Trailer Construction Guide

Purpose: This document is intended to provide information and instruction for students and Ag Mechanics teachers in planning and constructing legal trailer projects for exhibition at the Junior Agriculture Mechanics (JAM) Project show held in conjunction with the San Antonio Stock Show and Rodeo.

The primary goal of JAM is to encourage, facilitate and reward the learning that takes place in planning, designing, constructing and exhibiting an agriculture mechanics project. Please take the opportunity to learn and enhance the knowledge and skills involved in this teaching learning activity. We want you to learn how to design and build a legal trailer that can be used on all highways in the state. We also desire as stated in our goal that you learn from the experience of designing, building and exhibiting a trailer. For example if the GMAW process is used, read and study the process, for example: what is the purpose of the cover gas used and what are the advantages of argon or CO^2. Be able to answer questions such as – what is stick out, AWS number of welding wire used, how are the welding parameters voltage and current adjusted on the machine and how do they impact the weld, etc.? **Remember the trailer is a by product**.

I. Preparation – A lot of this can be conducted out of class at home or where computer access is available.

A. Research to conduct prior to Construction:

1. Review the current *Premium List* for up to date rules. JAM *Premium List* is found on http://www.sarodeo.com (Livestock Show/____ Premium List/Junior Contest/Agricultural Mechanics). Special Rule 18 *Transportation Statutes*: specifically address trailer rules.
2. Down Load from the http://jamshow.org (WEB) site the following documents. Note: Most of these documents should be included in Research Section (D) of the *Documentation and Research Package.*
    a. *Trailer Inspection Sheet* – used by the trailer inspectors and judges when evaluating the trailer at the show.
    b. *Documentation Check Sheet* – all projects must have a Documentation & Research package (Special Rule 16 in Premium List). This check sheet is used by the judges when evaluating the project.
    c. *Trailer Statutes Summary* - document identifies State and Federal Codes. There is a link on WEB to Texas Transportation Codes.
    d. *Trailer Federal Lighting Equipment Location Requirements* – A table is attached to this document that summarizes the federal and state codes for installing lights and reflectors on all trailers. Trailer inspectors use this table.
    e. *How to select Axles and Running Gear* – found on link to Redneck Trailer Supplies, under Additional Links - Product Catalog/Axle Assemblies.
3. View the Power Point Presentation on the WEB *JAM Trailer Rules and Codes* found under JAM Instructional Presentations.
4. Review Division 4 on WEB to view prior year awards showing pictures of winning trailers in each class and division.

5. Visit a business that sells trailers. Collect literature- catalogs from them.

6. Begin to develop *Documentation and Research Package* including *Material Safety Data Sheets* (MSDS) and or *Product Information* bulletins that are relevant to the project. How to select Axles and Running Gear from Red Neck is an example of a PI bulletin. Documentation is explained more in detail below

B. Design - Most all design decisions should be made prior to construction

Note: Many of the trailers shown at JAM are sponsored - built for someone paying for the materials who has requirements or suggestions impacting the trailer design to fit their specific request or needs. The builder must realize that if these design demands are opposed to the rules stated in the *Premium List*, or are not practical (for example no brakes on a 10 bale hay trailer) the project may be disqualified to show if illegal or at the least will be penalized and may not place for premiums or prizes. No agriculture exceptions are allowed for trailers shown at JAM.

1. Start by deciding what type of trailer is going to be built (i.e. Gooseneck Lowboy, 16' Bumper Pull Stock, Etc…). How large of trailer and what kind of capacity and load (weight capacity) is needed/desired (axle selection)? **Selection of running gear is the most important decision to make when designing a trailer for it influences many other aspects of the trailer- especially the total width of the trailer. The maximum width allowed by state and federal codes is 102 inches.**

2. Recommendations for 102 inch wide trailer - Axle, wheel, and tire selection.
   - 95 inch hub face axle - torsion or regular
   - 6 inch x 16 inch x 0 degree offset wheel
   - Tires 235 x 16 inch or narrower **NOTE: IF YOU ARE USING LARGER TIRES AND/OR WHEELS THEN A NARROWER HUB FACE WILL BE NECESSARY.**
   - Prior to welding spring hanger to trailer frame, make sure to check width of axles with wheels and tires installed on axles. Use a straight edge (3 ft. level is best method) to measure from outside tire to outside tire -- this measurement must be 102 inches or less. Tire bulge is included in width measurement because trailers at show are not loaded. Be sure to read and study *Trailer Statutes Summary* document alluded to previously.

