Hydro and Turbine Machines

Rotating Exciters Testing and Repair

Presentation

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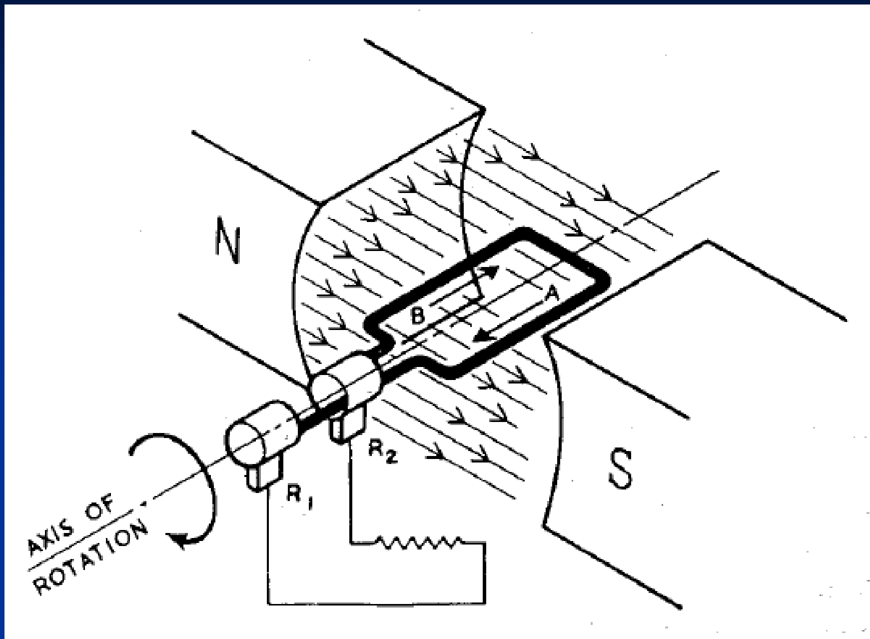
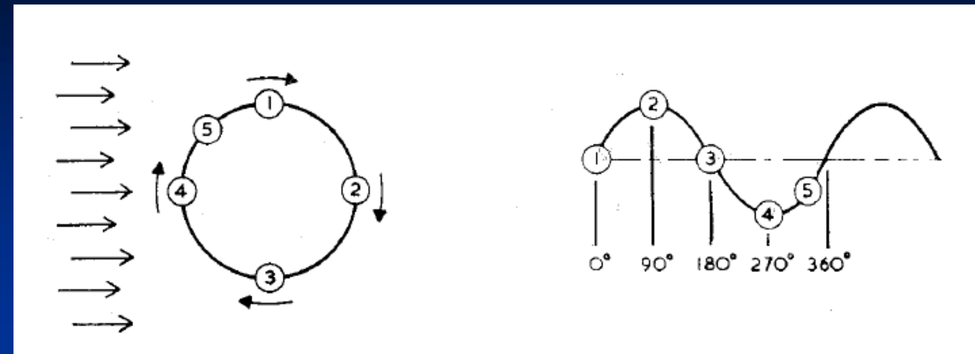
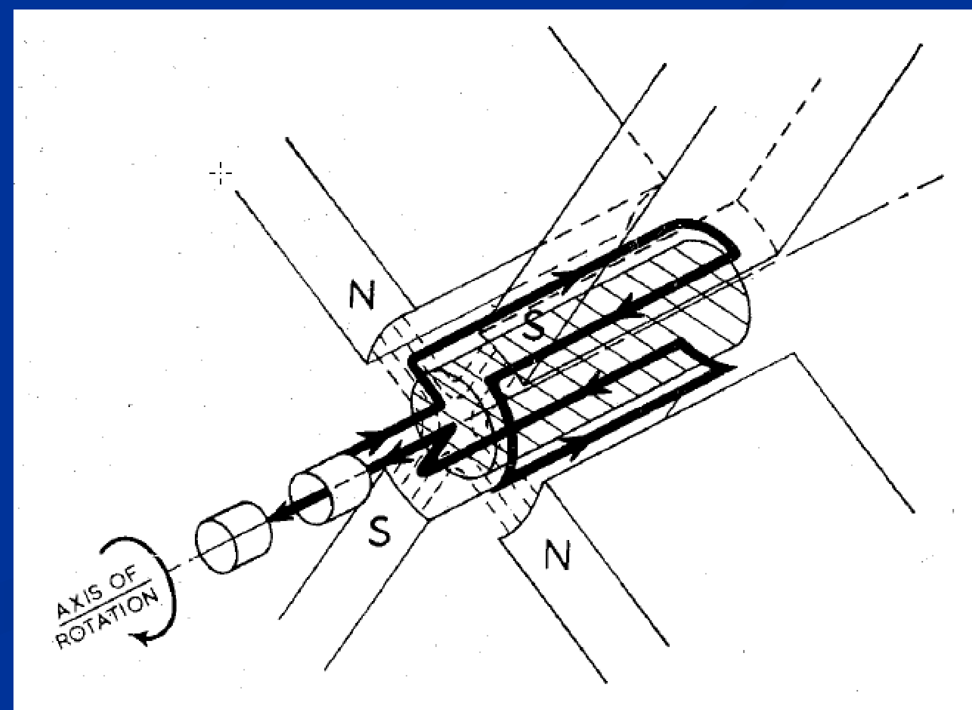
Generation Maintenance (GM) –Electrical Group
BC Hydro, British Columbia,Canada

Fundamentals of DC Machine Operation





Two -pole DC machine

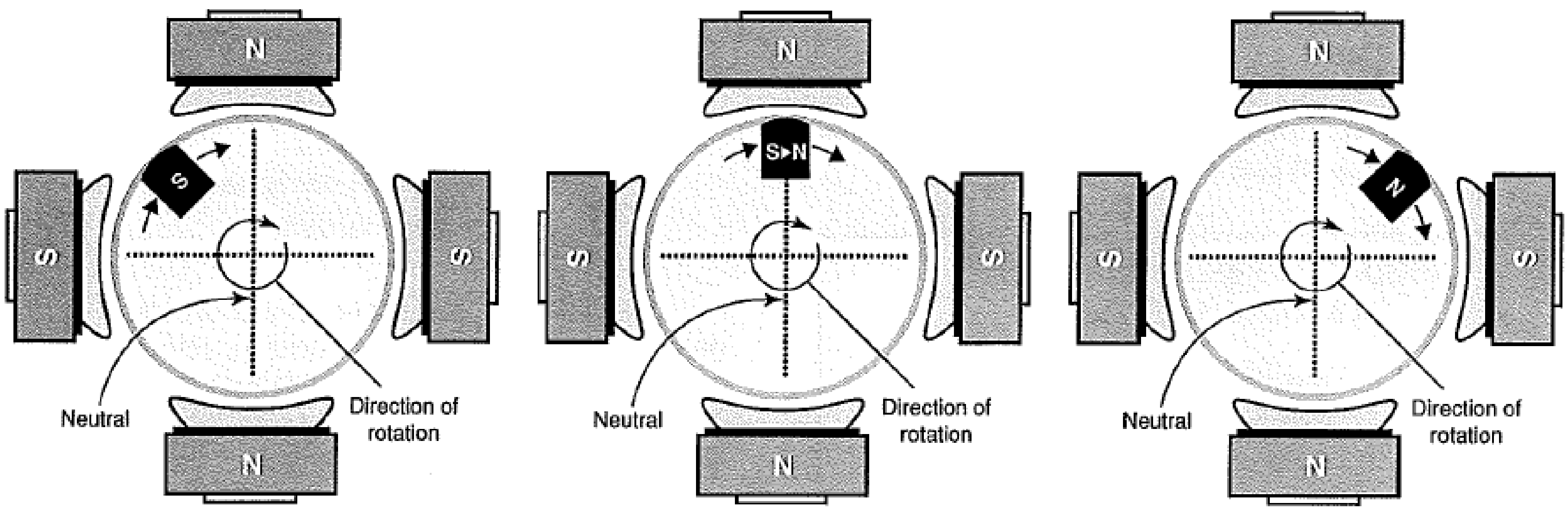


Four-pole DC machine

Fundamentals of DC Machine Operation(by EASA)

CHANGING ARMATURE COIL POLARITY TO CREATE ROTATIONAL MOTION

If the DC machine had only one magnet in the armature and its polarity never changed, the polarity of the armature magnet would draw it toward the nearest pole of opposite polarity where it would stop.

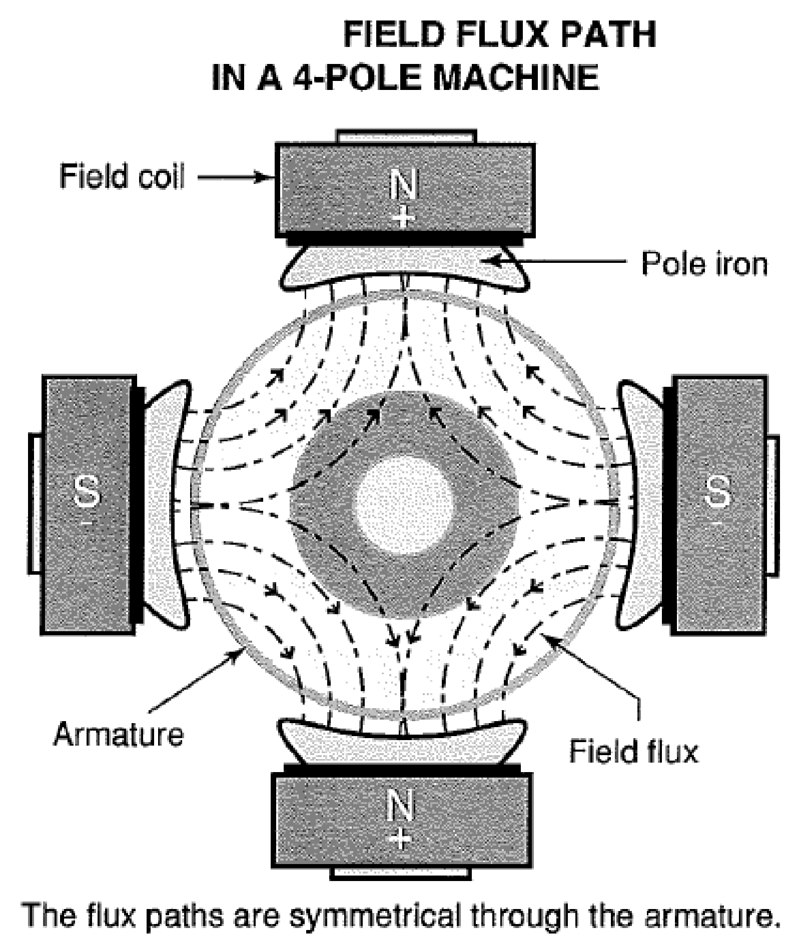


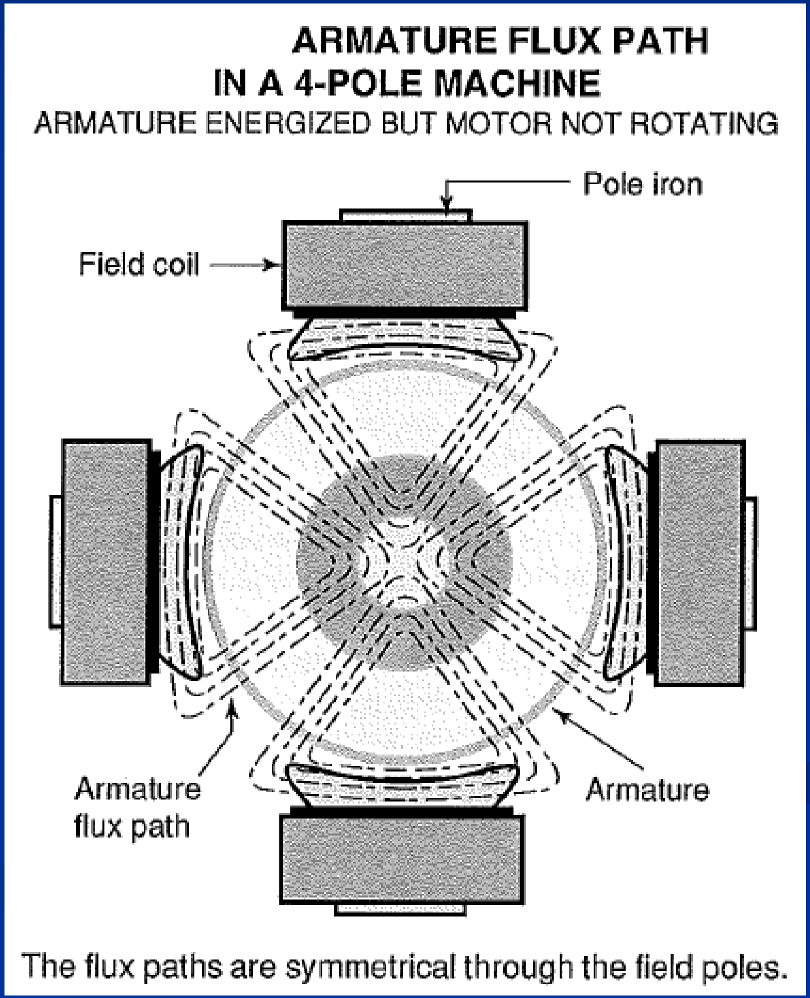
The armature magnet with south polarity is pulled toward the closest north pole while being pushed away from the closest south pole.

When the armature magnet reaches the brush neutral position, its polarity is changed from south to north. If the polarity did not change, the armature would stop rotating.

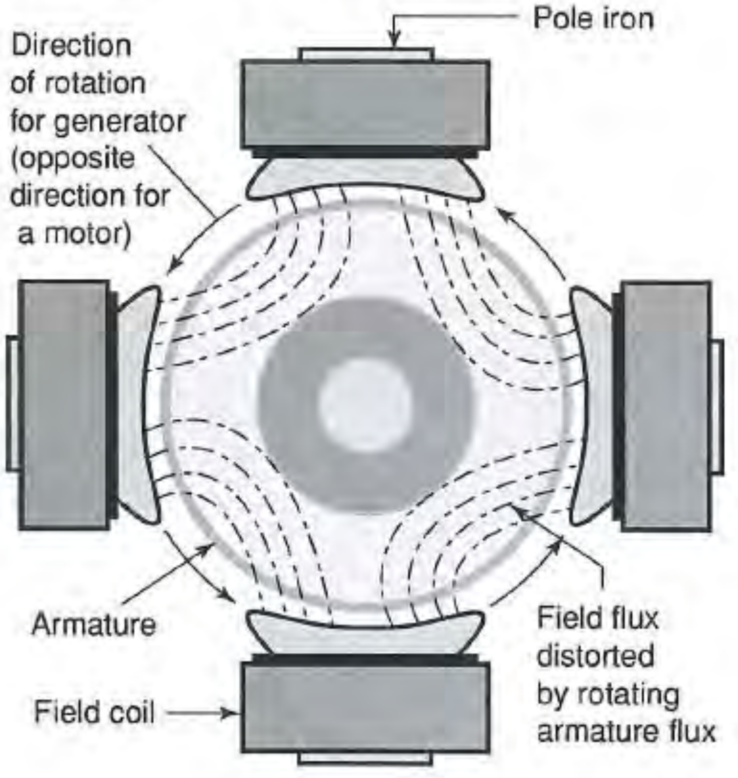
The armature magnet, now with north polarity, is pushed away from the closest north pole and pulled toward the next south pole.

Fundamentals of DC Machine Operation(by EASA)

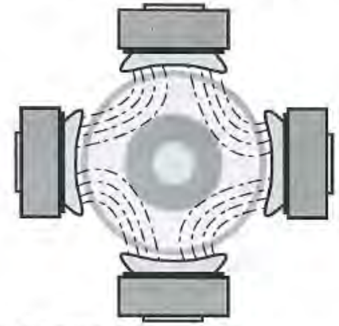




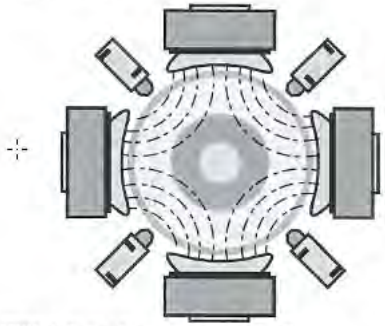
Fundamentals of DC Machine Operation(by EASA)



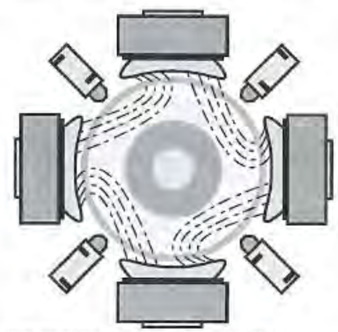
Armature flux passing through the fixed field flux deflects the field flux.



No interpoles
Without interpoles, the armature flux distorts the field flux.

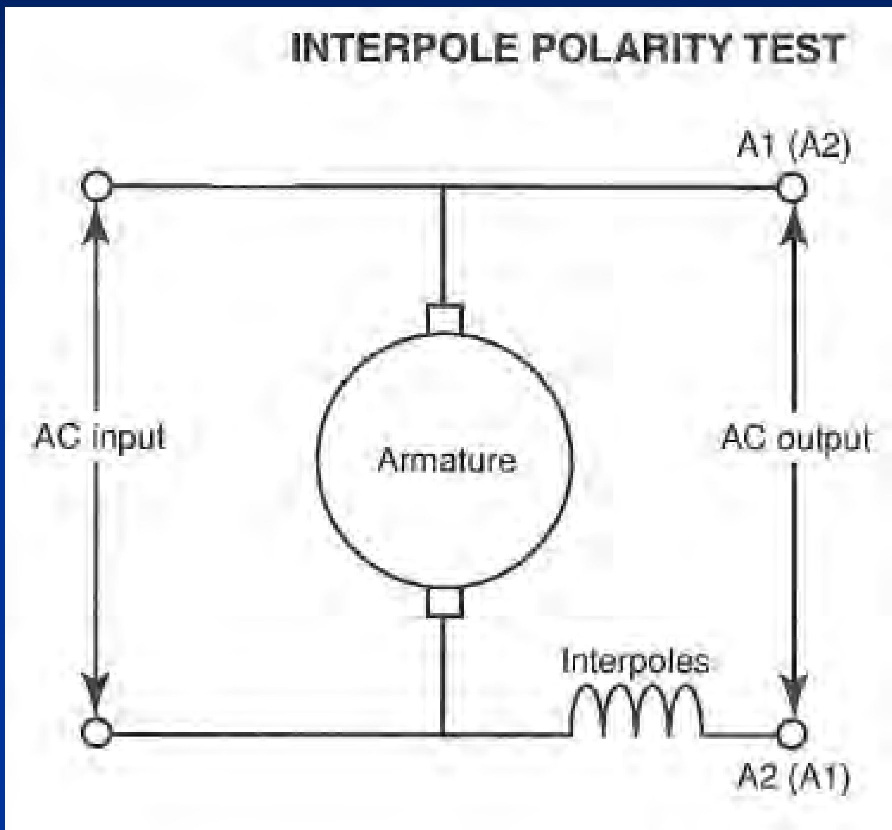


With interpoles, correct polarity
With interpoles added, the interpole flux opposes the armature flux, preserving the field flux.



With interpoles, reversed polarity
With the interpole polarity reversed, the interpole flux combines with the armature flux, further exaggerating the field flux distortion as the load increases.

DC machine Interpoles



Output Voltage < Input Voltage

Typical V_{output} = ¼ to 2/3 V_{input}

if interpoles polarity is correct.

- Interpole polarity should be such that they oppose the magnetic flux of the armature. Low-voltage AC, typically 30-60 volts, can be applied to the armature and interpole circuit to verify correct interpole polarity.
- Apply the voltage to two brushholders of opposite polarity.
- Measure the output voltage on leads A1 and A2 in the terminal box.
  - If the output voltage is less than the input voltage, the interpole polarity is correct. The typical output voltage of correct polarity interpoles is about one-half to two-thirds of the input voltage.
  - If the output voltage is higher than the input voltage, reverse the interpole leads.
  - If the voltages are the same, either the interpoles are disconnected, or the polarity sequence is wrong. Machines with compensating (pole-face) windings will typically develop a very low output voltage.

