LARGE MOTORS 101

MAY 2011

BILL LOCKLEY

SCOPE

- INDUSTRIAL /UTILITY MOTORS OVER 250 HP
- INDUCTION AND SYNCHRONOUS
- WHAT DO WE WANT FROM A MOTOR?
- WHAT DO WE ORDER?
- APPLICATION QUESTIONS
- TESTING
- INSTALLATION AND STARTUP
- KEEPING IT RUNNING

MOTOR RATINGS/TYPES

- ‘LARGE”
  - HIGHER POWERS (OVER 250 HP TYPICAL)
  - HIGHER VOLTAGES
  - FORM WOUND
  - INDUCTION OR SYNCHRONOUS, 3 PHASE

019D567T01

INDUCTION OR SYNCHRONOUS?

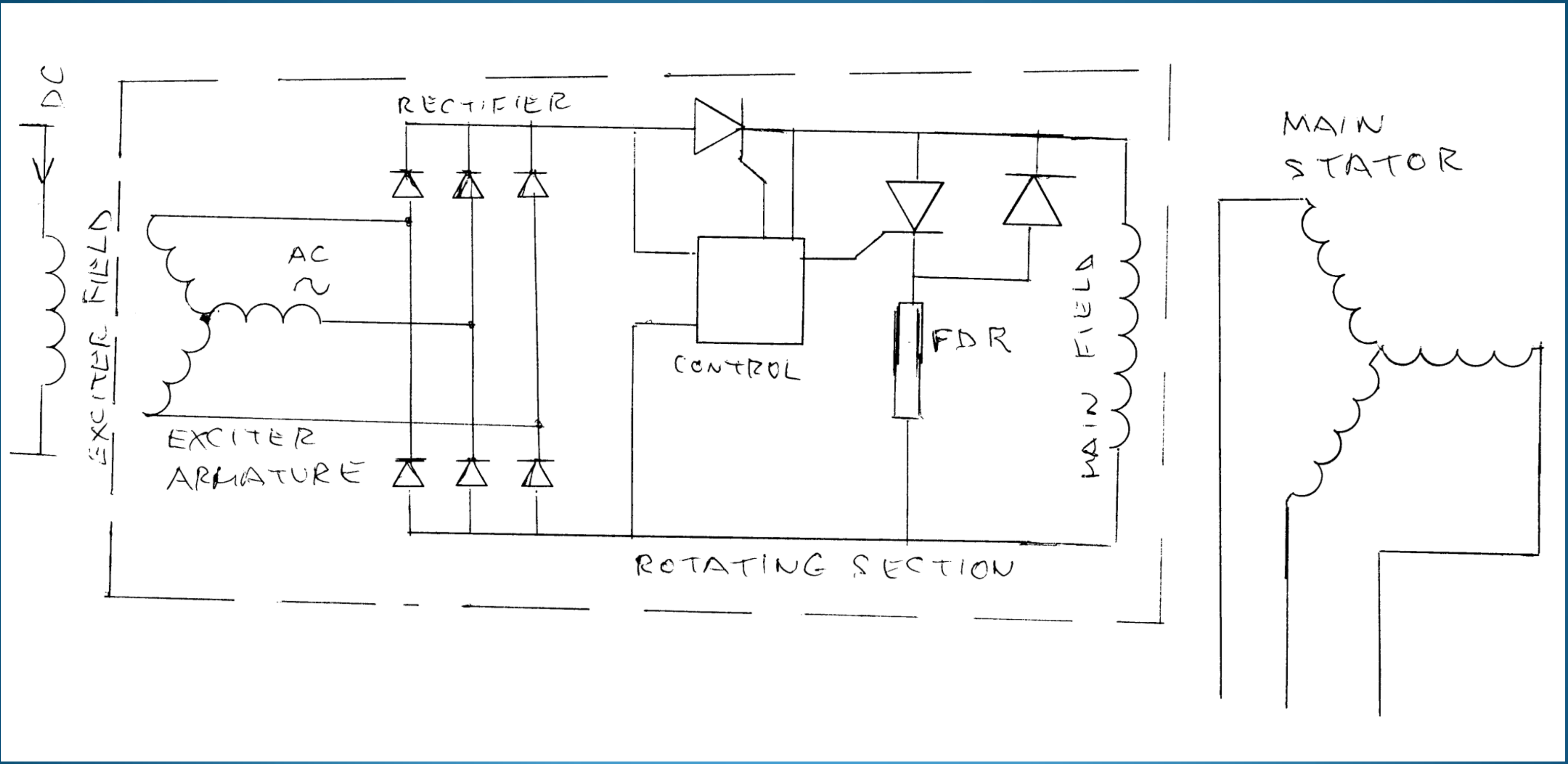
SYNCHRONOUS AND INDUCTION MOTOR COMPARISON

Factor	Induction Advantage	Synchronous Advantage
Capital Cost		
Power Consumption and Efficiency		
Power Factor		
Starting Current		
Accelerating Torque Margin		
Pulsating/Oscillating Torque During Starting		
Current Pulsations for non steady state loads such as reciprocating compressors		
Rotor Inertia (Application Dependent)		
Suitability for ASD		
Two Pole Applications		
Lead-Time		
Ride Through supply interruptions		

SYNCHRONOUS

- MOST ARE BRUSHLESS
- SLOW SPEED AND LARGE 4/6 POLES
- FIXED SPEED STARTS AS INDUCTION, RUNS AS SYNCHRONOUS
- STARTING WINDING SQUIRREL CAGE OR SOLID POLE
- DC FOR MAIN FIELD COMES FROM ROTATING RECTIFIER AND FIELD APPLICATION SYSTEM
- MAY HAVE FIELD DISCHARGE RESISTOR

EXCITATION SCHEMATIC



WHAT DO WE WANT FROM AN ELECTRIC MOTOR?

- MUST START AND DRIVE THE LOAD
- MUST BE DURABLE
- MINIMUM LIFE CYCLE COST
  - PURCHASE COST
  - REPAIRS
  - COST OF OUTAGES
  - INPUT ENERGY COSTS

