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Slip-On Water Tank Units

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Slip-On Tank Unit

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Introduction

The most common wildland fire engine in the United States combines a pickup truck with a slip-on tank and pump unit. Rural fire departments, state forestry agencies, and federal forest fire units all use "slip-ons." They can be found on both full size and mid sized pickups. Tank sizes vary from about 75 to 200

gallons, dependant on the truck's capacity and the weight of other items needed by the user. The popularity of pickup based water systems prompts many questions by those building or buying these units. This project provides some answers for those who think a slip-on tank will fill their need.

Standard Slip-On Units for Pickups

A slip-on tank is a box shaped unit that fits within a pickup truck cargo box, on a flat truck bed, on a trailer, or within some other truck cavity such as a utility body. For this report, we will limit discussion to tanks that are sized to fit within a pickup truck box. This is by far the most common application. Readers can broaden much of this information to other uses, if needed.

All this is packaged in one unit that can be placed in the truck's cargo box. Usually this unit must be secured and plugged into the vehicle electric system. Removal from the truck is relatively easy, allowing for storage during seasonal periods of low fire occurrence or for transfer to a different vehicle.

Most slip-ons consist of these elements:

Slip-on owners have obtained their units in several ways:

- tank for holding water
- a pump driven usually with an auxiliary internal combustion engine
- plumbing, including a hose reel with booster line to deliver water
- controls and instruments to manage and measure the water flow

- purchased a standard, off the shelf, tank and pump skid unit ready for mounting in the truck's box
- purchased a tank and outfitted the pump, reel and plumbing themselves
- designed or specified a custom tank and pump slip-on unit planned specifically for their needs

Tank Materials

Slip-on tanks have been commonly made from five materials: aluminum, fiberglass, polypropylene, mild steel, and stainless steel. Each has its advantages and disadvantages.

consider another material or check with the chemical manufacturer to determine its affect on the specific aluminum alloy you wish to use.

Aluminum - Most aluminum slip-on tanks are custom made. Its light weight makes it appealing for fire applications. Aluminum is costly and its welds are more prone to failure than with steel. Because slip-on tanks are relatively small, both of these disadvantages are minimized. Aluminum withstands weathering well and is very resistant to corrosion from water. It can be corroded by certain chemicals, and Class A foam is one. Certain aluminum alloys can be severely pitted when contacted by either Class A foam, concentrate, or by mixed foam solutions. This can be alloy specific and vary by the brand of foam being used. If you plan to mix foam chemical directly in your tank,

Fiberglass - For years, fiberglass was the material of choice for those wanting lighter weight, corrosion resistant, slip-on tanks. It is still common although it has lost market share to polypropylene. The fiberglass tank manufacturers normally offer several standard tank capacities. You can purchase fiberglass tanks and outfit them with pump, plumbing, or other accessories. Several distributors offer complete, ready to install, fiberglass slip-on units as well. Fiberglass has excellent corrosion properties and will withstand contact from both water and foam. In time, there will be some external degradation from the sun's ultra-violet rays, but fiberglass usually provides a long life.

Repairs can be made easily with materials readily found at a marina or auto body shop.

Polypropylene - In recent years polypropylene plastic has grabbed a share of the tank material market. "Poly" sheets are light and can be welded together to form the tank. Generally, poly tank manufacturers use 1/2 inch thick material. The plastic should be opaque to prevent algae formation and have some ultraviolet resistance. It is important to plan mounting strips and plumbing connections during poly tank design. This material forms a relatively light tank despite the relatively thick sheet used. Polypropylene is ideal for tanks when the tank is protected externally by other structures. In the case of a slip-on unit, the cargo box provides this protection.

Plastic welding can be done in a small shop setting. Welders (welders or welding machines) are relatively inexpensive. Getting opaque ultraviolet ray resistant materials may require finding a large plastic distributor. Most of the poly tanks come from the major poly tank manufacturers. These companies make some standard slip-on size tanks. Some also custom manufacture units. Several equipment suppliers utilize poly tanks for these ready to install slip-on pumper units.

Polypropylene does not absorb water readily and appears to be resistant to fire foam chemicals. Repairs will not be easy but the large tank manufacturers offer long-term warranties which often include on-site repair service. None of the poly tanks we have seen have had removable lids, so if you need to clean out something that is not right under the filler lid, you might be in for an adventure. One manufacturer now offers a removable lid model.

All-in-all, polypropylene is getting to be a very popular tank material choice. Although a bit higher in cost than some choices, it combines light weight and corrosion resistance, two desirable properties.

Mild Steel - Mild steel is the old standby. It is not used by tank manufacturers much but is still used by those who have a basic shop with a welder. Steel's chief benefits are its strength, ease of manufacture, low cost and wide availability. Its disadvantages include its higher weight and corrosion problems. In order to get a reasonable amount of life from a steel tank, you

must use some kind of rust preventative on the inside. Epoxy or galvanizing coatings have been successful. REC's [Report #11, "Rustproofing Treatments for Steel Water Tanks,"](#) lists several alternatives.¹ REC also has plans for a 150 gallon steel tank, (Report #34) and two different 200 gallon steel tanks (Report #33 and Report #40). Each of these tanks were designed for use in pickup style trucks.

Steel is not a good choice if you plan to mix foam in the tank. Foams attack mild steel aggressively. Zinc (galvanizing compound), a good choice for water-based corrosion protection, will not hold up well against foam. Mixed foam stored for a day or so in a steel tank will not bubble well, although it will retain its ability to penetrate fuels.

