2017 Winter Conference

Las Vegas, Nevada

Tim Mathson, Principal Eng.
Greenheck Fan Corp
tim.mathson@greenheck.com

Currently with AMCA Int'l
tmathson@amca.org

GREENHECK
Building Value in Air.

Seminar 25
Wire-to-Air Fan Power Performance and Energy Consumption

Measurement of
Fan Component Efficiencies

Learning Objectives

- Estimate fan system energy consumption at part load conditions
- Describe difference between direct-on-line and variable frequency driven motor performance
- Identify variables that impact the efficiency of drive system components
- Illustrate the interdependence of individual drive system components on overall fan efficiency

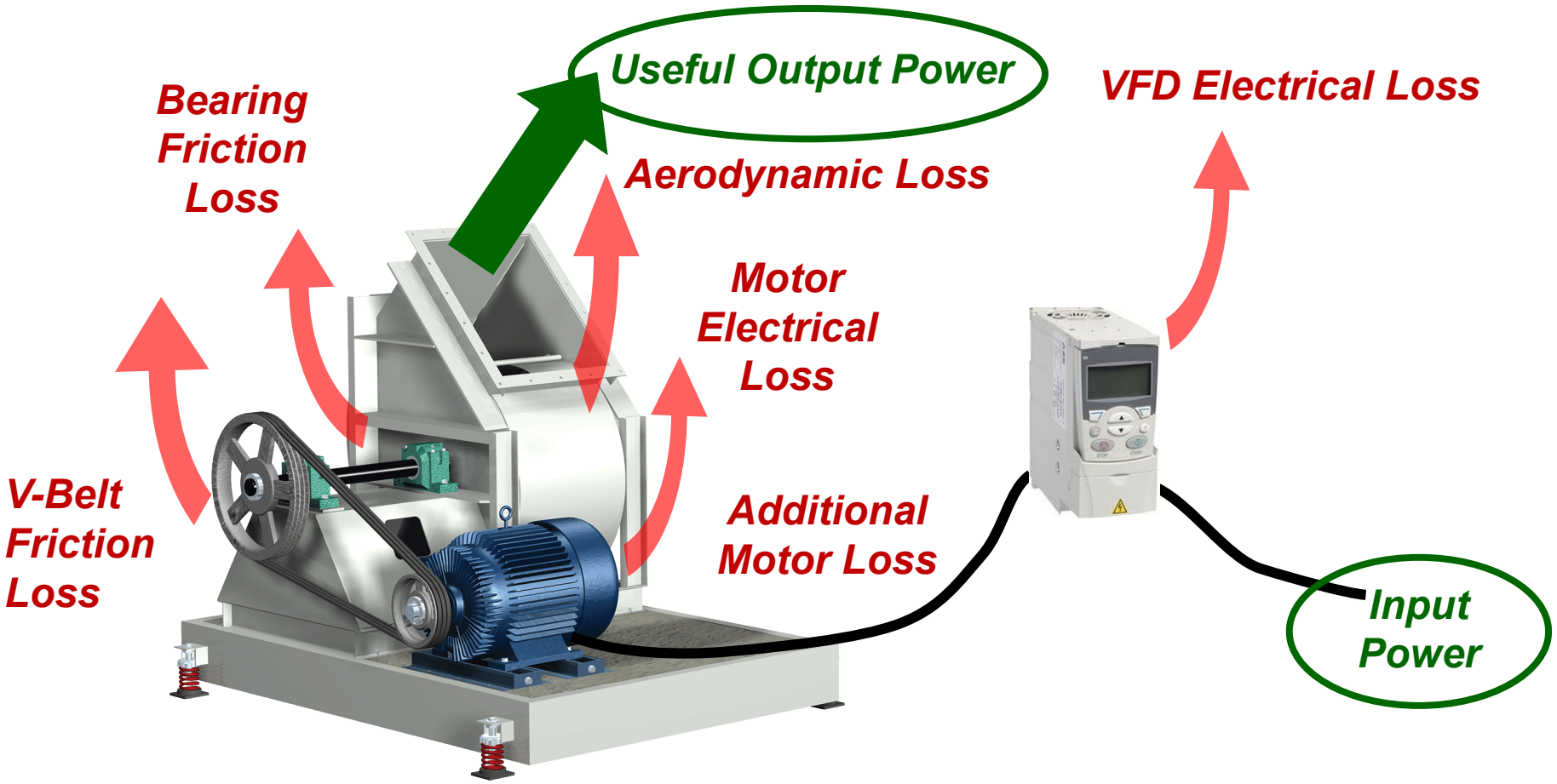
ASHRAE is a Registered Provider with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to ASHRAE Records for AIA members. Certificates of Completion for non-AIA members are available on request.

This program is registered with the AIA/ASHRAE for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Acknowledgements

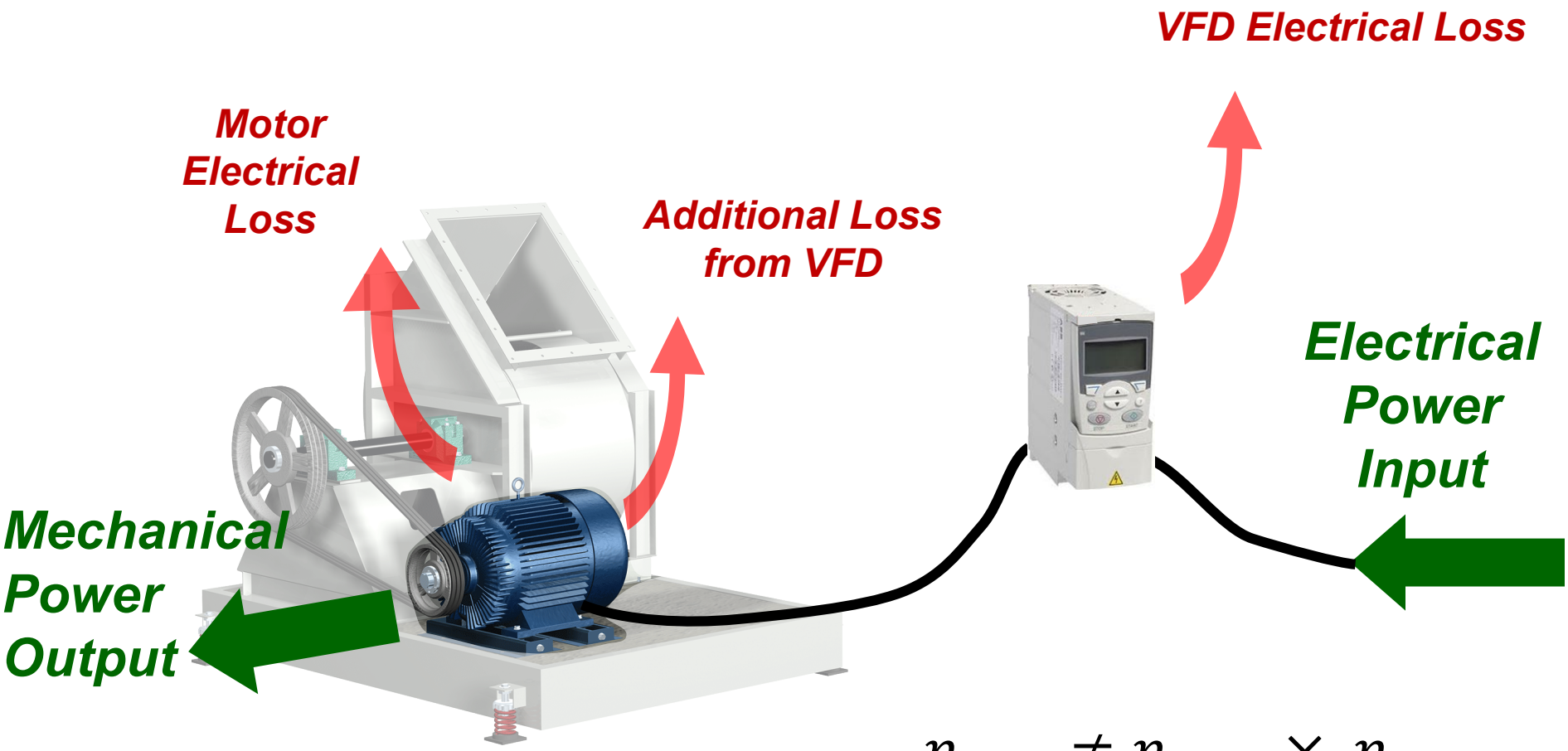
- Baldor Engineering staff
- ABB Engineering staff
- Chris Eiden, Greenheck

Agenda - Overall Energy Efficiency



$$\eta_{overall} = \frac{\text{Output Power}}{\text{Input Power}} = \eta_{fan} \times \eta_{trans} \times \eta_{mtr} \times \eta_{vfd}$$

Motor/VFD Efficiency



$$\eta_{m,v} \neq \eta_{mtr} \times \eta_{vfd}$$

Scope of Testing

Motors - Premium Efficient Induction

- 1, 5, 10 hp (.75, 4, 7.5 kW), 4 Pole, TEFC, 460V 60Hz

VFD's - General Purpose IGBT for HVAC

- 1, 5, 10 hp (.75, 4, 7.5 kW),
- Constant V/Hz, 4 kHz Carrier Frequency

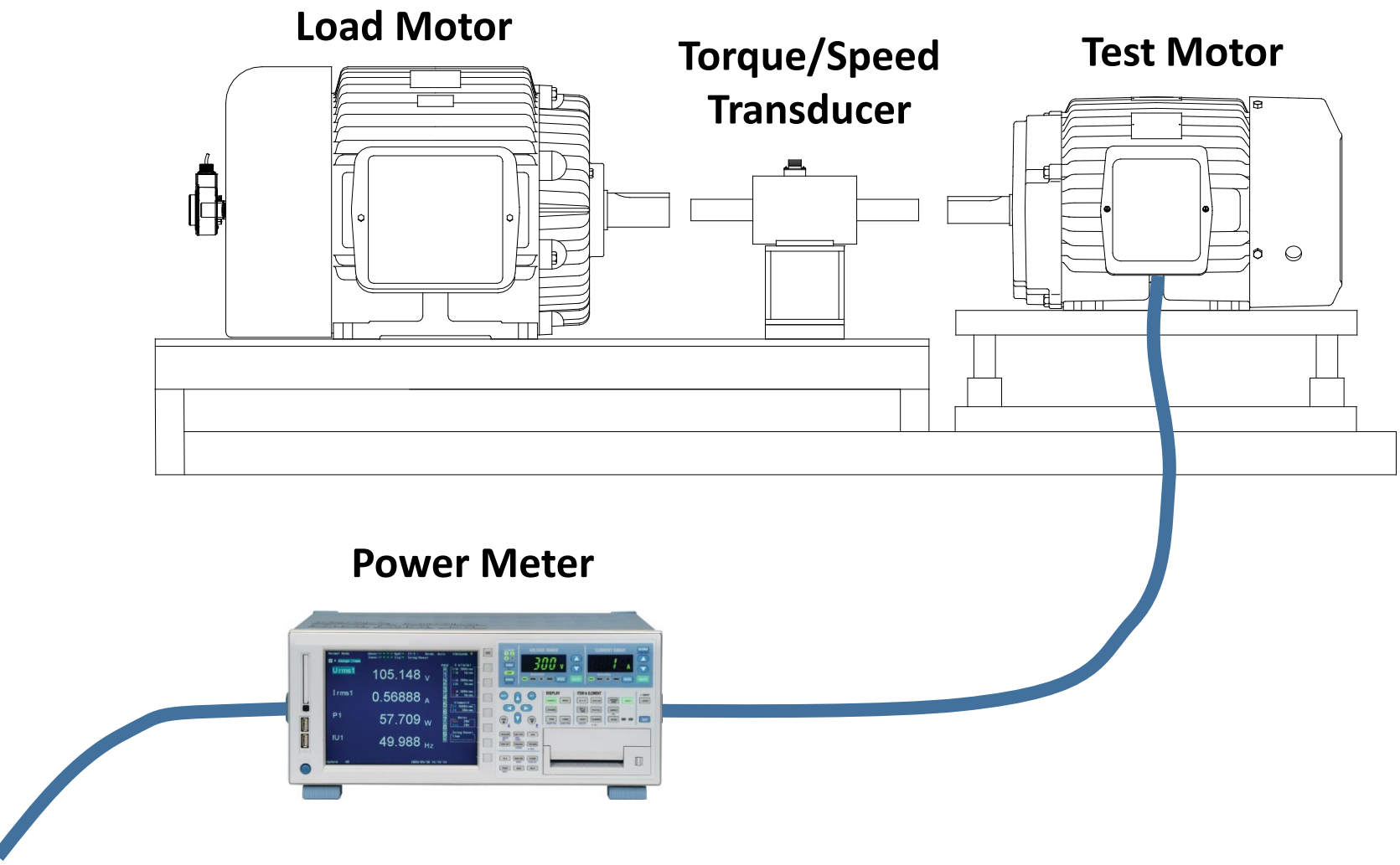
V-Belt drives

- Speeds 1200, 1800, 2700 RPM
- Service Factors 1.0, 1.5, 2.0, 3.0, 4.0
- Number of belts