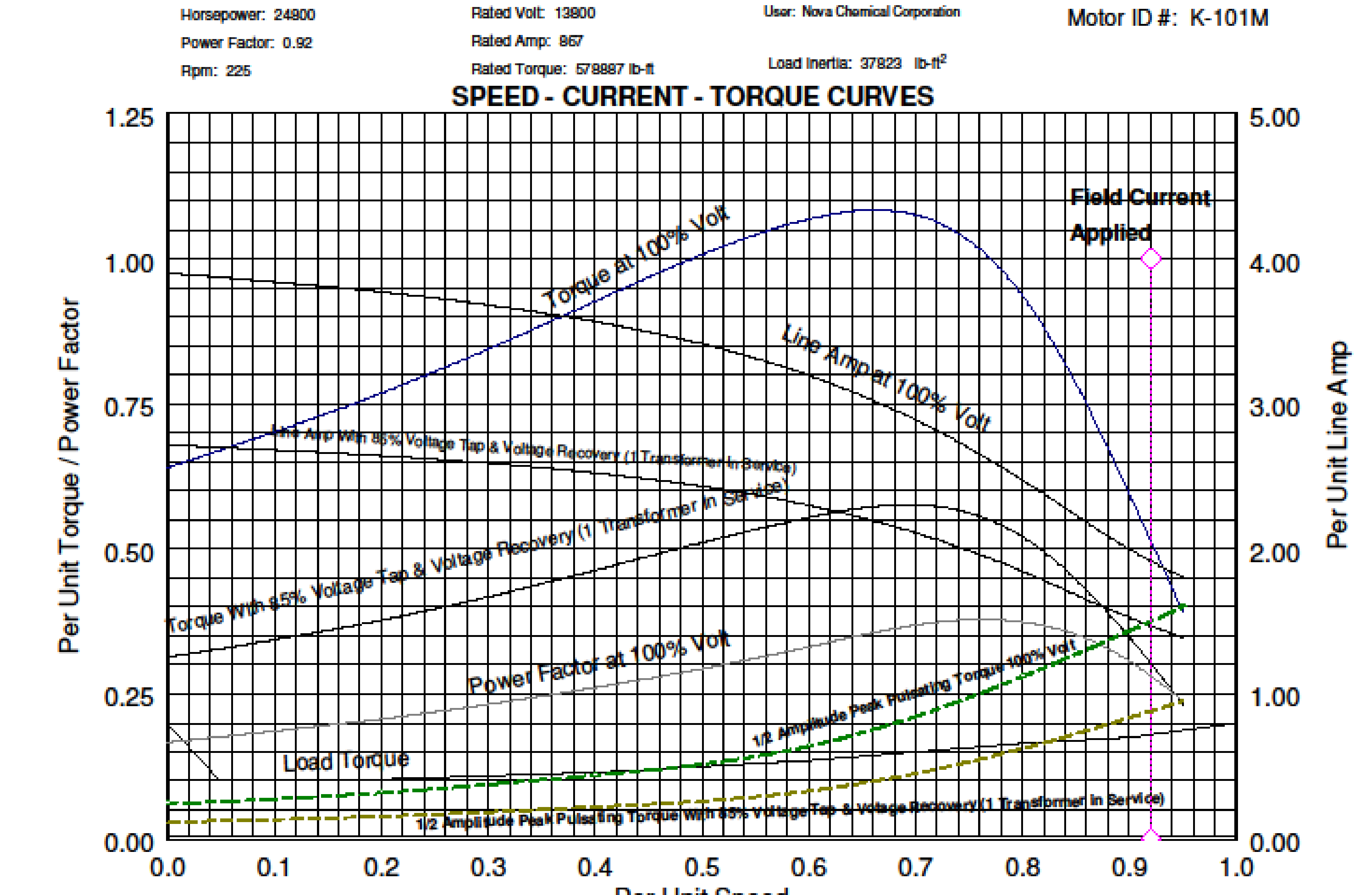
START AND DRIVE THE LOAD

- GENERATE MORE TORQUE THAN LOAD DRAWS THROUGH THE SPEED RANGE
- DON’T OVERHEAT ON HIGH INERTIA/LONG STARTS
- RUN COOL AT FULL LOAD
- WHEN REQUIRED, OPERATE OK ON A DRIVE

STARTING TORQUE

- MOTOR MUST GENERATE A MARGIN (10% MINIMUM) OF TORQUE OVER THE LOAD TORQUE THROUGH THE SPEED RANGE.
- MUST PROVIDE FOR REDUCED VOLTAGE DUE TO HIGH STARTING CURRENTS
- CURRENT PROPORTIONAL TO VOLTS $^{(1.1 \text{ TO} 1.3)}$
- TORQUE PROPORTIONAL TO VOLTS $^{(2.2 \text{ TO } 2.6)}$

STARTING



Horsepower: 24800
Power Factor: 0.92
Rpm: 225
Rated Volt: 13800
Rated Amp: 867
Rated Torque: 578887 lb-ft
User: Nova Chemical Corporation
Load Inertia: 37823 lb-ft2
Motor ID #: K-101M
SPEED - CURRENT - TORQUE CURVES
Field Current Applied
Torque at 100% Volt
Line Amp at 100% Volt
Line Amp With 85% Voltage Tap & Voltage Recovery (1 Transformer In Service)
Torque With 85% Voltage Tap & Voltage Recovery (1 Transformer In Service)
Power Factor at 100% Volt
1/2 Amplitude Peak Pulsating Torque 100% Volt
Load Torque
1/2 Amplitude Peak Pulsating Torque With 85% Voltage Tap & Voltage Recovery (1 Transformer In Service)
Per Unit Torque / Power Factor
Per Unit Line Amp
Per Unit Speed
1.25
1.00
0.75
0.50
0.25
0.00
5.00
4.00
3.00
2.00
1.00
0.00
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

STARTING

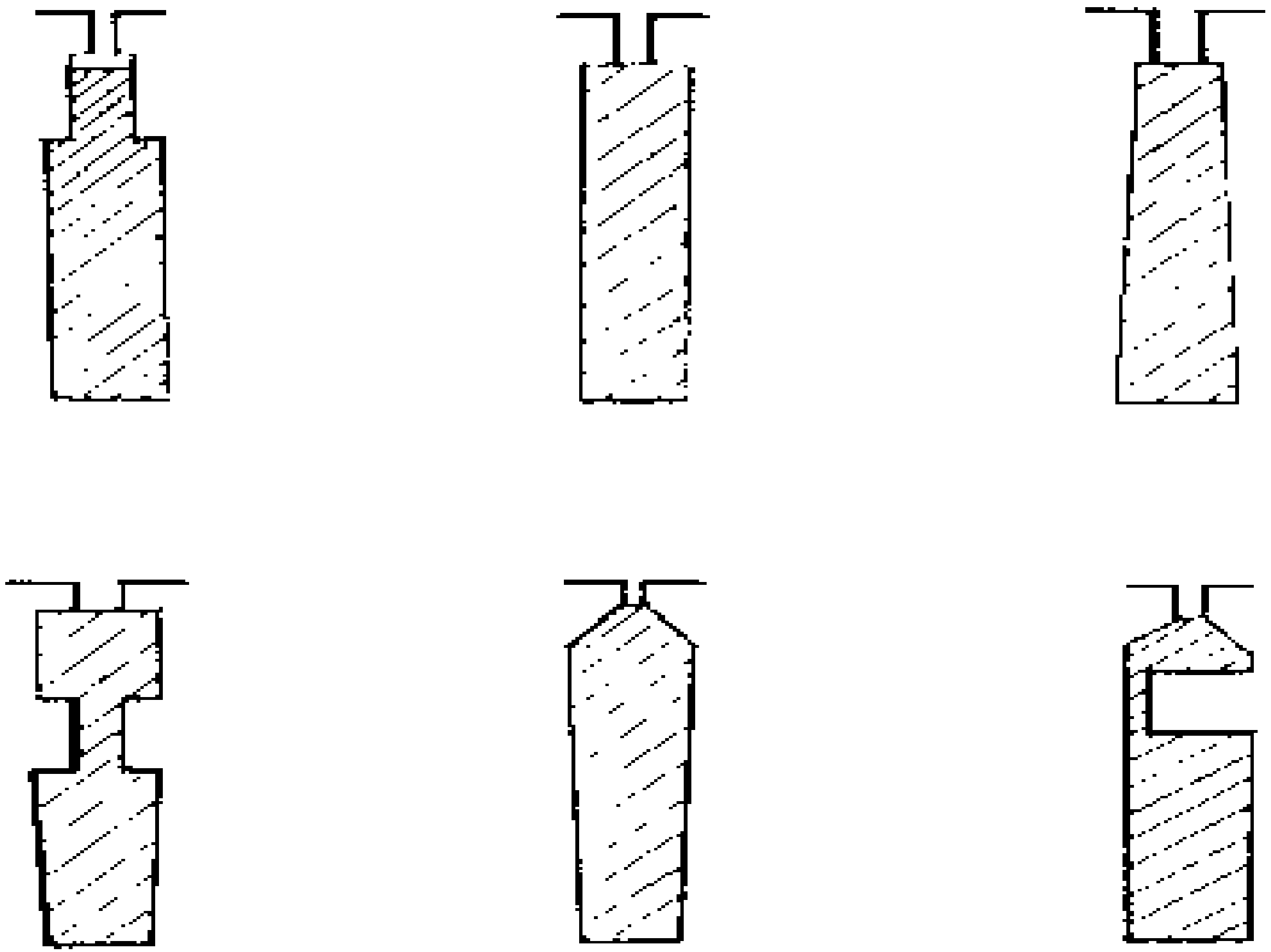
- TIME REQUIRED INCREASES WITH TOTAL INERTIA
- AT ZERO SPEED 100% OF POWER ACROSS AIR GAP (INTO ROTOR) GOES INTO HEAT
- PROPORTION OF HEAT DECREASES LINEARLY WITH SLIP
- 50% SPEED – 50% POWER GOES TO HEAT
- 90% SPEED – 10% POWER GOES TO HEAT
- UP TO 50^{o} C PER SECOND
- LONG STARTS GIVE HOT ROTOR
- 350^{o} C TYPICAL CAGE LIMIT (METALLURGY, DIFFERENTIAL EXPANSION)

ROTOR TEMPERATURE

- TEMPERATURE GRADIENT DURING START
- MOST LOCKED ROTOR LOSSES NEAR OUTER EDGE OF BARS
- AVERAGE RATE OF RISE = P_{ag} x SLIP/(M x SH)
  - P_{ag} = POWER ACROSS AIR GAP (INPUT POWER – STATOR LOSSES) (watts)
  - M = MASS OF CAGE (gm)
  - SH = CONDUCTOR SPECIFIC HEAT (copper 0.389 J/g.K)

ROTOR BAR DESIGN

- SHAPE
  - SINGLE, DOUBLE
  - DEEP BAR
  - COFFIN
  - INVERTED T
  - FABRICATED/CAST?
  - ETC
- MATERIAL
  - COPPER, ALLOY
  - ALUMINUM, ALLOY
  - CONDUCTIVITY
  - STRENGTH
  - DENSITY
  - SPECIFIC HEAT
  - THERMAL EXPANSION
  - BRAZE/WELD?



