HEAVY TRANSPORT TRUCK / TRAILER -TYRE MONITORING SYSTEM- FIELD TEST

Job 03088

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Report for: TYRE MONITORING SYSTEM- ROCKY'S OWN TEST REPORT

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To:	General Public
Copies:	LSM (PW / BV)/ ROCKY'S OWN (BRYAN SMITH)
Subject:	**FIELD TESTING REPORT- JOB03088**

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1. SUMMARY.

Management of the risks associated with operating heavy transport requires effective maintenance of tyres and wheels as critical components. On- road failures of these components can result in a catastrophic situation (wheel fire / tyre explosions / tyre failures).

This test investigation confirms that the LSM Technologies Tyre Monitoring Systems (TMS) can be an effective monitoring technology for providing an early warning alarm to a vehicle Operator of abnormally high tyre temperature and pressure (under or over), indicative of an incorrectly inflated tyre or mechanical failure (brake or bearing failure).

Through this field test investigation, it was clearly shown by the results that the TMS was able to provide tyre / wheel temperature and pressure information to the Operator before damage to the tyre / wheel took place with the Operator potentially avoiding a hazardous event.

2. BACKGROUND.

2.1 The Problem.

In the Heavy Transport industry, brake, wheel bearing and tyre failures can potentially cause high wheel hub and tyre temperatures on trucks and trailers. This can result in catastrophic equipment failure, fires and explosions causing substantial damage. It is paramount this risk be significantly mitigated or eliminated from Heavy Transport operations.

Furthermore, these events should be recorded to enable review and reporting for incident analysis. Also the TMSystem is required to alert the Operator so as to take corrective action to prevent damage to the vehicle, surrounding people, property.

Changes to recent Industry Standards/ Guidelines and Coroner Reports have set a precedent in demanding that TMSystem Technology is implemented so as to avoid such events.

2.2 Causes.

Statistical data shows that tyre related fires resulting in incidents, accidents and fatalities have a few common causes.

- Locked or dragging Brakes.
- Tyre overloading / excess speed.
- Tyre Lightning strikes (pyrolysis).
- Contact with power lines (pyrolysis).
- Wheel Bearing failures or Hub issues.
- Incorrectly inflated tyres or tyre damage due to periods of run-flat.
- Internal tyre damage caused by excessive speed, road camber deficiencies and tyre separation.

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2.3 Statistics.

Some relative statistics state that 33% of Truck Trailer fires are related to Wheels and Tyres.

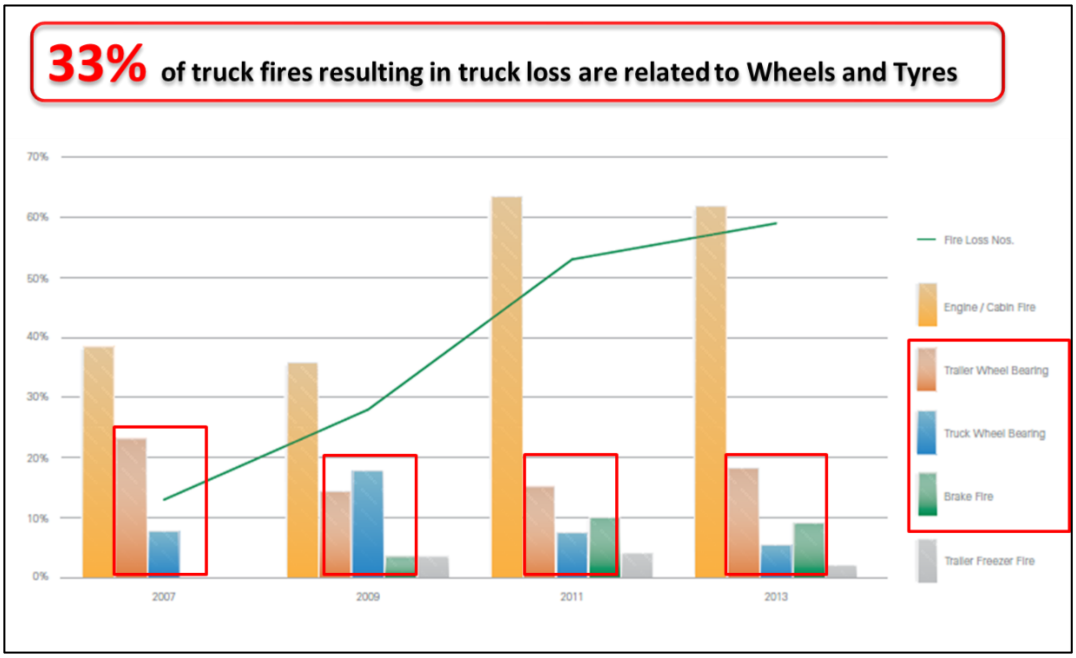


Figure 1: Wheel/Tyre Fires (source: NTI Major Accident Investigation Report - 2015)

Also stated that 25% of Heavy Vehicle crashes are directly related to tyres.

