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C-A OPERATIONS PROCEDURES MANUAL

15.3.3.25 C-AD Motor Generator (Siemens) Maintenance

(Booster/AGS Ring Power Supply Systems Group Procedure EPS-S-025)

Note: This document was formerly a C-A Group Procedure. The content of the group procedure was reviewed by the Technical Supervisor. All approvals and/or issue dates of the original group procedure are maintained for present use.

Hand Processed Changes

HPC No.	Date	Page Nos.	Initials

Approved: ***Signature on File***
Collider-Accelerator Department Chairman

Date

M. Bannon

Booster/AGS Ring Power Supply Systems
Group Procedure EPS-S-025
Original Issue Date: 10/20/03
Revision 00

Brookhaven National Laboratory

Brookhaven Science Associates

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C-AD MOTOR GENERATOR (SIEMENS) MAINTENANCE

June 23rd through August 31st, 2003,
after 4,784 hours of run time

Viorel Badea

Michael Bannon

Jon Sandberg

Date: October 20/2003

This document consists of 22 pages and contains 12 attachments

The operation was based on the following document:

List of mechanical tasks to be completed during Siemens summer 2003 maintenance.

Before stopping the machine for maintenance the following operations to be performed:

- **Take and record a vibration reading of the set.**
- **Record the coast down time.**
- **Install the newly designed "Laser Protection and Access Platform."**

After that the following operations to be accomplished:

- Open end covers generator (metal and fiberglass) and motor for inside inspection:
- Inspect the retaining rings, measure the gap, compare to previous measurements to assess stability of the system.
- Use boroscope to evaluate any changes that may have occurred inside of the machine. (Pictures to be taken for reference)
- Tap the pole wedges to asses the torque of the main retaining bolts.
- Break the main coupling and roll out the bearings for inspection.
- Measure the journal-bearing clearance (lead crush test)
- Reshape the metal seals (do not replace unless it becomes apparent that they are worn out. (Decision to be made after disassembly).
- Install new thermo couple.
- Install new pressure gauges (if we have them in house by then).
- Check and replace brushes as needed on generator and motor side.
- Clean collector rings and covers as well as space in between rings.
- Check and clean oil filters downstairs (both of them).
- Check torque of pedestal and buss connection bolts (100% of them)
- Clean inside of the machine as deep as accessible.
- Inspect heat exchangers and pit area for dust and clean. Function of the status of heat exchangers we may open one clean and repaint.
- Install newly fabricated head of "Liquid Rheostat Heat Exchanger" (we'll keep the other two as spares).
- Realign the machine using the "Optalign" device.
- Re-torque all the bolts by the given specs.

This operation is meant to detect and correct all the possible defects that might have occurred during almost one year of operation.

Viorel Badea 05-02-03

A. The vibration measurements were taken before the machine was shut down, and the results can be seen in attachments #1a. 1b, 1c
   The signature of the targeted points (pedestals 1,2 and 3) was similar to the one found by E in 2002
B. The coast-down time was: **1h and 17min.**
C. The newly designed "Laser Protection and Access Platform" was installed. An additional secondary platform was installed on the West side of the Generator.

Physical Inspection of Motor and Generator and Maintenance Performed

1. General Condition of Windings.

The new generator windings are in good shape. The inside of the machine had been vacuumed and cleaned with dry rags as deep as accessible. The air ducts were inspected and found to be clean. The pit area was also found to be clean.

The motor windings, air ducts and basement pit were in good shape and generally clean. They were cleaned again in the same way as the generator side.

2. Retaining Rings

The retaining rings were inspected visually from the front of the machine and with the boroscope from inside.

The gap between the stator and the outer diameter of the rings was measured and found to be unchanged from last year. (The results are shown in the next paragraph). While booroscoping the inside of the machine 39 pictures were taken and can be viewed at :\\dwg-server\ENG-ARCH\ags\mg_photo\siemens_03_photos

3. Stator-Rotor Alignment.

a) The Generator's Air Gap was checked and the variation was found to be as follows:

South mean = 0.5915; variation: +1.48%, -4.65%
North mean = 0.5763; variation: +1.17%, -2,83%
Please see attachment # 2

(GE results from 2002 were showing variations between +4.50% and –2.76%)

Since the Air Gap was within tolerance limits and close to last year's results, the stator was not moved.

Note: The readings were taken at the outer diameter of the retaining rings to minimize the errors generated by the expandable measuring devices used in the past. The lift pumps were on.

b) The Motor's Air Gap was checked and it was determined that the stator has to be moved West by 0.015".

After moving and pinning the stator, the air gap was as follows:

South mean = 0.1659; variation: +2.47%, -2.77%
North mean = 0.1662; variation: +1.85%, -1.16%
Please see attachment #3

(GE results from 2002 were showing variations between + 4.5% and –2.70%)

Note: New reamers were fabricated for the tapered and straight pins and consequently new pins were fitted into the holes.
A small size magnetic drill was purchased and used with a "Variac" device inserted in the main motor electric supply line (not in the magnet line) to lower the RPM of the drill in order to improve the texture of the reamed surface. (The fact that the motor's stator again moved East-ward was attributed to the rough texture of the pins' holes, which were reamed by hand in the past).

4. Brush Rigging.

The motor and generator brush rigging assemblies were found in good shape without excessive wear and tear. Some oxidation was found on the generator excitation collector rings.

We assume that the rust occurred due to the humidity in the MG room and obviously after the shut down. The rings were cleaned with a fine abrasive stone.

Before reassembling the brush rig the entire area was cleaned with:

PT 21 (environmental safe degreaser) **made by Captree** and recommended by GE.