SOLID POLE

- SYNCHRONOUS
- MOSTLY 4 AND 6 POLE
- STARTING HEATS STEEL POLE FACE
- RELIES ON CURRENTS IN STEEL FOR TORQUE

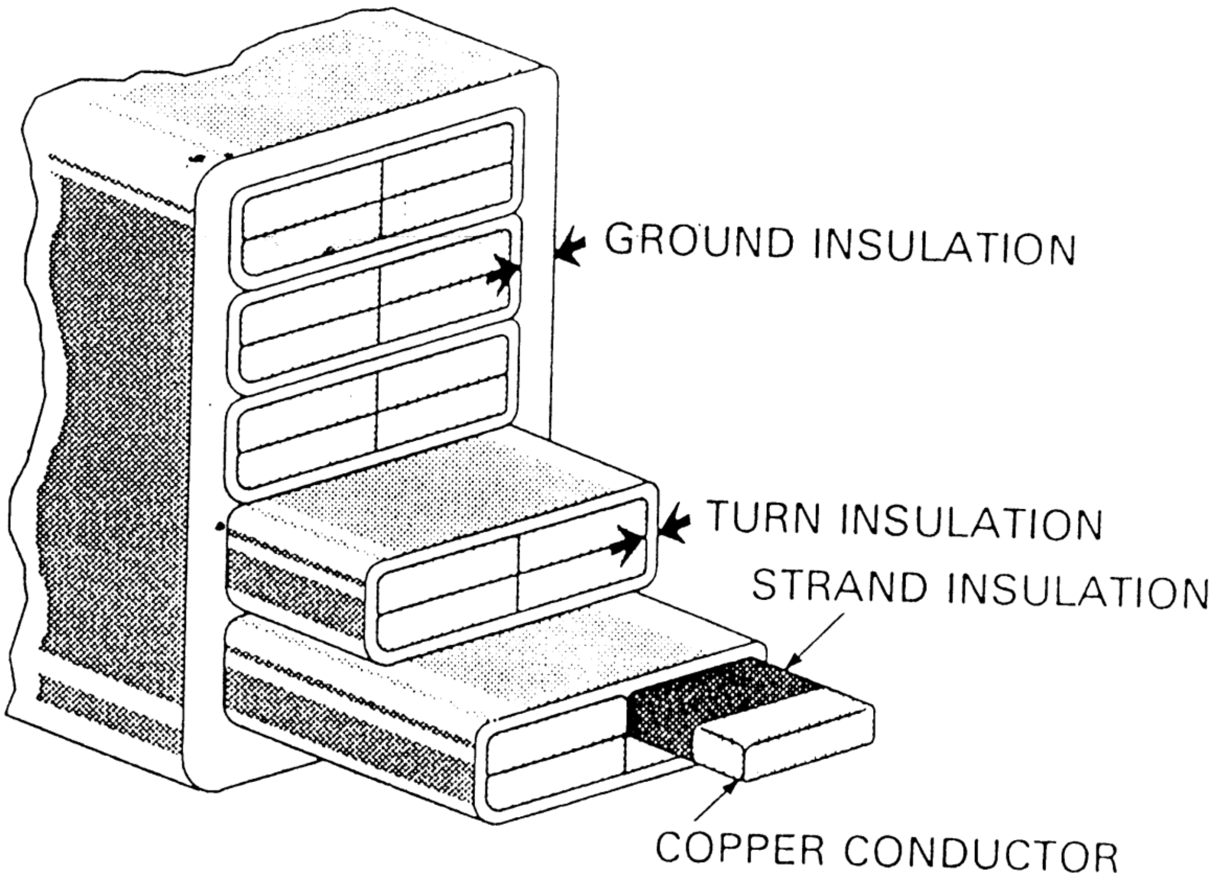
LOADED RUNNING

- INSULATION:
  - Run Cool
  - Thermal Ratings
  - Voltage Spikes
- BEARINGS:
  - Fatigue
  - Temperature
  - Vibration
  - Lubrication
- ROTOR:
  - Unbalanced Supply
  - Broken Bars
  - Rubs
- EXCITATION
- OTHER PARTS:
  - Fans
  - Frame
  - Shaft

INSULATION

- STRAND/TURN/ GROUND WALL
- VARIOUS MATERIALS:
  - ENAMEL
  - MICA
  - MYLAR
  - GLASS FIBER
  - DACRON
  - EPOXY OR POLYESTER TO HOLD IT TOGETHER

COIL INSULATION



Cross section of slot section of 13.8 kV, multi strand turn, multi turn stator coil.

INSULATION TEMPERATURE

- KEEP IT COOL
- CLASS F – 20000 HOURS AT 155 C
- ARRHENIUS – DOUBLE LIFE APPROXIMATELY EVERY 10 C COOLER
- 135 C – 80000 HOURS; 125 C -- 160000 HOURS
- CLASS B RISE – GIVES 120 C TO 130 C HOT SPOT IN 40 C

VOLTAGE/INSULATION

- STRESS ON GROUNDWALL
  - Power frequency
  - Impulse
- STRESS ON TURN/STRAND INSULATION
  - Power Frequency
  - Impulse
- PARTIAL DISCHARGE