Stainless Steel - Stainless combines strength and corrosion resistance, however weight and cost are major drawbacks. Since strength is not a property critical for slip-on tanks, other materials that cost less are usually a better choice.

¹ Project #11 report is available on the REC Web Site.

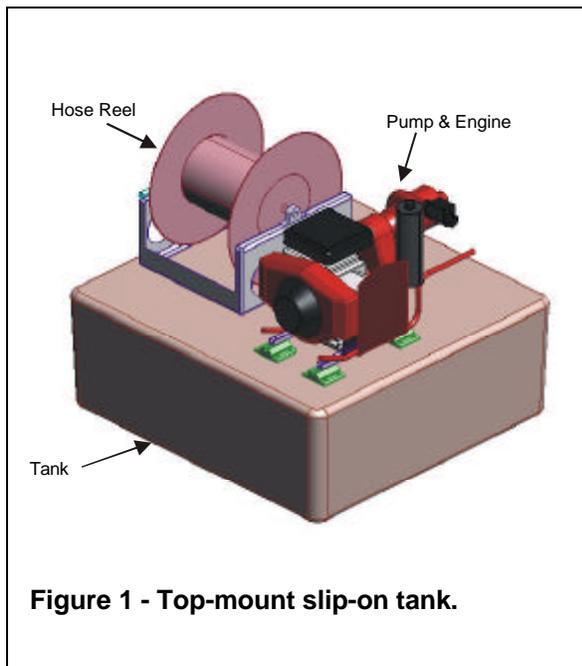
Other Tank Construction Issues

Tank Capacity – The size of the tank should be based on operational needs. Once the needed capacity is established, the pumper vehicle should be selected. When ready to go to the fire, the completed truck's weight should not exceed the manufacturer's gross vehicle weight rating (GVWR). "Determining Load Capacity" section found later in this report will help determine the finished vehicle's weight before you buy. Sometimes the tank capacity you desire is not practical for the size of the vehicle you can purchase. Compromise on the side of safety. Don't overload the vehicle.

The tank capacity for various size pickups varies with how weight is needed for stored or optional equipment items. Generally the upper limits are:

- 200 gallons for 1-ton
- 150 gallons for ¾ ton
- 100 gallons for ½ ton

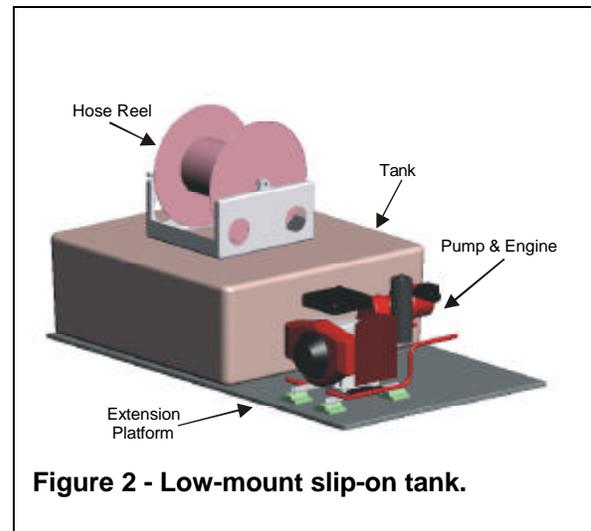
Equipment Mounting – Traditionally there have been two styles of slip-on units. The "top-mount" style has the pump, hose reel and other components mounted on top of the tank (Figure 1). This makes the unit compact, in terms of the floor space needed for mounting. This would be



necessary for short box pickup trucks.

The second style of slip-on is the "low-mount" (Figure 2). In this case, the tank is mounted on a flat platform that extends rearward past the end of the tank. The pump, plumbing, and controls are mounted on the platform extension which is located at the rear of the truck. This makes it easier to operate the pump than the "top-mount." There is extra weight, about 100 pounds, added for the platform. The platforms of standard supplier built units are generally about 7 feet long, so a full size pickup box may be required.

Suppliers of both of these slip-on tank types mount the reel on top of the tank. The reel is positioned so the booster line can come off either side of the truck. For tank sizes greater



than 100 gallons, the tank width will be just less than the approximate 4 foot wide truck bed. Normally the tank length is around 50 inches. The height varies with the volume of the tank. Figure 3 shows the approximate weight and sizes for typical polypropylene and fiberglass slip-on tanks.

Figure 3

Approximate Weight of Fiberglass or Polypropylene
Slip-On Tanks*
Weight includes auxiliary engine driven pump, hose reel, plumbing, and water.

Volume (U.S. gal.)	Weight (lbs.)	Height (in.)	Length (in.)	Width (in.)
125	1,550	17	51	48
150	1,770	19	51	48
200	2,200	25	51	48
250	2,660	Varies	Varies	48
300	3,240	Varies	Varies	48

* The above weights are dependant on construction methods, pump, and component selection. Dimensions and weights are generalized from a sample of commercially available slip-on tanks. Use for planning estimates only.

Removable Top or Not – Some manufactured tanks come with removable tops, some do not. For wildfire use, having a removable top is an advantage. Drafting or getting a refill from an “unknown” cooperators water source is common. Sometimes the water will be contaminated with stones, sand, or debris. Being able to clean this out easily and reliably is a plus. Wildfire slip-ons will likely be in service for a long time. That usually means there will be a time in its life that you will need to get into the tank.

Manufactured fiberglass units come with removable lids. Few polypropylene tanks do, although one leading manufacturer has them now. Metal tanks, aluminum and steel, might have either type of lid.

