RESEARCH ARTICLE OPEN ACCESS

Electro Static Precipitator for Spent Wash Application.

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ABSTRACT
The distillery sector is major polluting industries in India & world. These units generate large volume of dark brown colored wastewater, which is known as "spent wash". Liquid wastes from breweries and distilleries possess a characteristically high pollution load and have continued to pose a critical problem of environmental pollution in India and many countries.
Keywords*—*spentwash,Electrostaticprecipitator,Distillerycomponent

I. INTRODUCTION

A Discharge electrode with High frequency transformer and Three phase transformer electrostatic precipitator (ESP) has been developed for control of submicron particles which are very harmful and Hazardous to the environment generated in exhaust gas. In new designing E.S.P process is very much sophisticated to control the NOx , SOx along with CO, CO2, O2 and N2.

Because of new designing very fine particles could be agglomerated and captured effectively in the ESP. The electrical supplied voltage, the dust loading and the gas flow velocity at the ESP were considered while the supplied voltage of the pre-charger was varied from minimum level to maximum level of voltage in KV with respect to current in ma. The overall collection efficiency increased with the supplied voltage while the dust loading and gas velocity did not give strong effect. A model to predict the overall collection efficiency at various operating conditions could be evaluated from the experimental data and it has improved from 99.97% to 99.98%.

Features of Pipe and Spike Electrode :

Best corona generation properties among various types of Rigid Electrode.Mechanically stable electrodes for optimum rapping vibration transmission and effective dislodgement. Light weight ,ease of shipping site. Long life.

II. DESIGNING ASPECTS

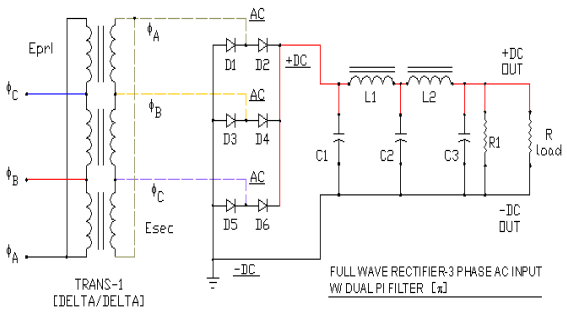
Three phase full converter conduction, High frequency transformer Design

Mechanical	Electrical
Pipe And Spike Electrode	High Frequency Transformer
	Three Phase Transformer

THREE PHASE FULL CONVERTER :

Three phase full converter is a fully controlled bridge controlled rectifier using six diodes are connected in the form of a full wave bridge configuration. All the six diodes are controlled switches which are turned on at a appropriate times by applying suitable supply.

The **three phase full converter** is extensively used in industrial power applications upto about 120kW output power level. The figure shows a **three phase full converter** with highly inductive load. This circuit is also known as three phase full wave bridge or as a six pulse converter. The diodes are conducted at an interval . The frequency of output ripple voltage is $6f_s$ and the filtering requirement is less than that of **three phase semi and half wave converters**



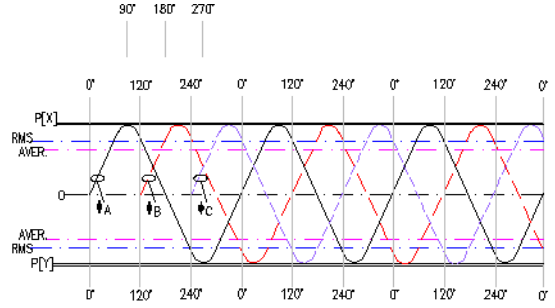
Diodes are conducting when applying the signal . During the different time periods, diodes are to conduct together and the line to line supply voltage appears across the load.the Diode D_2 and D_6 is reverse biased immediately and D_6 turns off . Diode D_1 and D_2 conduct together and the line to line supply voltage appears across the load. Diodes are numbered in the circuit diagram corresponding to the order in which they are conducted. . The figure shows the waveforms of three phase input

supply voltages, output voltage, the Diode current through D_1 and D_4, the supply current through the line 'a'.

