**Permeability Tests:**

The ability of water to flow through a saturated soil is known as permeability.

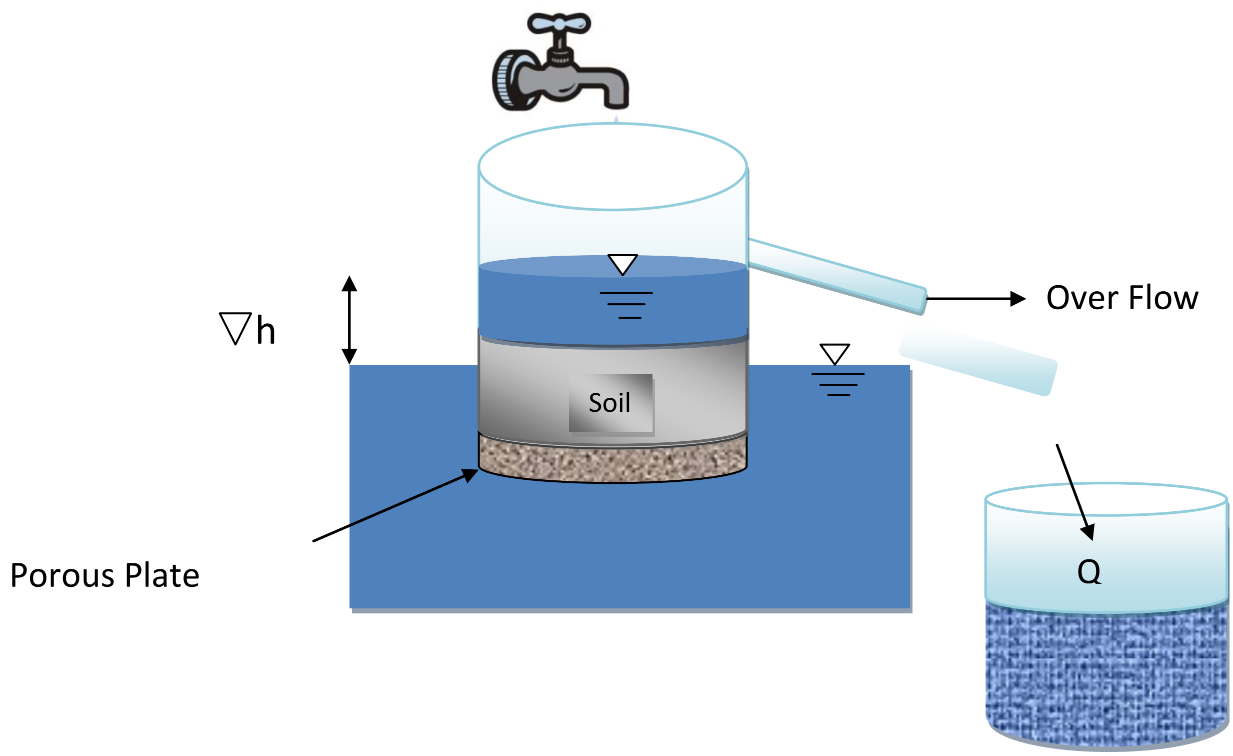
Or

The ease with which the water flow through the soil is known as permeability.

A high permeability indicates that water flows rapidly through the void spaces & vice versa.

A measure of the soils permeability is hydraulic conductivity, also known as the coefficient of permeability K.

**Constant Head Permeameter:**



A saturated soil specimen is placed in the Permeameter and then a head of water $\Delta h$ is maintained.

The hydraulic conductivity is based on Darcy's law:

$$\upsilon = ki$$

$\upsilon$= Velocity of flow in.

i =Hydraulic gradient.

k =Hydraulic conductivity (coeff. of permeability). ft/sec.; cm/sec

Hydraulic gradient is dimensionless.

i= $\Delta h/L$=Change in total head/length of the specimen

$$k = (QL) / (\Delta h.A.t)$$

Where k=Coeff. Of permeability

Q=Total discharged volume $ft^3$ in a given time

L=Length of the specimen ft

$\Delta h$= The total head loss for constant head Permeameter.

