Pump Test Pit Design Recommendations

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References

This article contains information from a variety of sources including recommendations from the National Board of Fire Underwriters

Design Recommendations

Fire apparatus pump test pits can be constructed in a variety of ways. Most truck manufacturers and some fire departments have on-site closed test pits. If the test pit is not designed or constructed to allow consistent pump testing, problems may develop. High water temperature, water turbulence, and aerating the water are all potential problems; all of these conditions, separately or in combination, can cause a pump to prematurely cavitate. The key design feature of any pump test pit is to provide a good consistent source of water free from entrained air and turbulence. Features such as baffles or walls with in the pit to separate the turbulent discharge section from the suction section are required to keep the suction area "quiet". Pump test pits that are little more than cisterns can work for low flows or for training on drafting procedures, however when a full capacity pump test is required, these reservoirs often prove inadequate.

Typically, a pump affected by the pit conditions will not meet its rated capacity for flow and pressure. It may meet the lower flow test points such as the NFPA 50% at 250 psi (17 BAR) test but may fall short of the full flow rating. Other factors that can not be controlled such as the atmospheric pressure (barometer) also affect pump performance, so a pump test pit design that has flaws may flow much better on a high barometer day and the same pump may have poor performance the next day when the barometer goes down to a lower level.

Some guidelines for designing a pit follow, but remember adjustment of internal baffles and hood design may be required to achieve the optimum results in any particular design.

Controlling Water Temperature

The NFPA uses 60°F water temperature for pump ratings. Higher water temperature brings the pump closer to cavitation and can restrict the performance of the pump. Water up to 90°F is still acceptable, unless it is coupled with turbulence and/or aeration. When you reach 100°F, pump test problems can result. The ambient water temperature can not be easily or cost effectively controlled, but the temperature rise during the test from pumping can be reduced. The best way to control water temperature rise to have sufficient pit water capacity. Temperature rise is caused by the energy expended to pump the water, friction, and truck heat exchanger functions.