     WARNING -- Unfortunately some axles vary in width which may make wheel width over 102 inches. Check manufacturers specifications prior to purchasing running gear – axles, springs, wheels, brakes etc.

3. Tires - Check tires because there may be great variations in width depending on brand -- could cause inside rubbing issues. Install mounted tires on bare axle and check inside measurement BEFORE beginning construction of trailer. Many exhibitors install over sized

tires. You must take into consideration the size tire you are using. Additional tire regulations are provided in *Trailer Statutes*.

4. Fender Clearance : JAM rules state there must be 4 inches of clearance between tire and fender for tandem axles. Tire size will influence where fender will be attached. IMPORTANT: When constructing utility trailers that have a top rail make sure, prior to welding top rail that it is high enough to raise the fender to provide the 4 inches. (Fenders fit underneath the top rail.) See Fig. below.

5. Floor Type: Choose a floor type that is appropriate for the intended use of the trailer, and that the proper method of fastening is used. (Note if using treated lumber, see that the fastener being used is compatible to lumber treatment - will not rust due to chemical in the treated lumber.)

6. Easy lube or standard grease caps may make axle over 102 inches. Grease caps will not be included in width measurement because they are not a load bearing structure of trailer. Appendix D of 23 CFR 658.15 and 658.16

7. Axle Considerations Note: Larger tires and/or wheels will influence recommendations below.

   - **Straight axles-** box width for trailer must be at least 12 inches less than hub face on axles. Example: 95 inch hub face - 12 inch = 83 inch box.

   - **Drop axles** such as cattle trailer: Example : 95 inch hub face - 15 inch = 80 inch box.

   - **Torsion axles** vary depending on degree of rotation of axle -- check with supplier.

   - **Axle placement**: where should the axles be located based on tongue weight? A good rule of thumb is placing axles at 2/3 the length of the trailer (not including the neck/tongue) See Axle Selection below

   - **Axle Selection**: Redneck Trailer Supplies is a good resource for selecting axle assemblies and has a step by step process for selecting the proper axle in their online catalog. See *How to Select Axles and Running Gear* in Redneck Trailer Supplies Catalog. http://www.redneck-trailer.com/2009/A/A2-A4.pdf Axle manufacturers specifications must be in Part D of Documentation

8. Begin to work on Drawings. Specific requirements are identified in the Premium List – Special Rule 16 - Documentation & Research. Documentation is discussed below.

   A working set of plans is a MUST. Drawing must be student drawn. Even if the project is a prototype and may require minor changes during construction, a starting base plan of what is to be accomplished should be made after thorough planning and before building. Drawings must be drawn to scale and be complete enough that they could be given to someone and they could build the project. Compiling a list of goals and project constraints can be a helpful way to pre-plan.

9. Begin to work on Bill of Materials (BOM)

   - Once a working set of plans is developed, move on to looking at the anticipated costs for the project. Get actual prices from your suppliers and develop yourself a ballpark budget for the build. This can be considered as a sort of rough draft for your Bill of Materials and allows you to have an idea of what financial constraints you may incur during construction.