A= area of the soil specimenft2

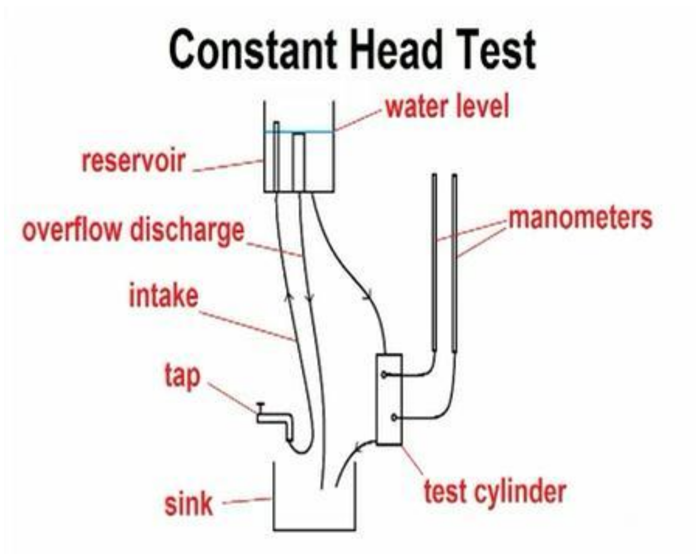
t=time (sec)

The constant head Permeameter is often used for sand soils that have a high permeability.

**Constant Head Test:**

**Step1: Set the apparatus**

Prepare the apparatus as shown in the figure.




1. First of all take 1kg of coarse grained soil in a container & measure the weight.
2. Place the filter paper at the bottom to prevent the soil being carried out.
3. Fill the cylinder with the soil sample.
4. Put the soil in three layers and compact each layer with the hammer as shown in figure. If our objective to measure the conductivity at a specific density measure the mass required given the volume of the cylinder and compact the sand enough to fill the cylinder completely.
5. The top surface of the soil should be leveled with the space for screen and cap.
6. Place the screen on top of the soil as well as the separator.
7. Place the cap on top of the cylinder and secure with three screws on top of it as shown in figure.
8. Record the mass of the container and rest of the soil.
9. Connect the intake line from the reservoir to the barb at the top of the test cylinder.
10. Connect the two outlets of the cylinder with the two monometers. These are to measure the pore water pressure at specific points.
11. Before filling the reservoir close the valve on the intake.

12. Turn the tape on and let the reservoir fill up. A discharge pipe is attached at certain level to keep the water level constant.

13. Once a certain level of water is reached it will discharge water to the sink when this happens the level of water is constant and we can begin the test.

**Step 2: Perform the test**

14. Now open the valve and let the water enter the soil sample.

15. Before we star measuring the flow rate we need the water to run through the sample this is to remove any trapped air. The pore water pressure will be recorded on two monometers.

17. Take a beaker record its mass on the table.

18. Use a stop watch to record the time. Simultaneously start the stop watch and begin filling the beaker with discharge water from the test cylinder.

20. Here we will aim a specific volume of water. Stop the stop watch and discharge at that particular volume. Now record the mass of the water plus the beaker as well as the time it took to fill in seconds. Repeat this test two more times each time with different increment in amount of water.