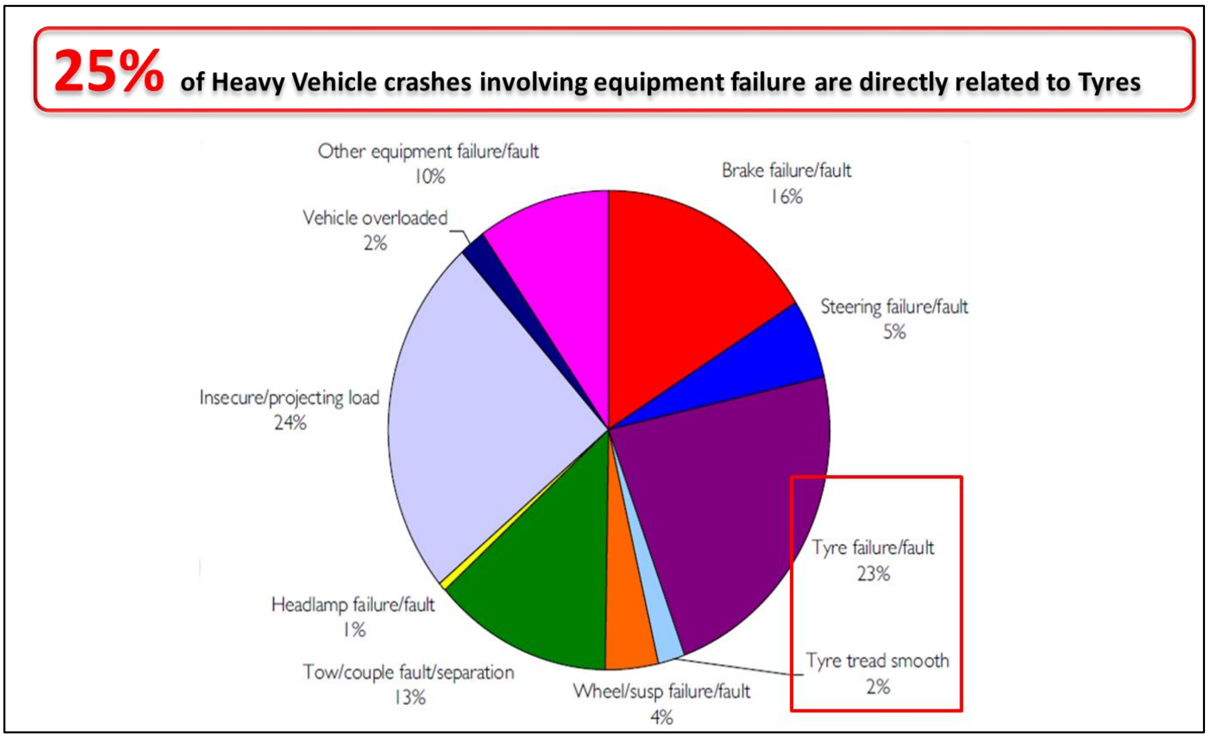


Figure 2: Heavy Truck Crash Data Analysis March 2012– NSW Centre for Road Safety

3. TEST OBJECTIVES.

The objectives of the TMSystem field testing was to establish that the Tyre Monitoring System (TMS) can provide sufficient information to the vehicle Operator in time for action to be taken to prevent tyre failure.

Testing and data was collected for the Trailer only for this testing.

4. SIMULATION.

It is assumed the trailer load, driving route, road surface, tyre type and speed were all similar to conditions that would occur under normal use of the vehicle. With this assumption in place the data gathered is relevant to the purposes of the project.

Similar results would be assumed to occur if actual brake malfunction (sticking/dragging) and wheel bearing failure (running dry/overtightened/malfunction) occurred through the course of normal vehicle operation.

5. TEST RIG / FIELD LAYOUT.

The LSM Technologies Tyre Monitoring System (TMS) Portable Field Test Kit was installed on a standard Prime-mover and a Tri-axle Flat Bed Trailer loaded with 2000 kg's (Concrete blocks).

The machinery used for the test was a Rocky's Own Transport 10 x wheel Prime-mover and 12 x wheel flat deck Trailer.

The TMS was set-up to monitor both Truck and Trailer tyre pressures / temperatures but only data from the Middle Axle Tyres / Wheels were utilised for the field test.

A controlled section of sealed road was used for the testing, measuring approximately 8 x kilometre distance. Support personnel and vehicles were provided, as well as a "Quit Fire" kit that would be used to extinguish a fire should such an event occur.

5.1 Test Trailer.

Figure 3: Test Trailer with test load on back

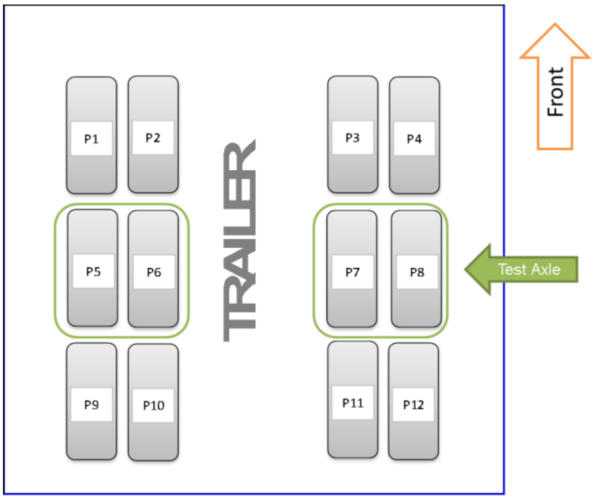
Figure 4: Test Trailer with test load on back

