

A. C. Generator Test Report

Generator Rating : 7.0 MW ; 13800 V ; 1800 RPM

Reference Standard - IEC 60034/NEMA

Project:-

COLUMBIA PULP POWER ISLAND

Customer :-

M/s.AIR CLEAN TECHNOLOGIES

Generator Manufactured By

TD Power Systems Ltd.,

27,28,29 ; KIADB Industrial Area

Dabaspeta ; Nelamangala Taluk;

BANGALORE - 562 111

INDIA

Tel : (91)(80) 22995700

Fax : (91)(80) 22995718

Web Site : www.tdps.co.in

A. C. Generator Test Report

Generator details

<u>Frame</u>	<u>TC150</u>	<u>Poles</u>	<u>4</u> No
<u>kVA</u>	<u>8750</u>	<u>Frequency</u>	<u>60</u> Hz
<u>kW</u>	<u>7000</u>	<u>Direction of rotation looking from DE</u>	<u>CW</u>
<u>Voltage</u>	<u>13800</u>	<u>Pf</u>	<u>0.8</u>
<u>Amps</u>	<u>366</u>	<u>Ambient</u>	<u>45 °C</u>
<u>RPM</u>	<u>1800</u>	<u>Insulation Class</u>	<u>F</u>
<u>Machine No</u>	<u>T-04420</u>	<u>Temperature Rise Class</u>	<u>B</u>

Customer M/s.AIR CLEAN TECHNOLOGIES

Test Date 5th April 2018

PO No - US0013R1 Dated:November 13, 2017

<u>Prepared By</u>	<u>Checked By</u>	<u>Approved By</u>
<u>Madhusudany</u>	<u>Seemias M.V</u>	<u>[Signature]</u>

A. C. Generator Test Report

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

TESTING ARRANGEMENT

The final testing has been carried for the Alternator with the following arrangement and the details:

<u>Test Description :</u>	<u>Routine Test</u>
<u>Cooler position :</u>	<u>TOP</u>
<u>Cooler bundles in operation :</u>	<u>2x50%</u>
<u>Approved QAP No. & Revision</u>	<u>TLM 18Q 002 R0</u>
<u>Reference Out line Drg No & Revision :</u>	<u>11051117 R2</u>
<u>DC motor (Prime mover) Sl. No & Rating .:</u>	<u>06060141-01</u> & 750 kW; 750 V; 1055A
<u>DC Drive Sl. No :</u>	<u>2008700/1</u>

Lube Oil, Water flow, Pressure details:

Particulars	DE		NDE	
	Measured	Specified	Measured	Specified
Water flow in LPM	450	450	450	450
Orifice diameter in mm	3.0		3.0	
Oil flow in LPM	6.0	6.0	6.0	6.0
Oil pressure (in kg/cm ²)	1.9	1-2	1.9	1-2

All the running tests has been carried with the above arrangements and mentioned flow rate and pressure was maintained during the test and same has been verified by the final inspector/s.

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Machine no	T-04420	Customer	M/s.AIR CLEAN TECHNOLOGIES
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Winding resistance in Ω (Ref. Std. : IEC 60034-4)

Avg RTD	29.7	deg C	Humidity	33	%	Reference temp	32.0	deg C
						Ambient	32.0	deg C
						Reference temp	95	deg C

Winding	Resistance Ω	in	Temp.in °C	Resistance @ ref temp	Design resistance @ ref temp	% error	Criteria	Ins Cl
Main armature	U-V	0.2005	29.7	0.2500	0.2546	-1.8	± 5% of design value	F
	W-U	0.2006		0.2501		-1.8		
	V-W	0.2005		0.2500		-1.8		
Main field	0.1394		29.7	0.1738	0.1927	-9.8	± 10% of design value	F
Exciter armature	U-V	0.00213	32.0	0.00263	0.0027	-2.5		F
	W-U	0.00212		0.00262		-2.9		F
	V-W	0.00211		0.00261		-3.3		F
Exciter field	4.959		32.0	6.129	6.595	-7.1		F
PMG Stator	U-V	0.2242	32.0	0.2771	0.279	-0.8	± 10% of design value	F
	W-U	0.2240		0.2769		-0.8		
	V-W	0.2238		0.2766		-0.9		
Main Space Heater	7.3							
Exciter Space Heater	72.2							

Result	Pass
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Note:All RTD's are 6 wire RTD

Winding RTD in °C (RTD Temperature in Static Condition)

RTD 1	29.9	29.6
RTD 2	29.9	29.9
RTD 3	29.9	30.1
RTD 4	28.6	30.4
RTD 5	29.6	29.9
RTD 6	30.4	30.4

Air temperature detector (ATD) in °C

Cold (Air)	DE	NDE	Hot (Air)	DE	NDE
RTD	33.2	33.0	RTD	33.5	33.8
	33.0	33.2		33.5	33.8

Bearing temperature detector (BTD) in °C

	DE	NDE
RTD	31.4	31.9
	31.4	31.9

Note: RTD - Resistance Temperature Detector, BTD - Bearing Temperature Detector, ATD - Air Temperature Detector

DE - Driving End, NDE - Non Driving End, Exc - Exciter, Temp. - Temperature

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Result	Pass
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Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Insulation resistance measurement (Ref. Std. : IEEE 43)

