Can a Variable Frequency Drive in an Air Compressor System actually realize your expected ROI ?

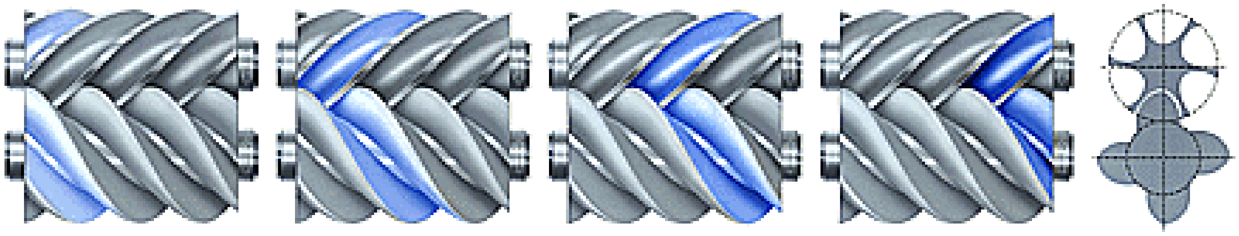
With utility costs rising we see an ever increasing number of industrial projects which seek to do more work with less energy.

For many years engineers recognized that money could (at least theoretically) be saved by changing the way they controlled electrical motors. In our technical world the VFD seems to have commanded a certain "technical panache" which is granted to few products or technologies. The concepts of soft starting and efficiency of variable speed operation were widely accepted before it was cool to be *green*. The cost was often noted as the only stumble stone but as the market matured-- unit prices declined we saw more applications being served.

It appears to be time we take a closer look at whether or not this technical reputation is/was deserved.

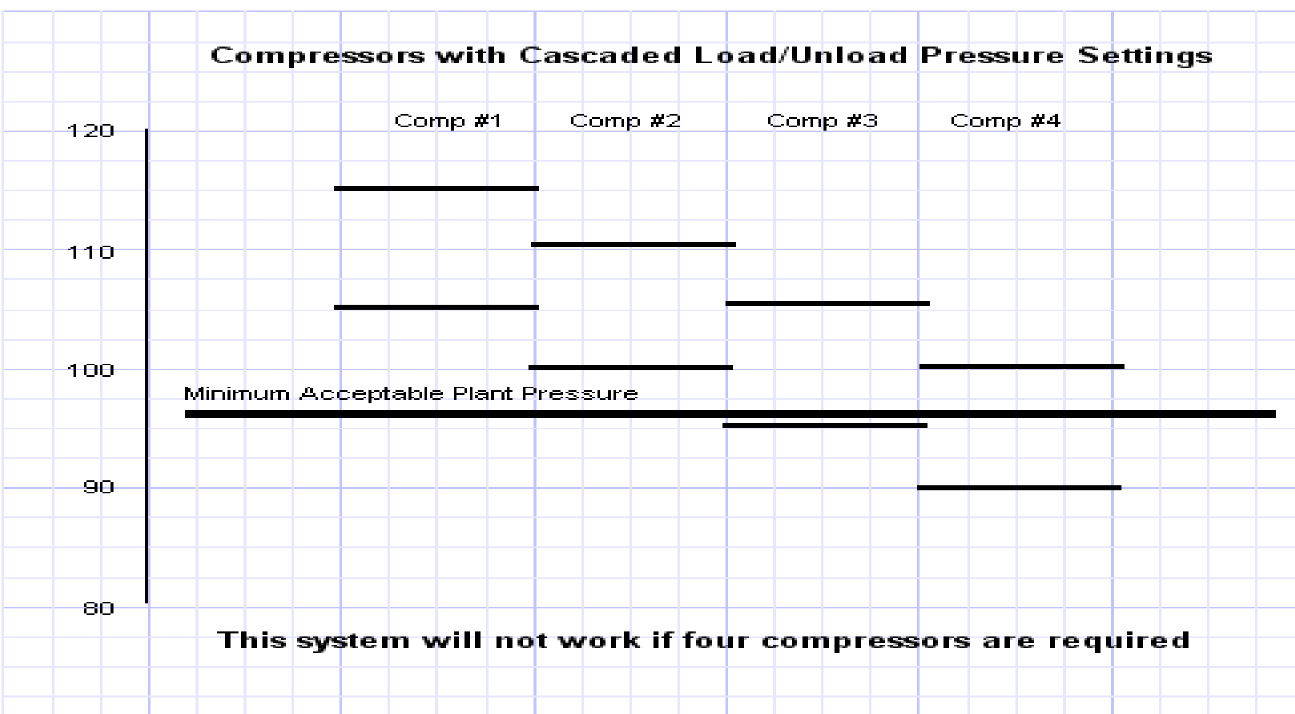
Project Managers today are being held accountable for ROI on their entire project.

