2014 Water Workshop

REDUCING ENERGY CONSUMPTION IN WATER PUMPING STATIONS

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THE ROAD TO ENERGY EFFICIENCY STARTS WITH AN ENERGY AUDIT

- Encompass Whole Facility
  - Find all the savings possibilities
- Insist on ASHRAE Level 2 Energy Audit
  - American Society of Heating, Refrigeration and Air Conditioning Engineers
  - Level 2 ensures technical and financial analysis for decision making
- Use Independent Qualified Firm
  - Look for PE, CEM or CEA certification
  - Independent: No tie to any equipment supplier or contractor
- Utilities Offer Energy Audit Incentives
  - Some utilities pay up to 50% of the energy audit fee

TYPICAL ENERGY AUDIT FINDINGS

- Lighting
- HVAC
- Motors
- Pumps
- Equipment
- Building Envelope
  - Windows
  - Insulation
  - Infiltration

LARGEST ENERGY SAVINGS OPPORTUNITY IN PUMPING STATIONS

- Lighting
- HVAC
- Motors
- Pumps
- Equipment
- Building Envelope
  - Windows
  - Insulation
  - Infiltration

Motors and Pumps

WHY MOTORS AND PUMPS ?

- Motors consume 90% of the energy in pumping stations
- Motors are the largest opportunity for savings money
- Running a motor costs more than 10 times its purchase price each year in energy costs alone
- Over life of motor, 98%+ of cost of ownership is operating cost

IF OWNING A CAR WAS LIKE OWNING A MOTOR

- Purchase price = $30,000
- Annual operating cost = $500,000
- Operating cost over life of car = $4,000,000

What would you be willing to do

to make your car run more efficiently?

How important is purchase price to you now?

WHAT IT COSTS TO RUN A MOTOR

- Rating = 100HP
- Hours of Operation = 8,760
- Cost per kWh = $0.09
- Demand kW = $7
- Purchase Price = $6,000
- Load Factor = 100%
- Motor Eff. = 92%

$$Annual\ Energy\ Cost = \frac{100\ x\ .746\ x\ 8760\ x\ 1\ x\ .09}{.92} + \frac{100\ x\ .746\ x\ 1\ x\ 7\ x\ 12}{.92}$$

Annual Energy Costs = $63,929 + $6,811 = $70,740 Purchase Price = $6,000

Then must add maintenance costs & operating losses!

CHANGING A STD. EFF. WITH PREMIUM EFF.

$$kWSaved = \frac{HP\ x\ 0.746\ x\ LF}{Eff_{std}} - \frac{HP\ x\ 0.746\ x\ LF}{Eff_{EE}}$$

$$kWh\ Saved = kW\ x\ Oper.Hours$$

$$\$\ Saved = kWh\ x\ cost/kWh + kW\ x\ cost/kW\ x\ 12$$

CHANGING A STD. EFF. WITH PREMIUM EFF.

- Rating = 100HP
- Hours of Operation = 7400
- Cost per kWh = $0.09
- Demand kW = $7
- Purchase Price = $4,200
- Load Factor = 90%

$$kW = \frac{100\ x\ .746\ x\ .9}{.83} - \frac{100\ x\ .746\ x\ .9}{.94} = 9.6\ kW$$

$$kWh = 9.6\ kW\ x\ 7400 = 71{,}040\ kWh$$

$$Cost\ Savings = (71{,}040\ x\ .09) + (9.6\ x\ 7\ x\ 12) = \$7{,}200/year$$

DO VFD DRIVES MAKE SENSE?

