# Comparison of the US DOE MotorMaster Plus to IEEE Std 112 Method B

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***Abstract: The present version of the US Department of Energy's MotorMaster Plus (MMPlus) software was released in 1995 with modifications related to reliability funded by Dreisilker Electric Motors, Inc., ALL-TEST Pro, and Pruftechnic, in 2000. In 1999, a study by the Washington State Energy Extension Center determined that the efficiency results from MMPlus were roughly equivalent to IEEE Std 112 Method B testing, the requirement by the Energy Policy Act of 1992 (EPAct '92). In this paper we will compare the findings of three of the same model number and manufacturer motors via IEEE Std 112 Method B to the findings of MMPlus and our independent observations.***

## Introduction

The introduction of MotorMaster Plus (MMPlus) the Windows® version by the US Department of Energy in 1995 provided a much needed resource for the implementation of motor retrofits by industry and commercial organizations. Around 1997 the inclusion of ORMEL 96, an Oak Ridge National Labs algorithm, provided a more accurate method of comparing motor efficiencies based upon simple operating data input at other than 100% load. A study published by the Washington State Energy Extension Center in 1999, "In-Service Motor Testing," identified that the average difference between MMPlus findings and IEEE Std 112 Method B[1] results was about 0.2% efficiency. Starting in 2000, a variety of instrument manufacturers included licensed copies of MMPlus with their technologies and the team of Dreisilker Electric Motors, Inc., ALL-TEST Pro, and Pruftechnic, funded modifications to the database for evaluating machines by condition. Since then small modifications have been made to the database, but the present version of MMPlus remains true to the version generated in 2000.

With the prospect of improvements in the 2010 Energy Policy Act, the potential use of MMPlus has returned for motor selection, retrofit, and repair versus replace decisions. In an early 2010 evaluation of three electric motors for energy efficiency the question was raised whether or not the MMPlus findings would be equivalent to IEEE Std 112 Method B testing.

The IEEE Std 112 Method B evaluation involves a series of tests designed to segregate the machine losses including the core losses, stator and rotor $I^2R$ losses, friction and windage losses, and stray load losses. This is the method recognized in the United States for evaluating electric motor efficiency including required use per the EPAct 92 to evaluate energy efficient motors. The test requires specific power requirements, instrumentation and load testing capabilities. Overall, machines the size of the ones used in this report take approximately a full day of testing.

The three machines selected were 150 horsepower, vertical motors, 1780 RPM, 60 Hz, 460 Vac, 167 Amp, and solid shaft. The machines were mounted horizontally as shown in Figure 1.

Figure 1: Motor Under Test

[1] IEEE, IEEE Std 112-2004: IEEE Standard Test Procedure for Polyphase Induction Motors and Generators, IEEE Standard, 2004

## IEEE Std 112 Method B Findings

The tests were performed over three days with results identifying some specific differences between the three machines. Retesting was performed on one machine to verify the findings.

Table 1: IEEE 112 Test Results

| | 25% | 50% | 75% | 100% | 125% |
|---|---|---|---|---|---|
| Mtr 1 | 90.2 | 95.0 | 95.2 | 94.5 | 93.6 |
| Mtr 2 | 89.4 | 93.2 | 94.0 | 94.0 | 93.6 |
| Mtr 3 | 92.7 | 94.8 | 95.0 | 94.3 | 93.7 |

## MMPlus Efficiency Testing Using ORMEL 96

Using the identical data from the IEEE Std 112 Method B tests, which included voltage, current, Watts, RPM, and power factor. The nameplate efficiency and power factors provided by the manufacturer were not entered.

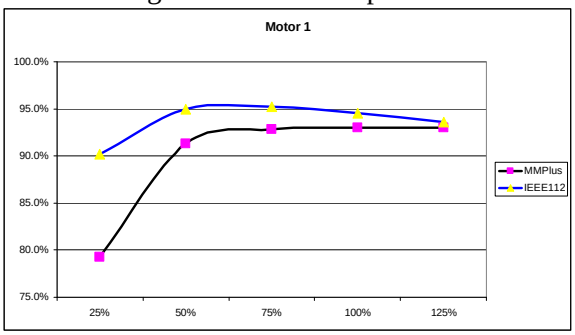
Table 2: MMPlus Test Results

| | 25% | 50% | 75% | 100% | 125% |
|---|---|---|---|---|---|
| Mtr 1 | 79.3 | 91.3 | 92.8 | 93.0 | 93.0 |
| Mtr 2 | 86.3 | 91.6 | 92.8 | 93.0 | 93.0 |
| Mtr 3 | 85.9 | 91.5 | 92.8 | 93.0 | 93.0 |

## Comparison of Methods

As noted between Tables 1 and 2 there is a definite difference in efficiency between the two methods. These are shown in Figures 2, 3, and 4.

