

In-Service Economics of Copper-Rotor, Ultra-NEMA Premium® Electric Motors

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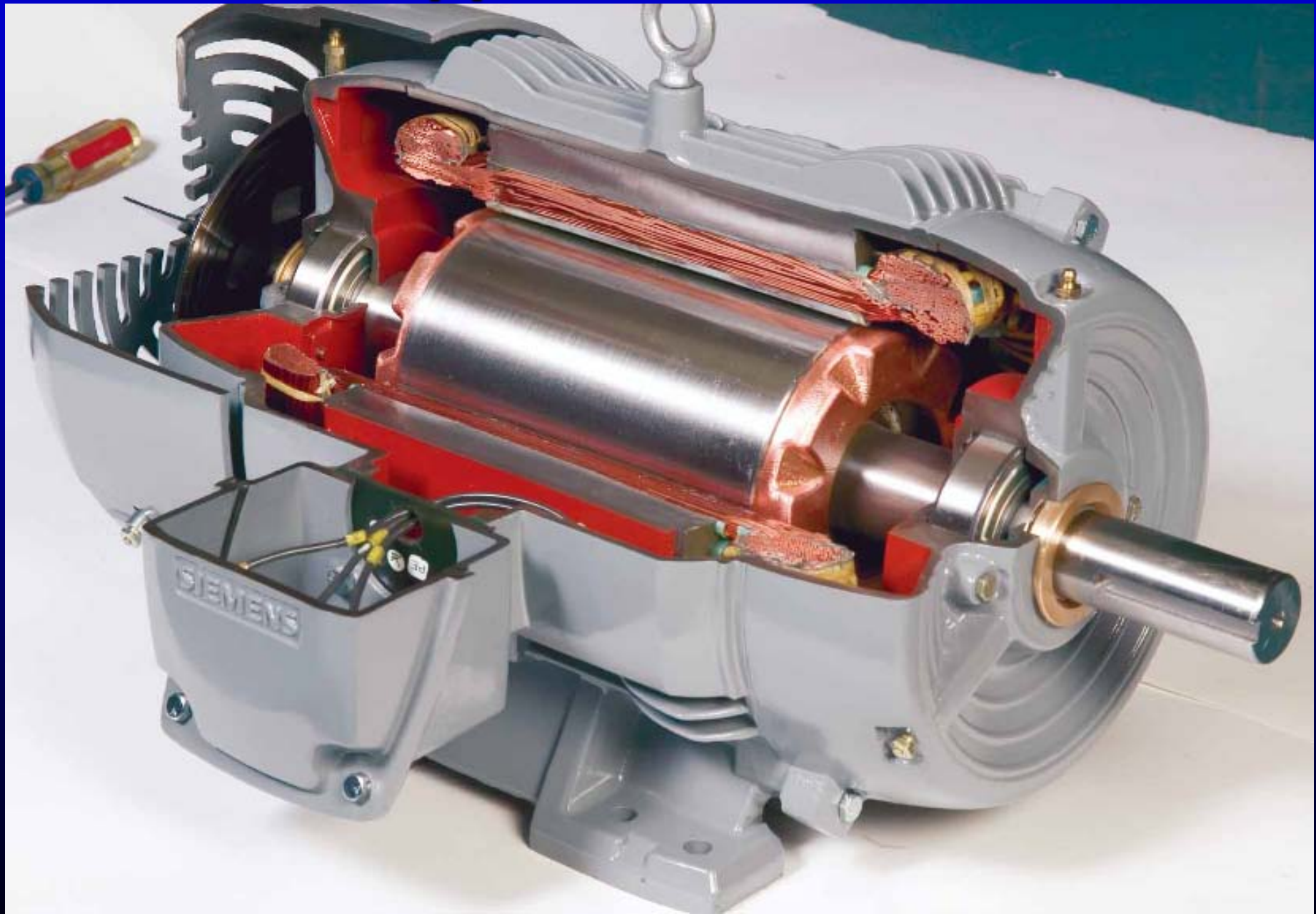
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2009 SMMA Fall Technical Conference