The application of a Rotary Screw Air Compressor, in such a system, provides us valuable insight to how the VFD could be applied with or, surprisingly, without benefits. When these machines were introduced in the 1970's the air compressor manufacturers, with a few exceptions, had utilized various methods of mechanical modulation in an attempt to match the compressor output to

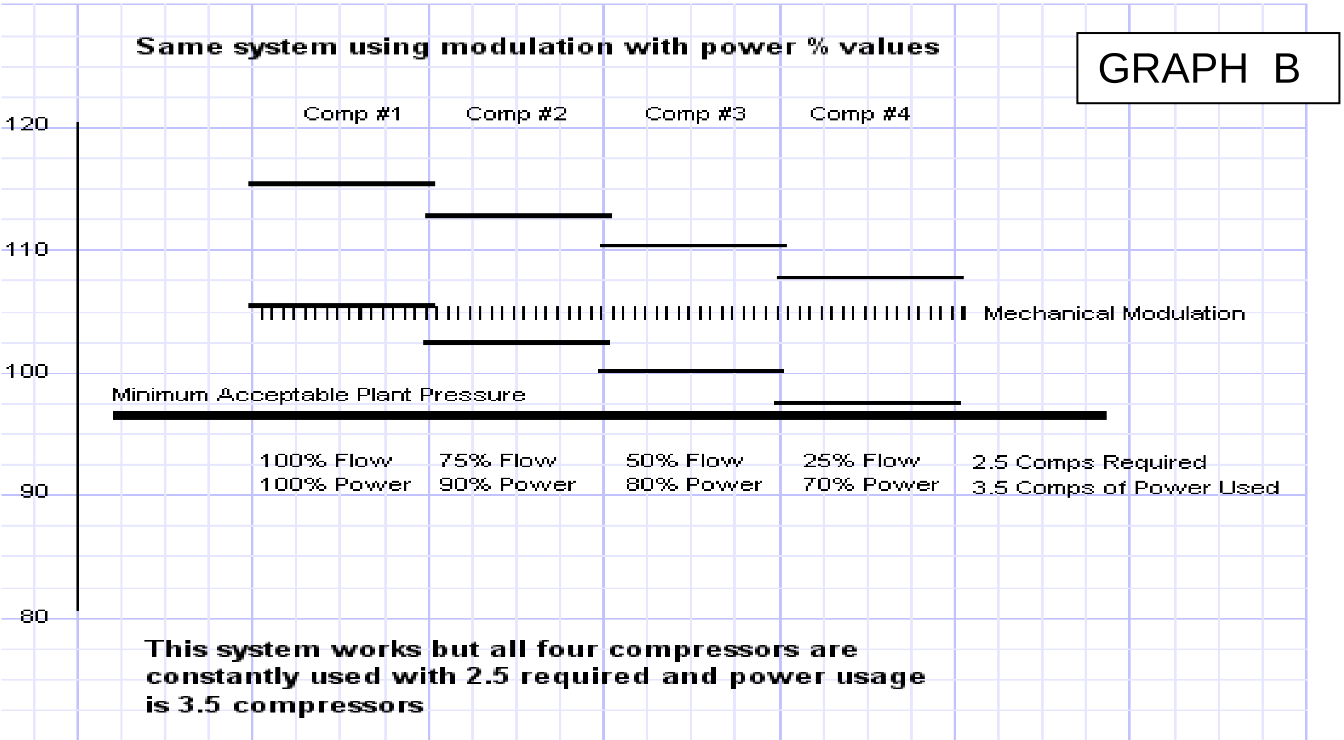


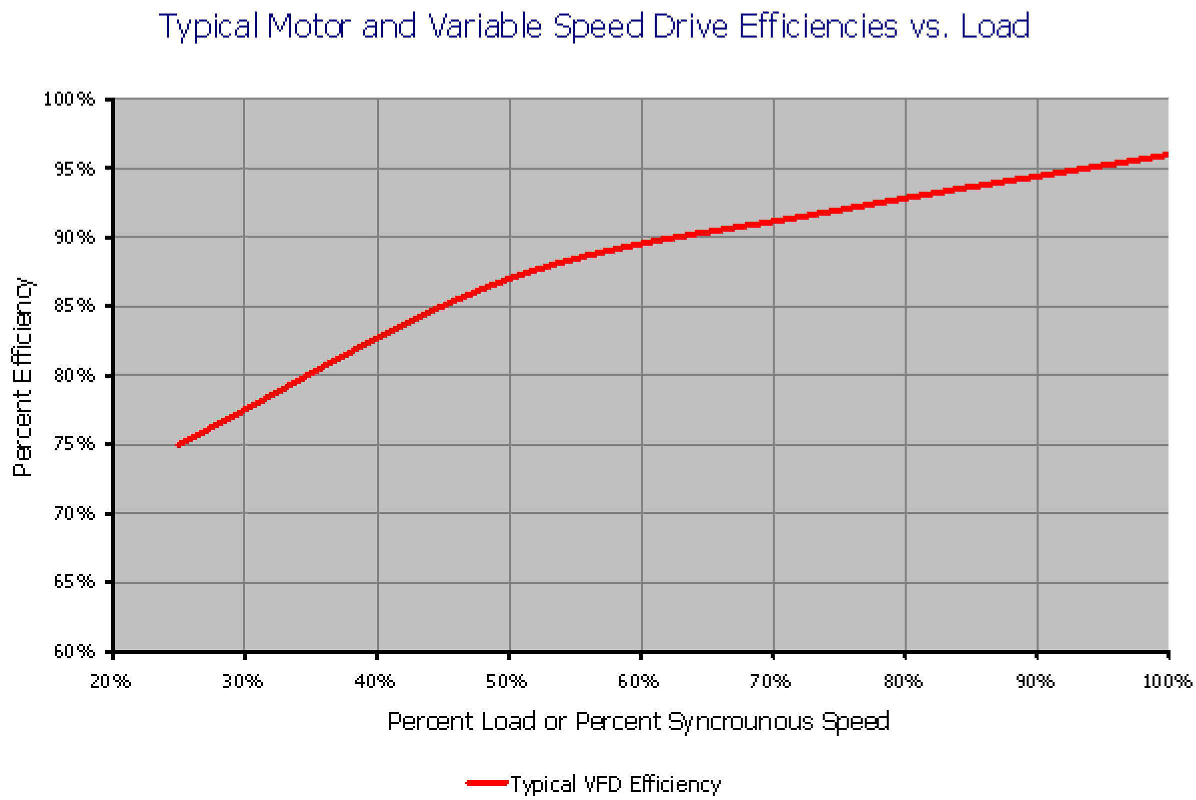
the plant demand. Modulation was also used to avoid "short cycling" in multiple compressor systems and those with a lack of capacitance. Unfortunately these various types of mechanical modulation proved extremely inefficient, with compressors being throttled to 40% capacity, but still using 70 to 80% of full load power. Mechanical modulation is also used when there are more compressors required than can adequately be set to operate with cascaded load / unload switches. It is not surprising that the manufacturers of non-modulating compressors were the first to introduce VFD's.

