OBJECTIVE 2.12 Identify factors that affect handling, steering, and braking to include ABS systems.

INTRODUCTION

During the operation of a motor vehicle, the driver seldom analyzes vehicle dynamics. The driver makes a series of sub-conscious adjustments in steering and speed selection to allow for continued vehicle control. This process becomes routine and the driver anticipates an uneventful drive. When there is a need for a dramatic steering or speed adjustment a driver reacts by drawing on impulse, training and habits. The percentages for successful completion of the maneuver are very low, as the driver often reacts too slowly or overreacts and has a collision.

A driver who understands how the laws of physics act on a vehicle recognizes that they cannot be violated without paying a penalty. The driver must also understand during emergency operation the increased speeds and distractions present are compounded by the changes in vehicle dynamics. Stopping distances are also affected by the speed increase.

CONTENT

Basic vehicle dynamics and factors which influence the operation of an emergency vehicle include:

1. Centrifugal Force - As a vehicle travels around a corner, there is an increase in the centrifugal force which impels an object outward from a center of rotation. The greater the speed, the greater the force. An example is when driving around a corner a vehicle fails to maintain the intended path of travel. This is oftentimes characterized by the rear of the vehicle rotating around the axis of the vehicle.

2. Centripetal Force - The opposite of centrifugal force; pushing toward the center. Characterized by a vehicle's ability to maintain its intended path of travel while cornering. Driving the vehicle in excess of the appropriate speed diminishes the effectiveness of centripetal force and gives way to centrifugal force.

3. Inertia - The tendency of a body to resist acceleration. The tendency of a body at rest to remain at rest and a body in motion to remain in motion in a straight line unless disturbed by an external force. Resistance to motion, action or change.

4. Momentum - The size and speed of the vehicle will determine the amount of time and distance required to stop it. The greater the mass or speed, the more time and distance necessary to effect a stop. P = WVZ

5. Velocity - The rate of change of position relative to time, speed of motion in a particular direction. (Vector)

6. Gravity - A constant pull of the earth, pulling all objects towards its center.

7. Friction - The force between two bodies that resist motion or tendency to motion. Sliding friction, rolling friction and stopped friction. Examples are a vehicle with locked wheels sliding, a moving vehicle and a vehicle at rest.

BASIC VEHICLE DYNAMICS MAY BE EXPLAINED AS FOLLOWS:

The combination of inertia and gravity allow a vehicle to remain stationary or continue in motion until acted on by other forces. The combination of vehicle weight and gravity give the vehicle mass. As the driver accelerates the vehicle, velocity becomes the dominant force. This velocity, combined with the mass, creates a level of kinetic energy stored in the vehicle. Kinetic energy is measured by taking into account both mass and velocity. This means the kinetic energy in a vehicle traveling 10 mph would be equal to 100 units. This same vehicle traveling at 40 mph would have 4 times the speed but 16 times the force (1600 units) acting on the vehicle. Convert the mph to units of force by squaring the mph:

MPH x MPH = UNITS OF FORCE
10 x 10 = 100
20 x 20 = 400
30 x 30 = 900
40 x 40 = 1600
50 x 50 = 2500
60 x 60 = 3600

DYNAMICS OF STEERING

1. Countersteering - A method of counteracting the forces created in a skid (dry or wet) by steering in the direction of the skid, or the intended path of travel.

2. Understeer - The handling characteristic of a vehicle that tends to increase the desired cornering radius as a vehicle progresses through a turn. A tendency of the vehicle to continue in a straight line and resist turning from a direct course of travel.

3. Oversteering - The handling characteristic of a vehicle that tends to reduce the desired cornering radius as a vehicle progresses through a turn, requiring the driver to rotate the steering wheel away from the direction of the turn.

DYNAMICS OF BRAKING

1. Braking

    a. Front Wheel Lock-up

        (1) Caused by improper brake adjustment or slick spot on the road.

        (2) Causes reduced braking ability and loss of steering.