HP = 300
Hours = 8760

$/kWh = $0.09
$/kW = $ 7

Standard Motor	NEMA Prem Eff Motor	With VFD
$221,867	$203,378	$126,184

Save $18,489 annually with a more efficient motor

OR…save $95,683 annually by adding a VFD to the same more efficient motor

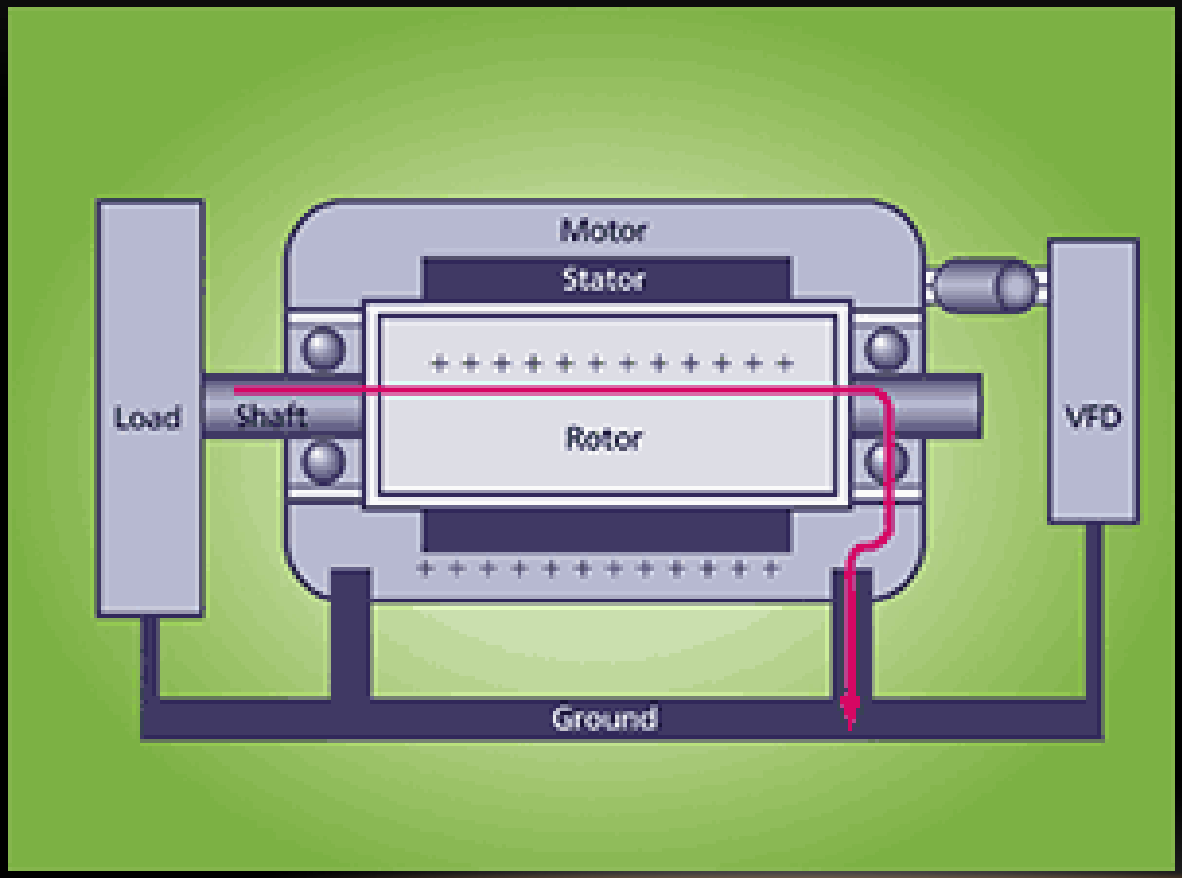
INVESTING IN A 300HP MOTOR WITH VFD

Item	Amount
Cost of Motor	$15,000
Cost of VFD	$16,000
Ship/Install cost	$5,000
Rebate	($18,000)
Total Investment	$18,000
Annual Energy Savings	$126,184
Simple Payback	0.14 Years
Return on Investment	700%

VFD TECHNICAL CONSIDERATIONS

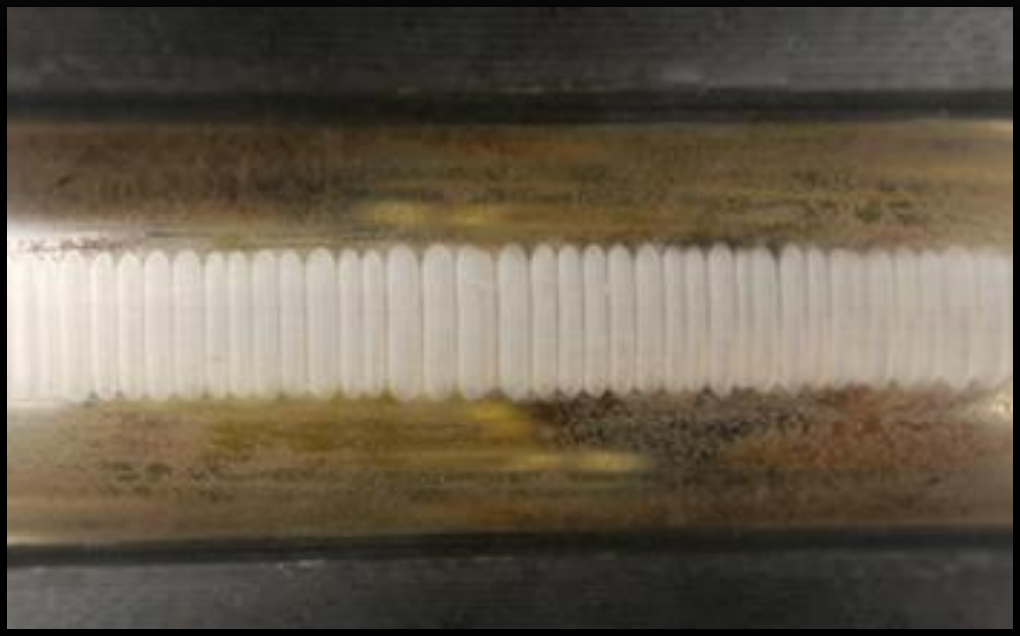
- Requires a varying load
- Requires inverter grade motor
- Limit VFD-Motor distance to 50 feet or less
- Preventive Maintenance critical for long term success
  - VFDs cause leakage current through bearings
  - 5^{th} and 11^{th} harmonic generate reverse torque
  - Current imbalance between phases < 10%
  - Voltage imbalance between phases < 3%
  - Watch for dV/dT exceeding CIV (corona inception voltage)
  - Thermal imaging should be compared every 3 to 6 months