   - It is recommended that a spreadsheet be constructed with the required columns in developing your Bill of Materials. Using a spreadsheet makes it easy to calculate the costs for example when you have a unit cost and have multiple units – cost per ft - and you purchased 22.5 ft – Spreadsheet calculates this for you using formulas you insert. Most importantly It also allows students to learn how to develop and use a spreadsheet computer program. Be sure to include opportunity costs, OC in the BOM if you have any materials that were donated to build the project

C. Design Considerations that impact State and Federal Codes

Additional Information is provided in *Trailer Statutes* and *JAM Trailer Rules and Codes Presentation* on the JAM WEB site

1. Safety Chains: All utility type trailers, gooseneck style trailers and cargo enclosed type trailers must have at the minimum of 2 safety chains of sufficient strength to carry a loaded to capacity trailer without allowing the trailer to fall on the ground, and must be of sufficient length to allow for a safe turning radius. The Presentation alluded to above illustrates a number of acceptable methods for attaching safety chains to the trailer tongue

2. Brakes: If trailer weight exceeds 40% of weight of the towing vehicle it must have brakes. In addition brakes are required if GWR (gross weight rating) is heavier than 4500 pounds it must be capable of stopping a 3000 pound or less vehicle and trailer. Any trailer with brakes must also have an emergency breakaway system.

3. Lighting Requirements: Must meet State Federal DOT lighting Codes . Protect lighting fixtures, especially those on rear from damage when backing up – protect them by making sure they do not extend beyond rear of trailer. They must be close enough to the rear so they are observable from center rear. The *Federal Lighting Table* (Link provided on WEB site) and the *Trailer Check Sheet* provide specific information in placing lights. The J*AM Trailer Rules and Codes Presentation* on the WEB shows examples of proper lighting along with other design considerations – safety chain attachment etc. See wiring below.

4. Special Considerations: When exhibiting a project especially a trailer it is advantageous to include accessory items to make it stand out, such as ramps, storage, tool boxes, tie downs etc.

5. License Plate and bracket: License Plate must be visible from rear and it must have a light. It may be placed on left or right rear and can be vertical. See *JAM Trailer Rules and Codes Presentation* on the WEB for examples. Farm Tags are allowed.

6. Tie downs (stake pockets, D Rings etc.) are especially important for utility trailers – low boys – all open trailers.

Number Required	Trailer Length	Axle Capacity
1 per side	Under 5 ft	Under 1,100 lbs
2 per side	Over 5 ft	Over 1,100 lbs
2 per side	Over 5 ft and less than 10 ft	
1 per side	Every additional 10 ft in length	

7. Hitch: ensure that your hitch is rated for the load that the trailer is designed to carry.

8. Jacks: How many? What size? Make sure that the jacks are rated for the weight of the trailer and anticipated weight when fully loaded. Jacks are required on all trailers.

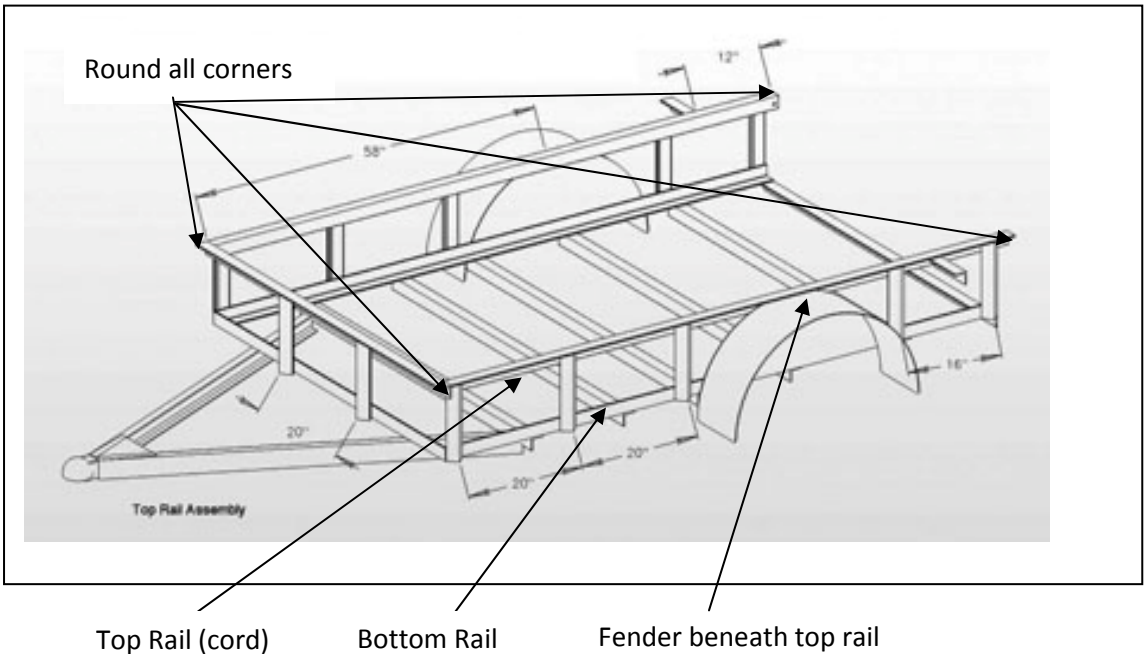
II. Construction – Includes Design, Workmanship and Degree of Difficulty