5.2 Tyre Monitoring System Test Rig.

 Figure 5: Tyre Monitor Display in Truck Cabin	 Figure 6: TMS Telemetry Hub to send Tyre Pressure / Temp Data	 Figure 7: RF Sensors on Tyres

6. TESTING METHODOLOGY.

a) Testing area was on a closed section of road with vehicles following to offer support in the event of a fire on the vehicle or roadside. LSM Technologies portable field test unit consisted of an MTR 360 TMSystem kit setup to read data from the trailer tyres only. This system uses Wireless RF Sensors screwed onto the valve stems to transmit pressure and temperature data from the tyres to the cabin, as well as the LSM Asset Management remote telemetry reporting / analysis software.



b) **Brake system malfunction** was simulated on the brake hub adjacent to wheel / tyres in positions P5 and P6 on the middle axle.

c) **Bearing failure** was simulated on the right side bearing tyres in positions P7 and P8 on the middle axle.

d) The operator was to drive the vehicle until an event occurred. Either; the high temperature and pressure alarms from TMSystem or the failure / fire of a tyre on the trailer.

a) On the occurrence of the event the Operator was to then instructed to stop the vehicle and take action to control the temperature of the trailer tyres.

b) Use of the TMS Portable Field Test Unit to investigate and record the sequence of events that may occur.

c) Gather and report tyre temperature and pressure data.

d) The middle axle was the test axle with the front and rear axles being Controls (unaffected Brakes / Bearings / Tyres).

e) Then two field tests were conducted on a closed road:

- **Brake Failure Simulation:** The left side wheels of the middle axle had the brake shoes wound on to the point where they were constantly creating friction on the brake drum. The vehicle then travelled quasi- continuously.

- **Wheel Bearing Failure Simulation:** The right side Wheel Hub (middle axle) had the no grease and the bearing preloaded / overtightened. Measurements from both the TMS (vehicle operational) and the IR Temperature gauge (vehicle stopped) were taken and recorded.

7. TEST PARAMETER.

Prior to testing commencing LSM performed preliminary checks on the TMS equipment to ensure it was operating correctly and connected to the online telemetry LSM Asset Management System.

During the first test which ran from 1000 hours until 1300 hours - a LSM technician travelled in the Truck cabin to view and note data being transmitted to the TMS In- cabin display. Simultaneously, a second LSM technician travelled in a separate support vehicle and monitored the recorded data being logged to the remote telemetry Asset Management System.

At the point of any event and immediately after the vehicle stopped a brake drum and hub temperature reading was taken using the IR thermometer and recorded. Tyre air temperature readings were also taken and recorded continuously during the tests using the LSM TMSystem and Telemetry Asset Management / Tracking software interface.

8. SYSTEMS OF MEASUREMENT:

- Temperature was measured in degrees Celsius using the TMS and a hand held infrared thermometer.
- Speed and time was measured using the GPS capability of the TMS and SafetyTrax software.
- Eight positive Control tyres 1st (Front) axle / 3rd (Rear) axle were used to asses test validity and compare measured data to the test tyre data on the 2nd (Centre) axle.

9. BRAKE FAILURE SIMULATION.

9.1 Test Procedure / Data Collection.

a) Only the left side wheels of the Centre Axle (P5 & P6) had the Shoes of the Brake wound on to the point where they were constantly creating friction on the wheel drum.

b) The Truck and Trailer had not been operating and the temperature of Brake Drum (using handheld IR) and Tyre (TMS) was measured at ambient (25 / 34 degC) before testing / vehicle movement began.

c) On an 8 x kilometre stretch of closed road the vehicle then travelled quasi- continuously back and forth until an alarm sounded on the TMS (80 DegC "HOT" alert threshold).

d) The test was started and after 23 minutes of travel (varying between 10 and 100 kms / hr) both the TMS and Asset Management / Tracking (remote telemetry system) reported a 80 degC "HOT" alert.

e) The Truck then continued for another 10 minutes (total test time of 33 minutes) of travel and then stopped. Using a handheld IR temperature gauge the Brake Drum temperature recorded 260 degC- note the TMSystem reported 117 degC at this point.

f) P1 (front axle / outer wheel tyre) / P2 (front axle / inner wheel tyre) temperatures are those of "normal" running wheels / tyres" and are provided as comparative to the test tyres / wheels. As depicted the tyre temperatures were within normal operating temperature limits.

g) Figure 8: Tyre vs Brake Drum depict the relationship between the Brake Drum and Tyre Sensor temperatures for positions P5 (outer wheel) and P6 (inner wheel).

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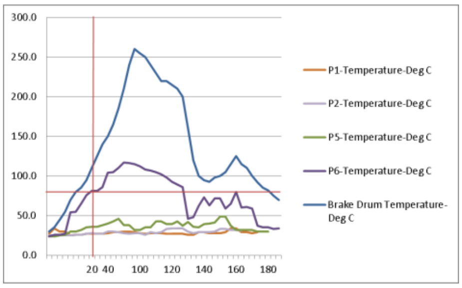

