NAK

CYCLONE SEPARATORS

فلاتر بيئة» لعوادم المولدات الكهربائية والإنبعاثات الصناعية.

NAKHOUL SARL CORPORATION

AIR DISTRIBUTION PRODUCTS SINCE 1976

www.nakhoulcorp.com

1 INTRODUCTION

• As part of its innovative products, and in view of the increasing demands over the restrictions related to the environmental protection, **NAKHOUL CORPORATION** developed and produced the NAK Cyclone Separator to address and control the problem of particulate matter emitted from diesel engines and other industry processes.

2 GENERAL INFORMATION

• Particulates, also referred to as particulate matter (PM), or suspended particulate matter (SPM), are tiny subdivisions of solid material suspended in air / gas streams.

• Some particulates are naturally found in the atmosphere (resulting from volcanoes, dust storms...), while others are created by human activities like combustion of fossil fuels in power generation, and various other industrial processes. Many different methods are employed to separate particulate matter from air / gas streams, from which we name :

- Bag Filters
- Gravitational Separator
- Electrostatic precipitators
- Catalytic filters
- Soot filters
- Cyclone Separators

• Out of all of the particulates' control devices, Cyclone Separators find a wide application in the industry today due to its inherent advantages :
low capital cost when compared to other particulates' control devices, maintenance free, high operating temperature.

3 FIELD OF APPLICATION

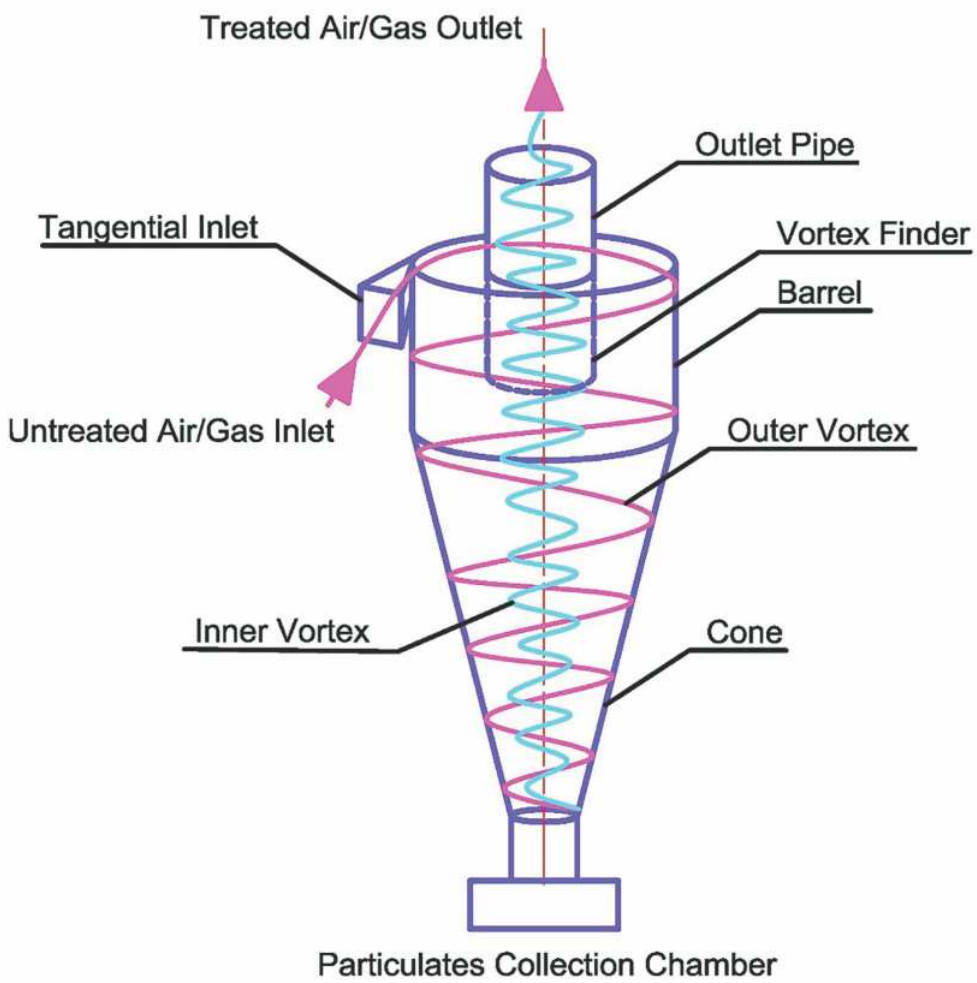
• **NAK Cyclone Separators** are used as air pollution control systems; they provide a reliable solution for removing particulate matter from air / gas streams at low capital cost.

• One important application is found in power generation systems, where NAK Cyclones are used to remove particulate matter (soot) from diesel engines' exhausted gases.

• **NAK Cyclone Separators** are also used in multiple other processes across many different industries like the cement industry, wood processing industry and others.