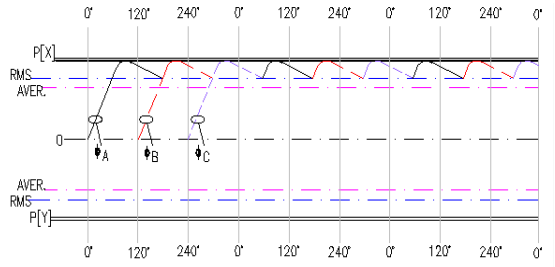
High frequency transformer with transformer switchover

One of the many requirements of the modern inverter is a broad, coordinated input and voltage range with a consistently high degree of efficiency across the entire operating range of the inverter.To satisfy this requirement, implementing a high frequency transformer (HF transformer) in most of its current inverters. This HF transformer has a transformer switchover that ensures a consistently high degree of efficiency right across the input voltage range.It is often incorrectly assumed that the maximum degree of efficiency at a particular voltage is one of the factors responsible for producing a good annual yield, when it is in fact the more or less constant degree of efficiency over the entire voltage range, maximum efficiency

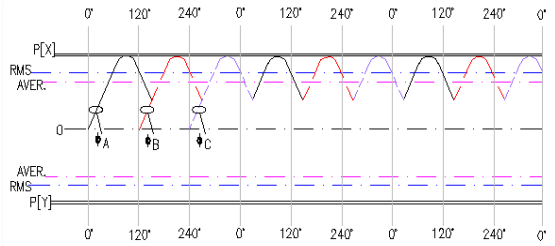
III. OUT PUT WAVE FORMS



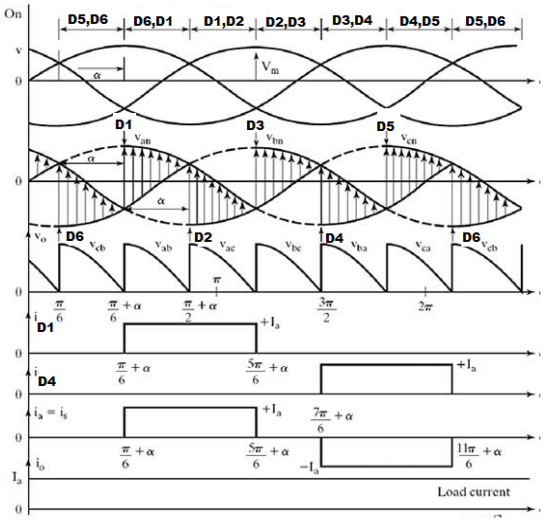
CURRENT FROM TRANSFORMER / INPUT TO DIODES [AC]



CURRENT AT FILTER OUTPUT TO DC LOAD [+DC OUT], [-DC OUT]



CURRENT FROM DIODES TO FILTER INPUT [+DC], [-DC]



HIGH FREQUENCY TRANSFORMER RECTIFIER CIRCUIT

T/r set used : HFTR reading
Spent wash feed : 11,487 kg/hr to 12 kg/hr
Coal feed : 4.5 to 5 tph.
Application : Esp for 12 tph boiler(spent wash/coal fired).
Boiler : 37.6 tph
Turbine load : 3.16 mw.

Condition : all fields are on condition at 12 spent wash.
Hftr readings : existing hftr readings

1 st and 2 field (both are combined)				Third(3rd)				Fourth(4 th)			
Vp	Vs	Ip	Is	Vp in V	Vs	Ip	Is	Vp	Vs	Ip	Is
362	65.4	57	599	70	45	75	220	190	42	75	249
370	66	56	350	199	45	72	219	192	45	78	248
375	67.1	54	335	190	44	75	214	200	45	72	249

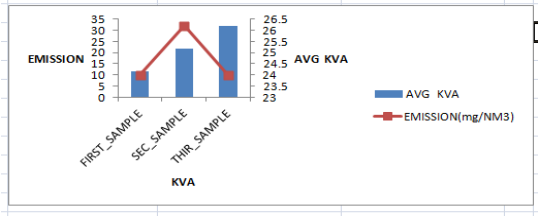
Vp : Primary voltage .in volts.,Vs : Secondary Voltage in KV,Ip : Primary current in Amp.,Is : Secondary current in ma.