GRAPH A



The advantage of a applying a VFD for modulation is that it is considerably more linear with power and is typically effective all the way to a 50% capacity throttle. It must be noted though, that VFD's have a typical energy inefficiency of 4-12%.



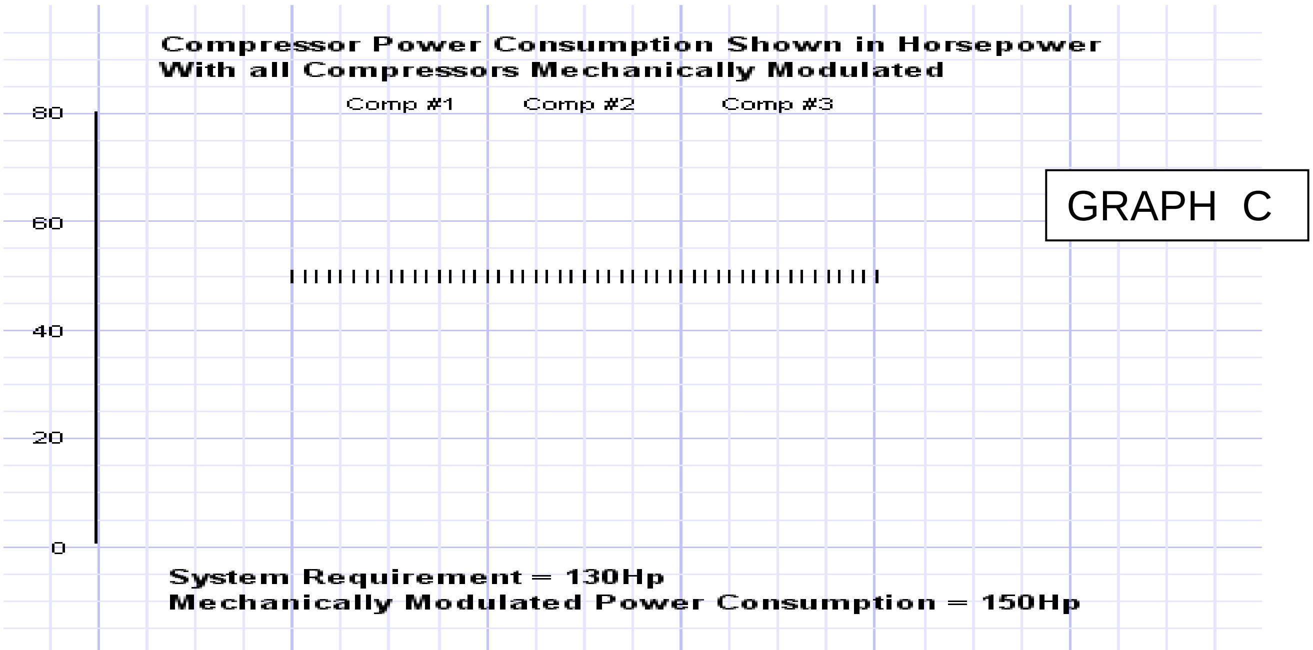


SINGLE COMPRESSOR SYSTEMS WITH CONSTANT DEMAND

In applications requiring a single air compressor or a constant demand where small deviations in demand fall within the optimal throttling range of the VFD Air Compressor, these VFD Compressors can be easily and well applied. Unfortunately, this ideal application with relatively constant demand is extremely rare. Rather, most manufacturing facilities have a widely varying air demand covering the capacity range of multiple air compressors.