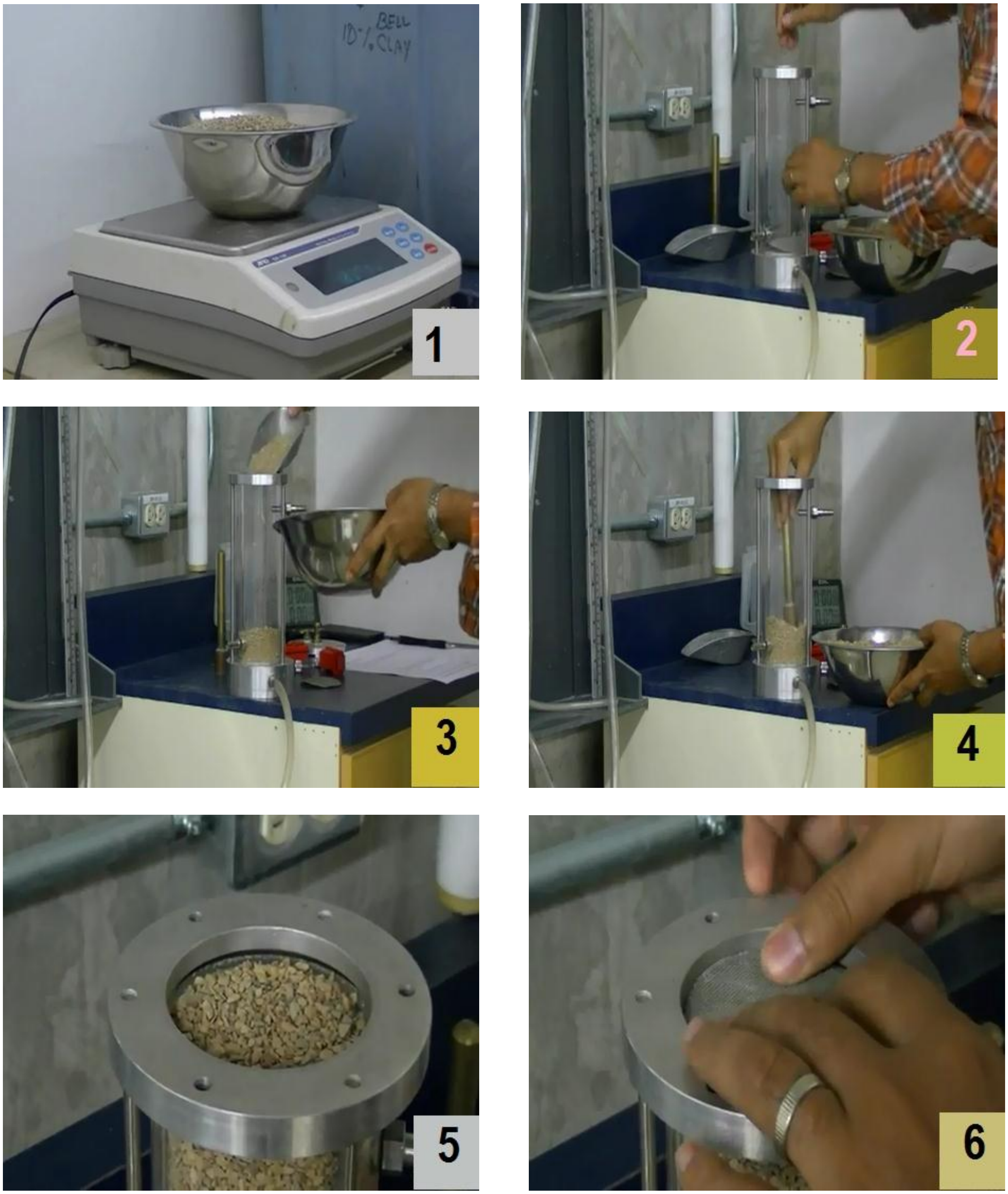
20. We calculate the head applied to the sample. To do this, measure the head to each monometer from the base of the cylinder.

21. Vertical distance between the outlets is recorded.

**Step 3: Calculate the Coefficient of Permeability**

22. Calculate the cross sectional area of the cylinder.

    It is important that the porous plate which supports the soil specimen has a very high permeability. As an alternative a reinforced permeable screen can be used in place of the porous plate. Another important consideration is that the specimen diameter should be at least ten times larger than the size of the largest particle.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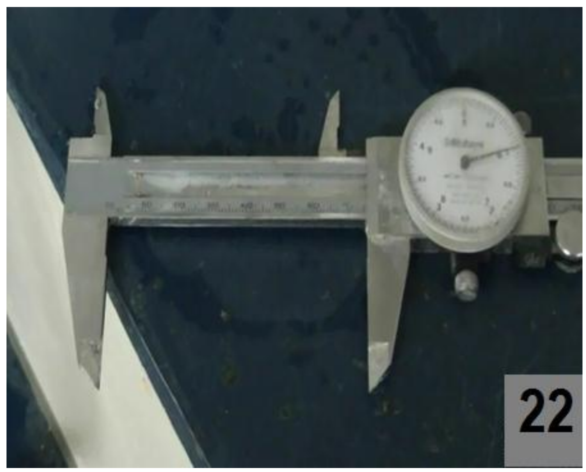
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**Falling Head Permeameter:**

This equipment is used to determine the hydraulic conductivity of a saturated silt or clay specimen. This test is best for silts and clays. Filter paper is often placed over the porous plate to prevent the migration of soil fines through the porous plate. Also, a frequent cause of inaccurate results is the inability to obtain a seal between the soil specimen and the side of the Permeameter. Because of these factors (migration of fines and inadequate sealing) a greater degree of skill is required to perform the falling head permeability test.

The objective of the falling head permeability test is to allow the water level in a small diameter tube to fall from an initial position $h_o$ to a final position $h_f$.

