

Flow Calculations

5/28/2024

Assumptions:

- 1. Turbulent flow regime
- 2. Fluid properties

Fluid: diesel at 60 de. specific gravity 0.88  
dyn viscosity ft^2/s 4.31E-05

<https://energy-models.com/pipe-sizing-charts-tables>  
<https://ntrs.nasa.gov/api/citations/19660024205/downloads/19660024205.pdf>

Schiller Darcy-Weisbach eqn  
 $0.0054 + 0.396/R \cdot dP = f \cdot L \cdot \rho \cdot v^2 / D$

total flow rate, gpm 11.5  
max duty cycle 50%  
total fuel per 12 hrs gal 4100  
Number of hoses 3  
hose flow rate, gpm 3.8  
P max psi 155

	Part	ID , in.	Length (ft)	L/D	velocity, ft/s	Re (vD/nu)	f	dP (psi)	total P (psi)	Notes
A	filter	2.00			0.39	1.52E+03	0.049	3.59		dP approximation per FAS
	manifold to reel	2.00	10.00	60.00	0.39	1.52E+03	0.049	0.00		
	manifold	4.00	30.00	90.00	0.10	7.58E+02	0.060	0.00		
	manifold welded tee	2.00		45.00	0.39	1.52E+03	0.049	0.00		
	elbow	2.00		45.00	0.39	1.52E+03	0.049	0.00		
	elbow	2.00		45.00	0.39	1.52E+03	0.049	0.00		
	hose	1.00	200	2400.00	1.57	3.03E+03	0.041	1.43	5.04	
B	filter	2.00			0.39	1.52E+03	0.049	3.59		dP approximation per FAS
	manifold to hose	1.00	6.00	72.00	1.57	3.03E+03	0.041	0.04		
	elbow	0.50		45.00	6.26	6.06E+03	0.034	0.36		
	hose	0.38	200	6400.00	11.14	8.08E+03	0.032	150.57	154.56	

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J. Rodgers

	Typical	Large	Superfrac	
Peak Fuel Consumption (gal) per 12 hr.	7500	12000	24000	
Avg Flow Rate (gpm)	10	17	33	
Avg. Duty Cycle	90%	90%	90%	
Total flow rate required (gpm)	12	19	37	
Avg. Duty Cycle	50%	50%	50%	
Total flow rate required (gpm)	21	33	67	

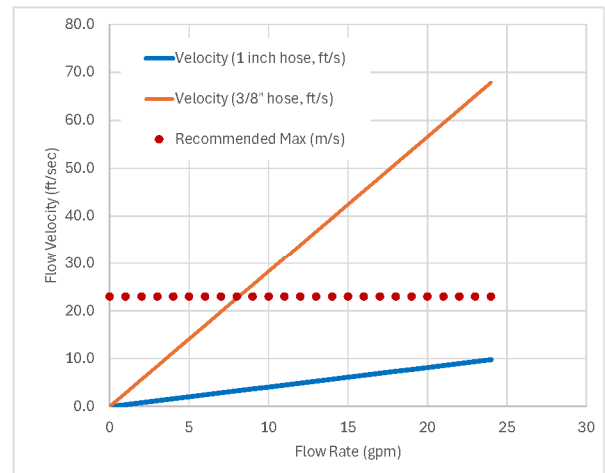
per information from FAS

assumed start-up and shut-down time required, max duty cycle achievable

comfortable duty cycle for nominal operations

**Flow Calculations**  
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Flow Rate (gpm)	1 Velocity (1 inch hose, ft/s)	0.75 Velocity (3/4 inch hose, ft/s)	0.5 Velocity (1/2 inch hose, ft/s)	0.38 Velocity (3/8" hose, ft/s)	Recommended Max (m/s)
0	0.0	0.0	0.0	0.0	23
1	0.4	0.7	1.6	2.8	23
2	0.8	1.5	3.3	5.7	23
3	1.2	2.2	4.9	8.5	23
4	1.6	2.9	6.5	11.3	23
5	2.0	3.6	8.2	14.1	23
6	2.5	4.4	9.8	17.0	23
7	2.9	5.1	11.4	19.8	23
8	3.3	5.8	13.1	22.6	23
9	3.7	6.5	14.7	25.5	23
10	4.1	7.3	16.3	28.3	23
11	4.5	8.0	18.0	31.1	23
12	4.9	8.7	19.6	33.9	23
13	5.3	9.4	21.2	36.8	23
14	5.7	10.2	22.9	39.6	23
15	6.1	10.9	24.5	42.4	23
16	6.5	11.6	26.1	45.3	23
17	6.9	12.3	27.8	48.1	23
18	7.4	13.1	29.4	50.9	23
19	7.8	13.8	31.0	53.7	23
20	8.2	14.5	32.7	56.6	23
21	8.6	15.3	34.3	59.4	23
22	9.0	16.0	35.9	62.2	23
23	9.4	16.7	37.6	65.1	23
24	9.8	17.4	39.2	67.9	23



