NEMA Motor Round Robin

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Hydro Québec
Innovation, équipement
et services partagés

Context

- National Electrical Manufacturers Association (NEMA) Motor and Generator Section
- Round Robin Testing Program
- NEMA Premium® Efficiency Motor Rated 5 hp (3,7 kW), 4-pole
- Perform Testing on the Same Motor by Different Participating Accredited Independent Laboratories (4) and Motor Manufacturers (7)
- Different Set-up, Instrumentation and Technical Staff

Context

- Agreement Not to Disclose Name of Participants
- Compare Results Based on the Same Testing Procedure IEEE 112-2004 Method B (Equivalent to IEC 60034-2-1 or CSA C390)

Approach

- Same NEMA Premium® Efficiency Motor Rated 5 hp (3,7 kW), 4-pole
- Thermocouples Installed in the Motor Prior to the First Test
- Use of the Same Calculations Template
- First Test and Last Test Performed by the Same Participant for Repeatability Assessment
- Seals Applied Against Tampering
- "True" Efficiency not Known
- "Average" Efficiency as Reference for Comparison

Steps for Efficiency (or Losses) Determination

- Cold Resistance Measurement
- Temperature Test or Heat Run
- Hot Resistance Measurement
- Load Points Measurements

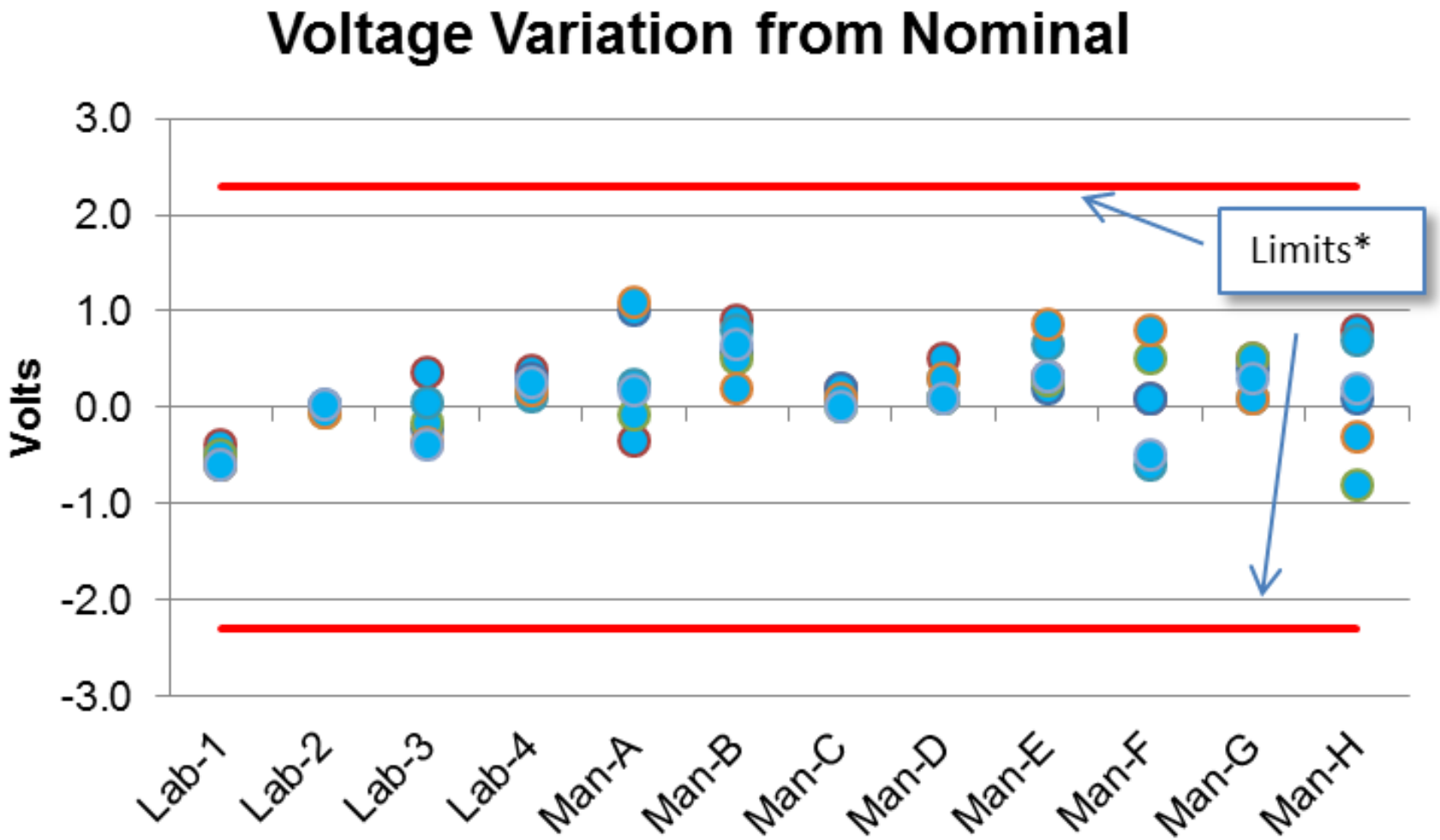
⇨ Load Losses:
Stator, Rotor, Additional

