TRAILER DESIGN CONSIDERATIONS

Things To Consider When Designing Your Cargo Trailer and How To Get The Most ROI From Their Cargo Trailer

WHAT IS E-BOOK OR WHITE-PAPER?

A white paper is an authoritative report or guide that informs readers concisely about a complex issue and presents the issuing body's philosophy on the matter. It is meant to help readers understand an issue, solve a problem, or make a decision. - Wikipedia 2017

OBJECTIVE

It is almost like learning a new language - axles, cross members, gross vehicle weight - it can be confusing. ELG is happy to take the time to explain the different options to you and to make sure that you make the right choice for your needs and that you have the correct trailer for your vehicle

SOLUTION

When shopping around, most folks just ask for the price of a trailer based on the size. There are many things to consider when just looking at price. Many times a "bare-bones" price is not a good value when options that are typically standard are added back to the price of the base model or inferior materials are used in construction.

Example:
Dealers of these low price models often cut corners by selling low quality products – including using hat post or z-post construction for sidewalls and roof, using an insufficient gauge metal, reduced height, measuring trailer length from the tip of the v-nose rather than the box size, and by eliminating options such as a sand foot, exterior lights, and door handles. Often aluminum stone guard is only put up 12”, rather than 24” on the lower quality models.
LOAD DISTRIBUTION

The load distribution between the hitch and the running gear is determined by placement of the axles in relation to the center of gravity.

The hitch weight for conventional, bumper type hitches should be 10% to 14% of the gross weight of the vehicle.

The remaining 86 to 90% of the load will be carried on the running gear, so make sure that the axles, wheels and tires are properly matched and have sufficient capacity rating to support this load.

The hitch weight for fifth wheel and gooseneck type hitches should be 15% to 20% of the gross weight of the vehicle. The remaining 80% to 85% of the load will be carried on the running gear, so make sure that the axles, wheels and tires are properly matched and have sufficient capacity rating to support this load.

Trailer handling may be adversely affected if the load(s) are concentrated at the ends of the vehicle. This condition can occur even when the hitch weight is within the recommended proportion of vehicle weight. Probable causes for this phenomenon may be excessive frame flexure and/or polar inertia.
Polar inertia and frame flex can impose dynamic loading on the axles and suspension system which may exceed the design loads and result in bending or fatigue failure.

Excessive frame flexure can affect ride if the natural frequency of the vehicle's structure matches the frequency of the suspension. Once the flex of the frame is in phase with the suspension's vertical movement, the dynamic load input to the suspension will cause it to deflect more than it would under static load conditions. This greater loading of the suspension results in greater rebound which causes greater frame flexing.

Now the larger degree of frame flexure is imposed on the suspension which causes an even greater vertical travel, and so on. If this condition exists, damage to the vehicle's structure can occur. Either the structure should be stiffened or the suspension characteristics should be altered to prevent this ‘in phase’ behavior.
Uneven side to side loading of a trailer can cause dog-tracking. For double eyed leaf spring and single slipper type springs, the front end of the spring is anchored to the vehicle frame. As the load increases, the spring arch flattens, resulting in a lengthening of the spring. Since the axle is attached near the mid-point of the spring, it will move rearward as the spring deflects. If the springs are unevenly loaded, the axle will be skewed relative to the vehicle centerline and may cause tracking problems.
A trailer designed to carry a load with a high center of gravity should have a wide enough axle track to prevent or diminish the tendency for the vehicle to tip over on curves or turns with little or no banking of the road surface. Trailers equipped with torsion axles must be towed in a level attitude to ensure even loading of the axles. Out-of-level towing results in higher loads being imposed on the axle at the low portion of the frame and less load on the axle(s) at the high end. This uneven load distribution may cause excessive stress concentrations on the frame structure. Uneven loading of non-equalized suspensions can also affect the ride characteristics by altering the natural frequency of the structure.
PART TWO : BRAKING

WARNING!
FOR TRAILERS USED IN COMMERCE, THE TRAILER AXLE(S) MUST BE EQUIPPED WITH BRAKES UNLESS THE GAWR OF THE TRAILER AXLE IS LESS THAN 3000 POUNDS AND THE HITCH LOAD IMPOSED ON THE TOWING VEHICLE DOES NOT EXCEED 40% OF THE TOWING VEHICLES GVWR. FOR OTHER DETAILS CONCERNING COMMERCIAL APPLICATIONS, REFER TO THE FEDERAL MOTOR CARRIER SAFETY REGULATIONS PUBLISHED BY THE U.S. DEPARTMENT OF TRANSPORTATION.
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- COMMERCIAL TRAILERS MUST COMPLY WITH THE REQUIREMENTS OF THE FEDERAL MOTOR CARRIER SAFETY REGULATIONS AS PRESCRIBED BY THE U.S. DEPARTMENT OF TRANSPORTATION WHICH CALLS FOR BRAKES ON EACH WHEEL FOR MOST APPLICATIONS.
- CONSULT THE REGULATIONS THAT PERTAIN TO THE TYPE OF TRAILER BEING BUILT.
- THE RECOMMENDED PRACTICE FOR ANY TRAILER DESIGN WOULD BE TO USE BRAKES ON ALL AXLES. THE USE OF TRAILER BRAKES CAN HELP PROLONG THE LIFE OF THE TOW VEHICLE BRAKES AS WELL AS PROVIDE FOR SAFER OPERATION.
BRAKE TYPES