		Ambient	27.3	deg C	Humidity	59.6	%
		Insulation Resistance in MΩ			Test Voltage (Volts)	Criteria	
		Before HV	After HV				
Main Armature	U	5520	5480		5000	IR > 100 MΩ	
	V						
	W						
Main field with Exciter Armature		3740	3700		500	IR > 10 MΩ	
Exciter field		44400	44300		500		
PMG Armature		65300	64600		500		
Main Space Heater		1130	1120		500	IR > 1 MΩ	
Exciter Space Heater		58400	58300		500		

Result	Pass
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High Voltage Test & Leakage Current Measurement (Ref. Std. : IEC 60034-1)

		High Voltage Test			Criteria
		Voltage(V)	Time	Leakage	
Main Armature	U	28600	1 min	630mA	HV shall withstand
	V			630mA	
	W			630mA	
Main field with Exciter Armature		1500	1 min	100mA	
Exciter field		1500	1 min	-	
PMG Armature		1500	1 min	-	
Main Space Heater		1500	1 min	-	
Exciter Space Heater		1500	1 min	-	

Result	Withstood
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Insulation Resistance of accessories in MΩ (Ref. Std. : IEEE 43)

BTD DE	> 250	Winding RTD's	> 250	ATD's	> 250
BTD NDE	> 250				

Criteria : >1 M ohm

HV Test done at 1.5kV - OK

Result	Pass
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Polarization index test(Combined UVW) (Ref. Std. : IEEE 43)

10th min IR = 29000 MΩ
 1st min IR = 5480 MΩ

PI = 5.29 PU

Criteria : > 2 PU

Result	Pass
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Phase Sequence Test (Ref. Std. : IEC 60034-8)

Generator DOR from DE CW UVW w.r.t RYB

DOR - Direction of rotation

Result	Pass
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OCC - Open Circuit Characteristic (Ref. Std. : IEC 60034-4)

% of V	Excitation		Armature Voltage
	Exc A	Exc V	V
130	8.36	46.6	18060.0
120	6.38	35.9	16550.0
110	4.92	27.7	15200.0
100	3.74	21.2	13830.0
90	2.80	15.7	12410.0
80	2.11	11.8	11040.0
70	1.58	8.9	9670.0
60	1.27	7.1	8430.0
50	1.03	5.7	7140.0
40	0.76	4.3	5610.0
30	0.54	3.0	4072.0
20	0.38	2.1	2805.0
10	0.18	1.1	1381.0
0	0.00	0.0	210.0

Voltage balance Test (Ref. Std. : IEC 60034-1)

L-L Voltage	U-V	V-W	W-U
	13888	13891	13891
% Variation	-0.01	0.01	0.01

Criteria :
Variation < ± 1%

Result	Pass
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Generator inherent voltage regulation (Ref. Std. : IEC 60034-4)

$$\begin{aligned}
 \text{Regulation} &= \frac{\text{Voltage @ full load excitation amps} - \text{Rated voltage}}{\text{Rated voltage}} \\
 &= \frac{18100 - 13800}{13800} \\
 &= \boxed{31.2} \%
 \end{aligned}$$

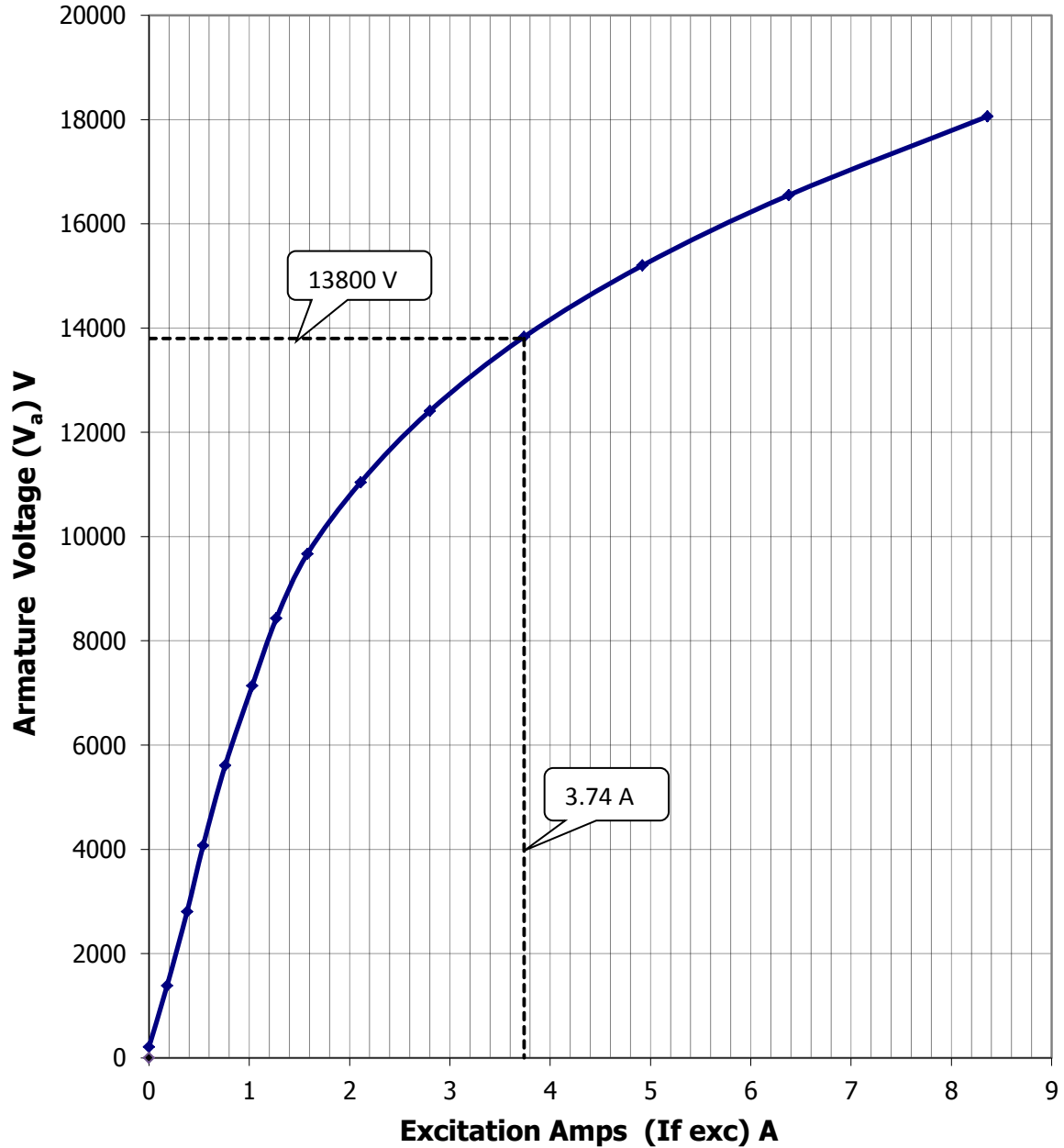
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A. C. Generator Test Report