VOLTAGE ENDURANCE

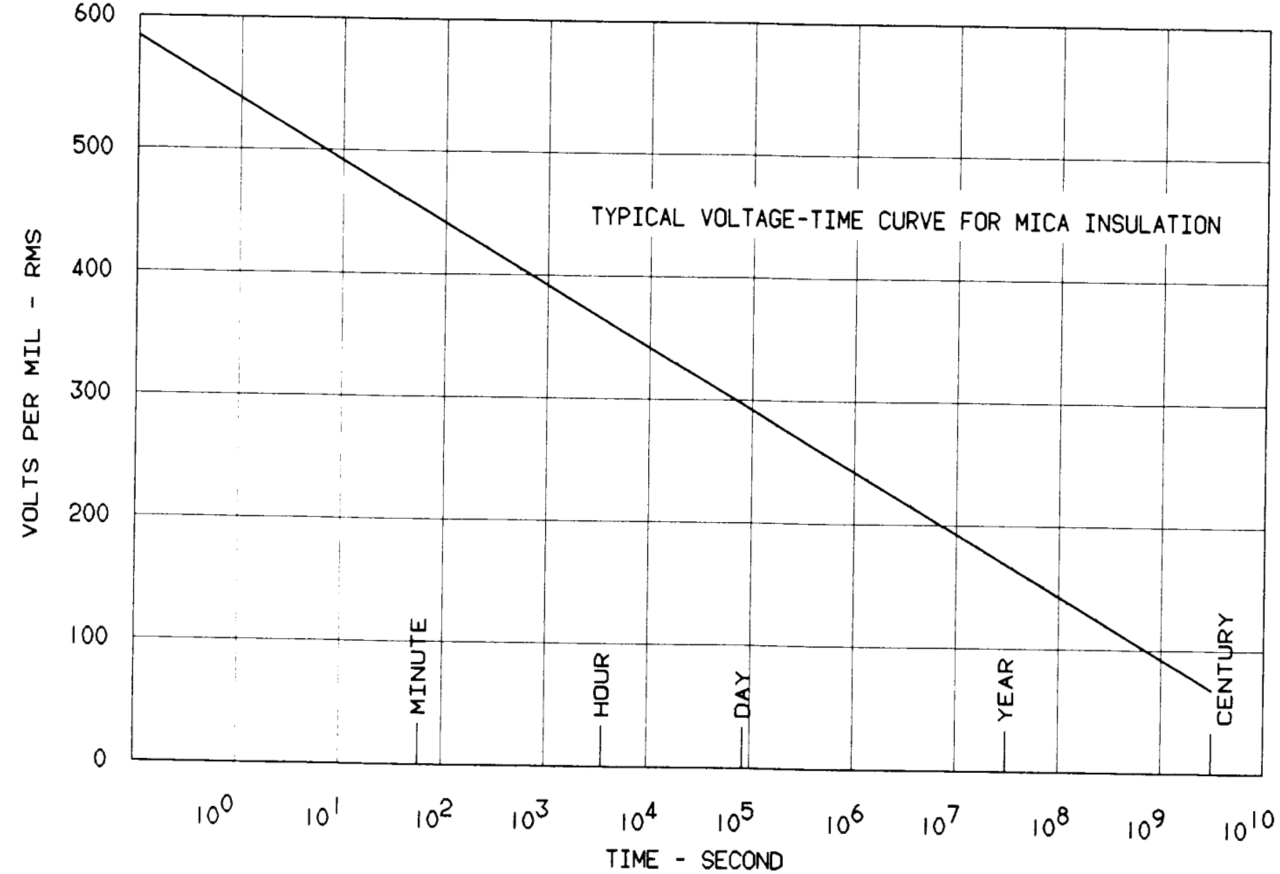


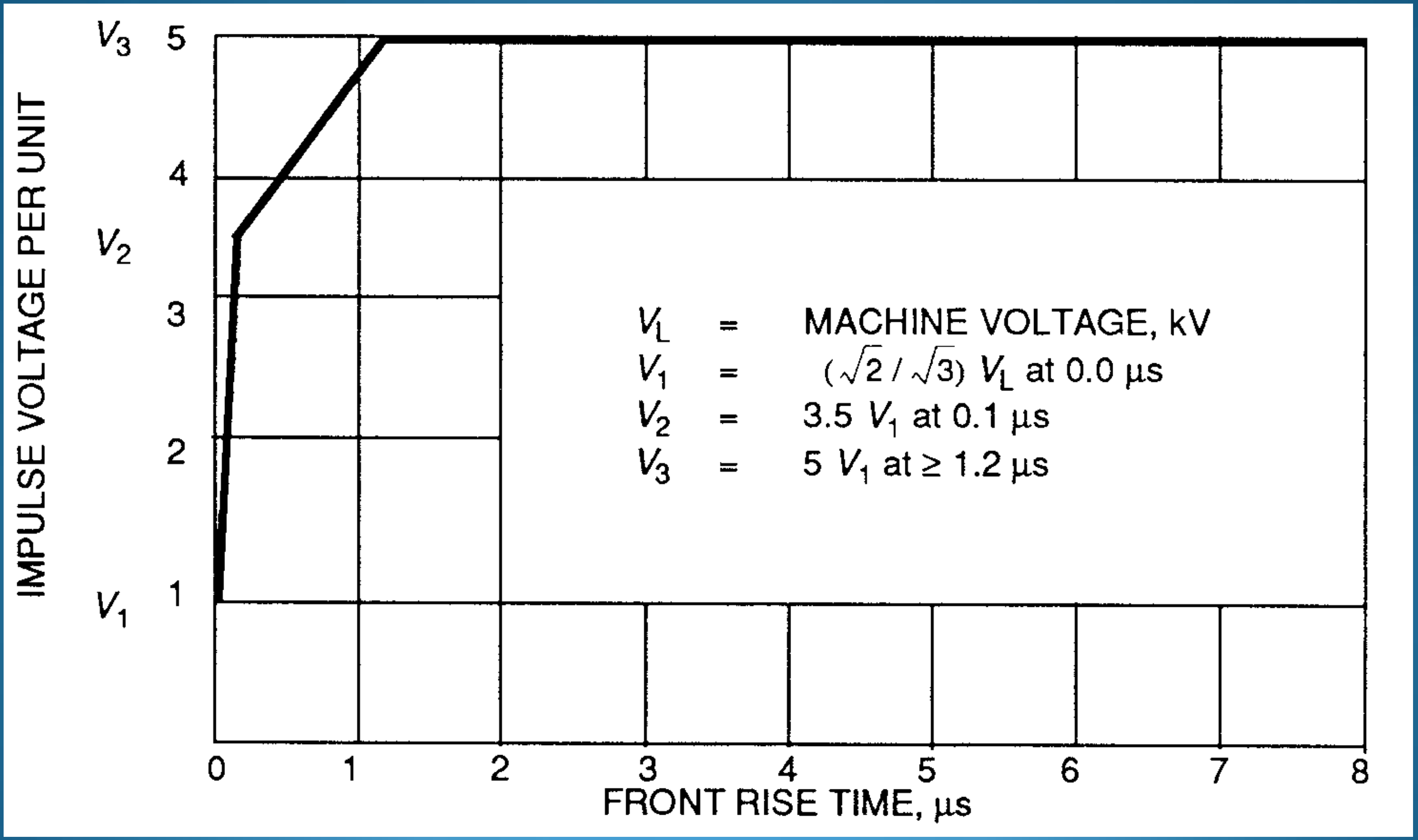
Fig 1

AC Voltage Endurance of Rotating Machine Insulation on Coils

INTERTURN STRESSES

- POWER FREQUENCY -- LOW STRESSES
- VOLTAGE IMPULSES
  - HIGH STRESSES TURN TO TURN ON LINE END COILS
  - FAST RISE TIMES ARE WORSE
  - IEEE 522
  - SURGE PROTECTION – ARRESTERS AND CAPACITORS (Arresters limit the volts, Capacitors reduce the dV/dt)
  - ANSI C62.21 GIVES GUIDANCE

POSSIBLE STRESSES IEEE 522



PARTIAL DISCHARGE

- LOW ENERGY BREAKDOWN IN INSULATION
- HIGH STRESSES, SHARP CORNERS AND VOIDS
- EVENTUALLY ERODES INSULATION
- USEFUL PREDICTOR OF INSULATION FAILURE
- AVOID PROBLEMS BY:
  - SMOOTH CONDUCTOR SURFACES
  - STRESS CONTROL COIL TREATMENT
  - MINIMISE VOIDS IN INSULATION
  - PD RESISTANT INSULATION

BEARINGS

- ANTI FRICTION
  - BALL, ROLLER, RADIAL, THRUST
  - L_{10} LIFE EXPECTANCY, LOAD $^{1/3}$ DEPENDENT
- HYDRODYNAMIC
  - SLEEVE, TILT PAD, THRUST (VERTICALS)
  - BABBIT METAL (TIN, LEAD ETC)
  - WEDGE OF OIL PREVENTS METAL TO METAL CONTACT
  - VIRTUALLY INFINITE LIFE

BEARING FAILURE

- LOSS OF LUBRICATION
- DIRT
- VIBRATION
- FATIGUE (ANTI FRICTION)
- TEMPERATURE
- ELECTRIC CURRENT

LUBRICATION

- OIL (HYDRODYNAMIC AND SOME HIGH SPEED ANTI FRICTION)
  - CORRECT VISCOSITY IMPORTANT (HIGHER VISCOSITY INCREASES LOSSES BUT MAINTAINS THE OIL FILM)
  - OIL RING (SLEEVE) OR PUMPED SYSTEM FOR NON SLEEVE, AND HIGHER LOSSES
- GREASE (OIL PLUS THICKENER)
  - REPLACEMENT INTERVAL TEMPERATURE DEPENDENT
  - SOME ARE SEALED TO KEEP GREASE IN AND DIRT OUT

