European Tyre and Rim Technical Organisation

RETREADED TYRES
IMPACT OF CASING AND RETREADING PROCESS ON RETREADED TYRES LABELLED PERFORMANCES

Content

1. EXECUTIVE SUMMARY

Truck tyres are typically collected after service and reused as part of a routine tyre retreading process, delaying their disposal and enhancing the environment through recycling. A used tyre can be restored after applying a new tread onto the casing via hot or cold process. The factors that play a role in the performance of a retreading tyre are related to the type, use and age of the casing as well as the tread characteristics and its related building process. The contribution of each and every factor largely varies based on the available range of casings, treads and processing conditions selected for the manufacturing of retreaded tyres.

In order to better understand how the labelling scheme could be extended to include retreaded tyres, as requested by article 14 of Regulation (EC) No 1222/2009 published in December 2009, ETRTO (European Tyre and Rim Technical Organization) has conducted and financed an extensive research program to assess the situation and impact of the relevant factors on the three performances labelled by R1222-2009.

Two Designs of Experiment have been organized in order to:

- Check the impact of the collected casing on the rolling resistance of the retreaded tyre,
- Check the impact of the manufacturing process on the rolling resistance, wet adherence and sound emission of the retreaded tyre.

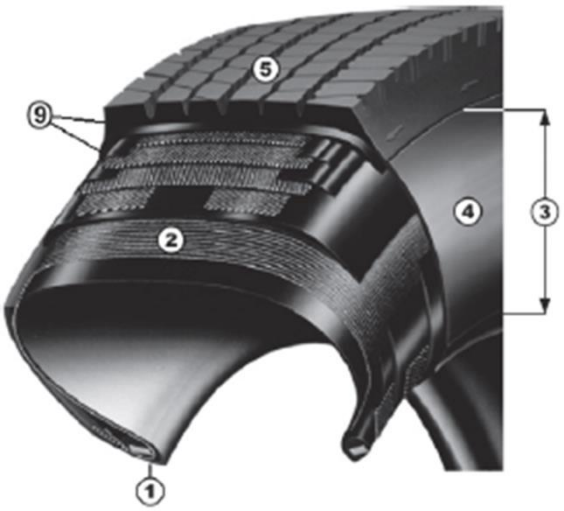
This document summarizes the findings of these experiments, and includes all the data resulting from the experiments.

About wet adherence and sound emission, the experiment has proven that the manufacturing process impacts, hence being noticeable, should most probably be mastered by retread industry, in a manner which could be sustainable, applying the current labelling scheme for C3 tyres.

About rolling resistance, the experiments have proven that casing impact and manufacturing process have a big impact, which can be partially mastered for manufacturing process, but cannot be mastered for the casing impact. Then, with current retreading operations, RR retreading labelling scheme same as new tyre is not feasible, unless every single retreaded tyres is tested individually, which is not sustainable for the retreading industry.

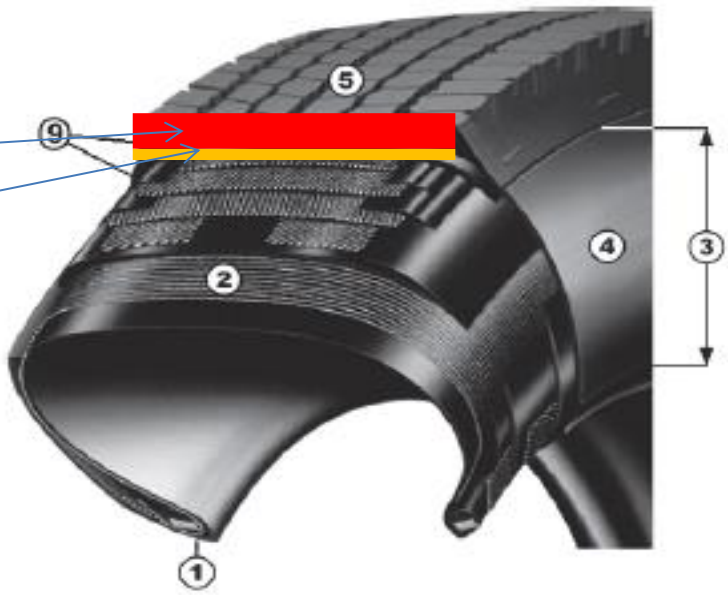
In order to find if any suitable scheme for rolling resistance performance could be available and sustainable for retread industry, further experiment should be organized, before making a decision.