Electric and hydraulic, shoe/drum – Electric brakes are similar to the hydraulic drum brakes used on automobiles and trucks. While those brakes are actuated by hydraulic pressure, generated by the master cylinder to expand the wheel cylinder, electric brakes function by the action of an electromagnet inside the brake drum. When a voltage is sent by the brake controller to the electromagnets, they are attracted to the rotating armature surface of the drum. The sliding friction of the magnets against the armature surface actuates a lever which in turn expands the brake shoes out against the drum surface. This is much like the action that occurs within a hydraulic brake when the wheel cylinder expands. The braking effort is modulated by varying the amount of voltage supplied to the magnets whereas, hydraulic brakes are controlled by the output pressure of the master cylinder.
Electric Brakes

The electric brakes on your trailer are similar to the drum brakes on your automobile. The basic difference is that your automotive brakes are actuated by hydraulic pressure while your electric trailer brakes are actuated by an electromagnet. With all of the brake components connected into the system, the brake will operate as follows:

When the electrical current is fed into the system by the controller, it flows through the electromagnets in the brakes. The high capacity electromagnets are energized and are attracted to the rotating armature surface of the drums which moves the actuating levers in the direction that the drums are turning.

The resulting force causes the actuating cam block at the shoe end of the lever to push the primary shoe out against the inside surface of the brake drum. The force generated by the primary shoe acting through the adjuster moves the secondary shoe out into contact with the brake drum.

Increasing the current flow to the electromagnet causes the magnet to grip the armature surface of the brake drum more firmly. This results in increasing the pressure against the shoes and brake drums until the desired stop is accomplished.
PART TWO: BRAKING

Electric brake controllers – These devices are used to supply a variable voltage to the electric brakes. The inertial type controller relies on a pendulum or an accelerate-meter to sense deceleration of the vehicle when the stop light circuit is activated.

Hydraulic/electric controllers are tapped into the tow vehicles hydraulic brake lines and sense the pressure in the system when the brakes are applied.

A third method of electric brake actuation is the electronic controller that employs a timing device. Triggered by the stop light circuit when the brakes are applied, the controller begins sending a pre-programmed voltage to the trailer brakes. The output can be tailored to ramp up over a prescribed time period and must be synchronized to the rate of deceleration desired.
Dexter Electric Brakes
Wired in parallel.

Breakaway Battery
Provides power to actuate trailer brakes in the event of trailer breakaway.

Breakaway Switch
Switches battery power to brakes if breakaway occurs.
**Controller**
Electric brake controller provides power to the magnets to actuate the trailer brakes.

**Battery**
Connect controller directly.

**Connector**
Used to connect and disconnect trailer and tow vehicle.  
(Always ground trailer brakes through connector).
Typical Trailer Wiring

Trailer

Double Filament Bulb

Stop & Left Turn Signal To Terminal #5

Auxiliary Circuit Terminal #7

Auxiliary Circuit Terminal #6

#1 Common Ground

#3 To Tail Running & License Lights

#5 Stop & Left Turn

#4 Battery Charge

#7 Aux. Circuit

#9 Aux. Circuit

#6 Stop & Right Turn

#2 Electric Brake

#8 Aux. Circuit

Breakaway Switch

Common Ground Terminal #1

Auxiliary Circuit Terminal #9

Yellow

Green

Red

Grey

Trailering Vehicle

7-Circuit Receptacle

Clearance & Tail Lights

Stop & LH Turn

Ground

Battery Charge

Stop & RH Turn

Brakes

Auxiliary

9-Circuit Receptacle

Auxiliary

Stop & LH Turn

Ground

Brakes

Stop & RH Turn

Auxiliary

View Looking into Tow Vehicle Receptacle
How to Use Your Electric Brakes Properly

Your trailer brakes are designed to work in synchronization with your tow vehicle brakes. Never use your tow vehicle or trailer brakes alone to stop the combined load.

Your brake controller must be set up according to the manufacturer’s recommendations to ensure proper synchronization between the tow vehicle and the trailer. Additionally, you may have to make small adjustments occasionally to accommodate changing loads and driving conditions.

Proper synchronization of tow vehicle to trailer braking can only be accomplished by road testing. Brake lockup, grabbiness, or harshness is quite often due to the lack of synchronization between the tow vehicle and the trailer being towed, too high of a threshold voltage (over 2 volts), or under adjusted brakes.

