SOCIALIST REPUBLIC OF VIETNAM
Independence – Freedom – Happiness

Ha Tinh, 30th December 2014

PROTOCOL No.: VA1-M4F-ESP-PTR-001

PERFORMANCE TEST FINAL REPORT FOR ELECTROSTATIC PRECIPITATOR SYSTEM

1. Accepted Object(s):

- Project: **Vung Ang 1 Thermal Power Plant 2x600 MW**
- Item: **Performance test for ESP- Unit 1**
- Location: **Electrostatic Precipitator 01 & 02 – Unit 1**

2. Acceptance Attendees:

a) EPC Contractor's representative: Vung Ang 1 Power PMB – LILAMA

- Mr. Huynh Huu Vinh Position: Commissioning Manager
- Mr. Mai Van Tu Position: Deputy Commissioning Manager

b) Subcontractor's representative: KNLC/ KONDOR_ECO - NARIME

- Mr. M.E. Smirnov Position: Project Director
- Mr. Duong Van Long Position: Project Coordinator
- Mr. Pham Van Thang Position: Engineer
- Mr. Smirnov Dmitri Position: Engineer
- Mr: Trinh Quoc Khanh Position: Engineer

c) Owner's representative: Petrovietnam Vung Ang – Quang Trach Power PMB

- Mr. Do Ngoc Tu Position: Deputy Technology Manager
- Mr. Phan Xuan Hoang Position: Engineer
- Mr. George Matei Position: Poyry Engineer

3. Acceptance Time and Location:

- Start: 08h00 16th December 2014
- Finish: 17h00 21st December 2014
- At: Vung Ang 1 TPP Site

4. Based on documentations for acceptance *(attachment file)***:**

- Performance test manual: VA1-KNLC-00HDE-GE-M4F-MAN-0056 – Rev 1;
- The list of Instrument and calibration for Instrument;
- Standard for testing methods;
- Report of Flue gas monitoring (report by National Working Environment Monitoring Station; Environmental Monitoring and Analyzing Center – Quang Ninh Department of Natural Resource and Environment).

5. Test result:

The parameters for 1 unit (characteristics)	Value in contract	Test result	Remark
1. Volume of Gas Nm^3/h	2.161.306	3.006.320	
2. Temperature drop through the ESP, ^oC	≤ 5	9	
3. Temperature of cleaned gas, °C	≥ 145	137	
4. Maximum pressure drop thru ESP, Pa (mmH_2O).	300 (30)	190 (19)	
5. Mass concentration of substances in gases at the inlet of the precipitator under normal conditions (temperature 0°C and pressure of 101.3 kPa), g/Nm^3, no more	≥ 37,6	12.27	
6. Outlet dust loading under condition of any one field out of service, mg/Nm3	< 140	105.92	
7. Outlet dust loading under all field in service, mg/Nm3	120	87.62	
8. ESP efficiency, (%)	99.65	99.30	
9. Total hopper storage capacity, hours	8	9.185	
10. Auxiliary power consumption for one Unit, kW	1150	917.75	
11. Equipment noisy level, dB (A)	80	50	
12. Maximum flue gas velocity, m/s	< 1.3	1.72	
13. Maximum insulating surface temperature above environment temperature	25	7	

6. TESTING METHODS

6.1 Sampling and analyzing methods: ISO 9096:2003

6.2 Temperature drop through the ESP

- Calculated by the formula:

$$\Delta T = T_1 - T_2 \ (°C)$$

- Where:

ΔT - Temperature drop through the ESP (°C);

T_1 – Temperature average at Inlet of ESP (°C);

T_2 – Temperature average at Outlet of ESP (°C);

- See the table in Item 7.1 of **Report of Flue gas monitoring,** we have:

$$\Delta T = 137 - 118 = 9 \ (°C)$$

6.3 Temperature of cleaned gas

- Temperature of cleaned gas by temperature average at Inlet of ESP: T_1 (°C);

- See the table in Item 7.1 of **Report of Flue gas monitoring,** we have: $T_1 = 137$ (°C);

6.4 Maximum pressure drop thru ESP

- Calculated by the formula:

$\Delta P = (P_1 – P_2)$ x1000 (Pa)

- Where:

ΔP – Maximum pressure drop through the ESP (Pa);

P_1 – Absolute pressure average at Inlet of ESP (kPa);

P_2 – Minimum Absolute Pressure average at Outlet of ESP (kPa);

- See the table in Item 7.1 of **Report of Flue gas monitoring,** we have:

$\Delta P = (98.79 – 98.60)$ x1000 = 190 (Pa) = 19 (mmH_2O).

6.5 Mass concentration of substances in gases at the inlet of the precipitator, Outlet dust loading under condition of any one field out of service and Outlet dust loading under all field in service see the table in Item 7.1 of **Report of Flue gas monitoring.**

6.6 ESP efficiency

- ESP efficiency are calculated by the formula (when all field in service only):

$$\eta = \frac{n-n1}{n} \text{ x } 100 \text{ (\%)}$$

- Where:

η – Electrostatic Precipitator efficiency (%);

n_1 – Outlet dust loading average under all field in service (mg/Nm^3);

n – Mass concentration of substances in gases at the inlet of the precipitator (mg/Nm^3);

- See the table in Item 7.1 of **Report of Flue gas monitoring,** we have:

$$\eta = \frac{12267.30-87.62}{12267.30} \text{ x } 100 = 99.30 \text{ \%}.$$

6.7 Total hopper storage capacity

- Clean one line of Ash system at 08h00, December 17, 2014 and Isolate this line then checking the time from cleaned to fully (when the hopper fully, the level switch will be show the Alarm in PLC system Scada of ESP).