- No-Load Measurements

⇨ Constant Losses:
Iron, Windage / Friction

- Calculations → Efficiency (or Losses) Determination

Test Set-up – Power Supply - Voltage

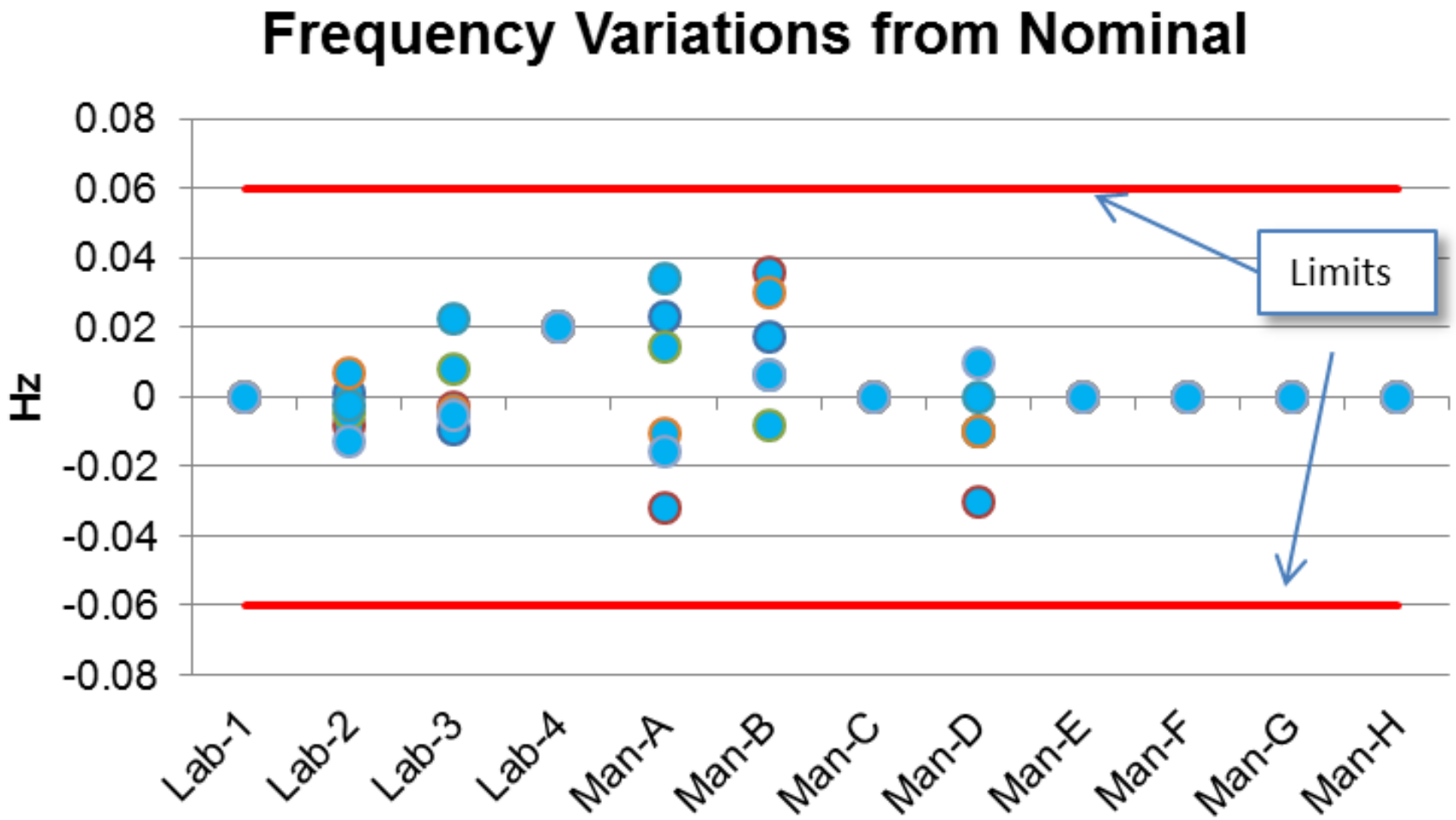


* CSA 390

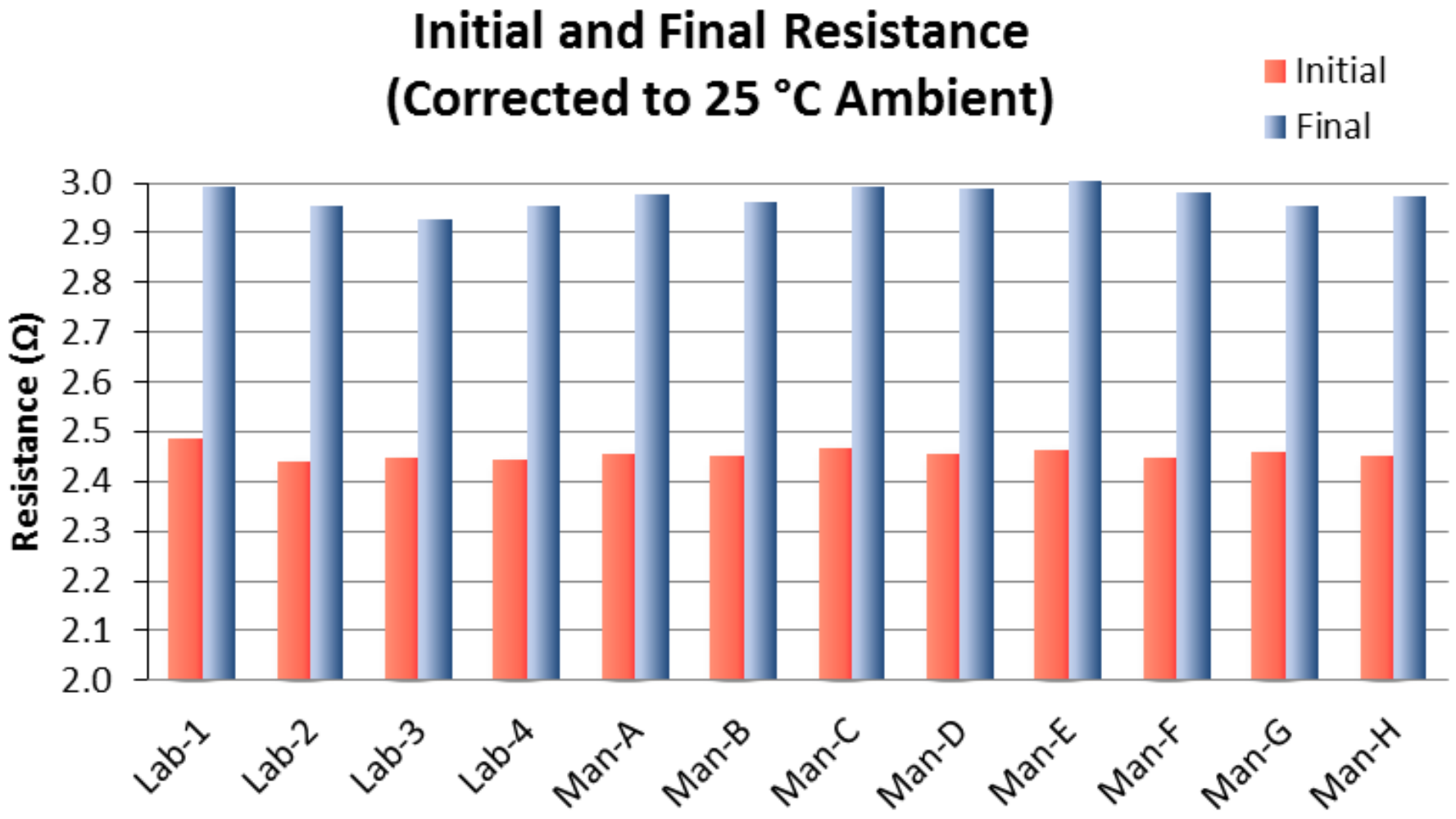
Test Set-up – Power Supply - Frequency

	Power Supply Frequency (Hz)					
	% Nominal Load					
	25%	50%	75%	100%	115-125%	125-150%
Lab-1	60	60	60	60	60	60
Lab-2	59.99	60.00	60.00	60.00	60.01	59.99
Lab-3	60.00	59.99	60.01	60.02	60.00	59.99
Lab-4	60.02	60.02	60.02	60.02	60.02	60.02
Man-A	59.97	60.02	60.01	60.03	59.99	59.98
Man-B	60.04	60.02	59.99	60.01	60.03	60.01
Man-C	60	60	60	60	60	60
Man-D	59.97	59.99	59.99	60.00	59.99	60.01
Man-E	60	60	60	60	60	60
Man-F	60	60	60	60	60	60
Man-G	60	60	60	60	60	60
Man-H	60	60	60	60	60	60