Copper-Rotor Motor



Die-Cast Conductor Bars

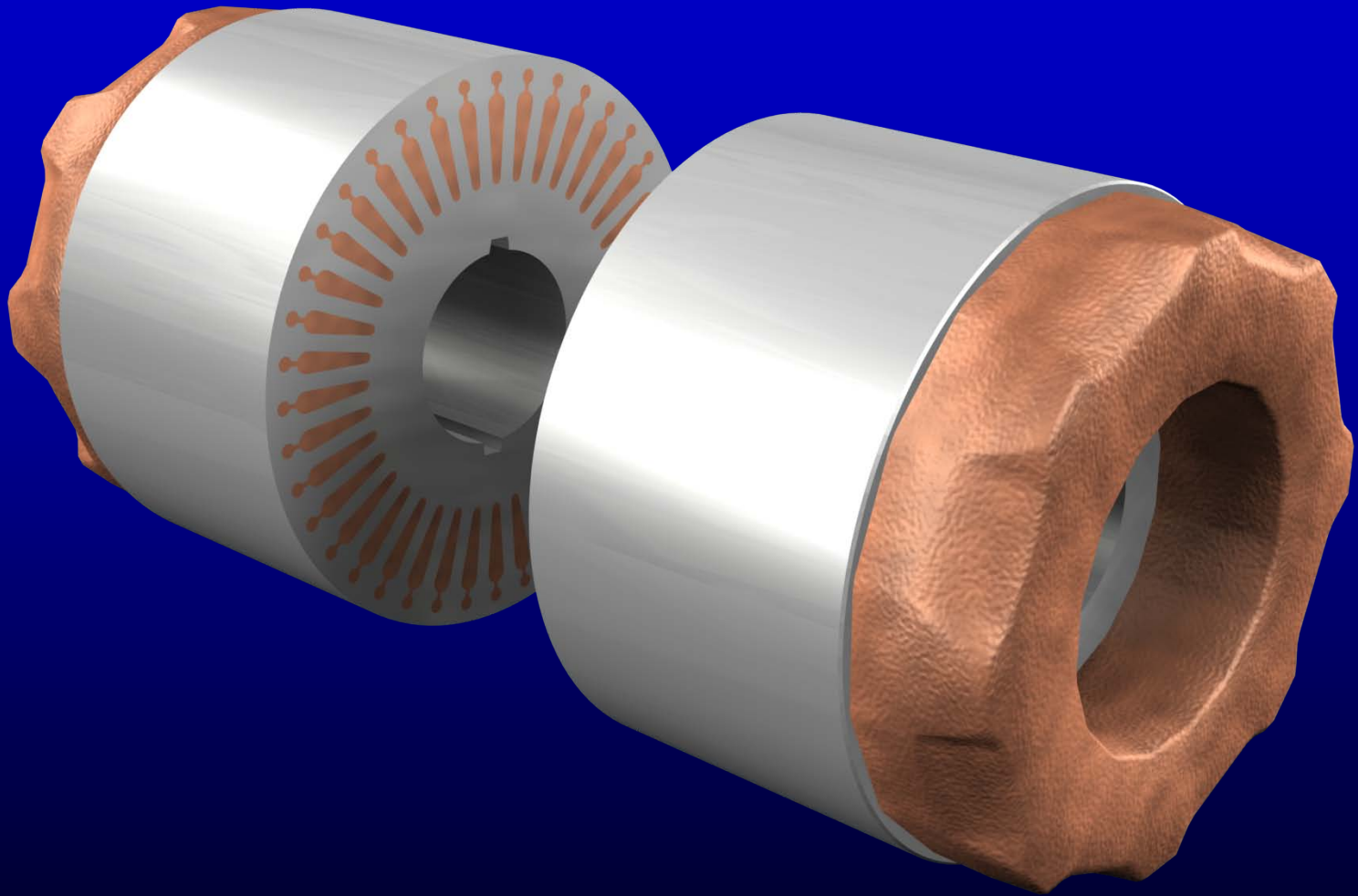


Table 1. Calculated (MotorMaster+) Efficiency, Cost Savings and Payback for Copper-Rotor, Ultra NEMA Premium Induction Motors