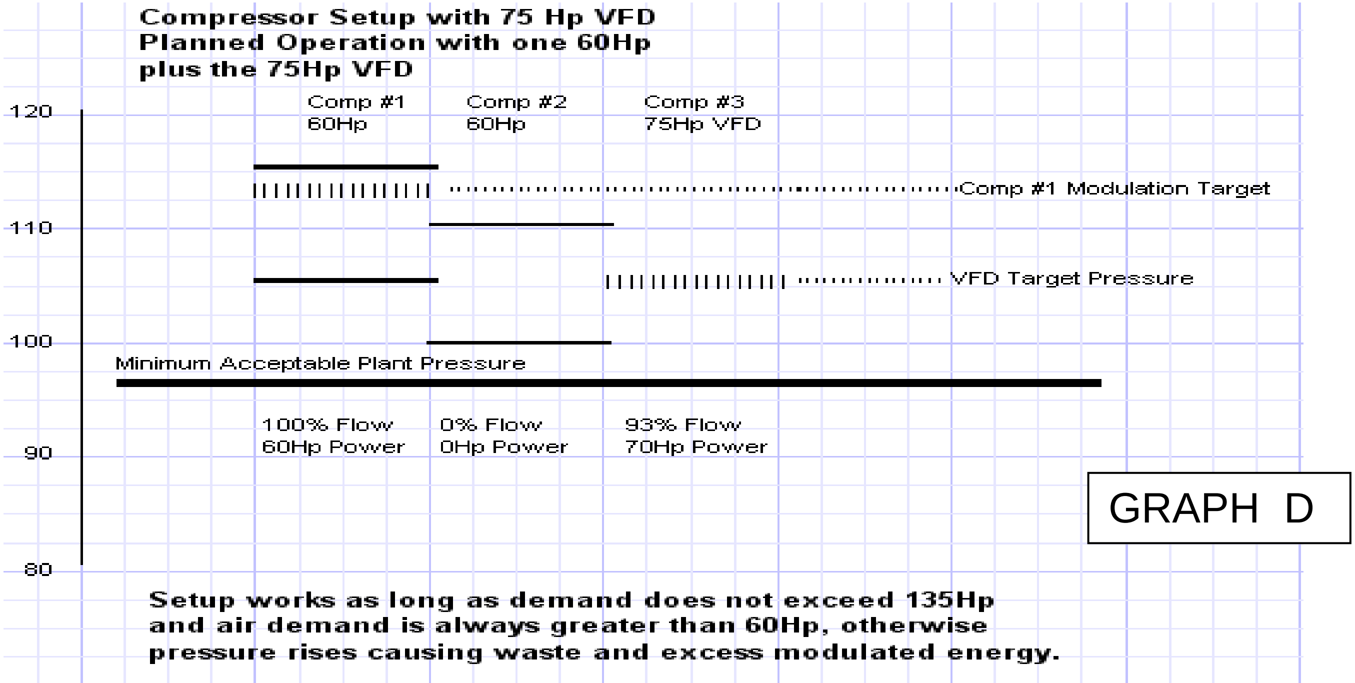
A MULTIPLE COMPRESSOR SYSTEM WITH AN OVERSIZED VFD

This system initially included three 60Hp Rotary Screw Air Compressors with mechanical modulation. The plant typically required 130Hp, which meant that all three compressors were running. With limited system capacitance, the client seeks to avoid short cycling when loading and unloading. This can be done setting all three compressors to modulate; but at what cost? Electric usage well exceeded the actual requirement of 130Hp due to the inefficiency of the mechanical modulation.

