

UNDERWATER OIL STORAGE METHOD AND SYSTEM

5 The present invention relates to an oil storage method and more particularly, to an underwater oil storage method, which keeps the oil tank under the water in a water pool so that the water in the water pool supports the pressure of the oil tank and isolates storage oil from the ground earth by means of the physical characteristic that the specific gravity of oil is lower than water.

10 An oil storage tank may be mounted above or under the ground. When building an oil tank above the ground, a strong floor construction must be built up on the ground. The floor construction must be strong enough to support the heavy cylindrical or spherical steel shell of the oil tank and the oil stored in the oil tank. A conventional oil tank uses a steel shell to bear the pressure of the oil stored therein. The capacity has
15 a limitation. Further, increasing the capacity of an oil tank will relatively increase the cost. For safety's sake, a retaining wall must be built around the oil tank(s) such that when oil leaks out of the oil tank(s), leaked oil can still be kept within the retaining wall to prevent contamination or any possible catastrophe. At present time, the capacity of Formosa Petrochemical Corp.'s oil tank is 130,000 square meters (the largest oil
20 tank in Asia Pacific area. This oil tank has a diameter about 86 meters and a height about 24 meters. The steel shell of the oil tank must strong enough to bear the pressure of 24M-depth storage oil and to provide a damping resistance against earthquake grade 6. It took about 2 years to finish the construction of the oil tank after finish of the ground construction. The total cost for this oil tank is about two hundred millions NT

dollars. Because this oil tank is exposed to the weather, it must be regularly maintained to remove rust and regularly painted. In case of a leakage of oil, the storage oil must be fully discharged out of the oil tank and cleaned so that a soldering process can be employed to seal the crevice. Maintaining this oil tank is a hard and expensive task.

5 Further, when directly building an oil tank under the ground, the cost is high. In case of a leakage occurred, it is difficult to detect such a leakage, and leaked oil will permeate into the soil to pollute underground water.

The document GB 01495 A.D. 1912 discloses a storage plant for inflammable liquids. The storage plant comprises a main basin filled with water; a tank arranged
10 entirely immersed within the water filled in the basin and comprising an opening provided in its bottom side to provide permanent fluid communication between the interior of the tank and the outer basin enclosing the tank; a supply pipe for the supply of inflammable fluid to the tank, ending near a roof of the tank and fitted with a valve; a vent and standpipe extending from the roof of the tank in such a manner that all air or
15 inflammable vapour, which may find its way into the tank or is produced there, escapes freely into the outer air and so that the fluid surface, where evaporation takes place, is reduced to a minimum. The storage plant further comprises a small water basin arranged aside the main basin; a supply-pipe connecting and providing fluid communication between the small water basin and the main basin; a discharge pit
20 arranged in the vicinity of the main basin; a discharge pipe having a first end extending from a roof of the tank into the tank to below the surface of the water level in the main basin and a second end opening into the discharge pit.

In operation of the storage plant, when the tank is emptied, i.e. its contents is allowed to run out, the water penetrates from the basin through the opening into the

tank and may fill the tank completely as well as the vent and the standpipe up to the level of the water in the basin. When the inflammable fluid is now fed in by way of the supply pipe, the water contained in the tank is pressed out by the entering fluid, through the opening and eventually through an overflow pipe until the tank is filled, whereby
5 the water level in the main basin is essentially kept constant.

The document JP 54 127019 discloses an oil storage plant comprising a main water basin enclosed by a wall structure; an oil tank arranged inside the main water basin and comprising side walls but no bottom wall so that the interior of the oil tank is in permanent fluid communication with the portion of the main water basin enclosing
10 the tank; a small water basin arranged beside the main basin; a pipe connecting the main water basin and the small water basin; and a pump provided in the pipe for pumping water between the main and the small water basin for water circulation therebetween. When the volume of oil in the tank decreases by discharge for use, water penetrates into the tank from below through the open bottom side and displaces the
15 discharged oil, and vice versa, oil filled into the tank for storage displaces water out of the tank into the main water basin.

