ABSTRACT

For many, the design and construction of an off-highway vehicular water tank is nothing more than the capping off of the rear end and placing a lid on an existing truck body. Advances in design and engineering have allowed progressive evolution of off-highway vehicular water tank design throughout the years with the addition of baffles within the tank to retard water flow. In doing such, designers of such water trucks have attempted to either retard water flow by either

1.) Modifying the path of the water, or
2.) Encapsulating the water in such a way that the water is sequestered in compartments.

While the principle of safety is at the heart of these water tank baffling methods used to minimize water surges that can often cause off-highway vehicular water tanks to roll over, they also pose additional problems for maintenance personnel.

INTRODUCTION

First, why have large off-highway vehicular water tanks?

The reasons to have off-highway vehicle water tanks are many:

1. Mine / quarry fugitive dust control so mine / quarry vehicles can safely operate in close proximity to each other (one large western U.S. mine on a hot summer day will spread 3,000,000 gallons of water on their property).

2. Haul road safety, at a mine it is no different than driving on a dusty gravel road as to being able to see the road and what might be ahead of or around you.

3. A mine that allows more than the allowed fugitive dust to escape from the mine property is in danger of being temporarily shut down.

4. Wet / damp mine haul roads help to lessen tire over heating, which tires on hot days with long hauls can reach super critical temperatures.

5. Fire fighting capabilities.

6. To chase (with the use of water tank water cannons / monitors) stray animals (such as deer / antelope / kangaroo, etc) away from and off of mine haul roads. (Photo 1)

MAIN SECTION

Safe Water Tanks: Safe Operation, Safe Maintenance.

(Photo 1)
There are three principal safety considerations to take into account when producing off-highway vehicle water tanks:

1. Sizing the tank volume to properly utilize the vehicle’s carrying capacity.
2. The stability of the combined loaded or partially loaded water tank - vehicle combination. Controlled water tank liquid movement equals stable vehicles, while uncontrolled liquid movement equals unstable vehicles.
3. The ability over the tank’s life to safely inspect and work on the tank interior (a tank by its very nature is often referred to as a confined space).

Where operational safety is paramount as it should be, the last two tank considerations need to control the actual tank design, while tank size must be large enough to properly utilize the carrying vehicles payload capacity.

As to tank size – First, let’s deal with the question, “Is water heavy?” Now to any of us who have carried a five gallon bucket of water, water seems heavy. Especially when one tries to keep water from getting all over oneself.

But, the weight of water is only relative, for in fact water is rather light, compared to many of the materials that off-highway vehicles carry.

Let’s consider some basic water density / volume facts:

1. one gallon of water weighs 8.35 pounds.
2. five gallons of water weighs 41.73 pounds (that five gallon pail of water one may have carried).
3. one cubic foot of water is 7.48 gallons.
4. one cubic foot of water weighs 62.426 pounds.
5. one cubic yard of water (27 cubic feet) is 201.97 gallons of water.
6. one cubic yard of water (27 cubic feet) weighs 1685.50 pounds.
7. one cubic meter of water (35.31 cubic feet) is 264.17 gallons.
8. one cubic meter of water (35.31 cubic feet) weighs 2204.56 pounds.
9. one ton metric (1000 kilograms) is 2204.62 pounds.

Said an entirely different way, at 4°C pure water has a density (weight or mass) of about 1 g/cu.cm, 1 g/ml, 1 kg/litre, 1000 kg/cu.m, 1 tonne/cu.m or 62.4 lb/cu.ft.

At 4°C pure water has a specific gravity of 1.

The density of water is 1685 per cubic yard, while the density of coal is 1500 to 1800 per cubic yard. This means that water tanks need to be sized almost like coal trucks.

Comparing water to various mined materials water in fact is relatively light!

For instance typical mine overburden will range from 1.543 tonne per cubic meter to 1.839 tonne per cubic meter (2600 pounds per cubic yard up to 3100 pounds per cubic yard) or, 1.55 to 1.84 density.