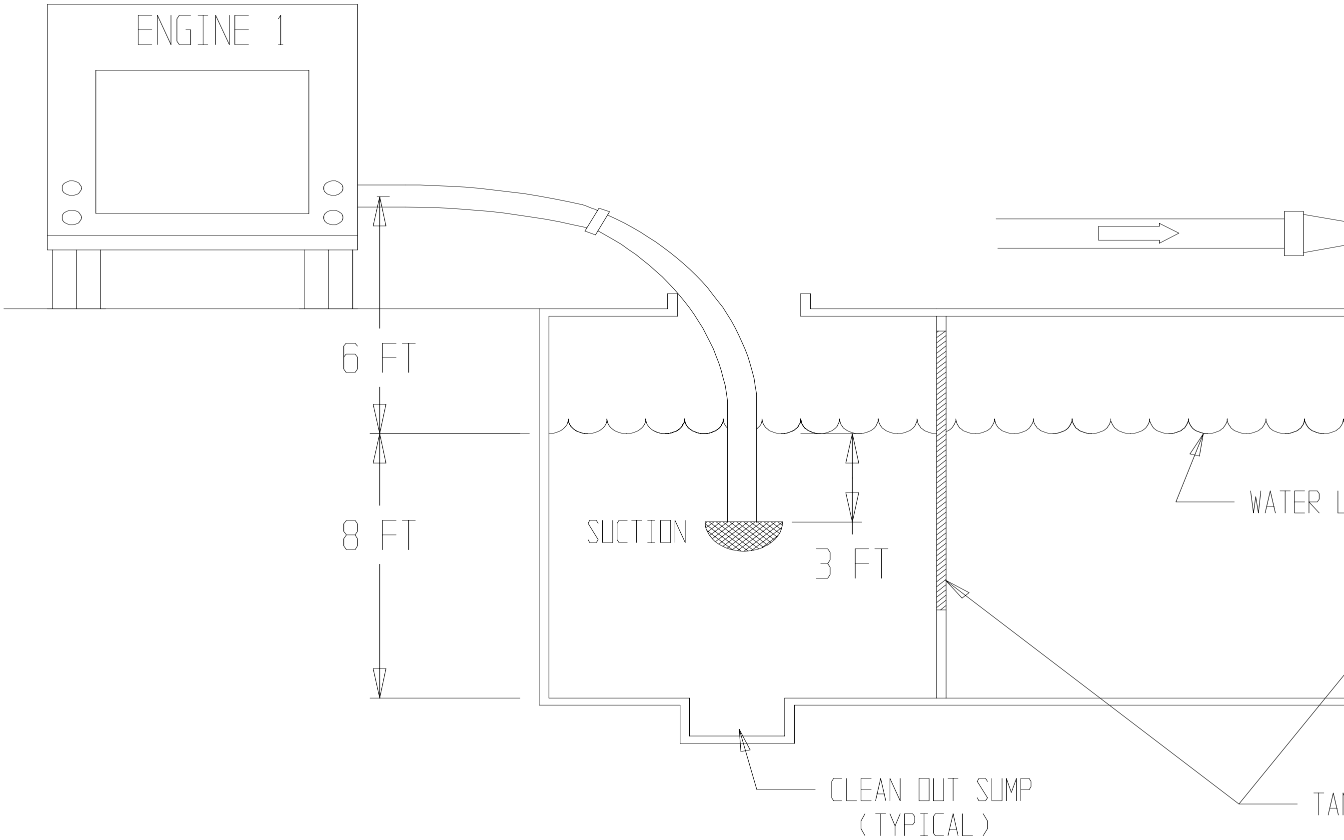
1. There should be a minimum of 10 gallons of usable water in the pump test pit for each GPM of pump capacity.
   For example, 2000 GPM pump x 10 gallons of pit water = 20,000 gallons total useable pit water capacity minimum. Increased water capacity gives you more reserve and a larger test pit can make other design features like less than optimum baffles less critical, so this is usually a good place to be conservative.
2. Keep in mind that fire pumps are available up to 3000 GPM. Also, if you will test two or more trucks at a time there will need to be extra reserve capacity built into the design. A Fire Department test pit that will only test a pump once in a while can obviously be smaller than a test facility where several pumps may be tested in a single day. Very high usage pits in hot climates require more water capacity or a cooling tower. Bigger is better when it comes to pit capacity. Consider the 10 gpm rule a minimum acceptable standard to avoid problems.
3. Pit water depth should be a minimum of 8 feet. In the past there has been a recommendation of a minimum between 13 and 15 feet. This extra depth can increase construction costs significantly in some areas, and as long as the other design considerations are met the 8 foot pit water depth has not shown any problems in actual practice. Digging a deeper pit will not hurt, but it is not necessary.
4. The test pit length should be longer than the width. The idea here is to get the discharge or water return as far away from the suction side the pit as possible. This helps keep the suction area of the pit quiet and free from air entrainment. Again a larger pit with more distance between the discharge/return and suction will be more forgiving of other issues or limitations. Typically the length of the pit is at least 2-$^{1}/_{2}$ to 3 times the width when the pit is a simple rectangle.

Controlling Water Turbulence

The discharge of the pump output thru nozzles or other flow measuring devices flow back into the return side of the test pit causing turbulence and aeration. To control this water movement, baffles and partitions are needed.

Test Pit Baffles

1. The first baffle isolates the discharge water turbulence from the rest of the pit. The wall or baffle should run the full width of the pit, and have small openings extending 6 inches down from top of pit and at least two open "windows" approximately 24 x 24 inches at the bottom of the pit. These windows are staggered so that they do not line up with the nozzle(s) discharging water back into the test pit. This baffle is located approximately ¼ distance of the tank length in a simple rectangular test pit. Obviously larger pits designed for larger pumps should have more windows to allow the water to flow from the discharge compartment to the next compartment in the test pit. This baffle forces the water to pass thru the windows that do not line up with the nozzles so that the water turns and has time to lose energy as it enters the next pit section. The small openings in the top of the wall are simply vents to allow air to circulate between the pit chambers. They are above the water line.
2. The second wall in the test pit forms a middle chamber with the first wall to further calm the water and allow any air to escape. Sometimes this baffle is omitted on test pit designs that are used with small to medium size pumps, but considering the test pit as a permanent capital investment, this extra wall helps assure that turbulence and currents do not affect the suction portion of the pit when flowing larger volumes of water and is a design option to seriously consider. This second wall has the same vents as the first baffle at the top of the wall. The vents again extending 6 inches down from the top of the wall are positioned so they do not line up with the suction hose openings or access points and are above the water level. The wall also has two large windows sized approximately 36 x 36 and positioned at the bottom of the wall and away from the suction hose position. Positioned correctly, these windows ensure that a low velocity flow is provided to the suction hose from both sides.
3. The actual suction section of the pit is where the pump will actually draw water. This last section of the pit should comprise 30-50% of the total pit volume. There are usually two suction hose access points to allow testing pumps up to 2000 gpm. Each opening should be complete with an access plate over it to keep debris out of the pit. A curb around the pit is also a good idea and some form of rail may be required for safety purposes.