4 OPERATING PRINCIPLE

Figure 1



- **NAK Cyclones** are basically centrifugal separators; they consist of an upper cylindrical part referred to as "barrel" and a lower conical part referred to as "cone".

- They rely on centrifugal force to separate particulate matter from the air / gas stream. The particulate matter - air / gas mixture enters the cyclone tangentially through the inlet opening. The curved walls of the cyclone convert the linear motion of the mixture into a double spiral vortex (refer to Fig.1).

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- The outer vortex spirals downwards increasing the air velocity; as a result, a centrifugal force is exerted on the particulates causing them to strike the outside wall. Due to friction, these particulates lose speed and slow down until they eventually fall into the collection chamber located at the bottom of the conical section.

- A secondary vortex swirling upwards towards the outlet pipe is created near the bottom of the cyclone's conical section.

- Depending on the design and efficiency of the Cyclone, lighter particulates, having smaller inertia, might be carried by the upwards vortex and exit the cyclone through the top outlet.

5 OPERATING CONDITIONS

- The operation temperature **NAK Cyclone Separator** can reach 600 °C, depending on the type and thickness of the construction material.

6 MODELS OF NAK CYCLONE SEPARATORS

- **NAK Cyclone Separators** are designed and fabricated following different sizes, configurations, and efficiencies, depending on each application.

- **NAK-SEC,** standard efficiency cyclone design, and NAK-HEC, high efficiency cyclone design, are the most commonly used devices for particulate matter control in various industries.

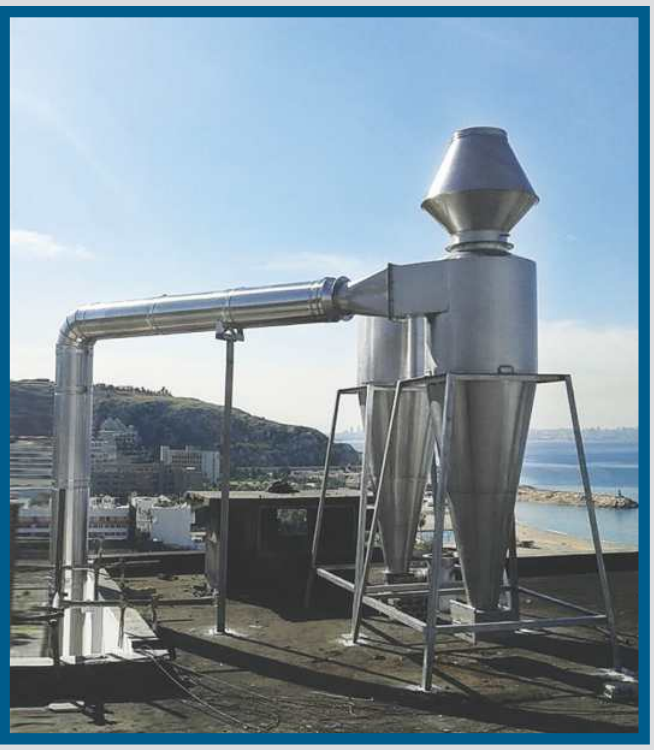
- Each configuration provides a different capture efficiency of the particulate matter.

- Other configurations, NAK-PEC, prime efficiency cyclone design, are manufactured upon request.

7 CONSTRUCTION MATERIAL

• Material selection and thickness are very important considerations when choosing a cyclone separator for a specific application.

• Some process systems may contain erosive and / or corrosive flowing mediums; therefore, it is necessary to select the proper construction material in order to minimize the adverse effects.



NAK STAINLESS STEEL CYCLONE SEPARATOR

NAK Cyclone Separator
can be fabricated from the following base materials:

- **A** | Painted black steel
- **B** | Galvanized steel
- **C** | Stainless steel AISI 304
- **D** | Stainless Steel AISI 316

8 PERFORMANCE

- The cyclone capture efficiency is usually expressed as "Cut-Off Diameter".

- The "Cut-Off Diameter" is defined as the size of particles that are likely to be collected with 50% efficiency by a given cyclone.

- As the "Cut-Off Diameter" increases, the capture efficiency decreases.

- On the other hand, increasing the velocity at the cyclone inlet improves the capture efficiency; however, care should be taken to ensure that the pressure drop remains within acceptable values.

- **NAK Cyclone Separators,** NAK-SEC and NAK-HEC, are built to control and remove particulate matters that are usually larger than 10 microns in diameter.

- However, higher efficiency cyclones, NAK-PEC, that are effective on particulates as small as 5 microns, are also fabricated upon request.

9 SELECTION

- **NAKHOUL CORPORATION** designed a special software for the selection of the NAK Cyclone Separator.
- The software was developed based on engineering calculations and documented studies and researches.

- The selection of the **NAK Cyclone Separator** is directly linked to the required efficiency (Standard Efficiency, High Efficiency, or Prime Efficiency), to the characteristics of the medium passing through the cyclone separator, and to the available static pressure at the source.

