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FIRE PUMP INSTALLATION

Introduction

This article is limited to Fire Pumps taking suction from water reservoir.

It is not intended to be a pump installation manual but rather will address some potential pitfalls.

The explanation will be accompanied by photos of actual installations.

The subjects to be discussed are:

- ❖ Pumps in underground rooms.
- ❖ Pressure maintaining by means of Relief Valves.
- ❖ Suction arrangements.
- ❖ Submergence problems,
- ❖ Long exhaust pipes for Diesel Pump..

Underground Pump Rooms

After an inspection exercise of a diesel split case pump located in an underground room, during which I succeeded in igniting external idle wood pallets storage and was experiencing at the same time the initiation of room flooding I called the local pump supplier and asked him how he dare accept such installation, he replied happily that he is happy to supply new systems to ever lasting clients.

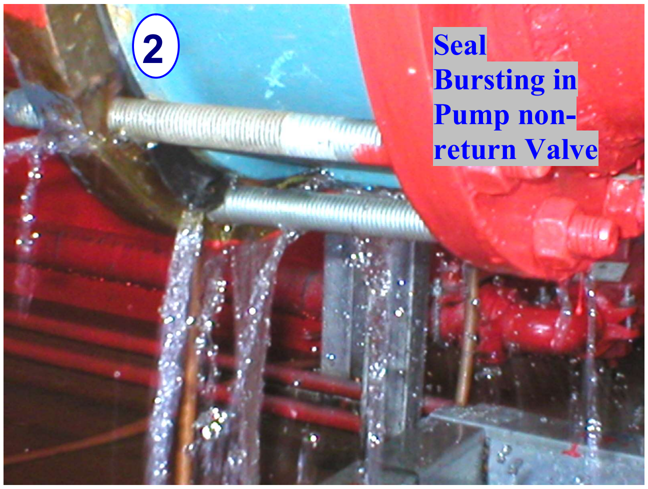
In fact he would be happy to visit the location in couple of days since he has to visit a nearby location where the pump room was flooded and the equipment was damaged.

During the last 10 years I attended quite of few of flooded rooms. The causes are:

1. In most designs the man-opening to the reservoir is overlooking the room, so that in case of malfunction of the float valve of the water supply the room is flooded. This cause is the leading cause of flooding.
2. Overflowing water into the room.
3. Diesel Pump is operating but the electrical submergible pumps that are supposed to remove to cooling are not functioning. I attended a fire case where the Fire Department tripped the electrical supply thus stopping the drainage pumps. The cooling water flooded the room.

Underground Pump, Cont-ed.,

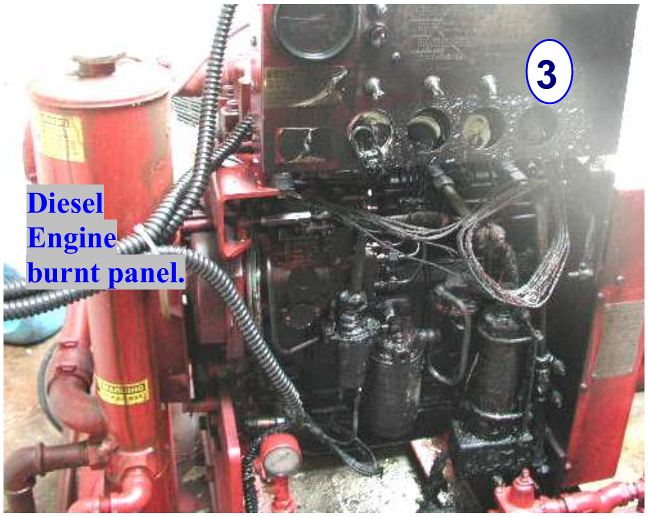
4. Breakage of the discharge pipe outside the room due to subsidence of the earth. The water found the lower place to settle in.
5. Pipe or accessories breakdown within the pump room (**Photo#2**).
6. Sprinklers operating in low areas. The water drains into the lower drainage area, overcoming the draining pump and taking the pump out of action.