HP	Mfr.	Full-load Efficiency %	Annual Savings,\$	Payback, y
5	Siemens GP100	90.2	147	0.36
	Siemens GP100A	90.2	147	0.01
10	Siemens GP100	92.4	260	0.67
	Siemens GP100A	92.4	260	0.33
20	Siemens GP100	93.6	370	0.96
	Siemens GP100A	93.6	370	0.57

Table 2. Existing Motors Replaced at Revere Copper Products

Motor	hp	Eff., %	Installed	Application
REM1	15	85.5	6/1992	1738 Strand, Rinse Tank #6 Pump Motor
REM2	15	85.5	6/1992	1738 Strand, Rinse Tank #6 Pump Motor
REM3	15	85.5	1/1992	1738 Strand, West Pre-Wash Pump Motor
REM4	10	Unknown	4/1969	1723 Reversing Mill, Roll Balance Hydraulic Pump #1
REM5	10	Unknown	4/1969	1723 Reversing Mill, Roll Balance Hydraulic Pump #2
REM6	15	85.5	1/1992	1723 Reversing Mill, Filter Media Vacuum Pump
REM7	20	89.5	12/1986	2391 Slitter, Main Hydraulic Pump Motor
REM8	7.5	Unknown	1967	1721 1st Rundown, Roll Balance Hydraulic Pump Motor
REM9	10	89.5	Unknown	1715 Top Cutter Blower Motor
REM 10	10	Unknown	Unknown	1738 DX Gas Pump

Table 3. Existing Motors Replaced at ACSD

Motor	hp	Eff. %	Annual kWh Use	Annual Operating Cost, \$	Application
ACEM1	10	85	36,792	3,400	Activated Sludge Pump
ACEM2	20	87.5	126,144	11,658	Recirculation Water Pump

Table 4. New Copper-Rotor Motors Installed at Revere Copper Products

Designation	Hp	Efficiency, %
RNM1	15	93.0
RNM2	15	93.0
RNM3	15	93.0
RNM4	10	91.7
RNM5	10	91.7
RNM6	15	92.4
RNM7	20	93.6
RNM8	7.5	91.7
RNM9	10	91.7
RNM10	10	92.4

***All motors are Siemens SD100, TEFC, NEMA Design B, 460 VAC, 1.15 SF, Insulation Class F**

**Table 5. New Copper-Rotor Motors Installed at Albany County
Sewage District Menands North Plant**

Designation	hp	Efficiency, %
ACNM1	10	91.7
ACNM2	20	93.6

*All motors are Siemens SD100, TEFC, NEMA Design B, 230/460
VAC, 1.15 SF, Insulation Class F

Table 6a. Calculated Operating Loads and Efficiencies – Existing Motors

Existing Motors	hp	Calculated Operating Load, %	Calculated Operating Efficiency, %
EM1	15	60.01	85.51
EM2	15	69.25	86.03
EM3	15	49.28	84.19
EM4	10	7.66	72.96
EM5	10	9.62	74.00
EM6	15	76.07	86.46
EM7	20	45.70	88.96
EM8	7.5	18.32	63.99
EM9	10	82.17	89.00
EM10	10	4.89	57.13
ACEM1	10	44.35	86.60
ACEM2	20	78.44	89.55

Table 6b. Calculated Operating Loads and Efficiencies – Copper-Rotor Motors

New Motor	Hp	Calculated Operating Load, %	Calculated Operating Efficiency, %
NM1	15	87.97	93.31
NM2	15	60.48	93.21
NM3	15	60.36	93.20
NM4	10	5.88	82.54
NM5	10	12.05	84.94
NM6	15	75.12	92.64
NM7	20	53.50	94.01
NM8	7.5	11.04	83.86
NM9	10	86.73	90.26
NM10	10	2.19	82.81
ACNM1	10	46.73	93.29
ACNM2	20	97.80	94.01

