GUIDANCE DOCUMENT FOR DESIGN OF AXIAL-FLOW VORTEX TUBE DUST COLLECTOR

(Additional document to the Guidance Document of Fuel Burning Equipment and Air Pollution Control System)

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GUIDANCE DOCUMENT for AIR POLLUTION CONTROL SYSTEM of FUEL BURNING EQUIPMENT

1.0 SECTION ON AXIAL FLOW VORTEX TUBES

Axial flow vortex tubes have been used for dust collection over the last 50 years. Their application is not as broad as other traditional technologies. They are primarily used for fly-ash, due to its resistance to wear as compared to cyclones.

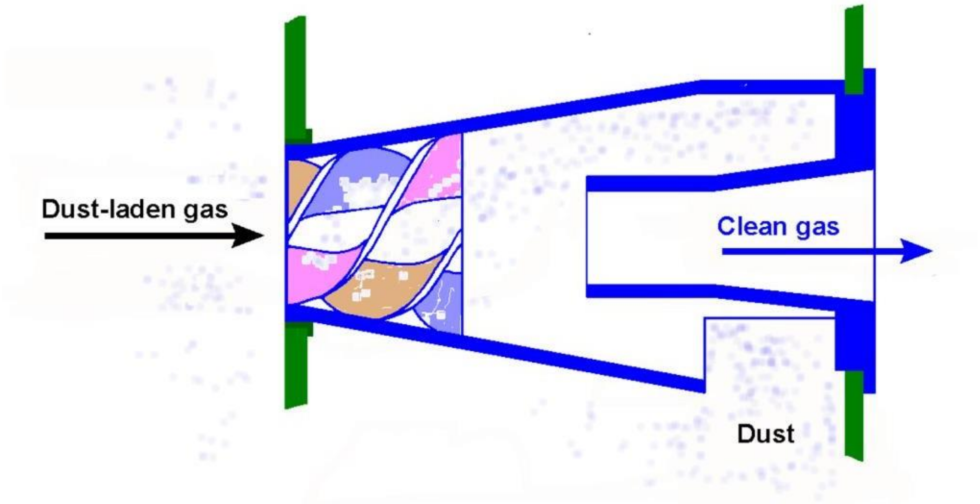

Figure 1 Schematic of an Axial Flow Vortex Tube

Axial flow vortex tubes are compact and have lower pressure losses than conventional cyclones, and therefore can achieve high collection efficiencies, especially when used in series.

Smaller tubes have the potential of higher efficiencies. Axial vortex tubes for collecting fly-ash typically ranges from 50 to 100 mm diameter per tube, and 200 to 2000 tubes per stage, based on the size of the tubes and the capacity of the boiler.

The figure below shows a typical schematic layout:

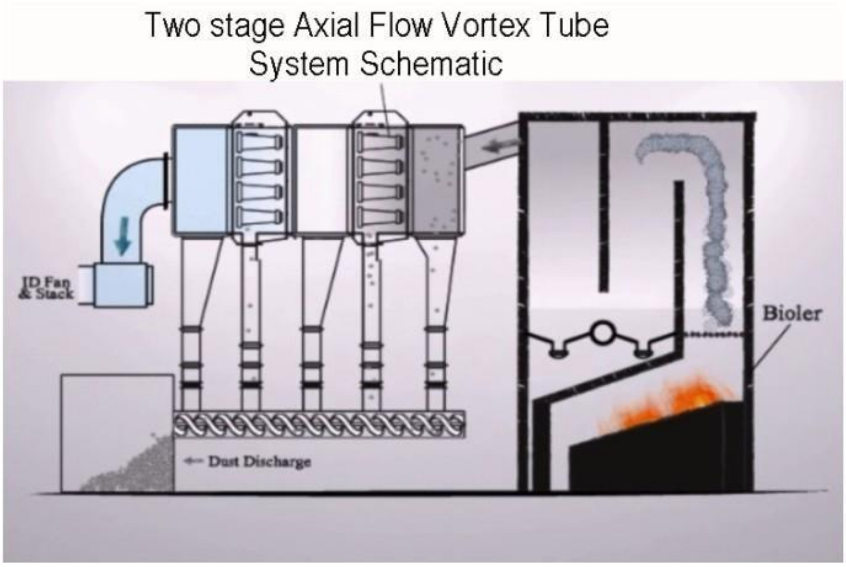

Figure 2: Typical Schematic Layout

Axial Flow systems are sold with performance guarantees, as the system performance may differ vastly from individual tube performance. The simplest guarantee is by “Grade Efficiency Curve” a collection efficiency based on a defined particle size distribution. More complex guarantees are based on fuel (ultimate analysis and, including ash content), furnace type and final emissions. Confirming these guarantees must be done by Isokinetic Testing, including Performance Testing using the applicable Malaysian Standards. (MS1596:2003 and MS1723:2017).