- Total hopper storage capacity is the time average from cleaned to fully. And we have result details as follow:

	Field 1	**Field 2**	**Field 3**	**Field 4**
Cleaned at	08h00	08h00	08h00	08h00
Fully at	16h35	17h00	17h20	17h50
Time for fully	08h35’ or 8.58h	09h	09h20’ or 9.33h	09h50’ or 9.83h

- Total hopper storage capacity calculated by the formula:

$$\delta t = \frac{t1+t2+t3+t4}{4} \text{ (hours);}$$

- Where:

δt – Total hopper storage capacity (hours);

t_1 – Total hopper storage capacity field 1 (hours);

t_2 – Total hopper storage capacity field 2 (hours);

t_3 – Total hopper storage capacity field 3 (hours);

t_4 – Total hopper storage capacity field 4 (hours);

- See the table above, we have:

$\delta t = \frac{8.58+9+9.33+9.83}{4} = 9.185$ (hours)

6.8 Auxiliary power consumption for one ESP

- Read the power consumption from 10 kV cabinet (medium voltage cabinet) and taking power consumption average.

Time (16/12/2014)			13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30
No	**KKS**	**Equipment**	**Power (kW)**							
1	10BBA01GS113	ESP 01	506	414	405	425	407	471	418	430
2	10BBA02GS124	ESP 02	445	517	538	470	431	463	485	517
Total			951	931	943	895	838	934	903	947
Average			917.75							

6.9 Equipment noisy level

- Test by tools name: Portable noise measurement instrument Sound Pro DXL.

6.10 Maximum flue gas velocity

- Equation state of gas in standard condition: $\frac{P1.v1}{t1} = \frac{P2.v2}{t2}$

- Where:

p_1 – pressure of gas in standard condition (kPa);

V_1 – capacity of gas in standard condition (Nm^3);

t_1 – temperature of gas in standard condition (°K);

p_2 – pressure of gas in working condition (kPa);

V_2 – capacity of gas in working condition (m^3);

t_2 – temperature of gas in working condition (°K);

- An unit of time, we have V_1 = Flow rate of gas for one ESP in standard condition.

- See the table in Item 7.1 of **Report of Flue gas monitoring,** we have: $V_1 = 1503160$ Nm^3

- Standard condition: $t_1 = 25^oC = 298°K$, $p_1 = 101.325$ kPa;

- Working condition: $t_2 = 137^oC = 410°K$, $p_2 = 98.79$ kPa;

$\Rightarrow V_2 = \frac{P1.v1.t2}{t1.p2} = \frac{101.325x1503160x410}{298x98.79} = 2121174.66$ m^3;

- Flue gas velocity v can be calculated as: $v = \frac{Q}{3600xS}$ (m/s)

- Where: v – Velocity of flue gas thru ESP (m/s);

Q - Flow rate of gas for one ESP in working condition (m^3/h);

S - The useful cross section of ESP (m^2);

- With S calculated as: S = the useful height of ESP x the useful wide of ESP;

- In design: The useful height of ESP: 13 m;

The useful wide of ESP: 66 passage x (0.4m/01 passage) = 26.4m;

- Therefore: S = 13x26.4 = 343.2 m^2;

- On the other: Q = V_2 (an unit of time) => v = $\frac{2121174,66}{3600x343.2}$ = 1.72 (m/s);

6.11 Maximum insulating surface temperature above environment temperature

- Test by tools name: Portable temperature measurement instrument Optex PT-3LF.

- Measuring point: 20 any point/01 ESP.

- Results table in Item 7.3 of **Report of Flue gas monitoring.**

- Maximum differing temperature between insulating surface temperature above environment temperature can be calculated as:

$\Delta T^* = T_2^* - T_1^*$ (°C);

- Where:

ΔT^* - Maximum differing temperature between insulating surface temperature above environment temperature. (°C);

T_2^* - Maximum insulating surface temperature average (°C);

T_1^* - Environment temperature (°C);

- See the table in Item 7.3 of **Report of Flue gas monitoring,** we have:

$\Delta T^* = 22 - 15 = 7$ (°C);

7. Conclusions:

- Accepted for completion of the performance test for ESP - unit 1 and agreement for carry out the next stage.

Enclosed:

Based documentations for acceptance;

Company	Name	Signature	Date
Sub - Contractor KNLC/NARIME	**M.E. Smirnov**		30/12/2014
	Duong Van Long		30/12/2014
	Pham Van Thang		30/12/2014
EPC - Contractor Lilama	**Huynh Huu Vinh**		30/12/2014
Owner - VQPP PVN			30/12/2014
			30/12/2014