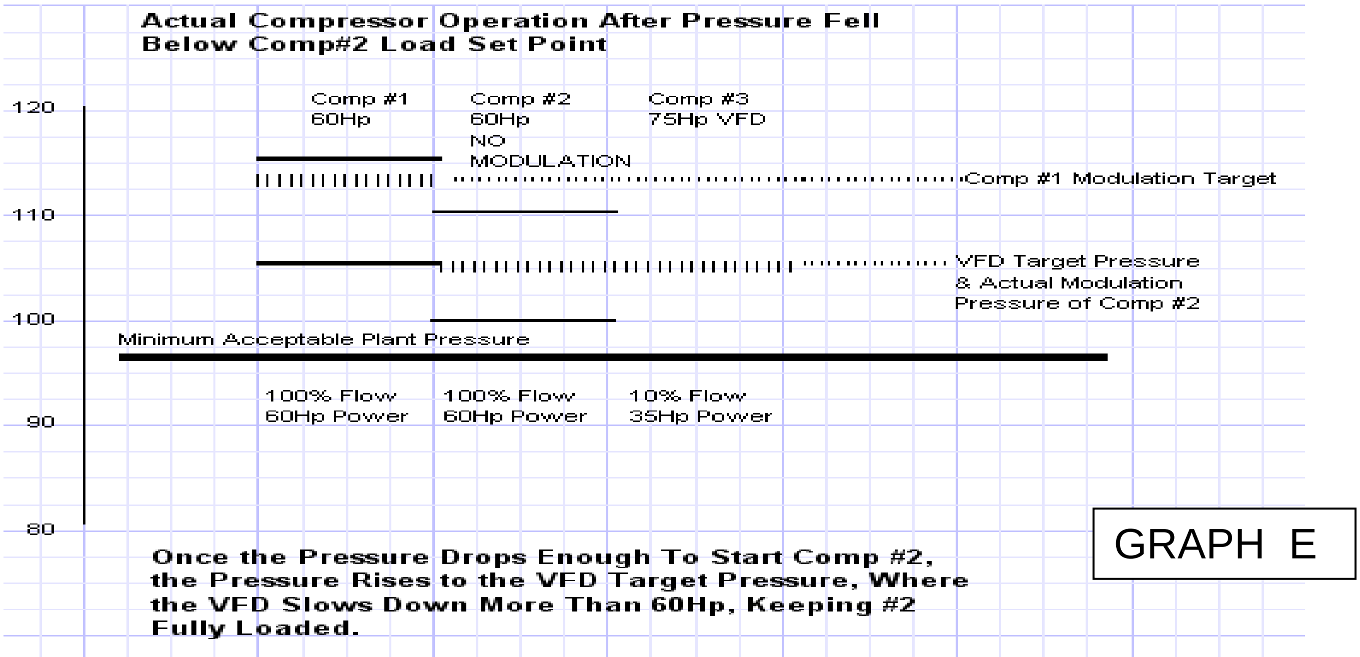


The compressor supplier recommended a 75Hp VFD Air Compressor to replace one 60Hp, making the assumption that with an average demand of 130Hp, the customer would use one 60Hp and the 75Hp for a total availability of 135Hp. The second 60Hp was set for auto backup to load at a pressure slightly below the VFD Target Pressure. Because of a fixed dead band pressure setting from the factory, the unload pressure setting had to be set above the VFD Target Pressure. In graph D you can see the actual system setup and planned ideal operation.

What was forgotten in the analysis is that occasionally, the air demand would peak above 130Hp, due to the use of compressed air for cleanup. This caused the pressure to fall and the second 60Hp to start and load.