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Open Circuit Characteristics (OCC) Curve

OCC Curve



Excitation current at rated armature voltage 3.74 Amps

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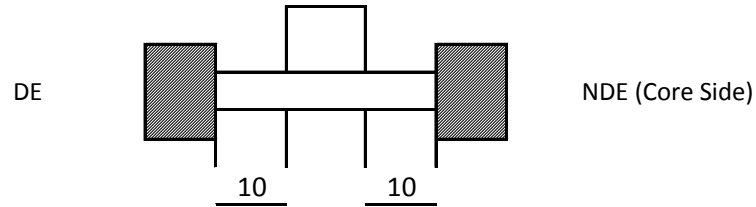
Shaft Voltage Measurement (Ref. Std. : IEEE 115)

DE-NDE	DE-E	NDE-E	Criteria
109mV	4mV	104mV	Insulated bearing < 5 V*

Result	Pass
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* - As per TDPS Internal Standard

Magnetic Center Position (Applicable only for sleeve bearing m/cs with end play)



Main Machine	23	mm
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Criteria: Clearance : Min 2 mm

Result	Pass
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PMG Voltage & Phase Sequence Test

PMG Voltage (Volts)	U-V	V-W	W-U
	198.8	198.1	198.9

MAKE	Frequency (Hz)
TDPS	180

PMG DOR from DE	CW	UVW w.r.t RYB
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Result	Pass
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DOR - Direction of rotation

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A. C. Generator Test Report

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Harmonics, THD & THF Measurement (Ref. Std. : IEC 60034-1)

1st Order	100%	21st Order	0.000	41st Order	0.110
2nd Order	0.010	22nd Order	0.000	42nd Order	0.000
3rd Order	0.010	23rd Order	0.010	43rd Order	0.110
4th Order	0.000	24th Order	0.000	44th Order	0.000
5th Order	0.390	25th Order	0.020	45th Order	0.000
6th Order	0.000	26th Order	0.000	46th Order	0.000
7th Order	0.080	27th Order	0.000	47th Order	0.010
8th Order	0.000	28th Order	0.000	48th Order	0.010
9th Order	0.000	29th Order	0.020	49th Order	0.010
10th Order	0.010	30th Order	0.000	50th Order	0.010
11th Order	0.070	31st Order	0.010	THD %	0.445
12th Order	0.000	32nd Order	0.000	THF %	0.317
13th Order	0.060	33rd Order	0.000	Criteria : THD < 5%	
14th Order	0.000	34th Order	0.000		
15th Order	0.000	35th Order	0.030		
16th Order	0.000	36th Order	0.000		
17th Order	0.000	37th Order	0.060		
18th Order	0.000	38th Order	0.000		
19th Order	0.020	39th Order	0.000		
20th Order	0.010	40th Order	0.000		