Figure 8: Tyre vs Brake Drum Temperatures

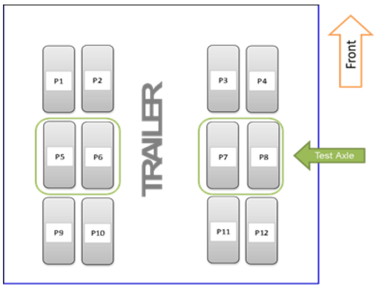

Figure 9: Trailer Test Tyres / Wheels

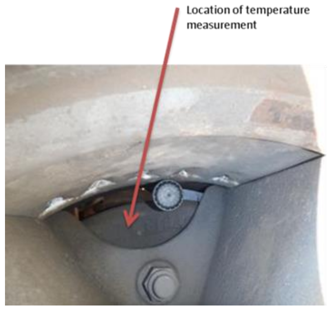

Figure 10: IR temperature measure point / Brake Drum

h) The vehicle then continued for a further 25 minutes of travel (at 10 to 100 kms / hr) and as can be derived from the above graph both Tyre Sensor and Drum Brake Hub dropped in temperature- most likely due to worn / loose (reduced friction) brake and drum components.

9.2 Observations.

The following observations where made from the testing:

a) P5 (Outer Wheel) as one of the test wheels / tyres depicted only slightly higher temperature (50 degC) compared to the "normal" tyres / wheels and did not trigger a Temperature Alert on the TMS. It is accepted that as this Wheel is not in direct contact with the Brake Drum, then the Tyre Temperature would also not be as effected much, compared to the P6 Inner Wheel.

b) As depicted in the above graph, P6 (inner wheel) Tyre Sensor provided an Over-temperature "HOT" alert (>80 degC) at an elevated temperature at the Brake Drum of 135 degC (interpolated from data). P6 of course sits directly over the Brake Drum and so heat transfer is more rapid.

c) The high temperature "HOT" alarm activated on the TMS In- Cab Display and was indicated on the SafetyTrax TMS interface when the tyre temperature reached 80 degC. The time from the start of the test to the high temperature "HOT" alarm was approximately 23 minutes.

d) Tyre Sensor Temperature and Pressure data (Air / Stem Temperature) was recorded continuously during the test procedures. However, only 2 x data points where recorded for the Brake Hub being start (25 / 24 degC) and finish (260 degC).

e) The TMS also continued to record temperature and pressure data and finished at 117 degC (P6- Inner Tyre) at the Brake Drum Temperature of 260 degC.

f) No fire or explosion events occurred.

10. BEARING FAILURE SIMULATION.

10.1 Test Procedure / Data Collection.

a) The bearings of the wheel only on the right side / middle axle was prepared without lubricant (dry bearings) and abnormally/ excessively preloaded.

b) All other test operating parameters where implemented as for 9.1 Test Procedure / Data Collection.

c) Measurements were taken from the wheel Control Hubs of the 1st axle and 3rd axle with 35 degC and 38 degC respectively when the vehicle was stopped.

d) Figure 11:Tyre vs Hub Temperature depicts the comparison between the RF Tyre Sensor temperature of the 2nd (Centre Axle) wheel and the bearing hub temperature. After about 45 minutes of driving the bearing hub temperature had increased to 150 ^{0}C (measured with the IR thermometer when stopped).

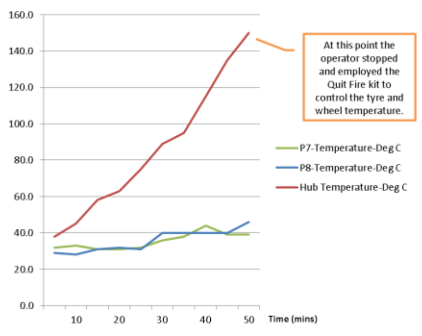

Figure 11:Tyre vs Hub Temperature

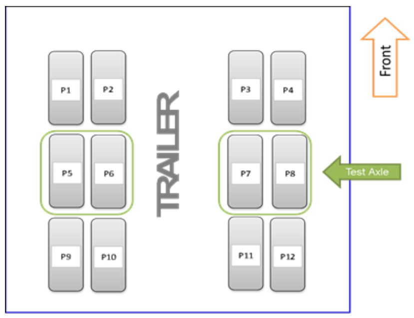

Figure 12: Trailer Test Tyres / Wheels

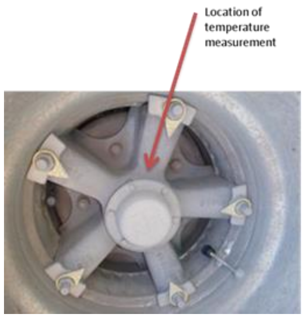

Figure 13: Hub Temp Measurement position

e) The TMS Sensors depicted a tyre temperature increase on P7 & P8 to 44 ^{0}C and 46 ^{0}C respectively. This did not activate a 'HOT' alarm at this point.

10.2 Observations.

a) In this test, a complete wheel bearing failure did not occur due to load, mechanical and also safety concerns (eg sudden wheel loss). However the results still showed the bearing wheel hub temperature increase to 150 degC.

b) The temperature difference between the Test Tyre Sensors and the Control Tyre Sensors was an difference of 16 degC. This indicates that the Bearing Wheel Hub temperature (150 degC) on the Centre Axle did not generate a significant effect on Tyre Sensor(s) temperature, which only increased P7 & P8 to 44 degC and 46 ^{0}C respectively.

c) It is worth noting that the ambient air temperature was 27-28 degC during the test.

11. SUPPOSITIONS / CONCLUSIONS.

The following suppositions / conclusions can be drawn from the above test data observations, historical statistics.

