Vehicle Software Solutions

Tire Deflation Warning System Definition/Results v1.9

1.1 Objectives

This document describes the tire deflation warning system that Vehicle Software Solutions provides. The Tire Deflation Warning system (TDW) is a low cost concept, in which the ABS wheel sensor information is used to evaluate the tire pressure status. When a low tire pressure is detected, a telltale notifies the driver.

2. Requirements

2.1 General

2.2 Functional Content

2.2.1 General Usage

Low tire pressure is a significant factor in causing decreased tire life and performance.

The tire pressure monitor will give the driver a warning indicating when low tire pressure is detected in at least one of the tires.

Indication of low tire pressure will also give the car owner savings in terms of:

- less wear on the tires and
- reduction in fuel consumption.
  (A tire with low pressure will increase the rolling resistance and therefore increase the fuel consumption.)

Since the tire pressure monitor is an indirect method of estimating the pressure status of the tires, it needs to be calibrated with the tire at nominal pressure to increase the sensitivity of the system.

2.2.2 General Behavior

The tire deflation warning system shall not issue any false warnings during normal driving situations or on any road surface with correctly pressurized tires.

The driver shall be notified if the tire deflation warning system cannot operate properly, e.g., the wheel rotation information is erroneous or unavailable.

2.2.2.1 Tire Deflation Warning

The tire deflation warning is divided into a number of sub functions:

- Monitor the tire pressure
- Calibrate the tire pressure monitor

2.2.2.1.1 Monitor the tire pressure

Driver - System Interaction:
When the tire pressures in any of the tires are found to be too low the driver is given a warning. The warning will be in the form of a telltale or message in the dashboard and

possibly also a chime. The details and specifications of the driver display signals provided by the TDW algorithm will vary based on the specific vehicle electrical architecture.

The tire pressure monitoring should not identify the particular tire(s) that is/are deflated for two reasons:

- If the low-pressure tire(s) were to be identified then the driver would be tempted to only inflate this tire(s) and not all tires.
- This would make the monitoring algorithm more complex.

At power up of the tire pressure-monitoring system will use the tire pressure warning status from the previous drive cycle as the initial status. This means that if the warning was set during the previous drive cycle then warning will be set (the telltale is turned ON) at power. In all other situations at power up the telltale is turned OFF. If the telltale is illuminated (ON) then it is not turned OFF until:

1. the tire pressure monitor is being calibrated
2. the tire pressures are again returned to there calibrated values
3. the system is powered down.

2.2.2.1.1.2 Functional Requirements

The tire pressure monitor shall be able to monitor the following tires:

- specified summer, winter, and all season tires.
- EMT's (Extended Mobility Tires – "run flat tires").

It is also assumed that the tires:

- are of the same type/size
- are of the same brand

At power up of the tire pressure-monitoring system shall initiate the tire pressure warning status with the status from the previous drive cycle.

When low tire pressure is detected, the driver is given a warning by turning ON the telltale. The telltale will stay illuminated until a determination is made that the pressure is nominal or the system is calibrated.

If low tire pressure is detected on one or more tires then a driver warning shall be issued.

A large and rapid tire pressure drop must always generate a warning within 2.5 miles.

The tire deflation warning may deviate from the specified low-pressure detection limit or give false warnings if the system has not been properly calibrated.

2.2.2.1.1.3 Performance

For a calibrated system, the acceptable low tire pressure detection limit and its corresponding delay is defined as:

1. At <8 psi deflated tire no warning shall be issued.
2. At 8 -15 psi deflated tire, the warning shall be issued in less than 5 miles.
3. At >15 psi tire deflation, the warning shall be issued in less than 2.5 miles.

The tire pressure monitor shall be active (be able to assess tire pressure status) if all of the following conditions are true:

- Vehicle longitudinal acceleration within ± 0.2 g
- Vehicle lateral acceleration within ± 0.1g
- Wheel slip for any wheel relative vehicle speed shall be < 1%,

The tire pressure monitoring shall be performed throughout the whole speed range.

2.2.2.1.2 Calibrate the tire pressure monitor

The calibration of the tire pressure monitor is required to account for variations in the rolling radius of the tires.

2.2.2.1.2.1 Functional Requirements

Driver - System Interaction:
The driver has to check and adjusted the pressure of the tires before activating the calibration mode. The driver initiates the calibration mode by pushing the calibration button for 5 to 20 seconds. After the calibration mode has been activated, this function will complete the calibration without further action by the driver.