	KVA(1&2 Field)	KVA(3rd Field)	KVA(4th Field)	AVG KVA	EMISSION (mg/NM³)
First sample	38.66	11.20	17.67	22.51	42.14
Sec_sample	44.31	17.38	18.67	38.38	44.32
Thir_sample	30.25	17.64	18.24	22.04	52.43

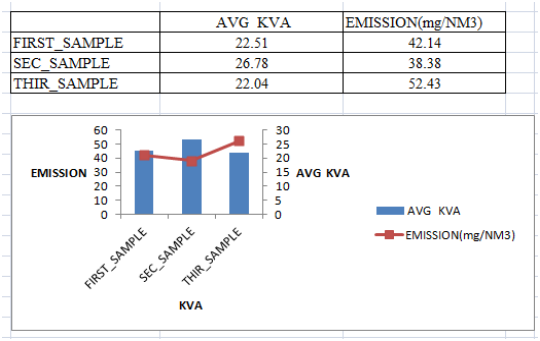
Date of sample : 11-02-2016.
Tr-set used : High frequency transformer
Application : esp for 12 tph boiler(spent wash/coal fired).
Boiler load : 36.8,36.4,36.4 tph
Coal feed : 4.1 to 4.5 tph..
Spent wash : 12.6, 11.7, 11.4 tph

	KVA(1&2 FIELD)	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
First sample	32.9206	20.837	18.797	24.18	10
Second sample	39.1212	18.421	18.023	25.18	32
Third sample	41.6056	18.797	18.2181	26.2	10

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	24.18	10
SEC_SAMPLE	25.18	32
THIR_SAMPLE	26.2	10



	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	22.51	42.14
SEC_SAMPLE	26.78	38.38
THIR_SAMPLE	22.04	52.43



THREE PHASE TR-SET READING
T/r set used : Three phase(3-ϕ) t.r set readings
Spent wash feed : 11,487 kg/hr to 12 kg/hr
Coal feed : 4.5 to 5 tph.
Application : esp for 12 tph boiler(spent wash/coal fired).
Boiler : 37.6 tph
Turbine load : 3.16 mw.
Condition : all fields are on condition at 12 spent wash.

POWER CON THREE PHASE(3-□) T.R SET READINGS (Existing transformer Replaced by Power con) :

1 st and 2 field (both are combined) (kraft powercon transformer)				Third(3rd)				Fourth(4 th)			
Vp	Vs	Ip	Is	Vp	Vs	Ip	Is	Vp	Vs	Ip	Is
250	**59**	**21.9**	**91.1**	**200**	**48**	**65**	**219**	**195**	**44**	**75**	**247**
250	**57**	**11.7**	**92**	**210**	**49**	**84**	**210**	**195**	**44**	**75**	**245**
251	**57**	**11.9**	**92.1**	**210**	**48**	**89**	**219**	**199**	**44**	**74**	**248**
230	**54**	**4.3**	**92**	**210**	**48**	**89**	**219**	**199**	**44**	**74**	**247**

Application : esp for 12 tph boiler(spent wash/coal fired).

Tr set used : three phase transformer rectifier set reading.
Coal feed : 4.1 to 4.6 tph.
Boiler : 37.5 to 37.7 tph
Turbine load : 3.18 mw.

Condition : all fields are on condition at 12.1 spent wash.
Power con Three Phase Readings : Three phase Transformer Rectifier set Readings

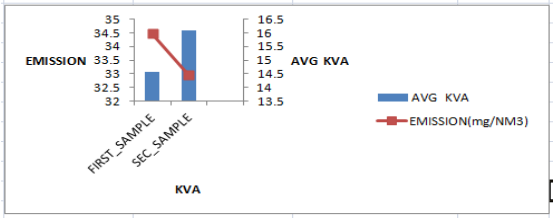
	KVA(1&2 FIELD)	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
FIRST SAMPLE	16.449	20.663	22.404	19.838	40
SECOND SAMPLE	16.366	20.663	22.404	19.811	64
THIRD SAMPLE	16.230	19.197	21.446	18.957	10

.
Tr-set used : three phase transformer.(power con).
Application : esp for 12 tph boiler(spent wash/coal fired).
Spent wash : 12.2,12,12.6 tph
Boiler load : 37,36.6,37.2 tph
Coal feed : 4.1 to 4.5 tph.
Spent wash : 12.2, 12, 12.6 tph.

