

## **Diamond Knowledge Base**

### **Road Tube Known Problems & Solutions**

Below we discuss the various problems that road tubes can cause. Road tubes present their own unique set of problems for automatic vehicle classifiers & counters. Being aware of these potential problems before installing your road tubes can greatly reduce the frequency of these problems. We divide each problem (or "error") into a separate section, and then list the known causes of the problem.

#### **Missed Axles**

Missed axles are the most frequent errors seen. They are caused, very simply, by the hardware (air switches, piezo or loops) inside the counter not reporting an actuation of the road tube when there is one. Some of the reasons for this are as follows:

Speed and Spacing.

The air switch in the Phoenix MDK is undoubtedly the best in the industry; however, even it is limited to 30 activations per second, or about 33ms per activation. If a second strike of the road tube occurs faster than 33ms, then the air switch will not report the second activation.

Does this ever happen? Yes, take for example a car towing a 2 axle trailer at 65 mph. A travel trailer typically has a spacing of 2.5 ft between axles, and 65 mph is about 95ft per second. Therefore, how long does it take between the first road tube hit by the travel trailer, and the second. This is  $(2.5\text{ft}/(95\text{ft/sec})) = 26\text{ms}$ . The air switch would not report the second axle of the travel trailer and this axle would be missed by the Phoenix MDK.

Lifted Wheels.

Some trucks have an optional axle which may be raised slightly off the ground (to save tread wear). The Phoenix MDK will not record it, but sometimes it can show up as an error if human observation data is being compared to the counter and the observer is not aware that the wheel is lifted.

Bouncing Vehicles.

Although uncommon, roads with dips or other irregular surface features can cause some truck axles to bounce slightly. This can occasionally lead to missed axles. Note that the Phoenix MDK looks at both sets of road tube activations, so this problem is minimized.

Improper Road Tubes or Installation.

The type, length, and method of installation of your road tubes can lead to increasing the number of missed axles; Always plug the end with a suitable device (unless the road tube is shorter than 25ft, and then DON'T

plug it); always plug the road tube onto the counter nozzle all the way; always use an approved brand, size and type of material for all of your road tubes; don't overstretch the road tube because the diameter shrinks the more you stretch it.

### Weak Signal with Longer Road Tubes.

Very simply, the longer the road tube, the farther the "sound" of an axle striking the road has to travel. Make sure you use road tube lengths as recommended in the next section.

### Sound Wave Interface.

To understand why this is a problem, you should understand that the Phoenix MDK air switch (like all air switches) uses a "sound wave" to detect an axle hit. This wave is very similar to a water wave, in that it starts at a point and moves down the road tube to the round piezo disk sensor in the air switch. It travels down the road tube at the speed of sound, which is about 767 MPH at 20 degrees Celsius, or 1125 feet per second. The force of this "wave" of sound bends the piezo disk in the counter and causes a voltage spike to be generated. It is this voltage spike which the Phoenix MDK detects an axle strike on the road tube. The following example shows how very close axle hits (such as with tandem axles on a truck) can actually interfere with each other and cause a missed axle.

- 1) Assume you have a 50' road tube stretched across a single lane of traffic. The road tube has been stretched 50" to make it tight. The end of the tube on the roadway is plugged and the other end is plugged into a Phoenix MDK.
- 2) A 5 axle single trailer truck traveling 55mph crosses the tube.
- 3) The first axle is detected with no problem.
- 4) The second axle (the first axle of the first tandem pair) hits the road tube. This causes FOUR sound waves to be generated, TWO from each tire.
- 5) The Left Tire will send two sound waves from it (1 in each direction) and the Right Tire will send two waves from it as well. The sound waves look something like the following:

-- -- ß A o B à -- -- -- -- -- -- -- -- ß C o D à -- -- -- -- (to Phoenix MDK)

Each letter represents a sound wave and the arrow next to the letter shows the direction the sound wave is traveling.

- 6) At this point the following things will happen: Sound "A" will travel to the end of the road tube and be absorbed by the plug. Sound "B" and "C" will travel towards each other, collide and be seriously weakened. Sound "D", however will be uninhibited and travel down the road tube towards the air switch on the Phoenix MDK.

Since all of the sound waves except "D" have been destroyed, we will only talk about sound wave "D" for the rest of this section, and it will be called the Wave.

- 7) The road tube had been stretched about 50", so it is now 54.16' long. Presuming the truck is in the

- 8) The wave will travel down the road tube towards the Phoenix MDK and contact the air switch in about 39ms (ms stands for milliseconds, or thousandths of a second).
- 9) After the Wave hits the air switch, it will bounce back and return up the road tube towards the vehicle. Thus, we have a weakened returning wave going back up the road tube.
- 10) The next axle on the truck hits the road tube about 56ms after the first (a 4.5ft spacing typical, on a 55mph vehicle). Once again, another sound wave "D" is generated and travels down the road tube towards the air switch.
- 11) At this point we have the following:

--- D2 à --- β D1 --- Phoenix MDK

One wave traveling down and one weaker wave returning. They will, of course, collide into each other at some point in the road tube, weakening both waves so that the second wave is too weak to register as an axle strike.

The question then becomes, if this is causing missed axles, why does a shorter road tube work better? If you take a 30' road tube, stretch it 50". Sound wave "D" will start about the 24' mark and therefore will take only 21ms to reach the air switch. Similarity, sound wave "D" will only take 21ms to return to the starting point (at the 24' mark). This makes the total time only 42ms for the first sound wave "D" to strike the air switch and return to the starting point.