On the motor collector ring 35 brushes were changed (out of 88), and fitted on the collector rings.

On the exciter collector ring 37 brushes were changed (out of 60) and fitted as above. The polarity was reversed on the excitation rings. (This operation is recommended by Siemens in order to minimize the metal transport by the brushes).

5. Heat Exchangers

The heat exchanger's covers was rusted inside, but the pipes were quite clean.
Every heat exchanger of the motor and generator was taken apart, the pipes cleaned inside, and the covers were sand blasted and repainted inside with:

Water-Immersible Epoxy, Mc Master Carr's Item # 77915T35.

New gaskets were made and the hardware was torqued to spec. Since some of the hardware showed some wear, a new set of hardware was ordered and was placed in storage to be on hand for the next shut-down.

The replacement of the hardware is recommended for the next machine overhaul.

During the 4-hour run on Oct. 16th I noted an increase of ~20% in the efficiency of the heat exchangers. I attribute that to the thorough refurbishing of the heat exchangers.

Since we have new tools for this operation, (that will shorten the duration of it) we should do the maintenance of these radiators every time we perform a major overhaul of the machine.

6. Coupling Bolts.

The coupling was separated and the bolts cleaned and, examined. No apparent defects were found. An attempt was made to X-ray one of the coupling bolts that emitted a squeaking sound during the torquing operation. The size of the bolt was too large for Central Shops' X-ray machine and consequently we had to settle for a lesser control operation, which was the "Dye Penetrant" test.

The bolt turned out to be sound and was reused. It was determined that the hydraulic tool, not the bolt, had caused the squeaking sound.

All holes were cleaned and anti seize compound was applied on the threads and clamping faces of the bolts.

The bolts were torqued to specification using the hydraulic tool HY-30XLCT. The operation was performed in two steps to ensure the uniformity of the clamping force on all bolts.

The hydraulic tool was serviced twice by its designer/manufacturer; once before it was used, and once afterwards.

The manufacturer recommended using -dry molycote lubricant on the moving parts of the wrench frequently during operations.

7. Bearings and Shaft Status.

A. Bearings Alignment

With the coupling separated by 1/8" and with the upper bearing covers off, an alignment measurement was performed using the "Optalign" device.

The machine was found to be very well aligned within 0.50 mills on all the mandatory points. (The indicated tolerance is +/- 0.001"). Please see Attachment #4

Under same conditions a redundant check was performed using a set of filler gauges between the two halves of the coupling. The results were the same.

Based upon the above results and the fact that the oil was without any traces of Babbitt in it, the decision was made not to roll out the lower part of the bearings. (Rolling out the lower halves of the bearings would have called for a new alignment procedure without a significant benefit).

B. Journal Bearings and Upper Bearing Status

The journal bearings were found in very good shape except for very minor nicks, which were easily corrected with a very fine granular stone. (These nicks could have occurred during last years handling of the set).

The lower part of the journal bearings -that was held inside the lower bearing during this maintenance period -were found slightly oxidized. The spots were cleaned with 3M cleaning pads. Please see attachments # 5, 6, and 7 showing the journals before cleaning.
Attachment #8 shows a typical picture of one of the journal bearings after cleaning.

The upper bearings were found in good shape and only a few spots had to be lightly scraped. These spots were located close to the bearing separation.

C. Bearings Clearances

The bearing clearances were checked using the "Lead crush test"

The results were as follows:

- Pedestal #1: average clearance = 0.664/0.609 mm (0.026"/0.024")
- Pedestal #2: average clearance = 0.667/0.667 mm (0.026"/0.026")
- Pedestal #3: average clearance = 0.124/0.165 mm (0.005"/0.006")

All of the above results are within the spec.
Please see attachments #9, 10 and 11.

D. Generator Shaft Inclination:

South End:	North End:
12 sec South End High	6 sec North End High

8. Shaft Rise with Lift Pumps:

- On July 7th before starting maintenance one test was performed. The results were:

Ped. #1	Ped. #2	Ped. #3
0.0060	0.0040	0.0055

- On July 29th after aligning the Motor's Stator, with caps on, coupling closed and without seals, another test was performed. The results were as follows:

Ped. #1	Ped. #2	Ped. #3
0.0060	0.0044	0.0067

9. Bearing Oil Seals.

The seals were taken apart, inspected and the decision was made that they don't need to be replaced; instead they were sharpened by using the "V shape" tool.

10. Generator Exciter Resistance Test.

On October 13/2003 the electrical resistance of the Exciter was measured.
Result: 41.6 mΩ. OK

11. Generator Stator Resistance Test.

Using a low resistance Biddle, the Generator Stator's Resistance was measured (using large cables).

Results:

- X-U = 1.25 mΩ
- Y-V = 1.25 mΩ
- Z-W = 1.25 mΩ

Please see Attachment #12

12. Liquid Rheostat.

The assembly was cleaned and repainted on the rusty areas.
The new dome was installed in place.

Start-up Test

- On October 7th we started the machine for the first running test, but on the ramp-up at 200RPM the east side laser tripped the machine and applied the brake. It was decided that

the laser could be out of alignment and was disabled. A second attempt was made and at 800 RPM the west side laser was counting pulses and tripped the machine.
At that point it was decided that the laser had to be realigned and that the machine must be examined inside to find out if the laser alarm was false or not.
The covers were taken off and we boroscoped the inside of the machine; but everything looked normal

We invited GE to examine the machine and give us their opinion.
Dan Hogan and John Munch came and believed that the machine looked good and could be safely turned on.