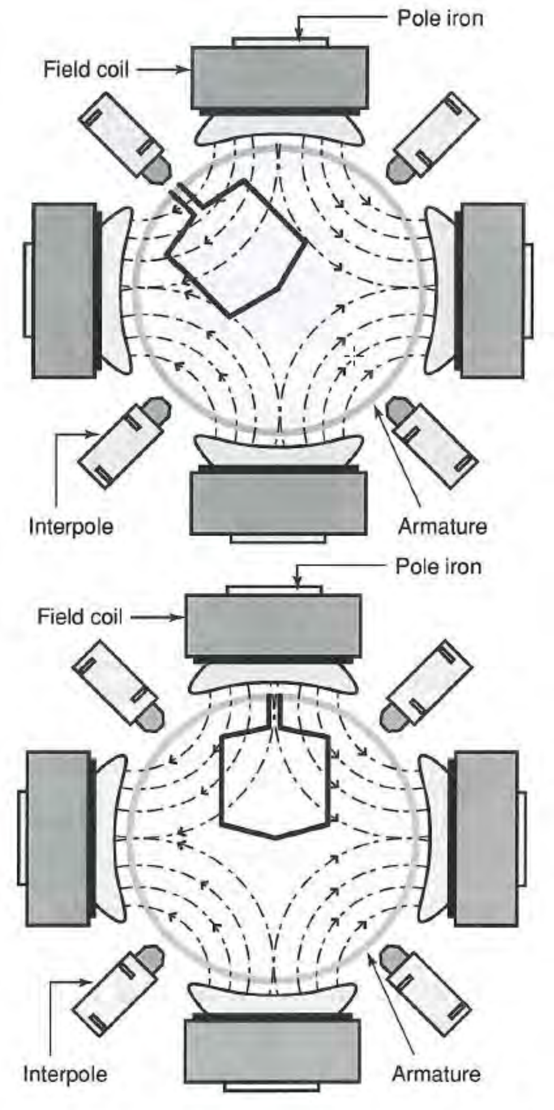
if V_{output} > V_{input}

reverse interpoles polarity

Fundamentals of DC Machine Operation(EASA)

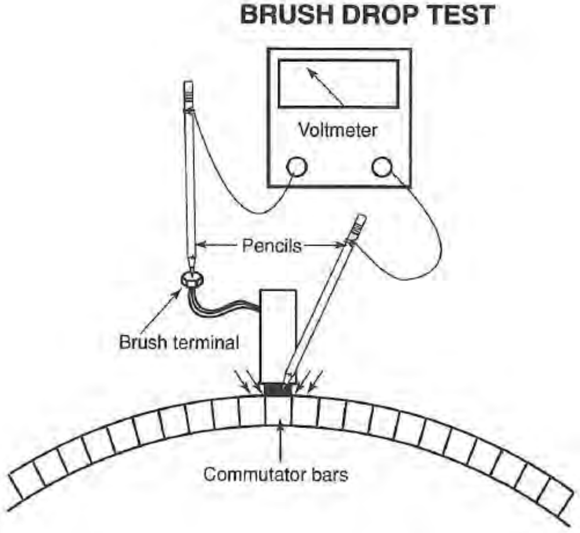
Electrical Neutral set up …
what
does this mean ?

Why it is necessary ?!



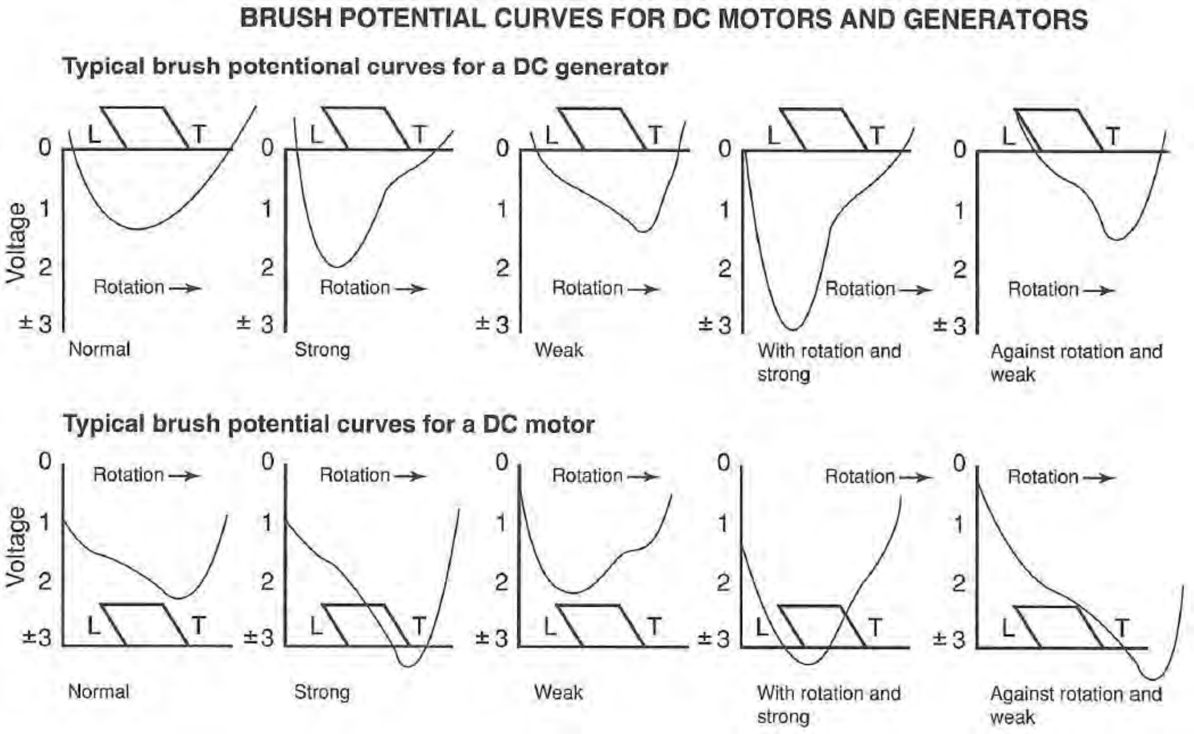
As the coil passes through the field flux (top), current is induced. When at the neutral position (bottom), no current is flowing in the coil.

Brush Potential Test



Take readings at center of the brush, at leading and trailing edges of the brush, as well as at one-half brush width ahead and one-half brush width behind.

The brush voltage drop curve is obtained by measuring the voltage from the brush terminal to various points on the commutator under the brush. This curve illustrates the current distribution at the brush face and thereby serves as an indicator of the condition of the magnetic field.



Electrical Apparatus Service Association, Inc.

SURGE COMPARISON TEST EXAMPLE

Each set of bar-to-bar test probes must span an equal number of bars for a meaningful test. Further, the total number of turns being compared must be equal. When an armature is equalized, the sides under test must also contain an equal number of equalizers.

The test voltage also must meet the requirements of Paschen's Law (i.e., at least 350 volts/turn) without exceeding the test voltage for the ground insulation.

$(2E + 1000)$

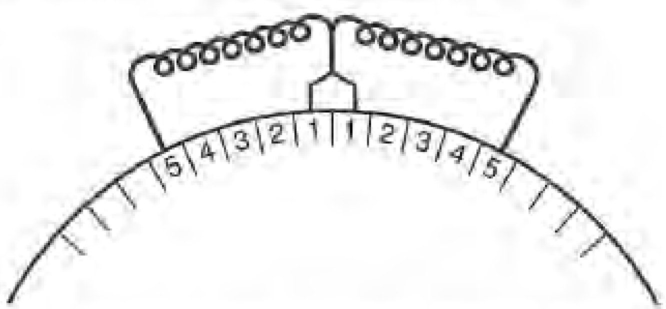
Where E = rated armature voltage

For example, a 500 volt armature (with a new or reconditioned winding):

$[2(500) + 1000] = 2000$ volts

$$\frac{2000 \text{ volts}}{\text{Minimum volts per bar}^*} = \frac{2000 \text{ volts}}{350} = 5.7$$

Only 5 bars should be spanned on each side.



*Unless the actual data is known, assume one turn.

Rotating Exciter

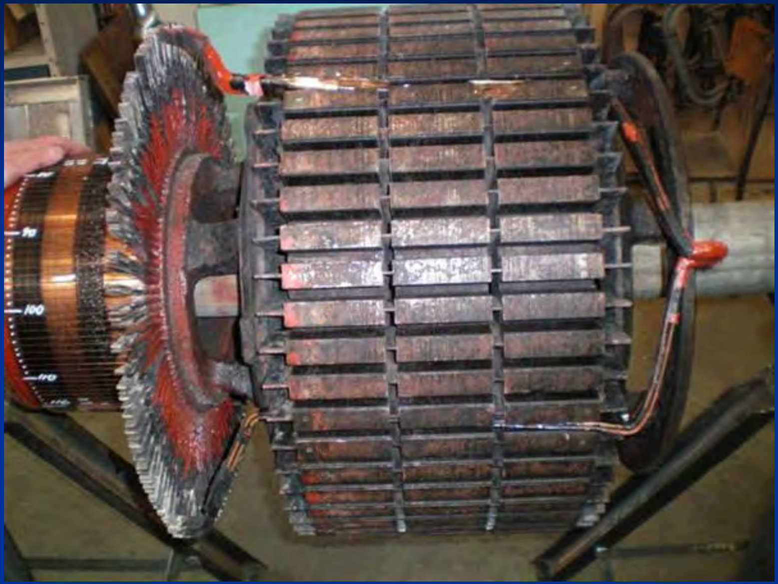
Refurbishment /rewind

Rotating exciter refurbishment/rewind

WORK PERFORMED ON ARMATURE:

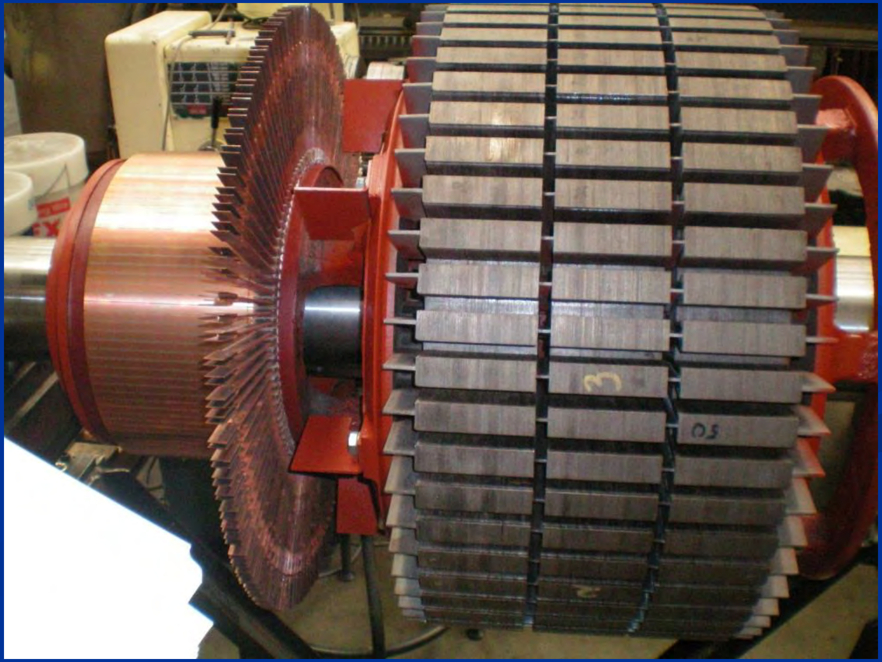
1-) MANUFACTURE MACHINING AND BALANCING MANDRIL
2-) COLD STRIP ARMATURE COILS
3-) RECORD WINDING DATA
4-) INCOMING CORE TEST (Attachment A)
5-) SOAK LAMINATIONS IN WATERGLASS SOLUTION AND BAKE
6-) RE- CORE TEST (Attachment B)
7-) INFRARED SCAN "A"
8-) ACID ETCH LAMINATIONS
9-) INFRARED SCAN "B"
10-) FINAL CORE TEST
11-) INSTALL NEW COMMUTATOR - FACTORY TESTS
12-) REWIND ARMATURE
13-) WEDGE
14-) TIG WELD CONNECTIONS
15-) RESIGLASS BAND AND BAKE
16-) VPI AND BAKE ARMATURE - TWO FULL VPI CYCLES
17-) MACHINE AND UNDERCUT COMMUTATOR
18-) COMMUTATOR PROFILE TEST
19-) APPLY NEW EPOXY STRING BAND
20-) FINAL ELECTRICAL TESTS
21-) DEBURR AND CHAMFER AND POLISH COMMUTATOR
22-) DYNAMIC BALANCE ARMATURE
23-) CRATE AND SHIP

Rotating Exciter refurbishment/rewind

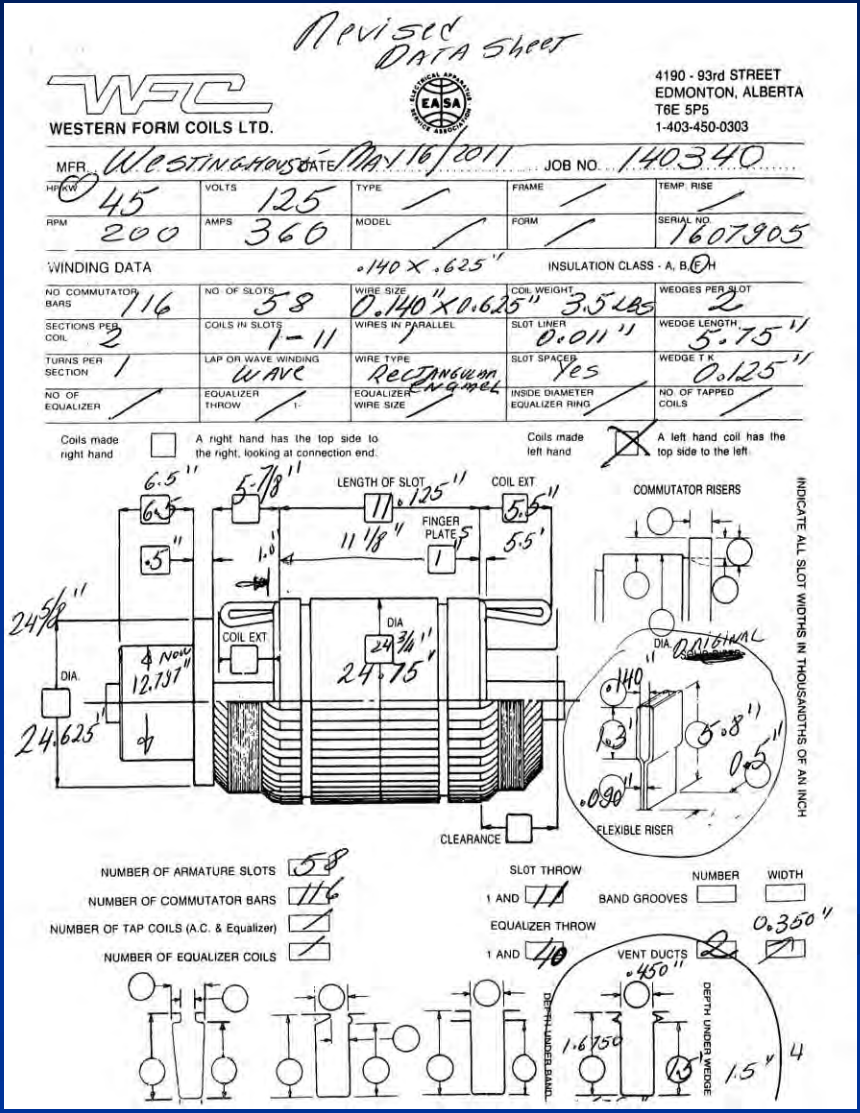


Armature core after winding removal.

Commutator has been replaced.



Rotating Exciter refurbishment/rewind



Revised DATA Sheet

WESTERN FORM COILS LTD.

EASA

4190 - 93rd STREET
EDMONTON, ALBERTA
T6E 5P5
1-403-450-0303

MFR. Westinghouse DATE May 16/2011 JOB NO. 140340

HP/KW 45	VOLTS 125	TYPE /	FRAME /	TEMP. RISE /
RPM 200	AMPS 360	MODEL /	FORM /	SERIAL NO. 1607905

WINDING DATA .140 X .625" INSULATION CLASS - A, B, F, H

NO. COMMUTATOR BARS 116	NO. OF SLOTS 58	WIRE SIZE 0.140" X 0.625"	COIL WEIGHT 3.5 LBS	WEDGES PER SLOT 2
SECTIONS PER COIL 2	COILS IN SLOTS 1 - 11	WIRES IN PARALLEL /	SLOT LINER 0.011"	WEDGE LENGTH 5.75"
TURNS PER SECTION 1	LAP OR WAVE WINDING WAVE	WIRE TYPE Rectangular Enamel	SLOT SPACER Yes	WEDGE T K 0.125"
NO. OF EQUALIZER /	EQUALIZER THROW /	EQUALIZER WIRE SIZE /	INSIDE DIAMETER EQUALIZER RING /	NO. OF TAPPED COILS /

Coils made right hand ☐ A right hand has the top side to the right, looking at connection end.

Coils made left hand ☒ A left hand coil has the top side to the left.

LENGTH OF SLOT 11.125"
COIL EXT 5.5"
FINGER PLATES 1"
COMMUTATOR RISERS
INDICATE ALL SLOT WIDTHS IN THOUSANDTHS OF AN INCH
COIL EXT
DIA. 24.75"
DIA. 24.625"
ORIGINAL
FLEXIBLE RISER
CLEARANCE

NUMBER OF ARMATURE SLOTS 58
NUMBER OF COMMUTATOR BARS 116
NUMBER OF TAP COILS (A.C. & Equalizer) /
NUMBER OF EQUALIZER COILS /

SLOT THROW 1 AND 11
EQUALIZER THROW 1 AND 40

BAND GROOVES NUMBER WIDTH
VENT DUCTS 2 0.350"

DEPTH UNDER BAND
DEPTH UNDER WEDGE

Armature Core Loss Test

Core loss test

During the rewind process an armature should be core tested if possible. Although part of a DC machine, the armature is actually an AC winding. The formula for the frequency of a rotating electrical machine AC winding is:

$$\text{Frequency} = \left(\frac{\text{Poles} \times \text{rpm}}{120}\right)$$

If the motor has 4 poles and is rated 2500 rpm, the armature frequency calculation would be:

$$\text{Frequency} = \left(\frac{4 \times 2500}{120}\right) = 83.3\ \text{Hz}$$

Note that in this example, the armature frequency is greater than that of typical line frequencies for AC machines. This illustrates the need to be concerned about armature core loss and hot spots.

If a commercial core tester is available, the test current can be passed through the armature shaft. If the loop test method is to be used, the core must have large enough ventilation ducts for the loop leads to pass through, below or within, the core iron. The core test itself will follow the guidelines of *EASA Tech Note 17*.

COMMUTATOR
REPAIR INDICATORS

SITUATION	RUNOUT (TIR*)	BAR-TO-BAR	UNDERCUT DEPTH
NEW	LESS THAN .0015	LESS THAN .0002	.050+
IN SERVICE	LESS THAN .003	LESS THAN .0003	.020
NEEDS REPAIR	MORE THAN .003	MORE THAN .0003	.010-

* = TOTAL INDICATOR READING

ALL VALUES ARE IN INCHES

COMMUTATOR MACHINING: TURNING AND UNDERCUTTING

PREPARING THE ARMATURE

1. Check tightness of commutator bolts (tightening nut) while commutator is hot. Tighten to manufacturer's specifications.	3. Make sure bearing seats run true before machining the commutator.
2. Repair commutator and armature winding as needed.	4. Wrap armature winding to keep chips out while machining the commutator.

TURNING THE COMMUTATOR

	ft/min = 0.26 x D x rpm where D (commutator diameter) is in inches	m/min = 0.00314 x D x rpm where D (commutator diameter) is in mm
SURFACE SPEED		
Single point carbide tool	300-500 ft/min	90-150 m/min
Synthetic diamond tool	Max 750 ft/min*	230 m/min*
DEPTH OF CUT	0.007 – 0.010 in	0.18 – 0.25 mm
FEED RATE	0.005 – 0.007 in/rev	0.13 – 0.18 mm/rev

*Or follow recommendations of manufacturer.
Note: Use a flat file to chamfer the ends of the commutator bars (0.040 in/1 mm).