Baffles – Baffles or swash partitions on the inside of the tanks prevent rapid momentum shifts of the water. This means better and safer

handling of the vehicle when cornering, stopping, or operating on side slopes with partial water loads. Baffling a tank is good practice. The distance between baffles or a tank wall and baffle should be no more than 36 inches apart. Baffles must be designed to allow adequate water flow between sections at the bottom of the tank. They must also allow adequate air flow at the top to prevent a vacuum build up.

Ports – At a minimum the tank needs a port to put water in and one to get it out. It is usual to have a large top mounted fill neck. If you plan to draft water using the unit’s pump, you will want a hose coupling connection into the tank of the appropriate size.

The pump needs to retrieve the water from the tank in order to pump to the supply lines. This tank outlet should be sized properly for the pump’s flow characteristics. If it is too small, cavitation or performance problems will occur.

Instruments, Controls, and Plumbing

The controls for most slip-on units are usually basic. Mounting some or all of them on a single panel can make operation easier. Below is a list of common switches, lights, valves, and electric items that could be considered on the operation control panel. Those marked with an asterisk are the most common panel mounted devices for auxiliary internal combustion driven pump systems.

- Pump engine ignition on-off (kill) switch*
- Pump engine start switch*
- Pump engine choke control*

- Pump engine throttle control*
- Pump discharge pressure gauge*
- Panel illumination light and switch*
- Pump intake vacuum gauge
- Auxiliary work light(s) switch
- Hose reel rewind
- Hose reel circuit breaker
- Pump engine hour meter
- Plumbing control valves
- Foam proportioner valves
- Pump engine power on-off indicator lamps
- Low pump pressure override switch
- Pump primer controls

Determining Load Capacity

Overloading a fire vehicle is all too common and happens for a variety of reasons. Usually it occurs for one of these reasons:

- Proper planning was not done before buying the vehicle or tank.
- Items were later added to the vehicle that were not considered in planning.
- An error was made during planning.
- "Fire agency "A" had 200 gallons on their truck so we figured we could too." Unfortunately fire agency "A's" vehicle was overloaded too!

You must do the homework first or risk owning a costly safety problem.

The manufacturer of each truck determines the Gross Vehicle Weight Rating (GVWR) for that vehicle. The GVWR is the maximum design load. The manufacturer also lists the Front Axle Weight Rating (FAWR) and Rear Axle Weight Rating (RAWR). These are the maximum design loads on each axle. None of these ratings should be exceeded. For wildfire control uses, it is good practice to reduce the load. A fire truck is fully loaded almost all the time. This is a heavier duty than the average pickup truck use profile. Loading the truck at 85 percent to 90 percent of the weight ratings will reduce operating costs, lengthen truck life, and provide a margin when operators decided they need to take more items.

The appendix contains two methods for planning the development of your slip-on unit. Appendix A is a simple worksheet that helps you estimate the overall weight of the completed vehicle. If you are comfortable with doing higher level calculations, Appendix B goes further. It guides you through a more thorough estimate that will yield the vehicle's final weight plus the weight on each of its axles. On its website, REC provides an interactive web page that allows you to enter the data and it calculates the results.

It is important to understand that it is possible to do this work before you buy a vehicle or slip-on unit. In fact, that is the best way to do it. Make sure that you get accurate weight and dimensional data from the manufacturer or

dealer. Make sure the curb weight² of the vehicle includes all the options you plan to order. If you just use the basic weight of the standard pickup, your answer will not be correct. You need the weight of the truck as you would order it.

Lastly, weigh the vehicle after the slip-on is added, the tank is full, all the fire tools are loaded, and the occupants are seated. If the weight or axle ratings are exceeded, you need to make some changes.

² The curb weight is the weight of the vehicle with all fluids full, as delivered from the vehicle manufacturer.

Securing Slip-On Tanks

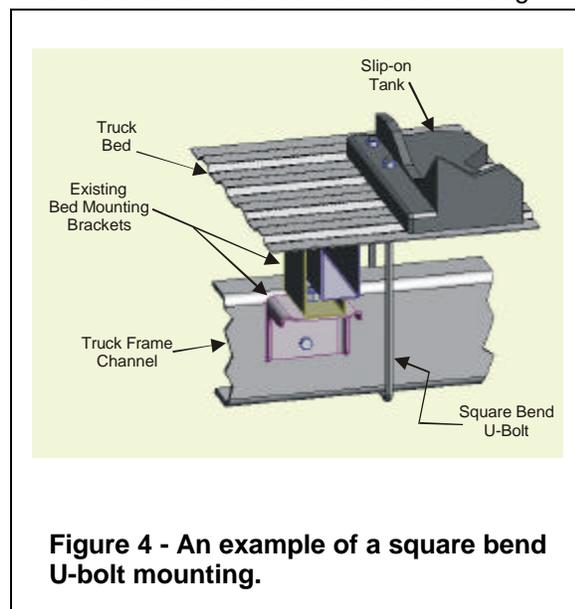
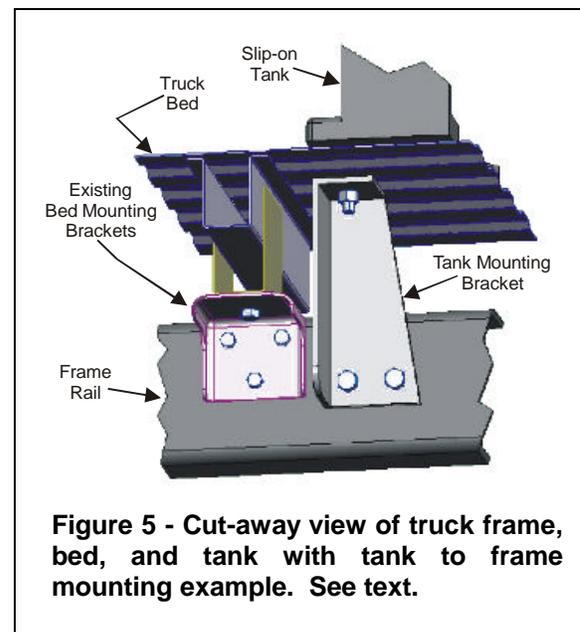
We are often asked what is a good way to secure a slip-on tank to a pickup truck. It is difficult to give a specific answer. Although similar, slip-on tanks are made by a variety of manufacturers, with a variety of materials, hence the best way to mount them differs. Likewise, pickup trucks are similar but there are some differences as to how cargo boxes are mounted to the frame. This again means a specific answer may not fit all situations. The key point is that a pickup bed is a relatively thin sheet of steel and it is not substantial enough to hold down a couple thousand pounds of payload. What we provide here are some examples of how slip-on tanks might be mounted.