The amount of time it takes for the water level to fall from $h_o$ to $h_f$ is recorded. Based on Darcy's law, the equation to determine the hydraulic conductivity k for a falling head test is as follows.

$$K=2.3(a\ L/A\ t)\ \log_{10}(h_o/h_f)$$

K = Coefficient of permeability

a = Area of standpipe

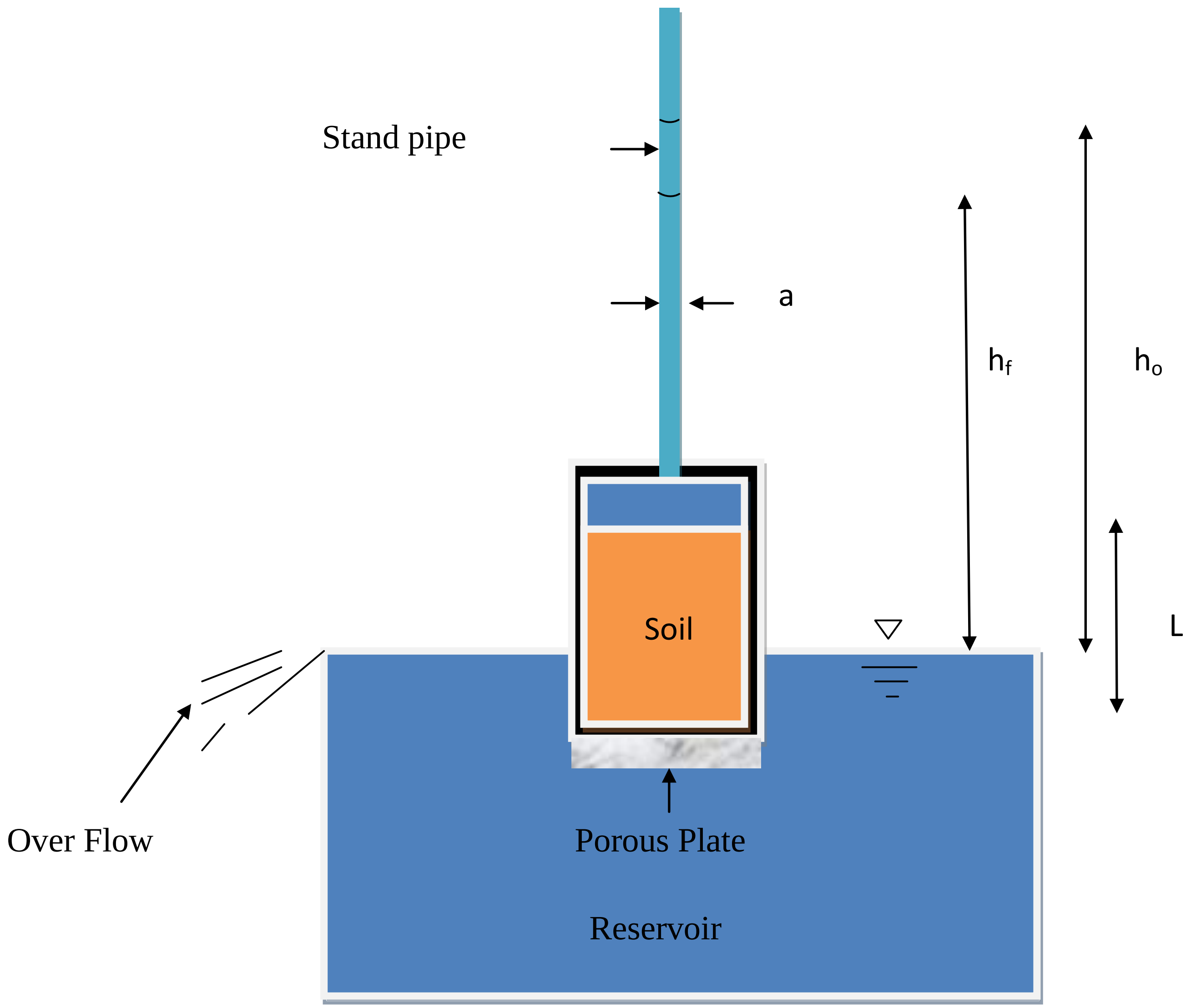
L = Length of soil specimen

$h_o$ = Initial height of water in the stand pipe

$h_f$ =Final height of water in the stand pipe

A =Area of soil specimen

t = Time it takes for the water level in the standpipe to fall from $h_o$ to $h_f$.


Stand pipe
a
$h_f$
$h_o$
L
Soil
Over Flow
Porous Plate
Reservoir

**Falling Head Test:**

**Step1: Set the apparatus**

1. Put together the cylinder. Unlike with the constant head test which uses a screen the falling head test uses a porous stone. Place the porous stone on the base as shown and then place the tube which acts as the cylinder walls on top of it. Thread the end cap with three screws secures it with three nuts.