COMMUTATOR RUNOUT AND FINISH

	Peripheral speed	
	≤ 5000 ft/min	> 5000 ft/min (25.4 m/sec)
Maximum total indicated runout	0.0030" (0.076 mm)	0.0015" (0.038 mm)
Maximum total indicated runout in any quadrant	0.0015" (0.038 mm)	0.0010" (0.025 mm)
Maximum between adjacent bars	0.0002" (0.005 mm)	0.0002" (0.005 mm)
Maximum taper (in/ft)	0.0020"/ft (.051 mm/m)	
Surface finish	40 to 60 micro-inches (1.02 to 1.52 microns)	

UNDERCUTTING THE COMMUTATOR

1. Type of undercut: U-shaped and beveled, as shown in Figure 1. (Note: In certain cases, the shop manager may determine that a different type of undercut should be used.)

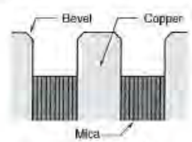
2. Depth of undercut: Factory specifications vary. A good rule to follow: make the depth equal to 1 - 1½ times the slot width.

3. Cleaning of slots: Use slotting files and hand scrapers to eliminate mica fins along the sides of slots.

Bevel the bar edges 0.015" (0.4 mm).

Clean the slots using clean, oil-free air.

Figure 1



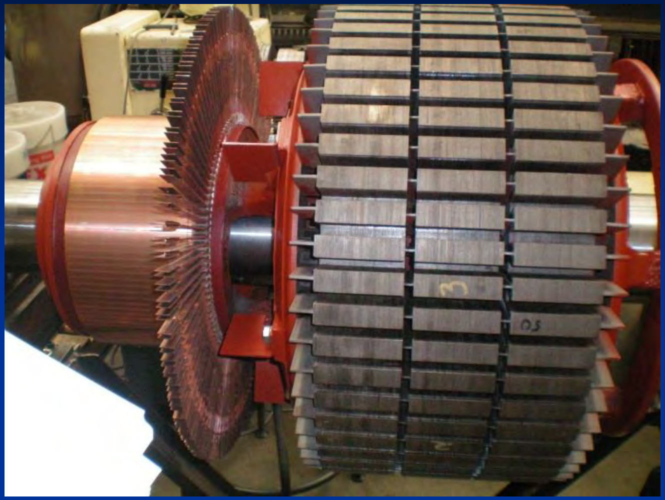
U-shaped undercuts and bevels.

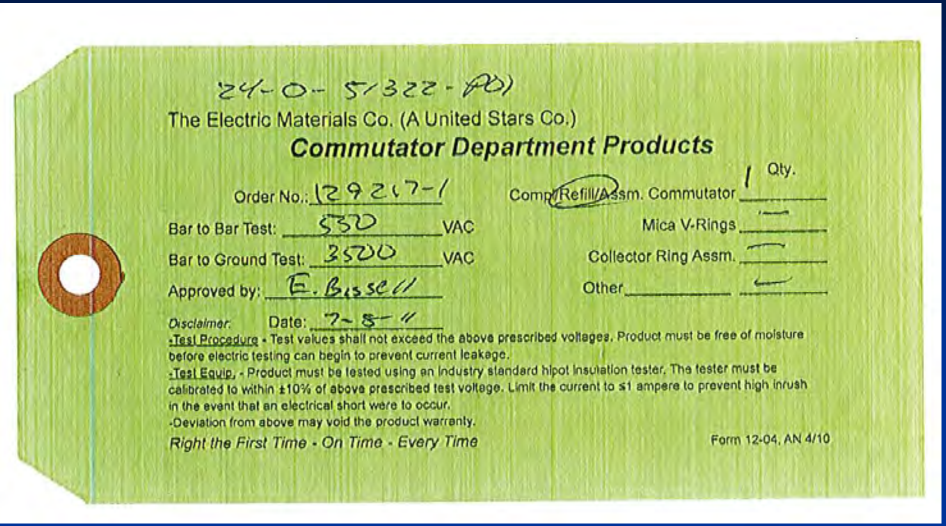
4. Polishing of commutator: Polish the commutator with a fine-grit stone or sandpaper to eliminate any minor burrs. The surface finish should be no more than 40 to 60 micro-inches (1.02 to 1.52 microns).

Note: Never use emery paper. Electrically conductive particles can lodge in the surface of the commutator bars and cause arcing.

5. Testing: Growler and bar-to-bar test.

Rotating Exciter refurbishment/rewind





24-0-51322-F01

The Electric Materials Co. (A United Stars Co.)

Commutator Department Products

Order No.: 129217-1

Comp/Refill/Assm. Commutator 1 Qty.

Bar to Bar Test: 530 VAC

Mica V-Rings —

Bar to Ground Test: 3500 VAC

Collector Ring Assm. —

Approved by: E. Bissell

Other —

Disclaimer: Date: 7-8-11

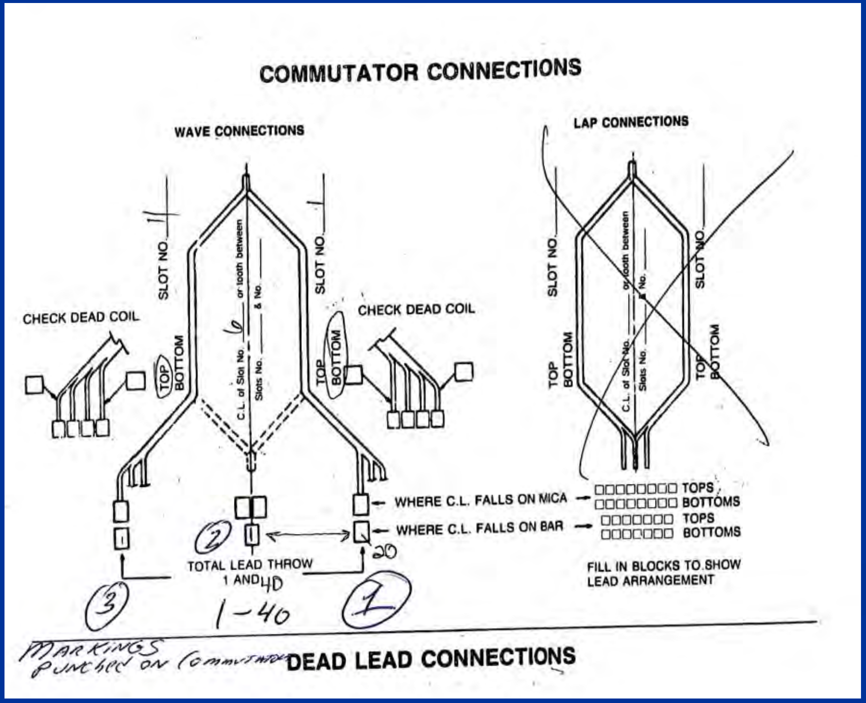
-Test Procedure - Test values shall not exceed the above prescribed voltages. Product must be free of moisture before electric testing can begin to prevent current leakage.

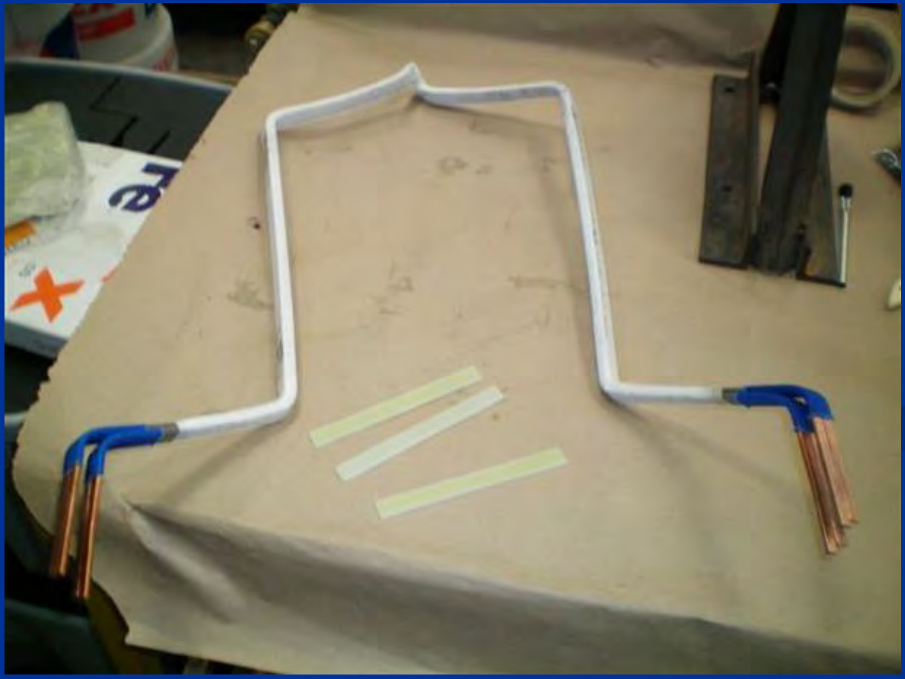
-Test Equip. - Product must be tested using an industry standard hipot insulation tester. The tester must be calibrated to within ±10% of above prescribed test voltage. Limit the current to ≤1 ampere to prevent high inrush in the event that an electrical short were to occur.

-Deviation from above may void the product warranty.

Right the First Time - On Time - Every Time

Form 12-04, AN 4/10





Rotating Exciter refurbishment/rewind

Before waterglass

BEAVER ELECTRICAL MACHINERY
7440 LOWLAND DRIVE
BURNABY, BC, CANADA V5J 5A4
6044315000

CORELOSS TEST REPORT

Date: 05-16-2011 S.O. Number: 140340 Customer: B.C. Hydro

NAMEPLATE DATA

Description :	Armature Core	RPM :	200
HP/KW/KVA :	45 / /	Volts/Ph/Freq:	125 / /
Manufacturer:	Westinghouse	Amps :	360
Frame :		Frame Type :	None
Enclosure :	OP	Temp/Duty :	/
Serial No. :	1607905	Model/Style :	
Other data :		Attachment :	

LEXSECO ARMATURE CORELOSS TEST

INPUT

Core length :11.061	Backiron depth:3.6	No. ducts/width:2 /.385
Core OD :24.75	Slot Depth :1.685	No. holes/dia. :0 /0

RESULTS

Flux/Tap : 2928 /12.5	Actual watts : 2084	Maximum limit : 10
Actual flux : 2928	Amp turn/inch : 6.999	Marginal limit : 6
Actual amps : 391	Watts/lb loss : 3.867	BI density : 85000

RECOMMENDATIONS

Coreloss is within normal range.
Check for hot spots by raising amps from 391
to between 782 and 1173 . If none found, core is OK.

COMMENTS

NO HOT SPOTS FOUND

Tested by: [signature] Reviewed by: [signature]

BEAVER ELECTRICAL MACHINERY
7440 LOWLAND DRIVE
BURNABY, BC, CANADA V5J 5A4
6044315000

CORELOSS TEST REPORT

Date: 05-31-2011 S.O. Number: 140340 Customer: BC HYDRO

NAMEPLATE DATA

Description :		RPM :	200
HP/KW/KVA :	45KW / /	Volts/Ph/Freq:	125 / /
Manufacturer:	WESTINGHOUSE	Amps :	
Frame :	NA	Frame Type :	Pre NEMA
Enclosure :		Temp/Duty :	/
Serial No. :	1607905	Model/Style :	
Other data :		Attachment :	

LEXSECO ARMATURE CORELOSS TEST

INPUT

Core length :11.061	Backiron depth:3.6	No. ducts/width:2 /.375
Core OD :24.75	Slot Depth :1.685	No. holes/dia. :8 /.375

RESULTS

Flux/Tap : 2531 /12.5	Actual watts : 1239	Maximum limit : 10
Actual flux : 2293	Amp turn/inch : 3.562	Marginal limit : 6
Actual amps : 199	Watts/lb loss : 2.659	BI density : 77007

RECOMMENDATIONS

Coreloss is within normal range.
Check for hot spots by raising amps from 199
to between 398 and 597 . If none found, core is OK.

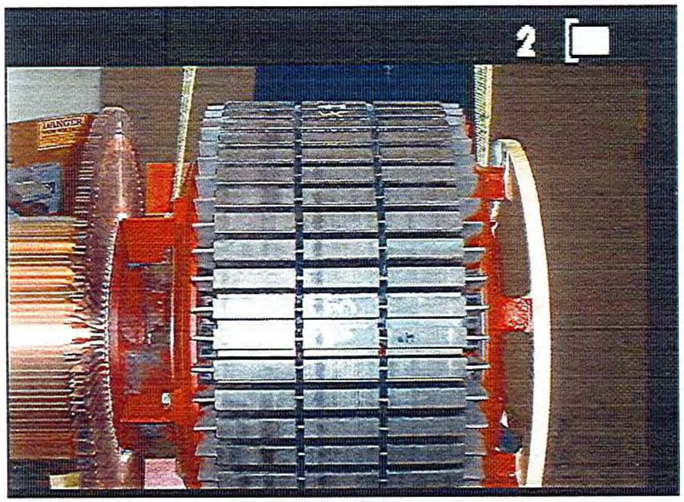
COMMENTS

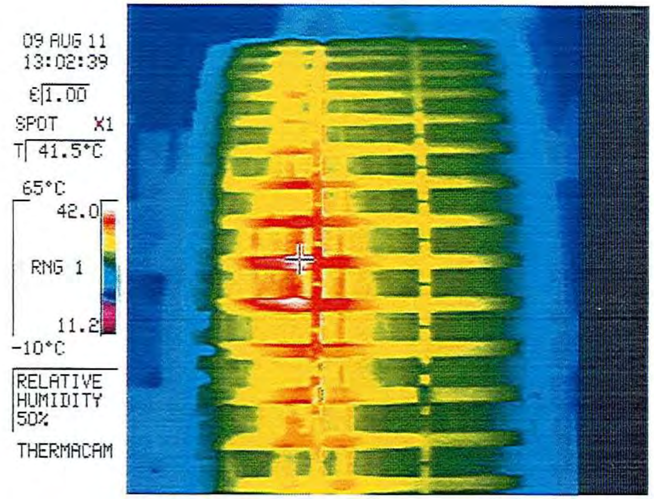
THIS TEST AFTER CORE WAS IN EGGWATER FOR THE WEEKEND
NO HOT SPOTS

Tested by: [signature] May 31/11. Reviewed by: [signature]

Rotating Exciter refurbishment/rewind

Infrascan
INFRARED SERVICES LTD





FAULT NO: 2 DATE: 9-Aug-11 TIME: 10:56 PERSONNEL: PBM AMBIENT: 20

LOCATION: 45KW EXCITER ROTOR
CORE LOSS TEST

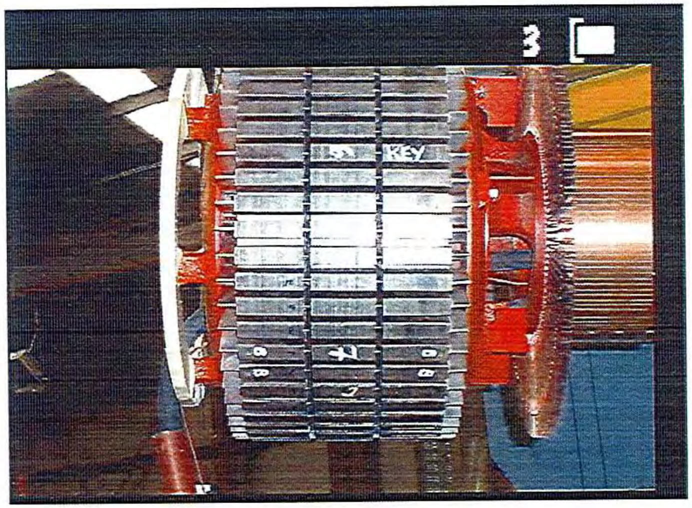
DESCRIPTION:

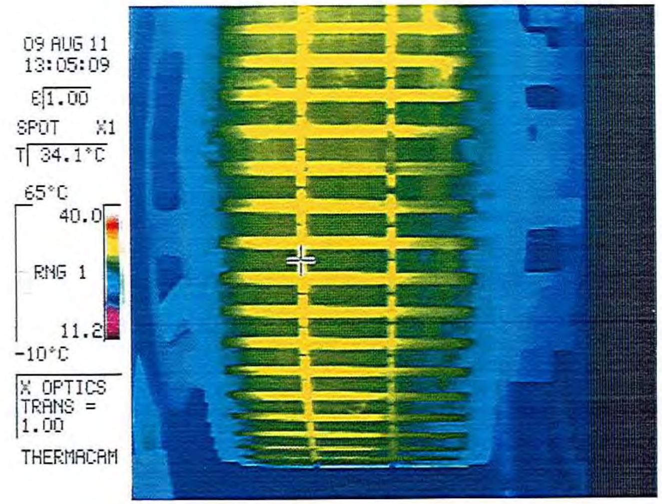
QUADRANT #2. FOR REFERENCE ONLY.

TEMPERATURE IN C		
OBJECT	NORMAL	RISE
41	32	9

Rotating Exciter refurbishment/rewind

Infrascan
INFRARED SERVICES LTD





FAULT NO: 3 DATE: 9-Aug-11 TIME: 11:02 PERSONNEL: PBM AMBIENT: 20

LOCATION: 45KW EXCITER ROTOR
CORE LOSS TEST

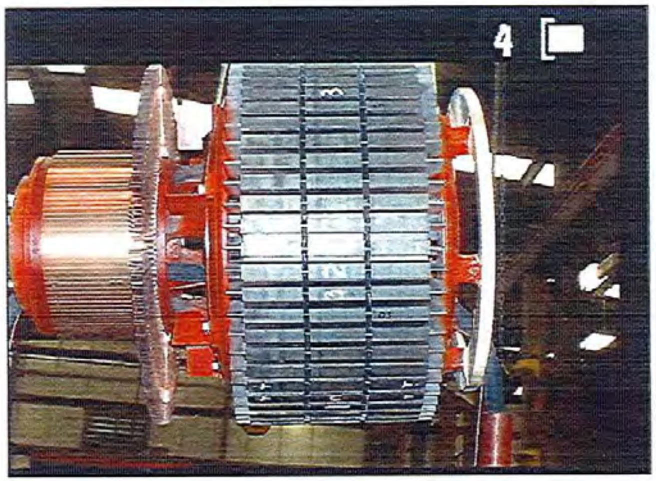
DESCRIPTION:

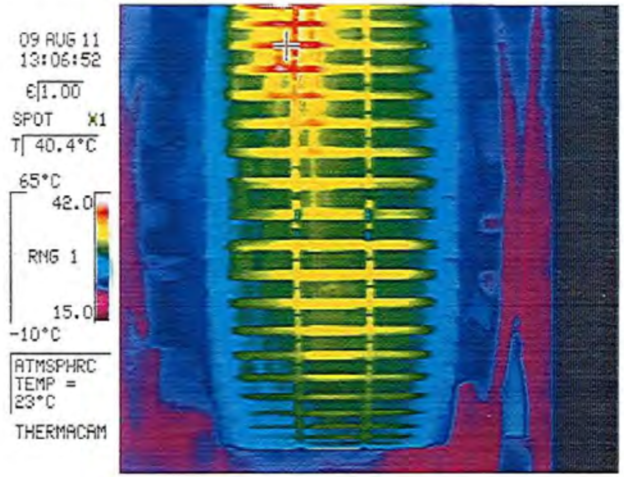
QUADRANT #3. FOR REFERENCE ONLY.