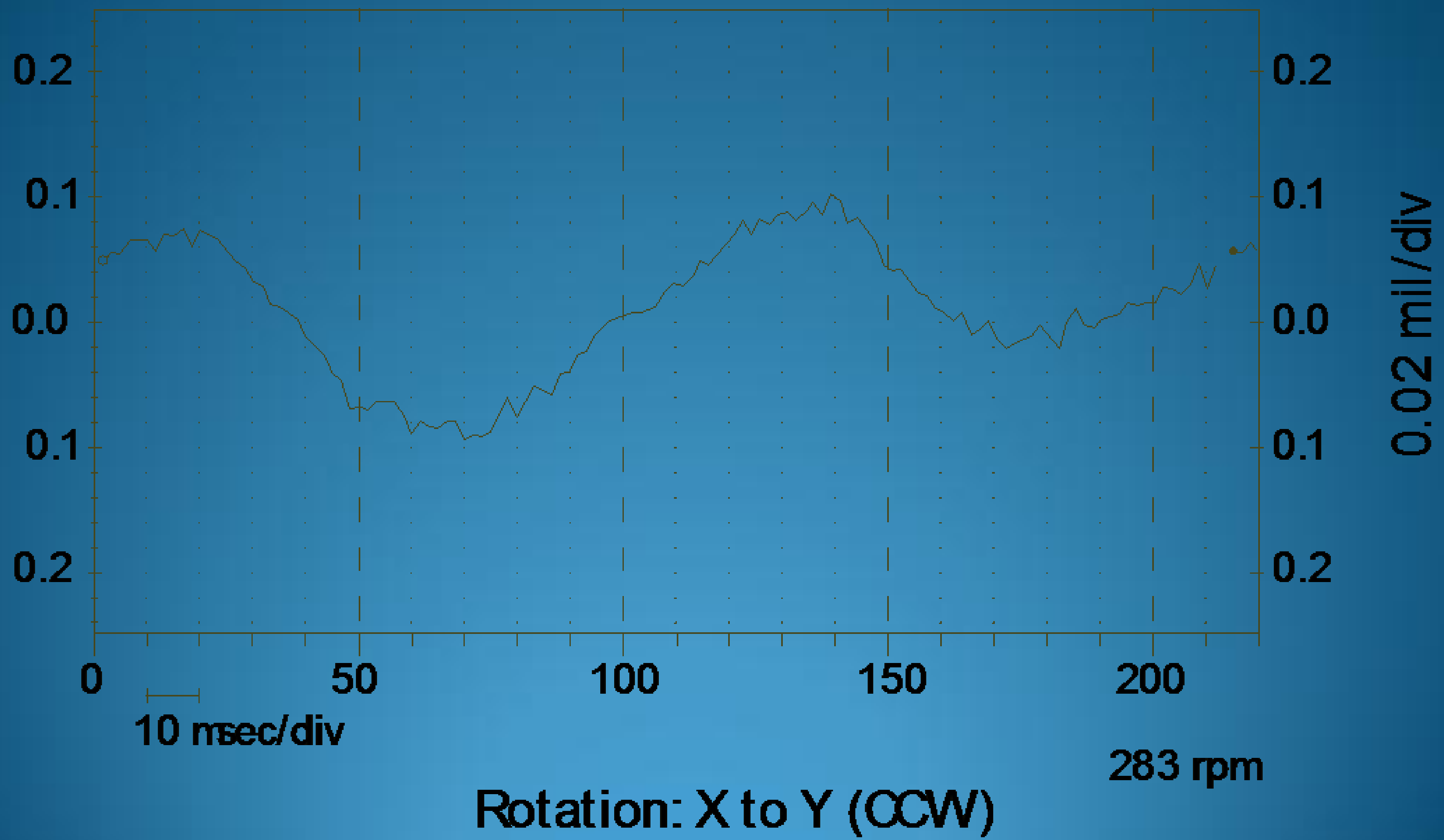
TEMPERATURE

- HIGH LUBRICANT TEMPERATURE REDUCES STIFFNESS OF OIL FILM
- FASTER CHEMICAL BREAKDOWN
- MAX. TEMPERATURE DEPENDS ON COMPOSITION (SYNTHETICS VERSUS MINERAL BASE)
- CAN AFFECT BEARING METAL STRENGTH AND STABILITY

VIBRATION

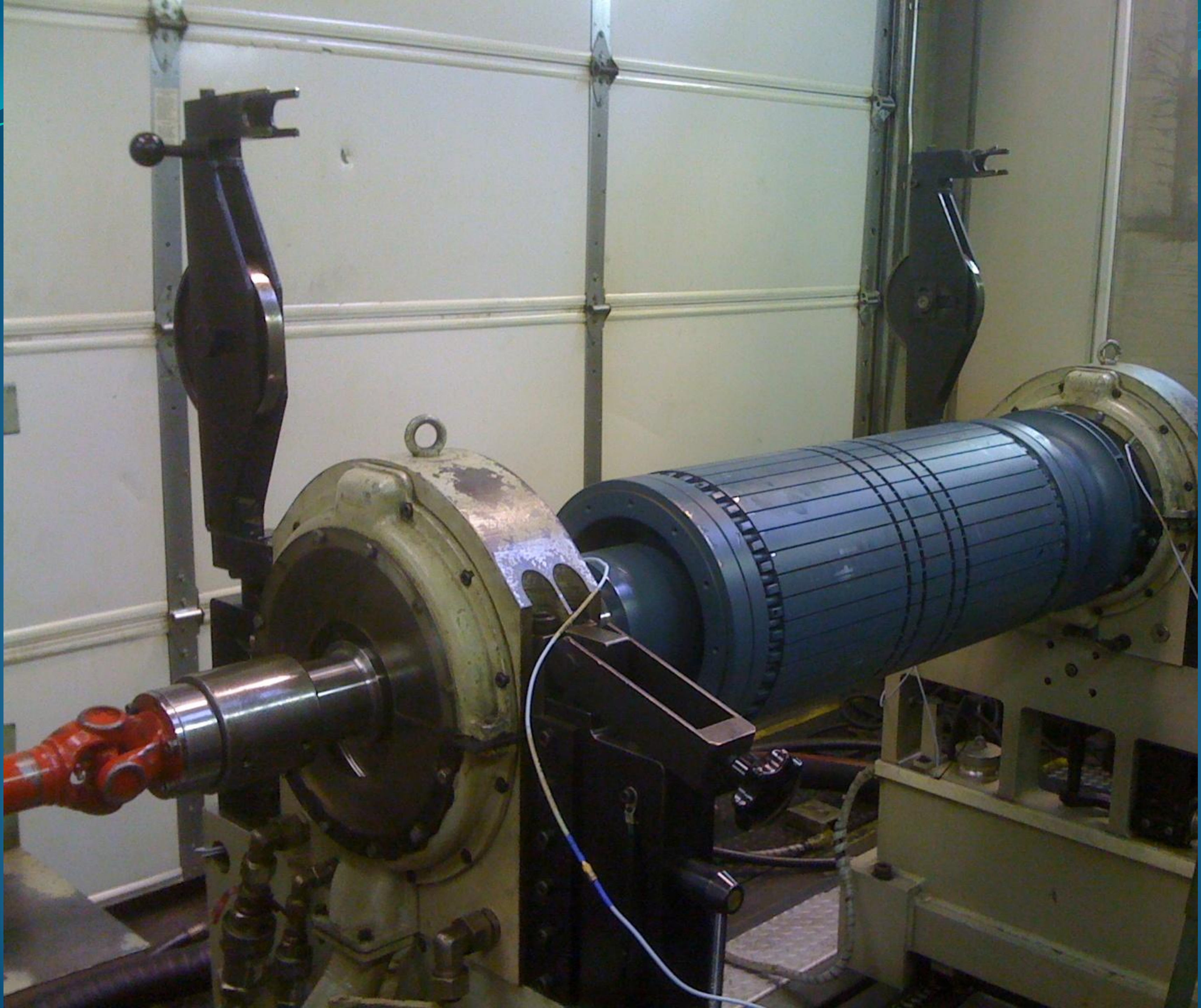
- CAUSES FATIGUE OF ANTI FRICTION BEARINGS
- AFFECTS OIL FILM THICKNESS (ANTI FRICTION AND HYDRODYNAMIC)
- MAY GIVE METAL TO METAL CONTACT, SMEARING
- CAUSES OTHER NON BEARING PROBLEMS
- SEISMIC VERSUS PROXIMITORS?