The flooding causes severe corrosion damage, short circuits and fires just like in **photo#3** on the left.

Pipe or accessories breakage cause Pump starting and significant flows. Water sucking into the engine destroys the engine. Sometimes the engine block burst and the oil is smeared all over the place.

In one location the cost of the temporary repairs exceeded $80,000 and the Insurer had to pay for additional $ 40,000 for a new pump installation.



In addition:

1. Most underground rooms have poorly designed ventilation.
2. Serious damp atmosphere is frequent as the pump room share the same space with the space above the reservoir. Within a short period the controller suffers severe corrosion.

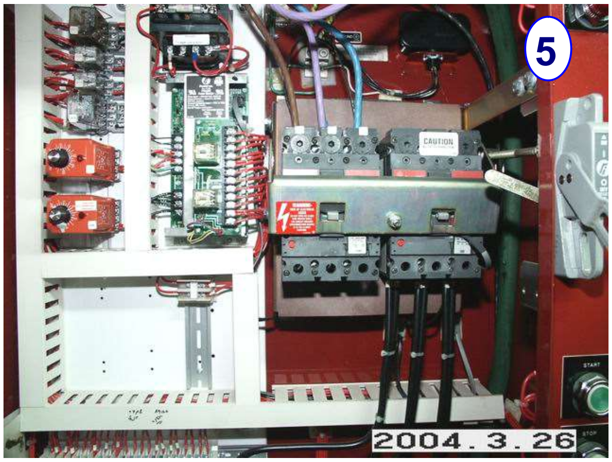
4

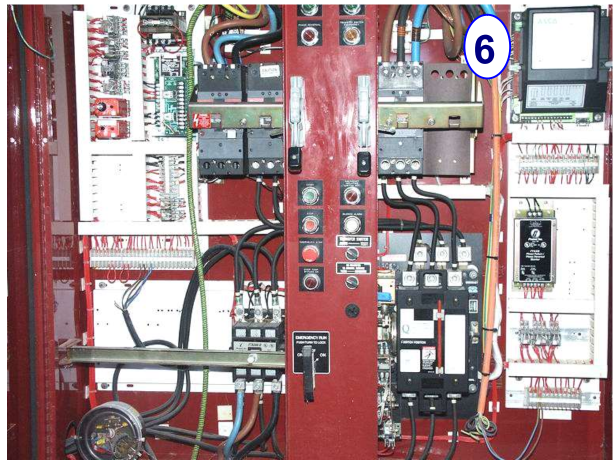
Underground Pump, Cont-ed.,

What happen to electrical and diesel pump controllers whist under water:

Electrical Pump Controllers;

Photos #5 & #6 depict 2 different cases of flooded electrical pump controllers. There is no apparent sign of any electrical damage.