VFD CAUSED BEARING WEAR

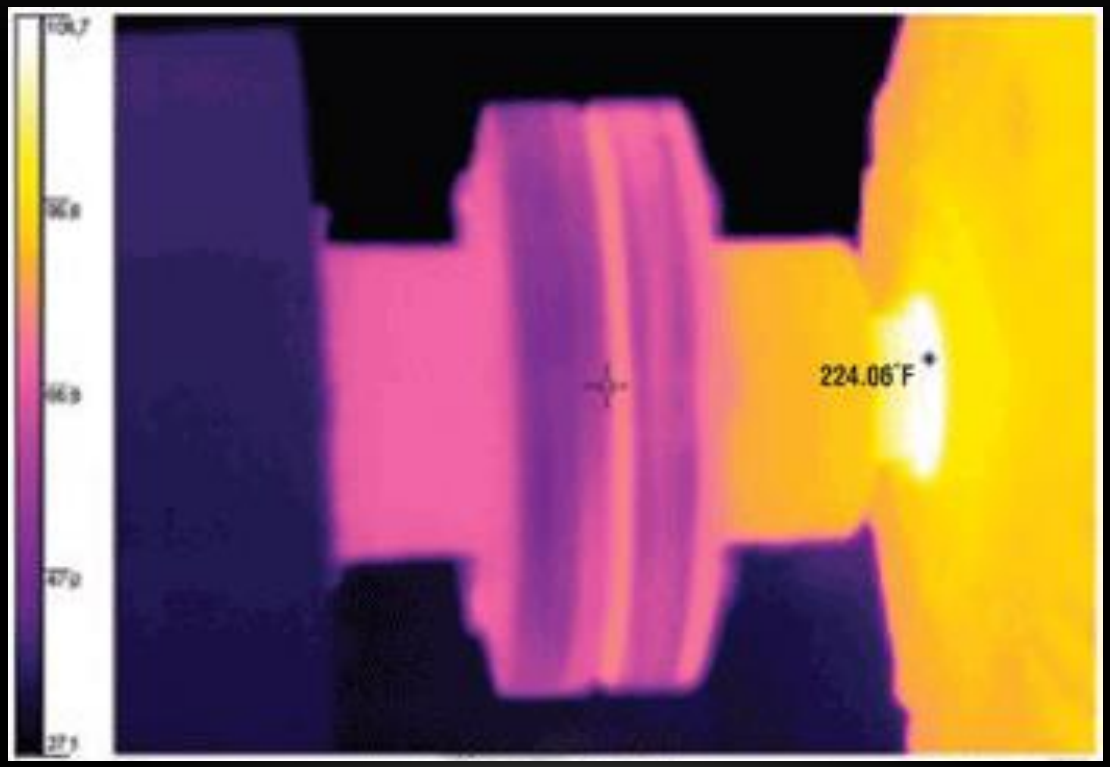


- Capacitive coupled leakage current
- Static electricity from load

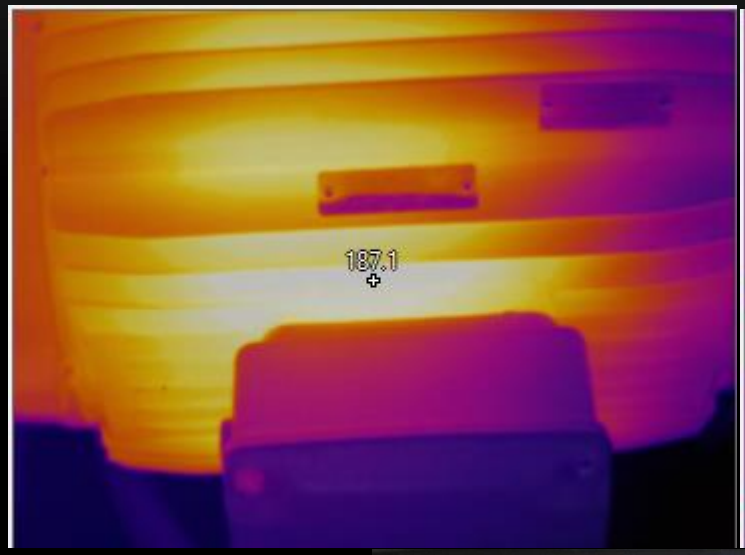
FLUTING IN BEARING CHASE CAUSED BY LEAKAGE CURRENT