Fan - 27" (685mm) Mixed Flow

- Belt or dynamometer driven

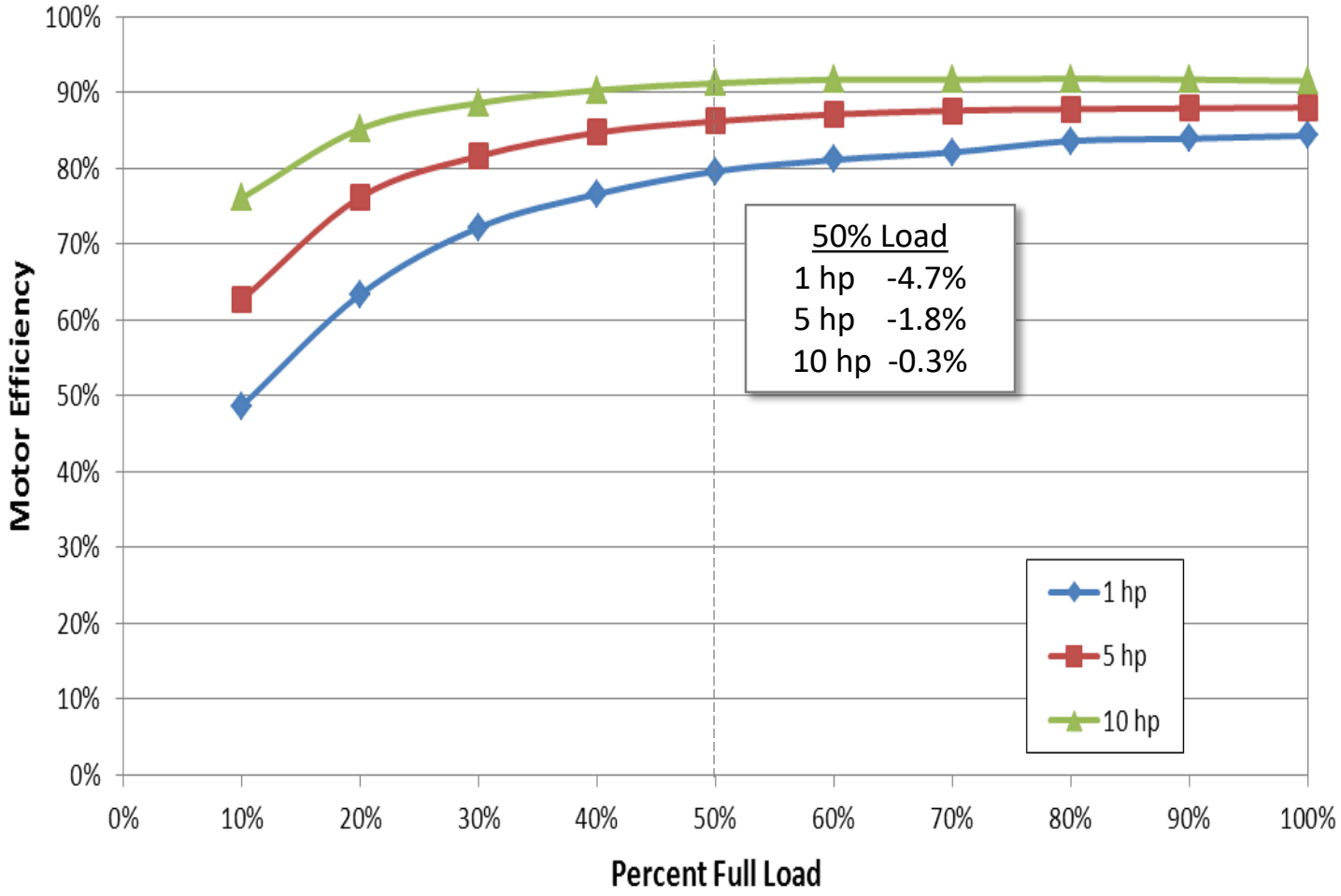
Motor Test Setup



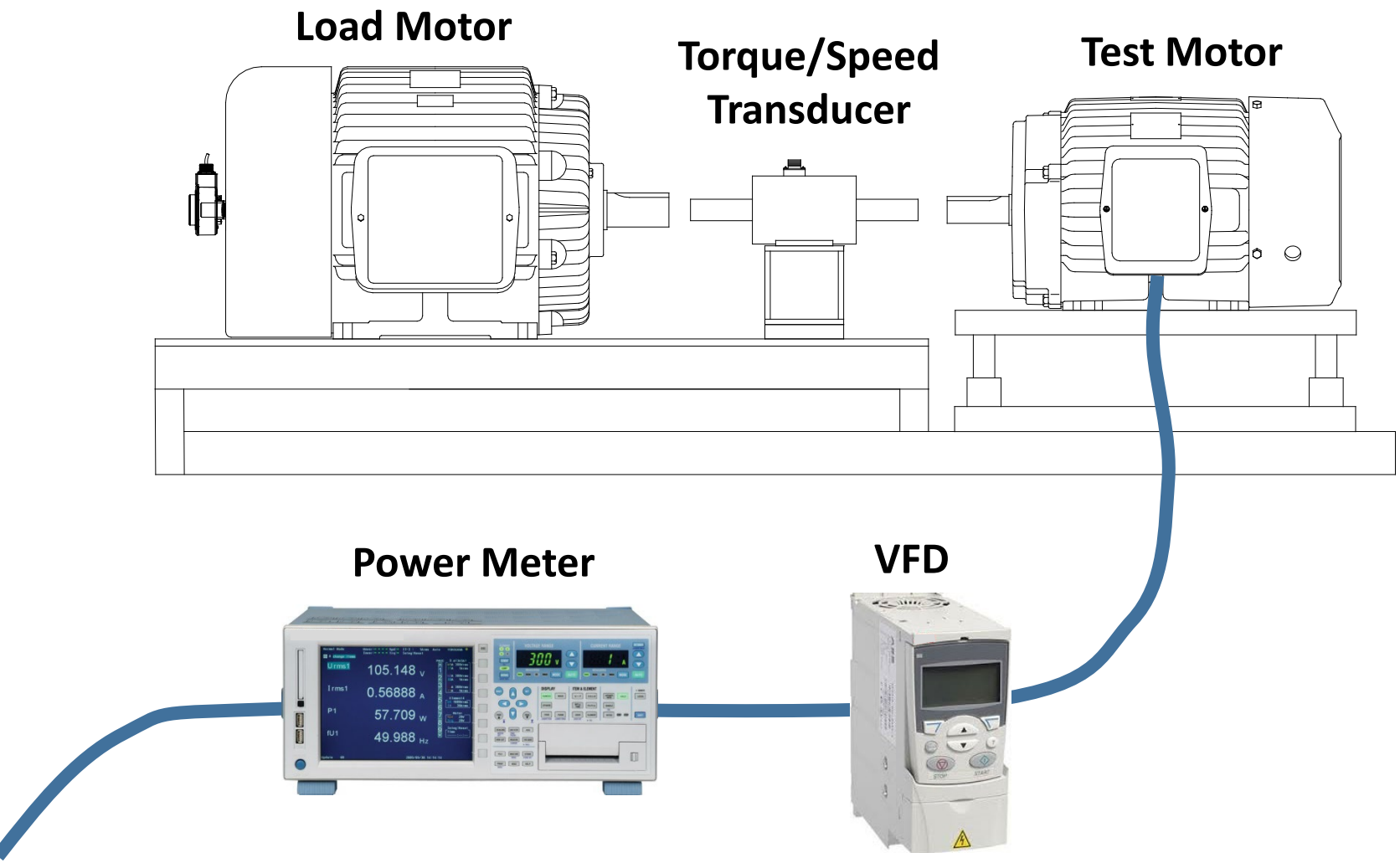
Results – Full Load Motor Efficiency, X-Line

Motor	NEMA Premium Nominal	Measured with 60 Hz Line Power	Difference from Nominal
1 hp	85.5	84.3	-1.2
5 hp	89.5	88.0	-1.5
10 hp	91.7	91.5	-0.2

Results – Part Load Motor Efficiency, X-Line



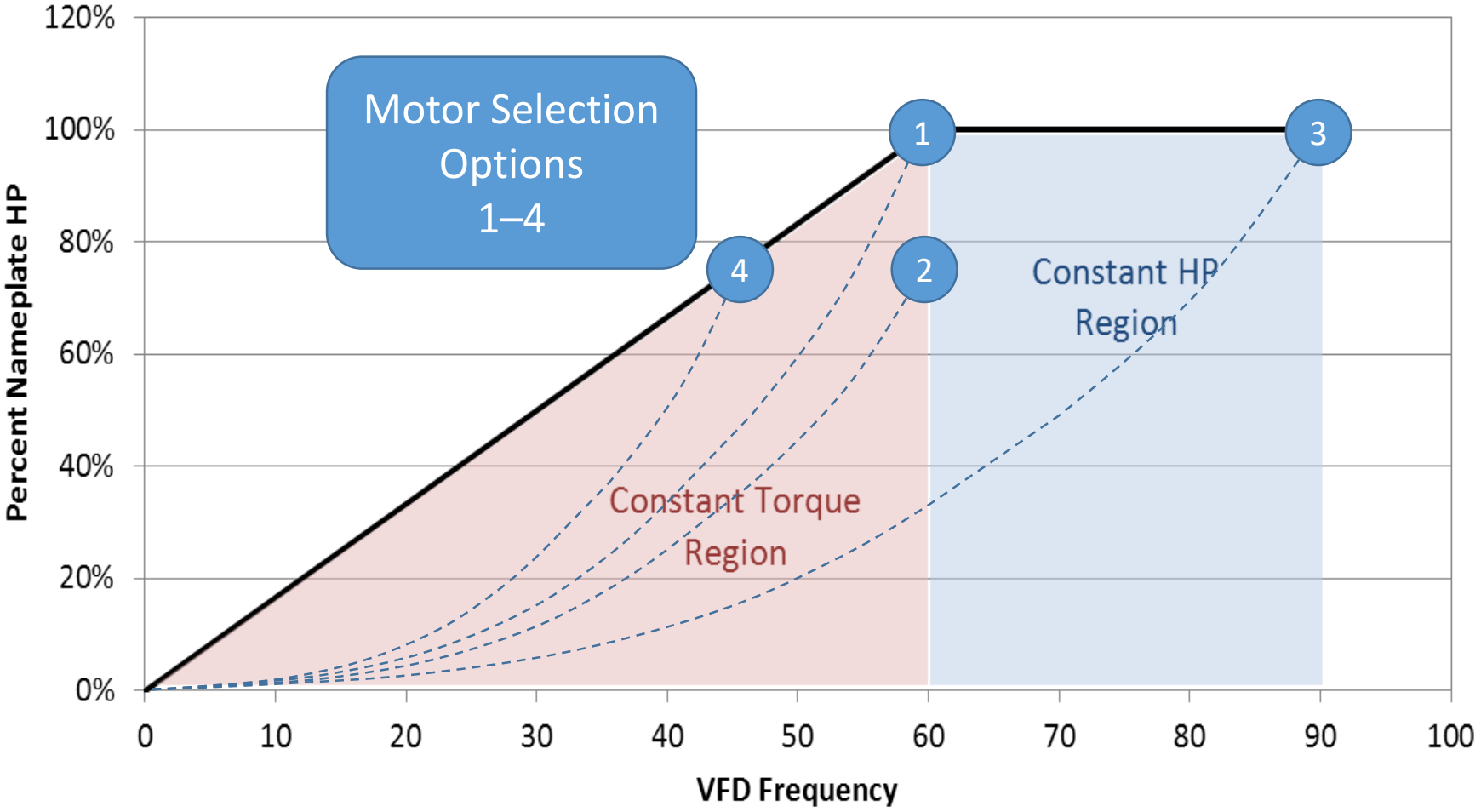
Motor & VFD Test Setup – AHRI 1210



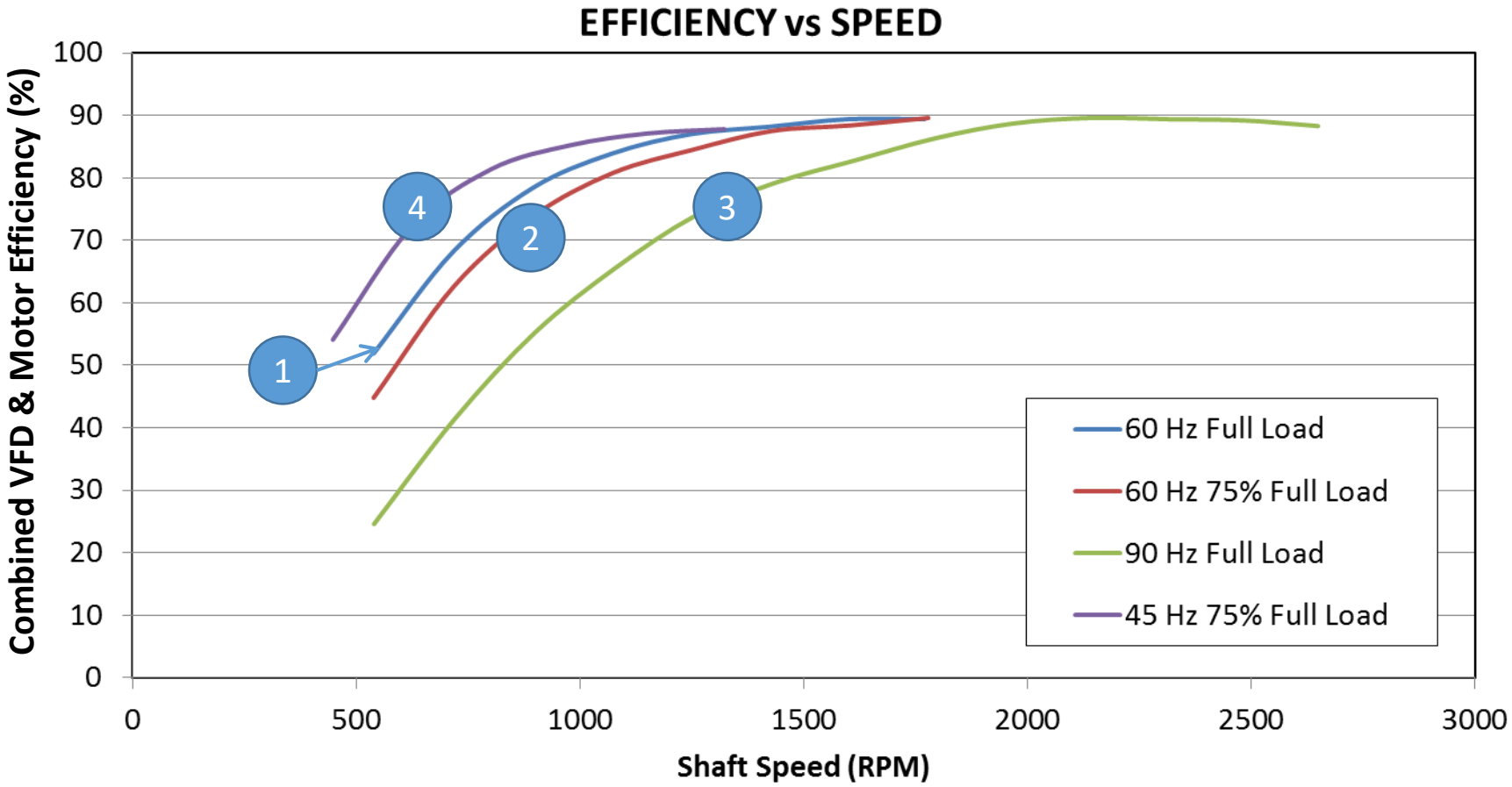
Results – Motor & VFD at Full Load

Motor	Motor Alone With 60 Hz Line Power	Combined Motor & VFD @ 60 Hz
1 hp	84.3	82.4
5 hp	88.0	87.0
10 hp	91.5	89.7