2. RETREADED TYRES: REMINDER OF CONCEPT, DEFINITION AND VOCABULARY

#	Name	Definition	
1	Bead	That part of the casing which is shaped to fit the rim	
2	Carcass/Casing	Rubber bounded cord structure of a tyre integral with the bead, which contains the inflation pressure	
3	Sidewall	Part of the pneumatic between the tread and the bead	
4	Sidewall rubber	Rubber layer on the sidewall	
5	Tread	Part of the pneumatic tyre which normally comes in contact with ground and will be worn	
9	Belts	Layer of material under the tread, that restricts the carcass in a circumferential direction	

Retread rubber

Cushion rubber



Retread:
To replace the worn tread (5) by a new cushion rubber and a new tread, reusing the existing casing which represents about ¾ of the total weight

3. IMPACT OF CASING ON RETREADED TYRE ROLLING RESISTANCE

Since a retreaded tyre is built from independent casing and tread and since the casing is the major contributor for rolling resistance, ETRTO has considered it was essential to check the casing influence on the total rolling resistance of a retreaded tyre, which basically is the rolling resistance of the casing added to the rolling resistance of the tread.

3.1. RESULTS SUMMARY

The data show that the casing used to build the retreaded tyre strongly impacts the rolling resistance of the retreaded tyre, since a retreaded tyre built with the same process, material and parameters but different casing could cover up to 3 labels depending of the casing used for the retread.

The retreader, not mastering the incoming casing rolling resistance, will not be able to master the retreaded tyre rolling resistance, unless measuring each casing, which is not industrially and economically feasible.

It will then not be possible to predict with any reasonable accuracy what will be the final class of a retreaded tyre, using the current labelling scheme.

3.2. DESIGN OF EXPERIMENT DESCRIPTION

In order to understand and measure the impact of the casing used to build a retreaded tyre on its rolling resistance, which is one of the three performances labelled under the European Union 1222/2009 regulation, ETRTO has designed and performed a design of experiment.

Based on each member experience, the design of experiment, run in 2012, has been set as follows:

- Four major companies participated in the study
- The experiments were conducted on two very popular sizes
  - 315/80 R 22.5 Drive or 385/65 R 22.5 Trailer
- Casings have been collected with 2 levels of criteria
  - Age: ≤ 3 years or ≥ 5 years
  - Type of use: Regional or long haul
  - Region of use: Northern Europe or Southern Europe
  - Number of retreadings: First retread or second retread
- Three repetitions were made for each experiment, and one spare casing was also collected
- Each set of casings was retreaded with a hot process and another identical set with a cold process.
- The compounds used for cold and hot retreading were as close to identical as possible (with however different curing parameters)
- All the retreads were made in the same factory at approximately the same time
- One casing of each set was measured for RR using the ISO 28580 conditions before retreading operation
- 3 retreaded tyres from each set were measured for RR using ISO 28580 conditions
- A total of 224 casings were collected and 223 RR measurements were made (100% of retreaded tyres, 33% of the buffed casing, 1 casing was damaged)

The resulting data are available in § 8.1 Design of Experiment “Casing Impact” data

3.3. DETAILED RESULTS

3.3.1. Global casing impact

As shown in §2 Retreaded tyres: reminder of concept, definition and vocabulary, retreaded tyres are composed of an existing casing and of a new tread, both having independent performances for RR. Basically, rolling resistance of casing & rolling resistance of tread should be added in order to get the rolling resistance of the retreaded tyre.