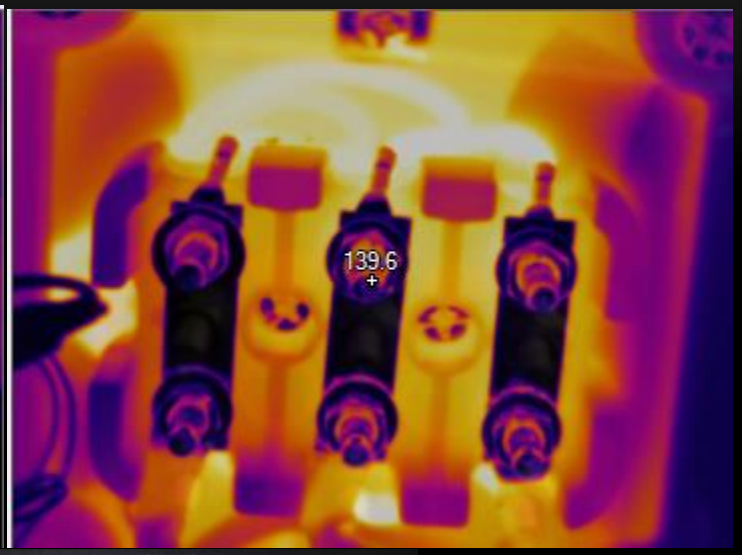


WHAT BEARING WEAR LOOKS LIKE



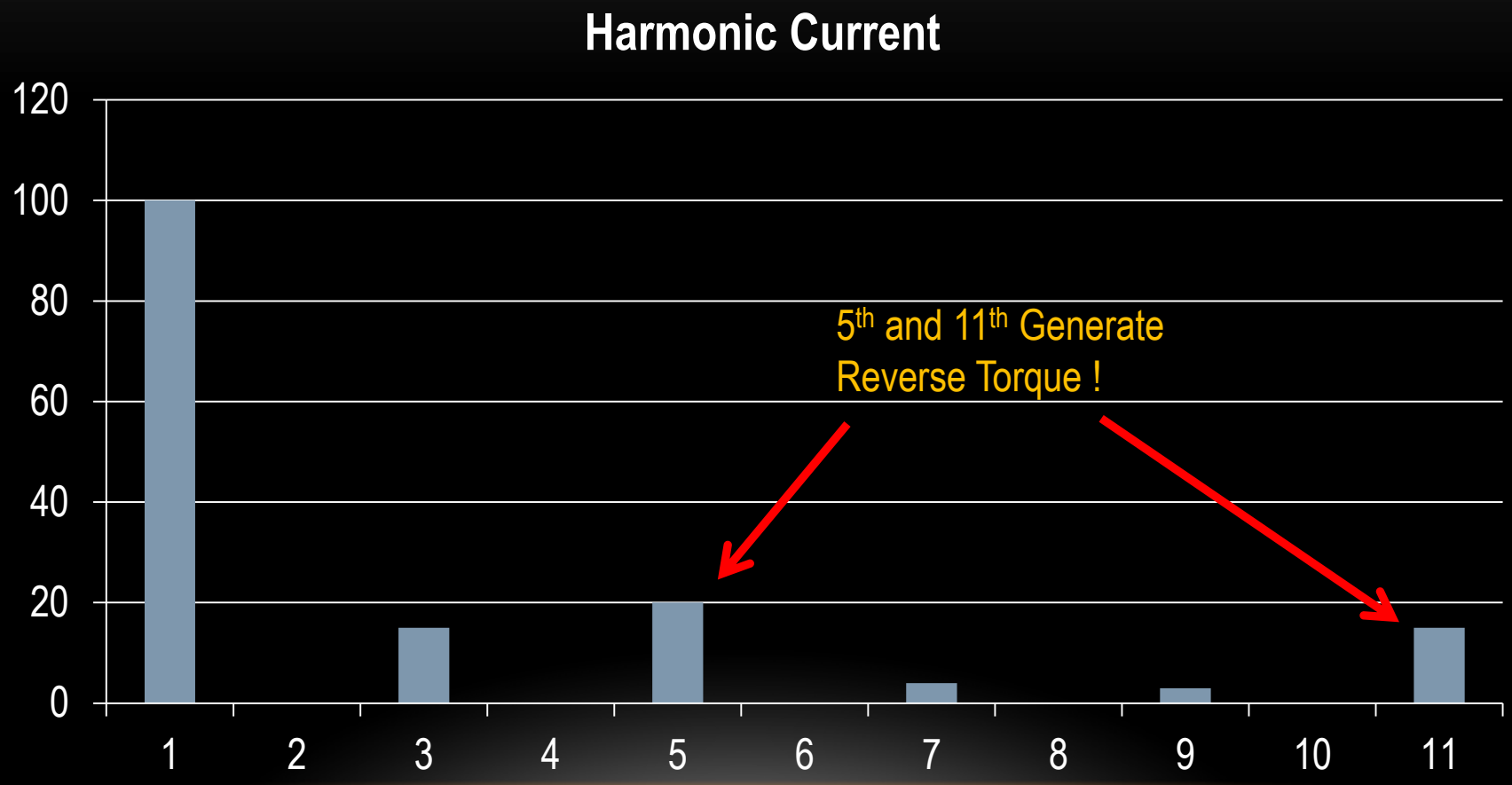
THERMAL IMAGING - EXTREMELY HELPFUL!