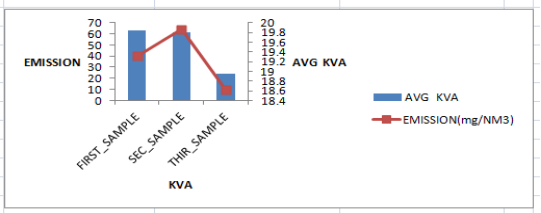
Power con Three Phase Readings : Three phase Transformer Rectifier set Readings.:

	KVA(1&2 FIELD)	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
First sample	5.69	20.2279	21.5724	15.829	17
Second sample	8.077	20.174	19.814	16.021	33
Third sample	6.866	20.194	20.262	15.774	33

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	14.565	34.47
SEC_SAMPLE	16.09	32.95



	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	19.838	40
SEC_SAMPLE	19.811	64
THIR_SAMPLE	18.957	10

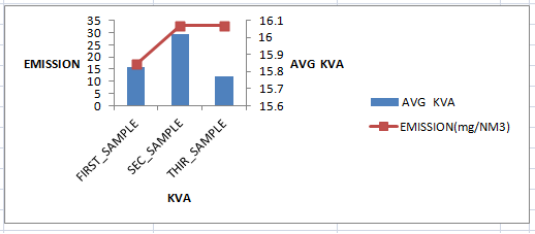


Tr-set used : three phase transformer rectifier set readings.
Application : esp for 12 tph boiler(spent wash/coal fired).
Boiler load : 37.7 ,36.7,36.6 tph.
Spent wash : 12,11.8,11.4 tph.
Coal feed : 4.1 to 4.5 tph.
Condition : all fields are on condition .

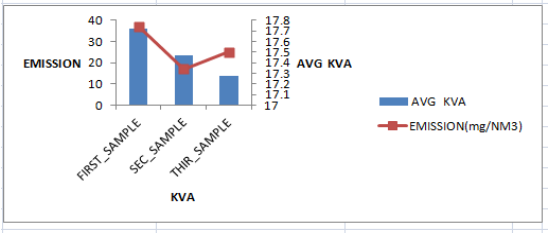
Power con three phase(3-□) t.r set readings (existing transformer replaced by power con)

	KVA(1&2 FIELD)	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
First sample	10.642	19.704	22.815	17.720	37
Second sample	10.530	19.233	22.6358	17.466	17
Third sample	11.592	16.446	23.79	17.276	25

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	15.829	17
SEC_SAMPLE	16.021	33
THIR_SAMPLE	15.774	33



	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	17.72	37
SEC_SAMPLE	17.466	17
THIR_SAMPLE	17.276	25



EXISTING H.F.T.R CONDITION
(ALL FIELD ARE ON CONDITION, BOILER CONDITION 37.7 TPH ,12 TON SPENT WASH .).
Application : esp for 12 tph boiler(spent wash/coal fired).
Spent wash : 11,600 kg/hr to 12.1 kg/hr
Coal feed : 4.2 to 4.6 tph.
Boiler : 37.7 tph
Turbine load : 3.18 mw.
Hftr readings: existing hftr readings

APPLICATION		E.S.P FOR 1 ɤ 40 TPH BOILER(SPENT WASH/COAL FIRED)		
FUEL USED		SPENT WASH + INDIAN/IMPORTED COAL		
SPECIFICATION NO		**(ALL FIELDS ARE ON CONDITION 12 TPH)**		
S.NO	PARAMETER	UNIT	DESIGNED	MEASURED
1	No of mechanical / Electrical fields	No.	4 MECH 4 ELECTRICAL	4 MECH/4 ELECTRICAL
2	Gas Flow At Inlet (Total)	AM3/HR	147600	150295
A	Gas Flow Per Pass	AM3/SEC	**41**	27.483
B	Gas Flow At Outlet	AM3/HR	95000	98940.48
3	Gas Temp At Inlet (Operating)	DEG C	200	200
3a	Gas Temp At Outlet	DEG C	175	175
4	Moisture	% v/v	16.06	14.85
5	Inlet dust load	GMS/NM3	77.63	77.63
6	Emission guarantee	MGMS/NM3	**100**	**134**
7	Collection efficiency	%	99.87	99.82
8	Plate area (total)	M2	4320	4320
A	Plate area (per pass)	M2	4320	4320
9	SCA	M2/M3/SEC	105.37	130.37
10	Velocity	M/SEC	0.57	13.29
11	Migration velocity (wd)	CM/SEC	5.51	7.418
	Treatment time	SEC	21.1	8.126
12	Suction pressure at esp Inlet	(-)MMWC	±400 mmWC	±400 mmWC
13	Pressure drop across The esp (top entry)	MM OF WC	25-30	9.2
14	Esp penhouse temp	ıC	90-110	100
15	Boiler capacity	TPH	40	36.6
16	Oxygen	%	6.45	6.15

Application : Esp for 12 tph boiler(spent wash/coal fired).
Spent wash : 11.8 kg/hr to 12 kg/hr
Boiler load : 36.7 ,37,37-tph.