        (3) Rear wheels act as a rudder and maintain straight-ahead slide.

    b. All Wheels Locked

        (1) Caused by a panic situation in which brakes are applied abruptly and hard enough to lock all four wheels.

        (2) The vehicle will probably skid in a straight line as long as variables such as road surface, tire tread, and air pressure are fairly even

        (3) Rear Wheel Lock-up

            (a) Caused by improperly adjusted brakes which cause rear wheels to lock while front wheels continue to rotate.

            (b) Vehicle will rotate around center mass in the horizontal plane.

        (4) Brake Fade - Most common during a drive when frequent use of the brakes does not allow for proper cooling

        (5) Weight Transfer

            (a) Occurs when the vehicle changes velocity or direction.

(b) As a vehicle accelerates, the front lifts, causing weight in rear to increase. This weight shift to the rear can cause loss of traction for front-wheel drive vehicles, but an increase in traction for rear-wheel drive vehicles.

(c) When braking the vehicle, weight is transferred to front wheels which have high braking efficiency.

(d) Change of direction transfers weight from one side of the vehicle to the other, which is more noticeable in vehicles with a higher center of gravity.

(6) Environmental factors

(a) Road surface - Wet, dry, surface debris, pavement type, and temperature.

(b) Road design - Flat, uphill, curve, crowned, banked.

(c) Visibility relative to perception time - Weather conditions, day or night, blind spots, other traffic.

(d) Wind

(7) Vehicle condition

(a) Braking system - Poorly maintained, low brake fluid.

(b) Suspension system and steering components - Bad shock absorbers, tie rods.

(c) Tires - Improper tire tread, improper tire pressure, alignment, ice studs, balance.

(d) Vehicle weight and distribution of extra weight - Uneven distribution, greater mass.

(8) Braking Systems

(a) Conventional - Drum disc.

(b) Four wheel disc.

(c) Anti-lock braking system (ABS).

ANTILOCK BRAKING SYSTEMS (ABS)[1]

What is ABS?

An antilock braking system (ABS) is the part of a vehicle's braking system that automatically controls braking pressure to prevent the controlled wheel or wheels from locking during braking.

Why Are Antilock Braking Systems Beneficial?

Motorists, when confronted with emergency situations, are likely to press too hard on the brake pedal, causing their vehicle's wheels to lock, which in turn causes skidding and loss of control. ABS, by preventing wheel lockup, allows drivers to maintain control of their vehicles even in "panic stop" situations. Maintaining control can be a key factor in collision avoidance. Most antilock systems also enable the vehicle to stop in a shorter distance, particularly on wet or slippery road surfaces.

How Does ABS Work?

On a vehicle equipped with an antilock braking system, wheel speed sensors detect wheel lock, and send signals to the brake pressure modulator to reduce brake pressure which allows the wheels to turn. The ABS then reapplies braking pressure to maintain maximum braking. This pressure regulation, in effect, pumps the brakes in the same manner a driver would, only much faster. During ABS operation, drivers would expect to feel the brake pedal pulsating. this pulsating occurs as a result of the brake fluid pressure changes in the brake system when the ABS is activated. This is not an unusual situation and the driver should continue applying pedal pressure as required.

Current antilock systems can release and reapply the brakes as many as 15 times per second. By allowing the wheels to continue rolling, the driver is always able to maintain control and stop the vehicle on slippery surfaces in a shorter distance then would be possible otherwise.

What Are The Major Components Of ABS?

1. The typical antilock system includes the following major components:

    a. Wheel Speed Sensors measure wheel speed, and then transmit this information to the electronic control unit (ECU).

[1]Adapted from a "Consumer Information" bulletin published by the U.S. Department of Transportation, National Highway Traffic Safety Administration, in December 1991.

b. Electronic Control Unit (ECU) contains computer functions, sensor signal processing circuits, output signals to the various ABS valves and components, and failure detection logic.

c. Brake Pressure Modulator reduces, holds, and restores pressure to one or more brakes, independent of the brake pedal effort applied by the driver.