VFD OUTPUT VOLTAGE – INSULATION FAILURE

NEGATIVE SEQUENCING



MOTOR MANAGEMENT, PREVENTIVE MAINTENANCE (PM)

- Well planned PM is key to dependable, long-life operation of motors, pumps and generators
- Unscheduled stoppage and long repairs are intolerable
- Leadership often sees value of PM but resists investment for proper tools, resources and training
- PM often needs to be pitched as a business case
- Case studies of prior breakdowns and resulting costs will help
- Once budget approved, develop a plan for each motor category

MOTOR MANAGEMENT PROGRAM

- Survey motors. Gather nameplate information (HP, RPM, enclosure, voltage, amps, etc.)
- Initially focus on motors that exceed minimum size and operating hours
  - 50 HP and above
  - 6,000 hours/year of operation minimum
- Collect info re Standard, EPAct and NEMA Prem. Eff.
- Constant load (not intermittent, cycle or fluctuating)
- Older or rewound motor

MOTOR MANAGEMENT PROGRAM

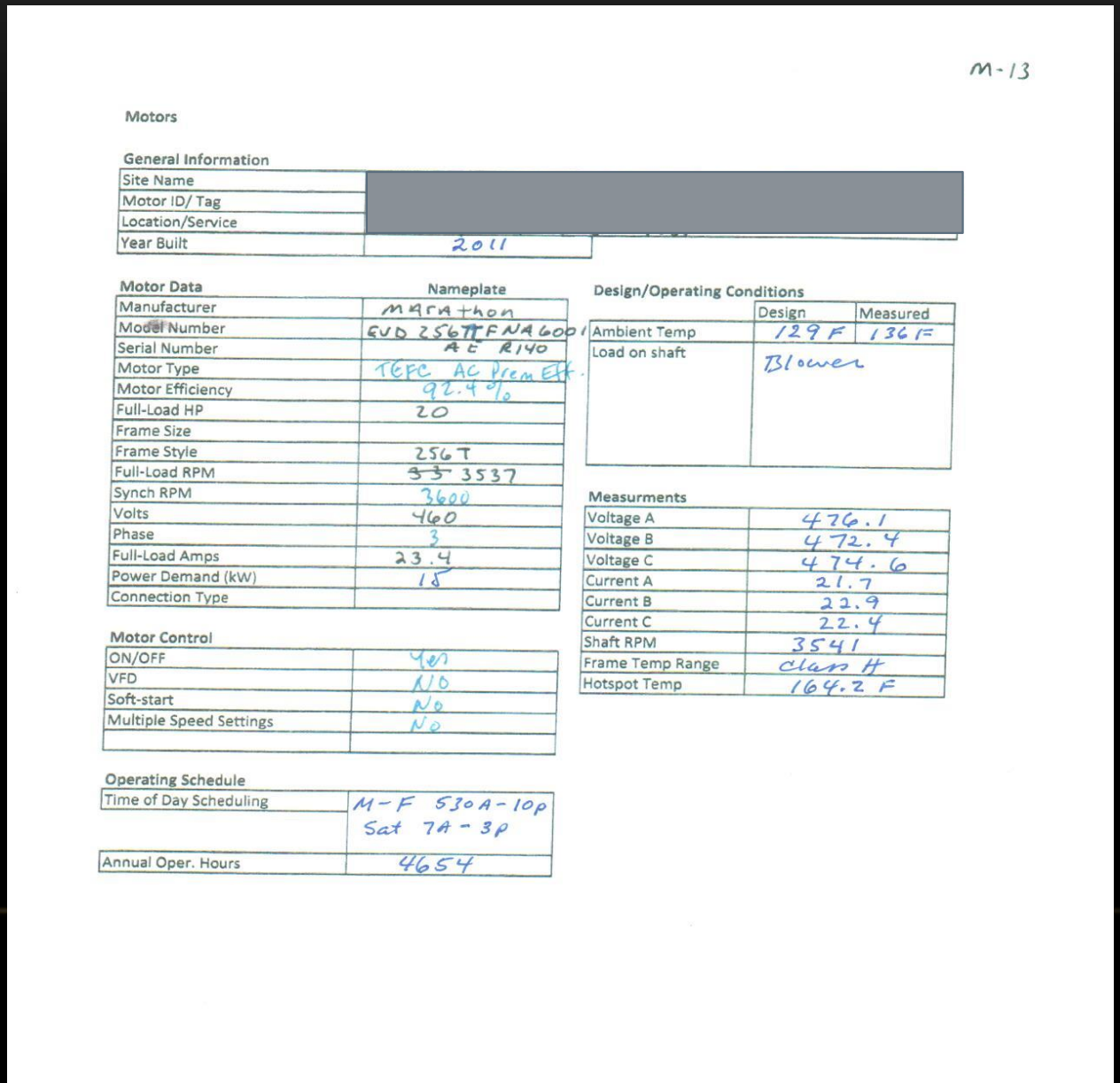
- Conduct Motor Replacement Analysis by the following three categories:
  1. Motors Offering Rapid Payback through Energy Savings. Motors that run continuously (8,000 or more hours/year.)
  2. Improved Reliability - Oversized Motors
  3. Utility Rebate Program - utility pays end-user to replace older inefficient motor with new NEMA Premium Motor.