If you have purchased a tank from a manufacturer, our advise is ask them how it should be mounted. They have designed mounting points on their tank and should have experience as to the best way to mount it in a pickup truck. It's possible that they have brackets and plans for doing so.

The best choice is to mount the tank directly to the truck's frame in some fashion near the four corners of the tank. Most tank designs provide a mounting flange near these four points. One method might be to use square bend U-bolts around the frame (Figure 4). The bolts will need to be made specially for this application. An advantage to this type of mounting is that no modification is needed to the frame of the truck. The U-bolts should be tensioned enough to

secure the tank against the truck's bed, but not so much that it crushes the frame, bed mounting members or bends the frame's flange.

Another method is to mount a bracket to the truck frame as shown in Figure 5. In this case the bracket is bolted to the centerline of the truck's frame rail, the top of the bracket extends to the bottom surface of the truck bed and is bolted through to the tank's mounting flange. Care must be taken when drilling holes into the truck frame. See our rules for drilling frame rails which is located in the shadow box.



The size and strength of the fasteners is dependent on the tank size and how many are used. The slip-on tank manufacturer should be able to help you in this regard. Bolts of the same diameter come in several different strengths, referred to as grades. The grade of a hex head cap screw is marked on its head. Lower grade bolts have no markings on the head, are made of low carbon steel and have unreliable strength ratings. Avoid using these bolts. Of the bolts with grade marks, Grade 5, and 8 are the most common. The higher the grade, the higher the strength.

Sometimes these slip-on tanks are being mounted to a pickup chassis that already had a heavy duty after market bed mounted to the frame. In this case, mounting the tank may be

as simple as bolting it near the four corners of the tank.

The above discussion is provided to give the reader a sense of some of the important

considerations necessary when mounting a slip-on tank to a pickup vehicle. It is not intended for a substitute for technical knowledge or experience.

References, Designs, and Suppliers

The following references include additional information on this topic. Suppliers names are listed for the convenience of the reader and should not be taken as an endorsement, nor is the supplier listing complete. It is certain that there are many small slip-on manufacturers of which we are not aware.

References

Water Handling Equipment Guide, National Wildfire Coordinating Group, March 1994. Has photographs and lists specifications for wildland fire units across the Nation. Some of these are slip-on type units. Order NFES #1275 from the National Interagency Fire Center, ATTN: Great Basin Cache Supply Office, 3833 South Development Avenue, Boise, Idaho 83705.

Wildland Fire Engine Component Guide, National Wildfire Coordinating Group, March 1994. Lists and discusses common components found on wildland fire vehicles. Has chapters which discuss tanks, pumps, and other components. Order NFES #1871 from the National Interagency Fire Center, ATTN: Supply, 3905 Vista Avenue, Boise, Idaho 83705.

[REC Newsnote #3, Guidelines for Designing Forest Fire Engines](#). 1998. Gives additional advise for designing and planning water tank vehicles. Available in pamphlet form or online at www.RoscommonEquipmentCenter.com.

REC Slip-On Tank Designs

REC has several publications that feature slip-on tanks with complete design details. These provide design ideas for those intending to contract for or make their own tanks.

REC Project #33, Tanker Handbook, Military 1-1/4 Ton, 4x4 Cargo Truck, includes design details for a 200 gallon steel slip-on unit. Available as a booklet.

REC Project #34, Tanker Handbook, Military 3/4 Ton, 4x4 Cargo Truck, includes design

details for a 150 gallon steel slip-on unit. Available as a booklet.

REC Project #40, Tanker Handbook, Military 880 Series 1-1/4 Ton, 4x4 Cargo Truck (Dodge W-200), includes design details for a 200 gallon steel slip-on unit. Available as a booklet.

REC Project #61B, Indiana 90 Gallon and 150 Gallon Aluminum Slip-on Unit. Includes design details for two aluminum tanks; one for full size and one for mid-size pickup trucks.

Slip-On Tank Suppliers

The following is a list of well known slip-on tank suppliers and manufacturers. It is not practical to list all suppliers of this product. Listing does not constitute an endorsement.

Cascade Fire Equipment Company
P.O. Box 4248, Medford, Oregon 97501
Telephone: (541) 779-0394 or 1-800-654-7049
E-mail: cascade@mind.net
Web Site: www.cascadefire.com/products/
Installation ready fiberglass and polypropylene slip-on units.