The present invention has been accomplished under the circumstances in view. It is therefore the main object of the present invention to provide an underwater oil storage method, which uses water to isolate storage oil from the ground earth by means
20 of the physical characteristic that the specific gravity of oil is lower than water. It is another object of the present invention to provide an underwater oil storage method, which automatically regulates the water level of the water that supports the oil tank, keeping the oil tank in balance. It is still another object of the present invention to provide an underwater oil storage method, which keeps the oil tank under the water in a

water pool, preventing contamination of storage oil to the surrounding ground earth, and allowing quick visual inspection upon an oil leakage.

To achieve these and other objects of the present invention, as claimed the underwater oil storage method includes the steps of a) excavating a cellar in the ground
5 earth and constructing a wall structure in the cellar to form a water pool; b) setting an oil tank having a predetermined shape and volume in the water pool; c) supplying a predetermined amount of water to the water pool; and d) filling the oil to be stored into the oil tank and regulating the amount of water in the water pool subject to the amount
10 of storage oil stored in the oil tank where the oil to be stored has a specific gravity lower than the water filled in the water pool, and the amount of the storage oil filled into the oil tank is less than the volume of the oil tank.

According to the invention, the step of filling the oil to be stored into the tank comprises filling water into the water pool simultaneously with filling oil into the tank. As a result, water pressure in the water pool is in balance with the pressure of the oil in
15 the tank and the wall of the oil tank bears a small pressure.

Filling oil into the storage tank and filling water into the water pool may be performed synchronously by means of a control of an auto water control system.

When pumping oil out of the tank for use, the auto water control system may automatically be pumping water out of the water pool into a spare water tank, thereby
20 keeping the water pressure in the water pool in balance with the pressure of the oil tank.

As further claimed, there is provided an underwater oil tank storage system a water pool defined in a wall construction under the ground earth to hold a predetermined amount of water; an oil tank set in said water pool and surrounded by water held in said water pool, and for holding an oil having a specific gravity lower

than that of the water held in said water pool; and a spare water tank set at one side relative to said water pool in fluid communication with said water pool for regulating the water level of water held in said water pool.

According to the invention, the storage system comprises an auto water control
5 system adapted to control that when oil is filled in the oil tank, water is simultaneously filled into the water pool.

The auto water control system is further adapted to automatically pump water out of the water pool into the water tank, when oil is pumped out of the oil tank for use, so as to keep the water pressure of water in the water pool in balance with the pressure
10 of the oil tank. Moreover, the oil tank may have no port at its bottom side.

The present invention will be explained in more detail in comparison to illustrative embodiments not falling under the invention and with reference to non-limiting embodiments, and with reference to the accompanying drawings, in which:

FIG. 1 is a flow chart of an illustrative underwater oil storage method useful to
15 obtain an understanding of the present invention;

FIGS. 2A~2F illustrate the construction and operation of an underwater oil storage system according to an illustrative embodiment not falling under the present invention;

FIGS. 3A~3F illustrate the construction and operation of an underwater oil
20 storage system according to an embodiment of the present invention; and

FIG. 4 is a schematic sectional view of an underwater oil storage system according to another embodiment of the present invention.

Referring to FIGS. 1 and 2A, an illustrative underwater oil storage method includes the steps of:

a) excavating a cellar in the ground earth 10 and constructing a wall structure 20 in the cellar to form a water pool 30, where the wall structure 20 is a continuous concrete wall set in the horizontal bottom and upright peripheral sides of the cavity formed in the ground earth 10 for protection and isolation;