AREAS TO COVER FOR GOOD PM PROGRAM

- Thermal Imaging
  - Over-heating (insulation class, impact on life)
  - Overloads
  - Imbalances
- Vibration Analysis
  - Included load on shaft (pump bearing)
- Load Analysis
  - Tachometer and slip equations
- Power Analysis
  - Phase imbalance
  - Overload
  - Harmonics
  - Power Factor
  - Power Quality

NEEDED - GOOD TOOLS AND EXPERTISE!

Create a Record for Each Motor



M-13

Motors

General Information

Site Name	[redacted]
Motor ID/ Tag	
Location/Service	
Year Built	2011

Motor Data	Nameplate
Manufacturer	Marathon
Model Number	EVD 256TFNA6001
Serial Number	AE R140
Motor Type	TEFC AC Prem Eff.
Motor Efficiency	92.4%
Full-Load HP	20
Frame Size	
Frame Style	256T
Full-Load RPM	~~33~~ 3537
Synch RPM	3600
Volts	460
Phase	3
Full-Load Amps	23.4
Power Demand (kW)	18
Connection Type	

Design/Operating Conditions

	Design	Measured
Ambient Temp	129 F	136 F
Load on shaft	Blower	

Measurments

Voltage A	476.1
Voltage B	472.4
Voltage C	474.6
Current A	21.7
Current B	22.9
Current C	22.4
Shaft RPM	3541
Frame Temp Range	class H
Hotspot Temp	164.2 F