Mallory Company
1040 Industrial Way, P.O. Box 2068, Longview, Washington 98632
Telephone: (360) 636-5750 or 1-800-426-6830
E-mail: info@malloryco.com
Web Site: www.malloryco.com
Installation ready fiberglass slip-on units.

Mertz, Inc./Marco Fire Apparatus
P.O. Box 150, Ponca City, Oklahoma 74602
Telephone: (405) 762-5646 or 1-800-527-1574
High pressure/low volume slip-on tank pump units.

National Fire Fighter Corp.
2511 West 5th Avenue, Eugene, Oregon 97402
Telephone: 1-800-423-8347
E-mail: info@nationalfirefighter.com or sales@nationalfirefighter.com
Web Site: nationalfirefighter.com
Installation ready aluminum, fiberglass, steel, or polypropylene slip-on units.

Pro Poly of America, Inc.
Ocala, Florida
Telephone: (352) 629-1414 or 1-800-944-9765
E-mail: propolyfl@aol.com
Web Site: www.propolyamerica.com/
Polypropylene water tanks (some models have
removable lids).

Robwen, Inc.
1989-A Blake Avenue, Los Angeles, California 90039
Telephone: (323) 665-5633 or 1-800-365-9281
E-mail: support@robwenl.com
Web Site: www.robwen.com/slip.html
Slip-on units with foam proportioner.

Sims Fiberglass Co.
P.O. Box 36, Jefferson, Oregon 97352
Telephone: (541) 327-2023
Fiberglass water tanks.

United Plastic Fabricating, Inc.
165 Flagship Drive, North Andover, Massachusetts
01845-6119
Telephone: (978) 975-4520
E-mail: info@unitedplastic.com
Web Site: www.unitedplastic.com
Polypropylene water tanks.

W.S. Darley & Co.
200 Anson Drive, Melrose Park, Illinois 60160-1087
Telephone: 1-800-323-0244
E-mail: darley@wsdarley.com
Web Site: www.edarley.com
Installation ready steel and polypropylene slip-on units.

Wildfire Pacific
P.O. Box 88540, Seattle, Washington 98138
Telephone: (253) 395-4444 or 1-800-426-5207
E-mail: pump@wildfire-equipment.com
Web Site: www.wildfire-equipment.com
Fiberglass tanks or installation ready slip-on units.

Appendix A - Slip-On Tank - Pickup Truck Loading Worksheet

Identify Truck Weight Ratings (from manufacturer)

1. Enter Gross Vehicle Weight Rating (GVWR). (A) _____ lbs.
2. Enter Rear Axle Weight Rating (RAWR). (B) _____ lbs.
3. Enter Front Axle Weight Rating (FAWR). (C) _____ lbs.

Determine Empty Pickup Truck Weight (obtain from manufacturer or by weighing)

4. Enter weight of pickup truck (include fuel) as delivered. (D) _____ lbs.
5. Enter amount of truck's weight (D) on the rear axle. (E) _____ lbs.
6. Calculate amount of truck's weight on front axle.
(D) - (E) = (F) (F) _____ lbs.

Determine Truck Payload Capacity

7. Calculate maximum available payload. (A) - (D) = (G) (G) _____ lbs.
8. Calculate maximum portion of payload that can be placed on rear axle. (B) - (E) = (H) (H) _____ lbs.
9. Calculate maximum portion of payload that can be placed on front axle. (C) - (F) = (J) (J) _____ lbs.

Determine Weight of Items to be Added

10. What is the maximum number of occupants? (K) _____ lbs.
11. Weight of Occupants. (K) x 200 lbs. = (L) (L) _____ lbs.
12. Weight of slip-on, water, pump and accessories. (M) _____ lbs.
13. Weight of other components and stored items. (N) _____ lbs.
14. Total weight of added items. (L) + (M) + (N) = (P) (P) _____ lbs.
15. Total weight of completed vehicle. Includes vehicle, slip-on tank unit, water occupants, and stored items.
(D) + (P) = (Q) (Q) _____ lbs.
16. Will the complete vehicle fall within target range (85%-90 % of GVWR)?
85% (A) x 0.85 (R) _____ lbs.
90% (A) x 0.9 (S) _____ lbs.
17. a. Is (Q) greater than (A)? Yes/No
If so, you will exceed the vehicle GVWR. Choose a smaller tank.
b. Is (Q) greater than (S)? Yes/No
If so, you should consider a smaller tank.
c. Is (Q) less than (R)? Yes/No
If so, you might consider a larger tank. If you do, recalculate to make sure you are within limits.
18. The load on each axle must be within the manufacturers ratings. This can be established prior to purchase as well but the procedure requires more understanding of static weight distribution as well as information on the location of center of gravities of the items to be placed on the truck. Appendix B illustrates this more complex calculation. REC's internet site has a calculator that simplifies this kind of calculation. Look under the "Wildland Engines" section of the site.

Appendix B – Calculating Total Load and Front and Rear Axle Loads

The worksheet included in Appendix A of this report estimated the total load of your system. It included the weight of the truck (curb weight), tank system, water, two occupants, and storage. It tells whether you have added too much load to the vehicle, a good calculation to start with, but doesn't help you predetermine the weight on each axle. There is a way to calculate the axle weights. It requires you to determine the location of the center of gravity (CG) of each item added to the truck. Then you must accurately input the weight and CG distance of the items into a formula.

This appendix illustrates a more complete but more complex method for analyzing the loads for a slip-on tank unit. REC's Slip-on Tank Load Calculator utilizes this method and is located at REC's web site, www.RoscommonEquipmentCenter.com. Using this calculator will allow you to change values quickly to make adjustments for differing scenarios.