PROXPAC ®
PROXIMITY TRANSDUCER SYSTEM
330801-28-00-165-07-02
IP68


0.2
0.1
0.0
0.1
0.2
0.02 mil/div
0
50
100
150
200
10 msec/div
283 rpm
Rotation: X to Y (CCW)

CAUSES OF VIBRATION

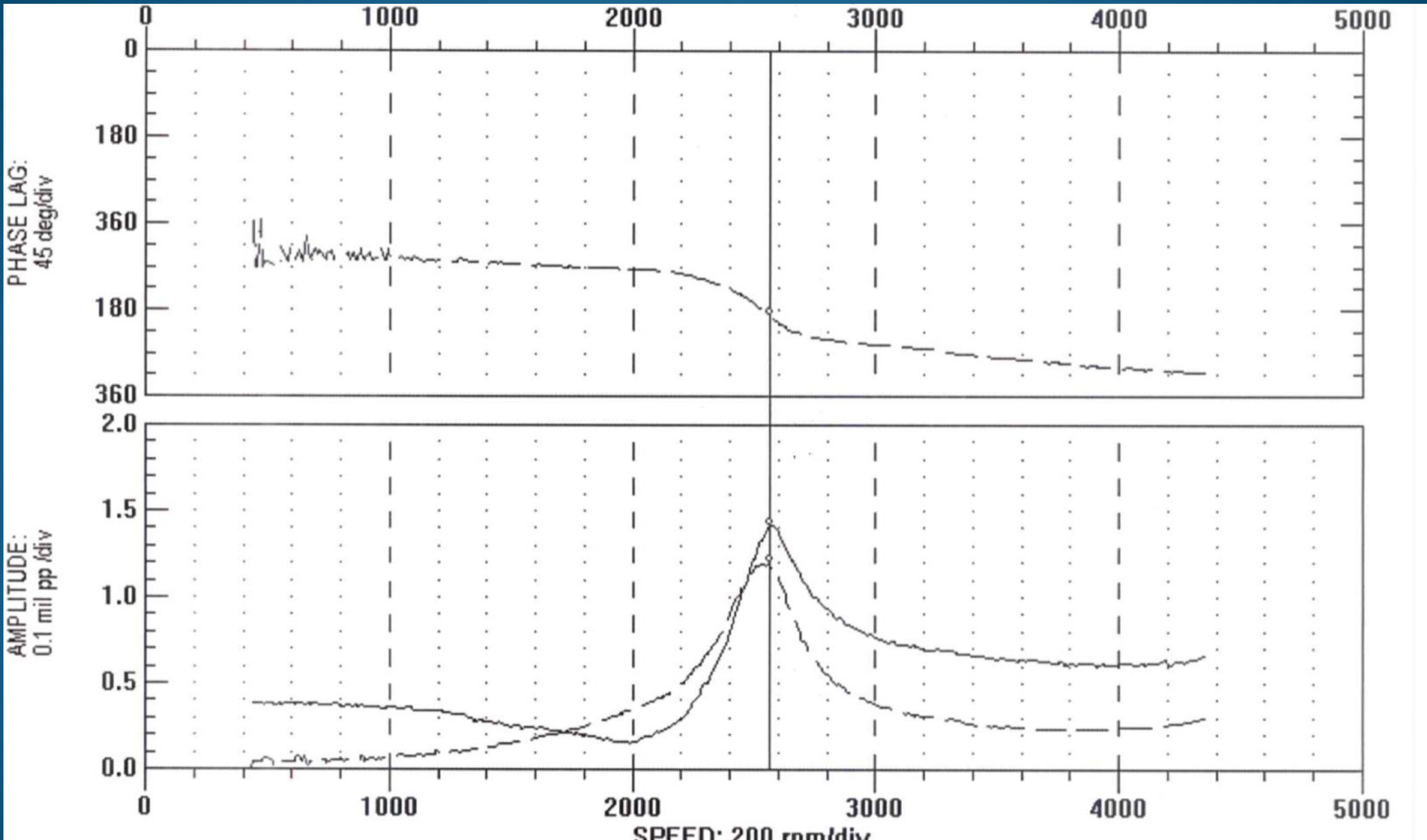
- UNBALANCE (4W/N)
- THERMAL VECTOR SHIFT
- MISALIGNMENT
- BENT SHAFT
- ELECTROMAGNETIC (2 x SUPPLY FREQUENCY)
- RESONANCE [SIMPLE SQRT (K/M)]



VECTOR SHIFT

50 micro m pp FULL SCALE

CCW ROTATION



0
1000
2000
3000
4000
5000
PHASE LAG:
45 deg/div
0
180
360
180
360
AMPLITUDE:
0.1 mil pp /div
2.0
1.5
1.0
0.5
0.0
SPEED: 200 rpm/div

BEARING CURRENTS

- STATOR/ROTOR SLOT COMBINATIONS *(ADDRESS BY MOTOR DESIGN)*
- WELDING *(DON'T WELD)*
- ASD NEUTRAL DISPLACEMENT *(APPLICATION)*
- ASD dV/dt *(APPLICATION)*
- ELECTROSTATIC FROM DRIVEN EQUIPMENT
- BEARING INSULATION, GROUNDING BRUSHES