Typical Western Coal on the other hand weighs in at about .881 tonne per cubic meter (1485 pounds per cubic yard) or .88 density.

The conclusion that we can draw is that a water tank on a truck and in particular on a large off-highway truck, to fully utilize the carrying capacity of that truck needs to be similar in size to what a Coal Body would be on that same truck.

So to properly size a water tank one needs to go thru the formulas as follows:
The following are examples of various size trucks and resultant tank sizes.

### A tank on a 100-ton truck

<table>
<thead>
<tr>
<th>Metric</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Truck gross vehicle weight</td>
<td>161,025 kg.</td>
</tr>
<tr>
<td>2. Truck chassis weight</td>
<td>48,582 kg.</td>
</tr>
<tr>
<td>3. Water tank weight</td>
<td>21,591 kg. (est.)</td>
</tr>
<tr>
<td>4. Truck empty weight</td>
<td>70,354 kg. (est.)</td>
</tr>
<tr>
<td>5. Net payload of water</td>
<td>90,846 kg.</td>
</tr>
<tr>
<td>6. Gallons / Liters of water</td>
<td>90,850 L</td>
</tr>
</tbody>
</table>

### A tank on a 200-ton truck

<table>
<thead>
<tr>
<th>Metric</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Truck gross vehicle weight</td>
<td>317,514 kg.</td>
</tr>
<tr>
<td>2. Truck chassis weight</td>
<td>95,222 kg.</td>
</tr>
<tr>
<td>3. Water tank weight</td>
<td>38,782 kg. (est.)</td>
</tr>
<tr>
<td>4. Truck empty weight</td>
<td>135,547 kg. (est.)</td>
</tr>
<tr>
<td>5. Net payload of water</td>
<td>183,585 kg.</td>
</tr>
</tbody>
</table>

As is readily apparent: to achieve the rated payload capacity of the hauling vehicle water tanks need to be sized (relatively large) accordingly.

### As to a stable tank hauling vehicle combination:

As many of us who have ever carried a five gallon bucket of water know it is very easy for that water to slosh out and spill. Uncontrolled water surging in a vehicular water tank is a recipe for disaster.

So, today all commercially produced mobile water tanks have some form of baffles. However, by their very nature, most of the common baffling systems have some form of access holes cut thru them. And, in fact such baffles which have large enough access holes for human
With baffle access holes which are typically as large as a fifty-five gallon drum lid, water can still rapidly surge thru a vehicular water tank’s interior. And though the flow of water may be slowed down, it is anything but stopped!

Further in the tank fabrication process these baffle access holes are how one moves from compartment to compartment as the baffles are welded in place and any interior tank coating is applied. Clearly no fun for the individuals tasked with producing or working on a tank either in the initial production of the tank or later on in servicing the tank.

A better approach is to plan on:

a. Having baffle access ports that allow for easy personnel movement throughout the interior of the tank for initial fabrication and later inspection / servicing of the tank. (Photo 6)

b. Having a way to fully close off the baffle access holes when the tank is in service, so that NO uncontrolled surge of fluid can occur between baffled compartments when hauling and dispensing water from the tank (Photos 7 and 8)

In this regard, interior rust-proof hinge baffle doors are the answer. (Photo 9)
Interior tank baffle doors are fine but what about some internal tank access via something other than top of tank fill holes.

To accomplish easy interior tank access exterior tank ingress / egress external tank access ports are added to the tank structure, with both a hand hold tie off point and a foot step for accessing and leaving the tank. (Photos 10 and 11)

For even further control of tank water surges the exterior tank shape can additionally mollify water surges which could cause a hauling vehicle to become unstable. So rather than have nice "rounded" tank surfaces which allow smooth water flow across a tank floor and up the tank sides (Photo 12),

These normally rounded surfaces can be irregular bends which by their very nature interrupt the flow of water across the tank floor and up the tank sides. (Figure 4)
And then as a final coup de grand, tank lateral water surge suppressors running the length of the tank side walls fully and completely control any water wanting to surge up the side of a water tank. (Photo 13)

Thus, total water tank stability can be assured as no uncontrolled water tank surges with attendant vehicle instability are allowed to occur.