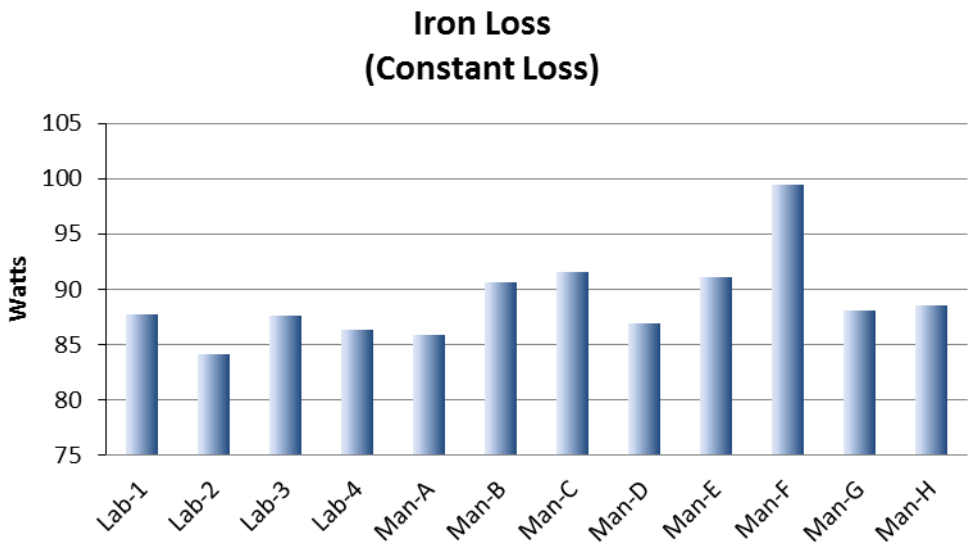
Test Set-up – Power Supply - Frequency

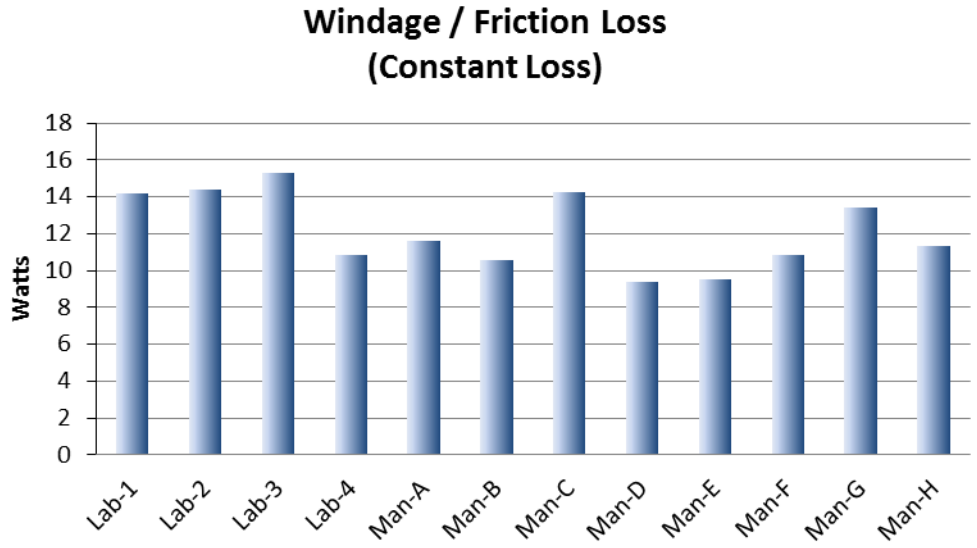


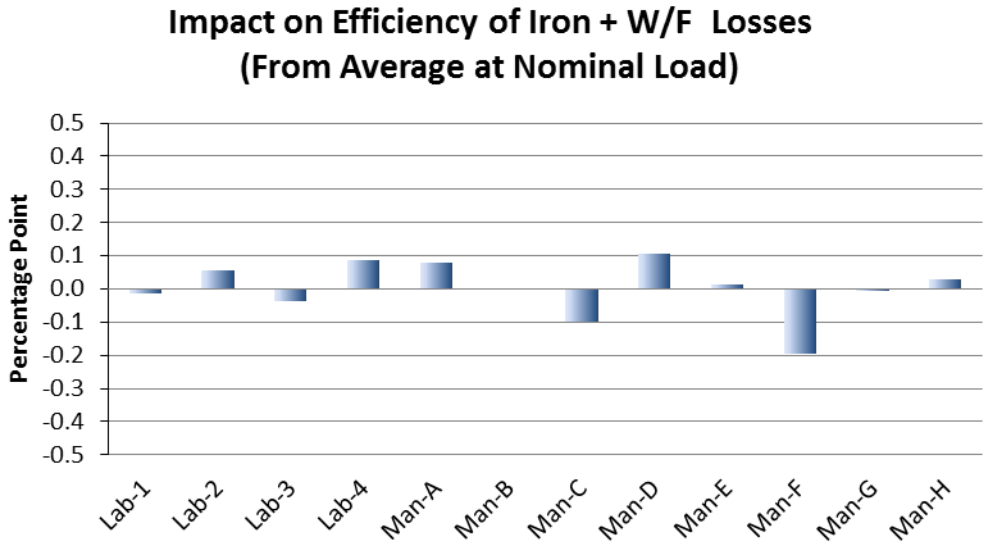
Resistance Measurements



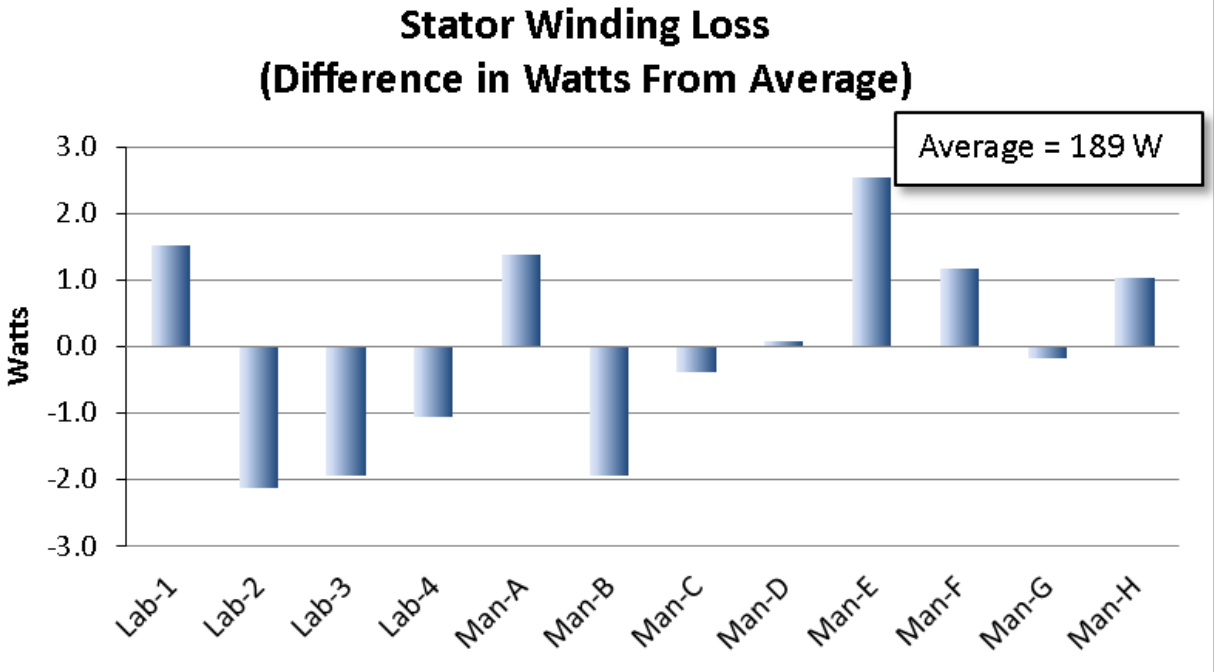
Constant Losses: Iron Loss – Windage / Friction Loss

