# AR ${AR}: Install Variable Frequency Drive (VFD) on Air Compressor Package

**Recommended Action**

It is recommended to supplement the existing 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**

|  |  |
| --- | --- |
| Annual Cost Savings | ${ACS} |
| Implementation Cost | ${MIC} |
| Payback Period | ${PB} |
| Annual Electricity Savings | ${ES} kWh |
| Annual Demand Savings | ${DS} kW |
| ARC Number | 2.4146.2 |

**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 ${HP} HP air compressor package operating at partial load.

**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 motor with a variable frequency drive. The table below shows the relative power consumption of a motor using VFD control, compared to a motor with standard controls[[1]](#footnote-1).

|  |  |  |
| --- | --- | --- |
| **Load %** | **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 1:** **Power Consumption of 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 motor'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 1:** **Power Consumption of Compressor for Different Control Schemes[[2]](#footnote-2).**

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

CPD = HP × C1 × FPC / ηExist

PPD = HP × C1 × FPV / ηProp

where,

HP = Horsepower of the motor; ${HP} HP

C1 = Conversion constant; 0.746 kW/HP

FPC = Power fraction of the motor using ${CT} control at average ${LF}% load

= ${FPC}% (from figure)

FPV = Power fraction of the motor with VFD at average ${LF}% load

= ${FPV}% (from table)

ηExist = Efficiency of the existing motor; ${ETAE}%

ηProp = Efficiency of the motor with VFD; ${ETAP}%

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

= ${CPD} kW

PPD = ${HP} 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} hours/day, ${DY} days/week, ${WK} weeks per year)

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 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}. Rebates are available for installing VFD’s in a manufacturing facility. The estimated rebate is shown below (see appendix for more details):

RB = ${RR}/kWh⋅yr × ES

= ${RR}/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

= ${IC} - ${MRB}

= ${MIC}

Therefore, the total implementation cost is: ${MIC}.

**The annual electricity savings for this AR 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 ${PB}.**

**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.precision-elec.com/shop/dcs800-s02-2050-07b/>
* <https://www.allsurplus.com/asset/184/18850>
* https://www.grainger.com/product/SCHNEIDER-ELECTRIC-Variable-Frequency-Drive-480V-55WR81

**<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)