During the calibration of the tire pressure monitor the driver will be notified by flashing the warning telltale.

It shall be possible to activate the calibration mode regardless whether a low-pressure warning has been issued or not.

2.2.2.1.2.2 Performance

Driven at steady speeds from 0-80 MPH, on straight asphalt or concrete road surfaces, the system shall complete calibration mode within 5 miles. Turning, acceleration and/or braking may extend the calibration period.

2.3 Design Requirements / Constraints

2.3.1 General

The Tire Deflation Warning System is based on coexistence with an ABS system. The individual wheel speed information is measured by the ABS system and sent to the tire deflation-warning module.

2.3.2 Interface

The tire pressure status shall be assessed by evaluating the individual wheel speed information for all four wheels. The details and specifications of the wheel speed signals provided to the TDW algorithm will vary based on the specific vehicle electrical architecture. Wheel speed signal general characteristics –

- Signals must be provided/sampled on a fixed periodic basis – recommended period </=100ms
- All speed signals must be sampled synchronously, i.e. within the same time sample period –Variations in transmission period due to bus timing ("jitter") are not critical, as long as one transmission per sample period is performed. -The recommendation is to transmit one serial data message containing all four speed signals.
- The bit length of the wheel speed signal is determined by the maximum speed required, the sample period, and the number of speed sensor transitions per revolution of the tire. – the data length shall be set to preclude overflows during the sample period.

The tire deflation warning system shall send a message to the dashboard to activate the tire deflation warning telltales.

The tire deflation system shall read the status of the tire deflation warning system calibration button.

During calibration of the tire deflation warning system shall notify the driver that the calibration is active by flashing the warning telltale or driver message.

Error detection of the ABS wheel sensors shall inhibit the assessment of tire pressure. The tire deflation warning system will then send a message to the information display notifying the driver that the system is not active due to ABS wheel sensor failure.

3.1 Requirements Validation Plan and Results

3.1.1 Tire Deflation Warning System

3.1.1.1 - validate no false detections

condition : deflation in 1 tire, all other tires nominal, repeat for 1 front, 1 rear tire.

Surface	**Speed**	**Distance**	**Pressure**	**Behavior**	**Result**
Asphalt/Concrete	0-80 Mph	100 miles	-4 psi	no-detect	*no-detect*
Rough Road	0-45 Mph	20 miles	-3 psi	no-detect	*no-detect*
Gravel	0-45 Mph	50 miles	-3 psi	no-detect	*no-detect*
Snow/Icy	0-45 Mph	10 miles	-3 psi	no-detect	---

3.1.1.2 - validate performance/convenience warning

condition : deflation in 1 tire, all other tires nominal, repeat for 1 front, 1 rear tire.

Surface	**Speed**	**Distance**	**Pressure**	**Behavior**	**Result**
Asphalt/Concrete	30, 70 Mph	N/A	-10 psi	detect < 5 mi	*detect < .8 mi*

Rough Road	35 Mph	N/A	-10 psi	detect < 5 mi	*detect < 3 mi*
Gravel	45 Mph	N/A	-10 psi	detect < 5 mi	*detect < 2.5 mi*
Snow/Icy	35 Mph	N/A	-10 psi	detect < 5 mi	---

3.1.1.3 - validate immediate service warning

condition : deflation in 1 tire, all other tires nominal, repeat for 1 front, 1 rear tire.

Surface	**Speed**	**Distance**	**Pressure**	**Behavior**	**Result**
Asphalt/Concrete	45 Mph	N/A	-18 psi	detect < 2.5 mi	*detect < .5 mi*
Gravel	45 Mph	N/A	-18 psi	detect < 2.5 mi	*detect < 1 mi*

3.1.1.4 - validate self clear warning

condition : deflate 1 tire, drive till warning set, return to all tires nominal

Surface	**Speed**	**Distance**	**Pressure**	**Behavior**	**Result**
Asphalt/Concrete	45 Mph	N/A	nominal	clear warning	*clear < .8 mi*
Gravel	45 Mph	N/A	nominal	clear warning	*clear < 2.5 mi*

3.1.1.4 - validate calibration range

condition : all tires nominal pressure, enter calibration mode

Surface	**Speed**	**Distance**	**Pressure**	**Behavior**	**Result**
Asphalt/Concrete	45 Mph	N/A	nominal	clear calibration mode	*clear < .8 mi*

The above validation results were measured on a 1999 Saab 9-5 (Michelin Energy MXV4, 215/55R16 tires) fitted with the VSS TDW system in April, 2000.