And, this is why and HOW tank size can be matched to a vehicles load carrying capabilities.

**Safe Tank Inspection and Maintenance:**

The life of a water tank (which can be many years) can be easily extended through regular annual / semi annual inspection and cleaning. (Figures 5 and 6)

It is worth pointing out at this point that the water being hauled in the typical mine / quarry water tank is anything but potable water.

The water is often pumped from a setting pond, a small catch basin lake, a stream, etc. the water is rarely suitable for human consumption.

If water is being pumped from a small on-site pond, there may even be fingerling fish in the pond. The feed lines or Horse's Heads that fill water tanks are often 6 to 8 inch diameter pipes. In fact there is at least one reported case of a dead rabbit getting into a tank and clogging the tank's pump inlet.

So for whatever the reason safe interior access to a water tank is highly desirable. (Photo 14)

And, just as a well planned tank baffling system will facilitate the quality manufacture of a water tank, so can that simple-to-implement interior baffle system with exterior tank ingress / egress doors ease the concerns
about venturing into the dark, dank interior of what the previous standard in water tanks has been.

To be able to safely venture inside a water tank without having to worry about some of the challenges of a confined space provides a real comfort to inspecting and maintaining a water tank that is designed from the beginning with the future in mind.

Does one really want to be like the mine where access to the interior of a water tank is achieved by cutting a hole in the side of the tank and later welding the hole closed after access to the interior of the tank has been finished?

Some other factors that lead to a comfortable water tank are having a bare minimum of welded piping joints. Yes, piping can be welded together to plumb the various water dispensing components of a water tank. However, as previously alluded to the water that often is hauled in mine quarry water tanks is anything but clean water. The water can be anything other than pH neutral. The result is that over time water tank piping can deteriorate to the point that leaks begin to occur. Those experienced with welding on a rusty pipe to fix a leaking pipe segment know that such welding can not only be frustrating but very difficult. The easiest way around this situation is eliminate as many welded pipe connections as possible.

By using Victalic® or Gruvlok®-style piping fittings to plumb water tanks, any pipe sections that in time fail from corrosive water are easily replaceable without having to get a boilermaker involved. (Photo 15)

Typical water tank options are:

1. Sprayheads across rear of water tank (Photo 16)

2. Sprayheads on upper top rear corners of water tank (Photo 17)

3. Sprayheads on front bumper of hauling vehicle (Photo 18)

4. Hose with reel and adjustable nozzle (Photo 19)
5. Water Cannon or Monitor remote controlled

6. Fire fighting induction Remote Controlled Water Cannon or Monitor

7. Tank water level monitor

And, almost anything else that can add to the versatility of a vehicle mounted water tank.

CONCLUSION

Over the years, advances in design and engineering have allowed progressive evolution of water tank design with the addition of interior baffles to inhibit water flow, minimizing surges that can often cause off-highway vehicular water tanks to roll over. Designers have attempted to prevent these surges by either modifying the path of the water, or limiting the water flow in such a way that the water is essentially sealed off from other compartments. While even though safety is at the heart of the water tank baffling methods, these baffles also pose additional problems for maintenance personnel. This paper describes a better way to minimize water surges while allowing personnel to access the interior of the tank both comfortably and safely.

ACKNOWLEDGMENTS

I want to thank in particular Beth Ward of Philippi-Hagenbuch, Inc. for her tireless efforts in editing and preparing this paper for publication. My appreciation is also extended to the Associates of Philippi-Hagenbuch, Inc. and Welerik Fabrications for their willingness to take the improved safe vehicular water tanks concepts developed thru continuous product development and bring them to successful fruition, Thank You.

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