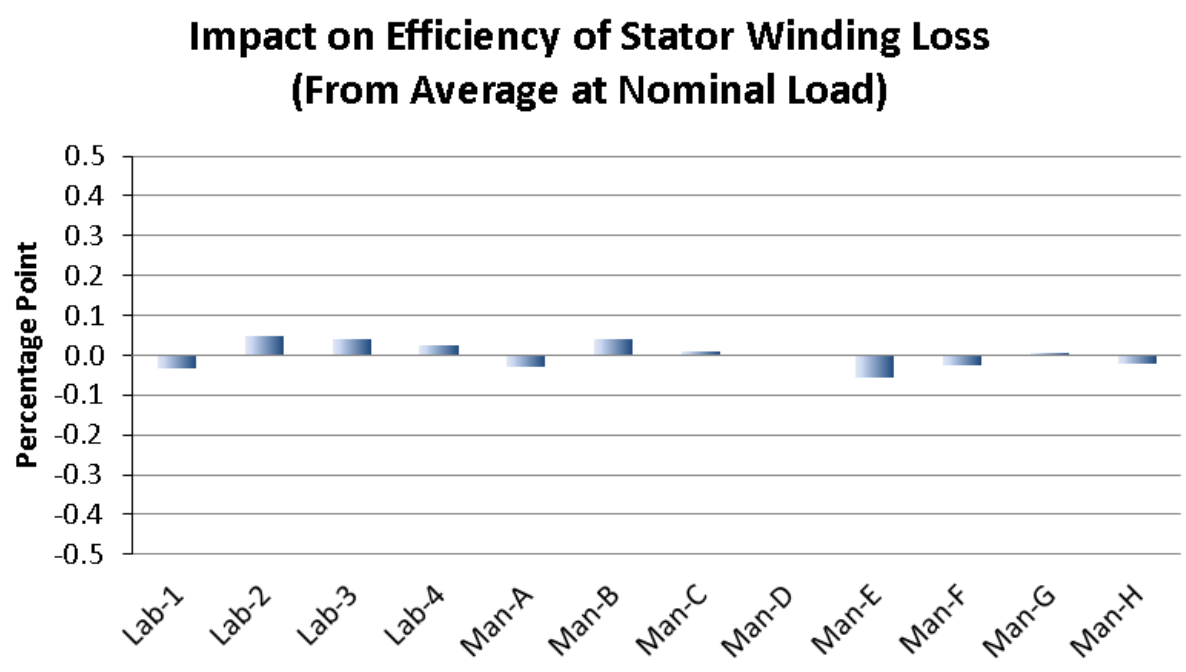




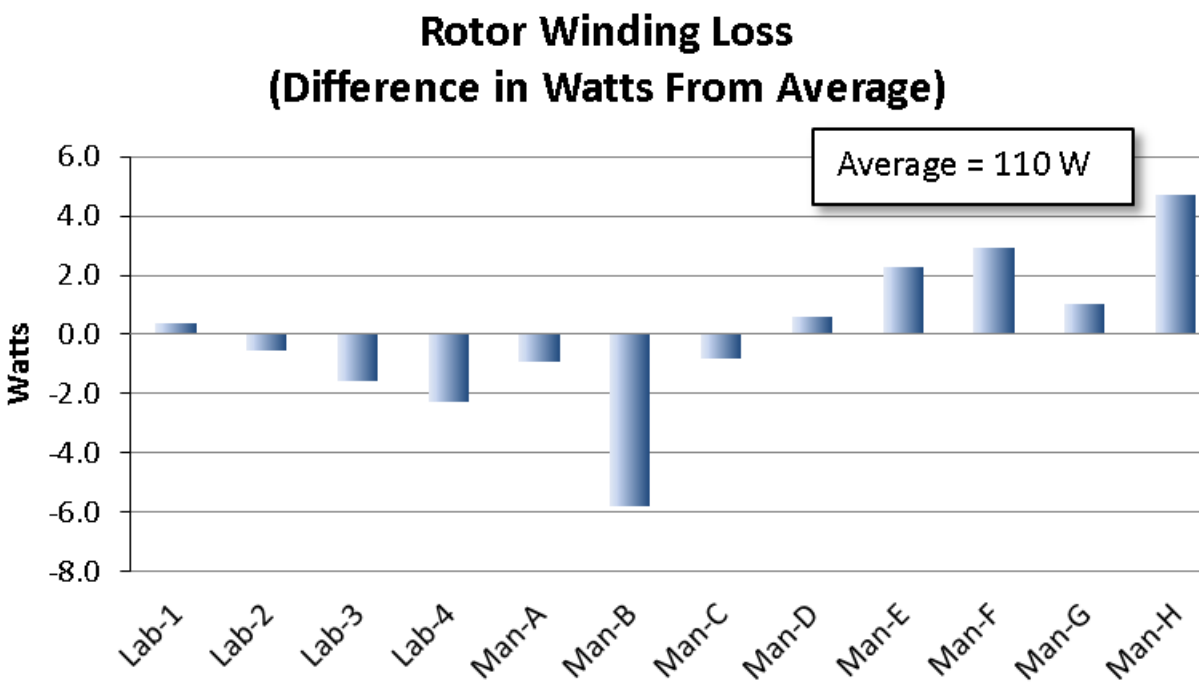


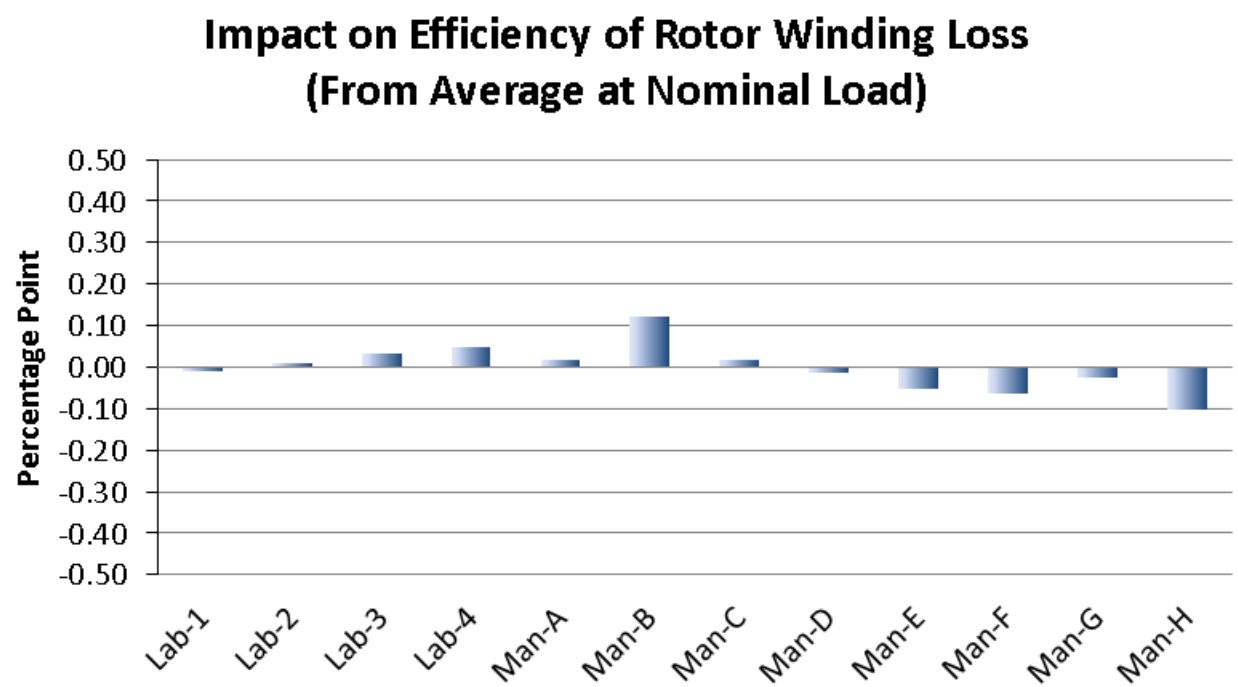
Stator Loss


Stator Winding Loss
(Difference in Watts From Average)
Average = 189 W
Watts
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
Lab-1
Lab-2
Lab-3
Lab-4
Man-A
Man-B
Man-C
Man-D
Man-E
Man-F
Man-G
Man-H

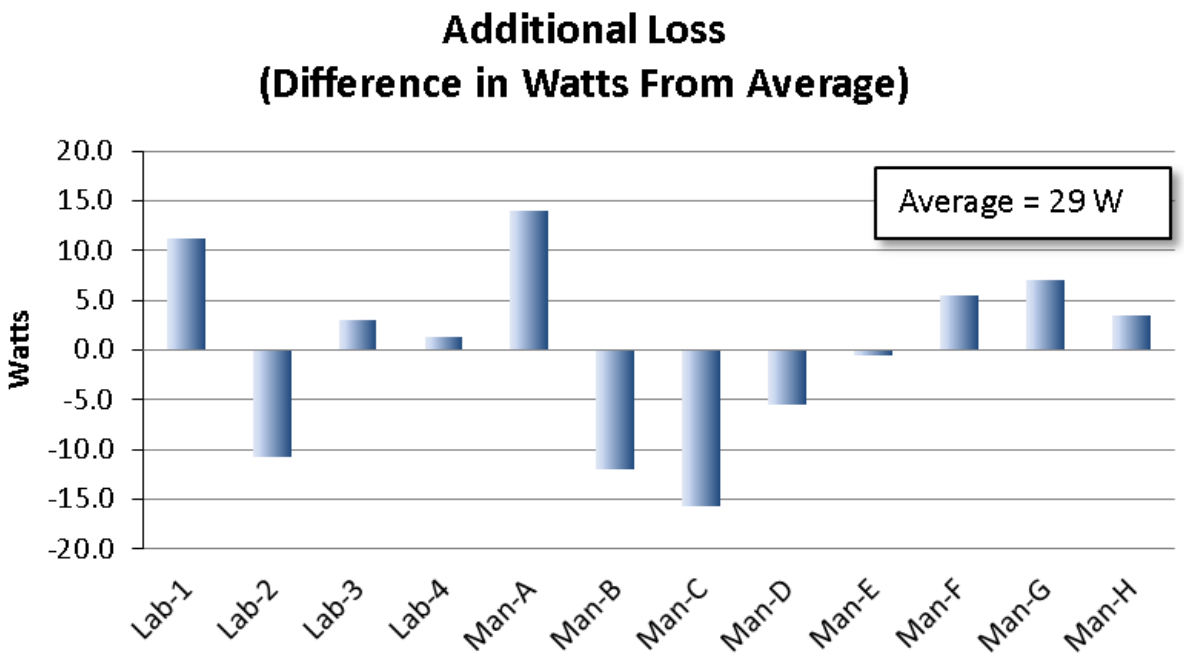

Impact on Efficiency of Stator Winding Loss