Figure 2: Mtr 1 Comparison




What was noted in the MMPlus dataset was that if the motor efficiency and power factor were included as part of the nameplate, the full load (100%) efficiency findings were the same as the nameplate and the curves were similar.

Figure 3: Mtr 2 Comparison

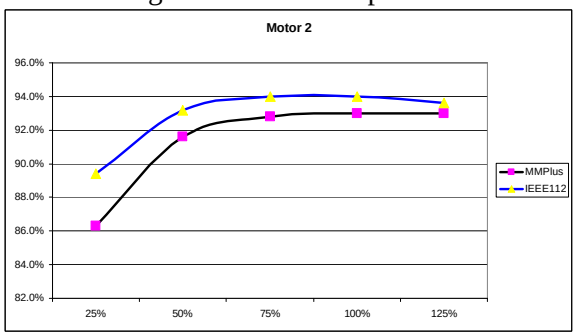
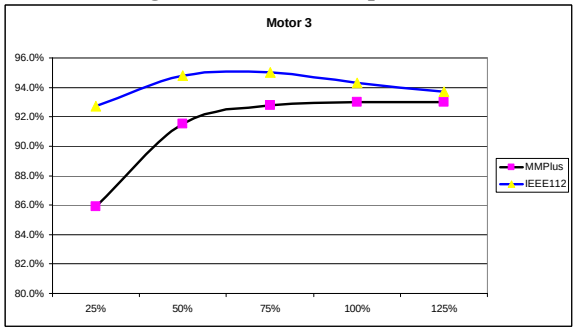



Figure 4: Mtr 3 Comparison




It was also noted that the heavier the loading on the motors, the closer the curves fit. When the 100% found efficiency is entered into MMPlus nameplate, the curves are virtually identical.

## Comment on MotorMaster Plus

The MMPlus system utilizes efficiency curve algorithms to roughly approximate an average efficiency curve based upon provided data at different load points. The ORMEL 96 system provides a more accurate method of performing a similar function. The result, as shown in Figures 2, 3, and 4, is that the curve roughly approximates the actual efficiency curve as tested with IEEE 112 Method B. The challenge is that if the nameplate efficiency is entered into the database, the curve will be anchored to that efficiency at 100% load. If some other non-regulated efficiency is entered, such as the catalog efficiencies which are what exist in the MMPlus database, the value provided may be higher or lower than the actual motor efficiency.

As a result, it is necessary to ensure that the efficiency data provided by the motor manufacturer is the NEMA Nominal Efficiency, as different standards will result in different efficiencies (ie: JAE and other Asian energy efficiency standards will result in higher efficiency ratings). This should be provided as the nameplate versus catalog efficiency, if possible.

The objective of software like MMPlus is to be able to make repair versus replace decisions and compare machines to each other. To date, the use of MMPlus provides the end user with a neutral, third party comparison capability that outmatches any other method available. This means that while you must be aware of the potential limitations of MMPlus as demonstrated in this paper, it still remains as an excellent tool for making energy-based decisions. For greater accuracy, the guaranteed or nameplate nominal efficiency must be provided.

## Conclusion

The standard for motor efficiency testing in the USA is IEEE Std 112 Method B. A US Department of Energy software program called MotorMaster Plus (MMPlus) provides a means to compare the impact of two different efficiency scenarios allowing for energy-based decisions. As demonstrated in this paper, while the system is sound, the accuracy of the information provided will effect the accuracy of the MMPlus system. Awareness, and the purpose of this paper, of the capabilities of MMPlus will allow the user of the system to make sound decisions.

To obtain your free copy of the MotorMaster Plus software, other energy software tools, and information, go to: http://www1.eere.energy.gov/industry/bestpractices/for_technical.html

## About the Author

Howard W Penrose, Ph.D., CMRP is the Vice President of Engineering and Reliability Services for Dreisilker, the Web Editor-in-Chief of the IEEE Dielectrics and Electrical Insulation Society, and the Director of Membership for the Society for Maintenance and Reliability Professionals (SMRP). He has won five consecutive UAW and General Motors People Make Quality Happen Awards (2005-2009) for energy, conservation, production, and motor management programs developed for GM facilities globally and is an SMRP Certified Maintenance and Reliability Professional (CMRP). Dr. Penrose is the author of the Axiom Business Book Award (2008 Bronze and 2009 Bronze) winning "Physical Asset Management for the Executive (Caution: Do Not Read This If You Are on an Airplane)," and the 2008 Foreword Book of the Year Finalist textbook, "Electrical Motor Diagnostics: 2nd Edition." Dr. Penrose may be contacted by email at hpenrose@dreisilker.com.