11.1 Locked Brake.

The test data and observations conclude that:

a) The heat transferred from a locked brake to the wheel rim is more efficiently transferred to the tyre rim on the inner wheel than that of the outer wheel on the test rig. This is presumed to be due to the inner wheel being closer (over) the brake drum hub.

b) Considering that the test was relatively short and that the Trailer was not sufficiently loaded, it can be presumed that the transfer of the drum / rim temperatures did not necessarily have time to transfer to the tyre air chamber. Subsequently, one could presume that the TMS Sensors actually recorded a combination of drum/ rim and air chamber temperatures.

c) Considering b) then it is essential that the TM Sensors are attached to solid / short Steel Air Stems so as to provide an early warning for "HOT" over- Temperature Alert.

11.2 Bearing Failures.

a) This test did not result in the TMS high temperature "HOT" alert being triggered. This is possibly due to the limited load on the Trailer axle.

b) One can also assume that the transfer of heat from the Bearing Hub will take somewhat longer to transfer to the Wheel Rim and the consequently to the TMS Sensor.

c) The bearing hub temperature of the Centre axle only rose to 150 degC before the test was stopped due to safety concerns, Bearing temperature is one thing to contend with during operation of the vehicle but the potential of a sudden loss of the wheel (failed bearing / broken axle) could have caused a catastrophic accident.

d) Possibly a fully loaded trailer (25,000+ kg) would have generated more heat, quickly and subsequently triggered the TMSystem "HOT" alert- but again safety concerns would need to be considered.

11.3 Tyre Fire Causes.

Research has been completed on inspections, reports and studies of past incidents and it is clear that wheel related tyre fires (and explosions) are predominately related to:

a) Bearing Failures.

b) Locked Brakes.

c) Incorrectly inflated tyres.

d) Temperature related Pyrolysis (ignition of internal air chamber gases).

e) Lightening strikes (Pyrolysis).

In considering such data (excluding lightening strikes), one also needs to consider the ignition points of material that may cause tyre fires (and explosions).

We know that metals do not catch fire and so bearings, brakes and rims do not "burn" and so can not be considered as ignition points.

However, one common aspect with failed bearings, locked brakes is that these events will cause tyres to drag along the road. It is accepted that the resulting friction between the tyre tread and the road will elevate tyre temperatures that will exceed the ignition point of the tyre rubber (>300 degC).

As such an event would also naturally heat the Wheel Rim and also the Air Chamber of the tyre then it would be safe to assume that the TMSystem "HOT" alert at 80 degC will initiate.

11.4 Effectiveness of TMSystems.

The following suppositions can be derived:

a) Irrespective of a Locked Brake or a Over- heated Bearing, it can be assumed that the ignition point for a tyre fire will most likely be the tyre itself from being "dragged". In such an event the TMSystem will provide a "Hot" alert and potentially avoid a tyre fire.

b) It is accepted as fact that under- inflated tyres will operate at higher temperatures due to the "flexing" of the side wall, rubbing together (dual sets) and when operated overloaded / excessive speed. Subsequently, with the use of a TMSystem and addressing low tyre pressure alerts, a tyre Fire / Explosion event can be potentially avoided.

c) Considering that the ignition points for tyre fires are the tyres themselves and related to friction between the road and the tyre tread, than it can be considered that the temperature will rapidly increase within the air chamber. Once again the TMS Sensors should be capable of providing and early Over- temperature alert.

d) Build- up of heat in the Bearing Hub and / or Brake Drum is localised and also will take some time to transfer to the Wheel Rim. Subsequently, TMS Sensors should be mounted on short / solid steel stems so as to provide quicker and initialisation of a "HOT" Over- temperature Alert.

12. SUGGESTIONS / NEXT STEPS.

The test data was at best rudimentary and so it would be advantageous to collect more data points, complete longer tests and so it is suggested that:

a) A longer stretch of test road be utilised so as to provide more continuous travel (no slowing and turning) which would also facilitate more frequent stopping and checking / recording of Hub / Brake Data.
b) Trailer is loaded to axle limits so as to produce more rapid and realistic operational conditions.
c) More physical data points are required so as to correlate to data attained by the TMSystem and Remote Monitoring.
d) Before further more severe / harsher testing be envisaged then a completed and thorough Risk Analysis should be implemented so as Safety is assured.

13. CONCLUSIONS.

It is a fact that correctly maintained bearings / brakes as well as loading / speed (within tyre specifications) of tyres will provide safer vehicle operation. Also important are correctly maintaining Tyre Pressures and Temperatures.

Safework, Mining and other Authorities acknowledge that critical to optimum tyre life, equipment and personnel safety is the gathering of data through monitoring and data logging technologies mounted on mobile plant. TMS technologies can monitor and record tyre pressure, temperature, speed and other parameters to improve safety and reduce associated risk events.

Subsequently, it is clear that potential use of a qualified TMSystem will improve safety on vehicles used in the Heavy Transport Industry and will potentially mitigate risks resulting from Tyre, Bearing and Brake failures as described above. By far, mitigation of risks are more enhanced than not using such technology!

