POWERED INDUSTRIAL TRUCK OPERATOR TRAINING -
STABILITY OF POWERED INDUSTRIAL TRUCKS

SUMMARY OF APPENDIX A

°   **A-1.   Definitions**

9   The following definitions help to explain the principle of stability:

   T   <u>Center of Gravity</u> is a point on an object at which all of the object's
          weight can be considered to be concentrated.
   T   <u>Counterweight</u> is the weight that is a part of the truck's basic
          structure that is used to offset the load's weight and to maximize
          the vehicle's resistance to tipping over.
   T   <u>Fulcrum</u> is the truck's axis of rotation when it tips over.
   T   <u>Grade</u> is a surface's slope that is usually measured as the number
          of feet of rise or fall over a hundred foot horizontal distance
          (measured as a per cent).
   T   <u>Lateral stability</u> is a truck's resistance to tipping over sideways.
   T   <u>Line of action</u> is an imaginary line through an object's center of
          gravity.
   T   <u>Load center</u> is the horizontal distance from the load's edge (or the
          fork's or other attachment's vertical face) to the line of action
          through the load's center of gravity.
   T   <u>Longitudinal stability</u> is the truck's resistance to overturning forward
          or rearward.
   T   <u>Moment</u> is the product of the object's weight times the distance
          form a fixed point. In the case of a powered industrial truck, the
          distance is measured from the point that the truck will tip over to
          the object's line of action. The distance is always measured
          perpendicular to the line of action.
   T   <u>Track</u> is the distance between wheels on the vehicle's same axle.
   T   <u>Wheelbase</u> is the distance between the centerline of the vehicle's
          front and rear wheels.

°   **A-2.   General**

9   Stability determination for a powered industrial depends on a few basic
       principles. There are many factors that contribute to a vehicle's stability:

T   vehicle wheelbase;

T   track;

T   height;

T   the load's weight distribution; and,

T   the vehicle's counterweight location (if so equipped).

9   The "stability triangle," used in most stability discussions, demonstrates stability simply.
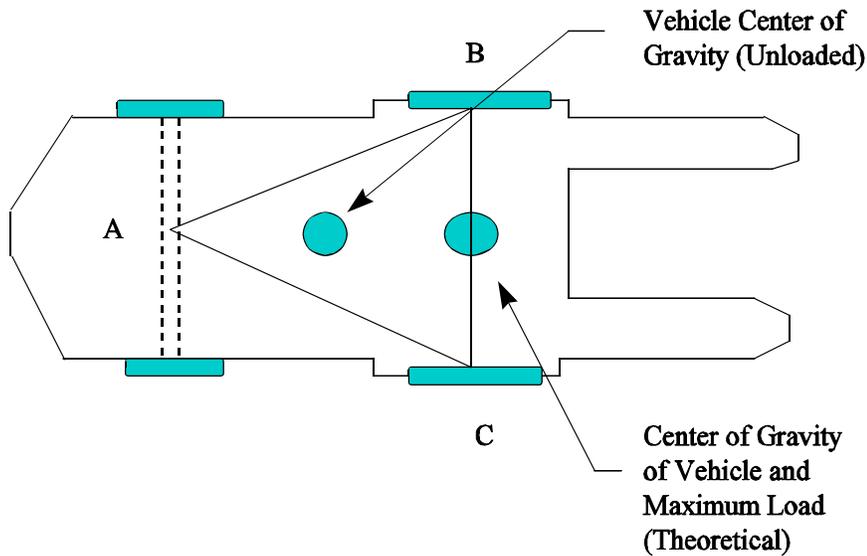
○   **A-3.   Basic Principles**

9   Determining whether an object is stable is dependent on the object's moment at one end of a system being greater than, equal to, or smaller than the object's moment at the system's other end. This is the same principle on which a see-saw works. If the product of the load and distance from the fulcrum (moment) is equal to the moment at the device's other end, the device is balanced and will not move. However, if there is a greater moment at the device's one end, the device will try to move downward at the end with the greater moment.

9   Longitudinal stability of a counterbalanced powered industrial truck depends on the vehicle's moment and the load's moment. In other words, if the mathematic product of the load moment (the distance from the front wheels, the point about which the vehicle would tip over) to the load's center of gravity times the load's weight is less than the vehicle's moment, the system is balanced and will not tip forward. However, if the load-moment is greater than the vehicle-moment, the greater load-moment will force the truck to tip forward.