Result	Pass
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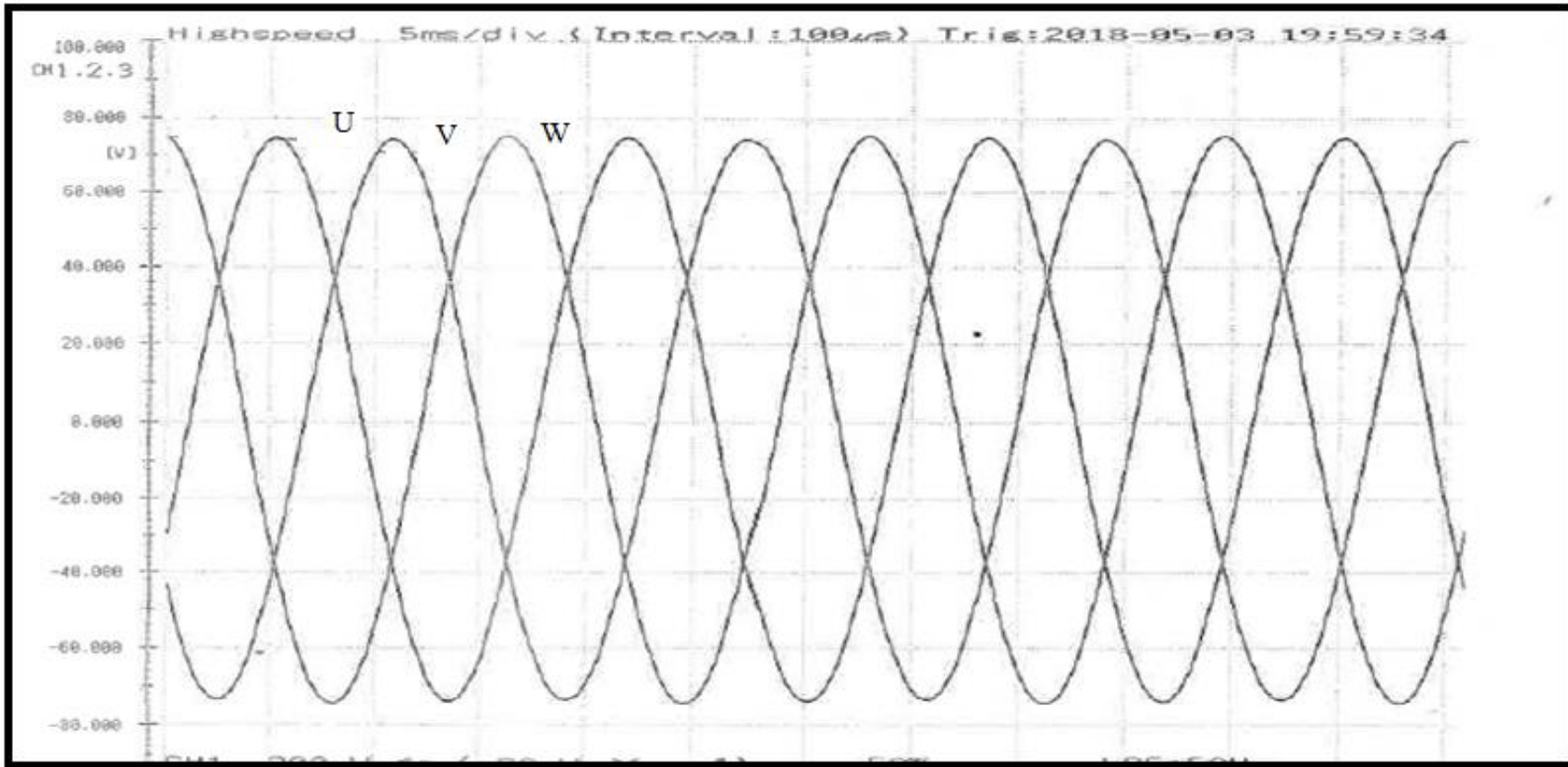
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Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Waveform Recording

PT Used: 15000/150V

RMS Voltage 13800 V



Note: Waveform amplitude displayed is in peak values.

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Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Vibration Measurement (Ref. Std. : IEC 60034-14)

Housing vibration

	DE		NDE		Condition	
	microns	mm/sec	microns	mm/sec		
Vertical	22	1.6	7	0.7	Rated Voltage	Criteria : < 2.3 mm/sec
Horizontal	9	0.7	21	1.1		
Axial	28	1.9	8	0.9		
	microns	mm/sec	microns	mm/sec		
Vertical	23	1.8	11	1.3	Rated Current	
Horizontal	10	0.9	17	1.2		
Axial	27	2.0	10	1.0		
	microns	mm/sec	microns	mm/sec		
Vertical	12	1.6	6	0.5	Before Over Speed	
Horizontal	13	1.9	11	0.8		
Axial	24	1.8	12	1.1		
	microns	mm/sec	microns	mm/sec		
Vertical	13	1.6	6	0.5	After Over Speed	
Horizontal	14	2.0	12	0.9		
Axial	25	2.0	13	1.2		

Result	Pass
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Note: Velocity in mm/s (rms), displacement (microns) in pk-pk

Shaft vibration (pk-pk)

Condition	DE		NDE		
	X	Y	X	Y	
Rated Voltage	8	9	12	9	Criteria : < 90 microns
	X	Y	X	Y	
Rated Current	9	8	10	9	
	X	Y	X	Y	
Before Over Speed	4	6	6	8	
	X	Y	X	Y	
After over Speed	4	6	11	12	

Result	Pass
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Over Speed Test (Ref. Std. : IEC 60034-1, 3)

Over speed test at	125 % of rated speed for	2 mins	Criteria : No abnormality
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Over speed test done at	2250 RPM
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Result	Pass
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A. C. Generator Test Report

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

SCC - Short Circuit Characteristic (Ref. Std. : IEC 60034-4)

