Issued: November 2023

Future Truck Position Paper: 2023-1

Recommendations Regarding the Use of Sensors in Future Tire Designs for Improved Tire Maintenance

Developed by the Technology & Maintenance Council's (TMC)
Future Tire Durability & Reliability Task Force

ABSTRACT

This Position Paper describes key factors identified by the Future Tire Durability and Reliability Task Force of ATA's Technology & Maintenance Council (TMC) related to integrating standardized sensor technology into future tire designs for improved tire maintenance in commercial vehicles. This paper provides industry with an overview a "Connected Tire" concept, the development of which fleets should encourage from vehicle manufacturers and tire suppliers.

INTRODUCTION

TMC's S.2 Tire & Wheel Study Group asked the Council's Future Truck Committee to explore and identify key factors related to integrating sensor technology into future commercial vehicle tires for improved tire maintenance. Accordingly, TMC conducted a survey of its fleet members in 2018 on this topic with questions generated by the Future Truck Committee's Future Tire Durability and Reliability Task Force.

Results of this survey are detailed in the Council's *Tire & Wheel Study Group Survey Report: Fleet Expectations on Tire Sensors*. Subsequently, the Task Force considered these results in formulating the future state-of-art technology referred to herein as the "Connected Tire Concept." This paper provides an overview a Connected Tire Concept, the development of which fleets should encourage from vehicle manufacturers and tire suppliers.

BACKGROUND

Tire inspections traditionally require a labor-intensive physical check of tire pressure and tread depths. Other parameters such as tire temperature or load are more elusive, requiring special equipment and inspections that are difficult to perform in great quantity. When any of these measurements are taken, they are done so at a discrete moment in time. Multiple inspections are required to obtain time dependent rates and histories at a high resolution. However, tire sensors are beginning to provide fleets with continuous data with which to make better maintenance decisions.

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While tire manufacturers have fielded various sensors for specific applications, TMC takes the position that a Connected Tire Concept could, in future, contain a multi-function sensor unit that continuously monitors desired parameters, providing the fleet maintenance manager with critical real-time tire information via the vehicle's telematics system.

SENSOR POWER

A sensor is a device which detects or measures a physical property in its environment, then sends the information to an electronic receiver. Often, a tire sensor employs a material in which electrical resistance changes with deformation caused by changes in pressure, temperature, or load. This change in electrical resistance is correlated to the cause and sent to the receiver. This requires some amount of electrical power, typically provided by a battery in today's tire sensors.

TMC's 2018 Fleet Survey indicated fleets view changing sensors or batteries to be a very undesirable maintenance action. It would be preferable for power to come from the vehicle or other source. Technology exists today for devices to generate electrical power from the deformation of the tire itself. In these devices, an electric charge builds up in the base material from mechanical stress. Wireless charging is also a technology that is maturing. In the Connected Tire Concept, one of these charging processes would power the multifunction sensor throughout the life of the casing.

SENSOR LOCATION

Current technology places sensors in various locations, including the rim drop center with a band, the tire inner liner via adhesive, or attached to the valve stem on either the tire side or as the valve cap. The most transparent of these to fleets is on the inner liner. The current technology requires such a sensor to be adhered to a finished tire, since certain sensor components cannot withstand tire curing temperatures which can exceed 300°F.

In the Connected Tire Concept, it would be desirable to imbed the sensor into the casing. Such high temperature tolerant devices would not only withstand new tire curing temperatures, but retread curing temperatures as well. Just as how current sensors are bonded to the tire center below the tread, the casing-imbedded sensor in the Connected Tire Concept would be in a similar location, since this is the area of least flexing.

SENSOR FUNCTION

As stated previously, the Concept Connected Tire Concept would have a single multi-functional sensor which senses the same parameters that manufacturers have demonstrated with present day technology. To a large extent, some sensors today are already multi-functional, the most common being the tire pressure monitoring system (TPMS) sensor that senses both pressure and temperature. Several tire manufacturers have added other functions such as radio frequency identification **(**RFID) or tread thickness with TPMS sensors.