5 b) setting an oil tank 40 in the water pool 30 and directly supporting the oil tank 40 on the bottom wall 31 of the water pool 30, where the oil tank 40 can be a metal, concrete or plastic container or a container made of any of variety of oil-proof materials subject to a predetermined size and has an oil access port 41 at the top side thereof. In the illustrative example, the oil tank 40 comprises at least one bottom port
10 42 at the bottom side thereof in communication with the inside space of the water pool 30 for allowing water to flow through the bottom port 42 between the water pool 30 and oil tank 40. The method further includes the steps of:

 c) supplying a predetermined amount of water W to the water pool 30, where water W can be city water, sea water, industrial waste water that is kept in the
15 water pool 30 by the wall structure 20; said predetermined amount means that an auto fluid supplying and adjusting mechanism is provided to control the amount of water W in the water pool 30 subject to the type of oil tank 40 and the volume of oil stored in oil tank 40; and

 d) filling oil O into oil tank 40 through oil access port 41, where oil O can
20 be raw petroleum, gasoline, mineral oil, animal oil, vegetable oil, or any of a variety of chemical fluids of specific gravity smaller than 1; the filling amount of oil O is less than the volume of oil tank 40 so that oil O filled in oil tank 40 does not flow out of oil tank 40 into the water pool 30 and then float on water W in the water pool 30 outside the tank 40.

Referring to FIGS. 2B and 2C, because the specific gravity of oil O (normally about 0.9) is smaller than the specific gravity (1) of water W, oil O will float on water W in oil tank 40 when filling oil O into oil tank 40 through oil access port 41, and water W will be gradually forced out of oil tank 40 into the water pool 30 subject to the increasing of the filling amount of oil O. Because the volume of the water pool 30 is constant, filling oil O into oil tank 40 causes increasing of the water level in the water pool 30. There is further provided a spare water tank 50 at one side of the water pool 30 on the same level. A connecting pipe 51 is horizontally provided between the water pool 30 and the spare water tank 50 near the top side. When the water level in the water pool 30 surpassed a predetermined high level, water W flows out of the water pool 30 into the water tank 50 through the connecting pipe 51 for further use.

Referring to FIGS. 2D~2F, when pumping oil O out of oil tank 40 through oil access port 41 for use, the amount of oil O in oil tank 40 is gradually reducing, the water level of water W in oil tank 40 is gradually increasing to lift oil O in the water tank 40, and the water level of water W in the water pool 30 outside oil tank 40 is gradually lowering. At this time, the spared water can be guided from the water tank 50 into the water pool 30. According to this embodiment, an auto water control system 52 which is formed of a water pump and a water level sensor is provided for detecting the water level of water W in the water pool 30 and automatically pumping water W out of the water tank 50 into the water pool 30 when the water level of water W in the water pool 30 dropped below a predetermined range. Therefore, the amount of water W in the water pool 3 and oil tank 40 is automatically adjusted subject to the amount of oil O in oil tank 40, enabling water W to support the gravity weight of oil tank 40 and to keep oil tank 40 in balance.

As indicated above, water W is used in the water pool 30 to isolate oil O from the ground earth and to support the gravity weight of the oil tank 40 and oil O contained in the oil tank 40 and to keep the oil tank 40 in balance by means of the physical characteristic that the specific gravity of oil O is smaller than water W.

5 In the illustrative embodiment and in an application example of the present invention, the oil tank 40 in the water pool 30 may have the depth of 24 meters. When the water tank 40 is filled up with oil O of specific gravity 0.9, the oil level of oil O in the oil tank 40 may be 2.4 meters above the water level of water W in the water pool 30. At this time, water W supports and sets off 90% of the pressure, and the oil tank 40
10 bears only the other 10% of the pressure. Therefore, when designing the material strength of the material for the oil tank 40, it needs only to consider the pressure of oil O of depth 2.4 meters but not the pressure of oil O of depth 24 meters. When storing oil O of specific gravity 0.99, water W in the water pool 30 supports and sets off 99% of the pressure, and the water tank 40 bears only 1% of the pressure. Therefore, the
15 invention breaks the conventional concept of constructing an oil tank with thick steel plate members. When constructing an oil tank of volume 130,000 square meters (Height 24M x Diameter 86M), it needs only to build up a concrete wall structure of Height 24M x Length 76M x Width 76M (saving about 10M x 10M ground area). By means of binding reinforcing steel wire rods, setting molding forms, pouring concrete,
20 and removing molding forms after setting of concrete, the desired wall structure 20 is built up, and the designed oil tank 40 can then be set in the water pool 30 thus formed. Further, using plastic or stainless steel plate members to construct the wall structure 20 instead of concrete accelerates the construction speed.