○   **A-4.   The Stability Triangle**

9   Almost all counterbalanced powered industrial trucks have a three point suspension system, that is, the vehicle is supported at three points. The truck's steer axle is attached to the truck by a pivot pin in the axle's center. When the points are connected with imaginary lines, this three-point support forms a triangle called the stability triangle. **Figure 1 depicts the stability triangle.**

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Figure 1.

Vehicle Center of Gravity (Unloaded)
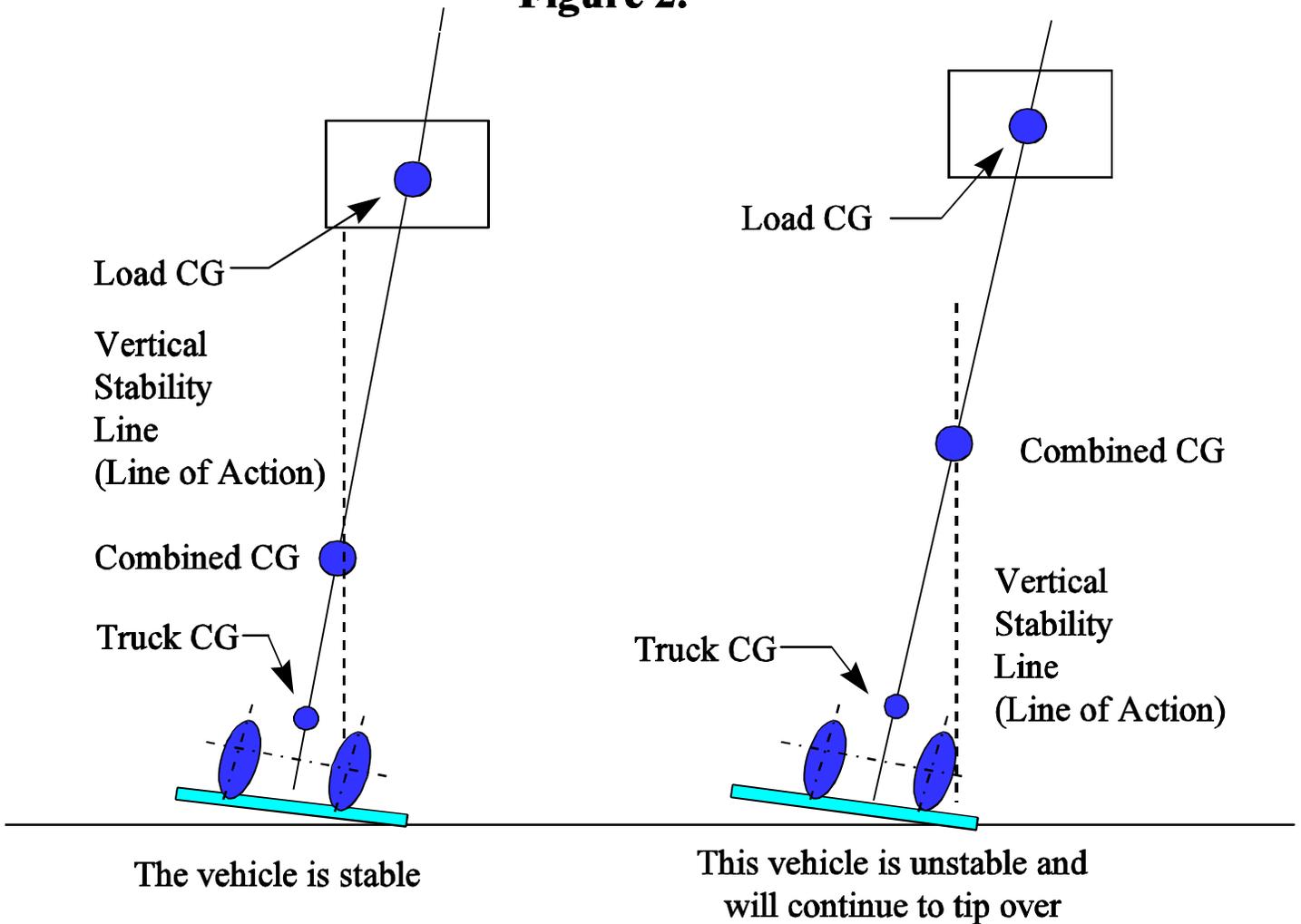
Center of Gravity of Vehicle and Maximum Load (Theoretical)

Notes:
1. When the vehicle is loaded, the combined center of gravity (CG) shifts toward line B-C. Theoretically, the maximum load will result in the CG at the line B-C. In actual practice, the combined CG should never be at line B-C.