TEMPERATURE IN C		
OBJECT	NORMAL	RISE
34	31	3

Rotating Exciter refurbishment/rewind

Infrascan
INFRARED SERVICES LTD





FAULT NO: 4 DATE: 9-Aug-11 TIME: 11:07 PERSONNEL: PBM AMBIENT: 20

LOCATION: 45KW EXCITER ROTOR
CORE LOSS TEST

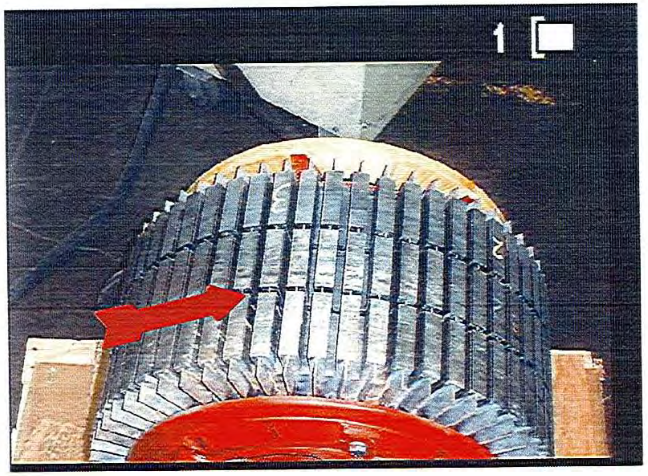
DESCRIPTION:

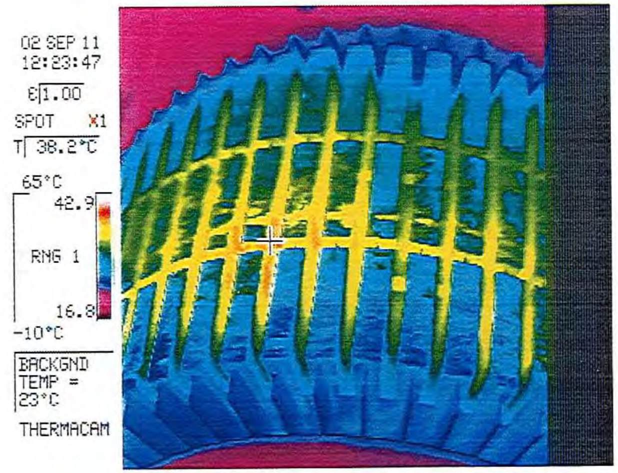
QUADRANT #4. FOR REFERENCE ONLY.

	TEMPERATURE IN C	
OBJECT	NORMAL	RISE
41	32	9

Rotating Exciter refurbishment/rewind

Infrascan
INFRARED SERVICES LTD





FAULT NO:	1	DATE:	2-Sep-11	TIME:	10:25	PERSONNEL:	PBM	AMBIENT:	20

LOCATION: 45KW EXCITER ROTOR
CORE LOSS TEST

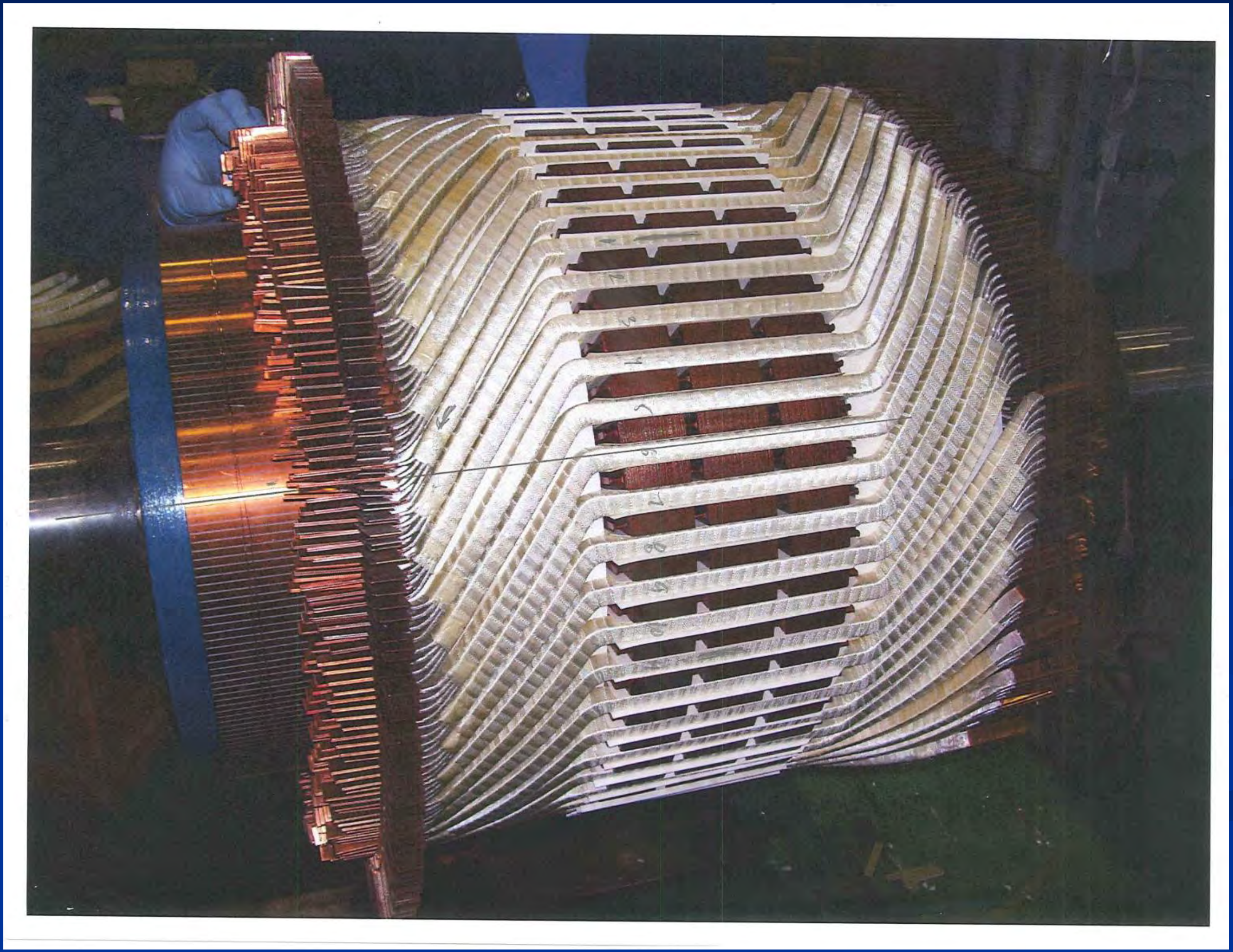
DESCRIPTION:

QUADRANT #2. FOR REFERENCE ONLY.
(SEE FAULT #2, AUGUST 9, 2011).

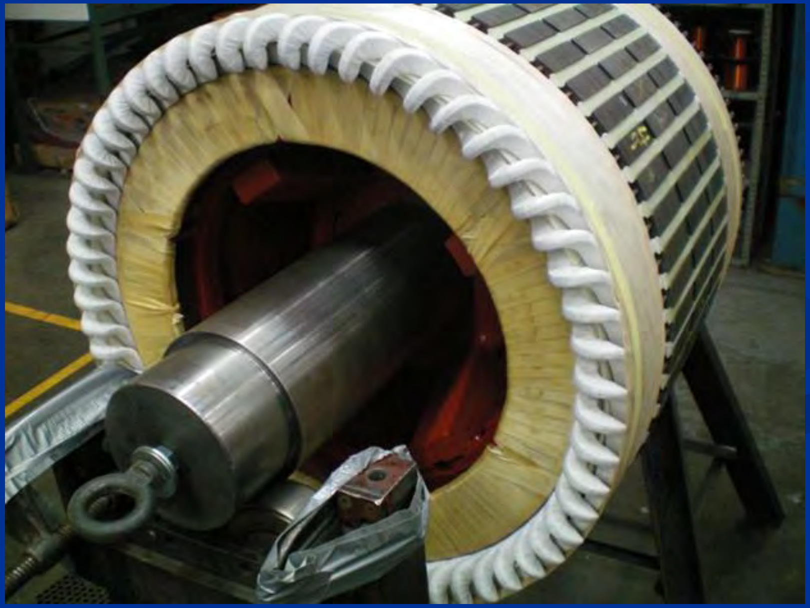
TEMPERATURE IN C		
OBJECT	NORMAL	RISE
38	33	5

Final
After Acid Etching
"B"

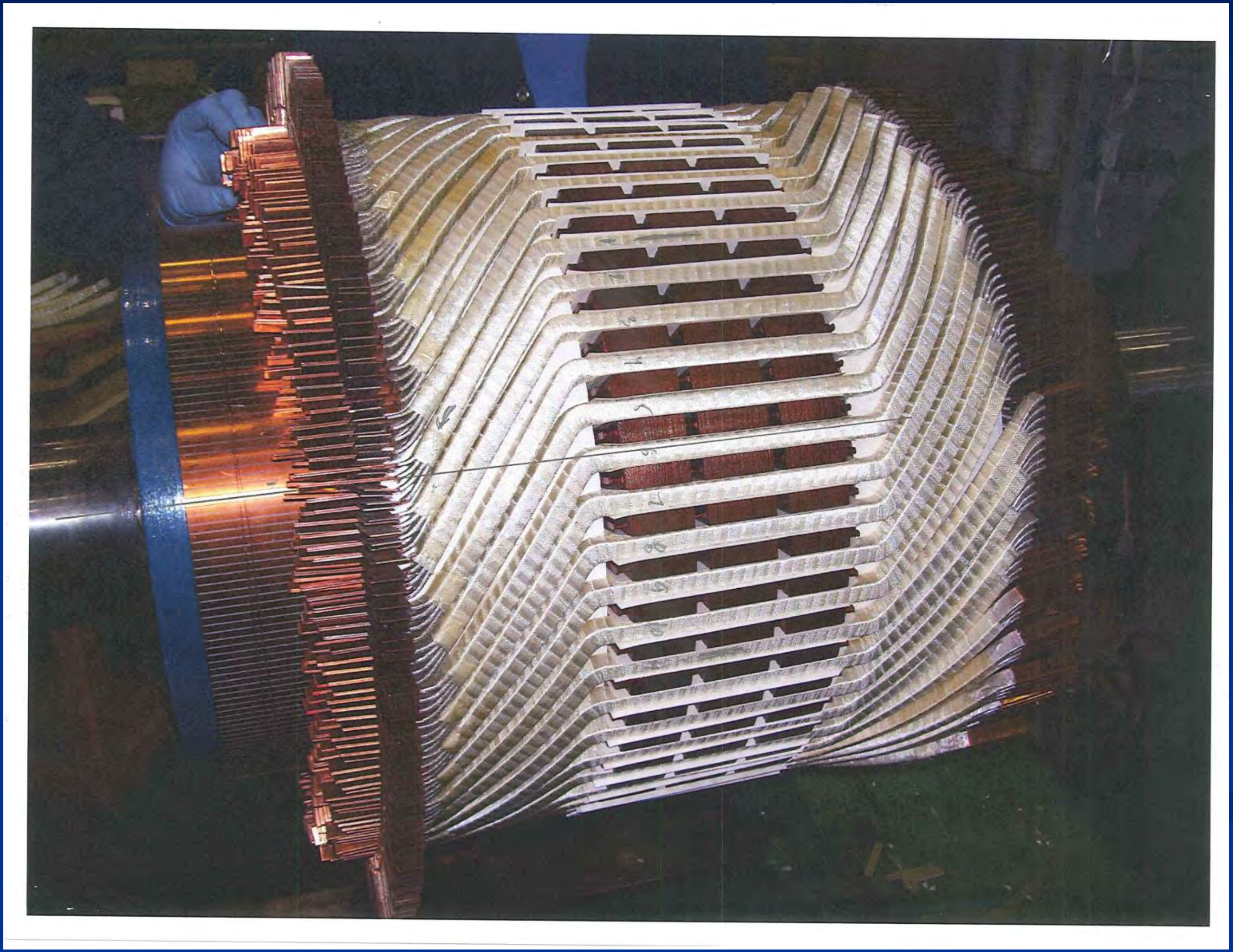
Exciter armature (**half coil** winding)



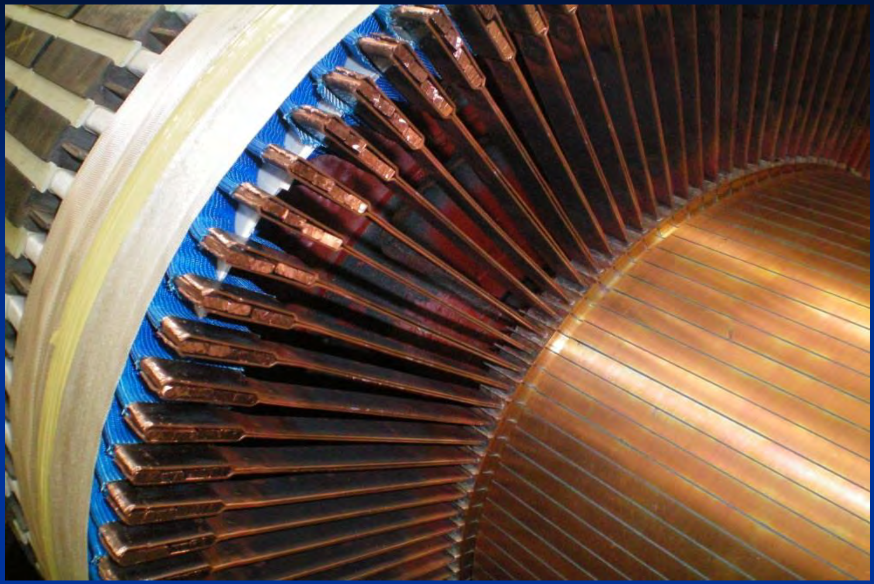
Rotating Exciter refurbishment/rewind

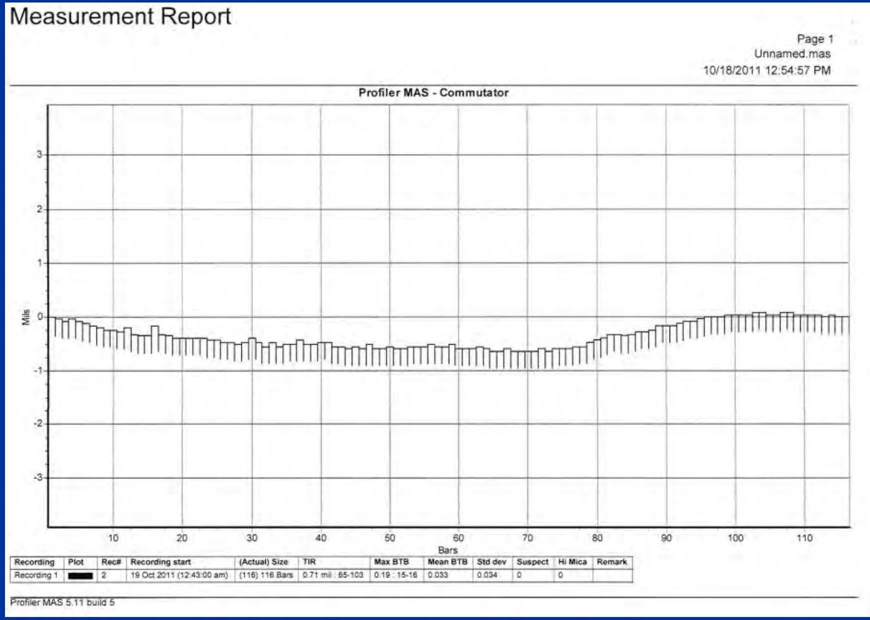


Exciter armature (**half coil** winding)

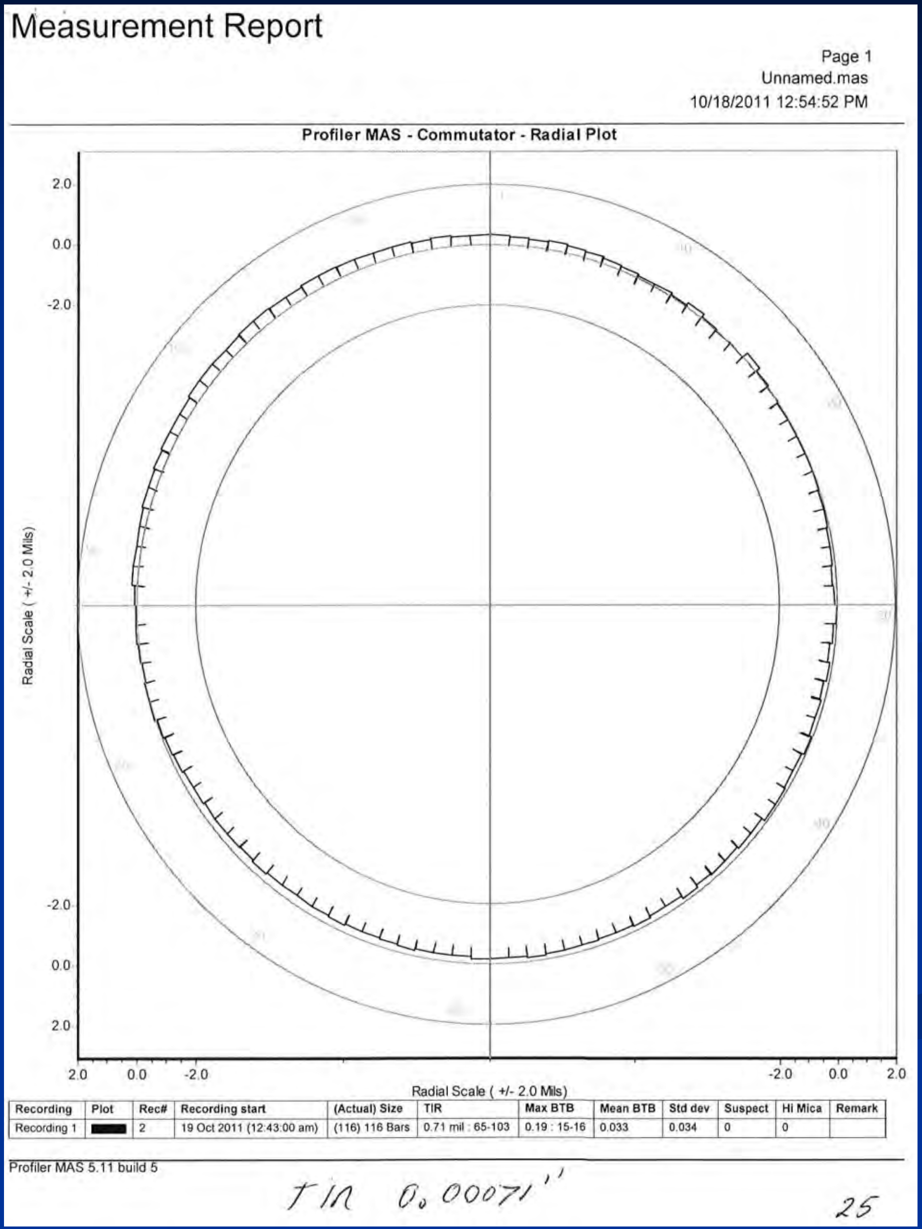


Commutator Profile Test



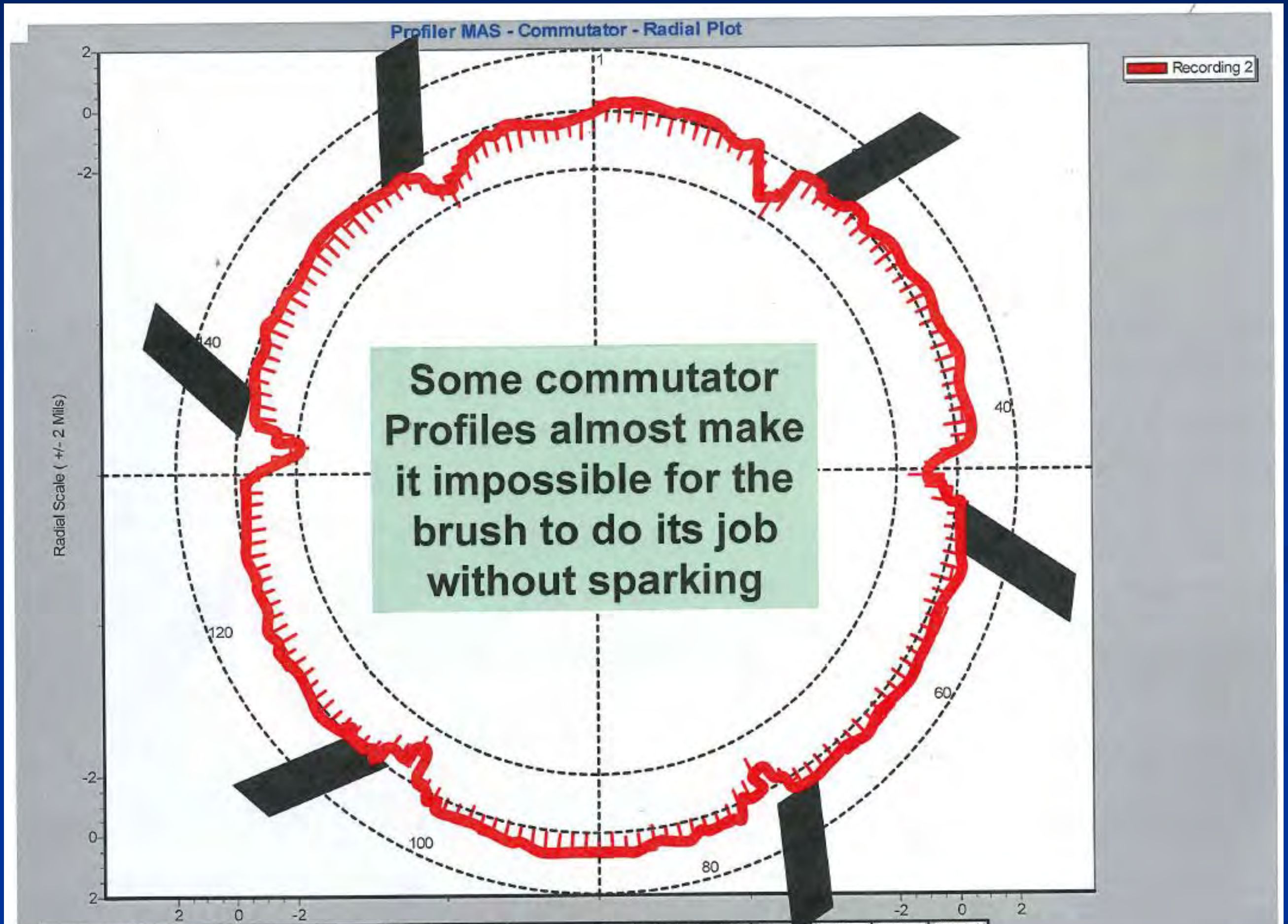


Recording	Plot	Rec#	Recording start	(Actual) Size	TIR	Max BTB	Mean BTB	Std dev	Suspect	Hi Mica	Remark
Recording 1		2	19 Oct 2011 (12:43:00 am)	(116) 116 Bars	0.71 mil : 65-103	0.19 : 15-16	0.033	0.034	0	0	