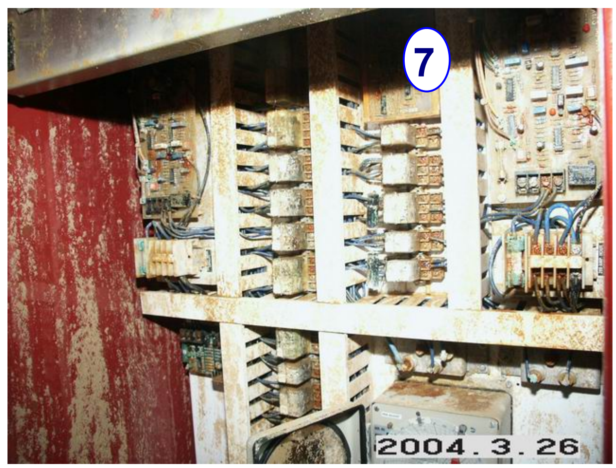


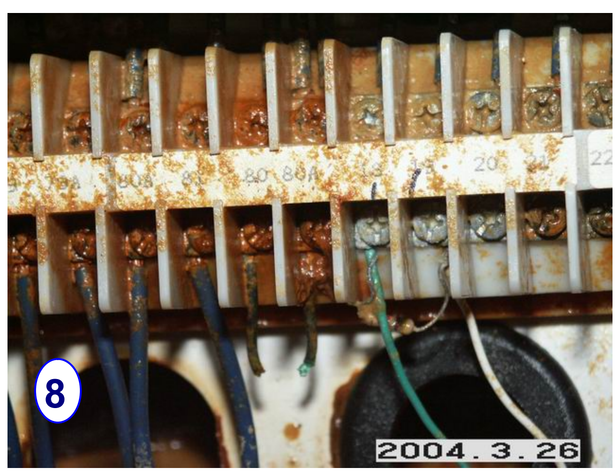


Diesel Pump Controllers:

Photos #7 & #8 depict a diesel pump controller that was totally immersed in water just like the Electrical Pump controller shown in Photo #5 (actually in the same room).

It may be seen that unlike the electrical pump controllers, the diesel pump controller is corroded. This is due to prolonged electrolysis caused by the DC 12 Voltage.





Underground Pump, Cont-ed.,

Photo #9 depicts a floating mechanism that controls the reservoir valve. It might stuck after prolong period of inaction.

This item has to be maintained as any other item in the pump house that has a role of preventing flooding.

It is interesting to note that while NFPA-20 requires protection from flooding (item 2-7.1) and recommend "special consideration" (item A-2-7), there is no provision regarding the maintenance of "flooding prevention means" in NFPA-20.

Quoting from NFPA 20:

2-7.1*

The fire pump, driver, and controller shall be protected against possible interruption of service through damage caused by explosion, fire, ***flood,*** *earthquake, rodents, insects, windstorm, freezing, vandalism, and other adverse conditions.*

A-2-7

Special consideration needs to be given to fire pump installations installed below grade. ***Light, heat, drainage, and ventilation*** *are several of the variables that need to be addressed.*

2-7.5

Provision shall be made for ventilation of a pump room or pump house.

2-7.6*

Floors shall be pitched for adequate drainage of escaping water away from critical equipment such as the pump, driver, controller, and so forth. The pump room or pump house shall be provided with a floor drain that will discharge to a frost-free location.

A-2-7.6

Pump rooms and pump houses should be dry and free of condensate. To accomplish a dry environment, heat can be required.

12.4.1.4 No audible alarm silencing switch, other than the controller main switch, shall be permitted for the alarms required in 12.4.1.3.

Underground Pump, Cont-ed.,

Recommendations:

1. Avoid the design where a Pump room is located in the lowest location in a building.
2. If this is inevitable, arrange of natural drainage with a capacity of at least 200% of the pump capacity.
3. Avoid the possibility of an arrangement whereby water accumulating on any protected floor might drain into the pump room. This is a self defeating arrangement.
4. Place the Pumps, Controller and the batteries as high as possible.
5. Emergency lighting is a must (in fact it is required by the NFPA-20, but many people ignore it).
6. Install water detector with an N.C. valve in the water supply line. The detector should be connected to the FACP of the building.
7. Two (2) Drainage pumps should be installed. Each pump should have a capacity exceeding the maximum water supply to the reservoir.
8. The Drainage pumps should be connected to emergency electrical supply with a fire rated line as any other critical safety equipment and the power lines should be supervised.
9. Ventilation Fans should follow clauses **8-3.2.1 & 8-3.2.2** and be connected to similar Emergency electrical supply.
10. Make sure that it would not be possible to silence any audible alarm originated from the pump house other then in the pump house itself.
11. Avoid long exhaust pipe and arrange drainage cock for accumulated condense water and acids.