This time is BEFORE the 56ms time it takes for the next axle to hit. Therefore, the first sound wave “D” is past the point of origin and cannot interfere with the next axle strike.

In summary, you are better off using shorter road tubes for faster speed vehicles. You are also better off using shorter road tubes for vehicles which have closer axle spacing (such as truck tandem axles). To minimize missing axles and maximizing accuracy we suggest using the following road tube lengths:

Speed	Road Tube Length
0-25 mph	60 ft
26-35 mph	50 ft
36-45 mph	40 ft
46+ mph	30 ft

While a shorter tube at faster speeds is always more accurate, we do not suggest using road tubes shorter than 30' due to potential damage to an air switch by very strong "sounds" (or signals).

## Extra Axles

This error, while not frequent, does happen. It is almost always a problem with the actual road tube installation, or with the road surface. Causes of extra axles are listed below:

#### Road Tube Bounce (slap).

Since the road tubes are made of flexible rubber, they move when they are hit. Depending on how tightly they are stretched, how far apart the anchors to the roadway are, and how heavy the vehicle crossing the road tubes is, the road tube may move only slightly, or it may move a lot. When a tire hits the road tube normally, the air switch is activated by the sound of that tire. If the road tube is moved a lot, it will return quickly enough to its original position and may “slap” the road tube with enough force to actually “sound” like another axle.

This error is minimized by the fact that the air switch will not re-activate for at least 33ms, and the road tube should be stabilized by then (but not always). You can also help this problem by tapping the road tube on the road at short intervals along its length.

#### Rutted Pavement.

**DO NOT INSTALL ROAD TUBES OVE BADLY RUTTED PAVEMENT.** This will cause the road tube to bounce widely when driven over by heavier vehicles. If you must install the road tubes in rutted pavement, tape them down heavily.

#### Road Tubes Not Perpendicular to Traffic.

This error (usually only at slow speeds) is caused by a vehicle not hitting the road tubes squarely. If the vehicle is going slow enough, the left tire(s) and the right tire(s) will cause an individual activation. This problem is most commonly seen in intersections, where vehicles are turning across the road tubes at slow speeds.

### **Bad Speed and/or Length**

This problem is infrequent, but can occur sometimes when the counter misses axles. For example, assume a 2 axle, 8 foot axle spacing vehicle traveling 60 mph crosses two road tubes spaced 8 feet apart. The spacing and timings occurred as below:

- 1) Road Tube 31 hit by first axle at 10:00:00.00000.
- 2) Road Tube #2 and #1 hit almost simultaneously by the first and second axles at 10:00:00.09090. Counter missed the Road Tube #2 hit (for whatever reason).
- 3) Road Tube #2 hit by second axle at 10:00:00.18181.

Since the counter waits for the first hit on #1 and the first hit on #2 to determine the speed, the speed will be determined by the second road tube #2 hit. This gives  $(8\text{ft}/.18181\text{sec}) = 44 \text{ ft/sec}$ , or 30 mph. This is only  $\frac{1}{2}$  the actual vehicle speed! Since the speed is calculated wrong, the counter will also give an incorrect length

value for the vehicle.

Note that this error is from the data, so it gave the values it could.

### SnMis (Sensor Miss) for Entire Vehicle

Like the previous error, this problem only occurs as a result of missed axles. "SnMis" (for sensor miss) is the Phoenix MDK's way of indicating that did not have enough sensor data, or got sensor data not in the right order to make a vehicle. Once a sensor miss occurs, the Phoenix MDK block out all further sensor activations on that lane for 1 second.

SnMis #0 occurs only with Axle-Pres-Axle or Pres-Axle-Pres combinations. This error indicated an improper sequence of sensor activations or missing one or more activation(s). SnMis #1 is that the counter only got a road tube #1 strike, with no further road tube activations. This can happen if a vehicle hits the first road tube, but misses the second while changing lanes. SnMis #2 is that the counter only received a road tube #2 strike, without first getting a road tube 1 strike. This, like SnMis #1, can happen if a vehicle crosses into the lane but misses' road tube #1. SnMis #3 is an over speed or under speed vehicle, and can optionally be used to indicate vehicles which only hit road tube #1 and road tube #2 once, with no further activations. Note that the counter will normally turn these types of activations into two axle vehicles with the axle length equal to the sensor spacing.

### One vehicle Shown as Two

This error is normally caused by a vehicle with an axle spacing greater than the maximum axle spacing setting in the configure system option. The counter defaults to 40.0ft. This value can be changed in the unit by the user if needed.

If you increase this value, you run the risk of counting vehicles traveling close together as one vehicle (two tailgating cars become one vehicle, usually turned into a four axle Scheme-F Class #8). However, the default axle classification table does have a definition to look for such instances and move them to a class 2 instead to correct this issue. A car closely following a truck will generally turn that truck into a class 13 under normal operation. To alleviate this from occurring, the Phoenix MDK has a tailgating feature that is specifically designed to look for tailgating cars. The tailgating feature is covered in section 2.

Note: This error can also be caused by missed axles. The Pegasus, Phoenix and Unicorn MDK resets its' time-out value after each axle hit, if you miss some and the counter does not reset its value, then the vehicle will be ended prematurely.

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