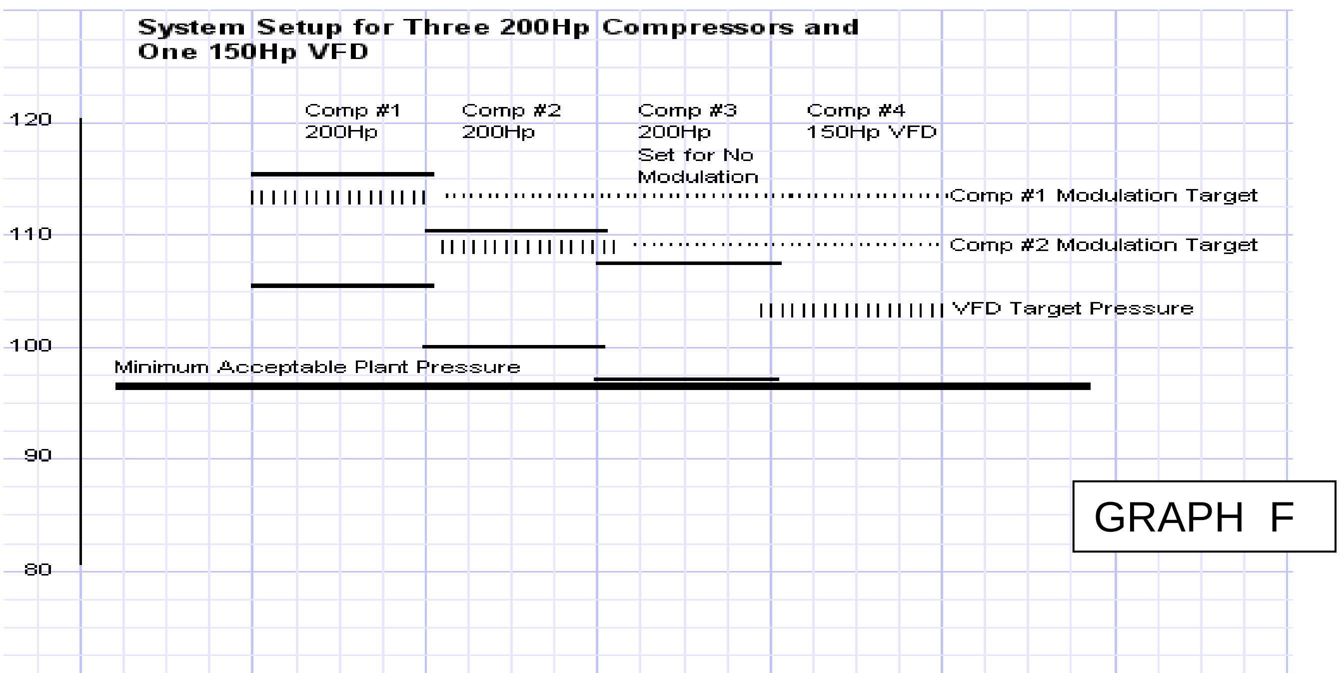
As the pressure increased with the additional 60Hp up to the VFD Target Pressure, the VFD Compressor slowed and then mechanically modulated and reduced its’ flow more than 60Hp, stopping the pressure rise.



Now the customer was back to operating three compressors and stuck there permanently when they actually only required three compressors for a short duration.

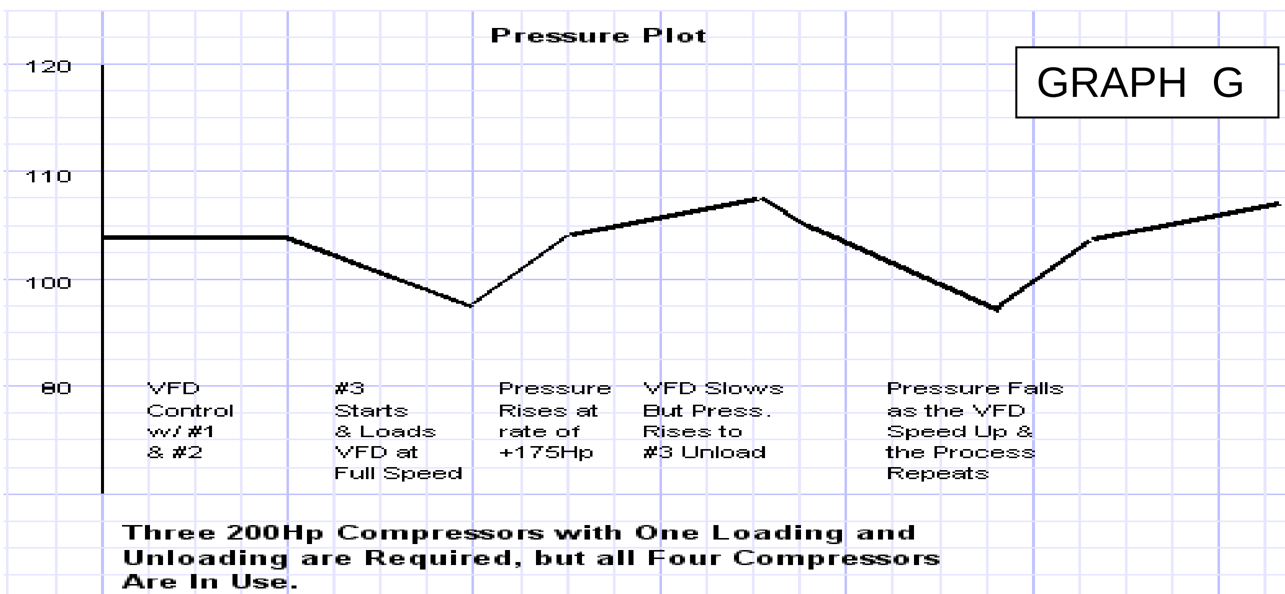
A MULTIPLE COMPRESSOR SYSTEM WITH AN UNDERSIZED VFD