% of load	Excitation		Armature Current in ampere			
	Exc A	Exc V	U	V	W	Avg
150%	7.63	43.1	556.0	558.0	557.0	557.0
110%	5.55	31.3	407.0	408.0	407.0	407.3
100%	5.02	28.7	367.0	368.0	369.0	368.0
75%	3.80	21.5	278.9	278.8	279.4	279.0
50%	2.53	14.4	187.2	187.6	187.9	187.6
25%	1.26	7.2	93.5	93.7	93.9	93.7
0%	0.00	0.0	1.8	1.8	1.8	1.8

150% overload test carried at **557.0 A** for 30 seconds (Ref. Std. : IEC 60034-1)

Result	Pass
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Short circuit ratio (SCR) (Ref. Std. : IEC 60034-4)

SCR = $\frac{\text{If exc OC}}{\text{If exc SC}}$ =

3.74
5.02

 SCR actual =

0.75
0.70

Criteria: SCR ≥ 85% of reqd value

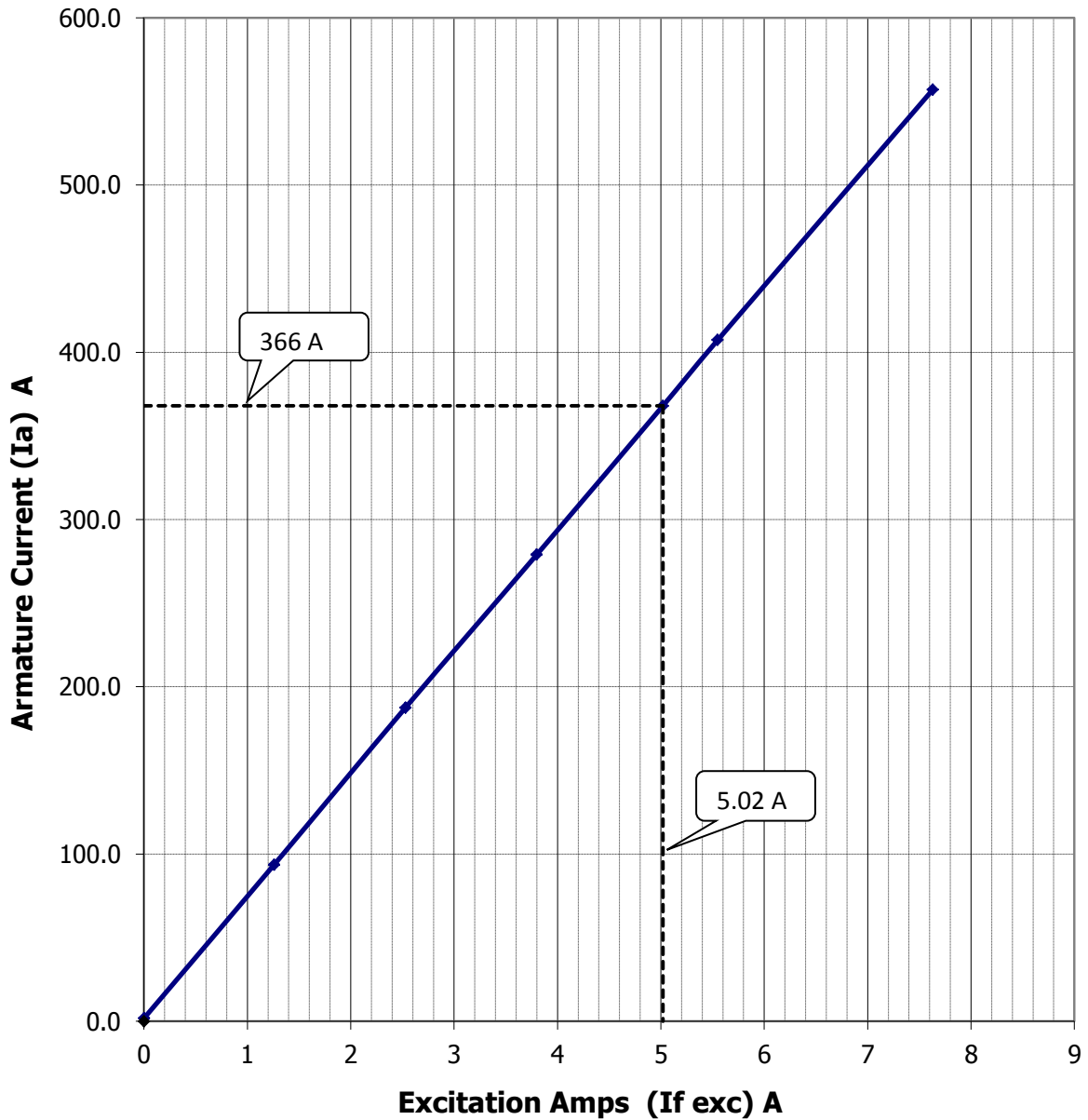
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Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Short Circuit Characteristics (SCC) Curve