Suction end of pit

a. Water depth on suction end must be sufficient to have three feet of water above the end of the suction hose. When setting up an apparatus for test NFPA usually requires 20 feet of suction hose and a strainer. The suction hose entering the pit and obtaining proper depth to the end of the suction strainer determines the apparatus placement and therefore determines the placement of the outer wall of the test pit. Most installations do not have the apparatus parked on top of the test pit, but keep the apparatus on solid ground while the test pit is off to one side.

b. A stanchion or tie down point at the suction openings to the test pit can be a convenient place to tie off a rope leading to the suction strainer on the end of the fire hose.

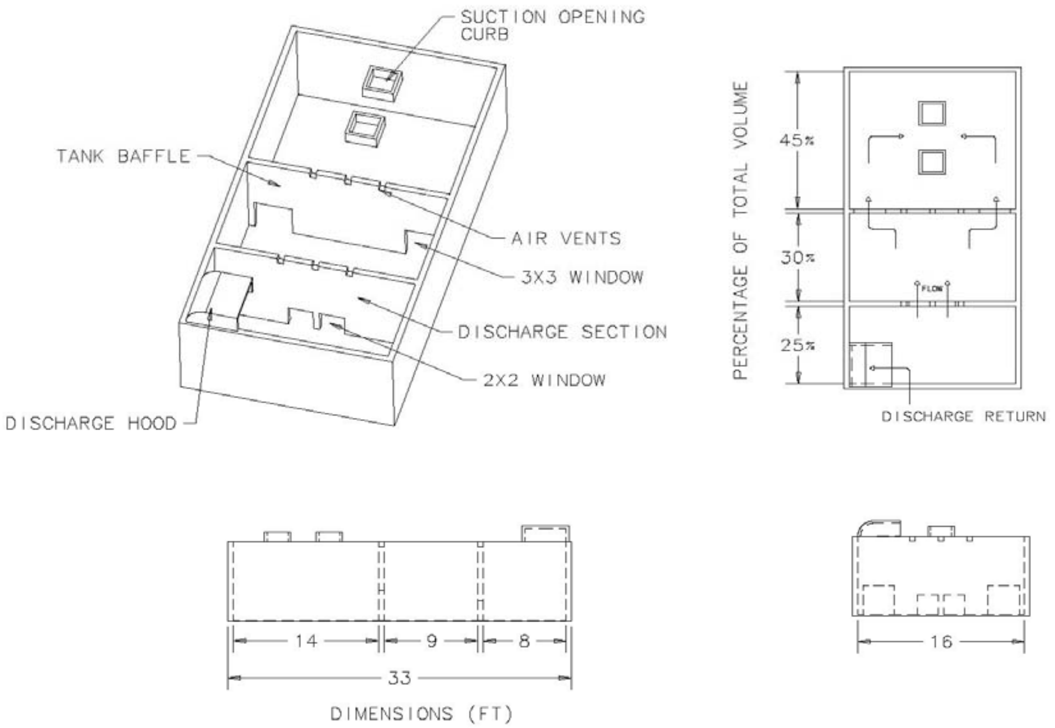
c. Always use a suction strainer and keep the hose off the bottom and away from the sides of the test pit. The test pit design should keep the inner walls far enough from the suction hose opening that having the hose coming within 18 inches of a wall is not an issue.

Controlling Pit Water Aeration.