2.0 DESIGN CONSIDERATIONS

There have been major developments in modern axial flow vortex tube systems, of which the following may be considered the most important in chronological sequence:

I. Panel Design

Panel design is important as far as the total system efficiency is concerned. Efficiencies as achievable in lab conditions with single tube test units, can be achieved with correct panel design.

II. Tube Design

In Conjunction with the panel designs, the tube designs are important. Some tubes can work without a scavenge flow (withdrawing gas through the dust outlet), while others need the scavenge, but generally speaking have a more define separation characteristic. Combining different designs increases the overall efficiency of multistage systems.

III. Quality Control Procedures

Advance quality control measures are a must to achieve consistent high efficiency over the lifespan of an axial flow vortex tube unit.

Figure 2 shows a modern TAS100 Filter System on a 45 ton/hour Palm Oil Fibre/shell fired boiler.

Figure 3: A Modern VORSEP TAS100 filter system on a Palm Oil Boiler

3.0 SYSTEMS TO MONITOR VORSEP FILTERS (Refer to figure 4)

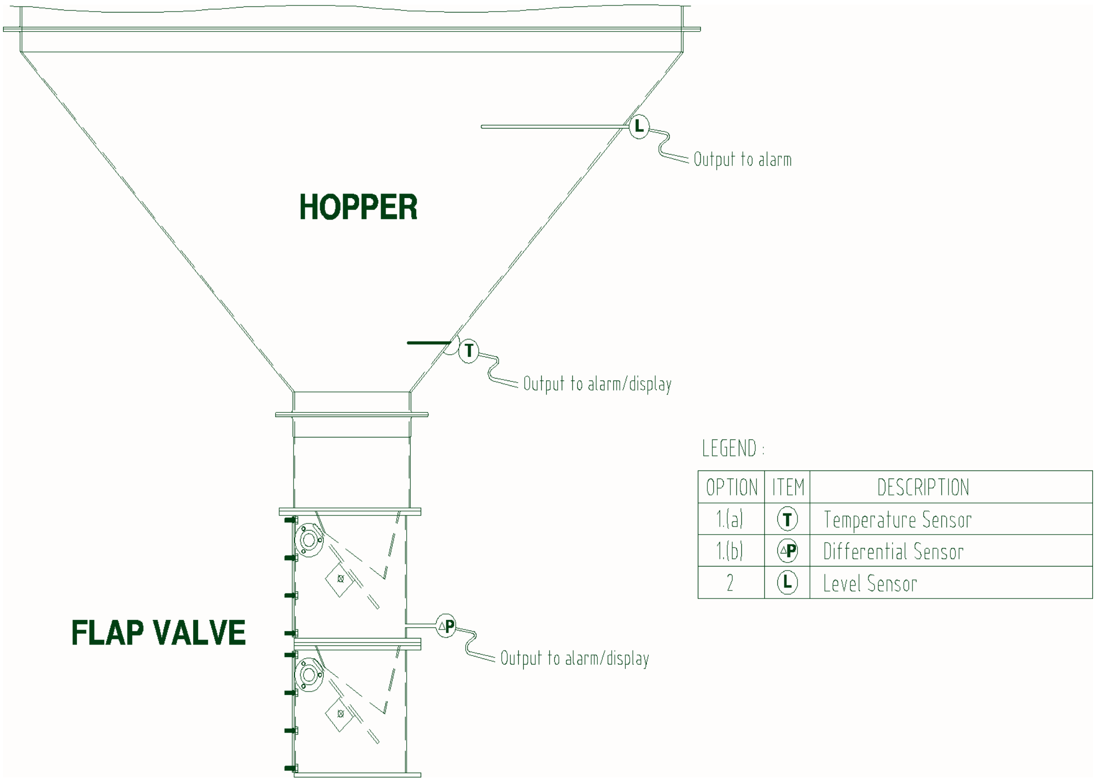

Figure 4 Monitoring of an Axial Flow Vortex Tube System

i) Monitoring the Motorized Double Flap Valves

The motorized double flap valves are an important part of the VORSEP System. Leaks in the valves causes drop in total efficiencies, especially for systems without modern scavenge units. There are two ways to monitor the flap valves.

a) The first method is by measuring the temperature just above the flap valve. This temperature should be consistent of normal boiler operation. Very high temperatures may indicate a leak and / or very low temperatures may show a leak or blocking.

b) The second method is by measuring the relative pressure between the two flaps. Though the pressure may differ according to boiler operation, it should be consistent for all the flap valves at the same pressure level. Leakages will be shown by pressure levels that changes outside the norm.