- Table 1 below, provides typical cyclones' diameters with selected flows and corresponding pressure drop. The figures mentioned there in relate to the gas exhaust from diesel engines.

CYCLONE Design Data (Diesel Engine Exhaust)

Project			
Consultant			
Client			
Diameter Selection			
Vc	4750	m3/h	Gas flowrate
0	1.2	g/m3	Dust load
µc	2.8E-05	Pa.s	Gas viscosty
0	0.67	kg/m3	Gas density
0	500.0	kg/m3	Solid density
Control Parameters			
Dc	1.20	m	Input Cyclone diameter Dc (m)
COD	13.97	µm	Cut off diameter (microns)
Δp	243.28	Pa	Pressure drop
Cyclone Geometry			
Selection of Cyclone Geometry			

Swift H

Standard Efficiency Cyclone' Dimensions

	Hc (m)	Bc (m)	Sc (m)	Di (m)	Lc (m)	Zc (m)	Ds (m)
1D/2D							
Lapple							
Swift							
Peterson							

High Efficiency Cyclone' Dimensions

	Hc (m)	Bc (m)	Sc (m)	Di (m)	Lc (m)	Zc (m)	Ds (m)
1D/3D							
2D/2D							
Stairmand							
Swift H	0.53	0.26	0.60	0.48	1.68	3.00	0.48

1 - Input the exhaust gas flow rate.
2 - Select the Cyclone geometry.
3 - Select the Cyclone diameter.
4 - Adjust the Cyclone diameter until calculated **cut off diameter** reaches target value, and corresponding pressure drop is acceptable.

10 RIGHT TO ALTERATIONS

- As part of its continuous development and innovation program, accurate performance data s generated and updated continuously, through the extensive field testing program.

- **Nakhoul Corporation** reserves its right to alter or amend any section of this manual without prior notice.

11 QUICK SELECTION DATA
(APPLICABLE TO GAS EXHAUST FROM DIESEL ENGINES)

CYCLONE DIAMETER Ø 0.4 M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-040	1200	16	250	2000	12	700	1.2
NAK-HEC-XX-040	1000	9.7	325	1500	7.5	760	1.6
NAK-PEC-XX-040	650	7.9	345	950	6.25	765	1.56

CYCLONE DIAMETER Ø 0.5M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-050	1900	17	260	3200	12.8	750	1.5
NAK-HEC-XX-050	1500	10.9	310	2300	8.6	735	2
NAK-PEC-XX-050	1000	8.65	340	1500	6.85	795	1.95

CYCLONE DIAMETER Ø 0.6M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-060	3200	17	360	4500	14.2	710	1.8
NAK-HEC-XX-060	2300	11.4	350	3300	9.35	735	2.4
NAK-PEC-XX-060	1500	9	380	2100	7.5	760	2.34

CYCLONE DIAMETER Ø 0.7M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-070	4500	18	385	6200	15.2	730	2.1
NAK-HEC-XX-070	3200	12	370	4500	10	740	2.8
NAK-PEC-XX-070	2000	9.8	365	2800	8.1	735	2.73

CYCLONE DIAMETER Ø 0.8M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-080	4500	18	385	6200	15.2	730	2.1
NAK-HEC-XX-080	3200	12	370	4500	10	740	2.8
NAK-PEC-XX-080	2000	9.8	365	2800	8.1	735	2.73

CYCLONE DIAMETER Ø 0.9M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-090	7000	21	340	10500	16.85	770	2.7
NAK-HEC-XX-090	5200	13.65	360	7500	11.2	760	3.6
NAK-PEC-XX-090	3250	11	360	4750	9	780	3.51

CYCLONE DIAMETER Ø 1.0M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-100	9000	21.5	370	12750	17.9	745	3
NAK-HEC-XX-100	6500	14.25	370	9200	11.85	750	4
NAK-PEC-XX-100	4100	11.5	380	5800	9.5	765	3.9

CYCLONE DIAMETER Ø 1.2M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-120	13000	23.5	375	18500	19.5	760	3.6
NAK-HEC-XX-120	9000	15.8	345	13200	13	750	4.8
NAK-PEC-XX-120	5800	12.5	370	8300	10.35	760	4.68

CYCLONE DIAMETER Ø 1.5M

CYCLONE DESIGNATION	Minimum Flow (m3/Hr)	Cut-Off Diameter @ Minimum Flow (µm)	ΔP @ Minimum Flow (Pa)	Maximum Flow (m3/Hr)	Cut-Off Diameter @ Maximum Flow (µm)	ΔP @ Maximum Flow (Pa)	Total Cyclone Lengh (m)
NAK-SEC-XX-150	19500	26.6	345	29000	21.7	765	4.5
NAK-HEC-XX-150	14000	17.6	345	20750	14.33	760	6
NAK-PEC-XX-150	9000	13.95	365	13000	11.5	770	5.85

improving the Air you Breathe

NAK

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