(From Average at Nominal Load)
Percentage Point
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
Lab-1
Lab-2
Lab-3
Lab-4
Man-A
Man-B
Man-C
Man-D
Man-E
Man-F
Man-G
Man-H

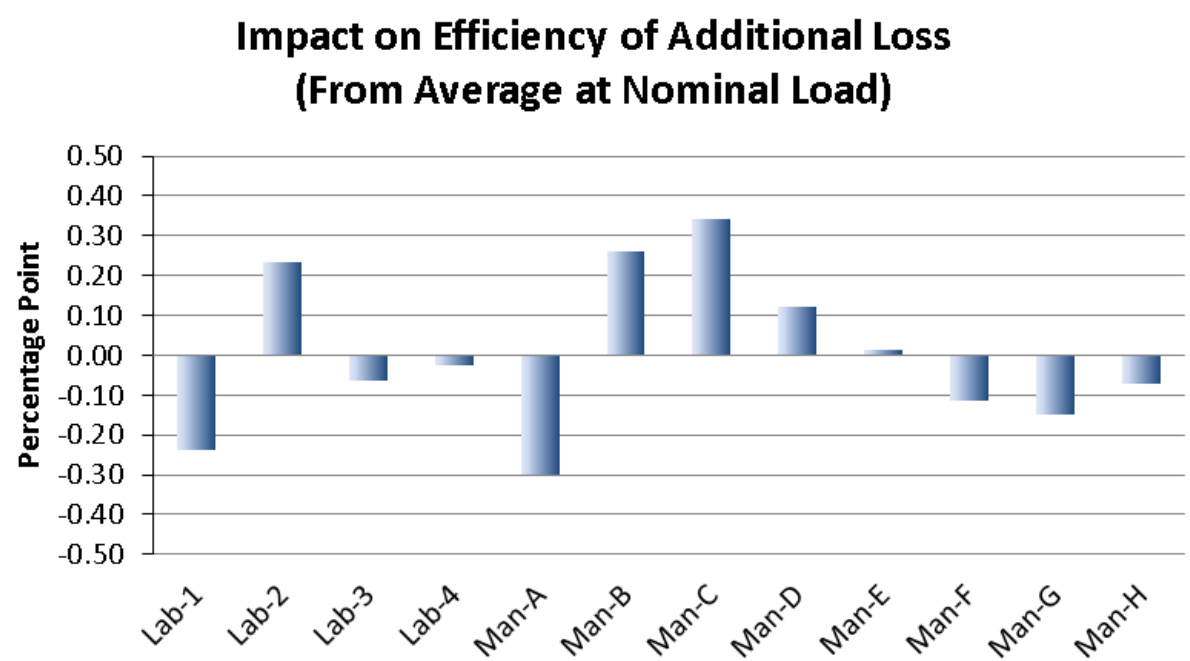
Rotor Loss


Rotor Winding Loss
(Difference in Watts From Average)
Average = 110 W
Watts
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
-8.0
Lab-1
Lab-2
Lab-3
Lab-4
Man-A
Man-B
Man-C
Man-D
Man-E
Man-F
Man-G
Man-H

