TIRE WEAR AND POSITIONING CONSIDERATIONS FOR THE U-HAUL TRUCK FLEET

Tires are one of the most critical components that need to be managed by modern and diverse vehicle fleet operators today. Not only can tires represent one of the largest maintenance issues for fleets, but they can also have a very significant effect on vehicle performance parameters. Many existing recommendations and procedures are rooted in decades old experiences and technologies. Additionally, it is important to review all procedures from the standpoint of individual fleet makeup, duty cycle, as well as operator/driver experience. What may be good for one fleet may not be optimal for another.

Sifting through Federal and State regulatory requirements will only provide minimal performance standards. Although those standards need to be met, they don’t paint an adequate picture of the numerous considerations that need to be managed in order to provide the best balance of performance objectives. A quick survey of large fleet operators illustrates different recommendations which may or may not be supported by sound engineering reasoning. When it comes to tires, anecdotal “evidence” is abundant.

One of the major considerations a truck fleet faces on a day to day basis is where to position replacement tires when the time or need presents itself. Unlike passenger vehicles, it is not unusual to replace one or two tires at a time, rather than the entire vehicle set. Compounding the issue is the complexity introduced by single and dual wheel configurations utilized in many truck based fleets. Generally speaking, it is common for light duty trucks to utilize 4 wheels, while most medium/heavy trucks utilize dual rear wheel (side by side) 6 wheel configurations.

U-Haul operates the largest truck fleet in the country with a total at any one time of close to 100,000 trucks. Of those, approximately 25% are 4 wheel light duty trucks with Gross Vehicle Ratings (GVWR) of less than 10,000 pounds, while the remaining 75% are 6 wheel medium duty trucks with GVWR of up to 20,000 pounds.

These trucks are rented to individual customers with diverse demographic backgrounds, not only from an experience level, but also from physical operating environments. Above all it is paramount to consider driver safety as the most important factor in tire maintenance and replacement policies. It is not unusual for a truck to experience level road and desert heat conditions on the same day as mountainous terrain with freezing temperatures and icy road surfaces.

U-Haul utilizes one of the most comprehensive and dynamic maintenance systems of any fleet operator today. Procedures and policies are updated on virtually a daily basis. Tire monitoring and replacement procedures are just one of the issues included in the overall process and they are continually reviewed for optimal performance and safety. Considerations such as mixing of brands and constructions, while very important, are not discussed in this paper.
A key question is whether to place the newest tire(s) on the front or on the rear of a vehicle in service. A survey of other US fleet operators failed to indicate a clear and consistent policy. In many cases this is attributable to diverse fleet composition, duty cycle, driver experience, and personal preference. U-Haul felt it needed to analyze the issue based on its own specific criteria and not just general opinion.

Figure 1 details some of the considerations which need to be managed in a comprehensive tire maintenance program. It quickly becomes apparent that some of these factors are in “tension” with each other and need to be carefully weighed in the context of not only what is possible within the daily operating environment, but also what is most important for our customers.

Although it is “a given” that Federal, Canadian and local laws must be met, other internal considerations can be managed and balanced for best performance. Additionally, these individual considerations need to be reviewed based on the specific truck equipment within the fleet. A review of the considerations indicates that from a vehicle dynamics standpoint, different policies were required for 4 wheel and 6 wheel trucks.

Vehicle braking, cornering and traction capabilities are directly affected by tire condition. However, there appears to be no differentiator in requirements for 4 or 6 wheel trucks. Additionally, it is felt that drivers can quickly adapt to individual vehicle capabilities within this category. Once a driver has familiarized him or herself to a specific vehicle, they are able to use good judgment and safely operate the truck during the intended use of a rental period.

Before proceeding to hydroplaning and RAL (rapid air loss) considerations, it is important to discuss some basic dynamic handling characteristics and terminology.

Figure 2 illustrates one of the most important vehicle handling characteristics as it pertains to the ability of an average driver to safely control a vehicle. **Understeer** can best be described as the tendency of a car or truck to steer less than the driver’s input would suggest. Although levels of understeer vary from vehicle to vehicle, it tends to introduce a stabilizing effect on the vehicle’s dynamic performance. Many times this characteristic is referred to as “push” or “plowing”. Within moderation, most drivers can overcome or adjust to this phenomenon by introducing more steer input towards the desired direction of travel. All modern cars and trucks are designed with a natural amount of understeer built in through suspension configuration and basic weight distribution. **Oversteer** describes a condition where a vehicle will tend to turn more than expected in the desired path. This condition can be very unstabilizing for the average driver and can catch a person by surprise. Most drivers are not trained to correct for this condition and in extreme cases can over-correct and subsequently lose control of the vehicle.