RELIEF VALVE AS PRESSURE MAINTAINING MEAN

Quoting NFPA 20:

A-2-2.4

It is poor design practice to over design the fire pump and driver and then count on the pressure relief valve to open and relieve the excess pressure. A pressure relief valve is not an acceptable method of reducing system pressure under normal operating conditions and should not be used as such.

Several problems may evolve from this method of pressure maintaining:

1. Oversize pump is costs more as hardware and in maintenance.

2. It is very difficult to handle the pressure surges throughout the system.

3. In concert with other mistakes pipe failures and resulting water damage may be manifested.

4. The relief valve competes with the demand in fire events. As the pressure drops, the relief valve is supposed to get closed. High flows may raise stones and debris from the reservoir floor and prevent closure of the valve.

5. It is not healthy for the diesel engine to get started weekly under full load developed within few seconds.

In response to my question I got the following answer from Clarke:

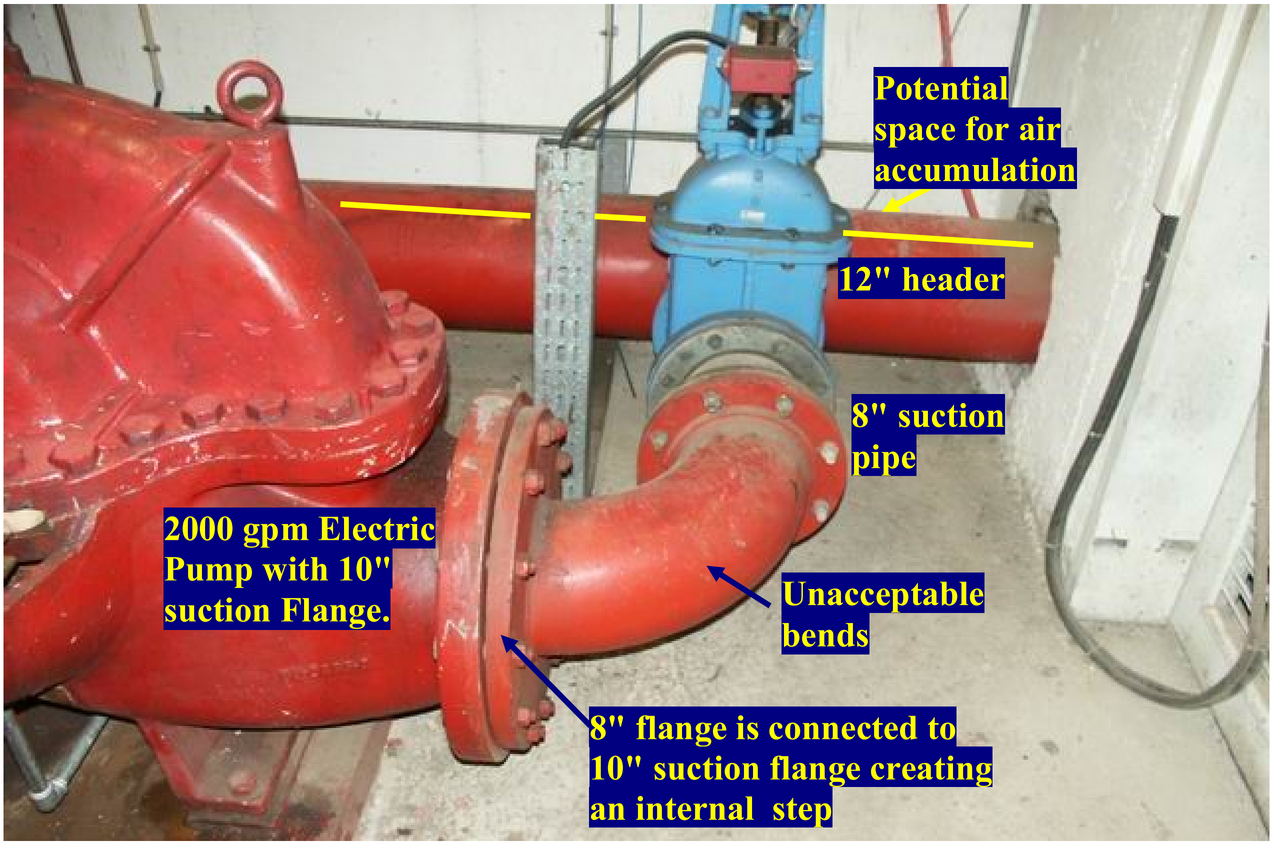
As the engine supplier, there is no problem running the engine at a full load during the weekly exercise as long as that load does not exceed the nameplate rating of the engine. ***The only consequence is that the engine will wear out quicker than if it was exercised at partial load.*** *The use of the relief valve to limit system pressure is a question best answered by someone who knows the system requirements and operating conditions stated by NFPA-20.*