Table 6c. Nameplate vs. Calculated Efficiencies – Existing Motors

Existing Motors	hp	Nameplate Eff., %	Calculated Operating Efficiency, %
EM1	15	85.5	85.51
EM2	15	85.5	86.03
EM3	15	85.5	84.19
EM4	10	Unknown	72.96
EM5	10	Unknown	74.00
EM6	15	85.5	86.46
EM7	20	89.5	88.96
EM8	7.5	Unknown	63.99
EM9	10	89.5	89.00
EM10	10	Unknown	57.13
ACEM1	10	85.5	86.60
ACEM2	20	85.5	89.55

Table 7. Energy Savings @ \$0.14/kWh

Existing vs. New	Location	Annual Energy Savings, kWh	Annual \$ Savings
EM1 vs. NM1	Revere	-20035.61	-2804.98
EM2 vs. NM2	Revere	12976.71	1816.74
EM3 vs. NM3	Revere	-5180.79	-725.31
EM4 vs. NM4	Revere	1639.53	229.53
EM5 vs. NM5	Revere	-576.34	80.69
EM6 vs. NM6	Revere	6262.91	876.81
EM7 vs. NM7	Revere	-5474.11	-766.37
EM8 vs. NM8	Revere	5533.65	774.71
EM9 vs. NM9	Revere	-1722.73	-241.18
EM10 vs. NM10	Revere	3575.62	458.59
ACEM1 vs. ACNM1	ACSD	730.83	102.32
ACEM2 vs. ACNM2	ACSD	-29491.51	-3008.81

Table 10. CRM Without VFD (ACSD)

Date	Voltage, V	Current, A	Pwr. Draw, W
1-14-09	487.7	26.7	17,639.3

Table 10. CRM Without VFD (ASEM2 – 20 hp)

Date	Voltage, V	Current, A	Pwr. Draw, W
1-14-09	487.7	26.7	17,639.3

Table 8. CRM, VFD Matched to Old Motor Speed, 58 Hz (ACEM2 - 20 hp), Throttle Valve Flow Control

Date	Voltage, V	Current, A	Pwr. Draw, W
4-16-09	494.9	25.9	14,306.9

Table 10. CRM Without VFD (ACEM2 – 20 hp)

Date	Voltage, V	Current, A	Pwr. Draw, W
1-14-09	487.7	26.7	17,639.3

Table 8. CRM, VFD Matched to Old Motor Speed, 58 Hz (ACEM2 - 20 hp), Throttle Valve Flow Control

Date	Voltage, V	Current, A	Pwr. Draw, W
4-16-09	494.9	25.9	14,306.9

Table 9. CRM, VFD Used to Control Flow (ACEM2 – 20 hp)

Date	Voltage, V	Current, A	Pwr. Draw, W
4-16-09	494.2	17.6	9,198.8

Table 11. Annual Energy Savings*

No.	Scenario	Annual kWh Use	Annual Electric Cost, (\$)	Annual \$ Savings at \$0.14/ kWh
1	Existing (old) motor	116,491	16,308.67	-
2	Copper rotor motor, no VFD	137,466	19,245.25	-2,936.57
3	New motor, VFD adjusted to old motor speed - with throttle valve	108,270	15,157.83	1,150.85
4	New motor, VFD controlling flow – throttle valve 100% open	69,814	9,774.01	6,534.66