**Flow Calculations**

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Hose Size (in)	1	0.38
Hose length (ft)	200	700
Hose volume (gal)	8.2	4.1

Flow Calculations  
45442

Assumptions

1. Turbulent flow regime
2. Fluid properties

Fluid: diesel at 60 degF  
specific gravity 0.88  
dyn viscosity 0.000004/0.0254^2/12^2

<https://energy-models.com/pipe-sizing-charts-tables>  
<https://ntrs.nasa.gov/api/citations/19660024205/downloads/19660024205.pdf>

Schiller  
0.0054+0.396/R^0.3  
Darcy-Weisbach eqn  
dP=L rho/2 v^2/D

total flow rate, gpm 11.6  
max duty cycle 0.5  
total foot per 12 hrs gal 1000\*ROUND(E11\*12\*50/E12/1000.1)  
Number of hoses 3  
hose flow rate, gpm 11.6/E14  
P max psi 12

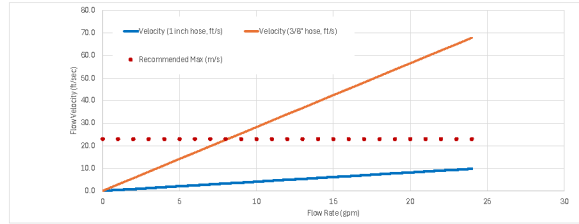
A	Part	ID , in.	Length (ft)	I/D	velocity, ft/s	Re (vd/mg)	f	dP (psi)	total P (psi)	Notes
	filter	2			=E8/E19*0.1357/(PI()*C20^2/4)*12^2/50	=F20*C20/2/8E-9	=0.0054+0.396/50^0.3	=E8/E13/2		dP approximation per FAS
	manifold to reel	2	10	=D28/C21*12	=E8/E19*0.1357/(PI()*C21^2/4)*12^2/50	=F21*C21/2/8E-9	=0.0054+0.396/50^0.3	=H21*E21*E8/E7*62.4/2^2/50^2/2/2/12^2		
	manifold	4	30	=D22/C22*12	=E8/E19*0.1357/(PI()*C22^2/4)*12^2/50	=F22*C22/2/8E-9	=0.0054+0.396/50^0.3	=H22*E22*E8/E7*62.4/2^2/50^2/2/2/12^2		
	manifold welded tee	2	46		=E8/E19*0.1357/(PI()*C23^2/4)*12^2/50	=F23*C23/2/8E-9	=0.0054+0.396/50^0.3	=H23*E23*E8/E7*62.4/2^2/50^2/2/2/12^2		
	elbow	2	46		=E8/E19*0.1357/(PI()*C24^2/4)*12^2/50	=F24*C24/2/8E-9	=0.0054+0.396/50^0.3	=H24*E24*E8/E7*62.4/2^2/50^2/2/2/12^2		
	elbow	2	46		=E8/E19*0.1357/(PI()*C25^2/4)*12^2/50	=F25*C25/2/8E-9	=0.0054+0.396/50^0.3	=H25*E25*E8/E7*62.4/2^2/50^2/2/2/12^2		
	hose	1	200	=D26/C26*12	=E8/E19*0.1357/(PI()*C26^2/4)*12^2/50	=F26*C26/2/8E-9	=0.0054+0.396/50^0.3	=H26*E26*E8/E7*62.4/2^2/50^2/2/2/12^2	=SUM(H20:H26)	
B	filter	2			=E8/E19*0.1357/(PI()*C28^2/4)*12^2/50	=F28*C28/2/8E-9	=0.0054+0.396/50^0.3	=E8/E13/2		dP approximation per FAS
	manifold to hose	1	6	=D28/C29*12	=E8/E19*0.1357/(PI()*C29^2/4)*12^2/50	=F29*C29/2/8E-9	=0.0054+0.396/50^0.3	=H29*E29*E8/E7*62.4/2^2/50^2/2/2/12^2		
	elbow	0.5	46		=E8/E19*0.1357/(PI()*C30^2/4)*12^2/50	=F30*C30/2/8E-9	=0.0054+0.396/50^0.3	=H30*E30*E8/E7*62.4/2^2/50^2/2/2/12^2		
	hose	8.375	200	=D31/C31*12	=E8/E19*0.1357/(PI()*C31^2/4)*12^2/50	=F31*C31/2/8E-9	=0.0054+0.396/50^0.3	=H31*E31*E8/E7*62.4/2^2/50^2/2/2/12^2	=SUM(H28:H31)	

Flow Calculations  
45440  
J. Rodgers

Peak Fuel Consumption (gal) per 12 hr.	Typical 7500	Large 12000	Superfrac 24000	per information from F, assumed start-up and comfortable duty cycle
Avg Flow Rate (gpm)	=C6/12/60	=D6/12/60	=E6/12/60	
Avg. Duty Cycle	0.9	=C8	=C8	
Total flow rate required (gpm)	=C7/C8	=D7/D8	=E7/E8	
Avg. Duty Cycle	0.5	=C10	=D10	
Total flow rate required (gpm)	=C7/C10	=D7/D10	=E7/E10	