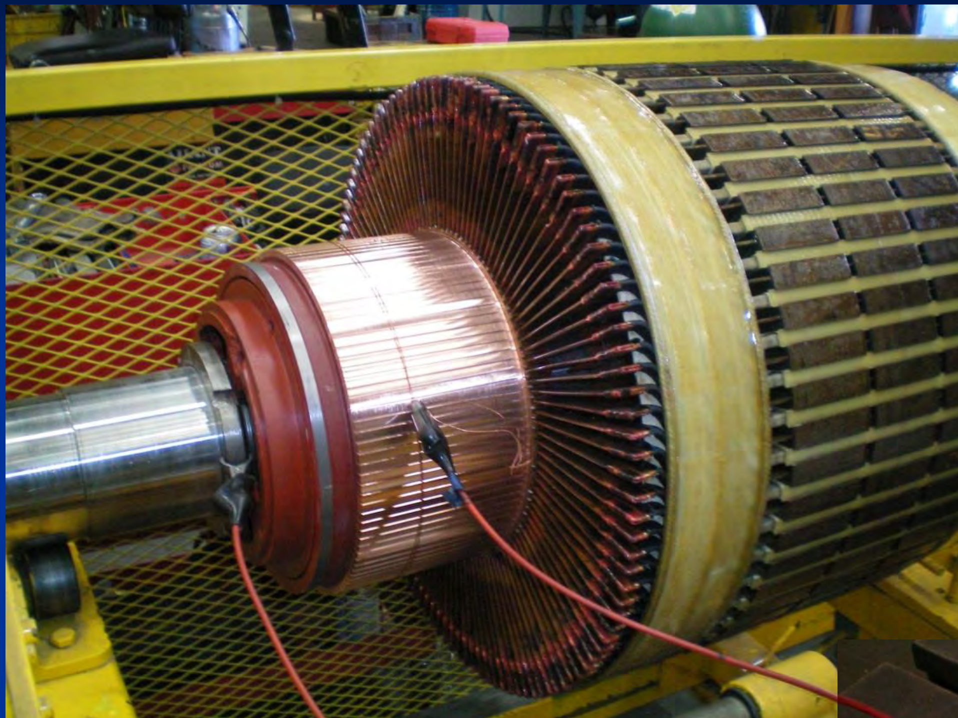
Recording	Plot	Rec#	Recording start	(Actual) Size	TIR	Max BTB	Mean BTB	Std dev	Suspect	Hi Mica	Remark
Recording 1		2	19 Oct 2011 (12:43:00 am)	(116) 116 Bars	0.71 mil : 65-103	0.19 : 15-16	0.033	0.034	0	0	

Commutator Profile Test Plot



Recording	Plot	Rec#	Recording start	(Actual) Size	TIR	Max BTB	Mean BTB	Std d v	Suspect	Hi Mica	Remark
Recording 2		2	25 Jan 2005 (2:39:23 pm)	(174) 174 Bars	2.52 mil : 133-85	0.82 : 17-18	0.162	0.174	0	0	

Commutator (armature winding) Megger Test

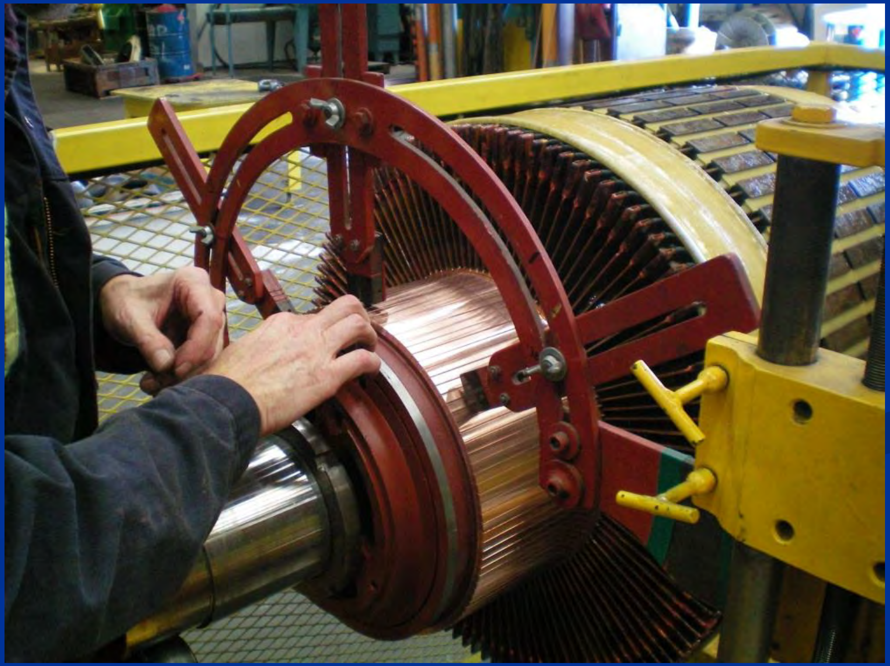


IR and PI measured at 1000 Vdc.

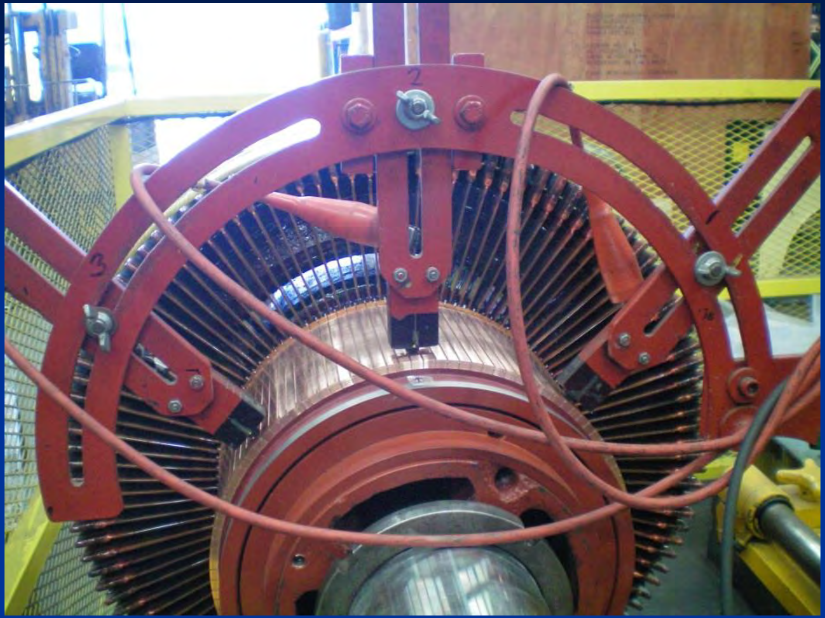
Commutator (armature winding) Surge Test

Commutator Surge test equipment

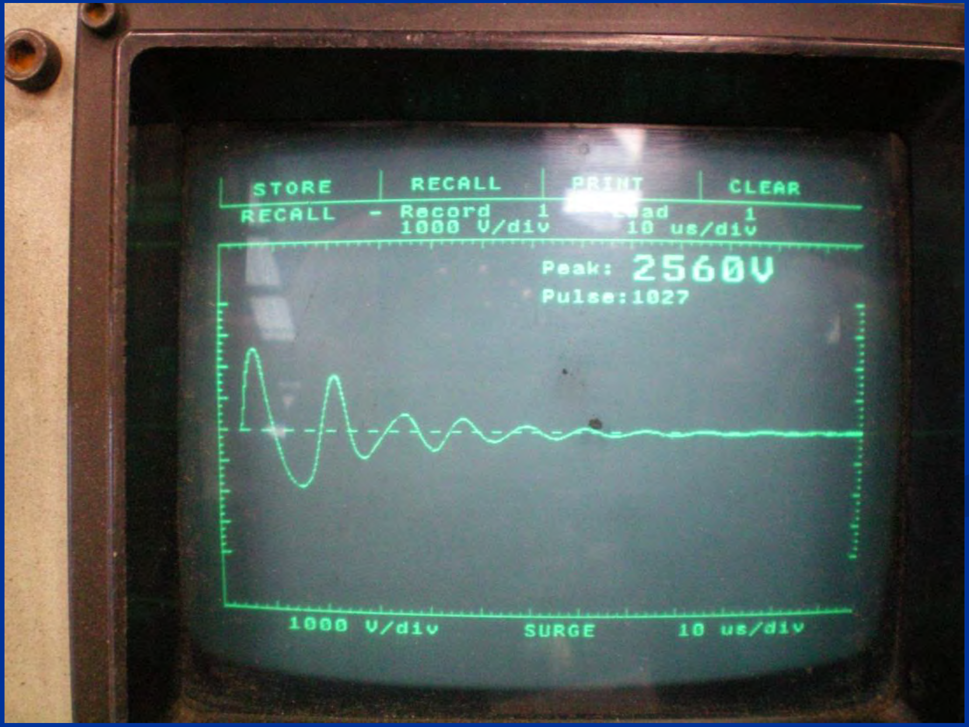
Surge test is being performed with
16 commutator segments span.



Commutator (armature winding) Surge test



Surge test voltage shall not exceed
the AC Hipot test voltage level

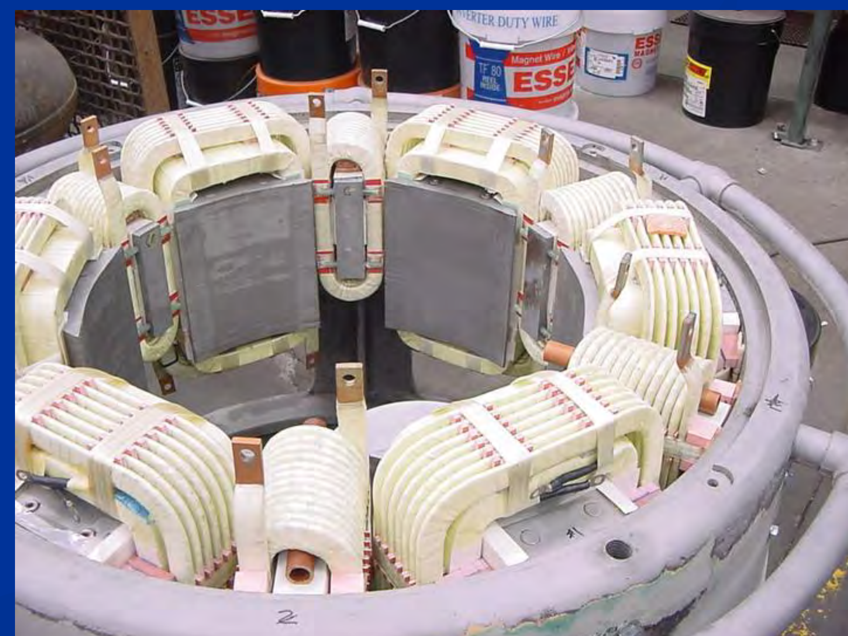


Surge comparison test wave form

WORK PERFORMED ON FIELD FRAME ASSEMBLY

1) INCOMING TESTS, REMOVE AND ROAST COILS
2) RECORD INCOMING DIAMETRICAL IRON MEASUREMENTS AND SHIMS
3) RECORD WINDING DATA
4) REWIND ALL SIX MAIN POLE COILS, U300 THERMO SETTIN EPOXY
5) BOLTED CONNECTIONS ON SHUNT COILS
6) ROAST, CLEAN AND RE-INSULAT SERIES WINDINGS
7) ROAST CLEAN AND RE-INSULATE INTERPOLE WINDINGS
8) REPLACE ALL COIL BLOCKING & SPACERS
9) CLEAN AND RE-INSULATE ALL JUMPERS
10) SILVER PLATE CONNECTIONS
11) CORN COB FRAME AND POLE PIECES

12) INSTALL NEW COILS
13) CHECK FINAL AIR GAP MEASUREMENTS(indicate where)
14) ADJUST SHIMS ON ONE INTERPOLE
15) TORQUE ALL BOLTS AND CONNECTIONS
16) FULL ELECTRICAL TESTS AS PER SPECIFICATIONS
17) POLARITY TESTS
18) RESISTANCE CHECKS
19) 400 HZ DROP TESTS and SURGE TESTS
20) VARNISH AND BAKE WINDINGS, 2 CYCLES
21) PAINT ASSEMBLY ASA70 ENAMEL
22) PALLETIZE AND SHRINK WRAP AND SHIP



G1 Field Frame Windings (were in bad condition before rewind)

All (6) Main Field winding removed

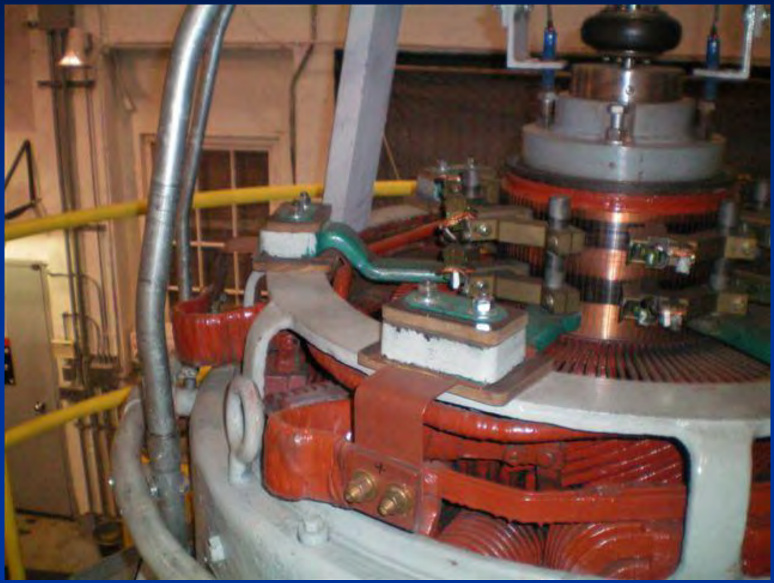
Six (6) Interpole windings with shims removed.

G1 Field Frame Windings (were in bad condition before rewind)

Main Field winding with shims removed.

Interpole winding and Series winding jumpers.

Rotating exciter (Field Frame windings)



Main Field ,Series Field and Interpole windings

Series Field and Interpole windings (have a few turns) and Main Field winding (has many turns).

Commutator (armature winding) Megger Test

Exciter Field Frame with Interpoles removed

Blocking and lashing of the Series Field winding to prevent it from moving.

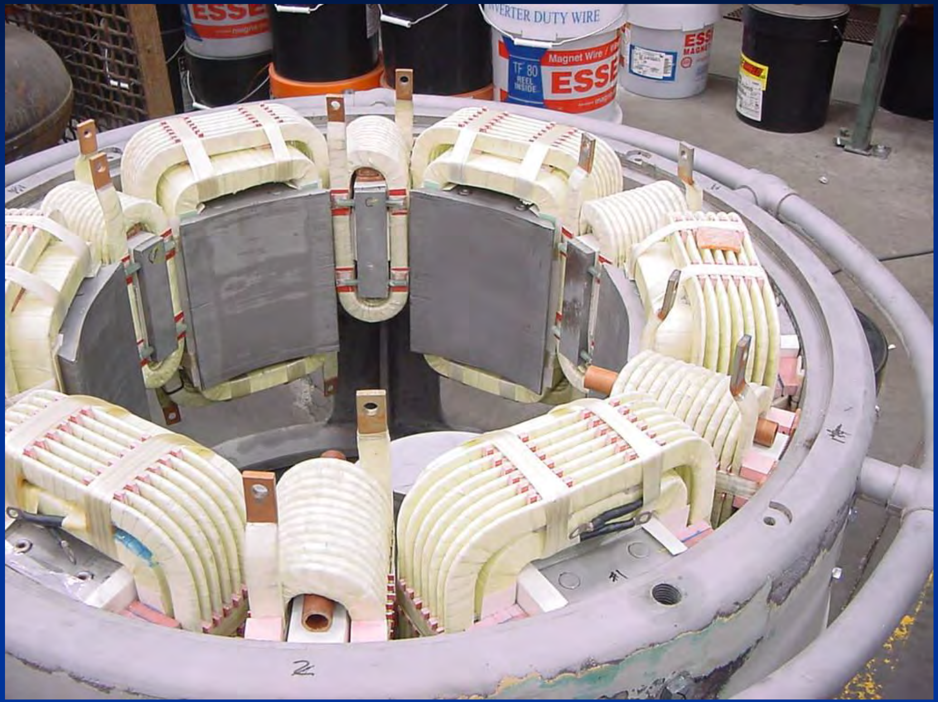
Rotating Exciter (Field Frame windings)