Determining the final axle weights is relatively simple for pickup/slip-on tank units. There are two reasons for this. First, there are relatively few components that are being placed on the vehicle. Secondly, the slip-on tank is designed to fit in the pickup box. Hence we know a lot about where the tank load will be placed.

In this section we will illustrate the calculation procedure using a real life example. For this example, we will use a low-mount slip-on unit because it is the more complex than a high-mount tank system. Figure B-1 illustrates the weights and distances that must be known to do the analysis. Each weight is denoted by a thick arrow pointing downward at the location of its center of gravity. In some cases there are more than one weight located at the same place. Each weight (or force) considered is listed in bold, capital letters. The weights considered here are:

R_{curb} = The portion of the truck's curb weight on the rear axle.

H = The total weight of the occupants. It is standard to use 200 lbs. per person. Hence, if there will be two occupants, use 400 lbs.

S = The weight of stored items. In this case we assume that all the stored items will be in one location in front of the tank.

T = The weight of the empty tank normally supplied by the manufacturer.

W = The weight of the water load which equals the volume in U.S. gallons, times 8.35.

RL = The weight of the hose reel with booster hose.

E = The weight of the tank extension platform. Low-mount fiberglass and polypropylene tanks normally have a platform to which the tank and pump are attached. This does not pertain to high-mount slip-ons.

P = The pump assembly weight.

F = The weight of foam proportioner.

F_{curb} = The portion of the truck's curb weight on the front axle.

The total weight of the truck when all the items listed above are placed on the vehicle is:

$$\text{Total} = R_{\text{curb}} + H + S + T + W + \text{RL} + E + P + F + F_{\text{curb}}$$

"Total" should be less than the GVWR.

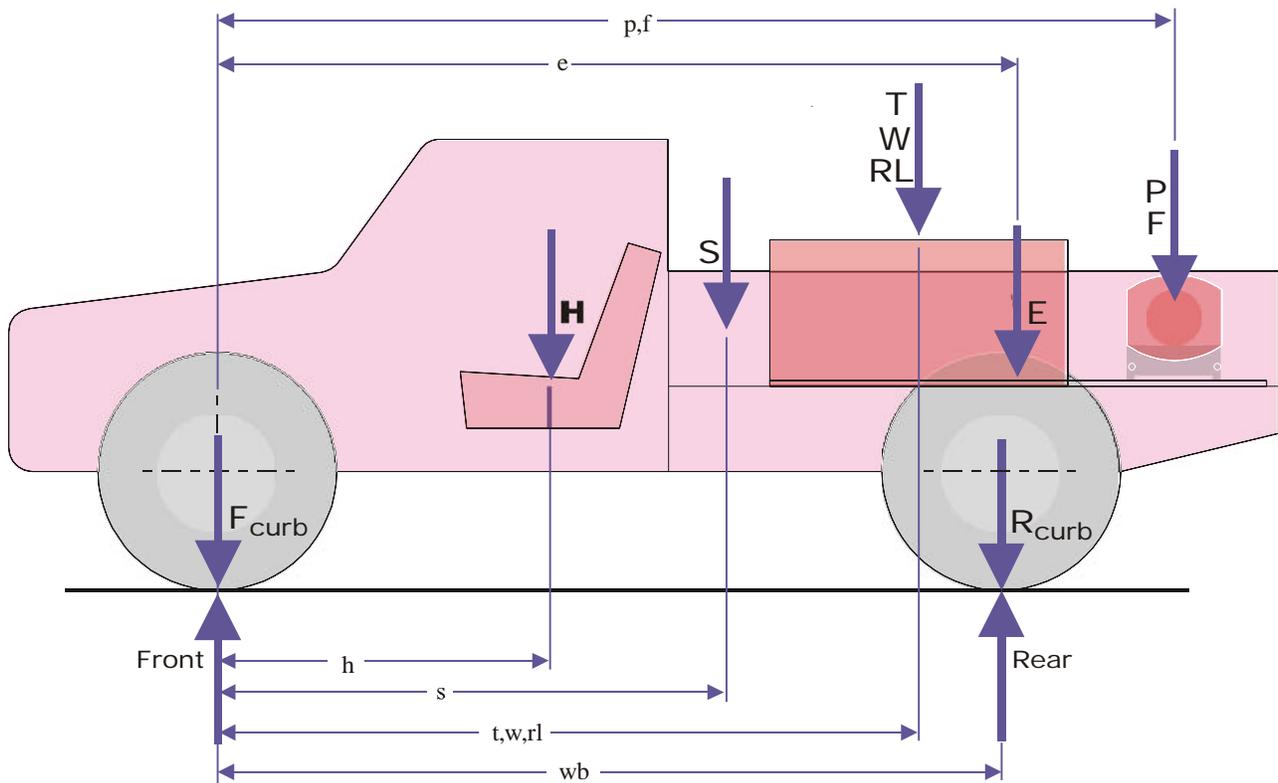


Figure B-1 - Forces (weights of installed items) and their center of gravities from the front axle centerline.

The important dimensions that you need are also shown in Figure B-1. These are shown in lower case letters on the diagram. We need the location of each force's center of gravity. The CG is the balance point of the item's weight. Our estimate will be accurate if we can find these within a couple of inches of actual, closer for heavier components.