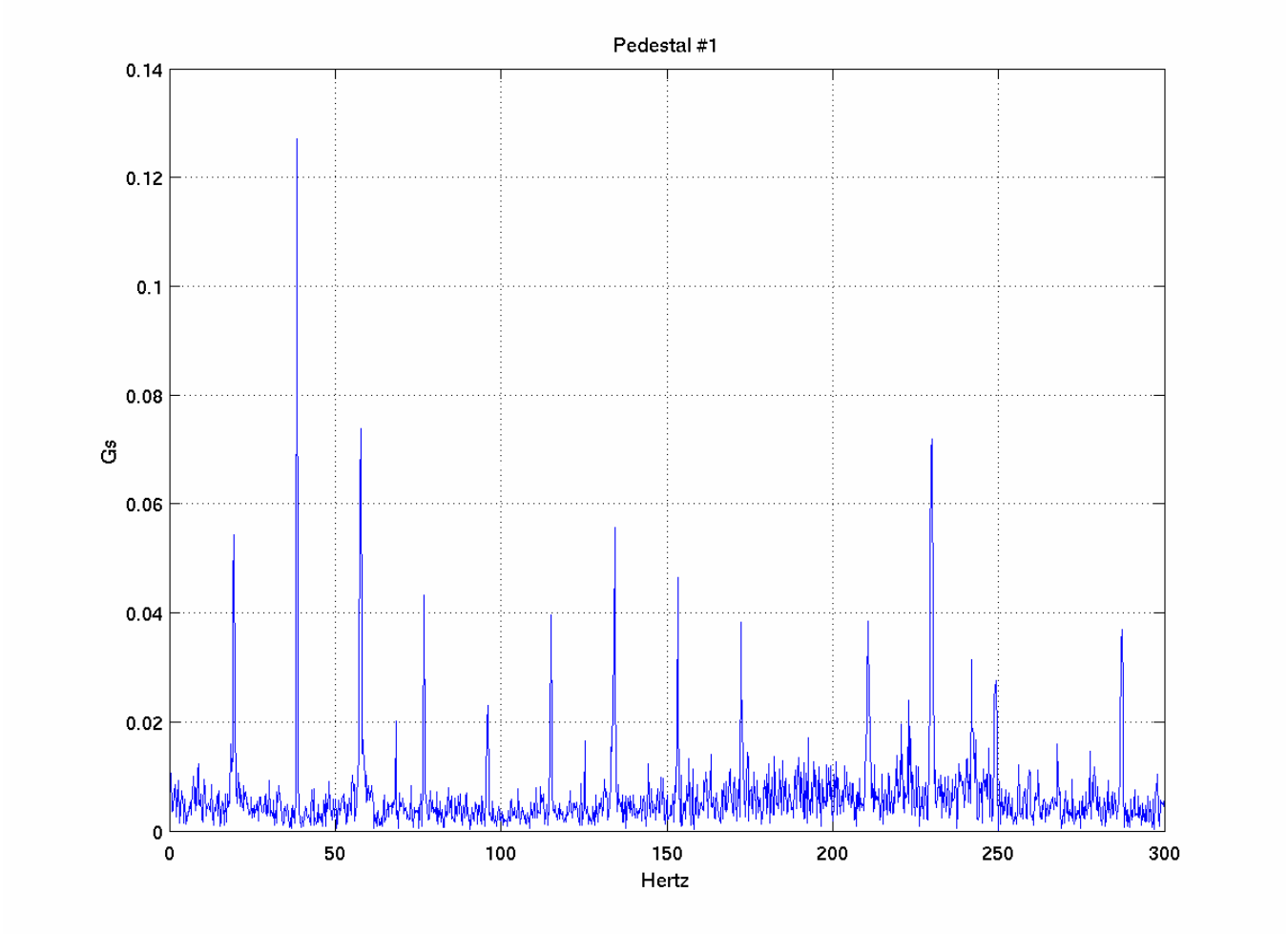
- On October 10th we realigned the laser beam as follows:
  East side @ 0.120" (3.048mm) away from the stator
  West side @ 0.100" (2.54mm) away from the stator

- On October 16th we started the machine without any incident and ran for 4 hours. The coast down time was 1h 33min. (without the Generator Brushes on).