In one case a diesel engine made by Caterpillar failed twice during the warranty period. The principle used to test the pump weekly by operating a monitor. A technician of the manufacturer was sent to investigate the cause and he said that "*the operator is not supposed to start the engine under high load. The lubrication system is simply not ready to accept an high starting load.*

Of course, the engine is supposed to accept emergency situation. It does not mean that ful loading is welcome weekly.

SUCTION PROBLEMS

Consider the arrangement in the following photo:



The **Suction Header** size is **12"**. It takes suction from the bottom of a reservoir and it has higher and lower sections that may lead to accumulation of air in the higher sections.

The 8" Branch is connected to the center of the head, so that an air pocket may be created in the top of the header.

The 8" bend does not follow item **2-9.6.2** of **NFPA-20**. A major fault is at the flange connection of the pump - **8"** pipe flange is connected to **10"** pump suction flange creating a step at the pump entrance.

In addition to the above violations of the code, the pressure is maintained by a relief valve.

Under starting tests air bubbles will return to the reservoir.

If a flow is initiated from the system by means of a sprinkler or a test valve, the air bubble will be swept into the system causing pressure surges.

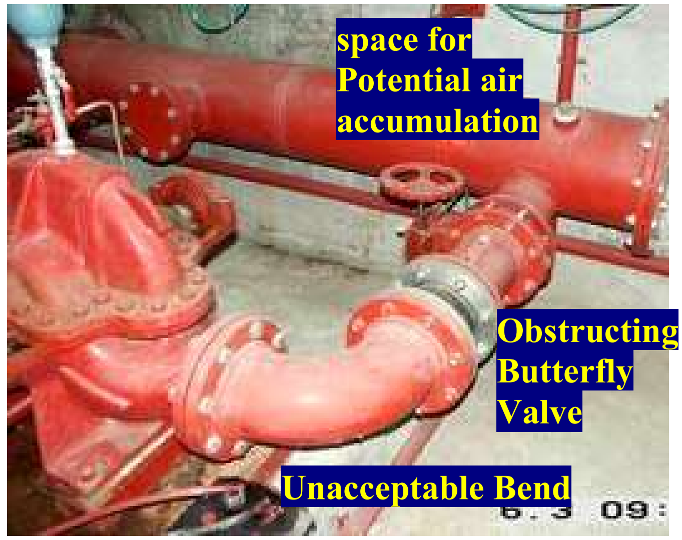
Indeed, within a period of two (2) years 6 sprinkler heads opened spontaneously. It is very strange that these were in the very same locations.

SUCTION PROBLEMS, Cont-ed;

The only explanation I can offer is the rare combination of (see the photo above):

- Potential for air pockets in the suction header.
- Vortex created in the suction flange.
- Pressure maintaining Relief valve causing full flow.
- Specific resonance in the system.