1. Strength and size of materials used in the construction.

   It is beyond the size and scope of this document to discuss Modulus of Elasticity and Section Modulus of materials. These are used by mechanical engineers when determining what sizes of angle iron, C channels, tubing etc. to use in the structural members of a vehicle. Please check with commercial trailer manufacturers if you deviate significantly from what they use in their construction of a similar trailer.

2. Top Rail of low boy (utility) trailers.

   Changing the basic design of trailers can have significant impact on load carrying capacity. Example: some of the lowboy trailers are being redesigned to have a side ramp – usually in the front to accommodate loading and unloading ATV – lawnmowers etc. This is accomplished by removing the top rail where ramp is located. The top rail is the top cord of a parallel cord metal truss and removing it places all the load on the bottom cord. If this is done the bottom member must be redesigned and strengthened to carry the load placed on it. Remember – trailer may be designed for small ATV but it may be used by someone to load a much heavier tractor. See Fig. below.



Figure

3. When installing running gear (axles, suspension, etc) follow manufacturer's instructions to the letter. This includes dimensions and weld patterns to be used to install spring hangers.

4. Check trailer for being square (measure diagonals) throughout construction & try to minimize warping due to welding, which can also affect your trailer being square.

Structural Tips

- Good idea to allow at least one half inch in width to cover distortion and warping as structure is welded.
- Use temporary braces and supports to hold structure "true" until all welding is finished. Allow several HOURS for complete cooling before removing temporary bracing.
- ALWAYS tack entire structure together before starting to weld.
- Check structural parts such as fenders closely before welding to make sure they are width you planned.
- Do not assume all purchased parts are consistent in measurements -- especially fenders of all forms and shapes. Check before installing.
- Install axles and wheels and tires to check fender clearance before welding fenders. Remember if top rail is installed too low then fender cannot be raised high enough to provide the proper tire clearance.
- Check inside and top clearance of tires.

5. DO NOT GRIND YOUR WELDS! Only grinding on weld beads allowed is for safety concerns and on box fenders. Judges want to see all welding. Also commercial trailer manufacturers cannot afford to grind welds – too time consuming . Exhibitors should be proud of their welding.

6. Sharp edges and corners - Round off with torch and/or grinding, this is an obvious safety concern. See figure above. It wouldn't be a bad idea to use a sanding disk in conjunction with a grinding wheel for a more finished look. Take special care not to put "grinder tracks" into the metal, these will show up in paint and detract from the finish of the project.

7. Wiring (Wiring Harness and Connectors)

    - Protection: When it comes to wiring your trailer, try and keep your wiring neat and protected. Do not allow wires to sag where they can catch on things and be damaged. Running wires through conduit or wiring harness is the preferred method of wiring. Take special care to protect wires at any point where they pass through metal or pass over a rub point. Make sure there are no pinch points – on top of axles or springs that could damage wires. Do not burn holes in angle iron (members) where wire will pass through. Remove all burrs when drilling through the metal. Ensure that all wiring connections are water tight.