2. The addition of additional counterweight will cause the truck CG to shift toward point A and result in a truck that is less stable laterally.

G	When the vehicle's line of action, or load center, falls within the stability triangle, the vehicle is stable and will not tip over. However, when the vehicle's line of action or the vehicle/load combination falls outside the stability triangle, the vehicle is unstable and may tip over. **See Figure 2.**

Figure 2.

Load CG

Vertical
Stability
Line
(Line of Action)

Combined CG

Truck CG

The vehicle is stable

Load CG

Combined CG

Vertical
Stability
Line
(Line of Action)

Truck CG

This vehicle is unstable and
will continue to tip over

A-5.   Longitudinal Stability

9   The axis of rotation when a truck tips forward is the front wheels' points of contact with the pavement. When a powered industrial truck tips forward, the truck will rotate about this line. When a truck is stable, the vehicle-moment must exceed the load-moment. As long as the vehicle-moment is equal to or exceeds the load-moment, the vehicle will not tip over. On the other hand, if the load moment slightly exceeds the vehicle-moment, the truck will begin to tip forward, thereby causing loss of steering control. If the load-moment greatly exceeds the vehicle moment, the truck will tip forward.

9   To determine the maximum safer load-moment, the truck manufacturer normally rates the truck at a maximum load at a given distance from the front face of the forks. The specified distance from the front face of the forks to the line of action of the load is commonly called a load center. Trucks with a 30,000 pounds or less capacity are normally rated at a given load weight at a 24-inch load center. For trucks of greater than 30,000 pounds capacity, the load center is normally rated at 36- or 48-inch load center distance. **To safely operate the vehicle, the operator should always check the data plate to determine the maximum allowable weight at the rated load center.**

9   Although the true load-moment distance is measured from the front wheels, this distance is greater than the distance from the front face of the forks. Calculation of the maximum allowable load-moment using the load-center distance always provides a lower load-moment than the truck was designed to handle. When handling unusual loads, such as those that are larger than 48 inches long (the center of gravity is greater than 24 inches) or an offset center of gravity, etc., a maximum allowable load moment should be calculated and used to determine whether a load can be safely handled.

T   For example, if an operator is operating a 3000 pound capacity truck (with a 24 inch load center), the maximum allowable load moment is 72,000 inch pounds (3,000 times 24). If a probable load is 60 inches long (30 inch load center), than the maximum that this load can weigh is 2,400 pounds (72,000 divided by 30).

- **A-6. Lateral Stability**

  9   The vehicle's lateral stability is determined by the lines of action's position (a vertical line that passes through the combined vehicle's and load's center of gravity) relative to the stability triangle. When the vehicle is not loaded, the truck's center of gravity location is the only factor to be considered in determining the truck's stability. As long as the line of action of the combined vehicle's and load's center of gravity falls within the stability triangle, the truck is stable and will not tip over. However, is the line of action falls outside the stability triangle, the truck is not stable and may tip over.

  9   Factors that affect the vehicle's lateral stability include the load's placement on the truck, the height of the load above the surface on which the vehicle is operating, and the vehicle's degree of lean.

- **A-7 Dynamic Stability**

  9   The dynamic forces that result when the vehicle and load are put into motion must also be considered. The weight's transfer and the resultant shift in the center of gravity due to the dynamic forces created when the machine is moving, braking, cornering, lifting, tilting, and lowering loads, etc., are important stability considerations.

  9   When determining whether a load can be safely handled, the operator should exercise extra caution when handling loads that cause the vehicle to approach its maximum design characteristics. For example, if an operator must handle a maximum weight load, the load should be carried at the lowest practical height, the truck should be accelerated slowly and evenly, and forks should be tilted forward cautiously. However, no precise rules can be formulated to cover all of these eventualities.