***20 hp ACSD motor operating 8760 h per year**

Table 12. Calculated Energy Savings Using VFD Motor Speed Control

Old Motor vs. New Motor	Location	hp	Operational Efficiencies, Old vs. New, %	Energy Savings, kWh/y	Annual \$ Savings @ \$0.14/kWh
EM2/NM2	Revere	15	86.0/93.5	5339.2	747.5
EM3/NM3	Revere	15	84.2/92.4	4304.5	602.6
EM6/NM6	Revere	15	86.5/92.7	5344.7	748.3
EM9/NM9	Revere	10	69.0/90.5	702.2	96.3
ACEM1/ACNM1	ACSD	10	86.6/93.1	2330.6	326.3

Table 13. Motor Replacement Scenarios (Rate = \$0.09242/kWh)

Scenario	Replacement Cost (\$)	Energy Savings (kWh/y)	Cost Savings (\$/y)	Payback Period, Yr (Mos)	10-y Saving (\$)
ACEM 1 - 20 hp					
CRM, valve control	2,471.00	8,221	759.78	3.25 (39)	5,127
CRM, VFD control	2,471.00	46,677	4,313.88	0.57 (6.9)	40,668
EPAAct motor	737.00	5,909	546.11	1.35 (16.2)	4,724
Avg. NEMA Premium® motor	1,286	6,823	630.58	2.0 (24)	5,020
ACEM 1 - 10 hp					
CRM + VFD	1,679	2,330	215.39	7.8 (94)	475
Revere (All Replaced w/ CRM + VFD)					
No. 2 – 15 hp 1800 rpm	1,889	5,339	493.43	3.8 (45.9)	3,055
No. 3 – 15 hp 1800 rpm	1,889	4,305	397.87	4.7 (57)	2,089
No. 6 – 15 hp 3600 rpm	1,905	5,345	493.98	3.86 (46.3)	3,034
No. 9 – 10 hp 3600 rpm	1,459	702	64.88	29.4 (353)	-810

Table 14. Motor Replacement Scenarios (Rate = \$0.14/kWh)

Scenario	Replacement Cost (\$)	Energy Savings (kWh/y)	Cost Savings (\$/y)	Payback (Yr/Mos)	10-y Saving (\$)
ACEM 2 - 20 hp					
CRM, valve control	2,471.00	8,221	1,150.94	2.15/25.8	9,038
CRM, VFD control	2,471.00	46,677	6,534.78	0.38/6.9	62,877
EPAAct motor	737.00	5,909	827.26	0.89/10.7	7,536
Avg. NEMA Premium® motor	1,286	6,823	955.22	1.34/16.2	8,266
ACEM 1 – 20 hp					
CRM + VFD	1,679	2,330	326.20	5.1	1,583
Revere (All Replaced w/ CRM + VFD)					
No. 2 – 15 hp 1800 rpm	1,889	5,339	747.46	2.5/30.3	5,585
No. 3 – 15 hp 1800 rpm	1,889	4,305	602.60	3.1/37.6	4,137
No. 6 – 15 hp 3600 rpm	1,905	5,345	748.30	2.54/30.5	5,577
No. 9 – 10 hp 3600 rpm	1,459	702	98.28	14.8 (178)	-476

Table 15. Temperature Rise Above Ambient, F

SITE	OLD/NEW MOTOR	Existing-to-New ΔT
Revere	NM1/EM1	-108.4
	NM2/EM2	-69.3
	NM3/EM3	-82.4
	NM4/EM4	-40.3
	NM5/EM5	-30.4
	NM6/EM6	-30.6
	NM7/EM7	-12.1
	NM8/EM8	-23.9
	MN9/EM9	-47.6
	NM10/EM10	-46.0
ACSD	NM11/EM11	-7.1
	NM12*/EM12	-41.2

*Speed matched to that of EM with VFD.

