# Recommendation ${REC}: Install New Compressor Package with Variable Frequency Drive (VFD)

**Recommended Action**

It is recommended to install a new air compressor package with a Variable Frequency Drive (VFD) <TANK>and air tank </TANK>to increase the savings at partial load compared with the current control system.

**Summary of Estimated Savings and Implementation Costs**

|  |  |
| --- | --- |
| Recommendation Type | Compressor |
| Annual Cost Savings | ${ACS} |
| Implementation Cost | ${MIC} |
| Payback Period | ${MPB} |
| Annual Electricity Savings | ${ES} kWh |
| Annual Demand Savings | ${DS} kW |
| ARC Number | 2.4226.2 |

**Current Practice and Observations**

In many commercial and industrial environments, the application of variable speed control is cost effective, where for air compressor packages at partial load conditions a system with a VFD can reduce the energy consumption more than any other control mechanism. Currently there is a ${HPC} HP air compressor package operating at partial load. The replacement compressor would become one of the main compressors for the facility, and one of the existing mains would be turned into a backup.

**Anticipated Savings**

The change in the power of a motor varies as the speed of the motor, or flow, changes, as per the following:

This relationship is used to estimate the energy use of a given air compressor with a variable frequency drive. The table below shows the relative power consumption of an air compressor using VFD control, compared to an air compressor with standard controls[[1]](#footnote-1).

|  |  |  |
| --- | --- | --- |
| **Load %** | **Air Compressor Power Consumption** | |
| **No Control %** | **VFD %** |
| 100 | 100 | 105 |
| 95 | 100 | 95 |
| 90 | 100 | 90 |
| 85 | 100 | 85 |
| 80 | 100 | 80 |
| 75 | 100 | 75 |
| 70 | 100 | 70 |
| 65 | 100 | 65 |
| 60 | 100 | 61 |
| 55 | 100 | 57 |
| 50 | 100 | 52 |
| 45 | 100 | 47 |
| 40 | 100 | 42 |
| 35 | 100 | 38 |
| 30 | 100 | 33 |
| 25 | 100 | 28 |
| 20 | 100 | 25 |

Table : Power Consumption of Air Compressor with Load.

Notice that a linear proportion is not exactly followed for VFD power consumption. This is a result of losses incurred by the variable frequency drive, which reduces the air compressor's efficiency. Therefore, with VFD control, as the flow rate decreases, the VFD/motor system efficiency decreases. Consequently, the actual power consumption is higher than the theoretical power consumption estimated by the linear proportion, with more deviation at lower flow rates. More accurate power consumption estimates can be obtained for varying flows if pump or fan curves from the manufacturers are available. The figure below shows the power consumption of an air compressor as a function of the control scheme and fractional capacity, or CFM production compared against the maximum rated value. This is used to gauge the power consumption of the existing system.

**Chart, line chart

Description automatically generated**

Figure : Power Consumption of Compressor for Different Control Schemes[[2]](#footnote-2).

The current power draw for a given air compressor, CPD, and the proposed power draw for a given air compressor with VFD, PPD, can be calculated as follows:

CPD = HPC × C1 × FPC / ηExist

PPD = HPP × C1 × FPV / ηProp

where,

HPC = Horsepower of the current air compressor: ${HPC} HP

HPP = Horsepower of the proposed air compressor: ${HPP} HP

C1 = Conversion constant: 0.746 kW/HP

FPC = Power fraction of the current air compressor using ${CT} control at ${LF}% load

= ${FPC}% (from figure above)

FPV = Power fraction of the proposed air compressor with VFD at ${LF}% load

= ${FPV}% (from table above)

ηExist = Efficiency of the existing air compressor: ${ETAE}%

ηProp = Efficiency of the air compressor with VFD: ${ETAP}%

CPD = ${HPC} HP × 0.746 kW/HP × ${FPC}% / ${ETAE}%

= ${CPD} kW

PPD = ${HPP} HP × 0.746 kW/HP × ${FPV}% / ${ETAP}%

= ${PPD} kW

The annual electricity savings, ES, for a given piece of equipment can be estimated as follows:

ES = (CPD - PPD)× OH

where,

OH = Annual operating hours when compressor is in use: ${OH} hrs/yr (${HR} hrs/day, ${DY} days/wk, ${WK} wks per yr)

ES = (${CPD} kW – ${PPD} kW) × ${OH} hrs/yr

= ${ES} kWh/yr

The annual demand savings, DS, for a given piece of equipment can be calculated as follows:

DS = (CPD - PPD) × C2 × CF

CF = Coincidence factor – probability that the equipment contributes to the facility peak demand per month: 100% per month

C2 = Conversion constant: 12 mos/yr

DS = (${CPD} kW – ${PPD} kW) × ${CF}%/mo × 12 mos/yr

= ${DS} kW/yr.

The total annual cost savings, ACS, is:

ACS = (ES × Electricity Cost) + (DS × Demand Cost),

= (${ES} kWh/yr × ${EC}/kWh) + (${DS} kW/yr × ${DC}/kW)

= ${ECS}/yr + ${DCS}/yr

= ${ACS}/yr.

**Implementation Cost**

Based on information obtained from suppliers, it is estimated that the cost of a new ${HPP} HP Compressor with Variable Frequency Drive (VFD) will be ${VFD} <TANK>and a new air tank will be ${ATP}, </TANK>with installation cost to be about ${AIC}. The total implementation cost is estimated as ${IC}. <REBATE>

Rebates are available for switching to VFD in a manufacturing environment (see appendix). The estimated rebate is:

RB = ${ERR}/kWh⋅yr × ES

= ${ERR}/ kWh⋅yr × ${ES} kWh/yr

= ${RB}

The incentives are capped at 50% of the project cost and makes the modified rebate savings MRB equals to ${MRB}. Hence, the modified implementation cost (MIC) is estimated as follows:

MIC = IC – MRB (Note: Rebate can’t exceed 50% of project cost)

= ${IC} - ${MRB}

= ${MIC}

Therefore, the total implementation cost is: ${MIC}.</REBATE>

**The annual electricity savings for this recommendation is ${ES} kWh, and the annual demand savings is ${DS} kW. The annual cost savings is likely to be ${ACS} and, with an implementation cost of ${MIC}, the payback period would be ${MPB}.**

**Implementation Cost References**

The below links are for implementation cost references. We do not endorse/recommend these brands or products. Furthermore, these products may or may not be suitable for the application. The client should contact a vendor(s) to conduct a detailed study of the process, to determine the best product for the recommended application.

**VFD:**

* https://www.northerntool.com/shop/tools/product\_200367822\_200367822
* https://www.aircompressorsdirect.com/Ingersoll-Rand-2545E10VP-460-Air-Compressor/p9324.html
* https://www.compressorworld.com/50-hp-variable-speed-drive-rotary-screw-air-compressor-with-sound-enclosure-210-cfm-at-125-psi-460-volt-3-phase-e50-vfd.html

**<TANK>Air Storage Tank:**

* https://www.mcmaster.com/4377K61/
* https://www.grainger.com/product/SPEEDAIRE-Air-Tank-240-gal-Tank-Capacity-6CJL3</TANK>

1. Electric Power Research Institute, *Adjustable Speed Drives Directory*, Table 3.1, p. 18, 1991. [↑](#footnote-ref-1)
2. Power Characteristics of Industrial Air Compressors, Chris Schmidt, Kelly Kissock, Ph.D., P.E [↑](#footnote-ref-2)