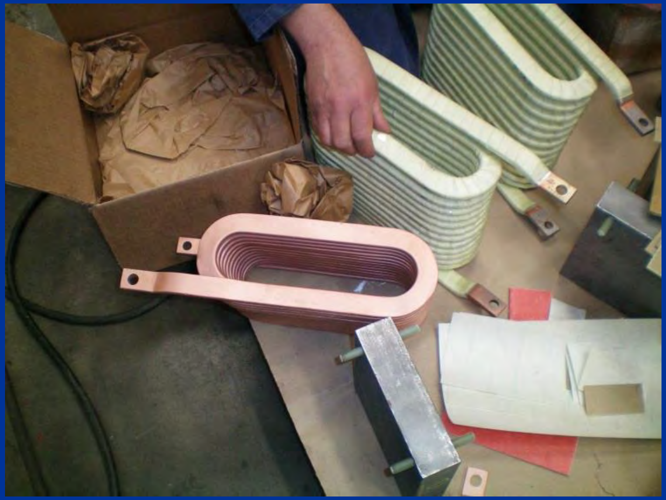
Interpoles winding

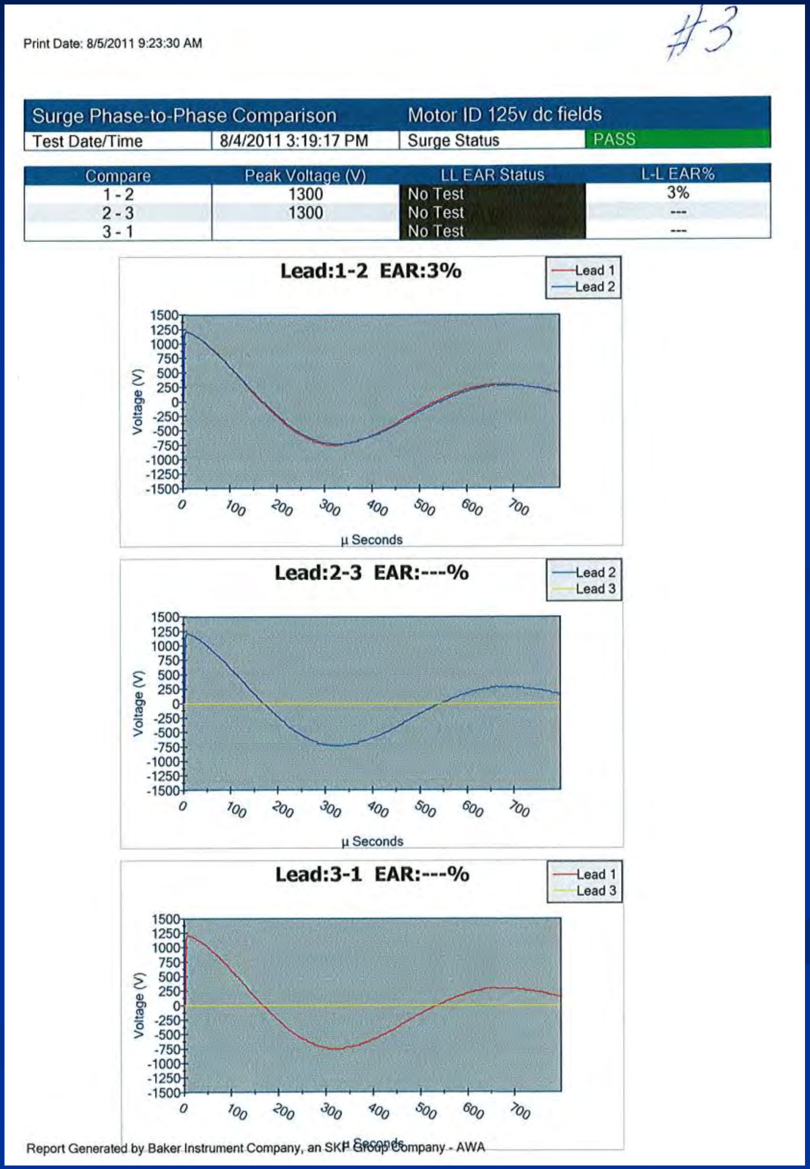
Rotating Exciter (Field Frame windings)

Main Field winding with shims

Main Shunt Field Winding Surge Test







Print Date: 8/5/2011 9:23:30 AM

#3

Surge Phase-to-Phase Comparison		Motor ID 125v dc fields	
Test Date/Time	8/4/2011 3:19:17 PM	Surge Status	PASS

Compare	Peak Voltage (V)	LL EAR Status	L-L EAR%
1 - 2	1300	No Test	3%
2 - 3	1300	No Test	---
3 - 1		No Test	---

Report Generated by Baker Instrument Company, an SKF Group Company - AWA

Rotating Exciter (Brush gear)

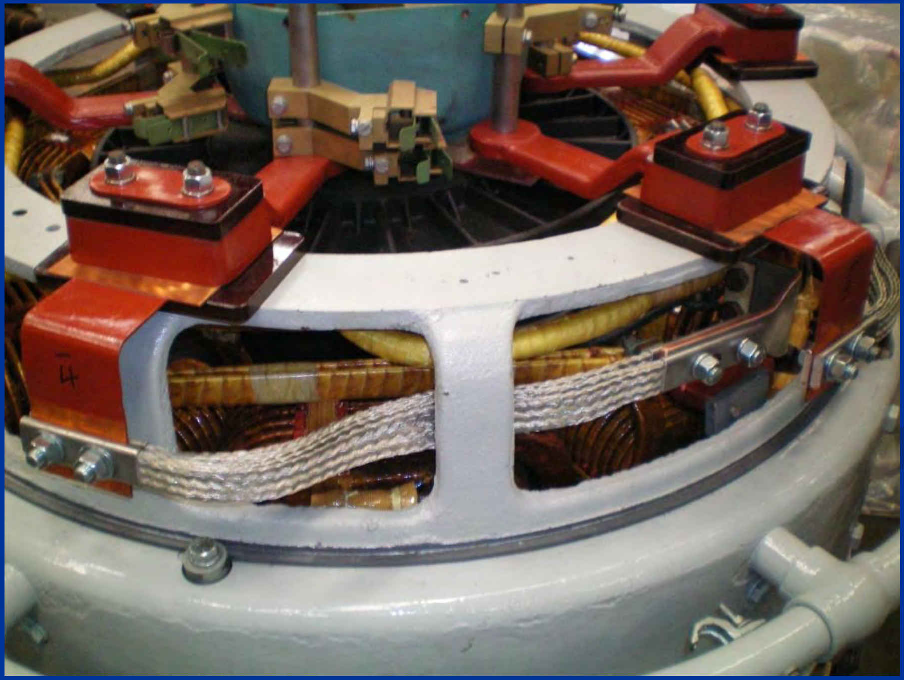
The number of brush holder arms (6)
is equal to the number of exciter field poles.

Brush gear yoke is in place.

Rotating exciter (Field windings) Interconnection

G1 commutator spins clockwise.

Hence, to improve brush gear performance modification has been made to the brush holders position. Brush holders have been 180º reversed to make brushes running with 15º trailing rather than with 15º leading angle.



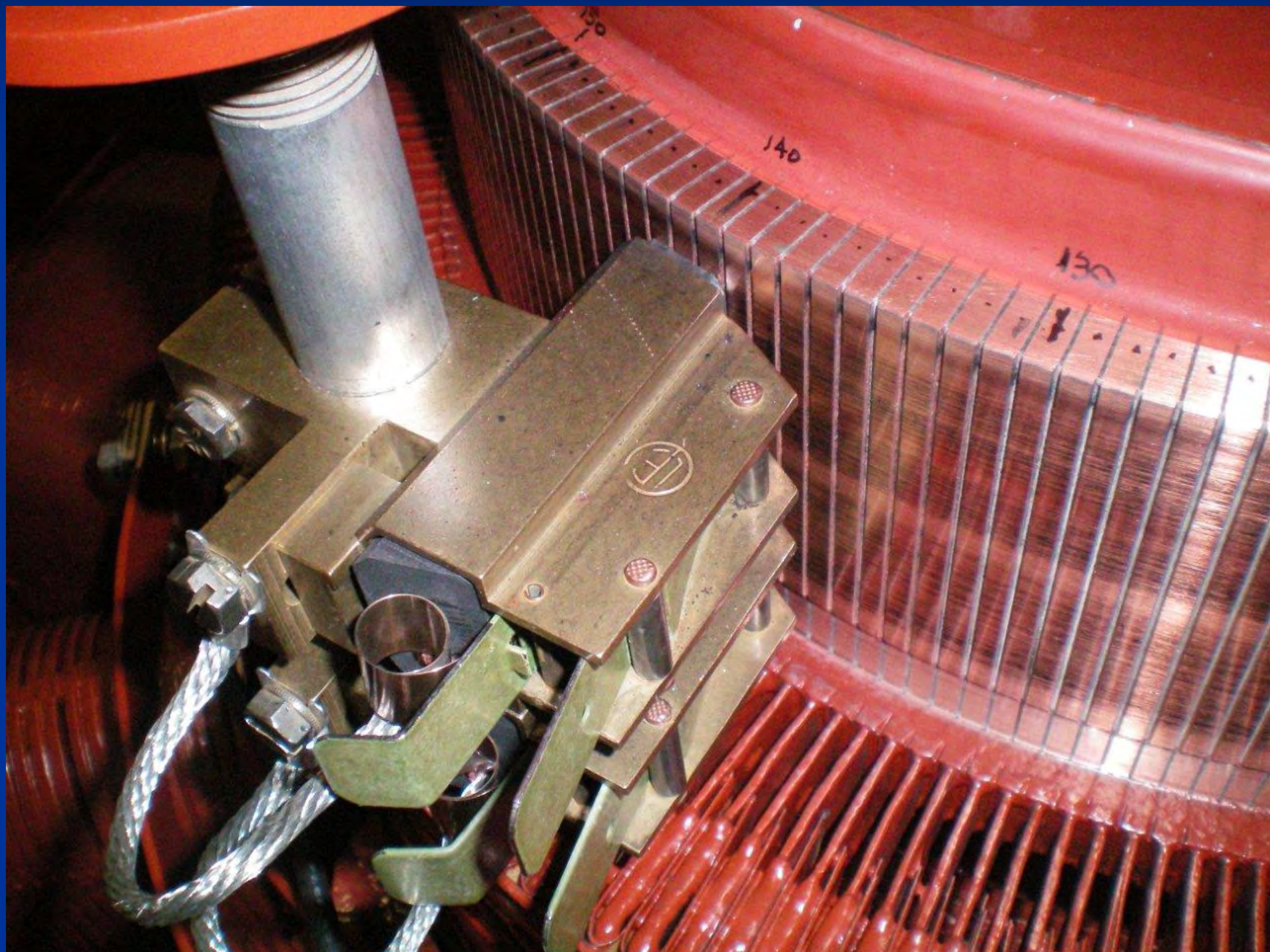
Modification has been also made to brush holders interconnection with the windings and flexible connectors have been installed.

Rotating exciter adjustments and testing at site

G2 exciter .

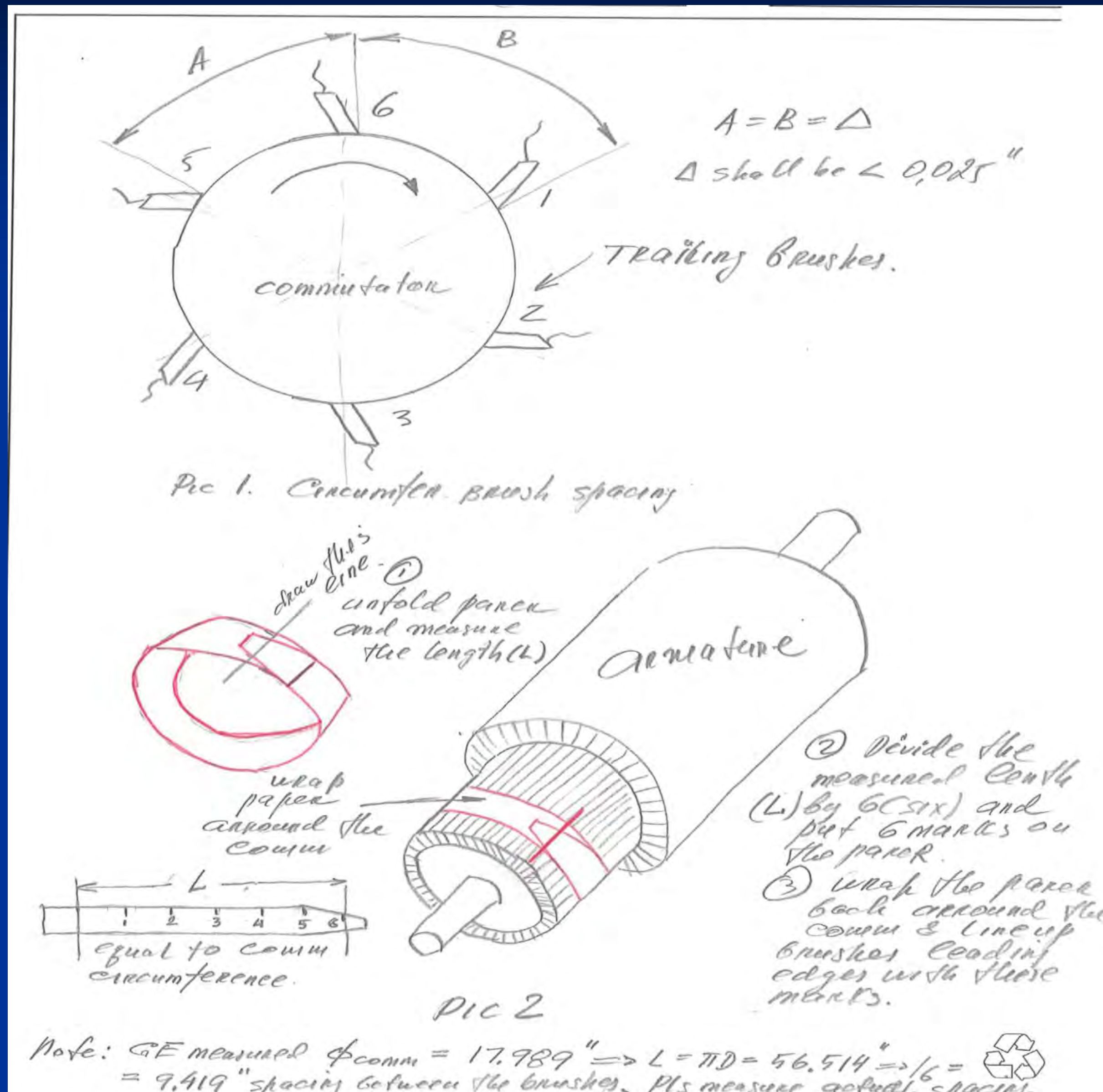
Rotating exciter adjustments and testing at site

G2 exciter spins CW (note : brush holder is set to TRAILING position because of its angle 15 Deg.



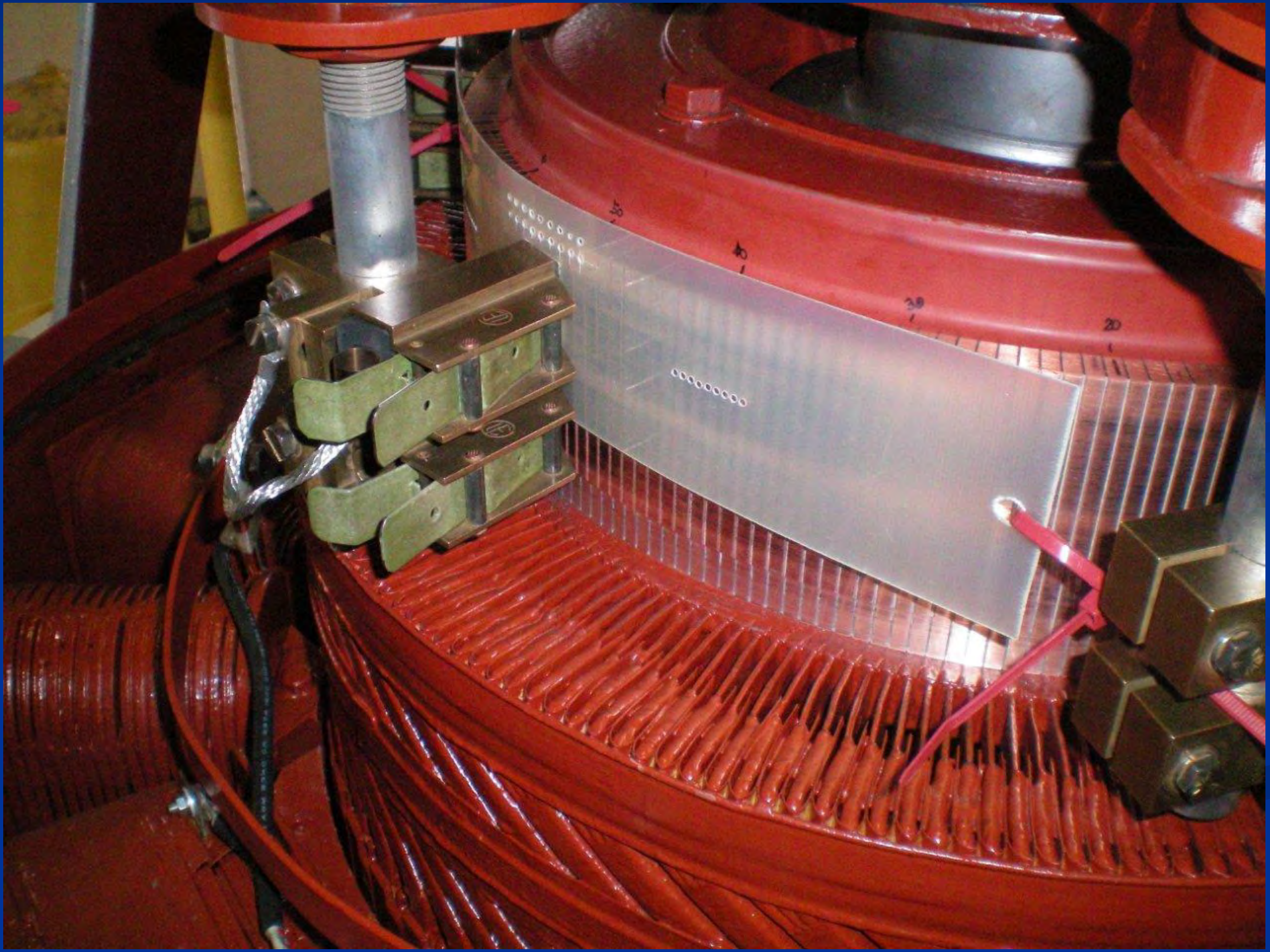
Rotating exciter adjustments & testing

Brush holders spacing adjustment



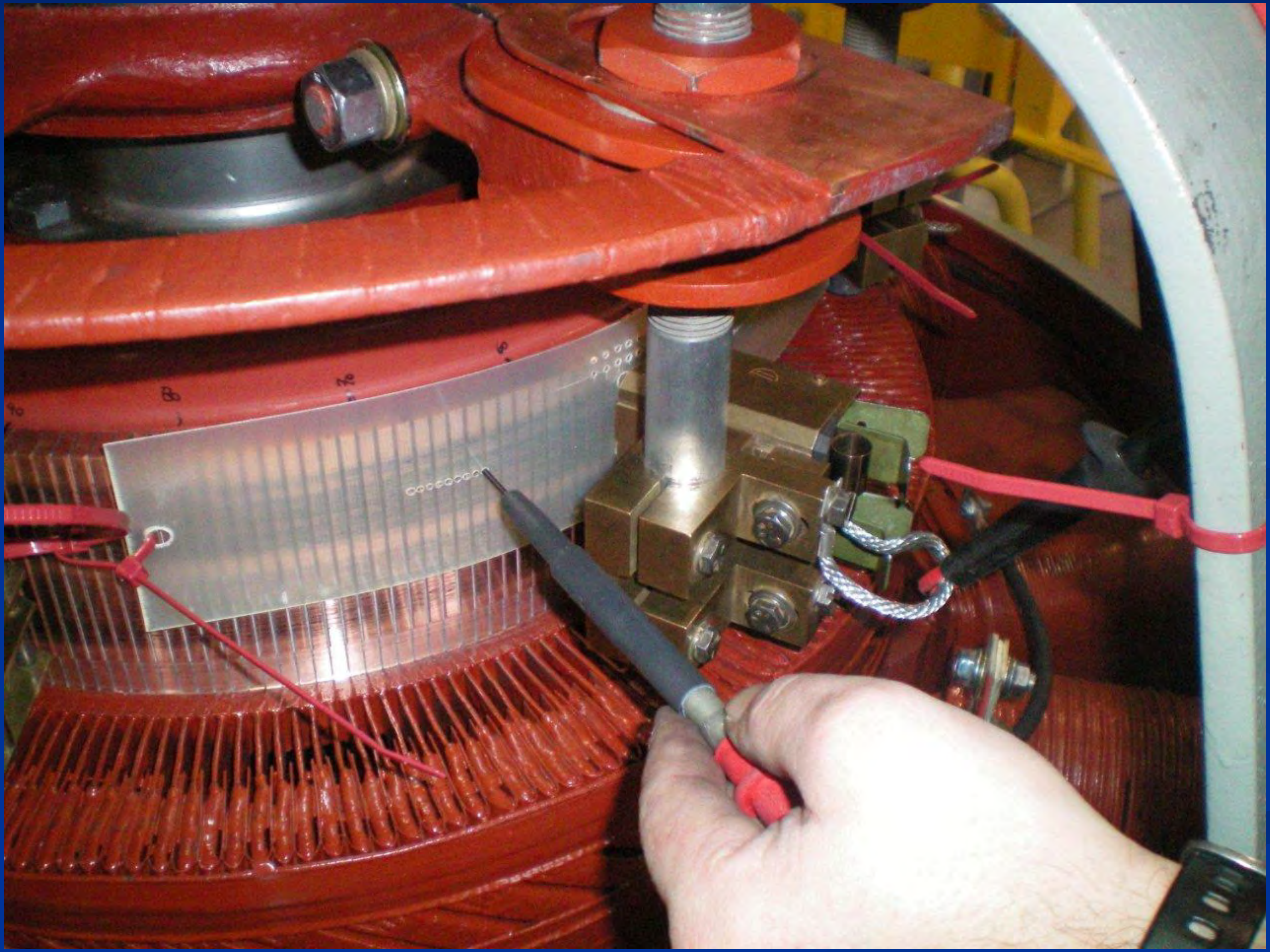
Rotating exciter adjustments and testing at site