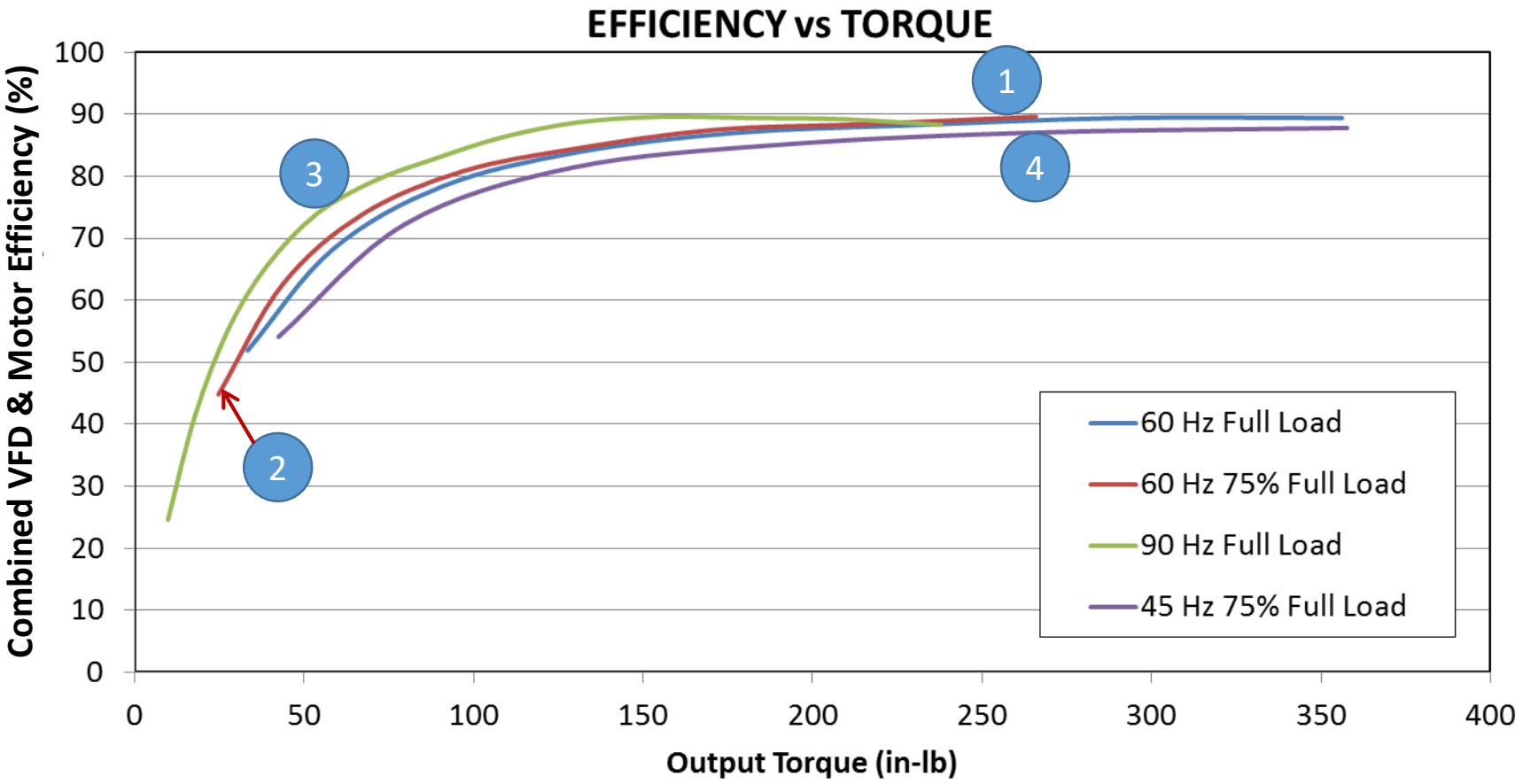
Motor & VFD - Part Load Operation



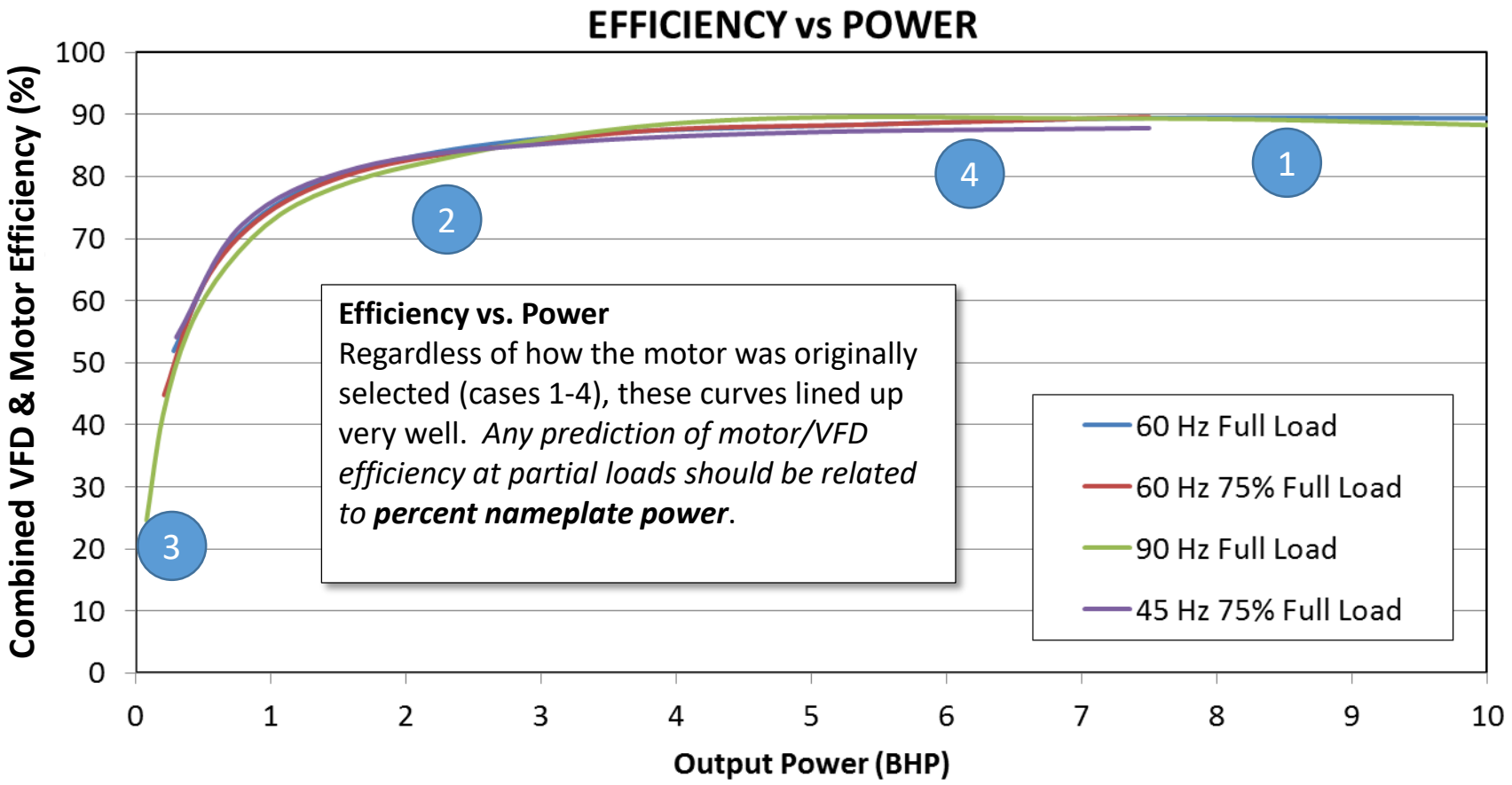
Results – 10 hp Motor & VFD at Part Load



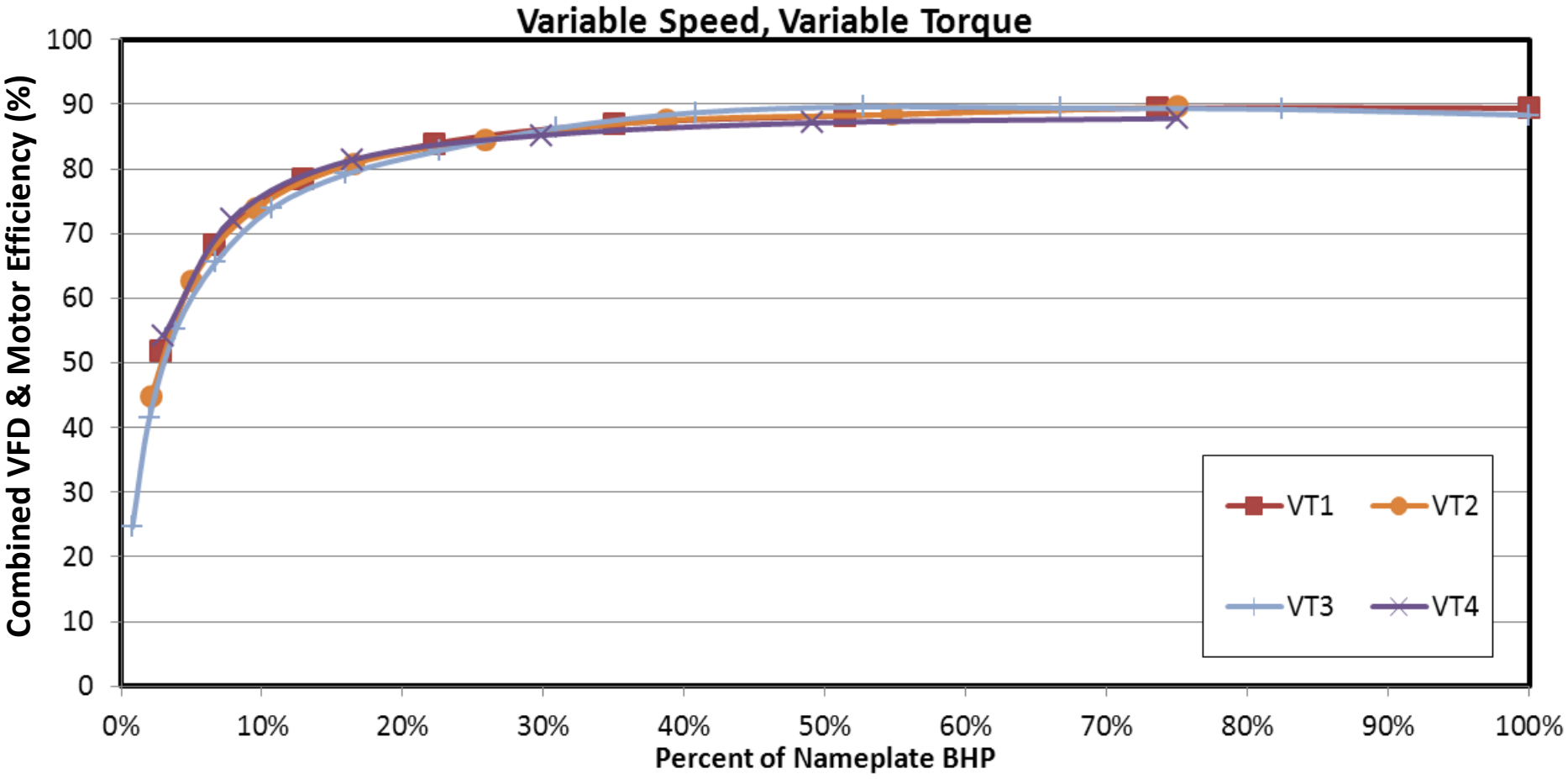
Results – 10 hp Motor & VFD at Part Load