Alarms may be connected to any of the two methods to alert operators.

ii) Monitoring the Hoppers

A dust discharge failure may be indicated by using a level sensor inside the dust hoppers. Typically an alarm will be sounded to alert operators. Refer annexure A of Daily maintenance Checklist and annexure B of Daily Performance Monitoring Logsheet.

ANNEXURE A

Daily Maintenance Checklist

Annexure-A: Daily Maintenance Checklist

NO.	DESCRIPTION	FREQUENCY	MON	TUE	WED	THU	FRI	SAT	SUN	CLEANED / REPAIRED / REPLACED	CHECKED BY
1	**VORSEP® Panels**										
	Dust accumulation in transition panel	Monthly									
	Blockages at VORSEP® tubes	Monthly									
2	**Scavenge Fans**										
	Excessive Vibration	Daily									
	Fan impeller	Weekly									
	Lubrication	Weekly									
	Fan bearings	Weekly									
3	**Dust Discharge Valve**										
	Leak	Daily									
	Bearing	Weekly									
	Cam	Weekly									
4	**Instrumentation**										
	Temperature sensor	Daily									
	Pressure Transmitter	Daily									
	Pneumatic Damper	Daily									
	Control Panel	Monthly									

ANNEXURE B

Daily Performance Monitoring Log-sheet

Annexure-B: Daily Performance Monitoring Log-sheet

TIME	START	STOP	TEMPERATURE AT HOPPERS [°C]					SYSTEM PRESSURE DROP [Pa]		REMARKS
			T_1	T_2	T_3	T_4	T_5	MAIN	SCAVENGE	
6:00 AM										
7:00 AM										
8:00 AM										
9:00 AM										
10:00 AM										
11:00 AM										
12:00 PM										
1:00 PM										
2:00 PM										
3:00 PM										
4:00 PM										
5:00 PM										
6:00 PM										
7:00 PM										
8:00 PM										
9:00 PM										
10:00 PM										
11:00 PM										
12:00 AM										
1:00 AM										
2:00 AM										
3:00 AM										
4:00 AM										
5:00 AM										

BOILER SHIFT PERSON-IN-CHARGE
(6:00 AM – 6:00 PM)

BOILER SHIFT PERSON-IN-CHARGE
(6:00 PM – 6:00 AM)

4.0 Biomass Boiler Operation Requirements

Boiler operation for Biomass boilers strongly influence the outlet emissions, boiler output and fuel consumption. Although this manual's main focus is on boiler control guidelines for emission controls, the guidelines given in this section will also enhance boiler output abilities (especially response rate of steam supply vs. demand) and lower fuel consumption.

i. Fuel Feed Control

Fuel feed control, by default, is by means of PID control based on steam pressure. In the case where this control proves unstable or not reliable, fuel feed may be manually control by experienced boiler operators to maintain the set steam pressure of the plant. However, good operation will aim at minimizing the steam pressure fluctuations.

ii. Forced Draft Control

The forced draft air is the combustion air supply which needs to be adjusted to maintain the desired air/fuel ratio. In order to do this, the forced draft air must be linked with the fuel feed control via a ratio control. If the forced draft control is controlled via a damper that excludes the fuel feeder fan and/or grate cooling fans, then the ratio control needs to be calibrated based on actual measurements.

FD ratio control ensures a stable air/fuel ratio, which results in stable furnace temperatures facilitating combustion and boiler response to more or less fuel feed.

iii. Furnace Draft Control

The furnace draft control must be independent of the fuel feed and FD controls. The ID fan speed or damper is controlled by means of a furnace pressure set point that may be controlled using a PID or hysteresis control loop.

iv. Air Fuel Ratio

The recommended maximum air/fuel ratio should give excess air of maximum 60%. The actual air/fuel ratio may be set during operation and fine-tuning, and adjusted according to user's choice of operation, but must be maintained for all normal firing conditions.

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EXCEL AIR ENGINEERING SDN BHD
(Manufacturer and Supplier for VORSEP® Axial-Flow Vortex Tube)