperature exhaust fans can be grouped into two general categories: emergency smoke evacuation and process ventilation. Generally speaking, emergency smoke evacuation fans may never be used, but they must be installed and be capable of exhausting high temperature air and smoke in the event of a fire. In contrast, high temperature process ventilation requires continuous duty exhaust of high temperature air, fumes or particulate. Both application types are uniquely different requiring special construction and system design considerations. In this article, we will examine both types of exhaust applications, looking first at the emergency smoke exhaust category.

Emergency Smoke Exhaust

Since emergency smoke exhaust deals with life-safety issues, there are governing bodies in place that identify and regulate specific design and performance standards. The administration and organization of the various governing bodies is subject to modification based on the needs of the industry. Currently, four such agencies are Industrial Risk Insurers (IRI), Southern Building Code Congress International, Inc (SBCCI), the National Fire Protection Association (NFPA), and Underwriters Laboratories, Inc. (UL).



IRI insures properties all over the world based on an informational manual, which details the construction requirements that belt drive emergency heat and smoke exhausters must meet in order to be covered by IRI.



SBCCI is a not-for-profit organization of government officials from the United States and several foreign governments, which serves a strong leadership role in the delivery of model building codes.

The purpose of the NFPA can be summarized into three main categories. First, NFPA promotes the science and improves the methods of fire protection and prevention, electrical safety, and other related safety goals. Secondly, it obtains and circulates information on these subjects. And thirdly, it secures the cooperation of its members and the public in establishing proper safeguards against loss of life and property.



The fourth organization is Underwriters Laboratories, Inc.. UL is a non-profit, independent organization that maintains and operates laboratories for examination and testing of devices, systems and materials to determine their relation to life, casualty hazards and crime prevention. UL has three safety standards that apply to emergency smoke exhaust products. UL705 is concerned with the mechanical and electrical construction to insure safe operation. All electrical components (motor, wiring, switches, enclosures, etc.) must be UL-listed. UL793 is concerned with the lifting mechanism for the butterfly dampers and the fusible link. In order for a product to be listed in the UL Directory under “Power Ventilators for Smoke Control Systems,” it must meet the requirements of both UL705 and UL793. Additionally, UL must witness a full-scale test of a fan operating for the required time at the specified elevated and temperature.



Inline smoke exhaust fans, like Greenheck’s TBI, can be listed in the UL directory under “Power Ventilators for Smoke Control Systems” without having to meet UL793, because inline fans do not require butterfly dampers since they are not mounted in an upblast configuration. Inline smoke exhaust fans are tested following ASHRAE Standard 149-200 “Laboratory Methods of Testing Fans Used to Exhaust Smoke in Smoke Management Systems”.

So what makes one fan more capable of sustaining higher temperatures than another fan? Each model has a recommended maximum operating temperature based on the construction materials, drive components, and airflow characteristics. The limiting temperature is determined to be the highest temperature that any component of the fan assembly will reach during any operating cycle. Similarly, the maximum operating temperature is typically determined to be the lowest temperature that begins to exceed the capacity of any one component. For example, in some cases the bearings may be the limiting component, while in other cases the fan’s impeller construction material may be the limiting component.

The construction material is perhaps the most obvious element of the fan to consider when dealing with a high-temperature application. In general, aluminum withstands maximum temperatures up to 250°F, standard carbon steel up to 750°F, and 316 stainless steel up to 1000°F.

Critical components are many times constructed of ferrous materials to withstand the higher temperatures. If temperatures were to exceed 300°F, for example, aluminum would be eliminated as a construction material option. Other construction considerations include bearing type, drive component selections, means of ventilation and cooling of the drive components, and insulation options.

The most common way of simplifying construction and component specifications to

accommodate high temperature applications is to maintain separate categories based on the specified temperature range and time requirements. Greenheck for example has four “Heat Option Packages” for high temperature operation. Heat Option I construction is designed for continuous operation between 200°F and 500°F. Heat Option II construction meets specifications requiring the fan to exhaust 500°F air for a minimum of four hours in an emergency smoke removal situation per IRI requirements. Heat Option III construction meets the specifications requiring the fan to exhaust 1000°F air for a minimum of 15 minutes in an emergency smoke removal situation per SBCCI. This construction also surpasses the IRI requirements for 500°F for a minimum of four hours. Heat Option IV construction meets specifications for UL Listed “Power Ventilators for Smoke Control Systems.” This includes the IRI requirement of 500°F for a minimum of four hours, the SBCCI requirements of 1000°F for a minimum of 15 minutes, and the Snow Load Test for butterfly dampers in UL-793.

While it may be tempting to choose a higher heat option than necessary "just to be safe", doing so can add considerable and unnecessary cost to the job. For example, selecting HT Option III when HT Option II is adequate adds insulation and high temperature bearings. These items would be considered "overkill" and add unnecessary extra costs.