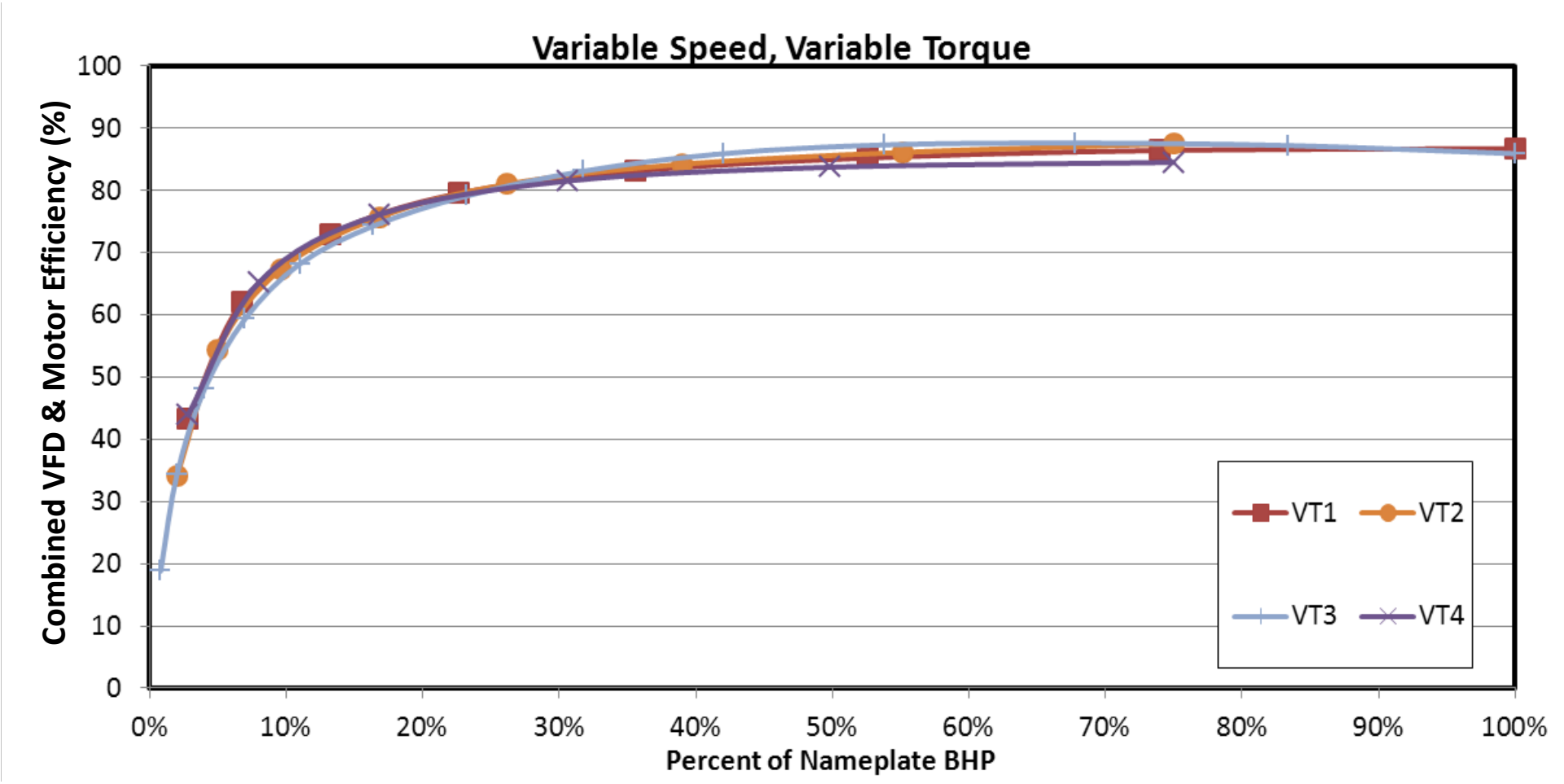
Results – 10 hp Motor & VFD at Part Load



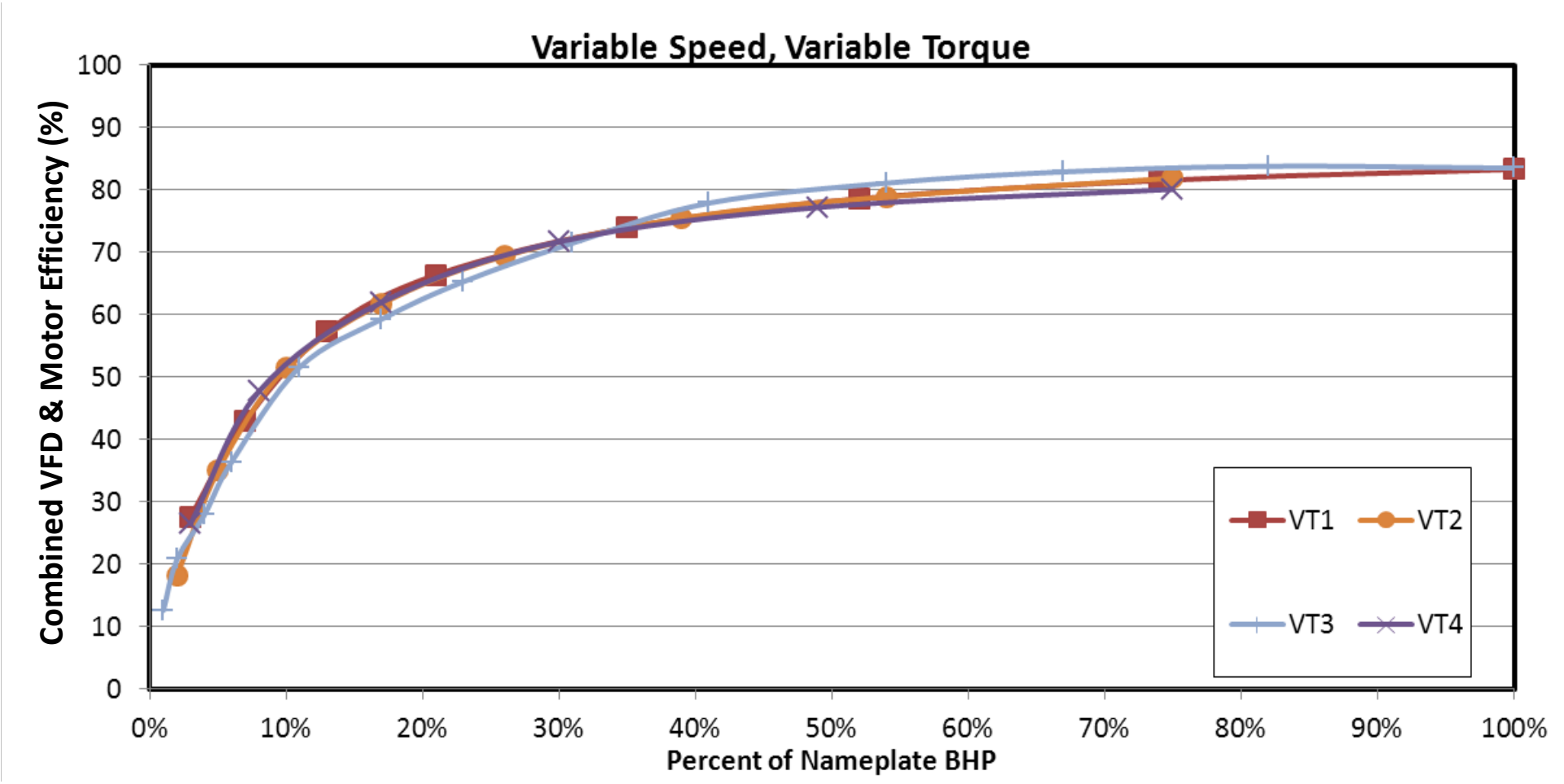
Results – 10 hp Motor & VFD at Part Load