**Temperature measured on shaft end.

Figure 2. Infrared and Digital Images of Motors EM2 (top) and NM2 (bottom)

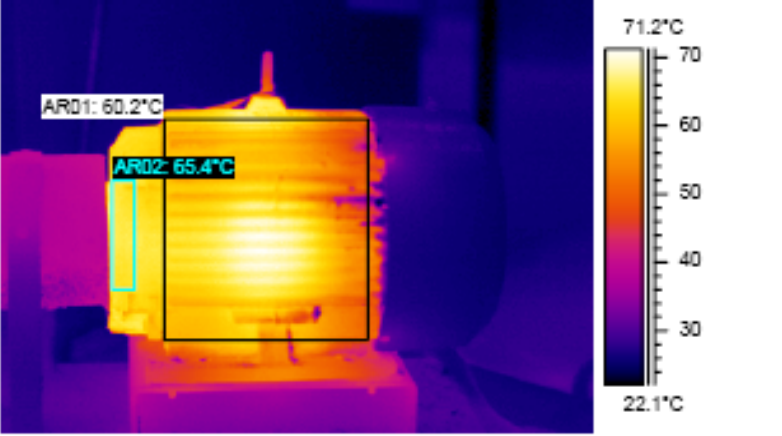

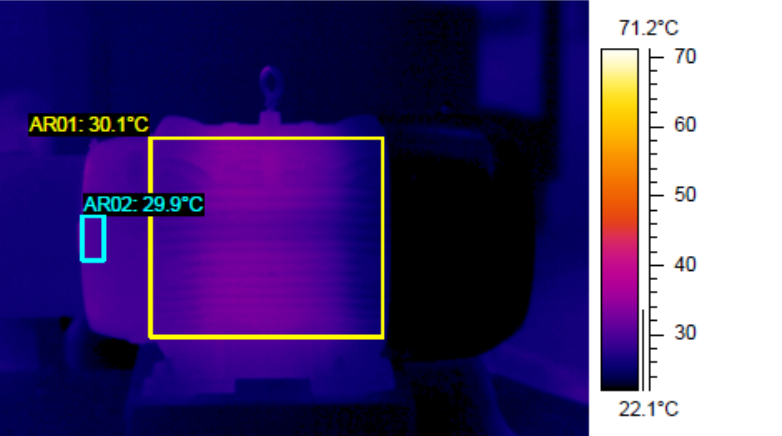

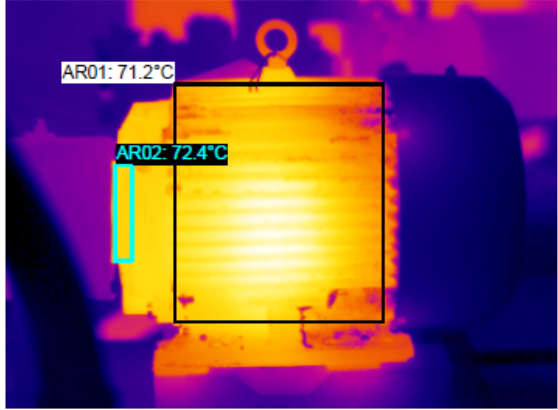

AMBIENT	MAX. TEMP. (AR01)	MAX. TEMP. (AR02)	RISES (Above Ambient)
22.1°C	71.5°C	66.7°C	49.4°C/44.6°C
Infrared Image: I1117-01		Digital Image: 5820	
			
AMBIENT	MAX. TEMP. (AR01)	MAX. TEMP. (AR02)	RISES (Above Ambient)
22.9°C	33.8°C	31.1°C	10.9°C/8.2°C
Infrared Image: I1208-03		Digital Image: 5836	
			

Figure 3. Infrared and Digital Images of Motors EM3 (top) and NM3 (bottom)

AMBIENT	MAX. TEMP. (AR01)	MAX. TEMP. (AR02)	RISES (Above Ambient)
23.2°C	82.8°C	74.1°C	59.6°C/50.9°C
Infrared Image: I1117-02		Digital Image: 5821	
			
AMBIENT	MAX. TEMP. (AR01)	MAX. TEMP. (AR02)	RISES (Above Ambient)
23.1°C	36.9°C	35.2°C	13.8°C/12.1°C
Infrared Image: I1205-01		Digital Image: 5833	