**Step 2: Perform the test**

2. Take the soil sample. Record the mass of the soil container plus soil.
3. Place the soil in the container and compact it putting it in three layers.
4. Place the second porous stone on top of it and then thread the end cap and securing it. Finally record the mass of the remaining soil plus container.
5. The cylinder for the falling head test consist just one water pipe line connect the line to the cylinder. Before we start the test we must saturate the soil.
6. There are three valves in the system. Make sure they are all open.
7. Start adding water at the top of the stand pipe when water starts coming out of the nozzle at the bottom we can proceed. Flush the air from the soil.
8. Close the valve at the top of the test cylinder so the water level in pipe remains constant bring the water to measurable level.
9. Record the time on stop watch for water to drop a certain distance. Start the stop watch and open the valve simultaneously. Wait for the water level to drop a certain distance and close the valve and watch simultaneously. Record both levels of water as well the time it takes to drop.

**Step 3: Calculate the coefficient of permeability**

10. Repeat this test three times and calculate the coefficient of permeability by putting the values in equation.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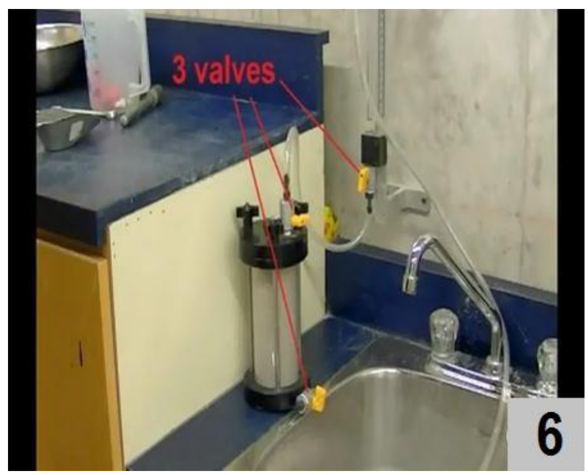
3 valves
6


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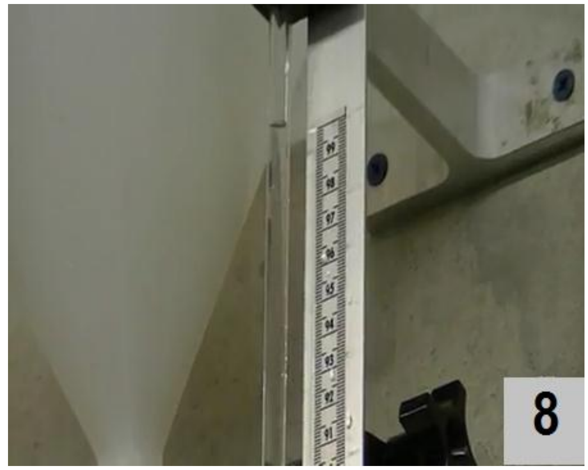
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A hydraulic conductivity of about $10^{-4}$ cm/sec is approximate dividing line between good drainage and poorly drained soils.

According to Terzaghi & Peck, the classification of soil according to hydraulic conductivity k is as follows:

High degree of permeability when k is over.1cm/sec

Medium degree of permeability when k is.1-.001cm/sec

Low degree of permeability when k is.001-$10^{-5}$cm/sec

Very low degree of permeability when k is $10^{-5}$-$10^{-7}$cm/sec

Practically impermeable k is less than $10^{-7}$cm/sec.

**Pb. In a constant head Permeameter test, the outflow Q is equal to 782ml in a measured time of 31 sec. the sand specimen has a diameter of 6.35cm & a length L of 2.54cm. The total head loss Δh for the Permeameter is 2.0m. Calculate the hydraulic conductivity.**

**Sol:**

$A = (\pi/4).d^2$

$\Delta h = 2.0m = 200cm$

$t = 31sec$

$Q = 782mL = 782cm^3$

$L = 2.54cm$

$k = (QL)/ (\Delta h.t.A) = (782 \times 2.54 \times 4)/ (200 \times 31 \times 126.72)$

$= 0.01cm/sec$

**Pb. In a falling head permeability test, the time required for the water in a standpipe to fall from $h_o$=1.58m to $h_f$=1.35m is 11.0h. The clay specimen has a diameter of 6.35cm & a length L of 2.54cm. The diameter of the stand pipe is 0.635cm. Calculate the hydraulic conductivity.**

**Sol.**

$h_o$=1.58m

$h_f$=1.35m

t=11h=39600sec

$d_{sp}$=6.35cm

L=2.54cm

$d_{standpipe}$=0.635cm

K=?

K= 2.3(a l /A t) $\log_{10}$ (ho/hf)

a= $(\pi/4).d_{st}^2$=0.3168$cm^2$

A= $(\pi/4).d_{sp}^2$=31.68$cm^2$

k=2.3× (0.3168×2.54/31.68×39600)×log (1.58/1.35)

k=1.0079×$10^{-7}$cm/sec.