ENGINEERING LETTER 31

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CENTRIFUGAL FAN DUST LOAD GUIDELINES

PURPOSE, SCOPE, & AUTHORITY

The purpose of the document is to provide guidance for centrifugal fan selection in applications with particulate in the gas stream. The wear life and effect on fan input power are calculated.

DEFINITIONS

Dust loading is the mass or weight of particulate passing through the fan per unit time. It can also be expressed in mass or weight per unit volume.

Throat Velocity is the velocity of the air passing through the inlet at the smallest diameter section of the inlet. The area of the shaft on center-hung arrangements is to be accounted for when calculating the velocity.

BACKGROUND / GENERAL REQUIREMENTS

The effects on fans of particulate in the gas stream is a complex subject. Variables include: dust load, particle size, particle shape, material hardness, temperature, particle velocity, particle distribution, fan size, blade form, wheel material, fan speed. Even with knowledge of all these variables there is no reliable method to predict the wear life of a fan. The factors presented here are to be used as a guide only. Actual experience for a given application needs to be included in the evaluation.

Note that values are expressed in terms of Standard cubic feet (SCF), not Actual cubic feet (ACF). Processes defined with flow in ACFM will need to be converted to SCFM to use this procedure.

PROCEDURE:

Blade Form Selection Guide

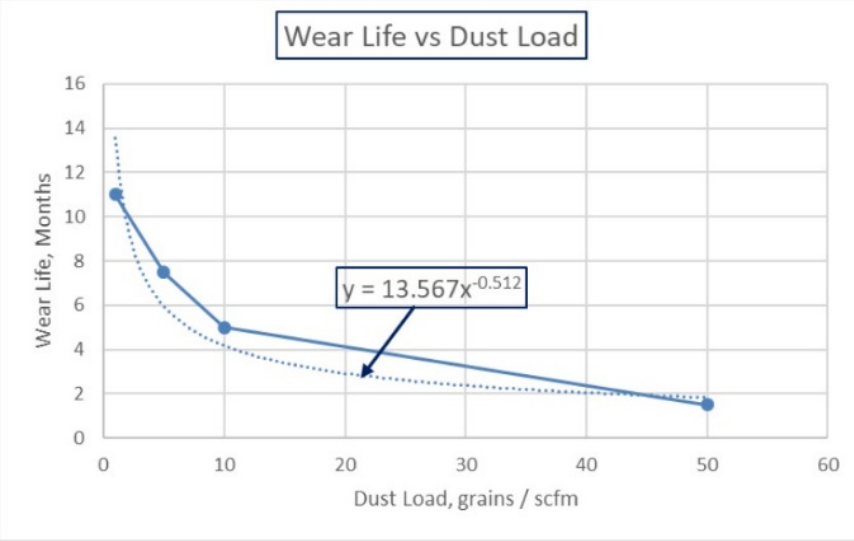
Use the following chart as an approximate guide for the maximum recommended dust load for various blade forms.

Blade Form	Max. Dust Load, grains / SCF
Airfoil (AF)	<1.0
Backward Inclined (BI)	5
Backward Curve (BC)	5
Radial Tip (RT)	30
Radial Blade (RB)	50
Paddle Wheel (PW)	100

WEAR LIFE CALCULATION

Calculate the estimated wear life as a function of dust load per:

$WL = 13.6 \times DL^{-0.512}$,(per graph below)
WL = Wear Life, Months
DL = Dust Load, grains/SCFM



The following chart is included for convenience to show relationship between grains/SCFM and pounds per minute for various volumetric flow rates of air.

		1	Pound =	7000	Grains					
		1	Grain =	0.000143	Pound					
Pounds per Minute Conversion										
		Grains per SCFM								
		1	2.5	5	10	20	40	50	75	100
Volume (SCFM)	100	0.014	0.036	0.071	0.143	0.286	0.571	0.714	1.07	1.43
	500	0.071	0.179	0.357	0.714	1.43	2.86	3.57	5.36	7.14
	1000	0.143	0.357	0.714	1.43	2.86	5.71	7.14	10.7	14.3
	2000	0.286	0.714	1.43	2.86	5.71	11.4	14.3	21.4	28.6
	5000	0.714	1.79	3.57	7.14	14.3	28.6	35.7	53.6	71.4
	10000	1.43	3.57	7.14	14.3	28.6	57.1	71.4	107	143
	25000	3.57	8.93	17.9	35.7	71.4	143	179	268	357
	50000	7.14	17.9	35.7	71.4	143	286	357	536	714
	75000	10.7	26.8	53.6	107	214	429	536	804	1071
	100000	14.3	35.7	71.4	143	286	571	714	1071	1429
	150000	21.4	53.6	107	214	429	857	1071	1607	2143
	200000	28.6	71.4	143	286	571	1143	1429	2143	2857
	250000	35.7	89.3	179	357	714	1429	1786	2679	3571
	300000	42.9	107	214	429	857	1714	2143	3214	4286
	350000	50.0	125	250	500	1000	2000	2500	3750	5000
	400000	57.1	143	286	571	1143	2286	2857	4286	5714
	450000	64.3	161	321	643	1286	2571	3214	4821	6429
	500000	71.4	179	357	714	1429	2857	3571	5357	7143

(Pounds per minute of dust = SCFM x grains/SCFM x 0.000143 pound/grain)

To account for other variables, multiply the calculated wear life by the following factors to result in a corrected wear life, WL_{CORR}:

Blade Form Factor:

FBF = 1.0 for Paddle Wheel (PW)
0.9 for Radial Blade (RB)
0.8 for Radial Tip (RT)
1.1 for Backward Inclined (BI)
1.3 for Backward Curve (BC)
0.2 for Airfoil (AF)

Inlet Throat Velocity Factor:

$FTV = (TV_{REF} / TV)^2$

TV_{REF} = 5,000, Reference Throat Velocity, ft./min.
TV = Throat Velocity, ft./min.

Particulate Hardness Factor:

$FPH = (PH_{REF} / PH)$

PH = Hardness of Particulate
PH_{REF} = Hardness of reference Particulate
Note: Any hardness units can be used but must be the same for both PH and PH_{REF}.

Blade Liner Hardness Factor:

F_{BL} = 1.0 for Carbon Steel (A36)
2.0 for A514
4.0 for Q&T 400
15 for Chrome Carbide

Corrected Wear Life, WLCORR:

$WL_{CORR} = WL \times F_{BF} \times F_{TV} \times F_{PH} \times F_{BL}$

Fan Input Power

When particulate (or liquid) is present in the air stream, the fan input power increases directly proportional to the combined mass flow rate of the air and particulate. The fan BHP curve should be increased by the Dust Load Factor:

$F_{DL} = (M_A + M_D)/M_A$
M_A = Mass flow rate of air
M_D = Mass flow rate of dust

Example:

Given: Fan air flow rate = 150,000 S CFM

Standard air density = 0.075 lb./cu.ft.

Process mass flow rate of dust = 50 grains per SCFM

Calculate mass flow rate of air:

M_A = 150,000 SCFM x 0.075 lb./cu.ft. = 11,250 lb./min.

Determine mass flow rate of dust per chart, above:

At 150,000 SCFM & 50 grains/SCFM, M_D = 1,071 lb./min.

Calculate Dust Load Factor:

$F_{DL} = (M_A + M_D)/M_A = (11,250 + 1,071) / 11,250 = 1.$