Because the oil tank 40 is set in the water pool 30 under the ground, it is not necessary to build up an additional retaining wall to protect the oil tank 40 against earthquake or any human beings' destruction behavior. Because the oil tank 40 is set under the ground, it is safe against human beings' destruction behavior, and storage oil
5 O is free from the effect of the surrounding weather. Further, no lightning arrester or the like is necessary. In case of an earthquake, water W in the water pool 30 absorbs shock waves. Because the oil tank 40 bears a small pressure, the manufacturing cost of the oil tank 40 can be greatly reduced.

FIGS. 3A~3F show an embodiment of the present invention. According to this
10 embodiment, the oil tank, referenced by 40a has an oil access port 41 at the top side, however the oil tank 40a has no port at its bottom side. Further, racks 43 are fixedly provided at the bottom wall of the oil tank 40a and supported on the top side of the bottom wall 31 of the water pool 30, allowing water to flow through the bottom side of the oil tank 40a, however storage oil O is prohibited from passing out of the oil tank
15 40a into water W in the water pool 30. When filling storage oil O into the oil tank 40a, water W is simultaneously filled into the water pool 30 by means of the control of the auto water control system 52, and therefore the water level of water W in the water pool 30 and the oil level of oil O in the oil tank 40a are synchronously raised (see FIGS, 3A~3C). On the contrary, when pumping oil O out of the oil tank 40a for use,
20 the auto water control system 52 automatically pumps water W out of the water pool 30 into the water tank 50, keeping the water pressure of water W in the water pool 30 in balance with the pressure of the oil tank 40a (see FIGS. 3D~3F).

In additional to the aforesaid big scale design, the invention is also applicable for a relatively smaller scale design for use in, for example, a gas station. According to

the other embodiment of the present invention shown in FIG. 4, a top cover 21 is covered on the wall structure 20 to close the water pool 30; the oil tank 40b is fixedly supported on a rack 43' (or racks 43') above the bottom wall 31 of the water pool 30 against floating of water W in the water pool 30, having an oil access port 41, which is comprised of an oil inlet pipe 41a and an oil outlet pipe 41b that are respectively upwardly extending from the top side of the oil tank 40b to the outside of the top cover 21, and an air pipe 41c equipped with a relief valve (not shown) and upwardly extending to the outside of the water pool 30 for discharging of air when the air pressure in the oil tank 40b surpassed a predetermined level. The functioning of this embodiment is substantially similar to the aforesaid second embodiment with the exception that the water level of water W in the water pool 30 surpasses the elevation of the top side of the oil tank 40b, i.e., the oil tank 40b is constantly kept under water W.

Preferably, the oil tank 40b is mounted on the rack 43' in a tilt angle, having a recessed water reservoir portion 44 at the lowest area on the inside and connected to an external water sensor 45 by a connecting line. In case water W leaks in the oil tank 40b, leak-in water will be accumulated in the recessed water reservoir portion 44 and detected by the water sensor 45, and a repair work can be quickly employed to prevent a further damage. In case the positive pressure type oil tank 40b has a damage and oil O leaks out of the oil tank 40b, leaked oil O will float on water W, and the worker in the gas station can easily find the problem and take the necessary measure to eliminate the problem. Same as the aforesaid various embodiments of the present invention, this embodiment uses water W to isolate storage oil O from the ground soil, preventing

pollution to the surrounding earth. Further, water W is used in the water pool 30 to support the oil tank 40b and the pressure of the storage oil O in the oil tank 40b.

In general, the invention provides an underwater oil storage system, which uses water to support an oil tank and storage oil in the oil tank and to keep the oil tank in
5 balance, preventing contact of storage oil with the ground earth.