14. APPENDICES.

Appendix A – Test 1: Brake Failure Simulation – Raw TMS Data Position 1

Location	Time	Pressure (PSI)	Tyre Air Temp. (°C)	Speed (km/h)
POS 1	10:01:36 AM	100.2	27.0	0
POS 1	10:13:07 AM	101.0	34.0	0
POS 1	10:18:36 AM	101.8	30.0	95
POS 1	10:18:48 AM	101.8	30.0	95
POS 1	10:24:27 AM	101.8	25.0	97
POS 1	10:35:35 AM	102.6	26.0	11
POS 1	10:35:47 AM	102.6	26.0	11
POS 1	10:41:15 AM	101.8	27.0	97
POS 1	10:47:06 AM	101.8	28.0	64
POS 1	10:52:35 AM	102.6	27.0	11
POS 1	10:52:46 AM	102.6	27.0	53
POS 1	10:58:14 AM	103.4	27.0	89
POS 1	10:58:26 AM	103.4	27.0	89
POS 1	11:09:34 AM	101.8	26.0	0
POS 1	11:09:45 AM	101.8	26.0	0
POS 1	11:26:33 AM	101.8	29.0	0
POS 1	11:26:44 AM	101.8	29.0	0
POS 1	11:38:04 AM	102.6	28.0	69
POS 1	11:49:13 AM	103.4	28.0	23
POS 1	12:00:44 PM	103.4	28.0	97
POS 1	12:06:13 PM	103.4	29.0	97
POS 1	12:17:44 PM	103.4	34.0	0
POS 1	12:28:54 PM	103.4	34.0	53
POS 1	12:45:54 PM	104.2	29.0	61
POS 1	12:51:34 PM	104.2	29.0	11
POS 1	12:51:45 PM	103.4	28.0	50
POS 1	12:57:14 PM	104.2	29.0	16

Appendix B – Test 1: Brake Failure Simulation – Raw TMS Data Position 2

Location	Time	Pressure (PSI)	Tyre Air Temp. (°C)	Speed (km/h)
POS 2	10:03:23 AM	106.6	25.0	0
POS 2	10:14:35 AM	106.6	25.0	8
POS 2	10:14:46 AM	107.4	25.0	8
POS 2	10:20:17 AM	108.2	25.0	84
POS 2	10:25:58 AM	109.0	25.0	97
POS 2	10:37:32 AM	111.3	26.0	85
POS 2	10:48:43 AM	112.1	29.0	84
POS 2	10:54:35 AM	112.1	28.0	77
POS 2	11:00:16 AM	112.9	29.0	89
POS 2	11:11:37 AM	112.1	33.0	0
POS 2	11:22:57 AM	111.3	34.0	0
POS 2	11:28:26 AM	110.5	34.0	0
POS 2	11:28:37 AM	110.5	34.0	0
POS 2	11:34:06 AM	109.8	30.0	85
POS 2	11:39:47 AM	112.1	28.0	97
POS 2	11:45:39 AM	112.9	29.0	85
POS 2	11:51:08 AM	113.7	29.0	76
POS 2	12:02:41 PM	113.7	29.0	69
POS 2	12:08:10 PM	112.9	30.0	87
POS 2	12:19:42 PM	112.9	33.0	0
POS 2	12:25:11 PM	112.9	33.0	0
POS 2	12:30:51 PM	112.1	32.0	60
POS 2	12:31:02 PM	112.1	32.0	60
POS 2	12:36:42 PM	112.1	31.0	85
POS 2	12:42:11 PM	112.9	29.0	71
POS 2	12:53:44 PM	112.1	30.0	64

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Appendix C – Test 1: Brake Failure Simulation – Raw TMS Data Position 5

Location	Time	Pressure (PSI)	Tyre Air Temp. (°C)	Speed (km/h)
POS 5	10:02:03 AM	104.2	24.0	0
POS 5	10:07:30 AM	105.0	24.0	0
POS 5	10:13:19 AM	105.0	25.0	0
POS 5	10:18:57 AM	105.8	26.0	95
POS 5	10:30:02 AM	107.4	30.0	79
POS 5	10:30:13 AM	107.4	30.0	79
POS 5	10:41:29 AM	109.0	43.0	97
POS 5	10:46:57 AM	109.8	46.0	64
POS 5	10:58:14 AM	109.8	38.0	89
POS 5	10:58:26 AM	109.8	38.0	89
POS 5	11:03:53 AM	109.0	32.0	0
POS 5	11:04:04 AM	109.0	32.0	0
POS 5	11:15:09 AM	109.0	35.0	0
POS 5	11:15:20 AM	109.8	35.0	0
POS 5	11:32:05 AM	109.0	43.0	72
POS 5	11:32:17 AM	109.8	43.0	72
POS 5	11:37:44 AM	109.8	39.0	69
POS 5	11:37:55 AM	109.8	39.0	69
POS 5	11:43:33 AM	110.5	43.0	16
POS 5	11:49:01 AM	110.5	37.0	31
POS 5	11:54:50 AM	111.3	42.0	82
POS 5	12:00:18 PM	111.3	36.0	97
POS 5	12:00:29 PM	111.3	35.0	97
POS 5	12:05:56 PM	111.3	39.0	97
POS 5	12:11:35 PM	111.3	40.0	0
POS 5	12:11:46 PM	111.3	41.0	0
POS 5	12:17:14 PM	112.1	49.0	0
POS 5	12:17:25 PM	112.9	49.0	0
POS 5	12:22:53 PM	111.3	37.0	0
POS 5	12:28:31 PM	110.5	32.0	53
POS 5	12:28:42 PM	110.5	32.0	53
POS 5	12:34:09 PM	110.5	32.0	76
POS 5	12:34:20 PM	111.3	32.0	76
POS 5	12:45:25 PM	112.1	30.0	72
POS 5	12:51:03 PM	111.3	30.0	48
POS 5	12:51:14 PM	112.9	30.0	11