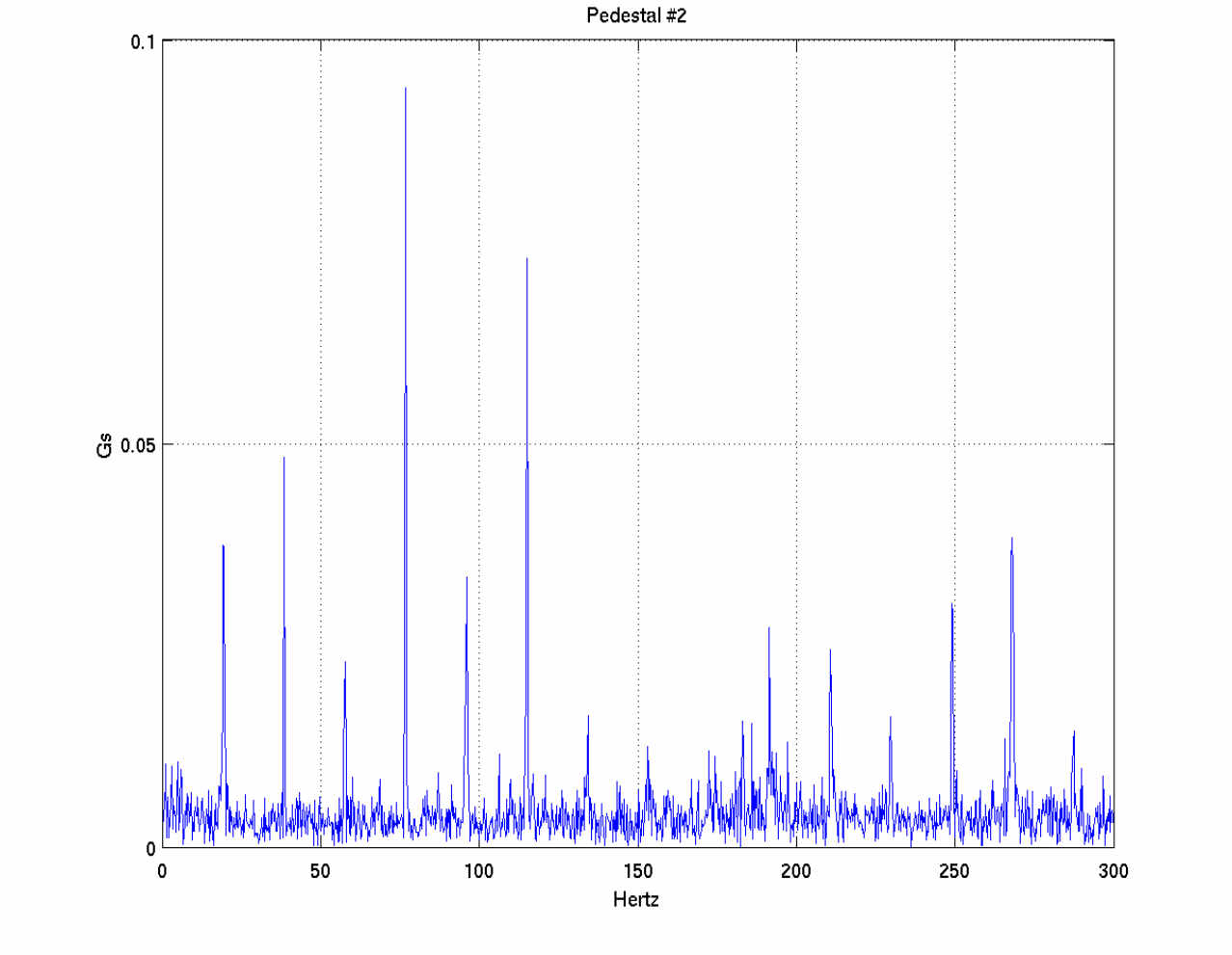
Recommendations

- I suggest replacing the existing laser transmitter and receiver (made of phenolic material) with new ones made of stainless steel. By doing this we hope to accomplish a higher reliability of the system. We need a 48-hour break to make the changes and align the laser beam.
- Next overhaul of the set we should replace the hardware pertaining to the heat exchangers. We already have the hardware in house and new tools for the job.
- During next summer or fall while we perform the next maintenance program we should run a couple of dehumidifiers in the room (or portable air conditioner units) to avoid the oxidation we noticed lately on the unprotected parts.
- I suggest to check the status of the new pins we inserted into the motor's stator, and to check the air gap as well.

