DAY TANKS

Design Considerations of a Day Tank Fuel Transfer System

TRAMONT
a UCA Group Company

OVERVIEW

This guide is designed to assist in specification of a Day Tank fuel transfer system, including pump lift, head and prime.

- **The information included in this document is meant as a general reference only.** Frictional head loss, lift, discharge pressure and other considerations may vary depending upon your physical location and system design.
- Consult an experienced hydraulic engineer when working with critical or borderline applications.

PUMP LIFT

A pump lifts fuel by displacing air from suction to the discharge line. This creates low pressure in the suction line, which allows the higher atmospheric pressure (14.7 psi at sea level) to lift liquid into this vacuum. If a perfect vacuum could be created and maintained, fuel could theoretically be lifted to 34 feet. Since a perfect vacuum is not possible, the lift a pump can actually achieve is approximately 50 percent of theoretical lift, or 17 feet at sea level (7.64 psi). To determine the total available lift, the following factors need to be considered:

1. **Vertical distance the pump needs to lift fuel.** This measurement is taken from the bottom of the main tank to the pump's inlet port.
2. **Total length and diameter of piping.** As piping gets longer and narrower lift is decreased due to friction (see Table One). All calculations are based on 60° F temperature. Frictional resistance increases as temperature decreases.
3. **Fittings in the line.** Fittings disrupt flow and create friction. These include elbows, tees and unions (see Table Two). Valves also need to be checked for possible pressure drops.
4. **Elevation above sea level**. As height above sea level increases, atmospheric pressure acting against the pump's vacuum is reduced, thereby reducing lift (see Table Three).

Example

Vertical distance	12 feet	Pump size	2 GPM
Total length of pipe	100 feet	Fittings in line	3 elbows, no valves
Pipe size	1 inch in diameter	Elevation (above sea level)	3,000 feet

Solution: Referring to Table Two, an elbow equals 2.6 feet of pipe (2.6 x 3 elbows = 7.8 feet). The corrected length of pipe is now 107.8 feet. Referring to Table One, the 107.8 feet is divided by 100 and multiplied by 0.5. Actual head loss is 0.54 feet. Therefore, the total lift needed for this system is the vertical distance plus 0.54 feet, or 12.54 feet. **Since the pump is safely capable of lifting 15 feet at 3,000 feet of elevation (see Table Three), this example will perform satisfactorily.** However, if a 3/8-inch diameter pipe had been used, the head loss would have been 15.8 feet. Adding the vertical distance to this figure equals 27.8 feet. The pump would not be able to lift the fuel. If the plumbing system cannot be built under a 17-foot lift limitation (at sea level), a remote pumping station must be used. This will be placed between the main tank and the Day Tank. The proper placement is determined by the pump lift calculation and the following pump head calculations.

PUMP HEAD

The pump's head is the theoretical vertical distance a pump will push fuel. Day Tank standard pumps (2 GPM; 1/3 HP) have 231 feet of head (100 psi). Refer to Table Four for larger pump and motor discharge rates. The pump is normally located on the Day Tank, but when pump lift demands are exceeded, a remote pumping station is required. This allows the use of the head (pushing) capabilities of the pump, which are significantly greater than lift. Factors that must be taken into consideration to determine total pump head are similar to pump lift calculations, with the following exceptions:

1. **Vertical distance the pump needs to push fuel:** This measurement is taken from the output port on the pump to the day tank's uppermost piping connection.
2. **Elevation is not a factor, but motor horsepower is taken into account.**

Example Two

Vertical distance	150 feet	Fittings	2 elbows, 1 check valve
Total length of pipe	175 feet	Pump	7 GPM
Pipe size	3/4 inch in diameter	Motor	1 HP

Solution: Referring to Table Two, a 3/4 inch elbow equals 2.1 feet of pipe (2.1 x 2 elbows = 4.2 feet), while the check valve equals 5.3 feet of pipe. The total adjusted length of pipe is 184.5 feet (175+4.2+5.31). Referring to Table 1, 184.5 feet of 3/4 inch pipe with a 7 GPM pump with 1 HP motor results in head loss of 28.3 feet (1.85 x 15.3). Total required head capacity calculates to 178.3 feet (150 + 28.3). With a pump discharge pressure of 100 psi available pump head is 231 feet (100x 2.31). **Available pump head exceeds required pump head capacity (231-178.3= 52.7). Therefore, this system will work.**

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PUMP PRIME

Maintaining the prime on a pump is critical. Fuel must be maintained in the suction side pipe with no air pockets. Foot valves at the main tank or check valves at the Day Tank can be used to prevent fuel flowing back to the main tank and losing prime.

Pump cavitation can occur when a pump is unable to properly discharge fuel. There are multiple causes, including:

- Total equivalent lift too high for pump
- Total equivalent head too high for pump
- Improperly plumbed systems
- Restrictions in lines
- Air leaks

Cavitation can occur gradually and will eventually ruin a pump. Vertical piping loops or "traps" should be avoided when designing a pumping system. Air pockets can become trapped in the high point of the vertical loop, resulting in pump cavitation. A hand pump is recommended for initial priming to avoid undue wear on the fuel pump. If the fuel pump must be used for initial priming, do not run for more than 60 seconds. Fuel should be flowing within that time. A fuel strainer is also recommended on the inlet side of the pump. Foreign particles entering the pump chamber will diminish its life expectancy. The strainer should be checked periodically to avoid particle build-up, which limits pumping capabilities.

SUMMARY

Proper engineering practices should always be used when calculating pump head and especially pump lift. By following these guidelines, costly repairs due to improper installations can be avoided.