High Temp Construction Features	High Temp Options			
	HT Option I	HT Option II	HT Option III	HT Option IV
165-degree fusible link damper lifters		X	X	
165-degree fusible link damper lifters (capable of lifting 10 lbs per square foot)				X
Vented belt and bearing tube	X	X	X	X
Insulated bearing plate, bearing cover and belt tube			X	X
Steel damper blades	X	X	X	X
Dual drives	X	X	X	X
High temperature bearings			X	X
Copper lubrication lines	X			
High temperature aluminum paint	X			
Heat slinger	X			
UL label for “Power Ventilators for Smoke Control Systems”				X

The chart on page 2 summarizes how the fan construction and components vary among Greenheck's heat options. Note that Heat Option I is specified for continuous duty high temperature applications, while Heat Options II, III & IV are normally for emergency smoke exhaust.

In addition to the general construction material of the fan, other considerations can be made to increase the limiting temperature. One of the most critical components of the fan are the bearings. So naturally if the bearings are kept out of the hot

airstream they are less susceptible to the effects of the high temperature, and therefore the air temperature can be higher than the limiting temperature of the bearings. Inline fans inherently have drive components in the airstream. In such cases, the unit can sometimes be designed so that cooler outside air is drawn over the drive components, providing some additional cooling.

Incorporating this type of external cooling is one of the main reasons Greenheck's medium pressure tube axial inline fan (TBI) can be used for high temperature exhaust applications.

There are, however, some arrangements that don't allow for the incorporation and benefits of external cooling. For instance, fans in arrangement 3 have the wheel suspended in-between the two bearings. Consequently, one or both of the bearings will always be located in the air stream. Similarly, direct drive fans are limited by the maximum operating temperature of the motor, since the motor is located directly in the hot air stream. That is why most often high temperature exhaust fans are required to be belt driven units; typically the motor is the temperature-limiting component of the unit when it is installed in the airstream.

Other than the installation location of the bearing within the fan assembly, other critical points to consider include the type of lubrication in the

bearing, as well as the construction of the bearing itself. There is a seemingly endless list of lubricants available for most any application, but the appropriate lubricant can add considerable life to bearing operation. In addition, high temperature bearings can be constructed with inherent construction modifications, such as a larger grease cavity to hold more lubricant.

Another common variation to the standard fan design is the addition of insulation. The bearing mounting plate, bearing cover and belt tube are the



Greenheck's TBI test set-up

UL-witnessed inline smoke exhaust test at Greenheck's test facilities. As a result of these tests, Greenheck's TBI was the first tube axial inline fan in the industry that is UL listed as a Power Ventilator for Smoke Control Systems.

most likely components to be insulated for a high temperature application. Greenheck automatically includes insulation for these components on all fans specified with either HT Option III or HT Option IV.

It is important to understand that emergency smoke exhaust fans are designed to operate effectively for the temperature and time limits stated as long as the power supply to the fan is not terminated. Since they

are not designed to sustain higher temperatures for continuous use, exposure to the extreme high temperatures caused by a fire likely would destroy some or all parts of the fan once the time design limit has elapsed, rendering it incapable of future operation.

High Temperature Process Ventilation

Fans that are built for continuous high temperature ventilation have many of the same construction features and options as those built for emergency smoke exhaust. For example, both are typically constructed of higher temperature ferrous materials, have high temperature bearings, have the motor and drive installed either out of the airstream or with some type of additional cooling capabilities, and incorporate some heat shielding or insulation.

There are, however, some distinct differences between the fan designs for the two application categories. One of the most common applications

for which continuous duty high temperature exhaust fans are specified is commercial kitchen ventilation.

Fans that are specified for continuous operation at higher temperatures need to be carefully selected taking into account air density corrections.

Although a fan will move the same amount of air at two different temperatures, the static pressure and horsepower requirements can change drastically as the density of the air varies with changing temperatures. For example, if a fan moves 3,000 cfm at 70°F it will also move 3,000 cfm at 500°F.

However, since the hotter air weighs much less than the 70°F air, the fan will require less brake horsepower and will create less static pressure.

(Reference "Understanding Temperature and Altitude Corrections" in Greenheck's Product Application FA/102-99 for further information on the effect of high temperature on fan performance.)

There are also some accessories and construction options that are incorporated into high temperature process fans to increase the limiting temperature. For example, a heat slinger can be installed on the shaft between the fan housing and the inboard bearing. A heat slinger is an aluminum disc that absorbs and dissipates some of the heat conducted along the shaft before it travels to the bearings. Many heat slingers incorporate fans that promote additional inboard bearing cooling because it circulates air with every rotation of the shaft.

Another common construction technique is the use of a heat gap. A heat gap is a physical gap between the bearing support structure and the hot fan housing. This separation slows the process of heat conduction to the bearings and drive components through the housing and support structure. An

expansion bearing should be installed where the fan shaft is predicted to conduct enough heat that it could expand to a length greater than that of the structure to which it is secured. This allows for expansion of the shaft within the bearing due to the higher temperatures.

High temperature applications can be found in many different areas of the air movement and control industry. It is important to remember that one high temperature fan design is not suited to all applications.

The following checklist can help you specify the appropriate equipment for the application.

- Emergency smoke evacuation or process
- What codes apply for
 - Temperature (start-up and operation)
 - Duration
- CFM and SP
- Fan location (inline, upblast)