    - Color Coding: It is best to follow industry standards on wiring your trailer. SAE J560 standard for trailer wiring is as follows

SAE J560 Standard	
Wire Color	**Lamp and Signal Circuits**
White	Ground return to towing vehicle
Black*	Clearance, side marker & license plate lamps
Yellow	Left hand turn signal & hazard signal lamps
Red	Stop lamps and antilock devices
Green	Right hand turn signal & hazard signal lamps
Brown*	Tail, clearance, side marker lamps & identification lamps
Blue	Blue Auxiliary (Electric Brakes)
* It is recommended to balance the circuits as practicable.	

    - Connectors – Terminals : Keep in mind that trailer connectors are generally available in a 4-Pin, 6-Pin, & 7-Pin connector, these color codes will remain the same regardless. (Note: Trailer connectors typically come with two different wiring diagrams, SAE J560 is the most common industry standard for wiring). Click on the following link to Redneck catalog for wiring diagrams for different terminals: http://www.redneck-trailer.com/2009/J/J29-J31.pdf

- Wire Size: Most manufacturers recommend the following wire gauges for the different circuits. Remember the smaller the gauge number the larger the wire size. See page 173 on following link: http://www.delcity.net/documents/catalog/14_trlrconn.pdf Note: side markers shown on trailer wiring diagram should be on widest point, in this example on fenders.

8. Painting: Finishing - When it comes time for Paint make sure that all surfaces are prepared and primed to allow for paint adhesion and to prevent rust bleeding. Any dirt, grinding marks, grease, weld flux - weld splatter (consider removing weld splatter with a cold chisel) will be apparent in the final finish. It is recommended that a wax -grease- oil removal be used prior to priming. It is very important to paint the entire underside of the trailer. This area, though not readily seen, is the most crucial part of the trailer and is the most susceptible to rust causing conditions.

III. Documentation

First of all ***Documentation is not a scrapbook***, it is a research portfolio. It includes those components identified in the *Premium List* and the *Documentation Check Sheet*. The *Documentation Check Sheet* is found on the WEB page. Judges use it when evaluating the project and will give a completed copy to the exhibitor identifying if the criteria have been met. There is also a *Documentation Presentation* provided on the WEB. Documentation is also used in evaluating Showmanship. See WEB for showmanship criteria. All students preparing a project for JAM should review documentation presentation.

IV. Presentation including Showmanship

Presentation includes entering the Project – Special Rule 1- found in the *Premium List*. *Naming/Describing Projects Document* is also found on WEB. It identifies what classes project should be entered in and how to name- describe them. Showmanship criteria are identified on the *Showmanship Scorecard* found on WEB. The *Premium List* identifies Project Presentation and Exhibitor Presentation criteria.

Technical Knowledge is also an important part of Presentation and will be evaluated by judges questioning exhibitor/s. Both Project and Exhibitor/s are evaluated to determine winning trailers.

V. Premium List and JAM Show website WEB

- The *Premium List* identifies all rules pertaining to JAM. Judging Criteria are identified and their weight in points are provided. Those projects that place and win are those where not only the project (trailer) is excellent but also the exhibitor is evaluated as outstanding.

The JAM *Premium List* can be found on the sarodeo.com web site alluded to above. There is a link to this site on the jamshow.org web site or you can click on the following::

http://www.sarodeo.com/client/media/5933/5934/2012_agricultural_mechanics.pdf

- The JAM Show website is invaluable when looking for information regarding the show. Instructors and students alike are strongly encouraged to take advantage of the information provided.

http://jamshow.org

- Materials provided on the jamshow.org are designed so student can begin their research and preparation for planning and designing project (trailer) without direct supervision of teacher.

REQUEST:

We will appreciate your comments regarding the helpfulness of this document and suggestions on how it could be improved. If you see errors in the document please point these out. Please e-mail Lon Shell at: tractor@lonshell.com

CONTIRBUTORS:

The following JAM Trailer Inspectors and Judges contributed to the contents of this *Trailer Construction Guide*.

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