Accordingly, the multi-functional sensor of the Connected Tire Concept would have the following functions:

- ***Pressure —*** While this may be the most mature technology deployed today in tire sensors, all current TPMS sensors are exposed directly to a tire's pressurized air. A TPMS sensor that is imbedded in the tire casing would need a modified approach to sensing tire pressure.
- ***Temperature —*** Temperature sensing is also a mature technology. But since current TPMS sensors read the air temperature at the installed location, they are less than optimal when a physical part of the tire anatomy is of interest, such as the bead, sidewall, shoulder or tread. The imbedded sensor on the tire centerline would obtain an accurate tread temperature. The Connected Tire Concept sensor might measure temperature in other anatomical areas of interest. The

sensor would then send multiple temperatures, and the fleet manager would know whether overheating is occurring in the bead, shoulder or tread centerline.

- ***Load —*** Load sensors in various forms are being demonstrated in field applications. Most available systems sense axle load, and tire load is assumed to be equally distributed. With the load being sensed in an individual tire, a fleet manager can be more aware of unevenly distributed loads, either across the axle (indicating unsafe load shift) or among dualed tires (indicating mismatched duals or less than optimal fifth wheel location).
- ***Tread Depth —*** Sensors that detect tread thickness (inferring tread depth) have been developed within an accuracy of 1.0 mm. Just as with classic tire inspections, fleet managers must know if a tire should be pulled for retreading. If this technology were available, more refined readings could indicate if a tire was wearing unevenly across its tread face and needed rotation to maximize tire life.
- ***Global Positioning System (GPS) —*** While GPS has become commonplace in commercial vehicle applications, there are advantages to having this feature embedded in the sensor of the Connected Tire Concept. A GPS function unique to a tire would help locate a specific tire in a crowded depot parking lot or storage building, for example.
- ***RFID Tags —*** RFID tags are in common use in certain applications throughout the tire industry. The tags can already withstand curing temperatures and are imbedded into the tire casing during manufacture. In fact, industry has converged upon an manufacturer-agnostic global standard for RFID tags — entitled International Standards Organization ISO/TC31/WG10, *Radio frequency identification tyre tags - Tyre attachment classification*. This tag can already store much tire information as per the global standard. If the tag is of a read/write variety, the RFID function of the multi-functional sensor could be expanded to include information such as the Tire & Rim Association Load & Inflation Tables for a specific tire size, or report the tire rolling resistance level to help a fleet manager comply with the U.S. Environmental Protection Agency's Greenhouse Gas (GHG) regulations or EPA SmartWay program.

SYSTEM INTEGRATION

In order to be useful, the sensor reader would feed into the vehicle telematics system. A fleet could determine which parameters should be communicated to the driver. If a tractor or trailer is equipped with a tire inflation system, the multi-functional sensor would communicate the need to increase pressure. This could be incorporated into an algorithm that identifies an air leak. The Connected Tire Concept, integrated with vehicle telematics, would allow for identification of its unique location/position on the vehicle, and self-adjust when tires are rotated.

CONCLUSION

Just as RFID tags evolved from being tire manufacturer-specific to globally standardized, the all-in-one multi-functional sensor in the Connected Tire Concept would do likewise, ensuring interchangeability across brands. For end-of-life considerations, materials used in the multi-functional sensors should be environmentally non-toxic and sustainable. Deployment of the Connected Tire Concept would not only eliminate the time-consuming and variably accurate classic tire inspection, it also would provide continuous monitoring of all the aforementioned parameters. A history of pressure, temperature, load, and tread wear rates would be available for every tire in service. This would increase the awareness of needed future tire maintenance events, which ultimately would enhance operational efficiency, lower tire expenses, and increase safety. ❑