Because of these basic handling traits, oversteer must be avoided if at all possible. This leads to the further discussion of hydroplaning and RAL (rapid air loss) as described in Figure 1.
Hydroplaning is a term used to describe when a tire rides above or on top of a thin film of water. This can result in a dramatic loss of traction with subsequent loss of ability to control the vehicle. Tire tread design and depth have a significant affect on a tire’s ability to manage the flow of water away or around the tread surface, thereby allowing tread contact with the road surface itself. Reduced tread depth can exacerbate the inability of the tire to manage this water flow. As indicated in Figure 2, loss of lateral stability by the rear tires can cause an undesirable oversteer condition. Additionally, the front tires do offer some “wiping” effect which tends to reduce the amount of water that rear tires must contend with. Although all types of vehicle and tire combinations can experience hydroplaning, high profile and high pressure truck tires tend to be less susceptible to hydroplaning than passenger car combinations.

Rapid air loss presents one of the most significant conditions which must be considered when replacing tires on a vehicle. It is commonly understood that tires with reduced tread depth are more susceptible to punctures and major damage inflicting road hazards which can cause rapid air loss including but not limited to what is commonly referred to as “blow-outs”.

Figure 3 illustrates what forces a RAL situation can exert on a vehicle. When a tire experiences a RAL, not only can the vehicle “kneel down” at the corner which suffered the RAL, but the tire/wheel combination itself also experiences an increased rolling resistance effect. Both of these factors cause a force vector which combined with the forward momentum vector will cause the vehicle to deviate from its desired path. The effect of this deviation can be significantly different if the RAL occurs on the steer axle (front) or the drive axle (rear).

In both the case of 4 and 6 wheel vehicles, a RAL on the steer axle can cause a moderate to high level of understeer. Although undesirable, most situations can be managed by the average driver by increasing the amount of steer input required to maintain a forward direction of the vehicle. When a RAL occurs on the rear of both 4 and 6 wheel vehicles, the lateral vector induces an oversteering effect. The degree of this effect is where 4 and 6 wheel vehicles can differ significantly. In the case of a 4 wheel vehicle, the tendency of the vehicle to “kneel” in the rear is significantly higher than that experienced with a 6 wheel vehicle. This “knealing” effect results in a higher tendency to cause an oversteer situation. Additionally, the lateral stabilizing capability at the rear of a 4 wheel vehicle is effectively reduced by 50%, while a 6 wheel vehicle will experience a loss of only 25%.
Again, as shown in Figure 1, numerous conditions need to be balanced or managed based on which factors are deemed most important for the individual needs of a fleet operator. For U-Haul, customer safety is the number 1 priority and tire placement is predicated by the need to maintain vehicle control under diverse conditions.

**For this reason, it is much more important to mitigate a RAL situation on the rear of a 4 wheel vehicle.** This condition reinforces the need to maintain the “best” tires on the rear of a 4 wheel vehicle if at all possible. As mentioned, 6 wheel vehicles do experience a similar situation but to a much lesser degree. Additionally, since modern vehicles are designed with a certain amount of overall understeer, a slight amount of oversteer caused by RAL on the rear of a 6 wheel vehicle will result in minimal disruption of controllability. **For this reason, it is more important to mitigate a RAL situation on the front of a 6 wheel vehicle.** For this reason, it is desirable to place the “best” tires on the front or steer axle of 6 wheel vehicles.
## FIGURE I

### TIRE WEAR AND POSITIONING CONSIDERATIONS

<table>
<thead>
<tr>
<th><strong>FEDERAL AND STATE REQUIREMENTS</strong></th>
<th><strong>TREAD WEAR</strong></th>
<th><strong>ODOMETER ACCURACY</strong></th>
<th><strong>VEHICLE DYNAMICS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum 4/32” steer axle, 2/32” non-steer</td>
<td>Rotate in order to balance uneven wear</td>
<td>Reduced tread on drive axle can cause &quot;over clocking&quot; of odometer</td>
<td>Minimal effect of tread depth on dry roads</td>
</tr>
<tr>
<td>Enforced by commercial vehicle agencies predominately for 18 wheel types</td>
<td>Generally steer axle tires receive cornering and alignment related wear</td>
<td></td>
<td>Usually not an issue with heavily loaded high profile tires running at high tire pressures</td>
</tr>
<tr>
<td></td>
<td>Rotation patterns vary by type of vehicle, tire, and manufacturer</td>
<td></td>
<td>Most significant driver related issue</td>
</tr>
</tbody>
</table>

#### BRAKING CORNERING Traction

- Minimize effect of tread depth on dry roads
- Significant effect for wet and icy roads with dynamics similar to rapid air loss effects
- Reabsorbs and front to rear
- Drivers adapt to particular vehicle characteristics

#### HYDROPLANING

- Rapid air loss
- Hydroplaning can surprise a driver
- Rear tires provide directional stabilizing effect
- Reabsorbs and front to rear

#### RAPID AIR LOSS

- Drivers adapt to particular vehicle characteristics
- Rapid air loss can surprise a driver

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Figure 3
RAPID AIR LOSS EFFECTS

Moderate to High Understeer

Moderate to High Oversteer

Moderate to High Understeer

Mild Oversteer

[Legend: ▪️ = INFLATED TIRE  ▐ = DEFLATED TIRE]