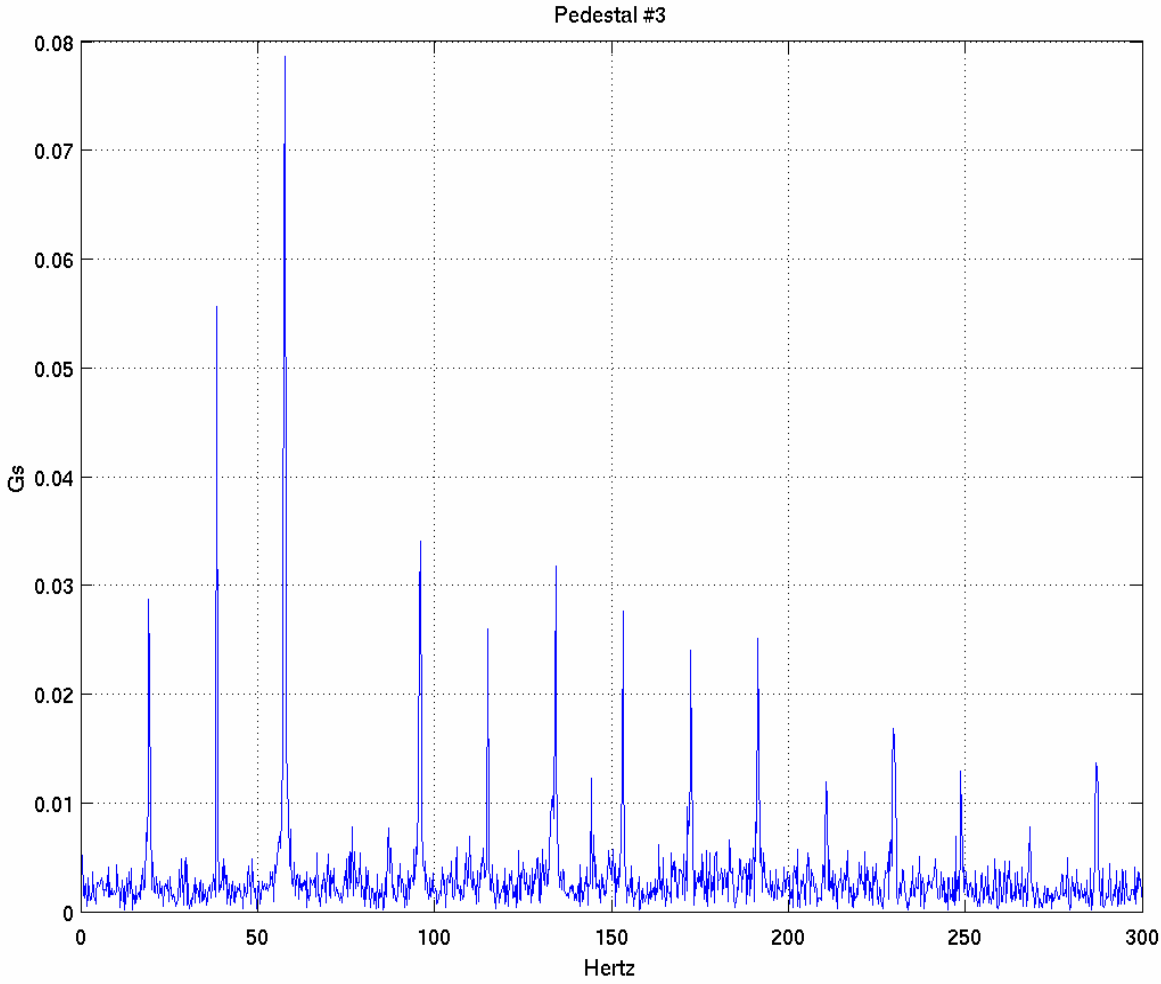
Attachment # 1a



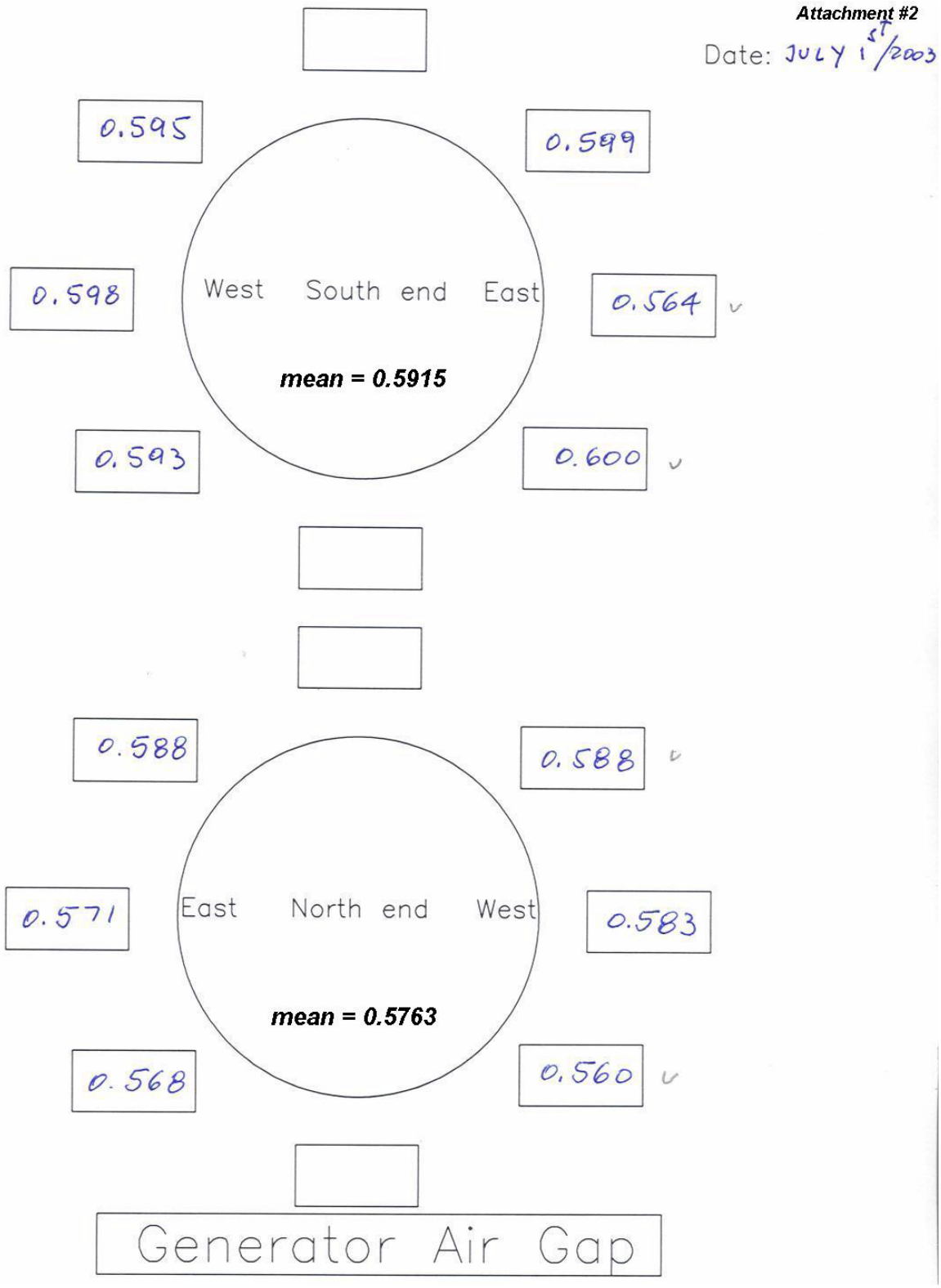
Attachment #1b



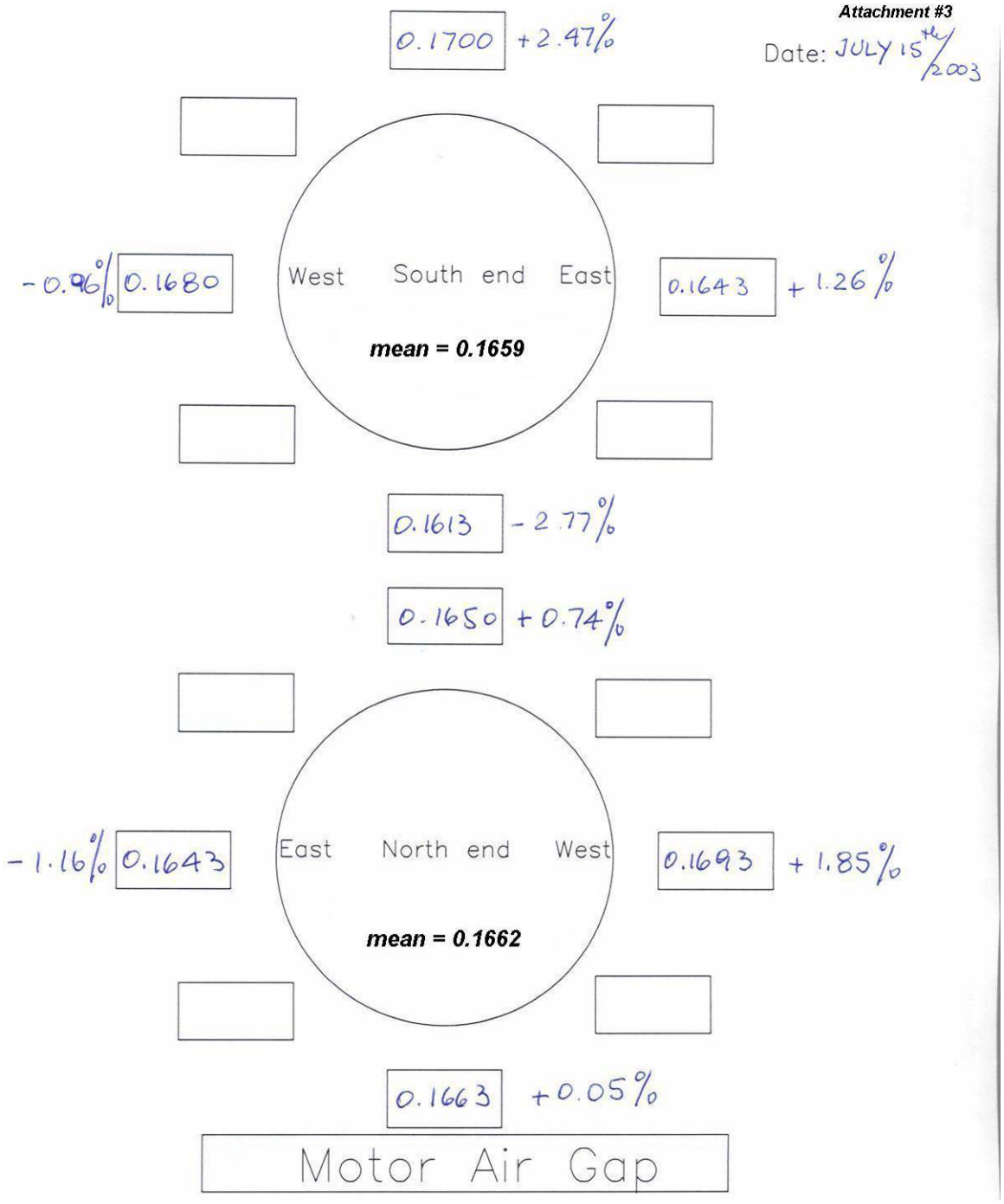
Attachment #1c



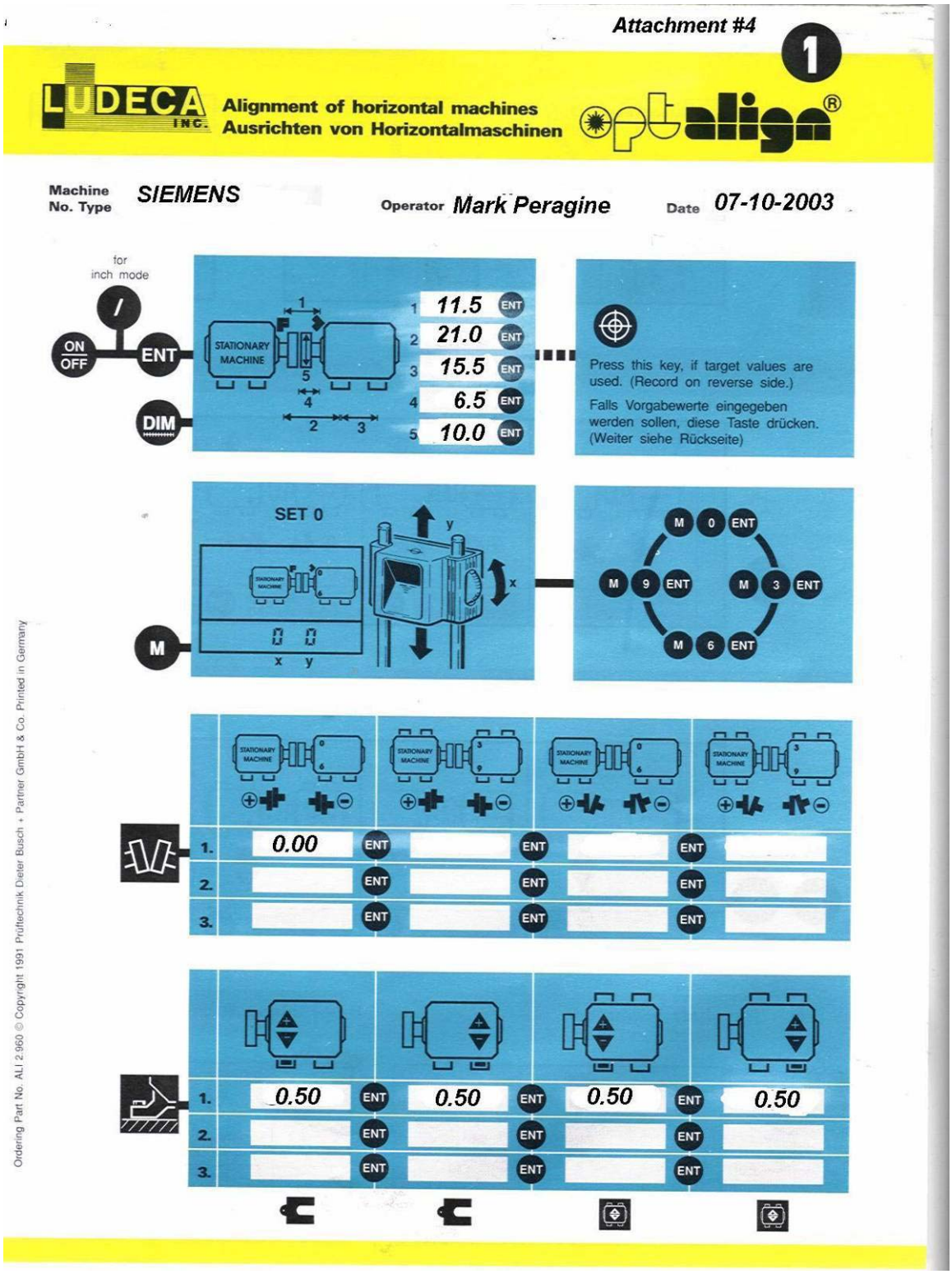
Attachment #2



Attachment #3

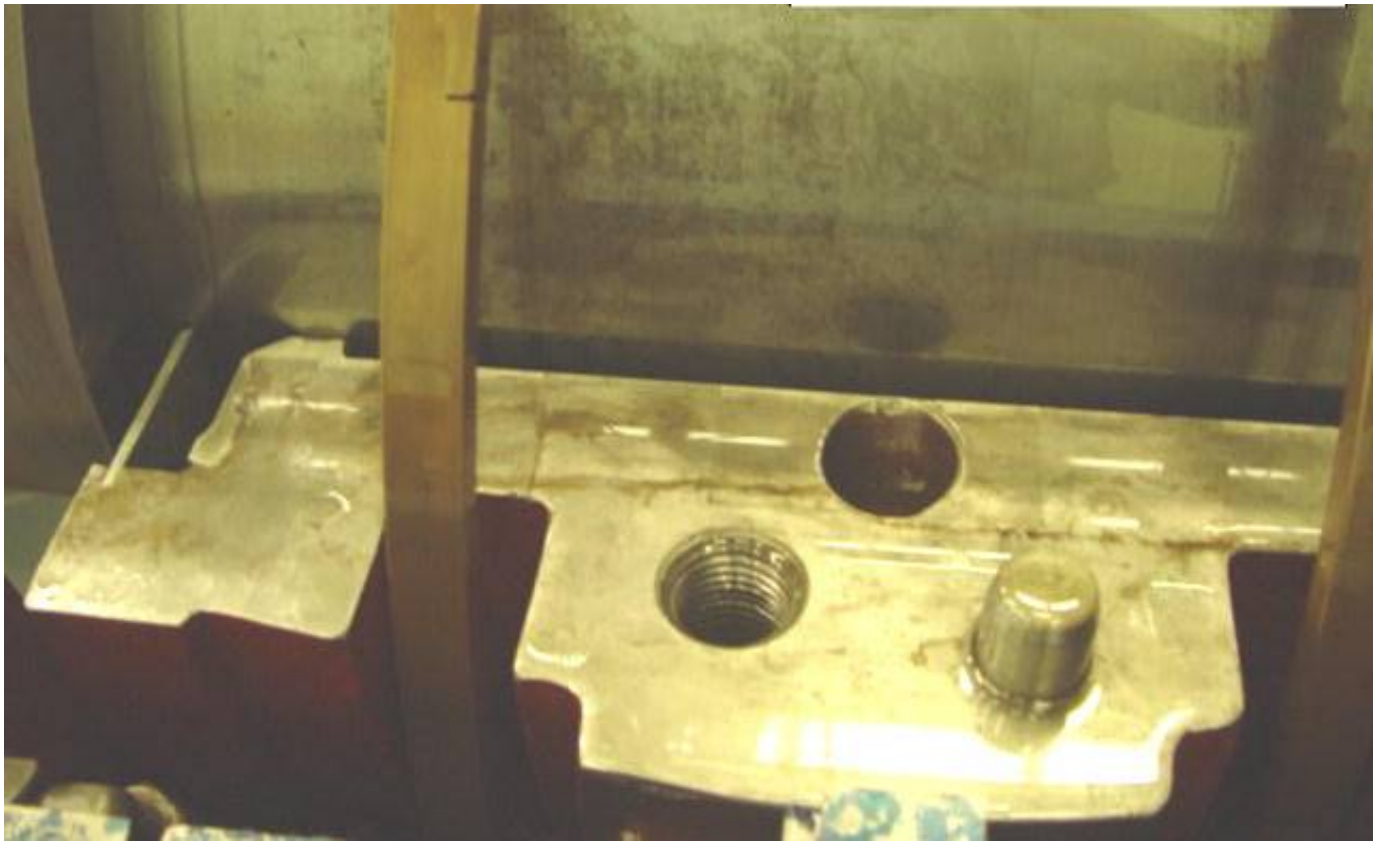


Attachment #4



Attachment #5

Attachment #6

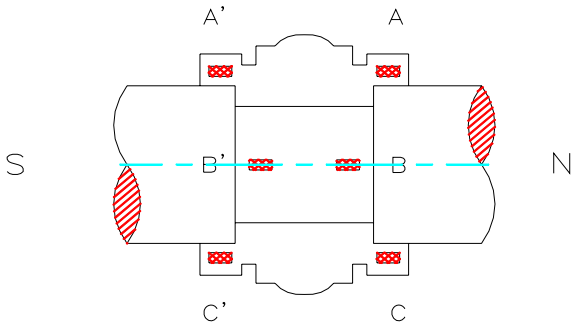


Attachment #7

Attachment #8

Attachment #9

Pedestal # 1
Lead crush test results
July 23rd/2003



A' = 0.0160 Shaft Diameter = 525mm A = 0.0160
B' = 0.0360 B = 0.0393
C' = 0.0090 C = 0.0103

Clearance @ B is: B - $\frac{A+B}{2}$ = 0.0393 - $\frac{0.0160+0.0103}{2}$ = 0.0262" = 0.664mm