Although particular embodiments of the invention have been described in detail for purposes of illustration, various modifications and enhancements may be made without departing from the scope of the invention defined by the appended claims.

Claims

1. An underwater oil storage method comprising the steps of:

a) excavating a cellar in the ground earth (10) and constructing a wall structure (20) in said cellar to form a water pool (30);

b) setting an oil tank (40a) having a predetermined shape and volume in said water pool (30);

c) supplying a predetermined amount of water (W) to said water pool (30); and

d) filling the oil (O) to be stored into said oil tank (40a) and regulating the amount of water (W) in said water pool (30) subject to the amount of storage oil (O) stored in said oil tank (40a) where the oil (O) to be stored has a specific gravity lower than the water (W) filled in said water pool (30), and the amount of the storage oil (O) filled into said oil tank (40a) is less than the volume of the oil tank (40a), characterized by

step d) comprising filling the water (W) into the water pool (30) simultaneously with filling oil (O) into the oil tank by means of the control of an auto water control system (52) and wherein when filling oil the level of water in the water pool and the level of oil in the oil tank are raised synchronously using the auto water control system,

further by

step e) when pumping oil out of the oil tank for use, the auto water control system automatically pumping water out of the water pool (30), thereby keeping the water pressure of water in the water pool in balance with the pressure in the water pool in balance with the pressure of the oil tank.

2. The underwater oil storage method according to claim 1, wherein step d) comprises synchronously raising the water level of water (W) in the water pool (30) and the oil level of oil (O) in the oil tank (40a).

3. The underwater oil storage method according to claim 1 or 2, further comprising the following steps:

building a spare water tank (50) under the ground earth (10) at one side of said water pool (30) and connecting a water pipe (51) between said water pool (30) and said spare water tank (50) for circulation of water between said water pool (30) and said spare water tank (50), and

5 providing an auto water control system 52 comprising a water pump and a water level sensor for detecting the level of water (W) in the water pool (30).

4. The underwater oil tank storage method according to claims 3:

10 wherein step e) comprises, when pumping oil (O) out of the oil tank (40a) for use, the auto water control system (52) automatically pumping water (W) out of the water pool (30) into the spare water tank (50), thereby keeping the water pressure of water (W) in the water pool (30) in balance with the pressure of the oil tank (40a).

5. An underwater oil tank storage system comprising:

15 a water pool (30) defined in a wall construction (20) under the ground earth (10) to hold a predetermined amount of water (W);

an oil tank (40a) set in said water pool (30) and surrounded by water (W) held in said water pool (30), and for holding an oil (O) having a specific gravity lower than that of the water (W) held in said water pool (30); and

20 a spare water tank (50) set at one side relative to said water pool (30) in fluid communication with said water pool (30) for regulating the water level of water held in said water pool (30),

25 an auto water control system (52) characterized in that said auto water control system is adapted to control that when oil (O) is filled in the oil tank (40a), water (W) is simultaneously filled into the water pool (30)

and that the auto water control system is used when filling oil such that the level of water in the water pool and the level of oil in the oil tank are raised synchronously,

30 thereby keeping the water pressure of water in the water pool in balance with the pressure of the oil tank.

6. The underwater oil tank storage system according to claim 5, wherein the auto water control system (52) is further adapted to automatically pump water (W) out of the

water pool (30) into the water tank (50), when oil (O) is pumped out of the oil tank (40a) for use, to keep the water pressure of water (W) in the water pool (30) in balance with the pressure of the oil tank (40a).

5 7. The underwater oil tank storage system according to claim 5 or 6, wherein said oil tank (40a) has no port at its bottom side.

 8. The underwater oil tank storage system according to any one of the claims 5 to 7, wherein said oil tank (40a) has an oil access port (41) at a top side thereof for oil input
10 output.

 9. The underwater oil tank storage system according to any one of the claims 5 to 8, further comprising a rack (43') for fixedly supporting the oil tank (40a) above a bottom wall of said water pool (30).