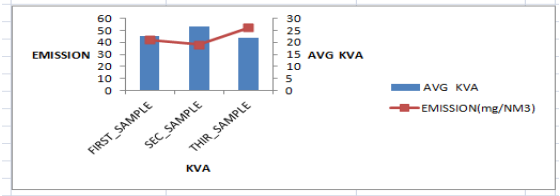
Spent wash : 12,11.5,11.8.
Coal feed : 4.1 to 4.5 tph.
Condition : all fields are on condition
two -three phase(3-ϕ) t.r sets connected in first and second fields readings (existing transformer replaced by power con) :
Condition : all fields are on condition

Two Three Phase Readings : Three phase Transformer Rectifier set Readings.

STUDY DATE		11-01-2015		
APPLICATION		E.S.P FOR 1 x 40 TPH BOILER(SPENT WASH/COAL FIRED)		
FUEL USED		SPENT WASH + INDIAN/IMPORTED COAL		
SPECIFICATION NO		**(ALL FIELDS ARE ON CONDITION 12 TPH)**		
S.NO	PARAMETER	UNIT	DESIGNED	MEASURED
1	No of mechanical / Electrical fields	No.	4 MECH 4 ELECTRICAL	4 MECH/4 ELECTRICAL
2	Gas Flow At Inlet (Total)	AM3/HR	147600	150295
A	Gas Flow Per Pass	AM3/SEC	**41**	27.483
B	Gas Flow At Outlet	AM3/HR	95000	98945.48
3	Gas Temp At Inlet (Operating)	DEG C	200	200
3a	Gas Temp At Outlet	DEG C	175	175
4	Moisture	% v/v	16.06	14.85
5	Inlet dust load	GMS/NM3	77.63	77.63
6	Emission guarantee	MGMS/NM3	**100**	**17.33**
7	Collection efficiency	%	99.87	99.978
8	Plate area (total)	M2	4320	4320
A	Plate area (per pass)	M2	4320	4320
9	SCA	M2/M3/SEC	105.37	130.37
10	Velocity	M/SEC	0.57	13.29
11	Migration velocity (wd)	CM/SEC	5.51	7.418
	Treatment time	SEC	21.1	8.126
12	Suction pressure at esp Inlet	(-)MMWC	±400 mmWC	±400 mmWC
13	Pressure drop across The esp(top entry)	MM OF WC	25-30	9.2
14	Esp penhouse temp	ıC	90-110	100
15	Boiler capacity	TPH	40	36.6
16	Oxygen	%	6.45	6.15

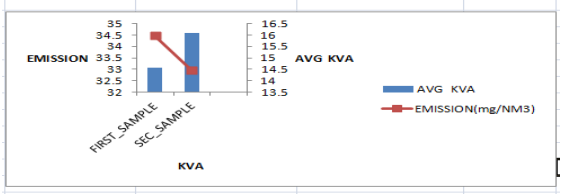
FIRST CONDITION
(H.F.T.R 1st & 2nd FIELD COMBINE ON 11-01-2016

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	22.51	42.14
SEC_SAMPLE	26.78	38.38
THIR_SAMPLE	22.04	52.43



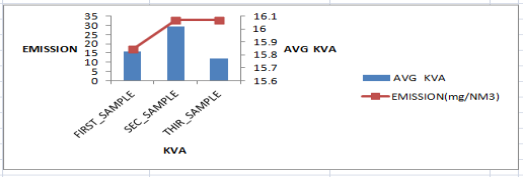
SECOND CONDITION
(3- TRANSFORMER 1st &2nd FIELD COMBINE ON 11-01-2016

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	14.565	34.47
SEC_SAMPLE	16.09	32.95



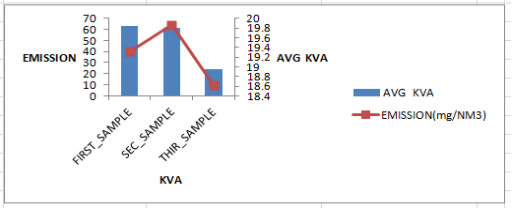
SIXTH –CONDITION
THREE PHASE TRANSFORMER CONNECTED