We are going to estimate these relative to the front axle as depicted in Figure B-1. The distances are:

- wb = The vehicle's wheelbase which is defined as the distance between the center lines of the front and rear axles. The manufacturer will provide this information.
- h = The distance from front axle to the CG of the occupant's weight. This will be approximately where the driver's buttocks meets the seat bottom.
- s = The distance from front axle to the CG of the stored item's weight.
- t = The distance from front axle to the CG of the empty water tank.
- w = The distance from front axle to the CG of the water.
- rl = The distance from front axle to the CG of the hose reel.
- e = The distance from front axle to the CG of the tank extension platform.
- p = The distance from front axle to the CG of the water pump.
- f = The distance from front axle to the CG of the foam proportioner.

The remaining unidentified items in Figure B-1 are "Rear" and "Front." These are the resulting forces or load on the truck's rear and front axle respectively. These are what we are trying to calculate.

In this relative simple example, all of the items that we are adding to the vehicle are located behind the front axle. When this is the case, the formula for finding "Rear" is simple, although it might look long.

$$\text{Rear} = \frac{(H \times h) + (S \times s) + (T \times t) + (W \times w) + (RL \times rl) + (E \times e) + (P \times p) + (F \times f) + (R_{\text{curb}} \times wb)}{wb}$$

Make sure that you compute the total for the top line (the numerator) of the equation and then divide that answer by "wb" (the denominator).

If you have a simpler situation, for example no foam proportioner, just substitute zero for the term " F" in the equation. In other words, you can reduce the equation by eliminating the weight of the component and its distance for any item you may not use.

Often the tank manufacturer will give you the weight of the tank with water, pump, and reel. If so, T, W, P, and RL will be combined and you may need to make an educated guess as to where the CG will be located. For a high-mount slip-on tank, the CG will likely be close to the mid-point of the tank.

Again, you cannot use this formula for items located in front of the front axle.

You can add an additional item to the truck equation. Take its weight and multiply it by the horizontal distance of its CG from the front axle. Add that to the equation numerator.

Our answer, "Rear", should be less than the manufacturer's given RAWR. If it isn't, then there is too much weight in the back end.

To get the load on the front axle, subtract "Rear" from the "Total" load.

$$\text{Front} = \text{Total} - \text{Rear}$$

Compare this with the manufacturer's Front Axle Weight Rating. It must be less as well.

An example using these formulas.

Figure B-2 shows the weights and approximate center of gravity for an actual case. The truck is a nominal one-ton capacity 4x4 pickup with cargo box. The slip-on unit is a 200 gallon low-mount fiberglass model with foam proportioner.

The forces F_{curb} and R_{curb} were determined by weighing the pickup truck with full fluids and no occupants prior to adding any of the fire related components. In other words, these are the weight on each axle as delivered from the dealer.

The weight of water, W, is found by multiplying the tank capacity by 8.35 lbs./U.S. gallon. The weight of the occupants is the number of occupants times 200 lbs. We chose to have two occupants, or 400 lbs. on the seat. This is standard practice.

The other weights were determined by asking the product's manufacturer or weighing the item. Figure B-2 shows these weights as used in the example.

Determining the center of gravity distances can be a little more difficult. Most water tanks of this type are symmetrical. In this case, the center of gravity is located halfway between the front and rear of the tank. Measuring from this point to the centerline of the front axle is relatively easy to do. Although not exactly precise, the center of gravity of most pump, hose reels, and foam proportioners will be very near the physical center of the item.