Notes:

1. 1 psi=2.31 feet of head is the conversion for water. As a general rule, this is a safe conversion for #2 diesel fuel.
2. For more precise calculations, refer to the following formulas and conversions:
   A. Head in Feet = PSI x 2.31/Specific Gravity
   B. PSI = Head x Specific Gravity/2.31
   C. Specific Gravity of #2 diesel fuel is 0.88 at 60° F
   D. Weight of #2 diesel fuel: 7.3 pounds/gallon
3. All calculations are based on 60° F. Allowances must be made for extreme temperature variances.
   A. Viscosity of #2 diesel fuel: 35 at 100° F; 40 at 70° F; 50 at 20° F; 80 at 0° F; 200 at -30° F
   B. An immersion heater is recommended for applications below 32° F

TABLE ONE: Frictional head loss in feet for 100 feet of standard weight pipe at 60° F at sea level, diesel fuel.

	Pipe Size						
GPM	**3/8**	**1/2**	**3/4**	**1**	**1-1/4**	**1-1/2**	**2**
2	15.2	5.5	1.1	.5	.2		
4	55.5	20.3	5.1	1.4	.5	.2	
7		61.0	15.3	4.6	1.2	.5	
10			26.3	8.5	2.5	.9	.2
19				28.5	7.5	3.5	1.2

TABLE TWO: Frictional loss in pipe fittings in terms of equivalent feet of straight pipe. For other types of valves and fittings consult manufacturer.

Pipe Size (in)	Ball Valve	45° Elbow	Std. Elbow	Std. Tee	Check Valve	Angle Valve	Globe Valve
3/8	.28	.70	1.4	2.6	3.6	8.6	16.5
1/2	.35	.78	1.7	3.3	4.3	9.3	18.6
3/4	.44	.97	2.1	4.2	5.3	11.5	23.1
1	.56	1.23	2.6	5.3	6.8	14.7	29.4
1-1/4	.74	1.6	3.5	7.0	8.9	19.3	38.6
1-1/2	.86	1.9	4.1	8.1	10.4	22.6	45.2
2	1.1	2.4	5.2	10.4	13.4	29.0	58.0

TABLE THREE: Lifting capacities at various elevations

Elevation (feet)	Available Lift (feet)
0 (Sea Level)	17
1000	16
2000	15.5
3000	15
4000	14.5
5000	14
6000	13.5

TABLE FOUR: Pump discharge pressure (psi)

	Nominal pump size (GPM) at 1725 RPM					
Motor HP	**2**	**4**	**7**	**10**	**19**	**23**
1/3	100	60	2			
1/2		100	20	2		
3/4			40	20		
1			100	40	20	2
1-1/2				80	40	40
2				125	60	60
3				150	100	125

DAY TANKS

Pump lift and head worksheets

REFER TO TABLES ON P. 2 OF TRAMONT DESIGN CONSIDERATIONS OF A DAY TANK FUEL TRANSFER SYSTEM

Gather the following information before beginning the pump lift and head worksheets below.

Vertical pipe length (FT)		Pipe diam. (IN)	
Horizontal pipe length (FT)		Pump (GPM)	
Elev. above sea level		Motor (HP)	

Elevation above sea level applies to pump lift only.

Motor HP applies to pump head only.

In-line fittings	Qty.	Value from Table 2	Qty. X size	In-line fittings	Size from Table 2	Qty. X size
Ball valve				Angle valve		
45° elbow				Globe valve		
Std. elbow				Other		
Std. tee				Other		
Check valve				Other		
		Total A			Total B	

Total A + Total B = ______ Enter this amount in Step 3 in the charts below.

Pump **ABOVE** main tank: Total **LIFT** required for Day Tank installation

1. Total vertical length of pipe (pump inlet to main tank bottom)		FT
2. Total length of pipe veritical and horizontal		FT
3. Additional length as a result of in-line fittings (See Table Two)		FT
4. Add results of #2 and #3		FT
5. Divide result of #4 by 100		CU. FT
6. Pipe size (diameter)		IN
7. Pump capacity		GPM
8. Frictional head loss (See Table One)		PER 100 FT
9. Additional head loss - Multiply results of #5 by #8		FT
10. Repeat steps in #2 thru #9 for each pipe size used in line		FT
11. Total lifting capacity needed (Add results of #1, #9 and #10)		FT
12. Elevation above sea level		FT
13. Available pump lift		FT
14. Subtract results of #11 from #13 (Step #13 - Step #11)		FT

IMPORTANT: Each pipe size in line must be calculated individually, then combined.

- If #14 is positive, **system is properly sized.**
- If #14 is negative, **system is beyond a safe lifting capacity.**
- If #1 is less than #13, **increase pipe size.**
- If #1 is more than #13, a **remote pumping unit is required.**

Pump **BELOW** main tank: Total **HEAD** required for day tank installation

1. Total vertical length of pipe (pump inlet to Day Tank inlet)		FT
2. Total length of pipe veritical and horizontal		FT
3. Additional length as a result of in-line fittings (See Table Two)		FT
4. Add results of #2 and #3		FT
5. Divide result of #4 by 100		CU. FT
6. Pipe size (diameter)		IN
7. Pump capacity		GPM
8. Frictional head loss (See Table One)		PER 100 FT (HORIZONTAL)
9. Additional head loss - Multiply results of #5 by #8		FT
10. Repeat steps in #2 thru #9 for each pipe size used in line		FT
11. Total head capacity needed (Add results of #1, #9 and #10)		FT
12. Pump discharge pressure (See Table Four)		PSI
13. Available pump head (Multiply results of #12 by 2.31)		FT
14. Subtract results of #11 from #13 (Step #13 - Step #11)		FT

IMPORTANT: Each pipe size in line must be calculated individually, then combined.

- If #14 is positive, **system is properly sized.**
- If #14 is negative, **system is beyond safe head capacity.**

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