

# Variable Inlet Guide Vanes Boost Centrifugal Compressor Efficiency

## Lower Your Compressor Operating Cost

- Save energy when running at less than full capacity
- Save energy on cooler days

Variable Inlet Guide Vanes are an ingenious yet simple option that, when installed on your centrifugal compressor, can deliver energy savings up to 9%. By replacing a standard inlet butterfly valve with a new Inlet Guide Vane assembly, substantial energy savings can be realized whenever the compressor operates at less than full load or when ambient air temperature is less than design temperature (usually 95°F, 35°C). Many manufacturers offer this option as a retrofit for existing compressors.

### Air Pre-Rotation Saves Power

Inlet Guide Vanes impart a whirling motion to the inlet air flow in the same rotational direction as the impeller. This decreases the power required to deliver the rated air flow and pressure. There are opportunities for energy savings when the compressor inlet is throttled. Throttling takes place under most operational circumstances, except when plant air demand requires full 100% flow *and* when ambient air temperature is the highest expected at that location. This means your compressor inlet is likely throttled during the majority of its operation.

### Adjustable Blades Rather Than a Butterfly Valve

Inlet Guide Vanes in their application consist of wedge-shaped steel blades mounted around the inside circumference of a short length of inlet pipe (see Figure 1). They are turned in synchronization by a ring, or yoke assembly, on the outside of the pipe. Each vane is designed with an air foil cross-section (similar to an airplane wing) to minimize air resistance when in its full open position (vanes positioned parallel to the air stream). The inlet guide vanes modulate from this fully-opened position to a fully-closed position, providing an infinitely variable degree of throttling and pre-rotation. When fully-closed, the blades overlap to block all air flow except that through a small center hole that is required for stable compressor operation (see Figure 2).

A standard actuator positions the yoke assembly. These are similar to the actuators used on a butterfly valve (see Figure 3). The existing control system required to operate the butterfly valve can also be used to operate the inlet guide vane (microprocessor and PLC systems provide the best results). Thus, it is typically easy to retro-fit existing centrifugal compressor installations with inlet guide vanes; only minor piping modification is required.

### Low Ambient Temperature Means Throttling Down

Temperature indeed does play a role in centrifugal compressor performance. Centrifugal compressors are designed to produce the rated flow and pressure on the hottest day expected (hot design day) at their installation location. At lower ambient temperatures, the compressor can deliver more air at the same pressure. Since this additional air is not normally required, the compressor intake must be throttled to match the plant demand. By throttling with inlet guide vanes, a substantial power savings can be realized in comparison with a butterfly throttle valve. Compressor operators will see this savings almost every day – every day, that is, when the temperature is below the design point, and/or when the plant air system demands less air than the maximum designed volumetric flow.

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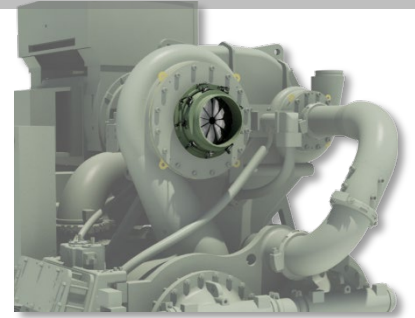


Figure 1: Inlet Guide Vane assembly mounted to first stage inlet of a centrifugal compressor.



Figure 2: Front-view of IGV in fully-closed position.



Figure 3: Side-view of mounted IGV showing the yoke assembly and actuator.

## Save During "Off-Design" Conditions

Compressors are designed to deliver required pressure and flow required for plant or process requirements under the most extreme anticipated atmospheric and air system demand conditions. These are often referred to as "design day" conditions.

"Design day" conditions are highly dependent upon the ambient atmospheric temperature and the demand for compressed air from the plant. For most applications in the northeastern United States, design day conditions are considered a "worst-case scenario" of 95°F (35°C).

However, "design day" conditions are rarely experienced at the compressor jobsite. If we consider the case of the winter season where temperatures mainly persist below the "design day" maximum, significant energy savings can be realized through the unique throttling effect provided by inlet guide vanes.

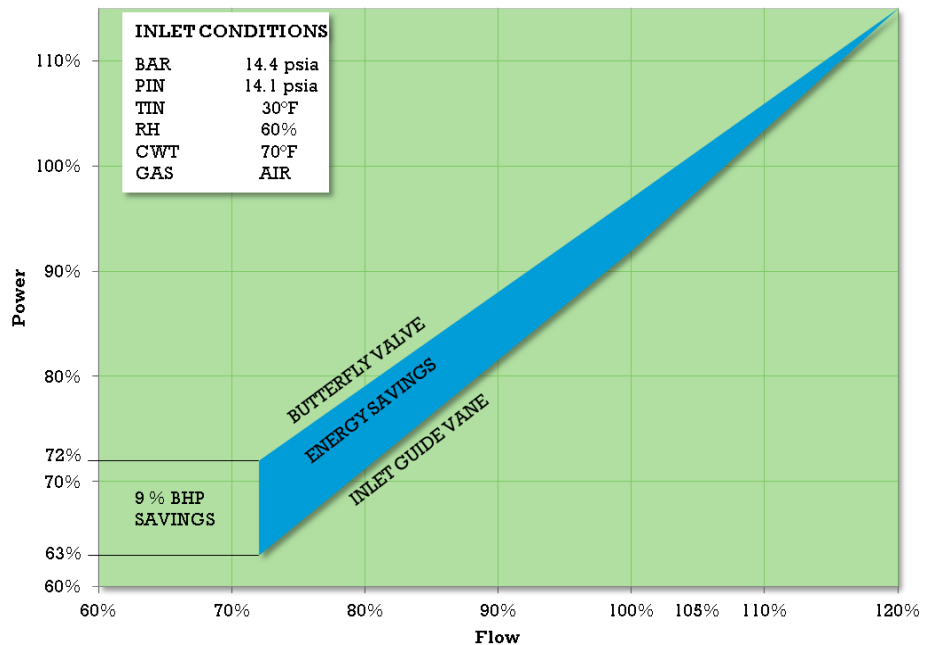
Additionally, for plant air applications, it is common that the design flow rate (maximum anticipated design volumetric flow rate for peak production requirements) is not required by the plant's compressed air system continuously.

The chart to the right considers the case where the atmospheric temperature is 30°F (-1°C) and where the demand of the compressed air system is 72% of the design rated flow.

At this temperature and volumetric flow demand, the inlet guide vanes throttle and impart a pre-rotation to the incoming airstream. Due to this pre-rotation, less power is required to compress the incoming airstream.

In this case, the IGV can reduce power consumption to 63% of the "design day" load. Under the same conditions, a compressor utilizing a butterfly valve (which does not impart the same favorable aerodynamic flow characteristics to the incoming airstream) would require 72% of design power to achieve similar performance. The difference represents a total net savings of 9% in power.

### Energy Savings INLET GUIDE VANE versus BUTTERFLY VALVE 3-Stage Compressor at Constant 100% Pressure



Conversely, properly sizing the compressor drive motor (oversizing) for a cold day, un-throttled operation mode, the integrally geared centrifugal air compressor can deliver up to 20% additional air flow above design. The additional flow will require more power.

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