Clearance @ B' is: B'- $\frac{A'-C'}{2}$ = 0.0360 – $\frac{0.0160+0.0090}{2}$ = 0.024" = 0.609 mm

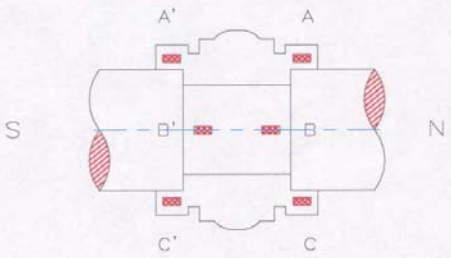
Since the Absolute Maximum Benchmark is: 0.9mm

@B location: 0.664 < 0.9 OK

@B' location: 0.609 < 0.9 OK

Attachment #10

Pedestal # 2
Lead crush test results



A' = 0.0145
B' = 0.0400
C' = 0.0130

Shaft Diameter = 525mm

A = 0.0135
B = 0.0413
C = 0.0115

Clearance @ point B is:

$$B - \frac{A+C}{2} = 0.04125 - \frac{0.0135+0.0115}{2} = 0.0263" = 0.667mm$$

Clearance @ point B' is:

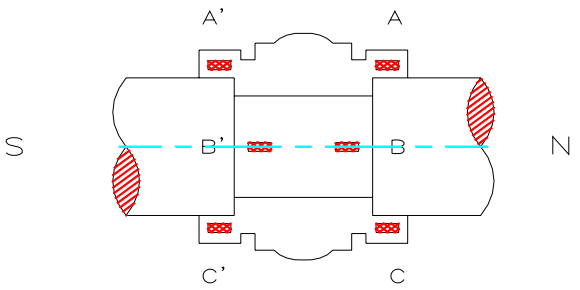
$$B' - \frac{A'+C'}{2} = 0.0400 - \frac{0.0145+0.0130}{2} = 0.0263" = 0.667mm$$

Since the Absolute Maximum Benchmark is: 0.9mm

@ B and B' location 0.667 < 0.900 OK

Attachment #11