2. Antilock systems control either the two rear wheels or all four wheels of the vehicle. In general, the four-wheel systems provide better stability and control during braking compared with the two-wheel systems because the steered wheels do not lock up.

In the event of a malfunction in the antilock system, braking, without ABS function, is maintained on the vehicle and a warning lamp on the instrument panel alerts the driver that the ABS is in need of repair.

LAW ENFORCEMENT TRAINING AND ABS:

Just as skills and knowledge are required by police officers concerning emergency driving, the same holds true for vehicles featuring ABS. Four elements have been identified which assist law enforcement departments familiarize and train personnel with ABS.

1. ABS video tape produced from the vehicle manufacturer

2. Driver's manual accompanying ABS equipped vehicles

3. ABS warning lamp symbol and functioning

4. Hands-on braking and handling familiarization prior to actual in-service emergency driving

(Automotive service technicians who work with ABS-equipped vehicles also require additional training. Technicians must receive manufacturer product service training on Antilock Brake Systems. This ensures that technicians are qualified to inspect and repair vehicles equipped with ABS.)

5. The four elements above may help officers recognize the improved efficiency of Antilock Brake System; however, it is important to emphasize specific features which characterize ABS. Items such as the pulsating effort of the brake pedal during activation of ABS is important information for officers. The knowledge of the ABS warning lamp symbol and functioning (see owner's manual), is also important for law enforcement officers. This explains that should the

ABS warning lamp symbol light up on the instrument panel during driving, the vehicle no longer has ABS brake capability.

However, traditional power brakes will be activated until the vehicle can be returned for service. Hands-on familiarization of the ABS braking and handling system completes the last element of training. By completing the above elements of ABS familiarization and training, officers will receive information which will assist them as they meet the challenges of emergency driving.

WHICH VEHICLES HAVE ABS?

Many vehicles now employ ABS. These vehicles may have an identifying plate or there may be some indicator on the sales slip.

GETTING USED TO THE WAY ABS WORKS.

1. When driving at high speeds, motorists are accustomed to hearing a screeching noise when they apply the brakes suddenly. This happens when a wheel locks up and the tire skids on the road surface. Since antilock brakes prevent wheel lockup, there is no screeching sound. The absence of a screech means that the ABS is working.

2. Motorists are accustomed to pumping their brakes to prevent wheel lockup. When the pedal is pushed on a car equipped with antilock brakes, some motorists notice a pulsing sensation. The antilock brakes are doing their own "pumping." Do not pump the pedal. If you do, you will defeat the purpose of the ABC or lessen the effectiveness of the brakes.

For further inquiries concerning Antilock Braking Systems, contact NHTSA's Traffic Law Enforcement Traffic Division at (202) 366-4295, or, NHTSA's Office of Defects Investigation (ODI). ODI is the office which conducts defects investigations and develops the necessary information to determine whether a safety defect exists and if a safety recall should be implemented. A toll free hotline number (888) 327"4236 is also available. The toll free number will put you in touch with an operator, who will pass the information on to a specialist.

SUMMARY

Basic vehicle dynamics and a number of factors influence the operation of an emergency vehicle. Knowledge of both basic vehicle dynamics and common factors such as braking will assist the operator in understanding how to effectively control an emergency vehicle.

SUGGESTED INSTRUCTIONAL METHODOLOGY

LECTURE WITH VIDEO

Support the content of this lesson plan with lecture including examples of characteristics of patrol vehicles having ABS as well as video footage of duty vehicles being operated in realistic conditions and performing typical duties.

RANGE

Select braking, turning, and combined courses from Chapter 8 to reinforce lecture and video presentations.

RESOURCES AND AIDS

1. Chapter 8 exercises.

2. Video footage of vehicles being operated in a wide variety of conditions and activities.

SUGGESTED EVALUATION METHODOLOGY

STUDENTS

1. Written or verbal responses to questions regarding stopping distance-related problems

2. Observation of performance of these maneuvers and methods during practice driving, on the practice range or on the street

COURSE

1. Repair records with vehicles equipped with ABS.

2. On-the-job observation, evaluation, or analysis of these maneuvers and methods