G2 exciter set up for **PVN** (Pencil Voltage Neutral) **Test**



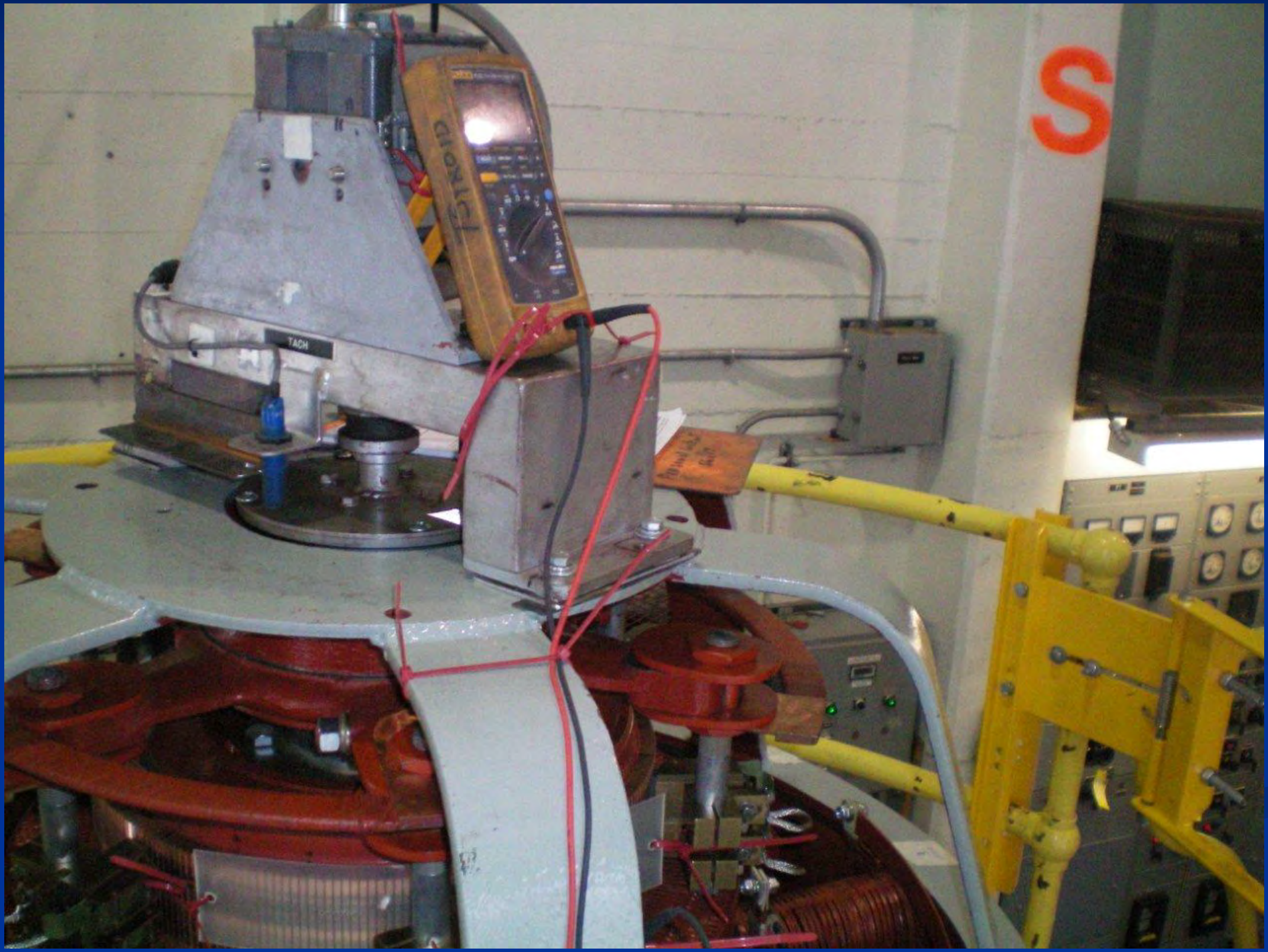
Rotating exciter adjustments and testing at site

G2 exciter Pencil Voltage Neutral PVN test on spinning machine .



Rotating exciter adjustments and testing at site

G2 exciter Pencil Voltage Neutral PVN test .



Rotating exciter adjustments & testing
Pencil Voltage Neutral (PVN) Test

Jan 27, 2011

PVN

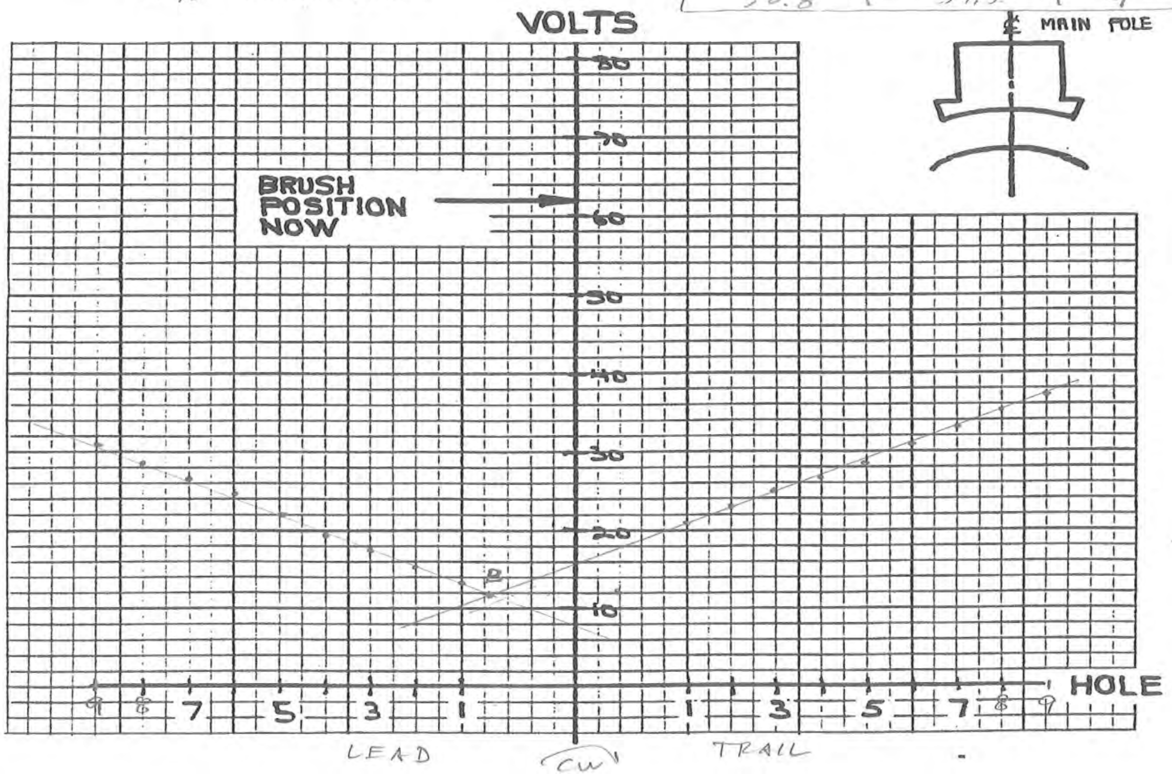
plot #11

N/P	ACTUAL	
	102V	VA
	0	IF
	257	RPM
	CW	ROT
	#3	STUD

rated speed, no load, Field breaker - opened

@ 30v - 5.5 T
8.7 L
-3.2/2 = -1.6+0.175 = 0.200"

LEAD	TRAIL	HOLE
13.6	21.3	1
15.6	23.4	2
17.7	24.8	3
19.7	26.4	4
22.0	28.5	5
24.3	31	6
26.5	33.5	7
28.7	35.5	8
30.8	37.5	9

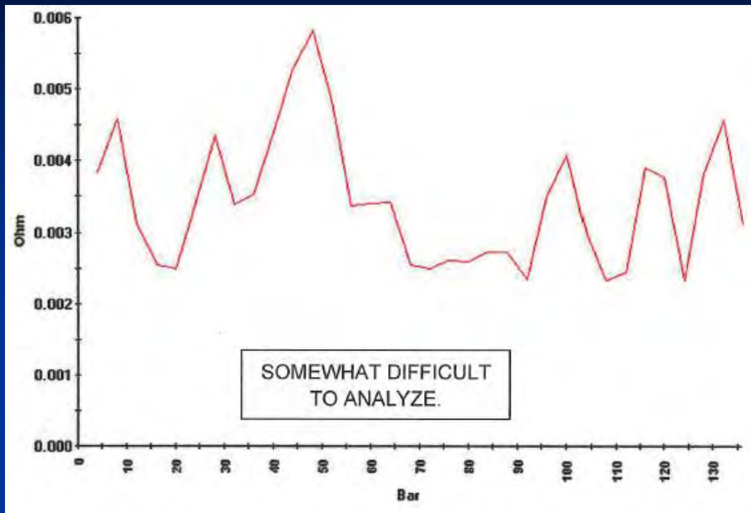


Importance of armature resistance test


ARMATURE WITH HIGH-RISERS


FAILED HIGH-RISERS

Bar-to-Bar (“Span of Bars”) Resistance Test method



Before repair

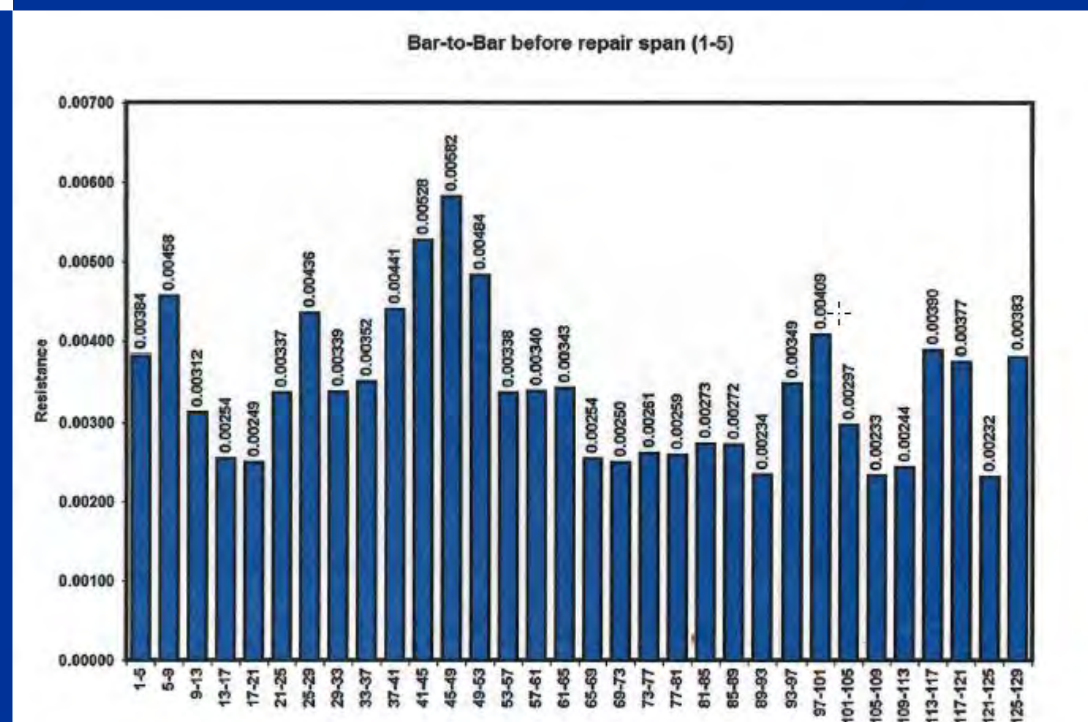
Acceptance criteria :

Deviation “ Span of Bars” < 1 %
Deviation “Bar-to-Bar” < 5 %

Graph below : Note variations in resistance measurements > 20%

RULE for Span method :
The span should be less than one pole-pitch.
Suggested span = ¼ of bar pole-pitch. The fewer number of bars spanned the more accurate the results.

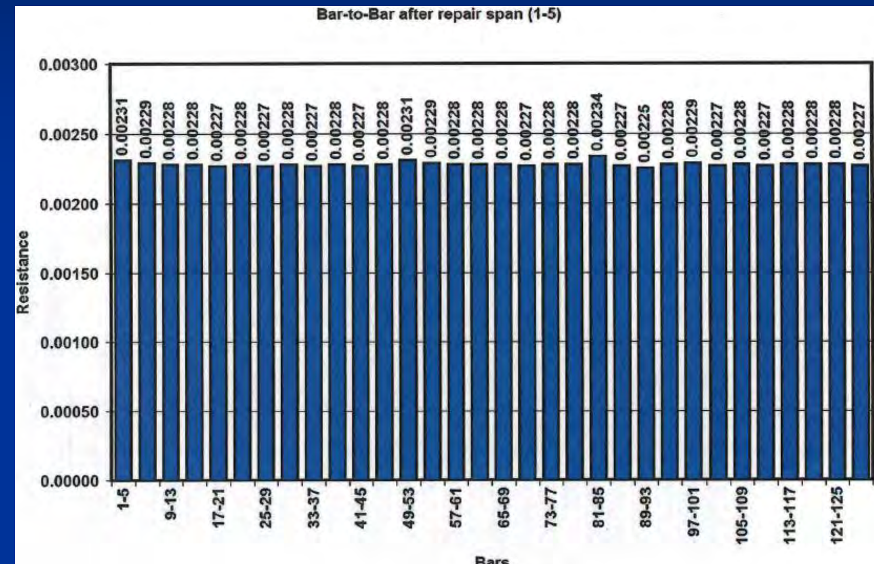
Bar per pole = Bars/Poles
126 bars/6 poles=21 bars
Bar pole Pitch= 1 & 22



Bar-to-Bar ("Span of Bars") Resistance Test method

After repair

COMMUTATOR LESS FAILED RISERS   COMPLETED ARMATURE REWIND

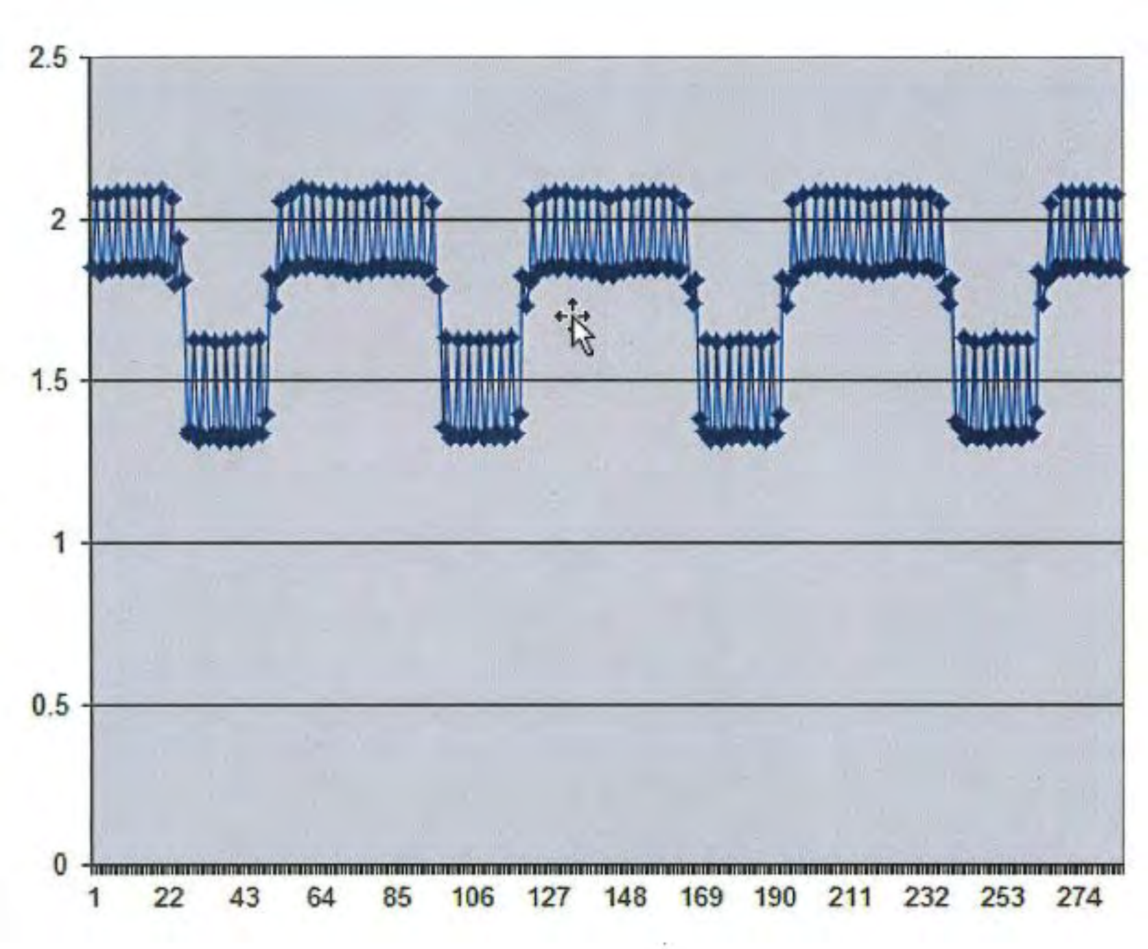


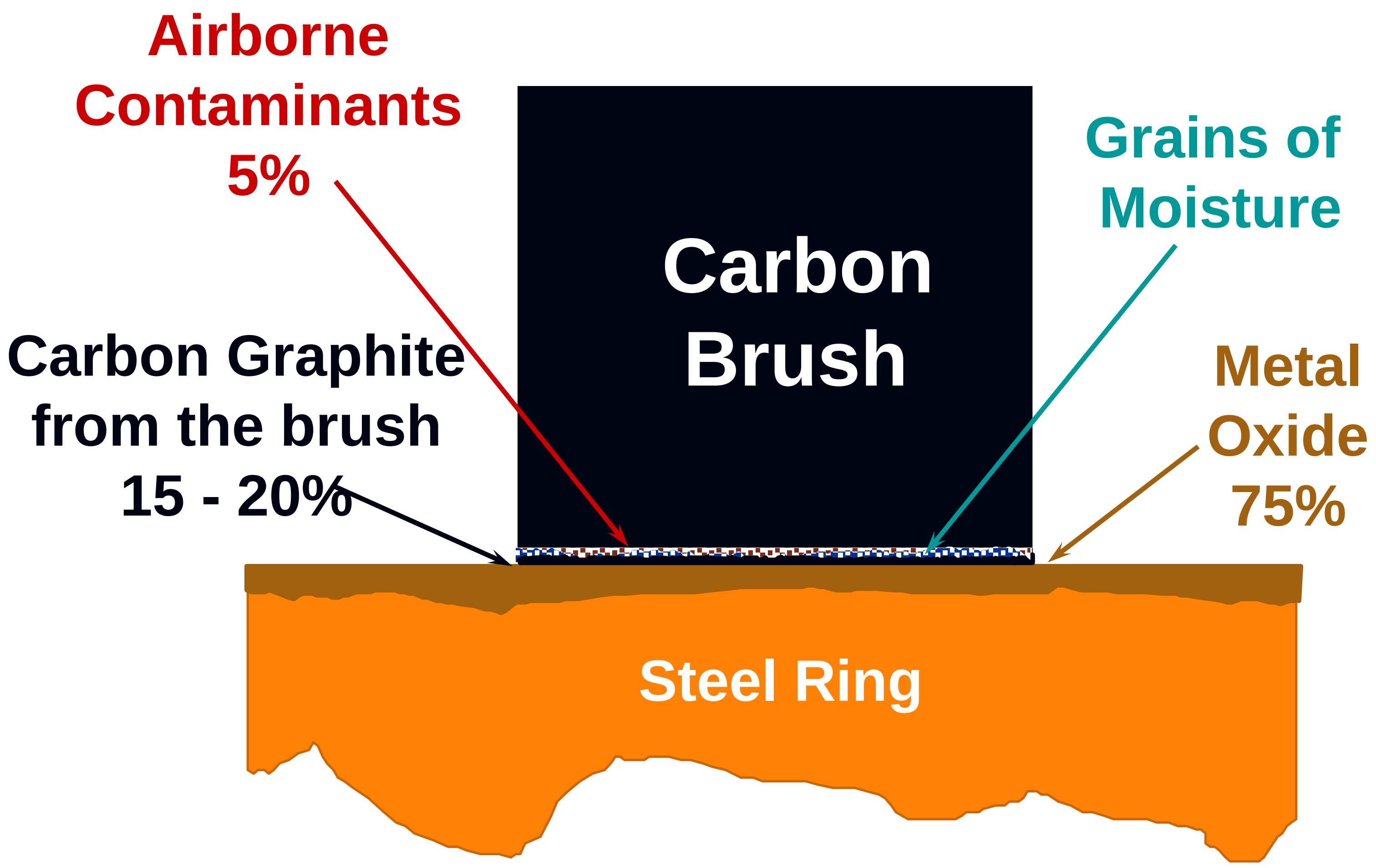
HELPFUL HINTS FOR BAR-TO-BAR TESTING

1. Caution when using spanned bars option.
2. Span bars ½ pole pitch or less, prefer ¼ pole pitch.
3. Dump raw data to Microsoft Excel- perform calculations of unbalance.
4. Convert raw data to Microsoft Excel bar chart.
5. Perform bar-to-bar testing on suspect spanned bars.