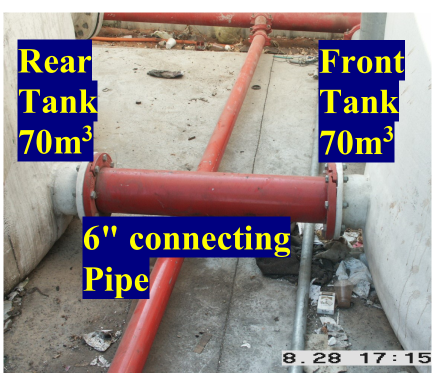
The photo on the right has an additional violation – the butterfly valve in the suction pipe. In this case the trouble is just waiting around the corner.

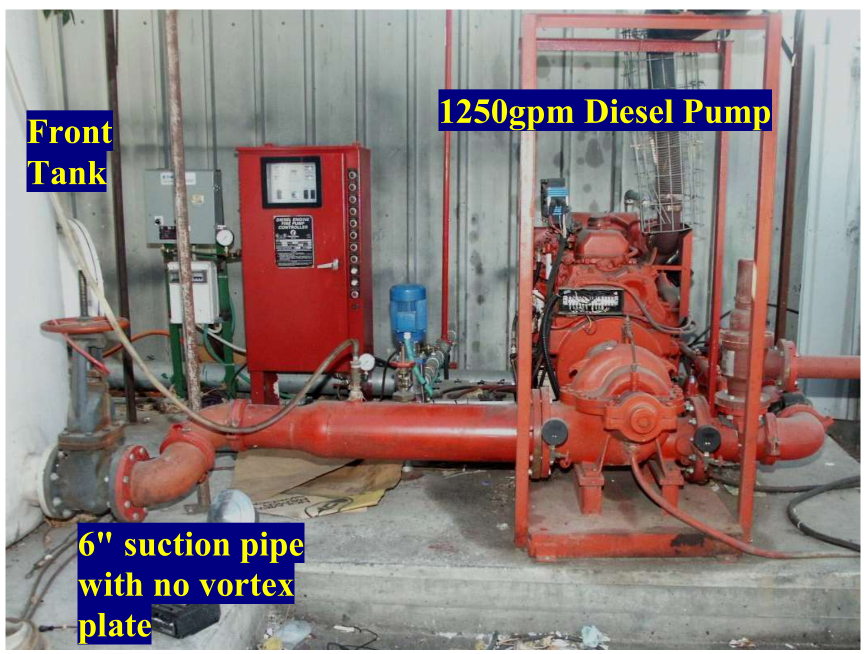


SERIOUS FAULTS IN PUMP –RESERVOIR INTERFACE:

The following photo is an illustration of a series of faulty arrangements on the reservoir side.

This setup includes **two tanks** connected with a 6" line (see below). The **1250gpm Pump** takes suction from the front tank only. The tank pipe is 6" and has no vortex plate.





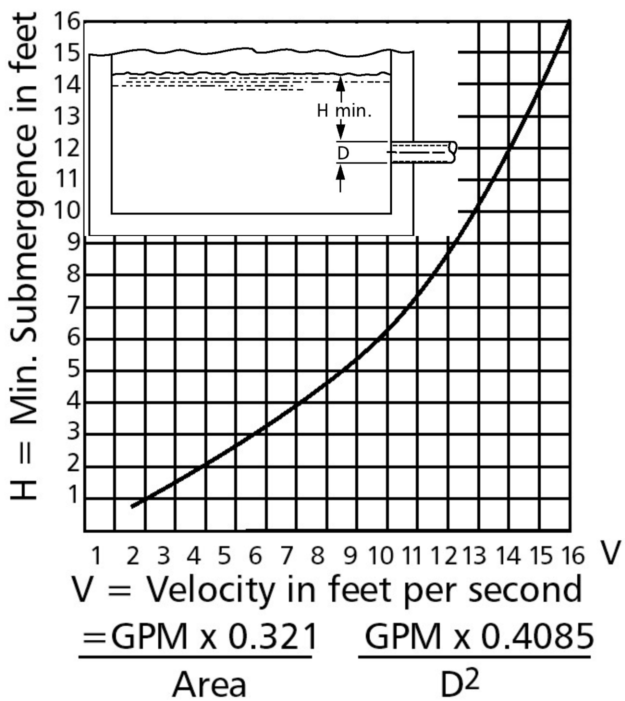
Vortex Problem and Tank arrangement in tandem reduce significantly the reservoir capacity.