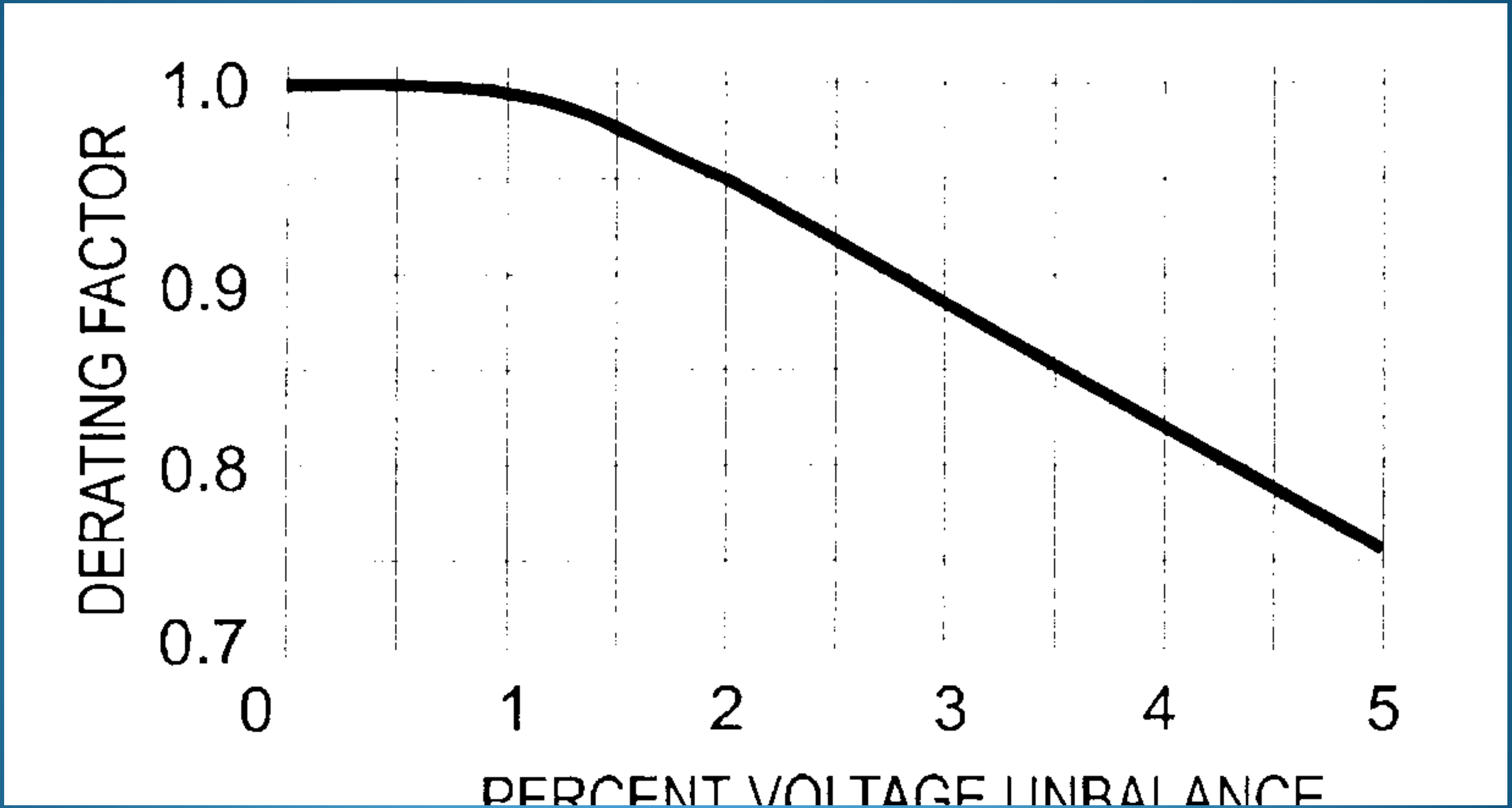
ROTOR DAMAGE

- UNBALANCE SUPPLY
- BROKEN BARS
- STARTING DUTY
- RUBS

UNBALANCED SUPPLY

- STATOR NEGATIVE SEQUENCE CURRENTS CAUSE 120 Hz ROTOR CURRENTS
- HIGH ROTOR CURRENTS CAUSE HEATING AND RETARDING TORQUE
- OVERHEAT ROTOR SQUIRREL CAGE
- SHOULD DERATE MOTOR

UNBALANCE SUPPLY



BROKEN BARS

- TORSIONAL OSCILLATIONS (RECIP. COMPRESSORS)
- OVERHEATING
- POOR BRAZING
- POROUS CASTINGS
- OVERHEATING
- BAR LOOSENESS

STARTING DUTY

- EXCESSIVE OR LONG DURATION STARTS
- LOCKED ROTOR
- OVERHEAT ROTOR
- DAMAGE CAGE AND LAMINATIONS

STATOR/ROTOR RUBS

- CAUSED BY:
  - BEARING FAILURE
  - “ROTOR PULLOVER”
- DAMAGES LAMINATIONS AND INTERLAMINAR INSULATION
- CAUSES EXCESSIVE LOSSES AND LOCAL OVERHEATING
- SCRAP, RESTACK OR OTHER REPAIR

EXCITATION (SYNCH)

- LOSS OF EXCITATION CAUSES PULLOUT AND OVERHEATING
- AVOID BY:
  - SECURE POWER SUPPLY (CVT, UPS)
  - COMPONENT REDUNDANCY WHERE PRACTICAL
  - BURN IN COMPONENTS
  - API 546 CLAUSE 2.5

OTHER DAMAGE

- SHAFT
  - BREAKAGE
  - BENDS
  - JOURNAL RUB
- FANS
  - BREAKING
- FRAME
  - BREAKING WELDS, CASTINGS

DURABILITY

- BUY THE RIGHT MOTOR
- TEST IT
- INSTALL AND START IT UP CORRECTLY
- MAINTAIN IT

BUY THE RIGHT MOTOR

- ACCEPTABLE BIDDERS
- *EVERGREEN CONTRACT?*
- DECIDE WHAT YOU NEED
- SPECIFY IT
- EVALUATE PROPOSALS
- ORDER MOTOR
- MAINTAIN DISCUSSIONS

ACCEPTABLE BIDDERS

- TRACK RECORD WITH US?
- TRACK RECORD WITH OTHERS?
- HAVE THEY DONE IT BEFORE?
- *DO WE WANT TO SET UP A PERMANENT DEAL?*

WHAT DO YOU NEED?

- OUTPUT POWER
- STARTING TORQUE
- START CURRENT
- START FREQUENCY
- LOSSES
- VOLTAGE
- MOUNTING
- HOSTILE ENVIRONMENT?
- ENCLOSURE
- SURGE PROTECTION
- FIXED OR ADJUSTABLE SPEED
- BEARINGS
- OSCILLATORY TORQUES
- SPARED/UNSPARED?
- TALK TO OPERATORS

SPECIFY

- SAY WHAT YOU WANT
- USE INDUSTRY STANDARD (PLUS EXCEPTIONS)
- API 541 – LARGE, CRITICAL INDUCTION
- API 547 – REGULAR INDUCTION
- API 546 – SYNCHRONOUS
- USE THE DATA SHEETS!

Form-wound Squirrel-Cage Induction Motors – 500 Horsepower and Larger

Downstream Segment

ANSI/API STANDARD 541-2003
FOURTH EDITION, JUNE 2004

Approved American National Standard
ANSI

American Petroleum Institute

Helping You Get The Job Done Right.[SM]

General-purpose Form-wound Squirrel Cage Induction Motors—250 Horsepower and Larger

API STANDARD 547
FIRST EDITION, JANUARY 2005

API
American Petroleum Institute

Brushless Synchronous Machines—500 kVA and Larger

Downstream Segment

API STANDARD 546
THIRD EDITION, SEPTEMBER 2008

GENERAL (CONTINUED)

Rev

Enclosure (2.4.1.2)

○ WP II (Weather Protected Type II) (2.4.1.2.2) ○ WP I (Weather Protected Type I) (2.4.1.2.2) ○ Guarded (2.4.1.2.?)

Air Filters *Required for WPII (3.5.2)* ○ Provisions Only for WPII or DPG (3.5.2) ○ Provide filters for WPII or DPG (3.5.4)

Air Filter Capability (3.5.1) *99% of particles ≥ 10 micron* ○ Other ____

○ Purchaser Specified Filters: Manufacturer ____ Type ____ Model ____

Differential Pressure Device (3.5.5) *Provisions Required for WPII* ○ Differential Pressure Switch (3.5.5) ○ Combination Switch / Gauge

○ Provisions Only for WPII or DPG (3.5.5) ○ Differential Pressure Gauge (3.5.5)

○ Purchaser Specified Device: Manufacturer ____ Type ____ Model ____

○ TEFC (2.4.1.2.5) ○ TEPV (2.4.1.2.3) ○ Other Enclosure ____

○ TEAAC (2.4.1.2.8) Heat Exchanger Tube Materials (2.4.1.2.8) ○ Aluminum ○ Alum. Alloy ○ Copper ○ Copper Alloy ○ Other ____

○ Stainless Steel 304 Series ○ Stainless Steel 316 Series (2.4.1.2.8) required for offshore applications

○ TEWAC (2.4.1.2.4) Heat Exchanger Tube Materials (2.4.1.2.4) *90-10 Cu Ni* ○ Other ____

○ Cooling Water Conforms with 2.4.1.2.4.2 ○ Water/Glycol Solution ○ Other Cooling Water Conditions (Attach Information)

Cooler Location/Orientation (2.4.1.2.4.?) ○ Supplier Decision ○ Above Stator ○ Other ____

Cooler Inlet Connection Location (Facing NDE) ○ Supplier Decision ○ Right Side ○ Left Side ○ Other ____

Tube Construction (2.4.1.2.4.?, 2.4.1.2.?) *Single Tube* ○ Double Tube ○ Redundant Coolers (2.4.1.2.4.?)

Leak Detection (2.4.1.2.4.?) *Required* Double Tube Leak Detector *Alarm Only* ○ Other Uses

○ Flow Sensor / Leak Detector Required (2.4.1.2.4.?) ○ Provisions Only ○ Relay Contacts: ○ Norm Open ○ Norm Closed

○ Purchaser Specified Device: Manufacturer ____ Type ____ Model ____

○ Cooler Air Inlet & Outlet Temperature Sensor Required (2.4.1.2.4.?) Type ____

○ Purchaser Specified Device: Manufacturer ____ Type ____ Model ____

○ Degree of Protection IP (2.4.1.2.1) IP ____ ○ Method of Cooling IC (2.4.1.2.1) IC ____

Hardware / Fasteners Material (2.4.1.?) *Stainless Steel enclosure fasteners through M12 (1/2 in.) inclusive* ○ 316 Stainless Steel

System of units for Hardware (1.3.?) ○ SI (Metric) ○ U.S. / North American Customary required for offshore applications

○ Provision for Pre-start Purging (2.4.1.?) Purchaser Specified Purging Details ____

Auxiliary motor driven fans (2.4.1.?) ○ Yes ○ No Fan Volts ____ phase ____ kVA

○ Manufacturer's Standard Paint ○ Purchaser Specified Special Paint Special Paint Specification ____

