

## AC VARIABLE FREQUENCY DRIVE SYSTEMS FOR INDUCED-DRAFT AND FORCED-DRAFT FANS

### Applying Variable Frequency Drives to Boiler Fans

Large AC variable frequency drives (VFDs) provide significant benefits when applied to induced-draft fans (IDFs) and forced-draft fans (FDFs) at fossil-fueled electric generating stations. By avoiding the use of mechanical flow dampers or louvers, which introduce air pressure drops, significant energy savings can be achieved.

IDFs and FDFs can be applied to two types of fossil-fueled boilers: pressurized boilers using FDFs, and balanced draft boilers using both FDFs and IDFs. Application of VFDs to both types of fans usually results in the most significant energy and capacity benefits for generating station applications.

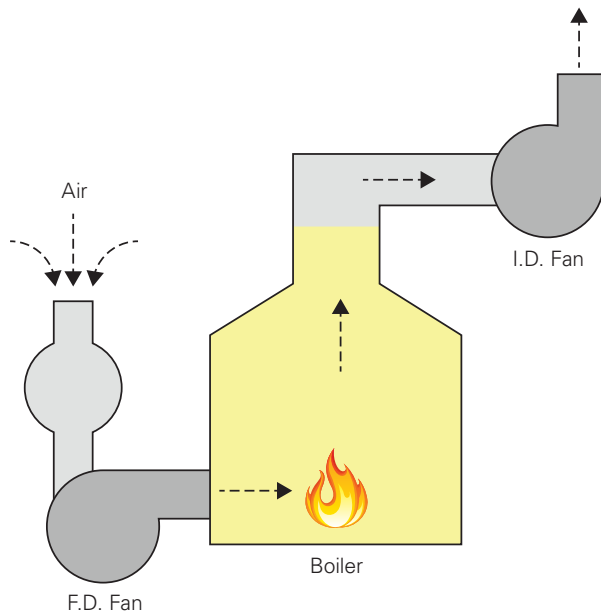


Figure 1. Balanced Draft Boilers

The benefits of applying a VFD are a function of the fan capability margins that usually exist for IDFs and FDFs. These margins result from conservative design and application practices that allow for boiler operation at rated continuous capacity when operating changes occur. Typical operating contingencies include fouling in the boiler resulting from soot and ash, increased excess air due to variations in fuel quality, and provisions for additional pressure drop in anticipation of the addition of air quality control equipment.

Fans with constant-speed motors require mechanical flow control equipment that introduce significant losses to the system. Devices commonly used to control flow and pressure are dampers, inlet guide vanes, and slip couplings such as fluid couplings. The losses introduced include throttling losses for dampers and guide vanes, and slip losses for fluid couplings. These mechanical losses are much greater than the corresponding electrical losses of solid-state electrical VFDs, which typically operate at efficiencies exceeding 95 percent. Elimination of the mechanical losses is usually the most compelling and easily quantified reason for applying VFDs.

### Reduced Starting Duty for Drive Motors

By applying VFDs, the starting duty for the motors can be greatly reduced, as compared to conventional across-the-line starting. When operating on a VFD, only running load current levels are required for acceleration. This negates the extra heat load in the motor and voltage sag conditions that can occur during an across-the-line start. This is important because boiler fan motors usually experience the most severe starting duty of any generating station motor due to the high inertia of the fans. Boiler fan motors are also often the largest motors in the auxiliary power system, which can translate to the largest voltage dips when starting across the line, further increasing the severity of the starting duty. Application of VFDs virtually eliminates starting voltage dip.

### Elimination of Repetitive Starting Restrictions

There are often severe repetitive starting restrictions placed on fan motors due to the heat generated by the large inrush currents during an across-the-line start. These restrictions allow the motors to cool between starts but can cause significant delays at the plant. For example: during plant startup and following maintenance shutdowns, fans may require balancing. During the balancing procedure the motor and fan are usually started several times, and the repetitive starting restrictions can frequently cause extended delays in completing the balancing. As mentioned above, application of VFDs to the fans eliminates both the starting restrictions and delays when starting the motor.

### Lower Short-circuit Current

During faults in the auxiliary power system, VFDs contribute significantly lower short-circuit current levels than constant-speed motors. Since the boiler fan motors are often the largest at the plant, the reduction in fault duty for switchgear and other system components can be significant. The net result of these savings is an increase in the total motor load that can be applied to a single switchgear bus or (for existing systems) a reduction in motor-starting voltage dips and short-circuit duties.

### Reduction in Risk of Boiler Implosion

IDFs are located on the exhaust gas side of a balanced draft boiler and are usually controlled to maintain a slightly negative pressure in the boiler. If a flame collapse occurs in the boiler, or if there is a sudden loss of air entering the boiler, the IDFs will evacuate the gas from the boiler and create a vacuum. If the fans have sufficient capability, a boiler implosion might occur.

Application of VFDs to IDFs can reduce the risk of implosion during one of these events. The ability of an IDF to create a vacuum in a boiler depends on the pressure the fan develops when the boiler has been evacuated and the flow is low or nonexistent. Until the mechanical guide vanes or dampers are closed, IDFs with constant-speed motors continue to pull a vacuum with the pressure associated with full speed.

When minimizing the risk of boiler implosion, there are two significant advantages to VFDs: normal operating speeds are usually lower compared to constant-speed motors and a VFDs control response is much faster. The pressure developed by the fan is proportional to the square of the speed (see Figure 2). Since fan motors powered by VFDs normally operate at less than full speed, this is a significant benefit. With typical fan application margins, IDFs operate at less than full speed even when the generating unit is operating at full load. Consequently, the pressure developed by the fan during a potential implosion condition is less when operating on a VFD.

Fan Characteristics

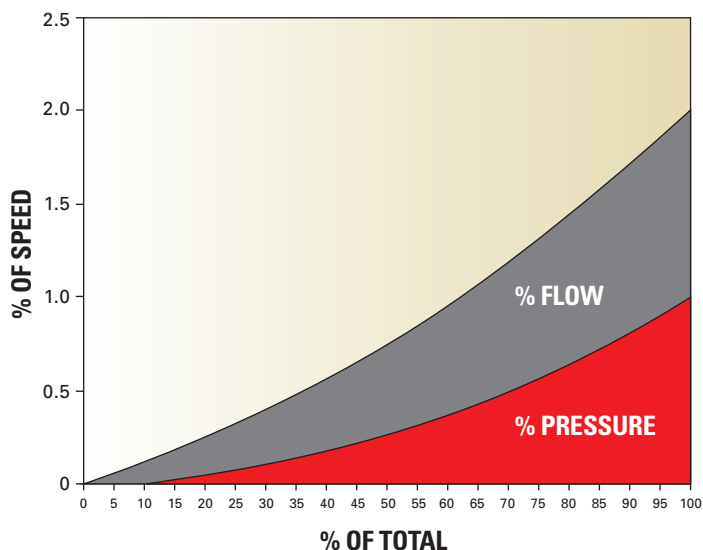


Figure 2. Fan Characteristics

The result of this reduced pressure is that less vacuum is applied to the boiler initially. In addition, many large VFDs are capable of regenerative braking. VFDs with regenerative braking are the only control system normally applied to fans that can provide powered deceleration. This enables much faster deceleration than is possible with de-energized coastdown. The result is to further reduce the risk of implosion.

Another benefit to operating at a reduced speed is that it decreases erosion and wear to fan impellers, tips, and other surfaces. The impinging speed of particulates in flue gas is reduced, improving the life of induced-draft fan impellers. Additionally, fan noise levels are lower at the reduced speeds.