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	15.829	17
SEC_SAMPLE	16.021	33
THIR_SAMPLE	15.774	33



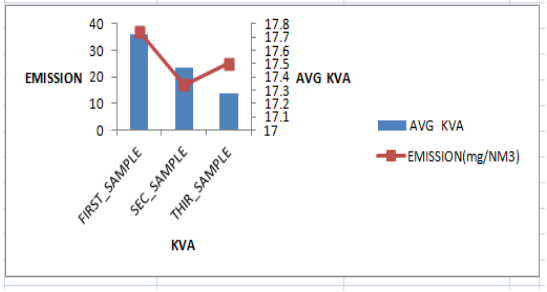
THIRD CONDITION
THREE PHASE T.R SET CONNECTED TO 1st and 2nd FIELD ON 09-02-2016

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	19.838	40
SEC_SAMPLE	19.811	64
THIR_SAMPLE	18.957	10



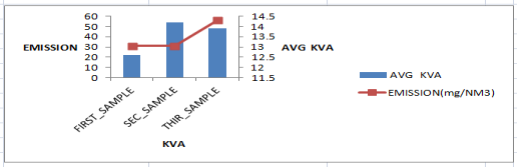
FOURTH CONDITION
(THREE PHASE T.R SET CONNECTED TO 1st and 2nd

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	17.72	37
SEC_SAMPLE	17.466	17
THIR_SAMPLE	17.276	25



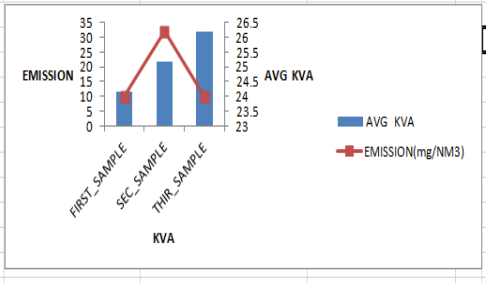
FIFTH CONDITION
(TWO THREE PHASE TRANSFORMERS CONNECTED

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	12.613	31
SEC_SAMPLE	14.218	31
THIR_SAMPLE	13.9	56



SEVENTH CONDITION
(H.F.T.R CONNECTED TO 1st and 2nd Field ON 11-02-2016)

	AVG KVA	EMISSION(mg/NM3)
FIRST_SAMPLE	24.18	10
SEC_SAMPLE	25.18	32
THIR_SAMPLE	26.2	10



H.F.T.R CONNECTED TO 1st & 2nd FIELD

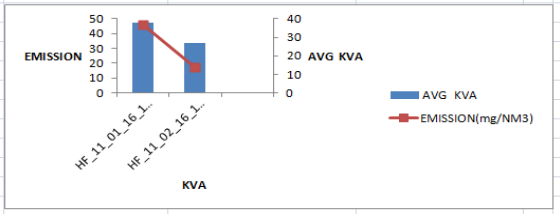
	KVA(1 &2	KVA(3rd	KVA(4th	AV G	EMISS ION(m
FIRST_ SAMPL E	38.66	11.20	17.67	22. 51	42.14
SEC_SA MPLE	44.31	17.38	18.67	38. 38	44.32
THIR_S AMPLE	30.25	17.64	18.24	22. 04	52.43

H.F.T.R CONNECTED TO 1st & 2nd FIELD

	KVA(1&2 FIELD)	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
FIRST SAMPLE	32.9206	20.837	18.797	24.18	10
SECOND SAMPLE	39.1212	18.421	18.023	25.18	32
THIRD SAMPLE	41.6056	18.797	18.2181	26.2	10

KVA VS EMISSION (H.F.T.R 1st &2nd FIELD)

	AVG KVA	EMISSION(mg/NM3)
HF_11_01_16_1&2FIE	37.74	46.29
HF_11_02_16_1&2FIE	26.78	17.33



KVA VS EMISSION (THREE PHASE TRANSFORMER CONNECTED TO 1&2 FIELD

	KVA(1&2	KVA(3rd	KVA(4th	AVG	EMISSION(mg/NM3)
4.56	7.67	16.71	18.22	14.20	
5.25	6.004	20.64	18.16	14.93	
AVG				14.56	34.47
5.55pm	6.03	21.44	18.32	15.26	
6.25pm	11.06	21.44	18.30	16.93	
AVG				16.09	32.95