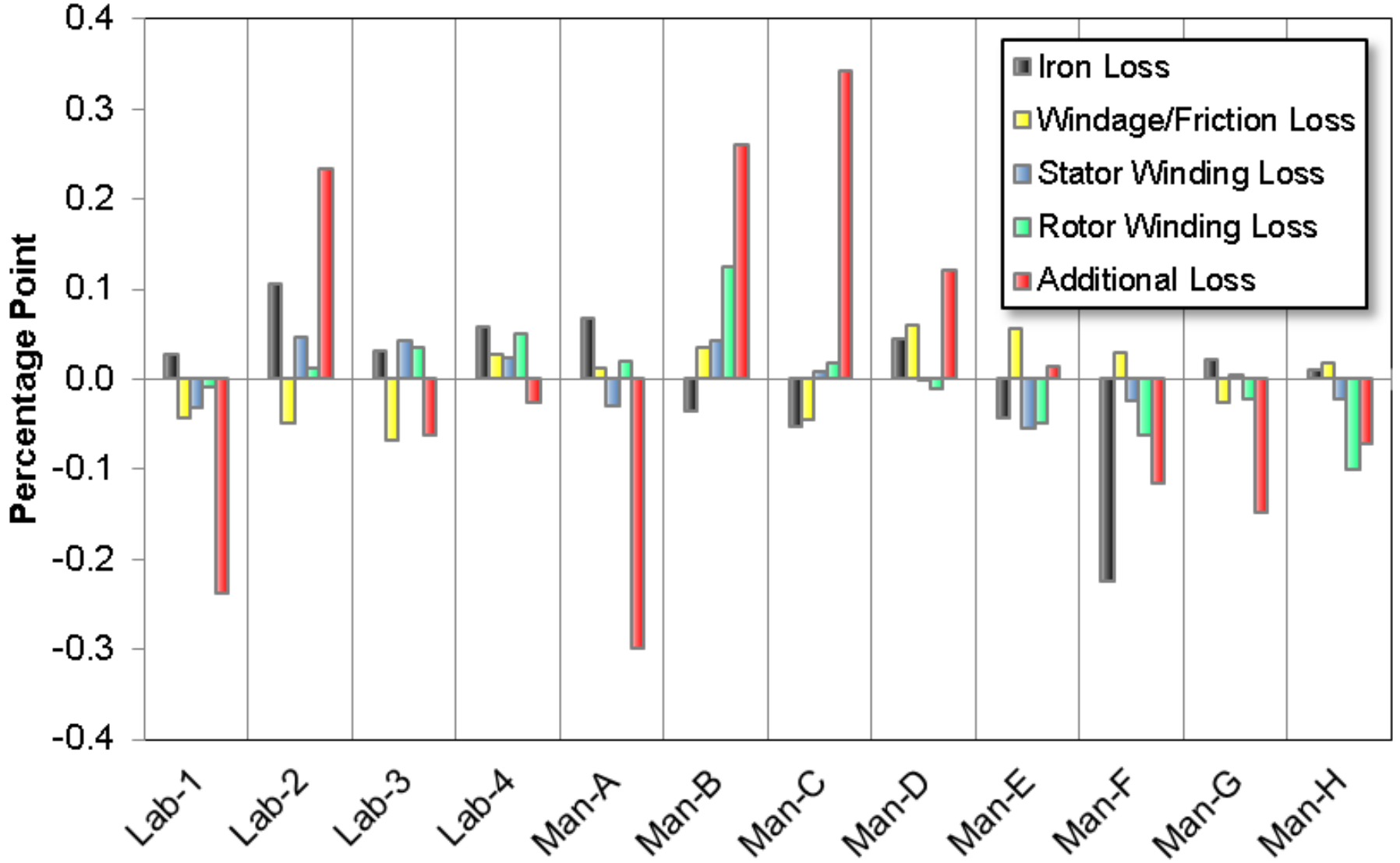

Impact on Efficiency of Rotor Winding Loss
(From Average at Nominal Load)
Percentage Point
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
Lab-1
Lab-2
Lab-3
Lab-4
Man-A
Man-B
Man-C
Man-D
Man-E
Man-F
Man-G
Man-H