Motor Control

ON/OFF	Yes
VFD	NO
Soft-start	No
Multiple Speed Settings	No

Operating Schedule

Time of Day Scheduling	M-F 530A-10p Sat 7A-3p
Annual Oper. Hours	4654

Convert Collected Data into Database

ID	Location	Make and Model	HP	Photo	Vibration	IR	Power	Condition	Comments
M1	806 Erema Cutter/Compactor	WEG Lenze 06AG008	22.8	Yes	Yes	Yes	Yes		Excessive bearing wear, severe current unbalance
M2	806 Erema Extruder	WEG LENZE TEO1FOXOXOX000091180	22.8	Yes	Yes	Yes	Yes		Severe bearing wear, excessive heating at power connection, overloaded
M3	2 1/2 - Extruder	RELIANCE 01KL517389DFT1	150	Yes	Yes	Yes	Yes		Excessive bearing wear; severe 5th and 11th harmonic
M4	3 Layer 1 - Extruder C				No	No	No		Machine down
M5	3 Layer 1 - Extruder B				No	No	No		Machine down
M6	3 Layer 1 - Extruder A				No	No	No		Machine down
M7	5 Layer - Extruder D	CONTRAVES 2190B450B03	10	Yes	Yes	Yes	No		Moderate bearing wear; non-std
M8	5 Layer - Extruder E	CONTRAVES N058/0413-FN112	10	Yes	Yes	Yes	No		Excessive bearing wear
M9	5 Layer - Extruder C	BALDOR P28800450035000	25	Yes	Yes	Yes	No		Moderate bearing wear
M10	5 Layer - Extruder B	CONTRAVES 2190B450B02	10	Yes	Yes	Yes	No		Excessive bearing wear
M11	5 Layer - Extruder A	BALDOR 59084771-001001-JN	50	Yes	Yes	Yes	No		Moderate bearing wear; non-std
M12	2 1/2 - Grinder	LEESON M286TDB10B	30	Yes	Yes	Yes	No		
M13	9 Layer - IBC Exhaust Blower	MARATHON EVD 256TTFNA6001	20	Yes	Yes	Yes	No		
M14	3 Layer 2 - Air Ring Exhaust	MARATHON DUB 215TTFS6001GWR140	10	Yes	Yes	Yes	No		
M15	9 Layer - Air Ring Blower	MARATHON EVD286TSTFN6001BHR1401	30	Yes	Yes	Yes	No		
M16	9 Layer - IBC Supply	MARATHON EVD286TSTFN6001BHR1402	20	Yes	Yes	Yes	No		Slight looseness
M17	9 Layer - Extruder A	RELIANCE 73424318-00-DR-T1	60	Yes	Yes	Yes	No		
M18	9 Layer - Extruder B	RELIANCE 7350638-001-CK-T2	40	Yes	Yes	Yes	No		
M19	9 Layer - Extruder C	RELIANCE 7350638-001-CK-T3	40	Yes	Yes	Yes	No		
M20	9 Layer - Extruder D	RELIANCE 7350638-001-CK-T4	40	Yes	Yes	Yes	No		
M21	9 Layer - Extruder E	RELIANCE 7350638-001-CK-T5	40	Yes	Yes	Yes	No		
M22	9 Layer - Extruder F	RELIANCE 7350638-001-CK-T6	40	Yes	Yes	Yes	No		
M23	9 Layer - Extruder G	RELIANCE 7350638-001-CK-T7	40	Yes	Yes	Yes	No		
M24	9 Layer - Extruder H	RELIANCE 7350638-001-CK-T8	40	Yes	Yes	Yes	No		
M25	9 Layer - Extruder I	RELIANCE 7342431A-00-DKT1	60	Yes	Yes	Yes	No		
M26	3 Layer 2 - Extruder A	SAFTRONICS 5CD184TA096B017	60	Yes	Yes	Yes	No		
M27	3 Layer 2 - Extruder B	SAFTRONICS CD203PA097A151	50	Yes	Yes	Yes	No		
M28	3 Layer 2 - Extruder C	GE 5CD84TA096B032	60	Yes	Yes	Yes	No		
M29	605 Erema - Extruder	SIEMENS ILE10011DC434AB4Z	15	Yes	Yes	Yes	No		Moderate bearing looseness
M30	605 Erema - Cutter/Compactor	SIEMENS ILA91866	20	Yes	Yes	Yes	No		
M31	Macchi reclaim				No	No	No		motor not accessible
M32	3 Layer 1 - IBC Suply				No	No	No		Machine down
M33	2 /12 - Air Ring Supply	BALDOR M3314T	15	Yes	Yes	Yes	No		
M34	3 Layer 1 - IBC Exhaust				No	No	No		Machine down
M35	3 Layer 1 - Air Ring Supply				No	No	No		Machine down
M36	5 Layer - Air Ring Blower	TOSHIBA B0202OLF2UMH01	20	Yes	Yes	Yes	No		
M37	3 1/2 - Extruder	RELIANCE 7135052-001-DJT1	150	Yes	Yes	Yes	No		
M38	3 1/2 - IBC Suply Blower	MARATHON DVF 254TTFNA6001 AER1401	15	Yes	Yes	Yes	No		
M39	3 1/2 - IBC Exhaust	RELIANCE P21G3319H	10	Yes	Yes	Yes	No		Moderate bearing looseness
M40	6" Extruder	POWERTEC A32EYS1000100000	250	Yes	Yes	Yes	No		Bearings at both ends have moderate wear
M41	6" - Air Ring Supply	BALDOR M4107T	25	Yes	Yes	Yes	No		Moderate bearing wear and looseness
M42	2" Extruder	GE 5OD363NA001AO15	30	Yes	Yes	Yes	No		
M43	6" - Grinder	LEESON C324T17FB7D	30	Yes	Yes	Yes	No		
M44	6" - Grinder	DELCO 1V9716L1	40	Yes	Yes	Yes	No		
M45	3 1/2 - IBC Exhaust Blower	MARATHON DVA 215TTFS6001GWR1401	10	Yes	Yes	Yes	No		
M46	GD VS-40 Air Compressor	RELIANCE 89864009	54.4	Yes	Yes	Yes	No		
M47	3 Layer 2 - Air Ring Supply	MARATHON BVA254TTFNA6001AER140	15	Yes	Yes	Yes	No		Slight bearing wear

UTILITY REBATES FOR MOTORS AND VFD'S – FIRSTENERGY

- Motors and VFD's fall under their custom program and pay $0.08/kWh saved, caped at 50% of project cost.