SCC Curve



Excitation current at rated armature current 5.02 Amps

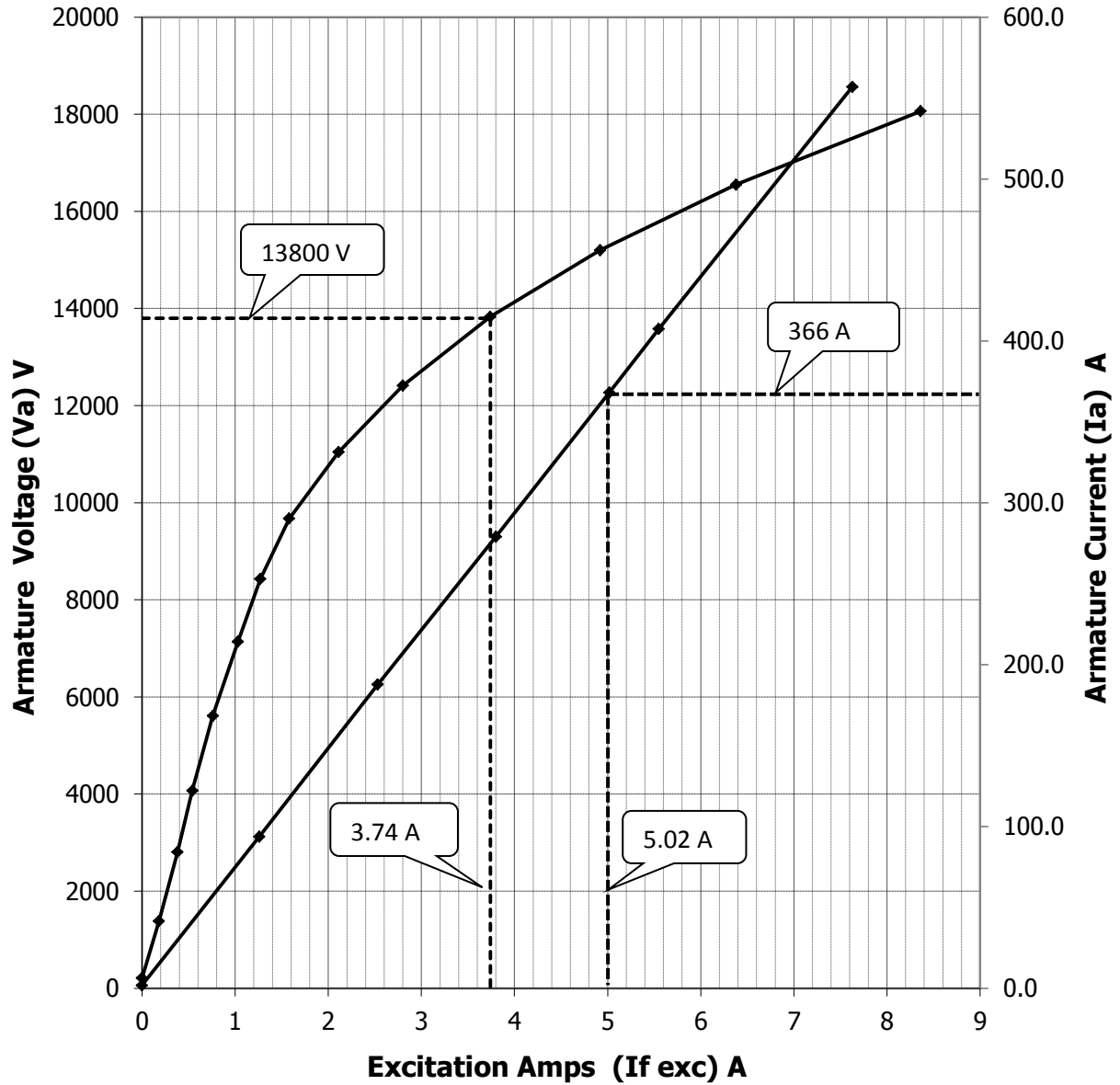
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A. C. Generator Test Report

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Open Circuit Characteristics (OCC) & Short Circuit Characteristics (SCC) Curve

OCC & SCC Curve



Excitation current at rated voltage 3.74 Amps

Excitation current at rated current 5.02 Amps

Short circuit ratio (SCR) 0.75

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A. C. Generator Test Report

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Efficiency calculation (Ref. Std. : IEC 60034-2)

Armature resistance(cold)	0.2005	Ω	
Field resistance (Rf cold)	0.1394	Ω	
Reference temp	95.0	°C	
RTD temp during SCC	55.8	°C	Rfsc @ 55.8 °C = 0.1531
RTD temp during OCC	43.6	°C	Rfoc @ 43.6 °C = 0.1467

DC motor power input

Condition	Voltage V	Current I	Total Power in kW	DC m/c Arm loss in kW	DC m/c Output in kW
Uncoupled	649.0	23.2	15.1 (A)	-	-
Coupled at rated speed	665.0	100.0	66.5 (B)	0.70	65.8 (B')
OC Rated voltage	666.0	173.3	115.4	1.41	114.0 (C)
SC Rated current	668.0	216.0	144.3	1.91	142.4 (D)

Main field current(Ifoc) at rated V	227.4	A	(Design Values)
Main field current(Ifsc) at rated A	345.0	A	