○ Manufacturer's Standard Paint Color ○ Purchaser Specified Special Paint Color Define Color and Code ____

Mounting ○ Foot Mounted Horizontal ○ Flange Mounted Horizontal ○ Foot & Flange Horizontal Mount

○ Foot Mounted Vertical ○ Shaft Down ○ Shaft Up

○ Flange Mounted Vertical ○ Shaft Down ○ Shaft Up ○ Foot & Flange Vertical Mount

Flange Type / Bolt Circle ○ Supplier Decision ○ Other ____

○ Vertical Motor thrust if selected, complete applicable areas of Driven Equipment / OEM section

○ Baseplate Furnished By (2.4.2.6) ____ ○ Soleplates Furnished By (2.4.2.6) ____

○ Connections for Field Piping other than specified in 2.4.3.1 ____

○ Non-intrusive Foundation applies (2.4.?.?) Description: ____

○ Train Non-intrusive System Dynamic Analysis Required From Machine Vendor (2.4.?.?) ____

Electrical System: Primary Power Source ____ Volts ____ Phase ____ Hertz Maximum Ground Fault ____ Amps

Method of System Grounding (2.4.?.?) ○ Resistance ○ Reactance ○ Ungrounded ○ Solid

3 Phase Fault Current at Machine Terminals (2.?.?) ____ MVA Let Through Energy (2.?.?) ____ I²t (Ampere squared seconds)

Min S.C. at Motor Bus (2.?.?.?) ____ MVA at ____ Volts X/R Ratio ____ Min Motor Terminal Voltage at Start ____ % rated

Other: ____

Pg – Ln TOPIC - Guide

2 – 2(3) **WP-II** - The WP-II (Weather Protected Type II as defined by NEMA) is a common enclosure. Air from outside the motor is drawn into and passed through its interior for cooling. The WP-II enclosure is intended for outdoor applications. It is constructed so that high-velocity air and dirt ingested by the motor can be discharged without entering the internal air passages to the electric parts of the motor. It may not be an appropriate choice where adhering dust is present or if the area does not have free air exchange. The hot air discharged from the motor can cause a closed-in area to become excessively hot. WP-II machines with a rated voltage over 4000 Volts may have a shorter insulation life due to tracking.

2 – 2(3) **WP-I** - The WP-I enclosure (Weather Protected Type I as defined by NEMA) is not commonly used in petrochemical applications. Air from outside the motor is drawn into and passed through its interior for cooling. The WP-I enclosure should be limited to sheltered or indoor locations which may be subject to slight weather intrusion or splashing water. It may not be an appropriate choice where adhering dust is present or if the area does not have free air exchange. The hot air discharged from the motor can cause a closed-in area to become excessively hot. WP-I machines with a rated voltage over 4000 Volts may have a shorter insulation life due to tracking.

2 – 2(3) **DPG** - The DPG or ODP enclosure (Drip Proof Guarded or Open Drip Proof as defined by NEMA) offers the least amount of protection from the local environment. If used, it should only be applied in an indoor environment with clean air. It is not recommended for outdoors and will probably give reduced reliability in all applications.

2 – 3(4) **Air Filters** - Air filters are required for WP-II machines by the Standard. They may also be specified for WP-I or DPG machines. In lieu of filters, provisions for filters can be specified also. It is highly recommended that either an air-filter differential-pressure switch, winding temperature detectors or both be used and wired to the control system as a means to annunciate alarm operators when the filters become dirty. The Standard requires that the filters capture 90% of 10 micron dust particles. When filters are specified, it is wise to order a set of spares so they can be exchanged from the motor and cleaned.

2 – 4(5) **Air Filter Capability** - The default requirement of the Standard is for filters that capture 90% of 10 micron dust particles. If a different capability is required, or if the Purchaser desires to further define what type of air filters are required, use the Other option provided.

2 – 5(6) **Purchaser Specified Filters** - If the Purchaser wants to specify a particular type of air filter, provide all the details asked on line 18.

2 – 6-8 (7-9) **Differential Pressure Device** - This device is recommended for any machine with air filters. The Standard only requires that provisions for a DP device are supplied. There are a variety of devices available that will detect the pressure differential across the air filters which will increase as they become clogged with dust and retard cooling air flow into the motor. Select one of the options provided on lines 6 and 7. Provisions may also be selected for WP-I and DPG machines. Local practice at the Site usually dictates if a gauge or switch or both are supplied. Note that if the motor is to be used in a Division 2 or Zone 2 area, and DP device that is supplied has contact type switches, the device must be housed in a certified enclosure. If the Purchaser wishes to specify a particular brand of DP device, then supply the details requested on line 8.

2 – 9(10) **Enclosure for 6kV and above** - The standard now requires the use of a Totally-Enclosed type of motor enclosure when the motor voltage rating is 6000 volts or greater. However, there may be applications where the Purchaser has successfully used a WP-II or similar enclosure and desires it again. To help clarify this for the Supplier, select this bullet if this choice is applicable.

2 – 10(11) **TEFC** - The TEFC enclosure (Totally-Enclosed Fan Cooled as defined by NEMA) is a construction where free exchange of air is prevented between the inside and outside of the motor. The motor is

EVALUATE PROPOSALS

- DO WE TRUST THE BIDDER?
- DOES IT MEET THE REQUIREMENTS?
- DISCREPANCIES, COMMENTS, EXCEPTIONS?
- NET PRESENT VALUE?
  - FIRST COST (PURCHASE, TESTING, SHIPPING)
  - STARTUP
  - LOSSES
  - AUXILIARIES
  - MAINTENANCE

DISCUSS/ORDER

- SORT OUT QUESTIONS BEFORE ORDERING
- IS IT STILL A GOOD DEAL?
- ORDER
- MAINTAIN COMMUNICATIONS DURING CONTRACT

TEST THE MOTOR

- CRITICAL
  - IN PROCESS QC CHECKS?
  - “COMPLETE” TEST
  - WITNESS?
  - VIBRATION?
  - HEAT RUN
  - STARTING PERFORMANCE?
  - OTHER?
- NON CRITICAL
  - “ROUTINE” TESTS?

INSTALL IT CORRECTLY

- CORRECT ALIGNMENT
- THERMAL GROWTH?
- FOOT COPLANARITY
- SOLID BASE?

START IT UP CORRECTLY

- ELECTRICAL CHECKS
- MECHANICAL CHECKS
- LUBRICANT?
- PROTECTION
- UNCOUPLED RUN

MAINTAIN IT

- KEEP IT DRY
- KEEP IT CLEAN
- KEEP IT COOL
- KEEP IT FRICTION FREE (Lubrication)
- MONITOR PERFORMANCE (Vibration, Temperatures, PD)
- CHECK/MAINTAIN IT AT TURNAROUND

REPAIRS

- SELECT THE REPAIRER AHEAD OF TIME
- IEEE 1068
- MAINTAIN CONTACT DURING REPAIRS
- GET PHOTOGRAPHS

IEEE

IEEE Standard for the Repair and Rewinding of AC Electric Motors in the Petroleum, Chemical, and Process Industries

IEEE Industry Applications Society

Sponsored by the
Petroleum and Chemical Industry Committee

IEEE
3 Park Avenue
New York, NY 10016-5997, USA

[illegible] March 20[illegible]

IEEE Std 1068™-2009
(Revision of
IEEE Std 1068-1996)

SPARKING

- MOSTLY DURING STARTS
  - High Currents
- AIR GAP
  - Keep Bars Tight, not broken
  - Cast better than Fabricated
  - Higher speed worse
- FABRICATED FRAME
  - Bonding Jumpers
- HIGH VOLTAGE WINDINGS
  - Tracking, Contamination

OPERATION ON DRIVES

- ROTOR VOLTAGE BUILDUP
  - $1/2CV^2$
  - Seldom if Ever an Issue? (MIE 15 TO 400 microjoule)
- “HIGH TORQUE/LOW SPEED”
  - Shaft Mounted Fan Cannot Remove Heat
- ROTOR TEMPERATURES
  - What Data There is –probably not an issue
- TORSIONAL OSCILLATIONS
  - Seldom an Issue with Modern Drives

THANK YOU

QUESTIONS?