Additional Loss

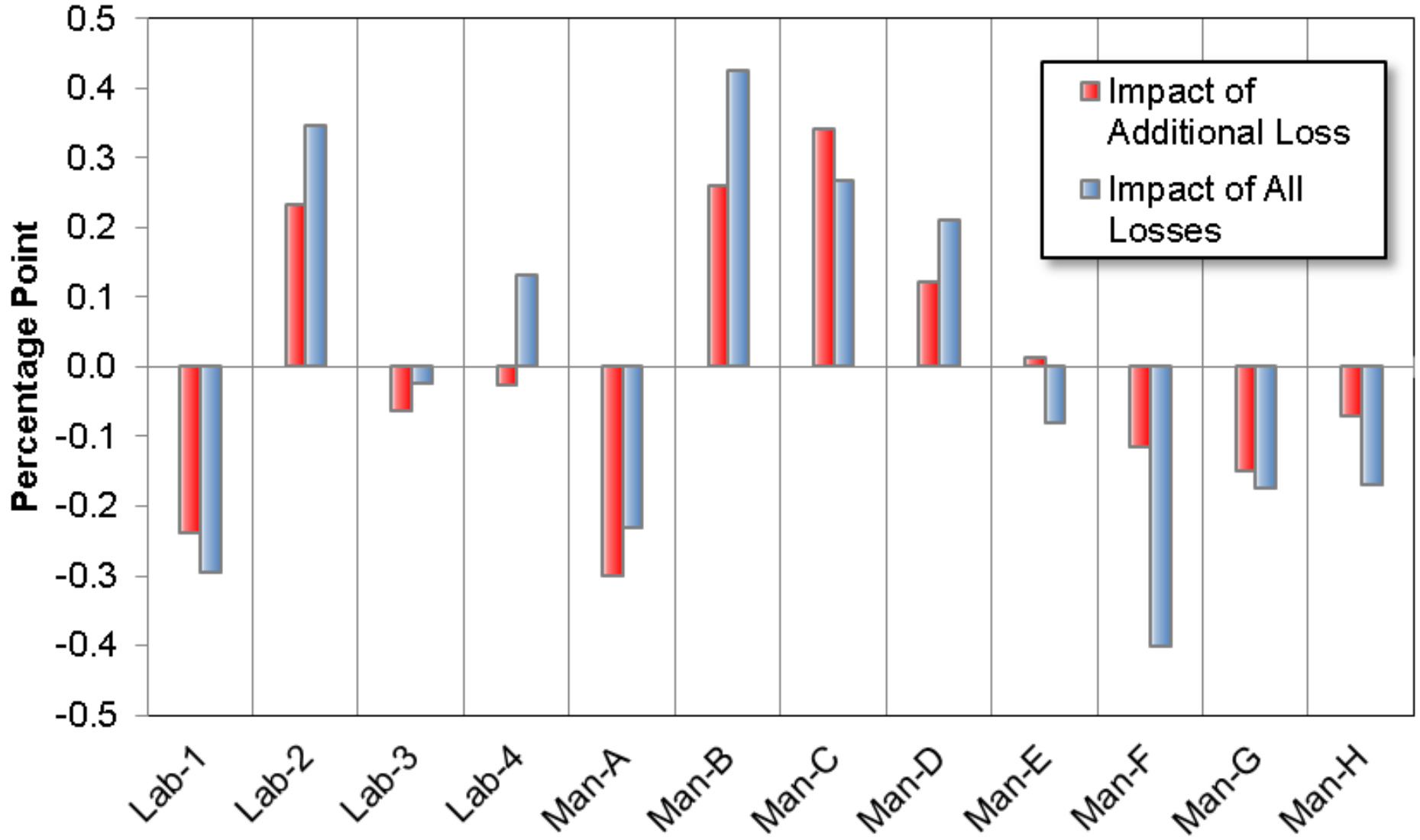




All Losses


Percentage Point
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
Iron Loss
Windage/Friction Loss
Stator Winding Loss
Rotor Winding Loss
Additional Loss
Lab-1
Lab-2
Lab-3
Lab-4
Man-A
Man-B
Man-C
Man-D
Man-E
Man-F
Man-G
Man-H