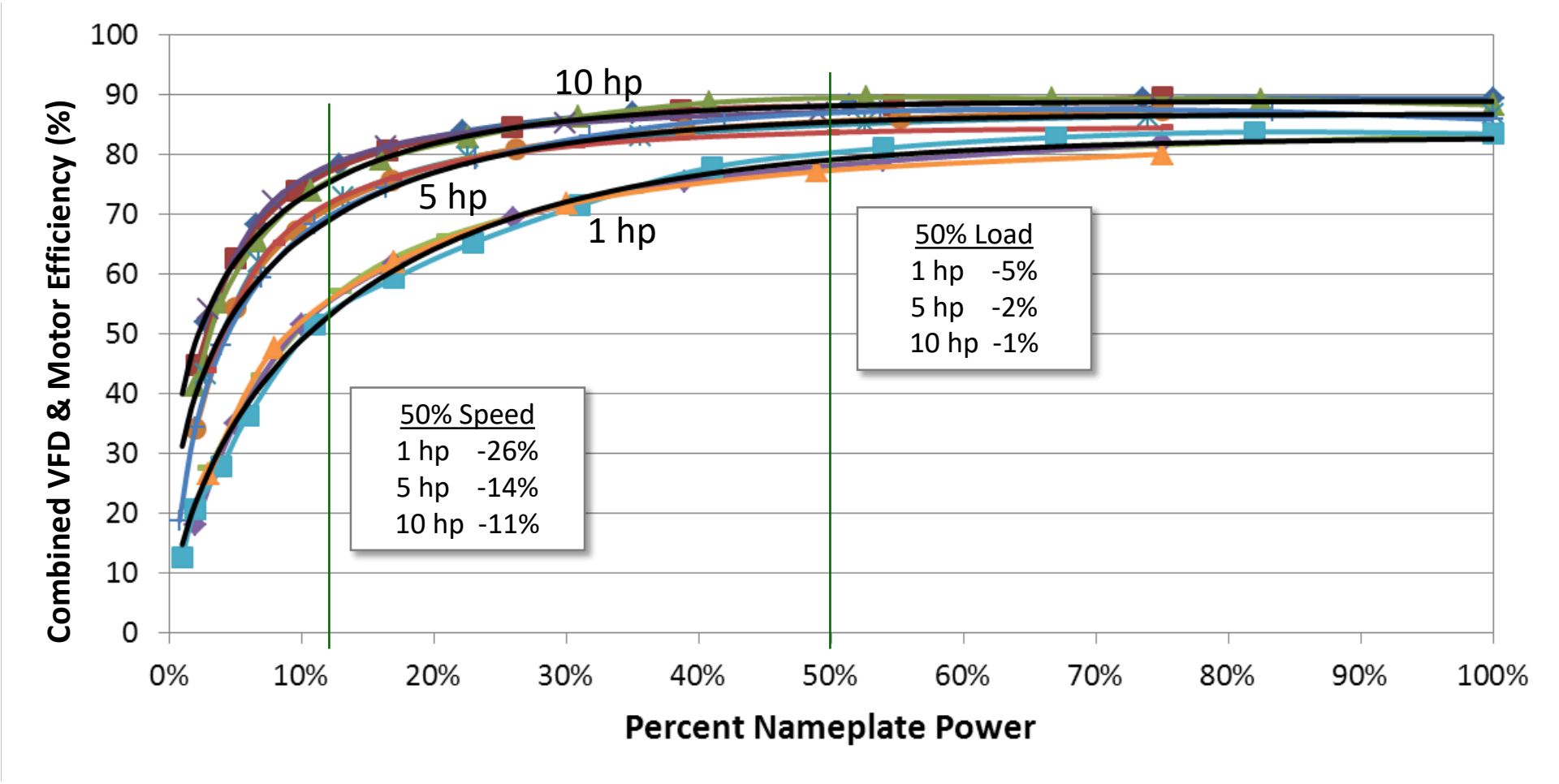
Results – 5 hp Motor & VFD at Part Load



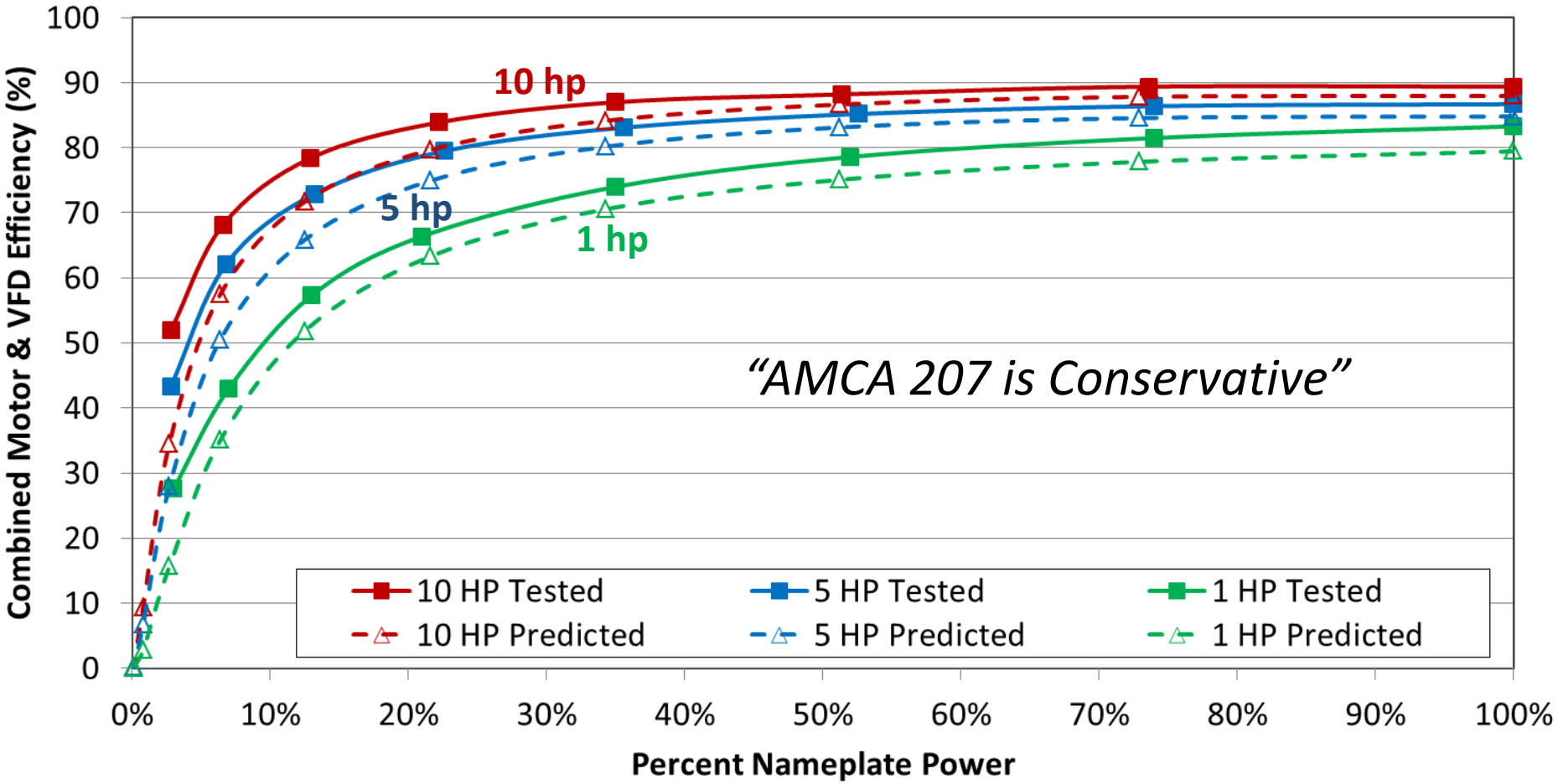
Results – 1 hp Motor & VFD at Part Load



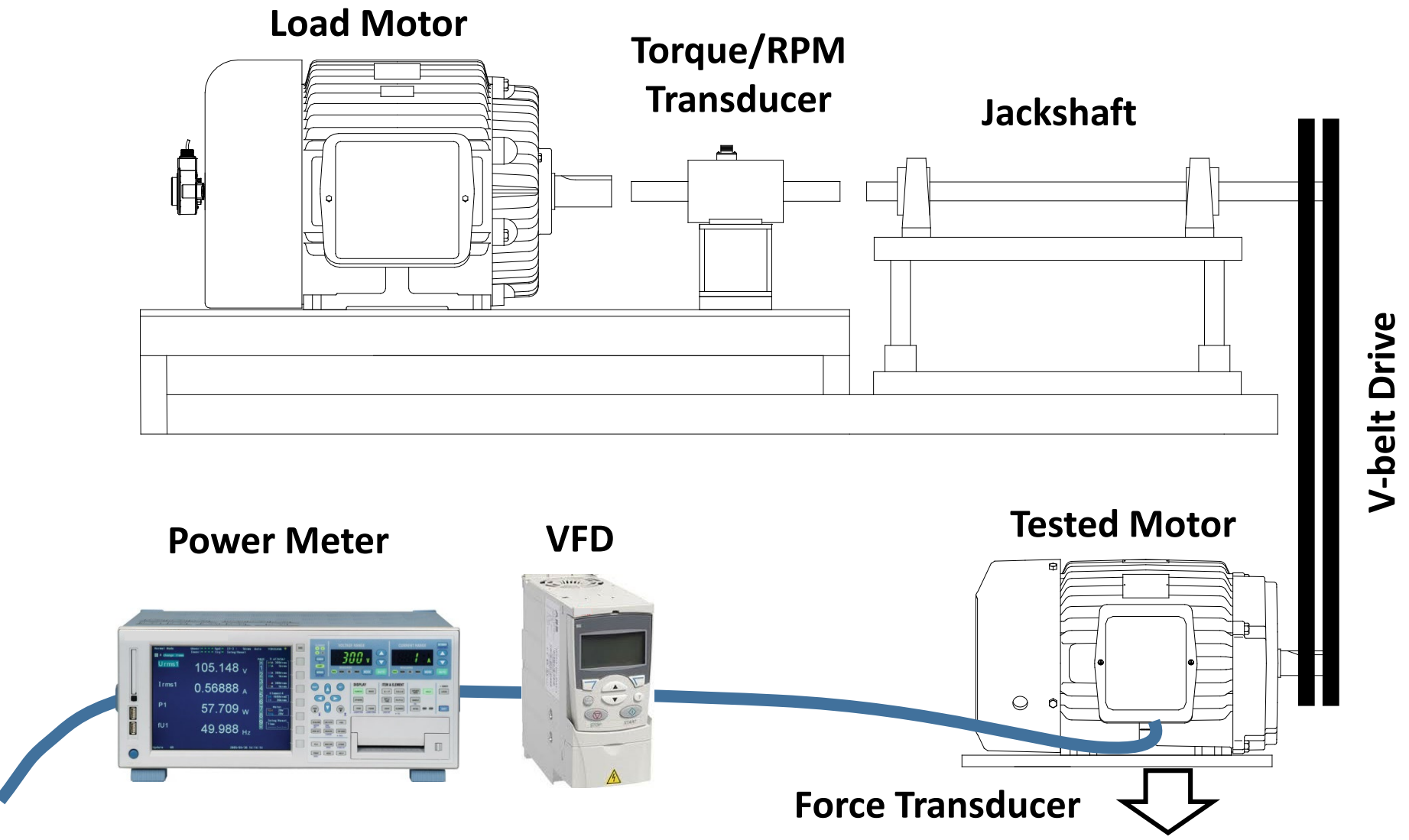
Results – Motor & VFD at Part Load



Results vs. AMCA 207 Prediction

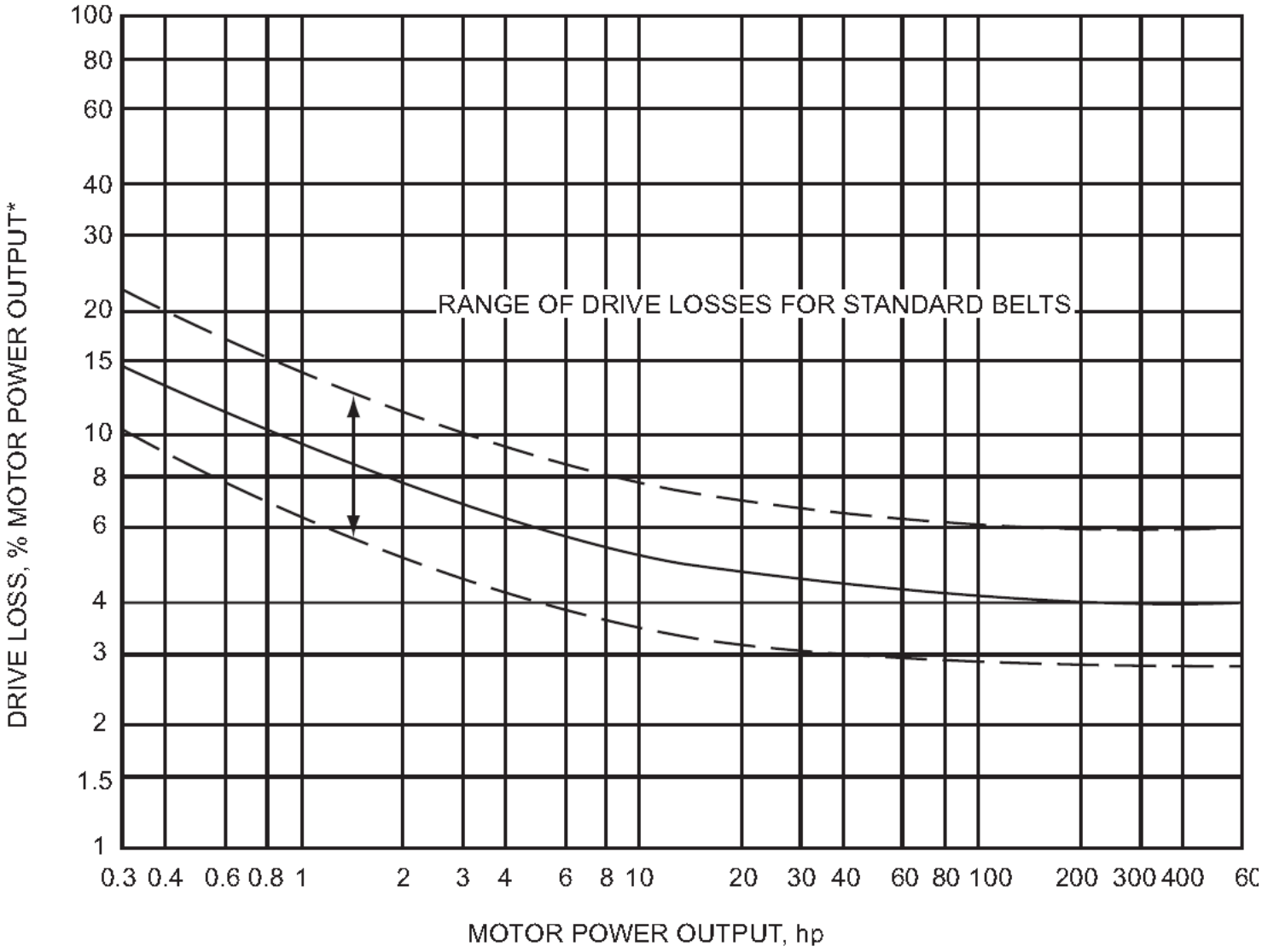


Belt Drive Test Setup

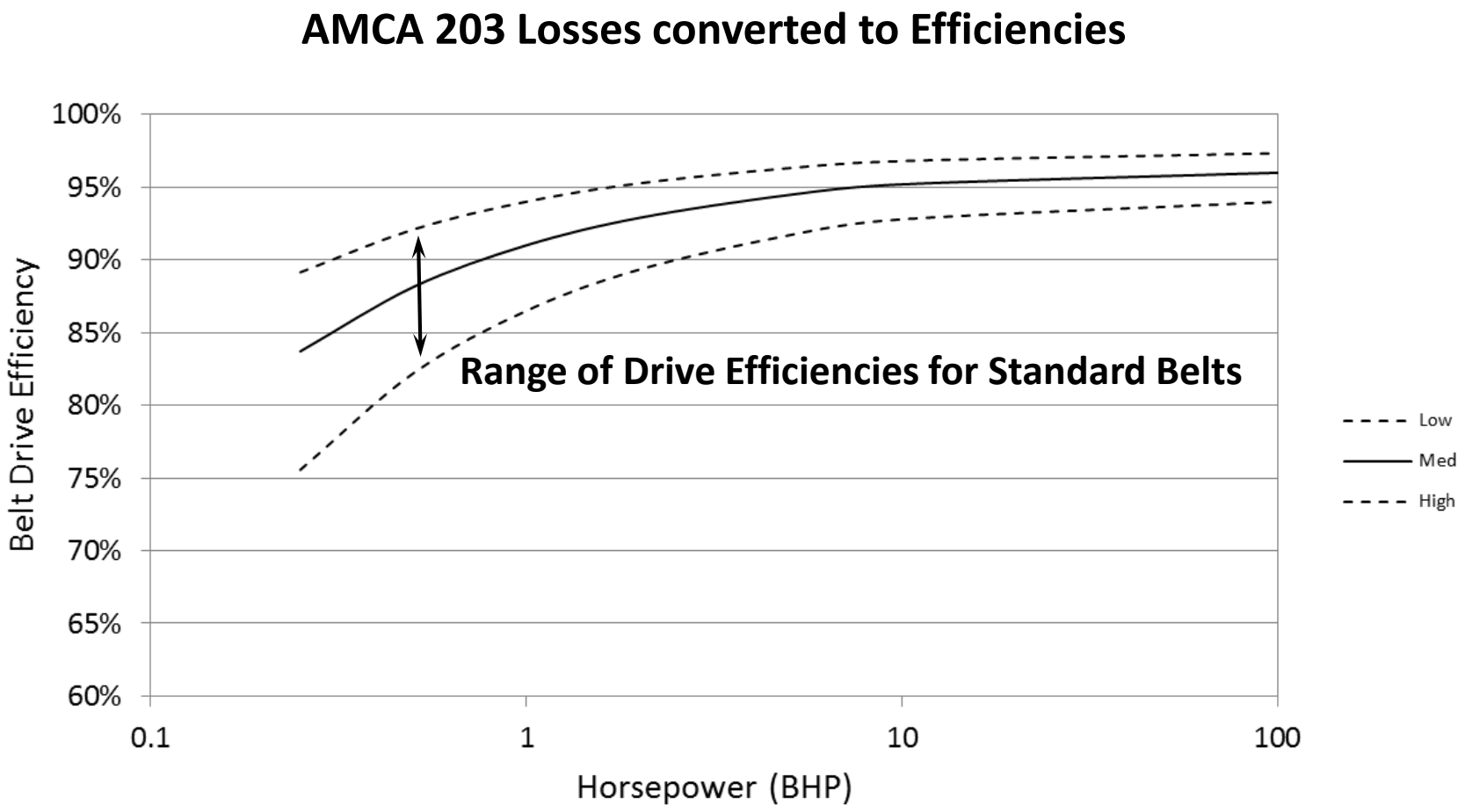


Belt Drive Efficiency – AMCA 203

AMCA 203
Appendix L



Belt Drive Efficiency – AMCA 203



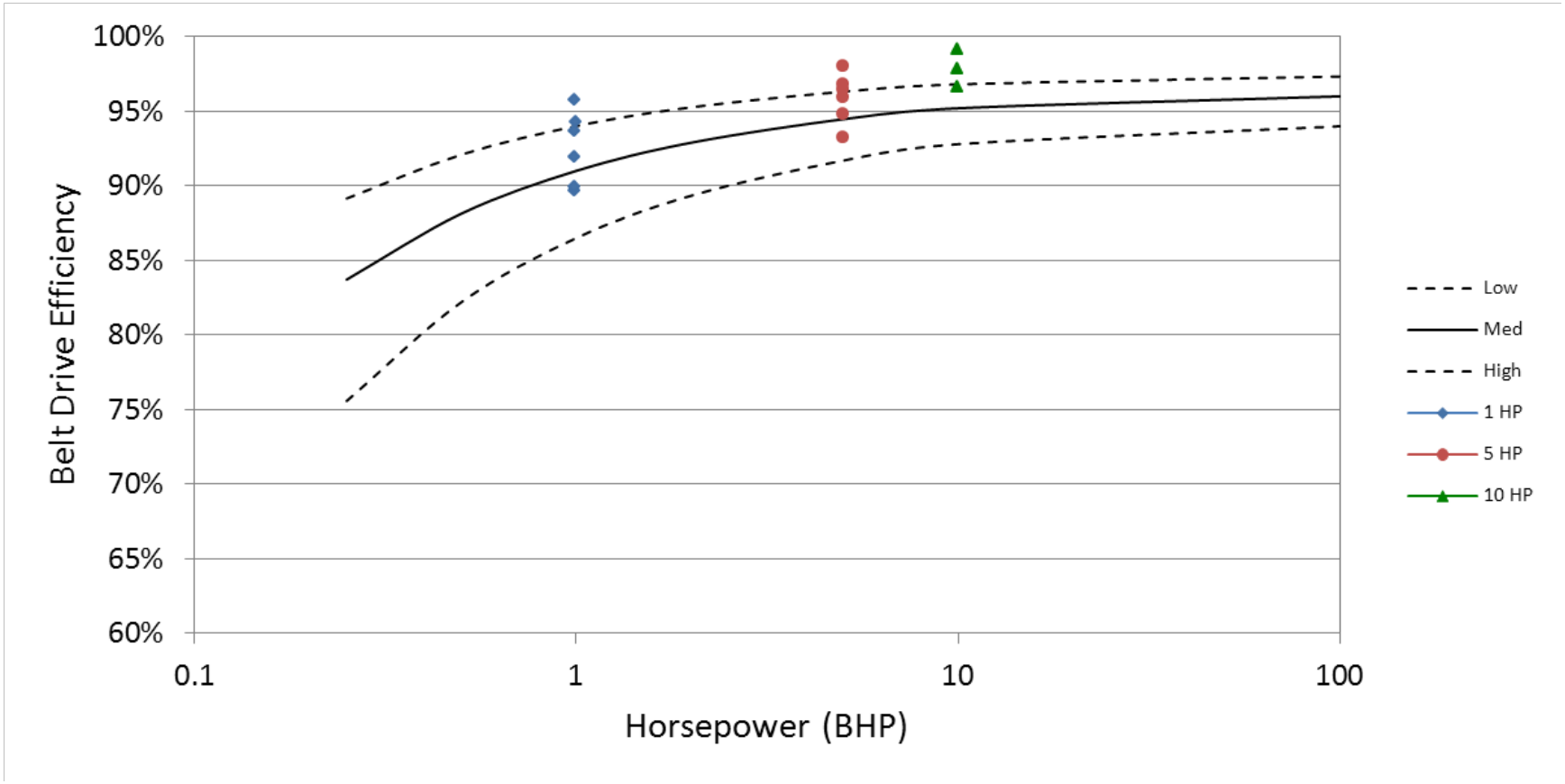
Belt Drive Efficiency

Experimental Variables:

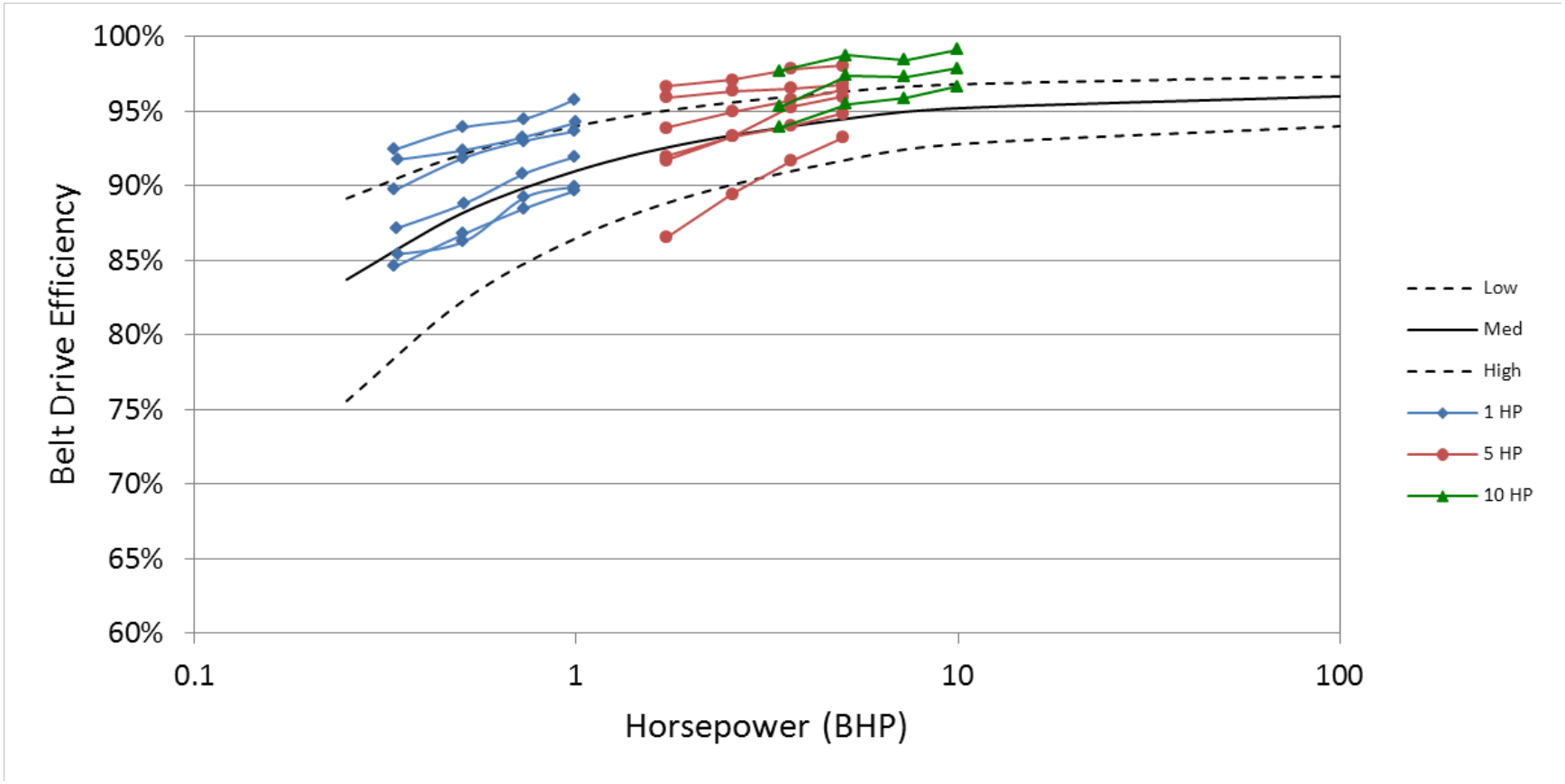
1. BHP
2. RPM
3. Service Factor

Motor HP	DriveN RPM	# Belts	SF	Full Load Eff.
1 HP	2700	1	1.5	94
		2	3	90
	1800	1	1.5	96
		2	3	90
	1200	1	1.5	96
		2	3	92
5 HP	2700	1	1.5	96
		2	3	93
	1800	1	2	98
		2	4	96
	1200	1	1	97
		2	2	95
10 HP	2700	2	1.5	97
	1800	2	1.5	98
	1200	2	1.5	99