Pedestal # 3
Lead crush test results



A' = 0.010	Shaft Diameter = 249 mm	A = 0.010
B' = 0.010		B = 0.010
C' = 0.0230		C = 0.02375

Clearance @ B is: B – (A/2 + C/2) = 0.010(0.010/2+0.02375/2)=0.004875"= **0.124mm**

Clearance @ B' is: B'- (A'/2 + C'/2) = 0.010 – (0.010/2 + 0.0230/2) = 0.0065" = **0.165mm**

Benchmark to be used for Max. Clearance is:
0.1% of Shaft Diameter that is: 0.249mm

@ B location: 0.124 < 0.249 OK

@ B' location: 0.165 < 0.249 OK

Attachment #12

SIEMENS MOTOR-GENERATOR ROTOR AND STATOR TEST PROCEDURE & RECORD SHT'S

SIEMENS MOTOR –GENERATOR TEST

DATE: 10/13/03 BY: MB

GENERATOR EXCITER RINGS(biddle low resistance measurement) S/N 7230 biddle meter.

41.6 milliohms using small clips with red & blk wire.

GENERATOR STATOR(biddle low resistance measurement)
Note: x,y,z are jumpered together

X-U 1.25 milliohms
Y-V 1.25 milliohms
Z-W 1.25 milliohms

} using large cables

GENERATOR EXCITER MEGGER TEST @ 500VDC

TEMP_____ HUMIDITY_____

FOR 0 min_____
30 sec_____
1 min_____
2 min_____
3 min_____
4 min_____
5 min_____
6 min_____
7 min_____
8 min_____
9 min_____
10 min_____

GENERATOR STATOR MEGGER TEST @ 2500 VDC
ALL PHASES SHORTED TOGETHER
TEMP_____ HUMIDITY_____

FOR 0 min_____
30 sec_____
1 min_____
2 min_____
3 min_____
4 min_____
5 min_____
6 min_____
7 min_____
8 min_____
9 min_____
10 min_____

PEDESTALS CHECK TO GROUND FLUKE 77 _____ OHMS
100VDC MEGGER_____OHMS

2