UTILITY REBATES FOR MOTORS AND VFD - AEP

NEMA Premium™ Efficiency Criteria Qualifying Motors Exceed NEMA Premium™ Efficiency							
Horse-power	3600 RPM		1800 RPM		1200 RPM		Incentive /Motor
	Open	Closed	Open	Closed	Open	Closed	
1	77.0%	77.0%	85.5%	85.5%	82.5%	82.5%	$8
1.5	84.0%	84.0%	86.5%	86.5%	86.5%	87.5%	$10
2	85.5%	85.5%	86.5%	86.5%	87.5%	88.5%	$13
3	85.5%	86.5%	89.5%	89.5%	88.5%	89.5%	$20
5	86.5%	88.5%	89.5%	89.5%	89.5%	89.5%	$25
7.5	88.5%	89.5%	91.0%	91.7%	90.2%	91.0%	$40
10	89.5%	90.2%	91.7%	91.7%	91.7%	91.0%	$45
15	90.2%	91.0%	93.0%	92.4%	91.7%	91.7%	$60
20	91.0%	91.0%	93.0%	93.0%	92.4%	91.7%	$75
25	91.7%	91.7%	93.6%	93.6%	93.0%	93.0%	$80
30	91.7%	91.7%	94.1%	93.6%	93.6%	93.0%	$90
40	92.4%	92.4%	94.1%	94.1%	94.1%	94.1%	$100
50	93.0%	93.0%	94.5%	94.5%	94.1%	94.1%	$120
60	93.6%	93.6%	95.0%	95.0%	94.5%	94.5%	$130
75	93.6%	93.6%	95.0%	95.4%	94.5%	94.5%	$140
100	93.6%	94.1%	95.4%	95.4%	95.0%	95.0%	$190
125	94.1%	95.0%	95.4%	95.4%	95.0%	95.0%	$238
150	94.1%	95.0%	95.8%	95.8%	95.4%	95.8%	$285
200	95.0%	95.4%	95.8%	96.2%	95.4%	95.8%	$380
250	95.0%	95.8%	95.8%	96.2%	95.4%	95.8%	$475

VFD Application	Incentive Amount
Supply/ Return Fan	$60/HP
Chilled Water Pump/ Condenser Water Pump	
Hot Water Pump	
Cooling Tower Fan	
Other HVAC Motor (Fan/ Pump)	
Process Fan and Pump Motor	

Pool Pump & Compressor Prescriptive Incentives		
VFD Application	Size Requirements	Incentive Amount
Pool Pump	N/A	$100/HP
New Compressor	≤ 150 HP	$100/HP

Installing VFDs on Existing Equipment

Incentives qualify for new VFDs, not replacement VFDs.
Prescriptive Incentives for VFD applications ≤ 200 HP*
(For motors >100 HP custom analysis is completed, but prescriptive incentives are paid.)

Installing VFDs on New Equipment

Subject to ASHRAE 90.1-2007 standards. If a VFD is required it is not eligible for incentives.

The following are the most common applications not eligible for incentives:

VFD Application	Required by ASHRAE 90.1-2007	Notes
Variable Air Volume (VAV) Fan Control	Motor ≥ 10 HP	Supply/ return fans
Hydronic Variable Flow Systems	Motor > 50 HP & Pump Head > 100 ft	Variable fluid flow pumps
Heat Rejection Equipment, Fan Speed Control	Motor ≥ 7.5 HP	Cooling towers, condensing units, etc.

UTILITY REBATES FOR MOTORS AND VFD'S – DUKE ENERGY

VARIABLE FREQUENCY DRIVES

For all VFD operations >2000 hours per year applied to HVAC fans and pumps and process pumps

HP	INCENTIVE/HP
From 1.5 hp to 50 hp	Up to $100.00/hp

Visit www.duke-energy.com for required efficiency levels.

UTILITY REBATES FOR MOTORS AND VFD'S – DP&L

Premium Motors

Measure	Rebate (per HP)
1.0 - 5.0 HP	$25.00
7.5 - 20.0 HP	$15.00
25.0 - 250.0 HP	$10.00

Variable Frequency Drives

Measure	Rebate (per HP)
1.0 - 250.0 HP	$40.00

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