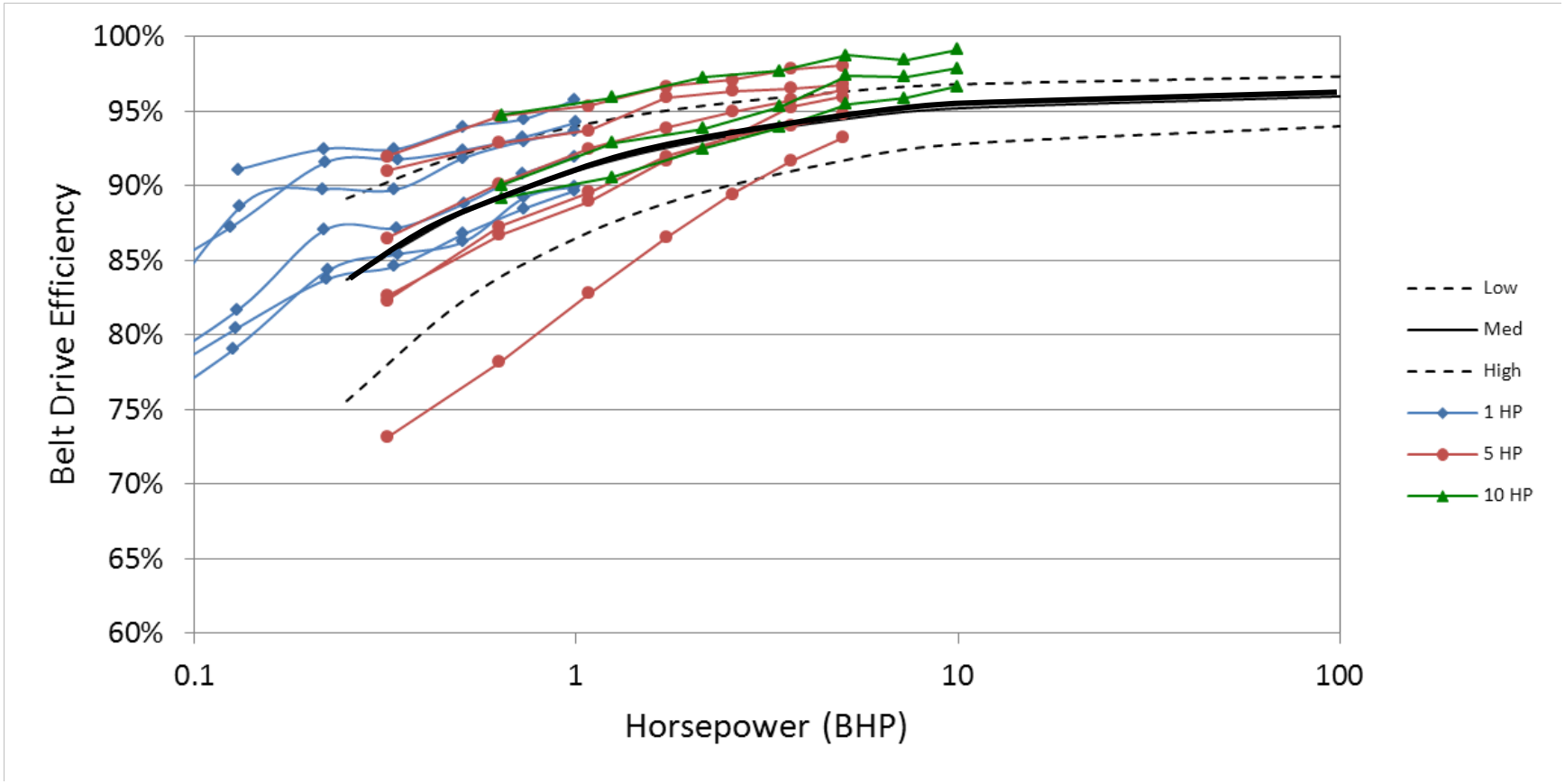
Results – Belt Drive at Full Load



Results – Belt Drive at Part Load



Results – Belt Drive at Part Load

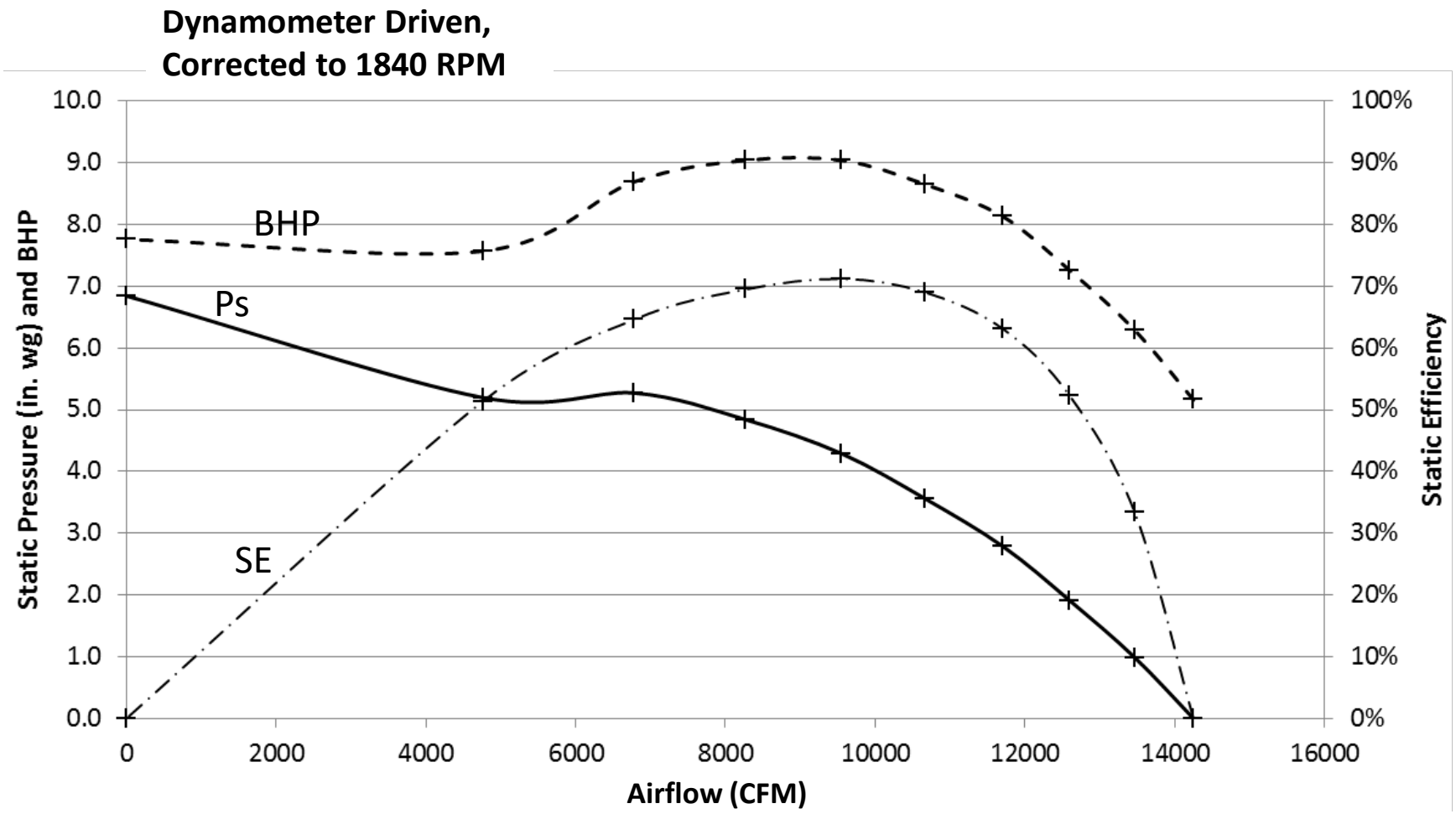


Fan Efficiency - 27” (685mm) Mixed Flow

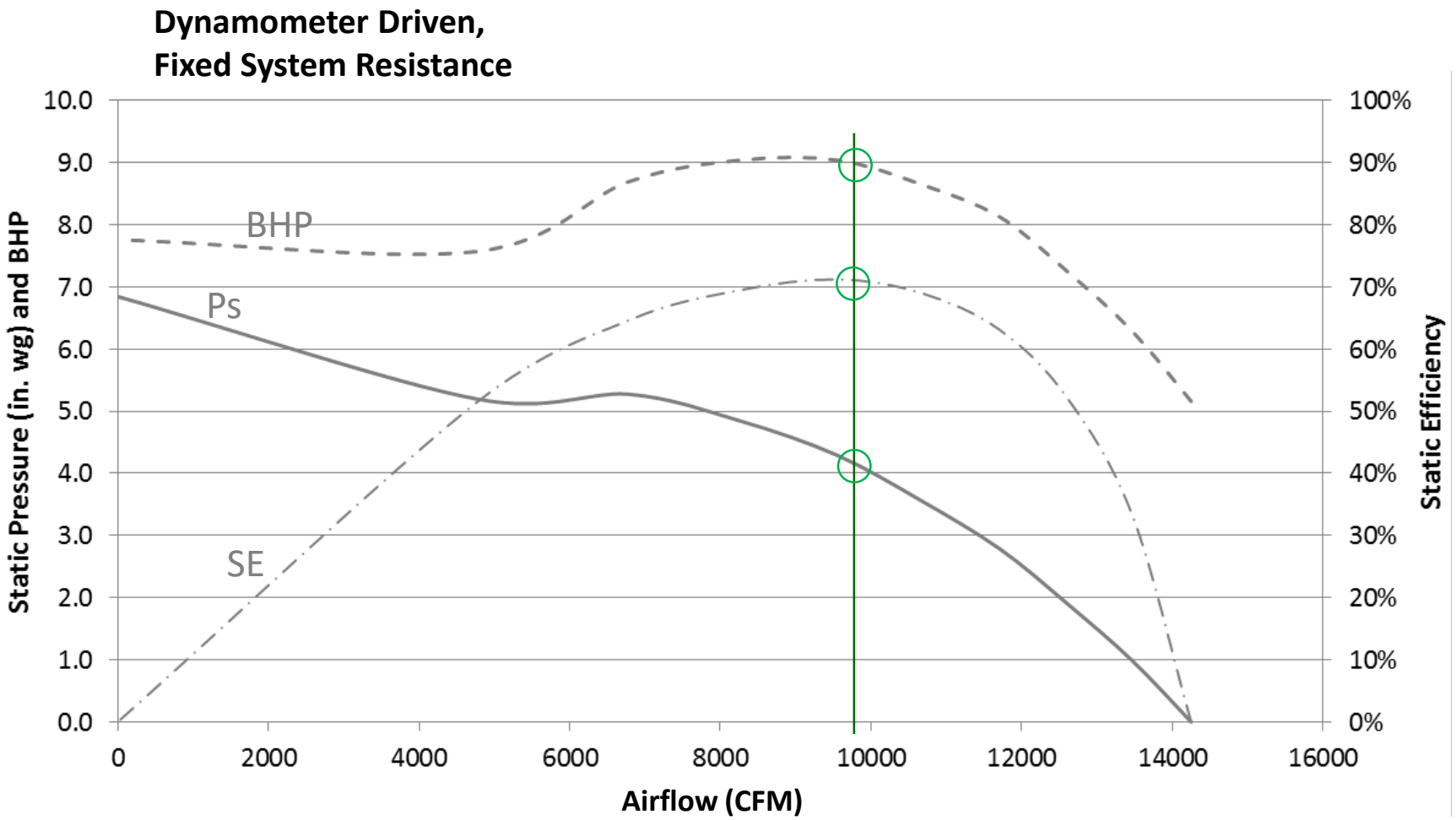
AMCA 210/ASHRAE 51 Test, Figure 12, Installation Type B