Before any synchronization adjustments are made, your trailer brakes should be burnished-in by applying the brakes 20-30 times with approximately a 20 m.p.h. decrease in speed, e.g. 40 m.p.h. to 20 m.p.h. Allow ample time for brakes to cool between application. This allows the brake shoes and magnets to slightly “wear-in” to the drum surfaces.
**Trailer Wire Size Chart**

<table>
<thead>
<tr>
<th>Number of Brakes</th>
<th>Hitch-to-Axle Distance in Feet</th>
<th>Recommended Minimum Hookup Wire Size (Copper)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td>12 AWG</td>
</tr>
<tr>
<td>4</td>
<td>Under 30</td>
<td>12 AWG</td>
</tr>
<tr>
<td>4</td>
<td>30-50</td>
<td>10 AWG</td>
</tr>
<tr>
<td>6</td>
<td>Under 30</td>
<td>10 AWG</td>
</tr>
<tr>
<td>6</td>
<td>30-50</td>
<td>8 AWG</td>
</tr>
</tbody>
</table>

Make several hard stops from 20 m.p.h. on a dry paved road free of sand and gravel. If the trailer brakes lock and slide, decrease the gain setting on the controller. If they do not slide, slightly increase the gain setting. Adjust the controller just to the point of impending brake lockup and wheel skid.

Note: Not all trailer brakes are capable of wheel lockup. Loading conditions, brake type, wheel and tire size can all affect whether a brake can lock. It is not generally considered desirable to lock up the brakes and slide the tires. This can cause unwanted flat spotting of the tires and could also result in a loss of control.
Magnets

Your electric brakes are equipped with high quality electromagnets that are designed to provide the proper input force and friction characteristics. Your magnets should be inspected and replaced if worn unevenly or abnormally. As indicated below, a straightedge should be used to check magnet condition. For best results, the magnet should be flat.

Even if wear is normal as indicated by your straightedge, the magnets should be replaced if any part of the magnet coil has become visible through the friction material facing of the magnet. It is also recommended that the drum armature surface be refaced when replacing magnets (see section on Brake Drum Inspection). Magnets should also be replaced in pairs - both sides of an axle. Use only genuine Dexter replacement parts when replacing your magnets.

![Diagram of magnets with labels: Straight Edge, Gaps show ABNORMAL WEAR (replace magnet), NORMAL WEAR]
PART 3: TRAILER AXLES

Torflex® – The Torflex® axle is designed as a completely self-contained axle and suspension system. This trailing arm type torsion axle employs natural rubber cords supporting heat treated inner bars of solid, medium carbon steel. Press-fitted and welded to the ends of these independently floating bars are the high strength steel torsion arm/spindle assemblies. These arms can be specified to a range of starting angles, which allow the designer to tailor the running height of the vehicle.
**WHAT IS TORFLEX®?**

The Torflex® suspension system is a torsion arm type suspension which is completely self contained within the axle tube. It attaches directly to the trailer frame using brackets which are an integral part of the axle assembly. The Torflex® axle provides improved suspension characteristics relative to leaf spring axles through the unique arrangement of a steel torsion bar surrounded by four rubber cords encased in the main structural member of the axle beam.

The wheel/hub spindle is attached to a lever, called the torsion arm, which is fastened to the rubber encased bar. As load is applied, the bar rotates causing a rolling/compressive resistance in the rubber cords. This rotating action provides the same functionality as conventional sprung axles with several operating advantages, including independent suspension.

Except for periodic inspection of the fasteners used to attach the Torflex® axle to the vehicle frame, no other suspension maintenance is required on Torflex® axles. They are, of course, subject to the maintenance and inspection procedures regarding brakes, hubs, bearings, seals, wheels, and tires as outlined in Dexter's current Operation Maintenance Service Manual (available for downloading at www.dexteraxle.com).
Leaf spring – These axles utilize high strength steel spindles welded to high strength tubing to form an axle beam. The spindles are usually available in either a straight or drop design to help designers establish the desired frame height or ground clearance. Leaf springs are attached to the axle using u-bolts and can be positioned either under or over the tube. Use under mounted springs (underslung) to lower the frame height and over mounted springs (overslung) to raise the frame. The designer can choose stamped steel hangers of varying heights to allow additional control of the vehicle height.
Specifying Axles

The axle capacity is usually determined by subtracting the hitch load from the Gross Vehicle Weight. The remainder will be the load to be carried by the axle(s). When making this calculation, be sure to consider the final load distribution. If the weight is shifted off-center laterally, the load imposed on the wheel(s) on the side closest to the load center will be greater. The load on the heavier side must not exceed one half the rated capacity of the axle(s).

Torflex® axles should be specified in such a way that will position the vertical section of their mounting brackets directly under the most rigid section of the frame members. This will help to ensure proper support of the axle brackets.

For applications requiring lower floor or frame heights, drop spindle axles as well as underslung springs on straight spindle axles can be used to achieve the desired height.

When Torflex® axles are called for, the starting angle of the torsion arm can be specified to be above the horizontal plane to accomplish the same results.

Leaf spring type axles must have sufficient clearance to the frame to operate properly (see Bump Clearance definition). If the spring hangers are too short, the axle may contact the frame during articulation of the suspension and result in overloading of the axle and possible damage.

If the spring hangers are too long and provide too much clearance, the springs may be damaged if excessive loads are encountered and the axle is allowed to move too much. If this condition exists, bump stops should be used to prevent over travel.