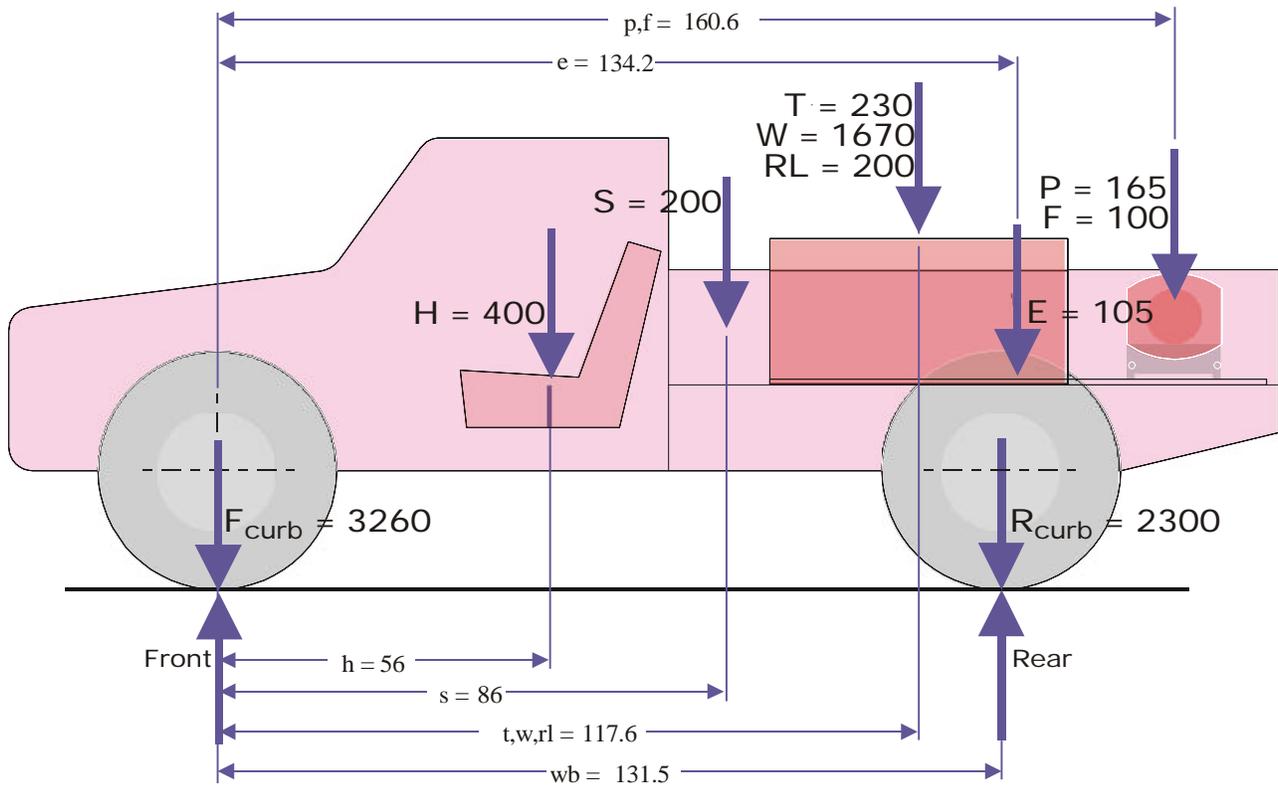


Figure B-2 –Example showing weights of objects and the distance of those items from the front axle. Distances are measured in inches. Weights are shown in pounds force.

For the case shown in Figure B-2, the formula (1) becomes:

$$\text{Total} = 2300 + 400 + 200 + 230 + 1670 + 200 + 105 + 165 + 100 + 3260 = 8630 \text{ lbs.}$$

And the rear axle load from formula (2) is:

$$\text{Rear} = \frac{(400 \times 56) + (200 \times 86) + (230 \times 117.6) + (1670 \times 117.6) + (200 \times 117.6) + (105 \times 117.6) + (165 \times 160.6) + (100 \times 160.6) + (2300 \times 131.5)}{131.5}$$

$$\text{Rear} = 4910 \text{ lbs.}$$

The front axle load from formula (3) is:

$$\begin{aligned} \text{Front} &= \text{Total} - \text{Rear} \\ \text{Front} &= 8630 - 4910 \\ &= 3720 \text{ lbs.} \end{aligned}$$

The weight ratings for the pickup truck are:

$$\begin{aligned} \text{GVWR} &= 9250 \text{ lbs.} \\ \text{FAWR} &= 4250 \text{ lbs.} \\ \text{RAWR} &= 5000 \text{ lbs.} \end{aligned}$$

For the 200 gallon tank and other items, we have come just under the weight ratings of the vehicle. In our judgment, the rear axle load is too high. We are only 90 lbs. (about 2 percent) under the axle rating. This gives us no room for error and no room to add additional items that may be needed. In this case, we would strongly advise reducing the tank size to 175 or even 150 gallons.

Appendix C - Drilling Holes in Truck Frame Rails

From time to time it is necessary to mount an item to a truck's frame rails. The frame rails are the most substantial mounting points available, but altering or modifying these parts should not be taken lightly. Before drilling into the frame, check with the truck manufacturer for information on what is allowable. If the manufacturer says not to, don't do it. Below are some things you should consider.

- Use existing holes, whenever possible. The manufacturer puts many holes in frames for the variety of optional items they may need to mount. Many of these will be unused. See if you can use some of these existing holes to accomplish the mounting. Often this will be the case.
- Do not drill holes in the frame flanges or upper or lower part of the web without guidance from the truck manufacturer. Figure C-1 shows the important parts of a frame channel. The channel's flanges contribute greatly to the strength of the frame. Weakening them by drilling holes is not advisable, unless you have the technical expertise or information that says otherwise.
- If holes are necessary, plan to drill any holes along or near the neutral axis of the frame. Most truck frames are symmetrical top to bottom, which means that the neutral axis is the center line of the frame (halfway down from the top). Figure C-1 illustrates the location of the neutral axis and shows two holes located directly along it. The darker gray stripe illustrates the approximate zone in which it's normally safe to drill.
- Do not drill holes too close together. A 2 inch minimum spacing is desirable but it is wise to check with the manufacturer for their advise.
- Watch out for other components when you drill. Brake, fuel, and electrical lines are normally routed inside the frame rails.

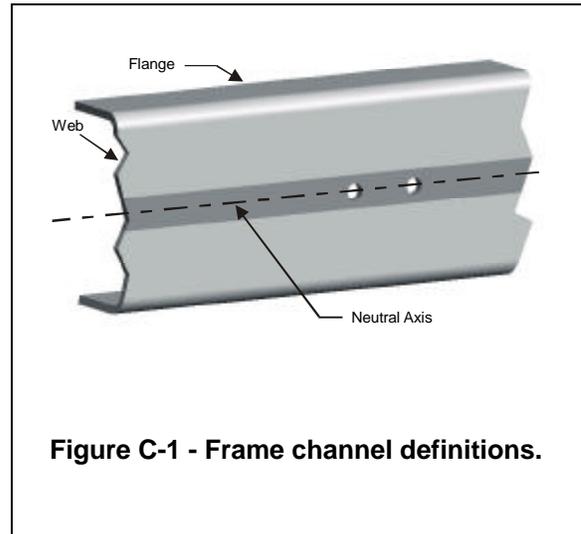


Figure C-1 - Frame channel definitions.

Some might have the urge to weld brackets to a truck frame rail. We strongly discourage this practice, unless you have direct consultation with the truck manufacturer. Welding may change the metallurgical composition and therefore the strength of some frame rail materials. Additionally, welded designs almost certainly will require welds somewhere other than the neutral axis. Only those with the proper technical knowledge and experience should attempt to weld brackets or other components to the truck's frame rail.