Extended fan shaft allows Dynamometer or Motor driven

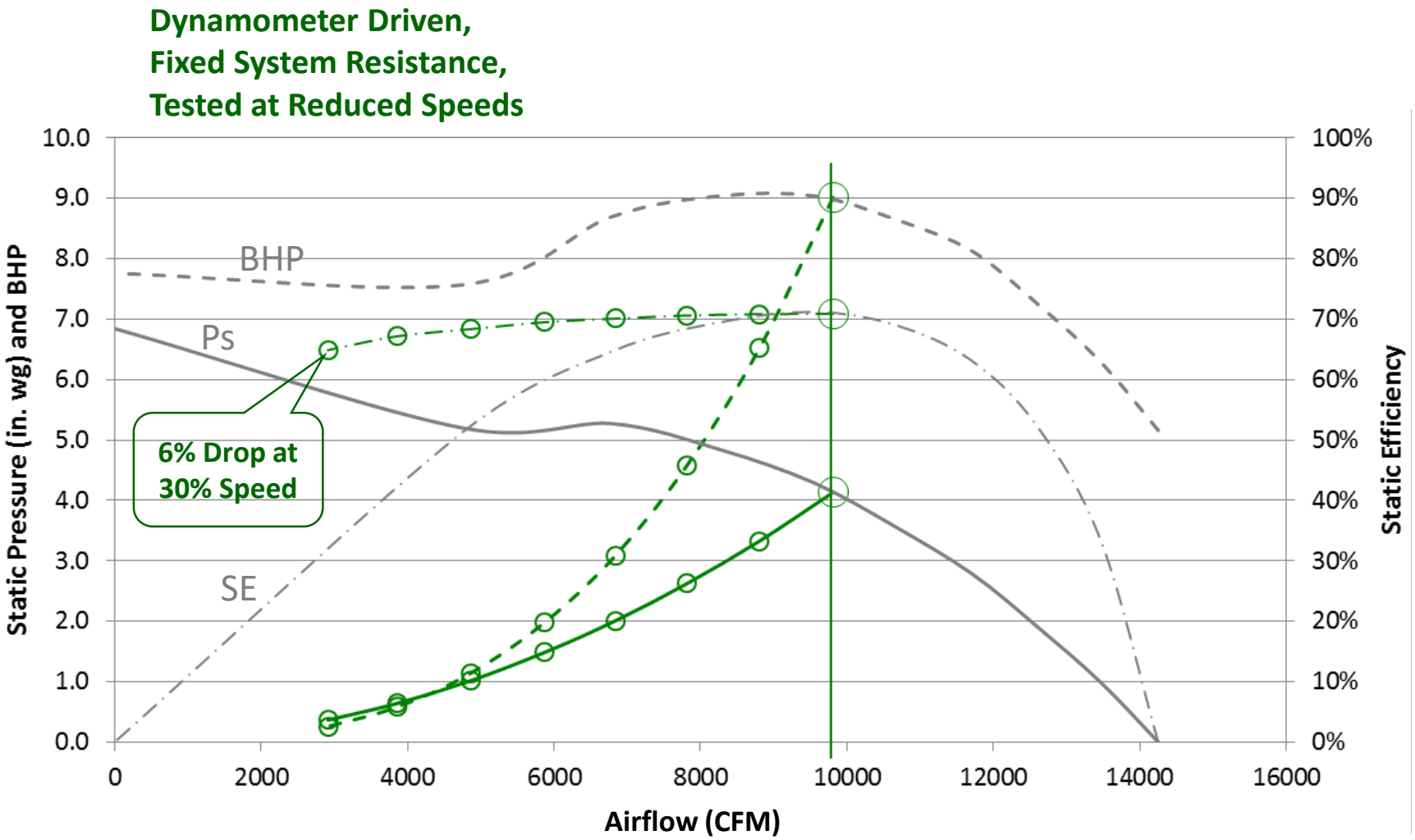
Fan Curve at Constant Speed



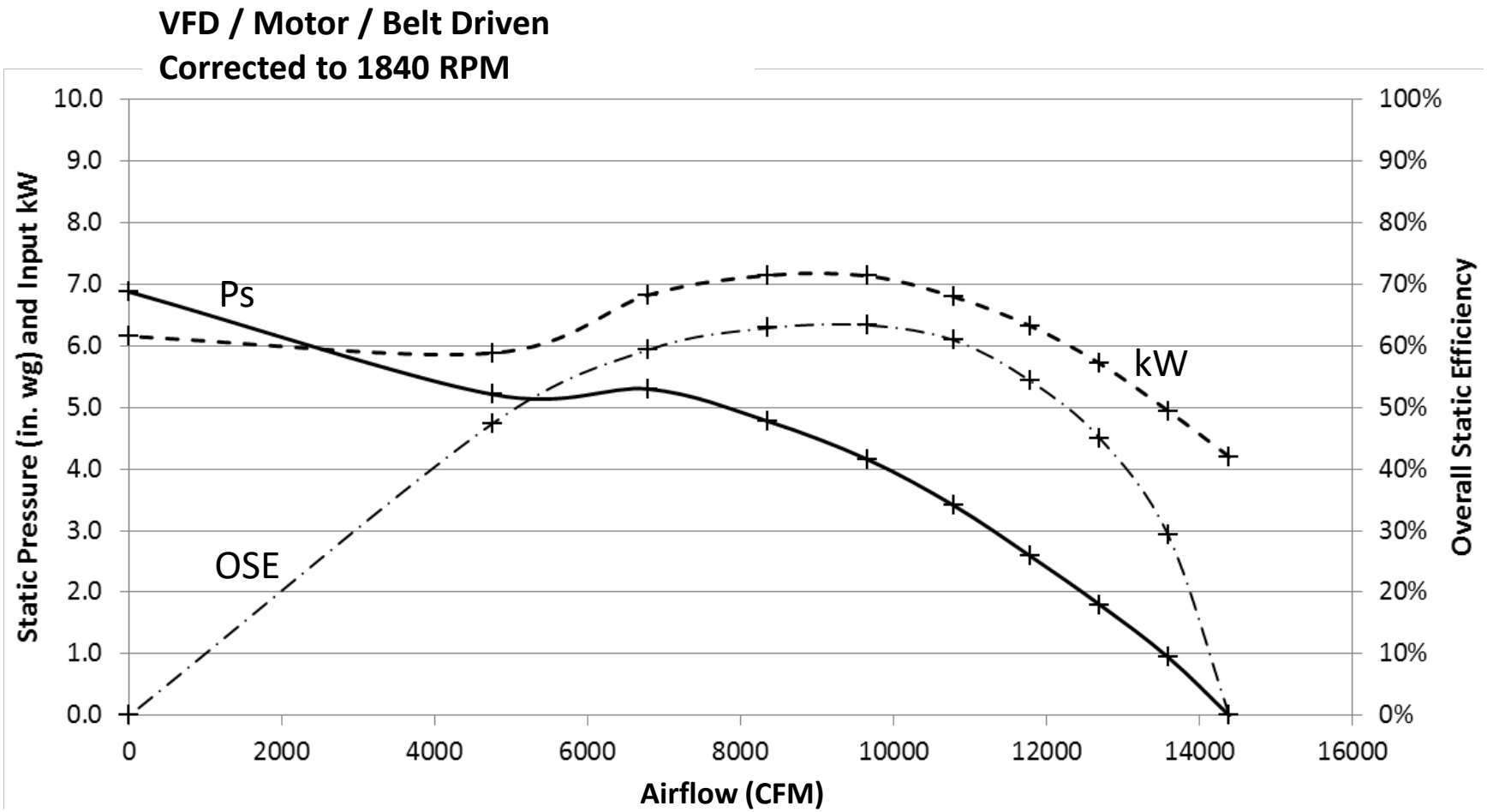
Fixed System Resistance



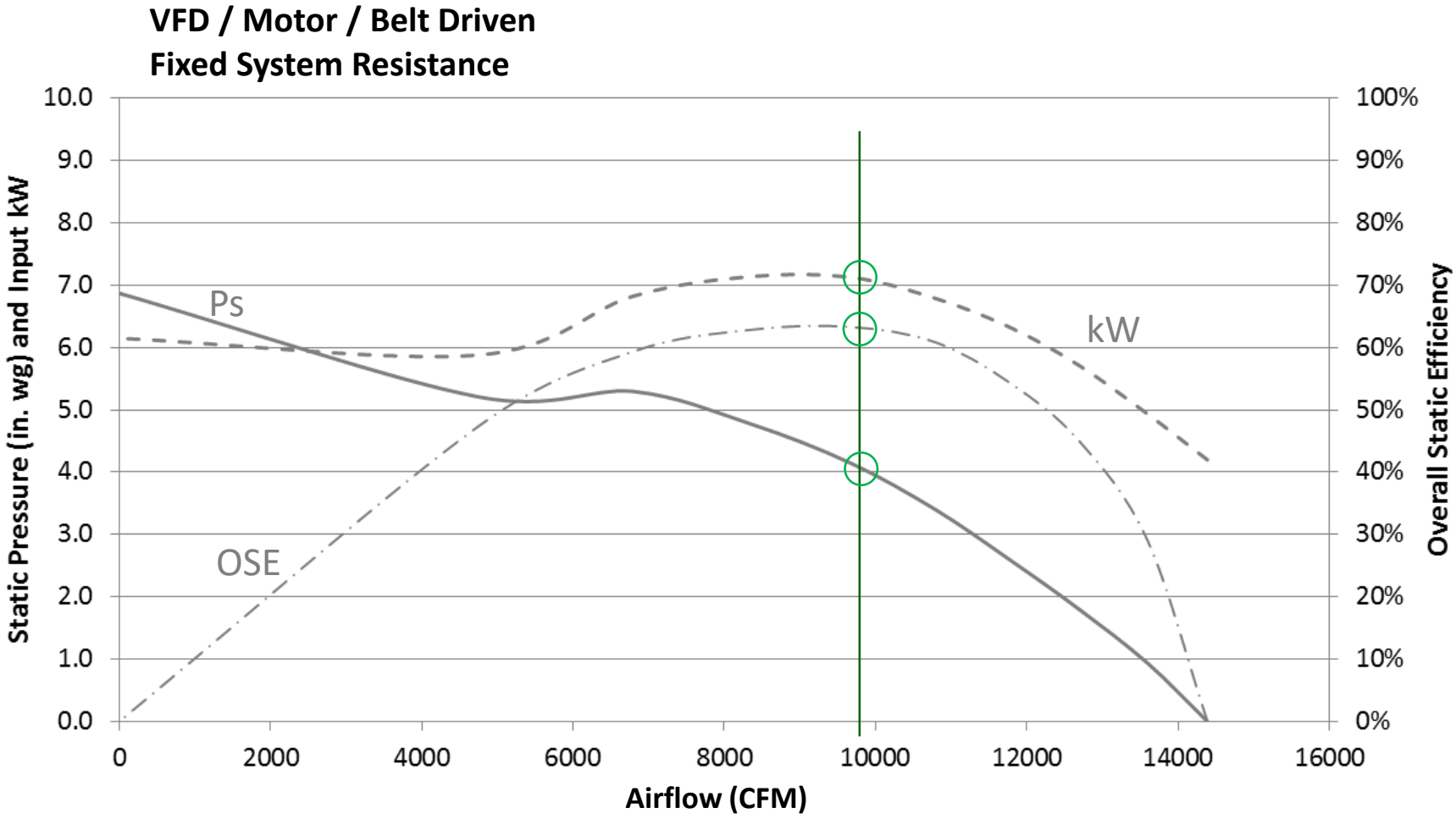
Variable Speed Test



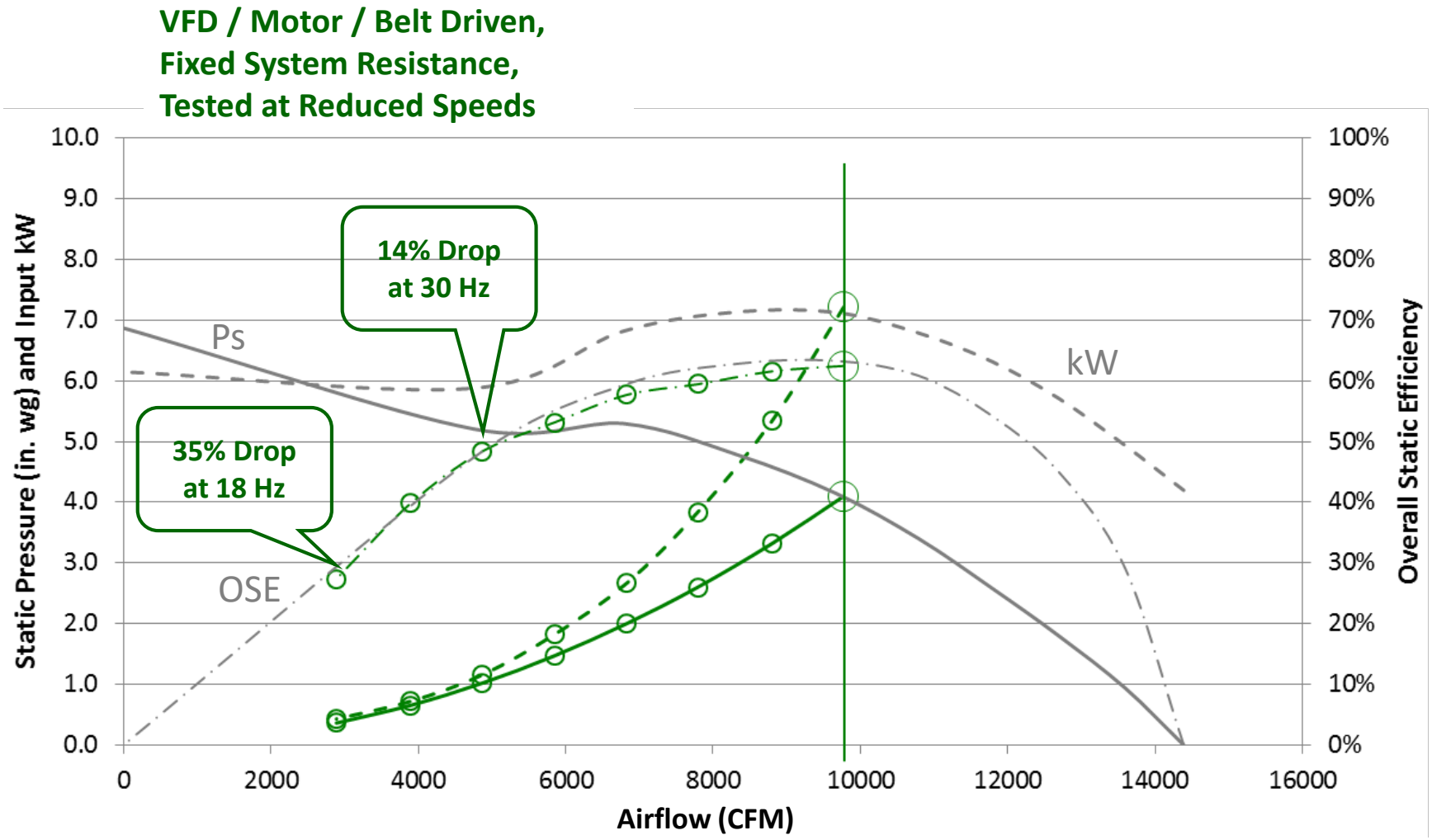
Fan Curve at Constant Speed



Fixed System Resistance

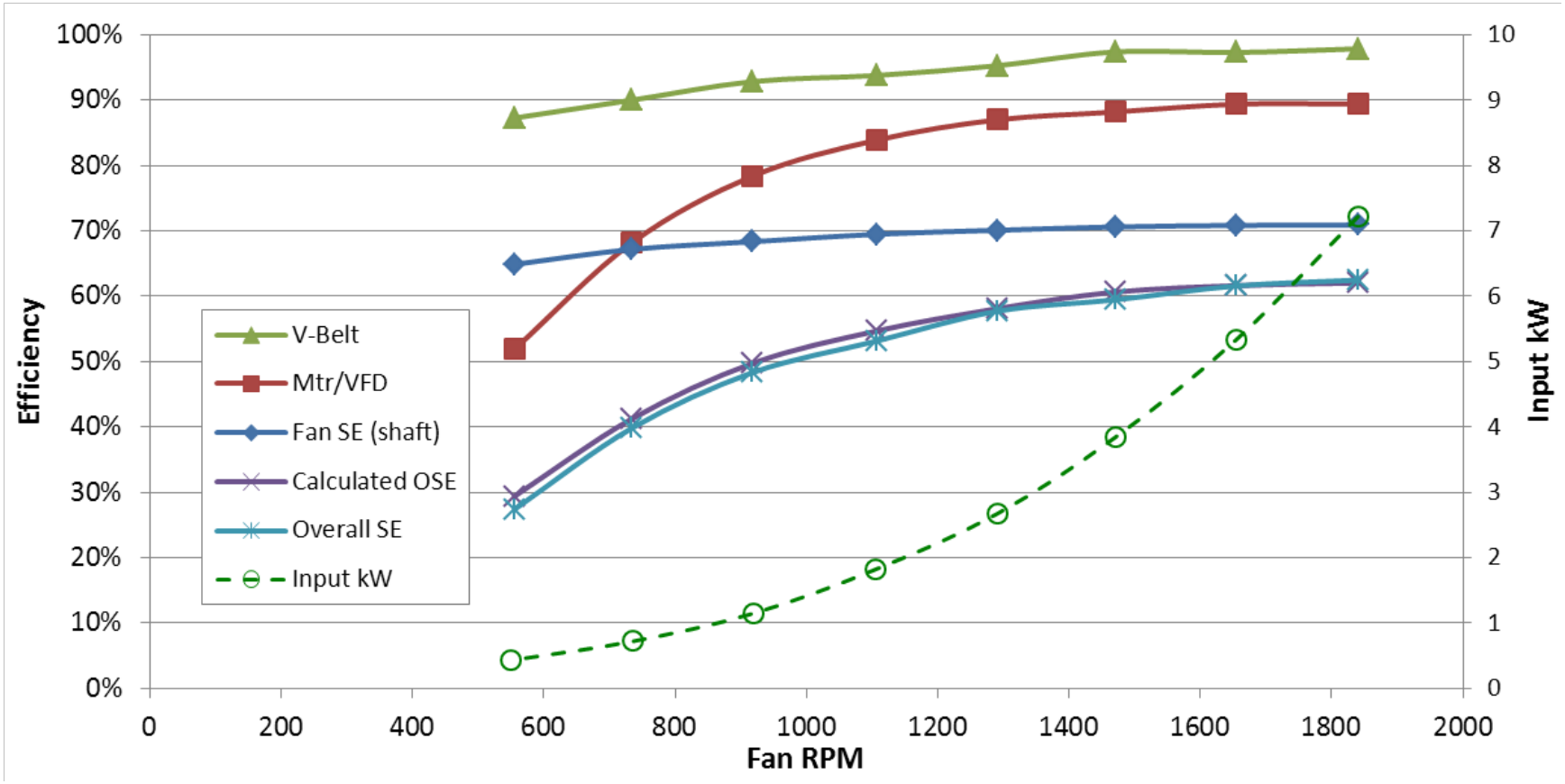


Variable Speed Test



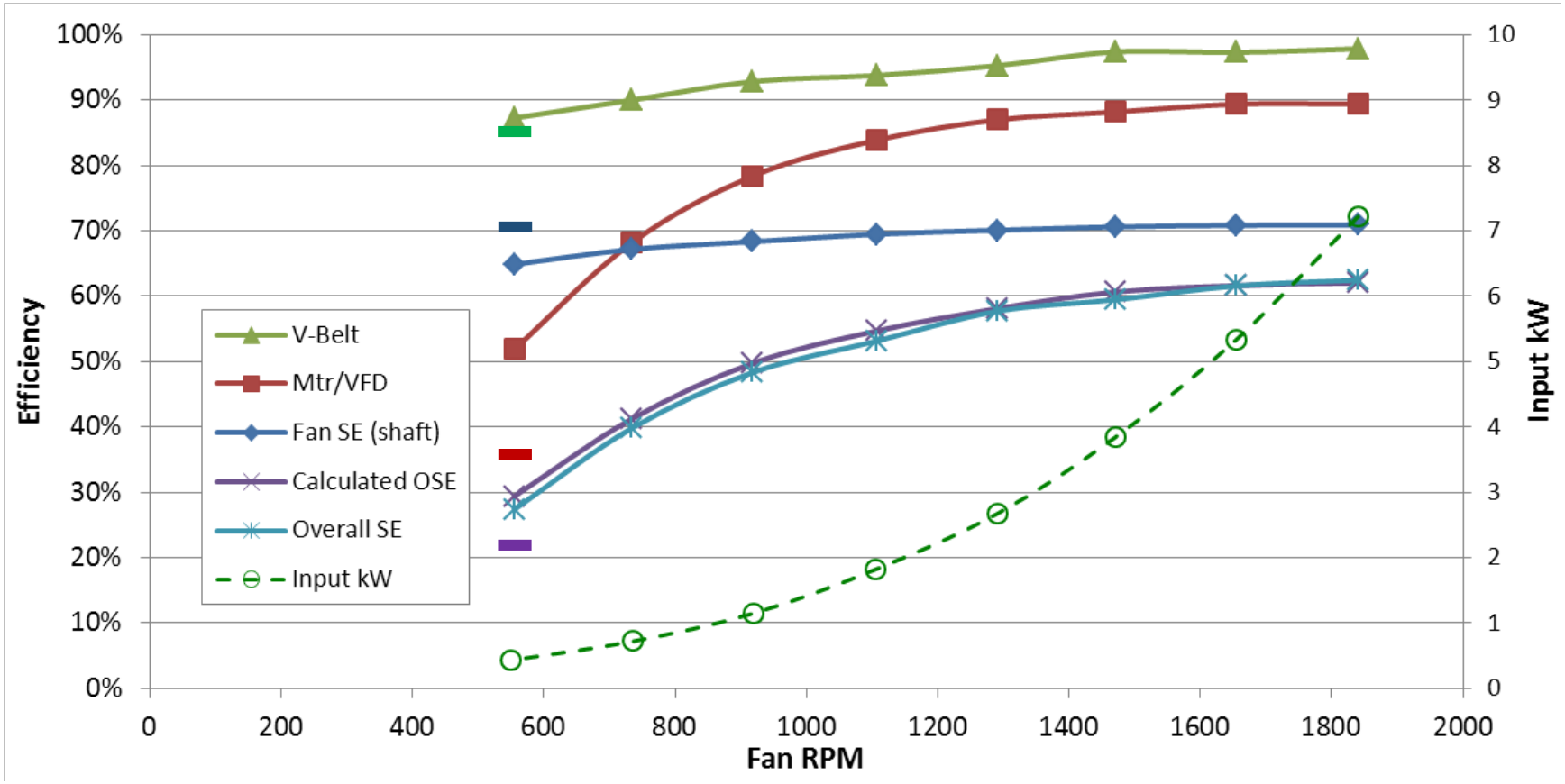
Overall Fan Static Efficiency

$$\eta_{overall} = \frac{\text{Output Power}}{\text{Input Power}} = \eta_{fan} \times \eta_{trans} \times \eta_{mtr} \times \eta_{vfd}$$



AMCA 207 Estimates

$$\eta_{overall} = \frac{\text{Output Power}}{\text{Input Power}} = \eta_{fan} \times \eta_{trans} \times \eta_{mtr} \times \eta_{vfd}$$



Conclusions

Component Efficiencies:

- Motor efficiency is a function of load and is typically available from motor manufacturers
- Motor/VFD efficiency is a function of load (power), regardless of torque or speed
- AMCA 203 V-belt drive loss estimates are reasonable, even at decreased fan speeds
- AMCA 207 is conservative, for belt drive and Motor/VFD efficiencies
- Fan efficiency drops slightly with speed
- Largest losses at part load are from Motor/VFD

Overall Efficiency:

- $\eta_{overall} = \eta_{fan} \times \eta_{trans} \times \eta_{mtr} \times \eta_{vfd}$

Bibliography

- AMCA 203 “Field Performance Measurement of Fan Systems”
- Draft AMCA 207 “Fan System Efficiency and Fan System Input Power Calculation”

QUESTIONS?

Tim Mathson

tim.mathson@greenheck.com

Currently with AMCA Int'l
tmathson@amca.org