In the next page I calculated the loss of capacity due to the vortex and tank tandem arrangement. The use of water for plant capacity allowing reduction of water level for fire demand further compounded the problem.

SUCTION PROBLEMS, Cont-ed;

The above arrangement has multiple faults:

- Too small reservoir capacity for the Risk Demand.
- A 6" suction pipe is too small for a 1250gpm pump (should be 8").
- Reduction of effective capacity due to the absence of a vortex plate.
- Further reduction of effective capacity due to suction from the front tank. This tandem arrangement creates cascaded levels, i.e. the water level in the rear tank is higher than that of the front tank. The head difference is a function of the pump's flow.
- No minimum capacity was assigned for fire fighting water.



The required Submergence minimum level:

Using the instruction in the figure on the right, I calculated the minimum required submergence for a demand of **1,000gpm:**

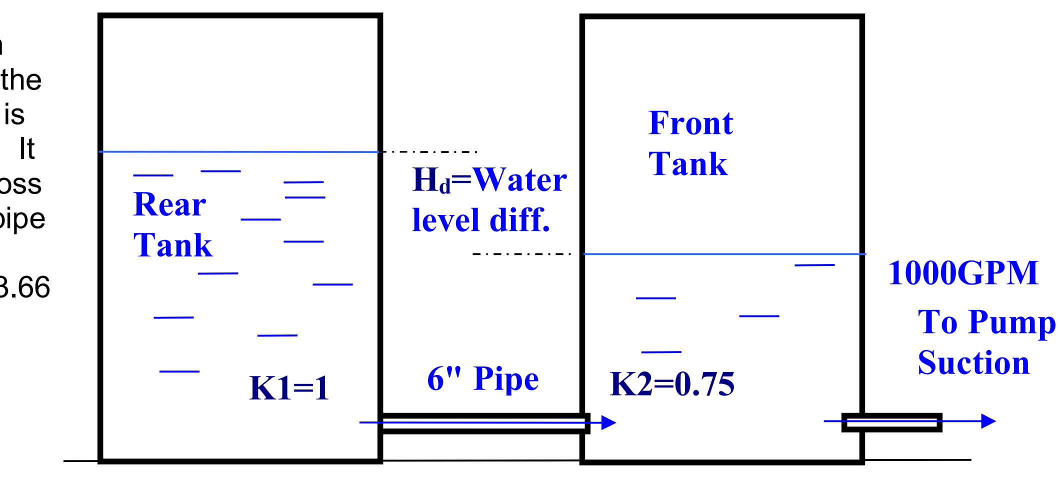
V=11.3 fpm, H= 7.5' (2.3m).

Bearing in mind the tank height is 22', the effective loss of the tank's capacity 34%!

Effect of Tank arrangement in tandem:

The friction loss across the **6" connection pipe** between the tanks (see the photo above) is a function of "$\mathbf{V^2/2g}$". The combined **K factor** for the pipe exit from the rear tank and entrance to the front tank is **1.75**.

For 11.3 fpm (3.46m/sec) the loss of head is 3.7' (1.13m). It reflects the loss due to exit, pipe length and entrance of 3.66 ft (1.13m)



$$H_d=K*v^2/2g=1.75*11.3\hat{}2/2x32.2=3.46+0.2=3.66ft$$

SUCTION PROBLEMS, Cont-ed;

Thus, for a flow of **1000gpm**, the difference of levels between the rear tank and the front tank is **1.13m**. This further reduces the front tank capacity by 17%.