Calculation

- 1 Main field current @ full load = If = $\sqrt{(Ifoc)^2 + (K \cdot Ifsc)^2 + 2 \cdot K \cdot Ifoc \cdot Ifsc \cdot \sin\Phi}$
 (K = 1.15 & sinφ = 0.6 for 0.8 pf Cylindrical rotor) = 563.4 A
- 2 Arm. Resistance @ ref temp/ Ph(Ra)= 0.12498 Ω
 Field resistance @Ref.temp (Rf)= 0.17375 Ω
 Arm. Resistance @ SCC temp/ Ph(Ra)= 0.11015 Ω
- 3 Main field loss during OC= (Ifoc)²*(Rfoc) 7.6 kW (E)
- 4 Main field loss during SC= (Ifsc)²*(Rfsc) 18.2 kW (F)
- 5 Copper loss during SCC =3*(Rated A)²*Arm res/ph@SCC 44.3 kW (G)
- 6 Losses
 - 1 Friction & Windage loss = (B')-(A) 50.7 kW
 - 2 Iron loss =(C-B'-E) 40.6 kW
 - 3 Copper loss = 3*(Rated current)²*Res @ref.temp= 50.2 kW
 - 4 Stray load loss = (D-B'-F-G) 14.1 kW
 - 5 Field loss=(If)²*Rf@Ref.temp 55.1 kW

Total losses = 210.8 kW

Efficiency@100%load @ 0.80 pf Output/Input 97.08 %

Criteria:
 Efficiency required @ 100% Load and rated pf
 = 96.90 %


Result	Pass
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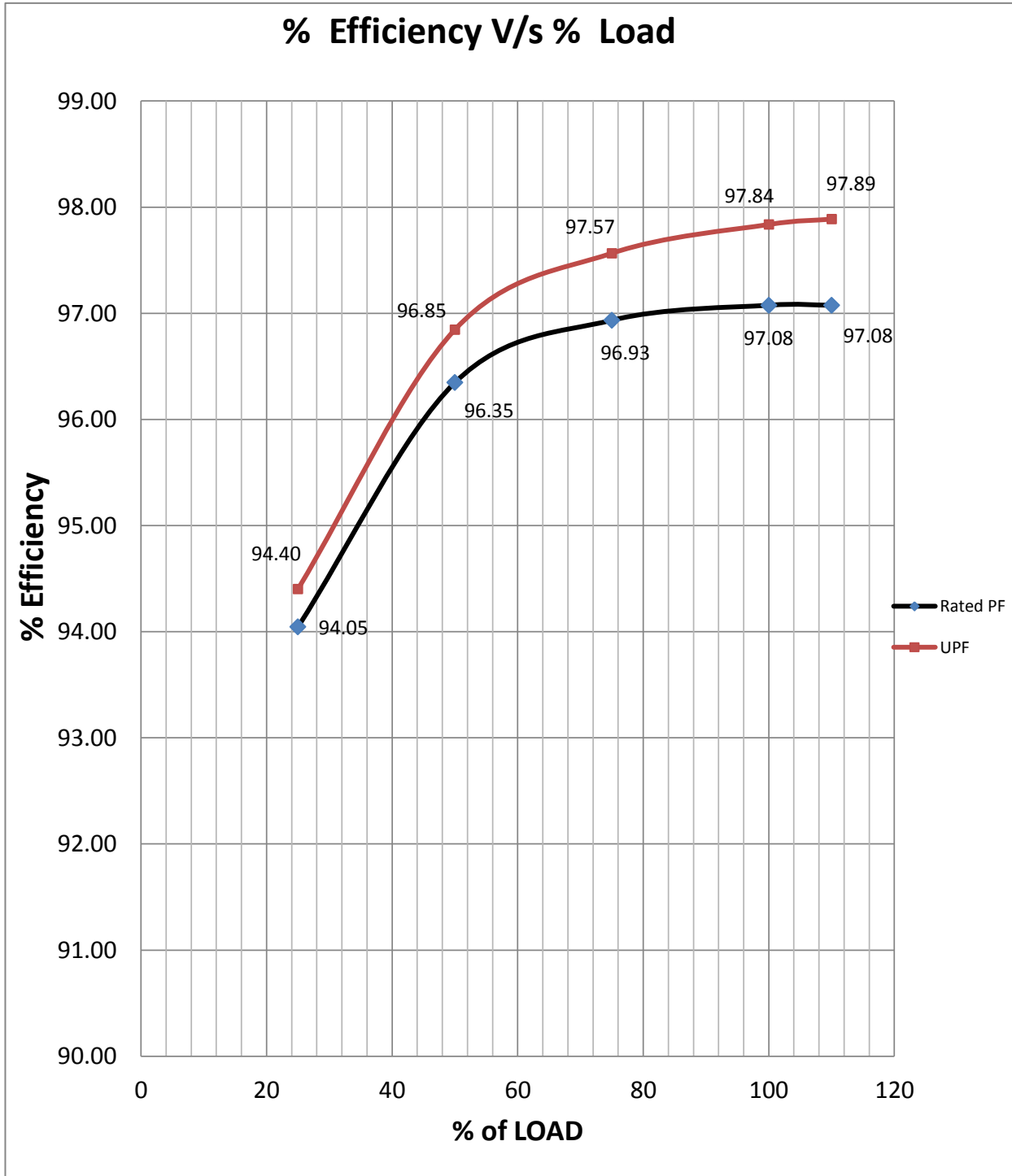
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Efficiency at different loads at <u>0.80</u> pf									
	Load								
	25%	50%	75%	100%	110%				
KW	1750	3500	5250	7000	7700				
KVA	2187.5	4375	6562.5	8750	9625				
PF	0.80	0.80	0.80	0.80	0.80				
V	13800	13800	13800	13800	13800				
A	91.5	183.0	274.5	366.0	402.6				
Main field A	297.7	381.0	470.6	563.4	601.1				
Exciter field A	4.7	5.9	7.2	8.6	9.1				
Mechanical loss kW	50.7	50.7	50.7	50.7	50.7				
Iron loss kW	40.6	40.6	40.6	40.6	40.6				
Copper loss kW	3.1	12.6	28.3	50.2	60.8				
Stray load loss kW	0.9	3.5	7.9	14.1	17.0				
Field loss kW	15.4	25.2	38.5	55.1	62.8				
Total loss kW	110.8	132.7	166.0	210.8	232.0				
Input kW	1860.8	3632.7	5416.0	7210.8	7932.0				
Out put kW	1750.0	3500.0	5250.0	7000.0	7700.0				
Efficiency %	94.05	96.35	96.93	97.08	97.08				
Required Eff %	93.60	96.00	96.60	96.90	-				
Tolerance 10% of (1-eff)	0.64	0.40	0.34	0.31	-				
Eff. required with - ve tolerance in %	92.96	95.60	96.26	96.59	-				
Efficiency at different loads at <u>1.0</u> pf									
	Load								
	25%	50%	75%	100%	110%				
KW	1750	3500	5250	7000	7700				
KVA	1750	3500	5250	7000	7700				
PF	1.0	1.0	1.0	1.0	1.0				
V	13800	13800	13800	13800	13800				
A	73.2	146.4	219.7	292.9	322.2				
Main field A	237.6	266.0	307.5	357.7	379.4				
Exciter field A	3.9	4.2	4.8	5.5	5.8				
Mechanical loss kW	50.7	50.7	50.7	50.7	50.7				
Iron loss kW	40.6	40.6	40.6	40.6	40.6				
Copper loss kW	2.0	8.0	18.1	32.2	38.9				
Stray load loss kW	0.6	2.3	5.1	9.0	10.9				
Field loss kW	9.8	12.3	16.4	22.2	25.0				
Total loss kW	103.8	114.0	131.0	154.8	166.2				
Input kW	1853.8	3614.0	5381.0	7154.8	7866.2				
Out put kW	1750.0	3500.0	5250.0	7000.0	7700.0				
Efficiency %	94.40	96.85	97.57	97.84	97.89				
Required Eff %	94.00	96.60	97.20	97.40	-				
Tolerance 10% of (1-eff)	0.60	0.34	0.28	0.26	-				
Eff. required with - ve tolerance in %	93.40	96.26	96.92	97.14	-				
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A. C. Generator Test Report