Flow Calculations  
45660

	1	0.75	0.5	0.38	
Flow Rate (gpm)	Velocity (1 inch hose, ft/s)	Velocity (3/4 inch hose, ft/s)	Velocity (1/2 inch hose, ft/s)	Velocity (3/8 inch hose, ft/s)	Recommended Max (m/s)
0	+886P231609P/F4C84*212	+886P231609P/F4C84*212	+886P231609P/F4E84*212	+886P231609P/F4E84*212	-710.925412
1	+887P231609P/F4C84*212	+887P231609P/F4C84*212	+887P231609P/F4E84*212	+887P231609P/F4E84*212	-710.925412
2	+888P231609P/F4C84*212	+888P231609P/F4C84*212	+888P231609P/F4E84*212	+888P231609P/F4E84*212	-710.925412
3	+889P231609P/F4C84*212	+889P231609P/F4C84*212	+889P231609P/F4E84*212	+889P231609P/F4E84*212	-710.925412
4	+8810P231609P/F4C84*212	+8810P231609P/F4C84*212	+8810P231609P/F4E84*212	+8810P231609P/F4E84*212	-710.925412
5	+8811P231609P/F4C84*212	+8811P231609P/F4C84*212	+8811P231609P/F4E84*212	+8811P231609P/F4E84*212	-710.925412
6	+8812P231609P/F4C84*212	+8812P231609P/F4C84*212	+8812P231609P/F4E84*212	+8812P231609P/F4E84*212	-710.925412
7	+8813P231609P/F4C84*212	+8813P231609P/F4C84*212	+8813P231609P/F4E84*212	+8813P231609P/F4E84*212	-710.925412
8	+8814P231609P/F4C84*212	+8814P231609P/F4C84*212	+8814P231609P/F4E84*212	+8814P231609P/F4E84*212	-710.925412
9	+8815P231609P/F4C84*212	+8815P231609P/F4C84*212	+8815P231609P/F4E84*212	+8815P231609P/F4E84*212	-710.925412
10	+8816P231609P/F4C84*212	+8816P231609P/F4C84*212	+8816P231609P/F4E84*212	+8816P231609P/F4E84*212	-710.925412
11	+8817P231609P/F4C84*212	+8817P231609P/F4C84*212	+8817P231609P/F4E84*212	+8817P231609P/F4E84*212	-710.925412
12	+8818P231609P/F4C84*212	+8818P231609P/F4C84*212	+8818P231609P/F4E84*212	+8818P231609P/F4E84*212	-710.925412
13	+8819P231609P/F4C84*212	+8819P231609P/F4C84*212	+8819P231609P/F4E84*212	+8819P231609P/F4E84*212	-710.925412
14	+8820P231609P/F4C84*212	+8820P231609P/F4C84*212	+8820P231609P/F4E84*212	+8820P231609P/F4E84*212	-710.925412
15	+8821P231609P/F4C84*212	+8821P231609P/F4C84*212	+8821P231609P/F4E84*212	+8821P231609P/F4E84*212	-710.925412
16	+8822P231609P/F4C84*212	+8822P231609P/F4C84*212	+8822P231609P/F4E84*212	+8822P231609P/F4E84*212	-710.925412
17	+8823P231609P/F4C84*212	+8823P231609P/F4C84*212	+8823P231609P/F4E84*212	+8823P231609P/F4E84*212	-710.925412
18	+8824P231609P/F4C84*212	+8824P231609P/F4C84*212	+8824P231609P/F4E84*212	+8824P231609P/F4E84*212	-710.925412
19	+8825P231609P/F4C84*212	+8825P231609P/F4C84*212	+8825P231609P/F4E84*212	+8825P231609P/F4E84*212	-710.925412
20	+8826P231609P/F4C84*212	+8826P231609P/F4C84*212	+8826P231609P/F4E84*212	+8826P231609P/F4E84*212	-710.925412
21	+8827P231609P/F4C84*212	+8827P231609P/F4C84*212	+8827P231609P/F4E84*212	+8827P231609P/F4E84*212	-710.925412
22	+8828P231609P/F4C84*212	+8828P231609P/F4C84*212	+8828P231609P/F4E84*212	+8828P231609P/F4E84*212	-710.925412
23	+8829P231609P/F4C84*212	+8829P231609P/F4C84*212	+8829P231609P/F4E84*212	+8829P231609P/F4E84*212	-710.925412
24	+8830P231609P/F4C84*212	+8830P231609P/F4C84*212	+8830P231609P/F4E84*212	+8830P231609P/F4E84*212	-710.925412



**Flow Calculations**

45440

Hose Size (in)	1	0.38
Hose length (ft)	200	700
Hose volume (gal)	$=PI()/4*C4^2*C5*12/231$	$=PI()/4*D4^2*D5*12/231$