Water aeration can be caused by direct discharge stream injection into the pit reservoir resulting in pit water surface turbulence. In addition to the baffles or walls described earlier, this turbulence can be reduced by deflecting the water flow from the nozzles utilizing a discharge hood. The discharge hood utilizes curved back plate to direct discharge water flow from what is typically a horizontal nozzle flow back down into the pit. The action of the water striking the inside of the curved hood tends to dissipate some of the energy of the water and diffuse the stream so there is far less disturbance of the surface of the water in the test pit. This hood must be at least two feet wide with a flat top as high as needed. This hood could be the full width of the pit and may be steel, thick aluminum, or concrete with a curved steel back plate.

Additional Pit Features

1. Baffle construction can be poured concrete, concrete blocks or possible even treated wood products, although the latter has durability concerns and concerns about wood debris clogging the pumps.
2. A manhole cover access should be provided into both ends of pit, and built-in ladders in pit at manhole covers are a good idea.
3. The baffles do not have to be removable as long as there is service access to each section of the test pit. Take note the entire test pit structure would be considered a “confined space” and there are OSHA and other safety regulations and signage requirements and rules that need to be understood and adhered to regarding entering such an environment.
4. The sketch on the next page shows a design concept for a test pit. It shows some generic design features that can benefit a specific test pit design. Key to the concept is keeping the turbulent return section of water away from the quiet suction area so that the test pit more nearly simulates the condition of pumping from a large body of water without the problems associated with re-circulating water. The dimensions shown are provided to show rough proportions and are not exact. This sketch does not take into account various methods of construction or specific site requirements. The builder of a test pit must keep in mind all applicable ordinance and safety rules.



DESIGN CONCEPT: FIRE APPARATUS PUMP TEST PIT

5. A pair of suction hose access openings (minimum number) with covers and handrail guards should be integrated into the design, not added later.
6. Discharge hood opening needs hinged cover plates or some method of covering to keep debris out of the test pit. One designer made the exterior of the structure out of red brick with a curved steel baffle inside and used an old cast iron boiler door as a method of covering the opening to prevent debris from entering the pit while providing an appearance that meets the needs of the Fire Department Headquarters.
7. Pit will need to be drained, depending on use, for cleaning, servicing, or modification. A sump in each chamber will allow you to pump out the pit more completely. Local ordinances may determine how the pit water can be removed and disposed of.
8. Previsions will be required to hold discharge test nozzles or flowmeters.
9. You will need the ability to read water depth.
10. Water temperature will need to be checked and monitored. All tests should have the barometer, air and water temperature recorded.

11. Suction hose hookup to truck must maintain a downward slope for its entire length. There should be no humps in the hose hookup. Air traps are not acceptable. Provisions to test with suction hoses on both sides of the apparatus is recommended for 1750 to 2000 GPM pumps. For pumps 2250 GPM and larger, multiple hoses may be used on both sides of the apparatus. The above design guidelines can be incorporated in to a U shaped pit where the apparatus sits in the center of the U for dual suctions or other arrangements can be made to accommodate larger pumps that may require dual drafting hoses for proper testing.
12. The vertical lift from the typical pump suction connection to the water line should not exceed 6 feet. This will allow testing of a wide variety of pumps. NFPA designates 10 foot lift for smaller pumps and 6 foot lift for larger units.
13. A flat, level apparatus pad is required. Apparatus parked at an angle may cause an air trap, which is not acceptable.
14. Some test pit designs incorporate a screened weir design. This helps strain the water to remove floating debris. The screen and weir should be placed close to the discharge side of the pit as the water fall action across the weir can entrain additional air in the pit water.
15. A designer adding a pool filter to keep pit water clean needs to keep in mind that Fire Apparatus pumps are typically cast iron with various amounts of brass and stainless steel. While there are some stainless and bronze pumps in service, iron or aluminum pumps are not designed to pump chlorinated pool water. Any chorine treatment should be kept to a minimum and provisions for flushing the pump and water tank after testing should be provided in this case. High chlorine levels may also affect the vapor pressure of the water which may lead to premature cavitation and pump performance problems. While a pool filter is acceptable to keep water clean, pool chlorination techniques are not.

Providing a consistent test environment for the testing of Fire Apparatus pump ensures that the equipment is properly evaluated for a lower cost, longer service life free from un-necessary repairs that could be considered due to poor pump performance caused by a poor test environment.