Appendix D – Test 1: Brake Failure Simulation – Raw TMS Data Position 6

Location	Time	Pressure (PSI)	Tyre Air Temp. (°C)	Speed (km/h)
POS 6	10:00:23 AM	105.0	24.0	50
POS 6	10:06:10 AM	105.8	26.0	0
POS 6	10:11:34 AM	105.8	26.0	0
POS 6	10:17:21 AM	105.8	27.0	84
POS 6	10:28:22 AM	112.9	54.0	10
POS 6	10:28:33 AM	112.9	55.0	16
POS 6	10:34:13 AM	115.3	65.0	74
POS 6	10:38:28 AM	118.5	76.0	85
POS 6	10:39:45 AM	119.3	81.0	97
POS 6	10:39:56 AM	118.5	81.0	97
POS 6	10:40:31 AM	121.7	86.0	97
POS 6	10:42:21 AM	121.7	104.0	97
POS 6	10:42:28 AM	118.5	105.0	97
POS 6	10:43:04 AM	117.7	117.0	97
POS 6	10:45:33 AM	55.5	115.0	77
POS 6	10:45:49 AM	41.1	108.0	10
POS 6	10:46:01 AM	41.9	107.0	19
POS 6	10:46:21 AM	36.4	105.0	19
POS 6	11:27:45 AM	121.7	46.0	0
POS 6	11:27:56 AM	122.5	48.0	0
POS 6	11:31:42 AM	120.9	62.0	72
POS 6	11:43:14 AM	123.3	73.0	16
POS 6	11:48:55 AM	124.1	63.0	85
POS 6	11:54:25 AM	125.7	72.0	82
POS 6	11:54:36 AM	125.7	72.0	82
POS 6	12:00:18 PM	125.7	59.0	97
POS 6	12:05:46 PM	125.7	65.0	97
POS 6	12:11:27 PM	127.3	80.0	0
POS 6	12:22:59 PM	121.7	60.0	0
POS 6	12:23:11 PM	122.5	61.0	0
POS 6	12:28:09 PM	119.3	59.0	8
POS 6	12:39:54 PM	117.7	37.0	77
POS 6	12:45:31 PM	116.1	35.0	61
POS 6	12:45:42 PM	116.1	35.0	61
POS 6	12:56:45 PM	116.1	33.0	19
POS 6	12:56:56 PM	116.1	34.0	16

■ Report for: TYRE MONITORING SYSTEM- ROCKY'S OWN TEST REPORT

Appendix E – Test 2: Wheel Bearing Failure Simulation – Raw TMS Data

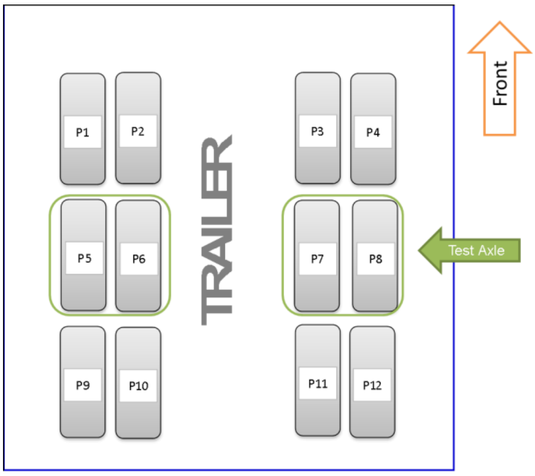
Location	Time (min)	Pressure (PSI)	Tyre Air Temp. °C	Speed (km/h)
POS 7		109.0	30.0	0
POS 7	10	109.0	31.0	63
POS 7		109.0	31.0	63
POS 7	20	110.5	32.0	89
POS 7		110.5	36.0	53
POS 7	30	112.9	38.0	93
POS 7		112.9	44.0	11
POS 7	40	112.9	39.0	93
POS 7		112.9	39.0	26
POS 7	50	112.9	39.0	16
POS 8		109.0	28.0	0
POS 8	10	109.0	29.0	66
POS 8		111.3	31.0	53
POS 8	20	112.1	32.0	93
POS 8		112.9	31.0	93
POS 8	30	112.9	40.0	8
POS 8		112.9	40.0	8
POS 8	40	112.9	40.0	93
POS 8		113.7	40.0	26
POS 8	50	115.3	46.0	16

Appendix G: P6 (Inner Tyre) Locked brake test pressure / temperature data.