The total loss of capacity of the reservoir (2 tanks) is **42.5%.**

However, the reservoir was also used for plant consumption. It is estimated that during the fire event, the reservoir capacity had a shortage of 33%, i.e. the net capacity was just **94m^3** (0.67x140m^3). The loss due to vortex & tandem arrangement is **66m^3**. The remained net capacity was merely **34m^3**.

Thus, in terms of supply duration, for a demand of **1,000gpm**, the water supply was sufficient for less than **9 min.**

LONG EXHAUST PIPE OF DIESEL ENGINE

The 275 HP Diesel Engine driving a 2,500gpm pump failed after 18 working hours. The pump was tested weekly and the fuel in the tank was taken care of as instructed.

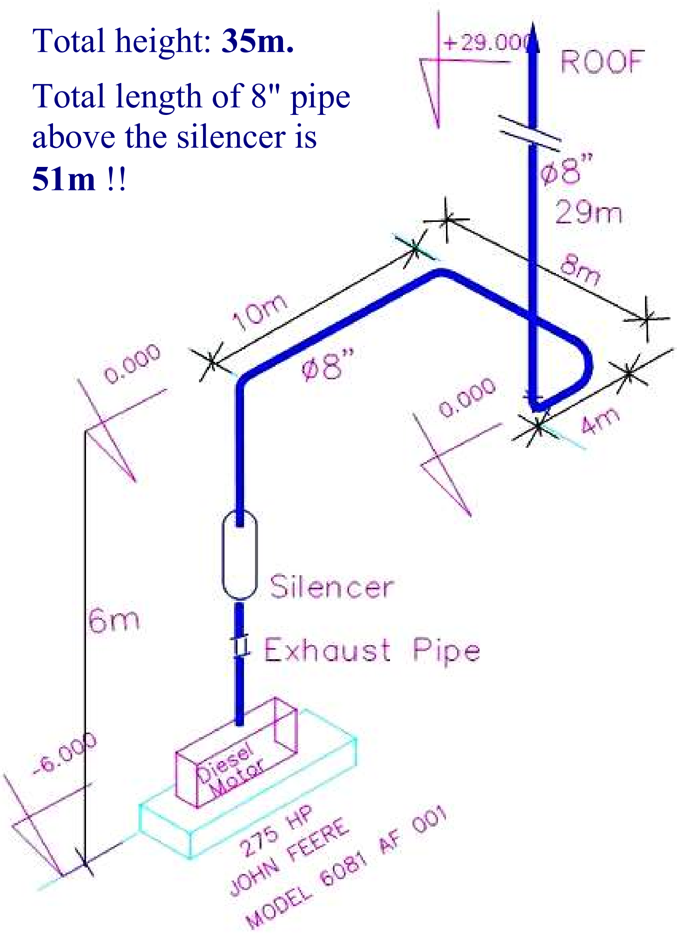
The condition of Turbo-charger, Pistons and the rings thereof indicated ingress of water into the engine.

The mishap is clearly due to the length of the exhaust pipe. See on the right sketch sent from the client.

The combustion formula is:

$C_{12}H_{26} + 13.5\,(O_2+3.72N_2) \rightarrow$
$13\,H_2O + 12\,CO_2 + 50.2N_2$

The Volume of 51m of 8" pipe is=2.6m^3. 17% of the effluent is water vapor, i.e. 450 liters.



LONG EXHAUST PIPE, Cont-ed;

Actually, there will be excess air and hence less water vapor. The amount of water in grams would be in the order of 150. This amount does not include water in the fuel and moisture from the outside air drawn-in upon cooling of the exhaust pipe.

Since SO_2 and NO_x gases are emitted as well, acids will be condensed within the pipe.

Assuming that this process repeated itself about 36 times (18 work hours, 30min each run), the effect is obvious.

Yours faithfully,

Dan Arbel

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