Bar-to-Bar Resistance Test
(armature winding with Equalizers)

Expect repeatable pattern
on good commutator and armature winding





Slip Ring Film Makeup

Why Brushes Wear so fast ?

- Carbon rubbing on bare copper/steel
  - high friction
- Comm/slipring surface with good film
  - low friction

Rule of thumb : brush wear 0.003 to 0.006 inch/day

or about **5 mm / 1000** hours

Humidity

Units

- Relative Humidity (RH) - %
- Absolute Humidity – grains / lb dry air

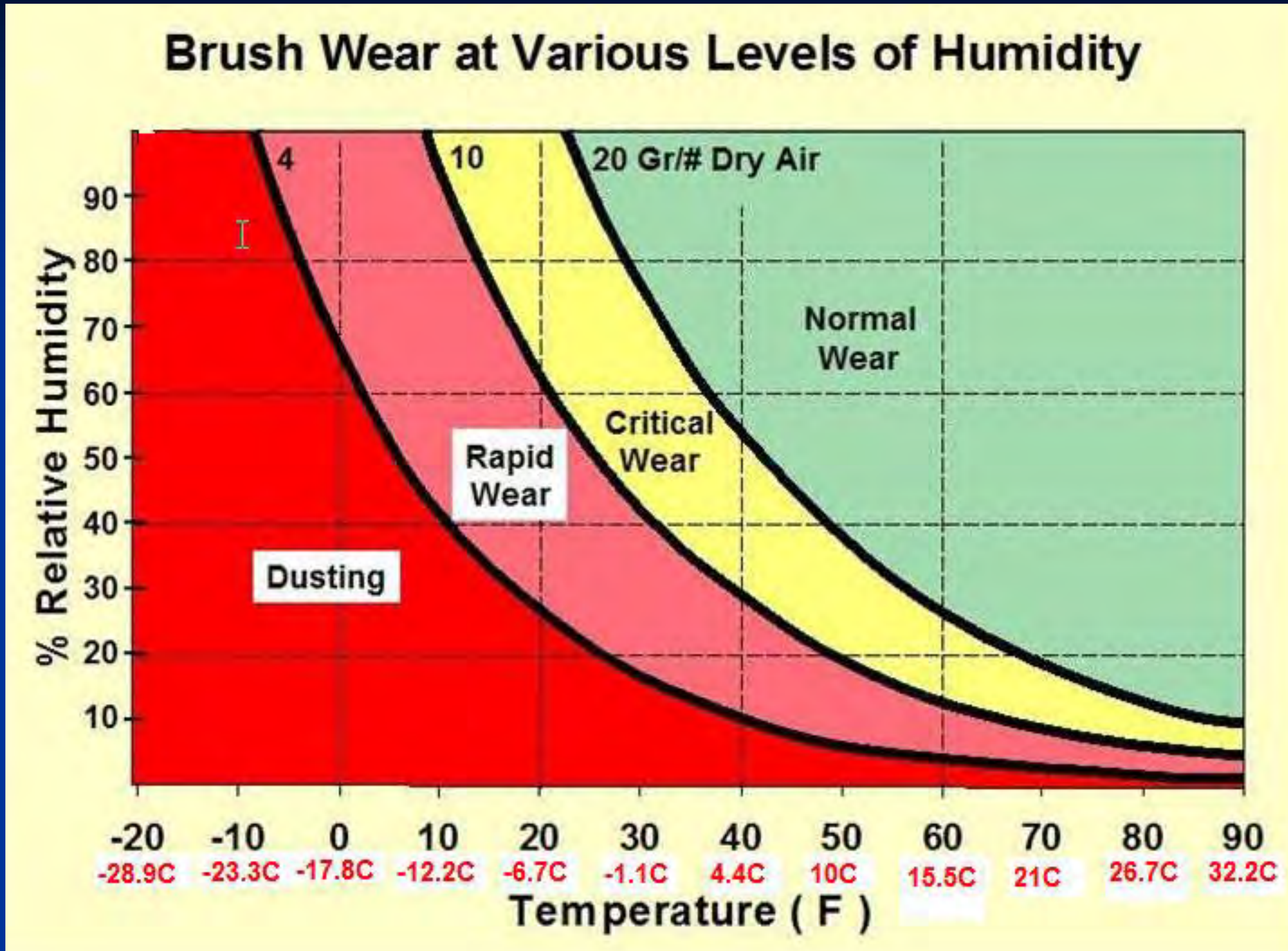
  1 grain = 0.000143 lbs

Two critical thresholds : 2 and 25 g of water / m ^{3} of air

- less than 2– brush wear
- above 25 – commutator deterioration

Rapid Brush Wear :

- about 20 % RH at 75 F, 24°C or
- about 40% RH at 55 F, 13°C


Brush Wear at Various Levels of Humidity
4
10
20 Gr/# Dry Air
Normal Wear
Critical Wear
Rapid Wear
Dusting
% Relative Humidity
90
80
70
60
50
40
30
20
10
-20 -10 0 10 20 30 40 50 60 70 80 90
-28.9C -23.3C -17.8C -12.2C -6.7C -1.1C 4.4C 10C 15.5C 21C 26.7C 32.2C
Temperature (F)

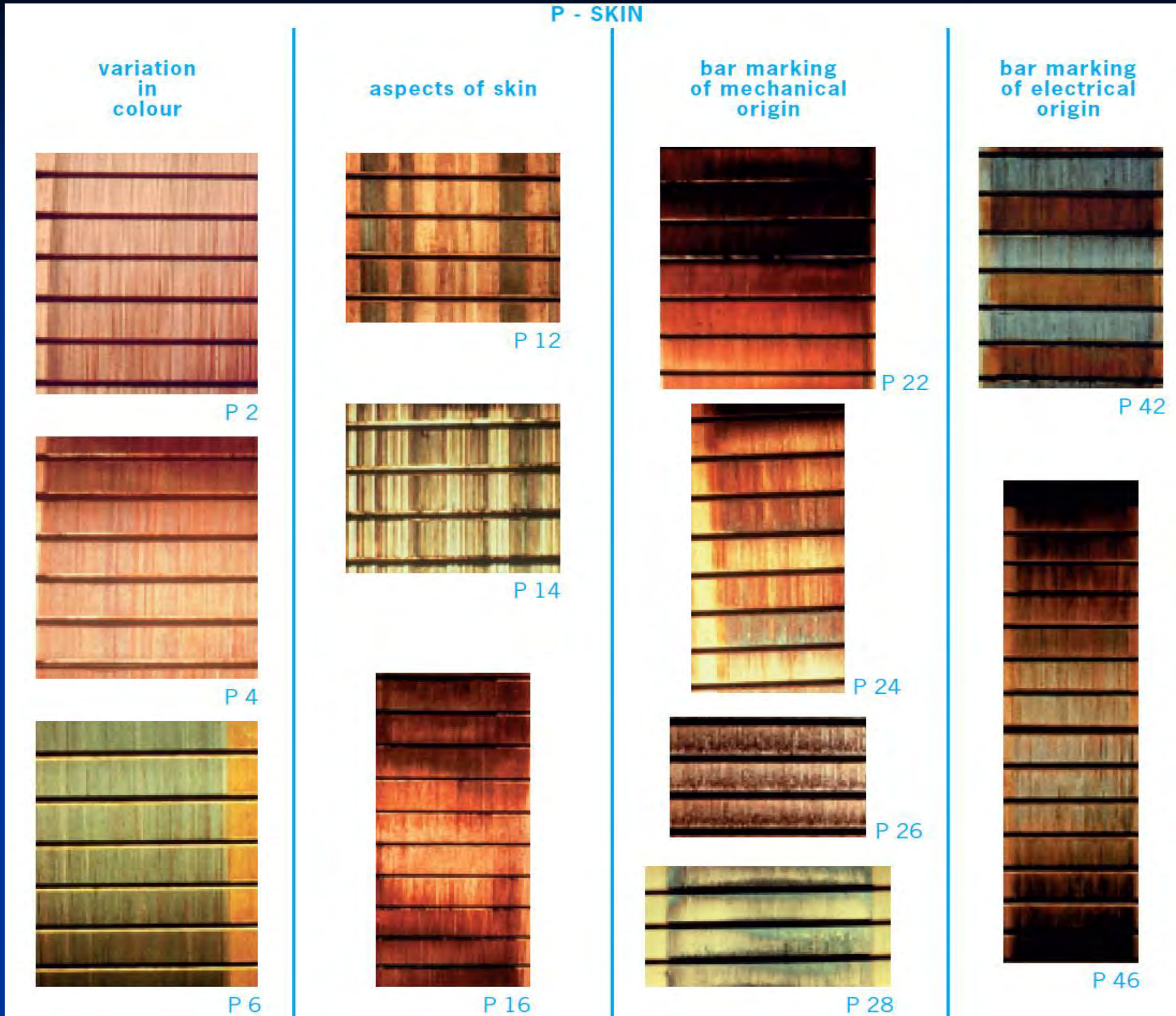
What is Good Commutator Film ?

Commutator filming is a continuous process !

(formed and stripped and formed and ....maintained)

Commutator COLOR

- Chocolate brown or burnished bronze to dark brown
- It is not bright copper or burned black copper color
- Uniform in color


P - SKIN
variation in colour
aspects of skin
bar marking of mechanical origin
bar marking of electrical origin
P 2
P 4
P 6
P 12
P 14
P 16
P 22
P 24
P 26
P 28
P 42
P 46

Requirements For Good Film

In General :

Brush Current density :	55-85 Amps/in²
Commutator Surface Temperature :	60-90°C
Water Vapor (optimum):	8-15 g of water/ m^3air
Brush Pressure :	2 to 4 lbs/in²
Commutator Surface Speed (D, rpm)	< 8,000 fpm
Brush Material or Grade	no MAGIC brush
Lack of Contamination (vapors)	Silic.,Sulf.,Chl.
Mechanical Integrity and Setup	El neutr,alignm.

Brush angle

- Trailing : at least 5° (5-15° common use)
- Reaction : 30-35° (with 22 ° minimum safe)

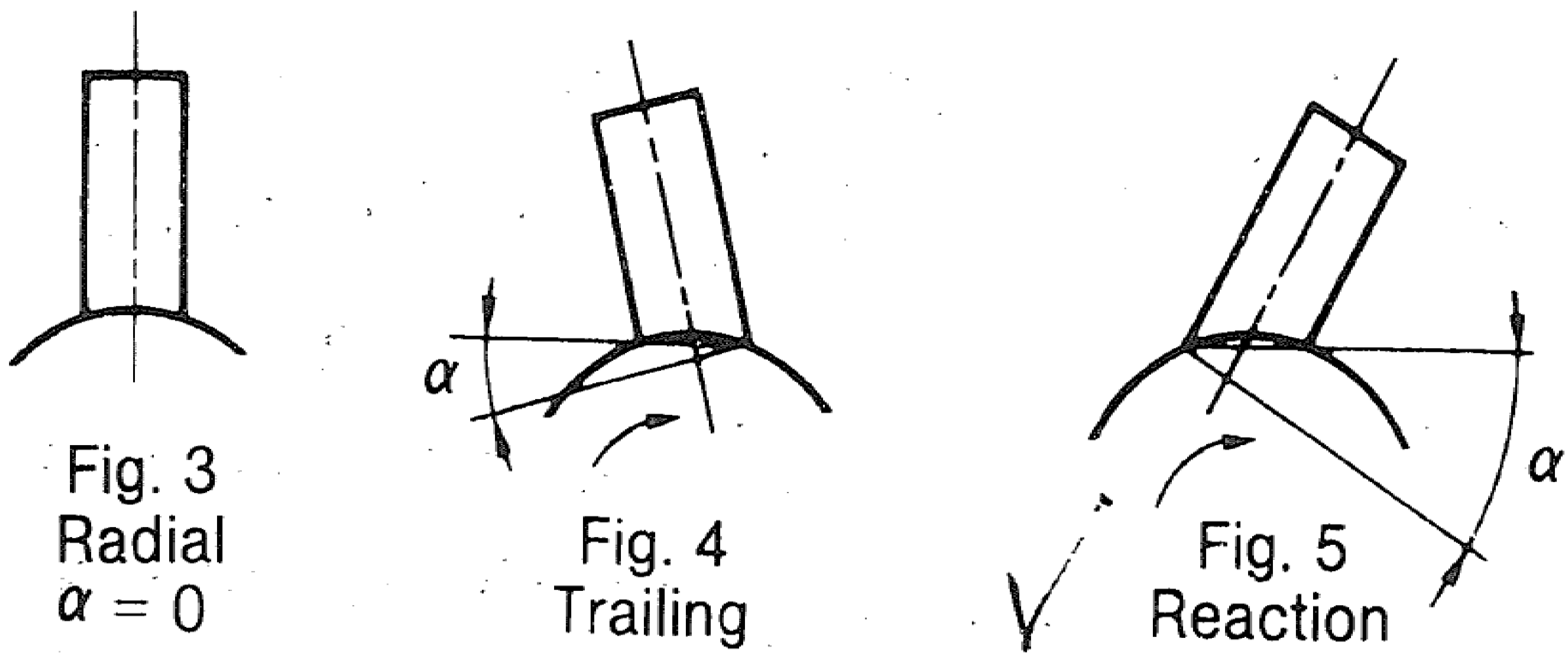


Fig. 3
Radial
$\alpha = 0$

Fig. 4
Trailing

Fig. 5
Reaction

PRINCIPAL CHARACTERISTICS

GRADE GROUP	GRADE	Apparent density	Resistivity µΩ.cm (µΩ.inch)	Shore Hardness	Flexural strength MPa PSI	Contact drop ΔU en V	Friction	Maximum current density A/cm² (A/inch²)	Upper speed limit m/sec. (ft/sec.)	Metal content %
Carbo-graphitic	A 121	1,75	2 200 (710)	30	25	M	L	12 to 20 (75 to 125)	≤ 15 (≤ 49)	
	A 122	1,67	45 000 (16 000)	27	20	H	L	10 to 12 (65 to 75)	≤ 15 (≤ 49)	
	A 176	1,60	52 500 (21 717)	40	20	H	L	8 to 10 (50 to 65)	30 (98)	
	A 210	1,57	25 000 (10 000)	30	16	M	L	8 to 10 (50 to 65)	≤ 25 (≤ 82)	
	A 252	1,57	45 000 (16 706)	27	16	H	L	10 to 12 (65 to 75)	≤ 25 (≤ 82)	
Soft graphitic	LFC 501	1,46	1 900 (835)		8	M	M	6 to 10 (40 to 65)	75 (246)	
	LFC 554	1,26	2 000 (835)		10	M	M	11 to 13 (71 to 84)	90 (295)	
Electro-graphitic	EG 34D	1,60	1 100 (460)	35	25	M	M	12 (75)	50 (164)	
	EG 389P	1,49	1 600 (668)	29	19	M	M	12 (75)	50 (164)	
	EG 396	1,52	1 600 (668)	27	19	M	M	12 (75)	50 (164)	
	EG 362	1,62	2 500 (1 045)	35	21	M	M	12 (75)	50 (164)	
	EG 40P	1,62	3 200 (1 336)	57	27	M	M	12 (75)	50 (164)	
	EG 313	1,70	4 700 (1 963)	54	21	M	L	12 (75)	50 (164)	
	EG 367	1,53	4 100 (1 720)	48	21	M	M	12 (75)	50 (164)	
	EG 332	1,52	4 200 (2 025)	48	21	M	M	12 (75)	50 (164)	
	EG 387	1,63	3 300 (2 000)	60	39	M	M	12 (75)	50 (164)	
	EG 300	1,57	4 200 (1 680)	58	24	M	L/M	12 (75)	50 (164)	
	EG 98	1,60	3 400 (1 503)	60	33	M	M	12 (75)	50 (164)	
	EG 369	1,57	5 100 (2 030)	55	25	M	M	12 (75)	50 (164)	
	EG 319P	1,46	7 200 (3 007)	52	26	H	M	12 (75)	50 (164)	
	EG 321	1,46	6 600 (1 420)	54	26	H	M	12 (75)	50 (164)	
	EG 365	1,62	5 300 (2 840)	48	15	M	M	12 (75)	50 (164)	
Impregnated electro-graphitic	EG 7099	1,72	1 150 (460)	40	34	M	M	12 (75)	45 (148)	
	EG 9599	1,61	1 600 (640)	33	28	M	M	12 (75)	45 (148)	
	EG 9117	1,69	3 300 (1 320)	77	32	M	M	12 (75)	50 (164)	
	EG 8019	1,77	4 700 (1 880)	77	31	M	M	12 (75)	45 (148)	
	EG 8067	1,67	3 900 (1 600)	77	36	M	M	12 (75)	45 (148)	
	EG 8220	1,82	5 000 (2 180)	90	48	M	M	12 (75)	50 (164)	
	EG 7097	1,68	4 000 (1 560)	80	35	M	M	12 (75)	50 (164)	
	EG 341	1,57	7 025 (2 800)	74	34	H	M	12 (75)	50 (164)	
	EG 364	1,58	6 500 (2 720)	73	35	H	M	12 (75)	50 (164)	
	EG 6489	1,57	6 900 (2 720)	75	35	H	M	12 (75)	50 (164)	

CONTACT DROP

The value of contact drop and friction is given by the use of symbols having the following significance

Symbol	Indication	Contact drop in volts Sum of both polarities	Friction
H	High	H > 3	H > 0.20
M	Medium	2.3 < M < 3	0.12 < M < 0.20
L	Low	1.4 < L < 2.3	L < 0.12
VL	Very low	0.5 < VL < 1.4	
VVL	Very very low	VVL < 0.5	

Jig to seat the brushes in the shop

Questions ?