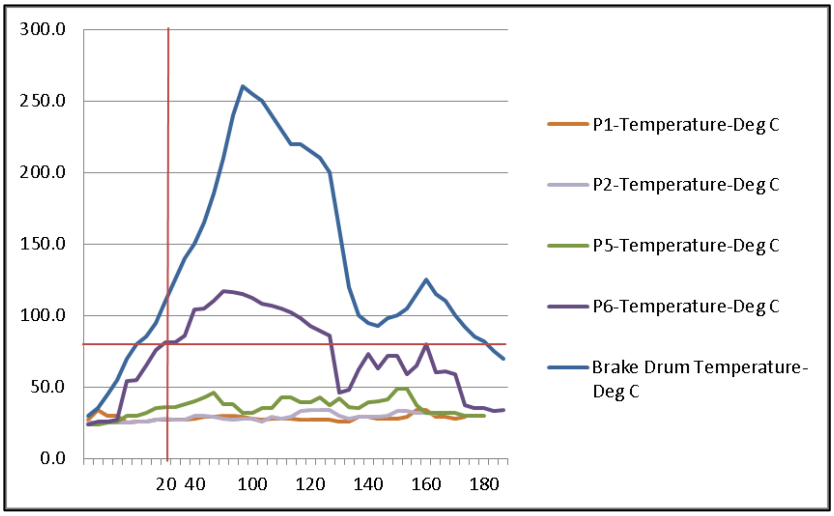
Tyre Position	Time	Pressure	Temperature	Speed km/h	Alert Information
Vehicle: Portable Field Test Unit Driver: Not Assigned Last Location: Richardson Road, Rockhampton, Rockhampton Regional, Queensland, 4701, AU Trailer ID: NA					
POS 6	10:00:23 AM	105.0	24.0	50	-
POS 6	10:06:10 AM	105.8	26.0	0	-
POS 6	10:11:34 AM	105.8	26.0	0	-
POS 6	10:17:21 AM	105.8	27.0	84	-
POS 6	10:28:22 AM	112.9	54.0	10	-
POS 6	10:28:33 AM	112.9	55.0	16	-
POS 6	10:34:13 AM	115.3	65.0	74	-
POS 6	10:38:28 AM	118.5	76.0	85	-
POS 6	**10:39:45 AM**	**119.3**	**81.0**	**97**	**High Tire Temp on Tractor POS 6**
POS 6	10:39:56 AM	118.5	81.0	97	-
POS 6	10:40:31 AM	121.7	86.0	97	-
POS 6	10:42:21 AM	121.7	104.0	97	-
POS 6	10:42:28 AM	118.5	105.0	97	-
POS 6	10:43:04 AM	117.7	110.0	97	-
POS 6	10:44:05 AM	113.7	117.0	8	-
POS 6	10:44:53 AM	99.4	116.0	56	-
POS 6	10:45:33 AM	55.5	112.0	77	-
POS 6	10:45:49 AM	41.1	108.0	10	-
POS 6	10:46:01 AM	41.9	107.0	19	-
POS 6	10:46:21 AM	36.4	105.0	19	-
POS 6	10:47:13 AM	(0.3)	102.0	64	-
POS 6	10:47:48 AM	0.5	98.0	84	-
POS 6	10:48:35 AM	(0.3)	93.0	84	-
POS 6	10:48:58 AM	0.5	89.0	84	-

Report for: TYRE MONITORING SYSTEM- ROCKY'S OWN TEST REPORT

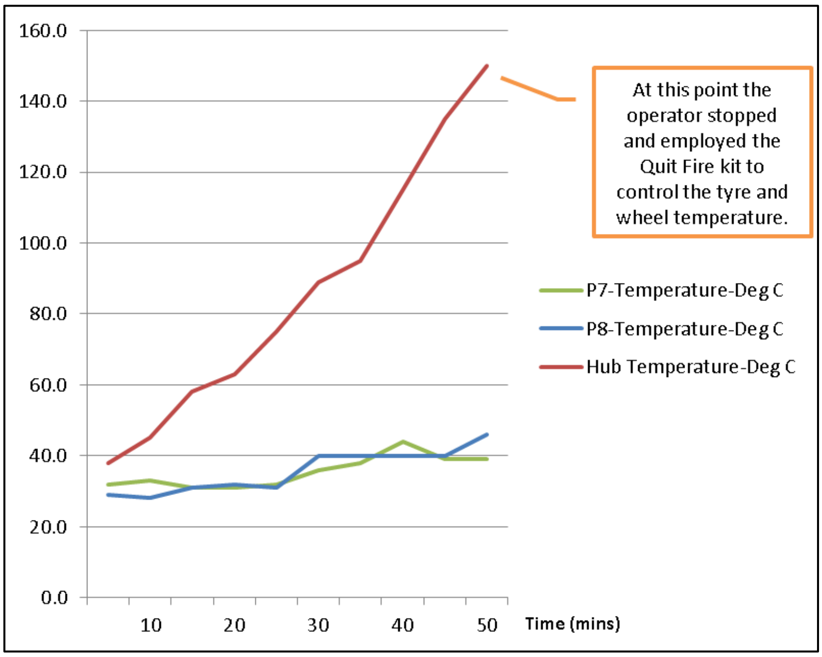
Appendix H: Test positions / Axles Locked Brake / Bearing testing point



Appendix I: Data Graph- Figure 8: Tyre vs Brake Drum Temperatures



Appendix J: Data Graph: Figure 11:Tyre vs Hub Temperature



Appendix K: "Quit Fire" Kit

- This kit has been implemented by Rocky's Own Transport to allow the operator to control some incidents immediately.
- The kit consists of a tank under the trailer with a fire retardant and water mixture. This mixture is delivered using compressed air through a hose long enough to reach all tyres on the trailer.
- There is sufficient pressure to reach the tyres from a safe distance while maintaining the 45^0 angle.