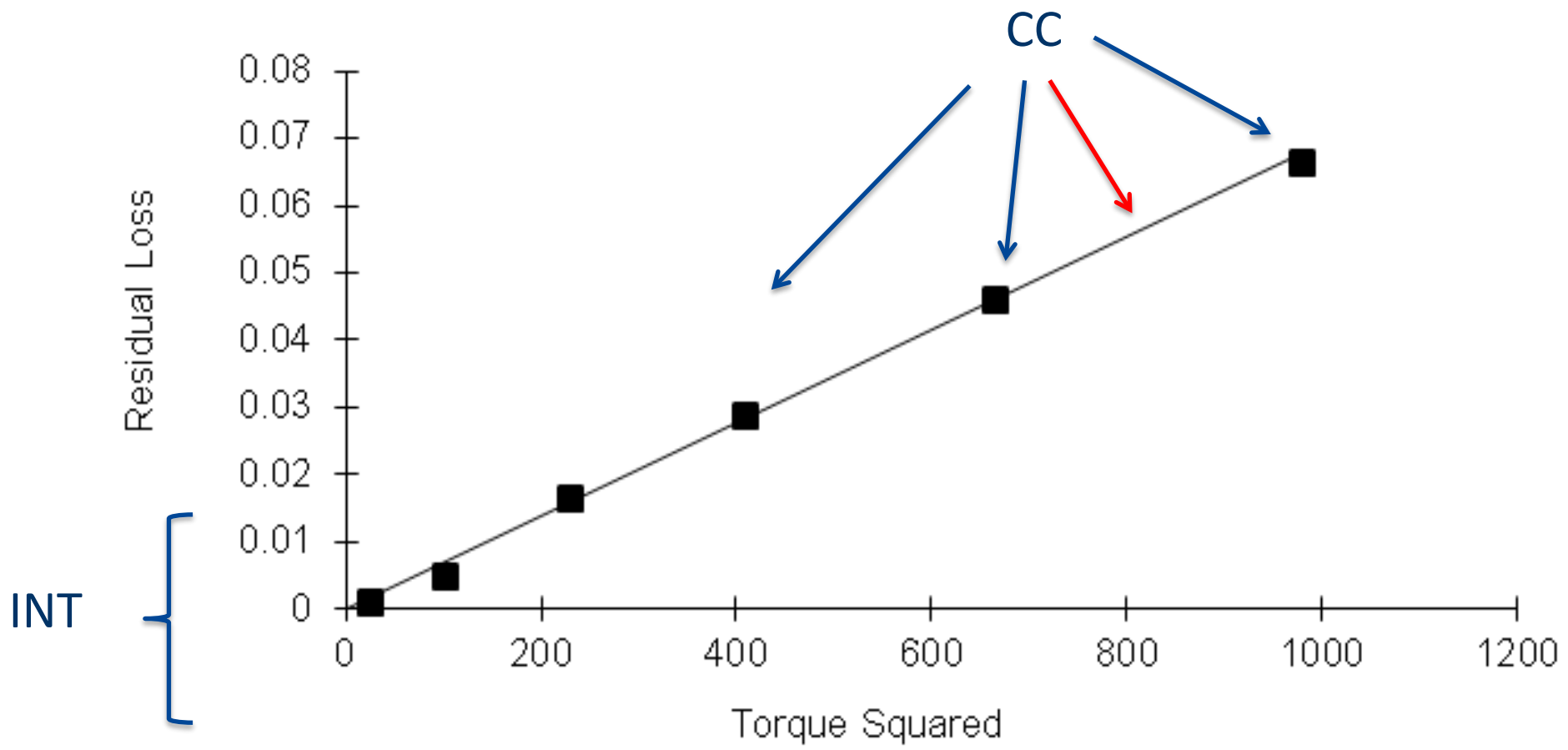
Impact of Additional Loss



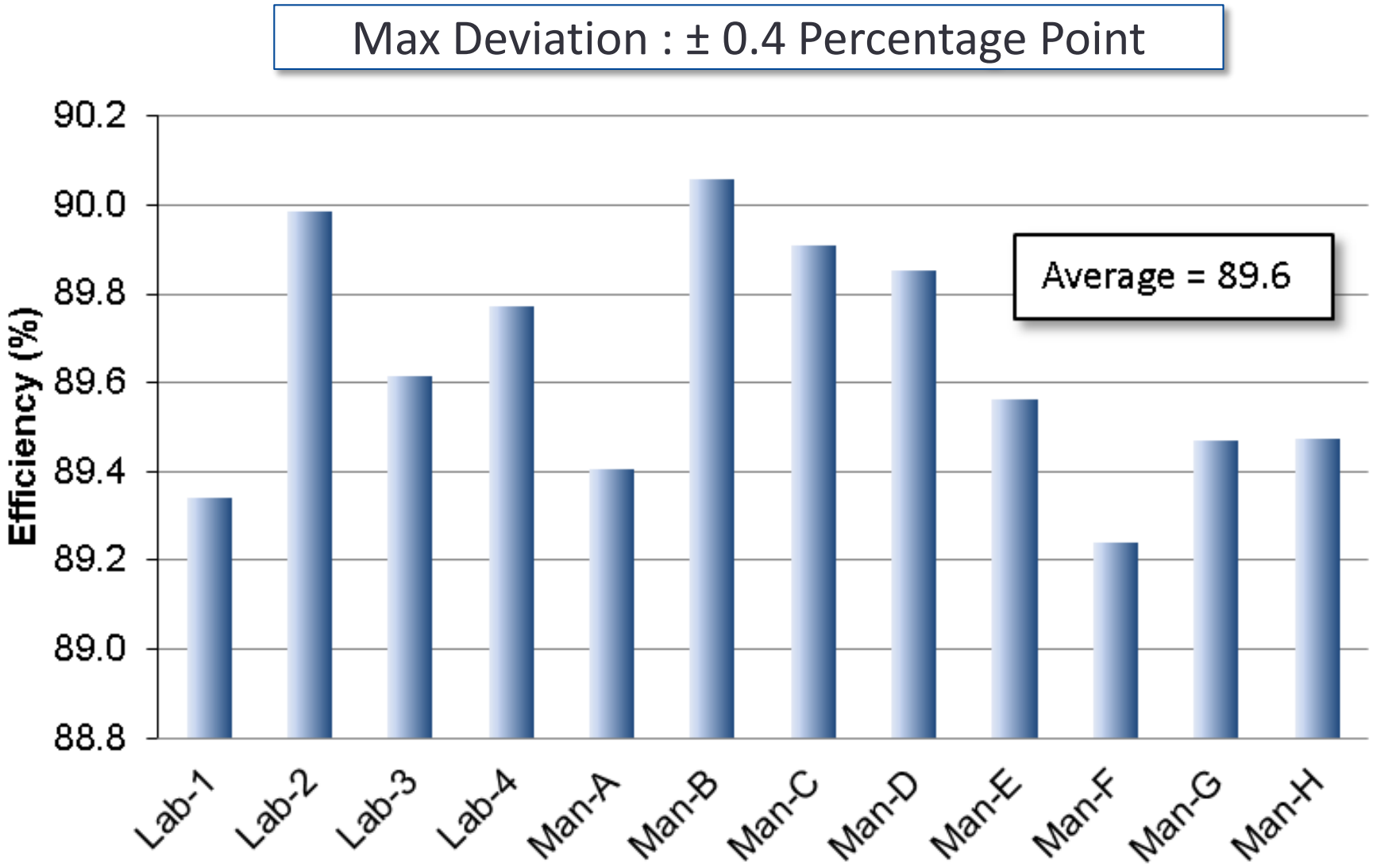
Additional Loss → Linear Regression Analysis

- Torque Measurement → Residual Loss → Additional Loss
- Additional Loss Not directly Measured but Computed
- Standard Requirement: Correlation Coefficient ≥ 0.90
- No Requirement for Intercept
- All Labs except One had Correlation Coefficient ≈ 0.99
- But some of Them had Large Value of Intercept
- Large Intercept → No Reconciliation
- Difference in Torque Transducer Calibration?

Additional Loss → Linear Regression Analysis



Nominal Efficiency

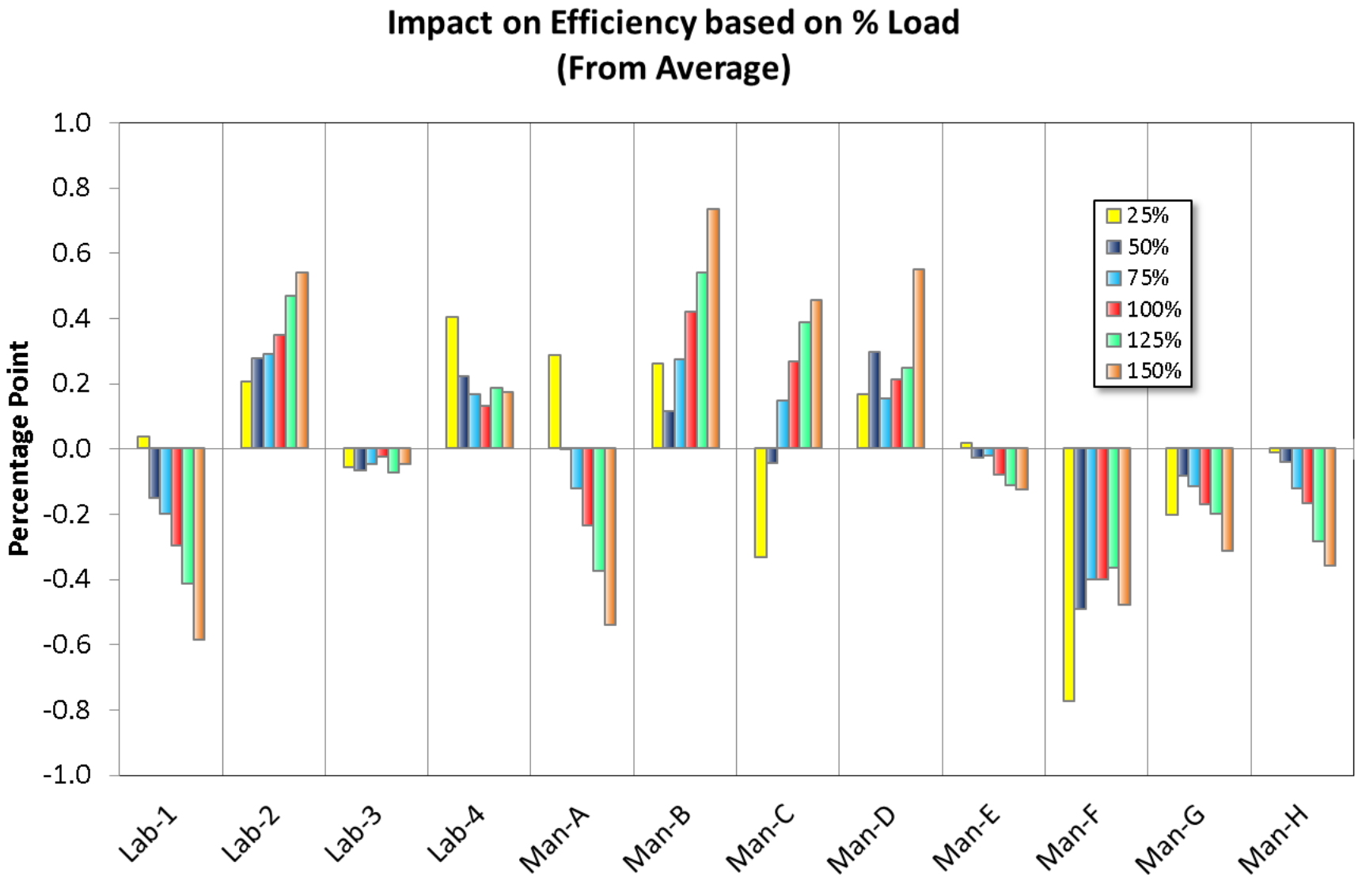


NEMA Efficiency Levels

NEMA Premium 5 hp
4-pole (3.7 kW)

- 90.2 %
- 89.5 %
- 88.5 %

Impact on Efficiency vs Load



Conclusions

- 11 Participants Testing the Same 5 hp (3.7 kW), 4-pole Motor
- ± 0.4 Percentage Point over Average Efficiency of 89.6 %
- Maximum Variability Between Participants → Additional Loss
- All Labs except One had Correlation Coefficient ≈ 0.99
- Intercept Not Necessarily Considered (but Should)
- Torque Measurement and Calibration
- To Achieve Best Result → CC Near 1.00 and an INT Toward 0.00
- Difficult to Meet Such Requirements for Larger Motors

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