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				



Date 5th April 2018

A. C. Generator Test Report

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Comparison Table

Sl.No	Test Item	Design Value	Tested Value	Unit	Tolerance
1	Resistance @ ref Temp of				
	i) Main Stator	0.25460	0.24997	Ω	±5%
	ii) Main Rotor	0.19270	0.17375	Ω	± 10%
	iii) Exciter Armature	0.00270	0.00263	Ω	± 10%
	iv) Exciter Field	6.595	6.129	Ω	± 10%
2	Insulation Resistance of				
	i) Main Stator	-	5480	MΩ	≥ 100
	ii) Main Rotor with Exciter Armature	-	3700	MΩ	≥ 10
	iii) Exciter Field	-	44300	MΩ	≥ 10
3	DOR view from DE	CW	CW	-	-
4	Excitation current @ OC	-	3.74	A	-
5	Excitation current @ SC	-	5.02	A	-
6	Short circuit Ratio (SCR)	0.7	0.75	-	≥85% of required value
7	Max Housing Vibration @ Rated Voltage	-	1.9	mm/sec	< 2.3 mm/sec
8	Max Shaft Vibration @ Rated Voltage	-	12	μm	< 90 μm
9	Shaft Voltage	-	109mV	mV	< 5 V
10	Efficiency at rated power factor & at				
	i) 25% Load	93.60	94.05	%	-
	ii) 50% Load	96.00	96.35	%	-
	iii) 75% Load	96.60	96.93	%	-
	iv) 100% Load	96.90	97.08	%	-

CALIBRATION STATUS REPORT

Frame	TC150	kVA	8750	kW	7000	Voltage	13800	min ⁻¹	1800
Machine no	T-04420			Customer	M/s.AIR CLEAN TECHNOLOGIES				

Measuring Instruments Used in Testing of Alternators

Sl.No	Measurement	Measuring Instrument	Instrument Sl.No	Caliberation Due
1	Winding Resistance	Digital milli Ohm meter	A01142C10	14.02.2019
2	Insulation Resistance	Digital Megger	374/090709/1829	23.03.2019
3	Excitation Current & Excitation Voltage	Digital Power Analyser	91LB20984	10.01.2019
4	Armature voltage , Armature current Harmonics .	Digital Power Analyser	91F820315	10.01.2019
5	Vibration	Vibration Meter	2K15G1307	15.11.2018
6	Shaft Voltage , RTD & Space heater Resistance	Digital Multimeter	38420721	12.08.2018
7	High voltage for Low voltage	HV Breakdown Tester 0-5 kV	90504006	03.04.2019
8	High voltage for Heigher voltage	HV Breakdown Tester 0-30 kV	7624/10187/07-08	22.11.2018
9	Phase sequence test	Phase sequence meter	063/08	20.11.2018
10	Armature voltage	Potential transformer	Z5403	28.06.2018
11	Armature current	Current Transformer	A20770,A20771,A20773	10.01.2019

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