(THREE PHASE TRANSFORMER CONNECTED TO 1&2 FIELD ON 09-02-2016)

	KVA(1&2 FIELD)	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
FIRST SAMPLE	16.449	20.663	22.404	19.838	40
SECOND SAMPLE	16.366	20.663	22.404	19.811	64
THIRD SAMPLE	16.230	19.197	21.446	18.957	10

(THREE PHASE TRANSFORMER CONNECTED TO 1&2 FIELD

	KVA(1&2 FIELD)	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
FIRST SAMPLE	10.642	19.704	22.815	17.720	37
SECOND SAMPLE	10.530	19.233	22.6358	17.466	17
THIRD SAMPLE	11.592	16.446	23.79	17.276	25

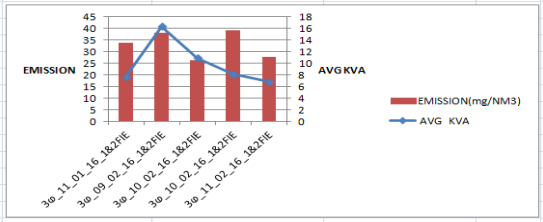
(THREE PHASE TRANSFORMER CONNECTED TO 1&2 FIELD

	KVA 1st FIELD	KVA 2nd FIELD	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
First sample	7.996	9.404	13.03	20.024	12.613	31
Second sample	7.860	9.474	19.554	20.054	14.218	31
Third sample	8.132	6.029	20.639	20.8024	13.900	56

THREE PHASE TRANSFORMER CONNECTED TO 1&2 FIELD

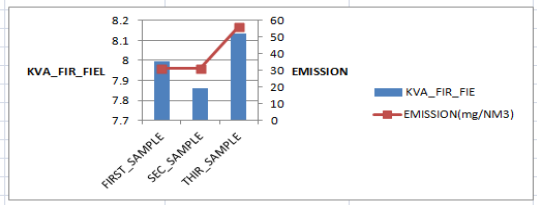
	KVA(1&2 FIELD)	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
FIRST SAMPLE	5.69	20.2279	21.5724	15.829	17
SECOND SAMPLE	8.077	20.174	19.814	16.021	33
THIRD SAMPLE	6.866	20.194	20.262	15.774	33

	AVG KVA	EMISSION(mg/NM3)
3φ_11_01_16_1&2FIE	7.69	33.71
3φ_09_02_16_1&2FIE	16.348	38
3φ_10_02_16_1&2FIE	10.92	26.33
3φ_10_02_16_1&2FIE	8.14	39.33
3φ_11_02_16_1&2FIE	6.87	27.66

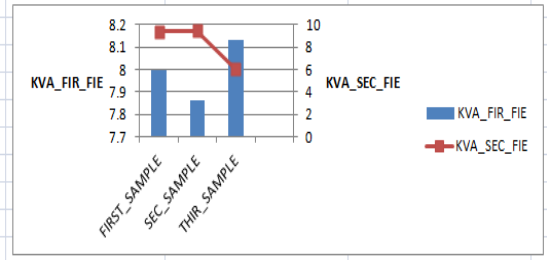


	KVA 1st FIELD	KVA 2nd FIELD	KVA(3rd FIELD)	KVA(4th FIELD)	AVG KVA	EMISSION mg/NM3
FIRST SAMPLE	7.996	9.404	13.03	20.024	12.613	31
SECOND SAMPLE	7.860	9.474	19.554	20.054	14.218	31
THIRD SAMPLE	8.132	6.029	20.639	20.8024	13.900	56

	KVA_FIR_FIE	EMISSION(mg/NM3)
FIRST_SAMPLE	7.996	31
SEC_SAMPLE	7.86	31
THIR_SAMPLE	8.132	56



	KVA_FIR_FIE	KVA_SEC_FIE
FIRST_SAMPLE	7.996	9.404
SEC_SAMPLE	7.86	9.474
THIR_SAMPLE	8.132	6.029



	KVA_SEC_FIE	EMISSION(mg/NM3)
FIRST_SAMPLE	9.404	31
SEC_SAMPLE	9.474	31
THIR_SAMPLE	6.029	56