This example included three 200Hp Rotary Screw Air Compressors with mechanical modulation and all three compressors running. The compressor supplier calculated the average air demand to be 500Hp and recommended a new 150Hp VFD Air Compressor as a "trim" compressor. This unit combined with two fully loaded 200Hp Compressors should be perfect and maintain constant pressure with the VFD operating at 66%, and one 200Hp as an auto backup.



What was missed in the analysis was that occasionally the demand peaked at over 550Hp causing the third 200Hp compressor to start and load. As the pressure rose into the VFD Target Pressure, the VFD slowed down to 75Hp, but with a new total capacity on line of 675Hp, the pressure continues to rise up to the unload setting of the last 200Hp Compressor. When this compressor unloaded, the pressure fell and the VFD Compressor increased speed to a full load of 150Hp, but because the air demand is greater than 550Hp, the pressure continued to fall, causing the 200Hp to reload and the cycle repeats. So instead of only using three 200Hp Compressors to satisfy the slightly greater than 550Hp requirement, the customer is now using all three plus the VFD. This continues until the demand falls below 550Hp at which time the 200Hp will unload and time out, leaving the VFD to trim. The real problem is that the plant demand increased to greater than 550Hp all the time and all four compressors ran constantly, even though three 200Hp compressors could handle the demand.

The compressor supplier could have supplied a 200Hp VFD, but at a demand of 500Hp it would have been operating at the bottom of its' throttle range and due to VFD losses, its' output was less than the original 200Hp Compressors. Had the supplier provided a 250Hp VFD unit, the customer would have incurred additional initial cost.



CONCLUSIONS & RECOMENDATIONS

Part of our challenge is often the business process by which improvements are attempted. If we could fix the process, the problem would be defined better with adequate data collection and understanding. With a poor foundation clients are often led to over simplistic control strategies that don't take into account real world variability of systems.

Properly applied VFD Air Compressors have benefits and can be used to reduce energy while delivering a stable pressure, but without proper system operational details, this is very difficult. Even with adequate information, as plant air demand changes, the application changes as well. Intelligent Automation Systems have been applied to manipulate the compressors to insure that the VFD Compressor is used as much as possible to "trim" the system and to avoid the use of extra compressors as detailed above.

One should always be aware of expert's bias offering their product as part of a solution; noting that it may not be the optimum solution.   It appears that when the term VFD is used many electricity suppliers are anxious to provide rebates and incentives, but we recommend the end user must carefully weigh the benefits of the VFD versus other solutions such as added system capacitance or pressure control stations. Consider all proven system solutions coupled with energy reduction programs.