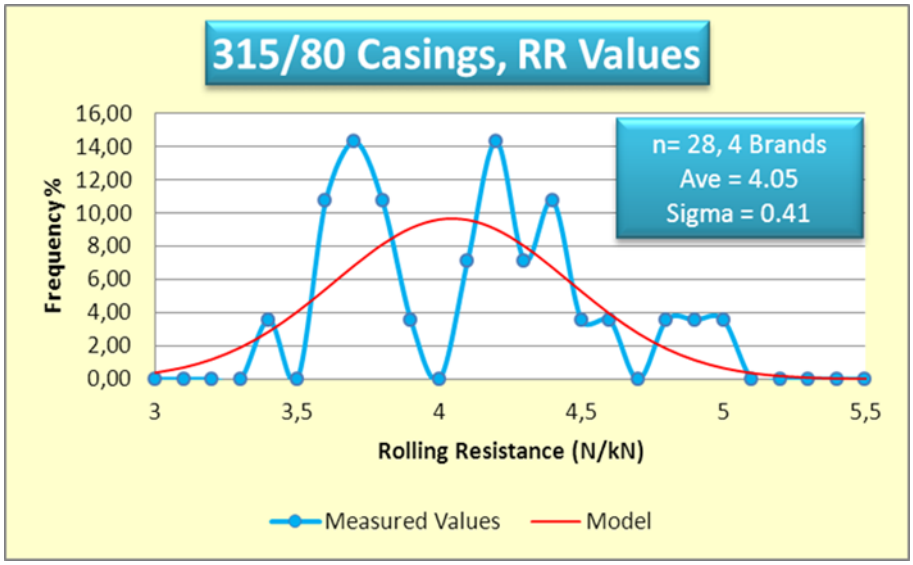
The first step of the survey has then been to analyze the contribution of the casing, the second being to analyze the total rolling resistance of the retreaded tyre.

3.3.1.1. Tyre casing rolling resistance contribution

The first step of the Design of Experiment has been to check the contribution of the casings, by measuring the rolling resistance of the casing (following regulations 1222/2009 and 1235/2011 measurement method and alignment).

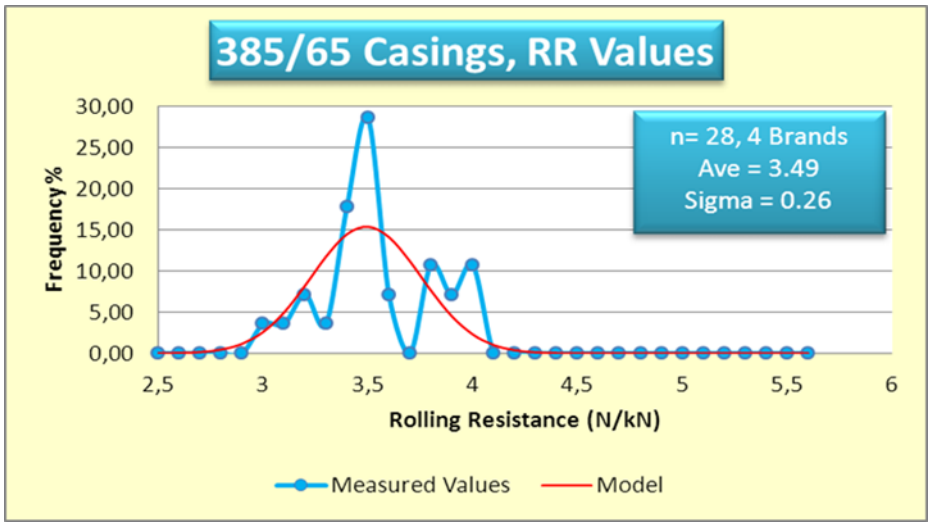
Due to their design, components, materials, usage, casing rolling resistance can vary:

- For 315/80R22.5:



  - On measured data, from 3.4 N/kN to 5 N/kN, meaning a variation of 1.6 N/kN, which can change the label up to 3 classes.
  - Average value being 4.05 N/kN, standard deviation being 0.41 N/kN, and assuming a Gauss repartition, 99.9% of the casings available on market could be in a range of 2.5 N/kN, which can as well change the label up to 3 to 4 classes

- For 385/65R22.5:



  - On measured data, from 3.0 N/kN to 4.0 N/kN, means a variation of 1.0 N/kN, which can change the label up to 2 classes.
  - Average value being 3.49 N/kN, standard deviation being 0.26 N/kN, and assuming a Gauss repartition, 99.9% of the casings available on market could be in a range of 1.6 N/kN, which can change the label up to 2 to 3 classes

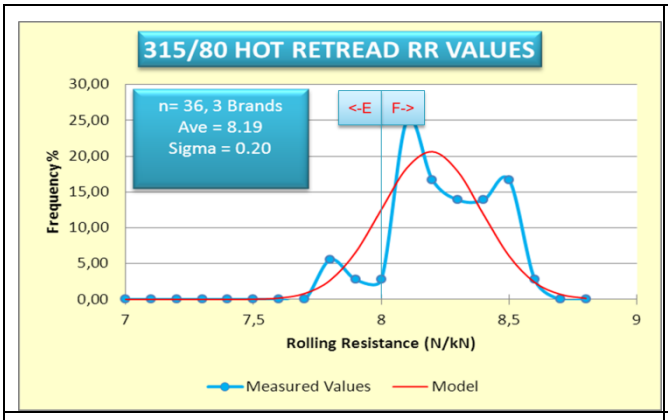
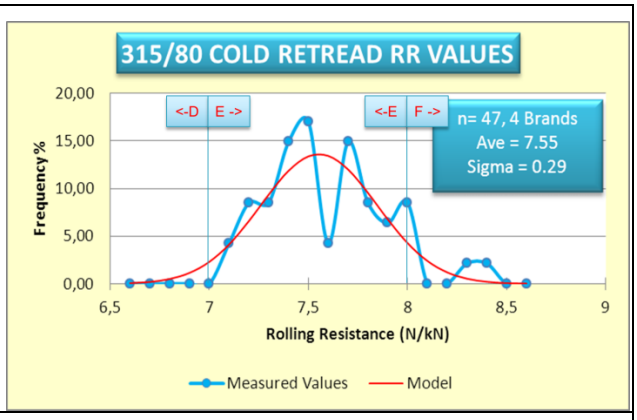
3.3.1.2. Casing impact on retreaded tyre rolling resistance and labels

In the second step, all the available casings have been retreaded, using the cold process for half of the casing and the hot process for the second half.

For each process, hot and cold, the same compound, pattern and parameters have been used.

After retreading, rolling resistance of each retreaded tyre has been measured, following 1222-2009 and 1235-2009 measurement method and alignment.

- For 315/80R22.5:

<table>
<tr>
<td> 
</td>
<td> 
</td>
</tr>
<tr>
<td>On average there is a 23% chance that a hot retreaded 315/80 R 22.5 casing should result in a tyre graded E, and a 77% chance it should be F, without solution to predict which label E/F is the right one.</td>
<td>On average there is a 4% chance that a cold retreaded 315/80 R 22.5 casing will result in a tyre that should be graded D, a 5% chance it should be F, and a 90% chance it should be E. The possible results cover 3 classes of grading, , without solution to predict which label D/E/F is the right one.</td>
</tr>
</table>

- For 385/65R22.5:

<table>
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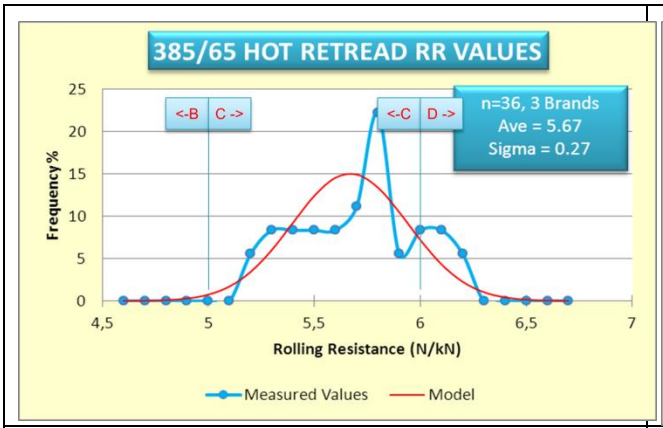
<td> 
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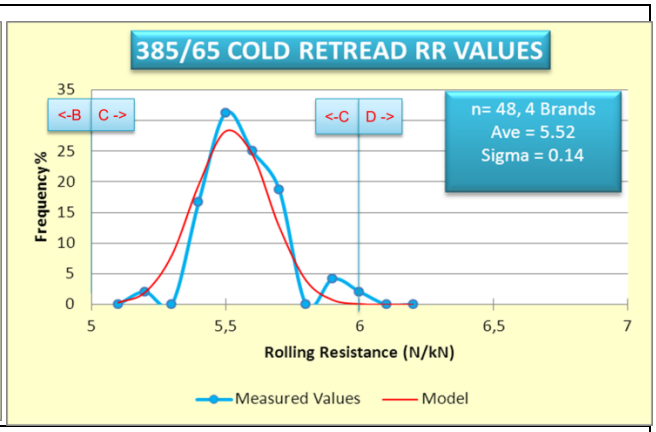
<td> 
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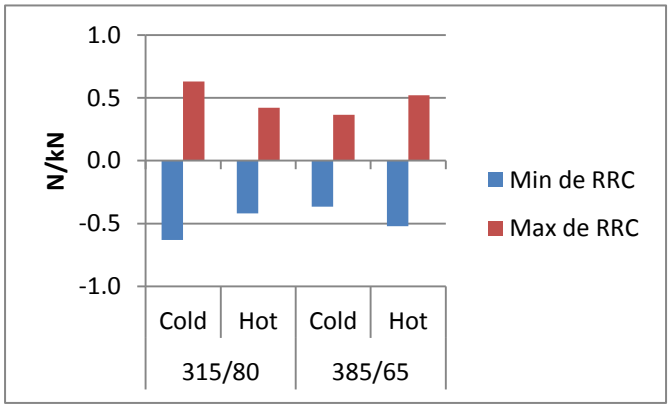
<tr>
<td>On average there is nearly a 5% chance that a hot retreaded 385/65 R 22.5 casing will result in a tyre that should be graded D, and a 95% chance it should be graded C. There is also a small chance it should be B. without solution to predict which label B/C/D is the right one.</td>
<td>On average there is nearly a 100% chance that a cold retreaded 385/65 R 22.5 casing will result in a tyre graded C, because the average of the measured tyres, plus /minus 3 sigma, is equal to a range from 5 to 6, which is same as class C</td>
</tr>
</table>

Data show that rolling resistance of retreaded tyres sample are spread on at least 0.73 N/kN (385/65 Cold), and up to 1.23 N/kN (315/80R22.5 Cold), not including spreading of population assuming a Gauss repartition, which would increase the spread up to 1.74 N/kN with 6 sigma. Depending on the average value, these values indicate that at least 2 labels will be covered by one

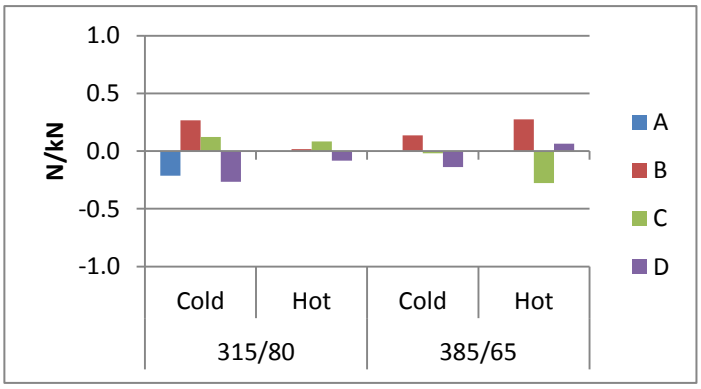
retreaded tyre, using the same process, compound, pattern and parameters, depending on the casing origin.



Global casing impact on rolling resistance:

Comparing the minimal and maximal value of casings of same size retreaded with the same process and same components, these data show again that casing origin (brand, individual casing, and all the other parameters) has a strong impact on the final result, the maximal difference being 1.26 N/kN on the selected sample.

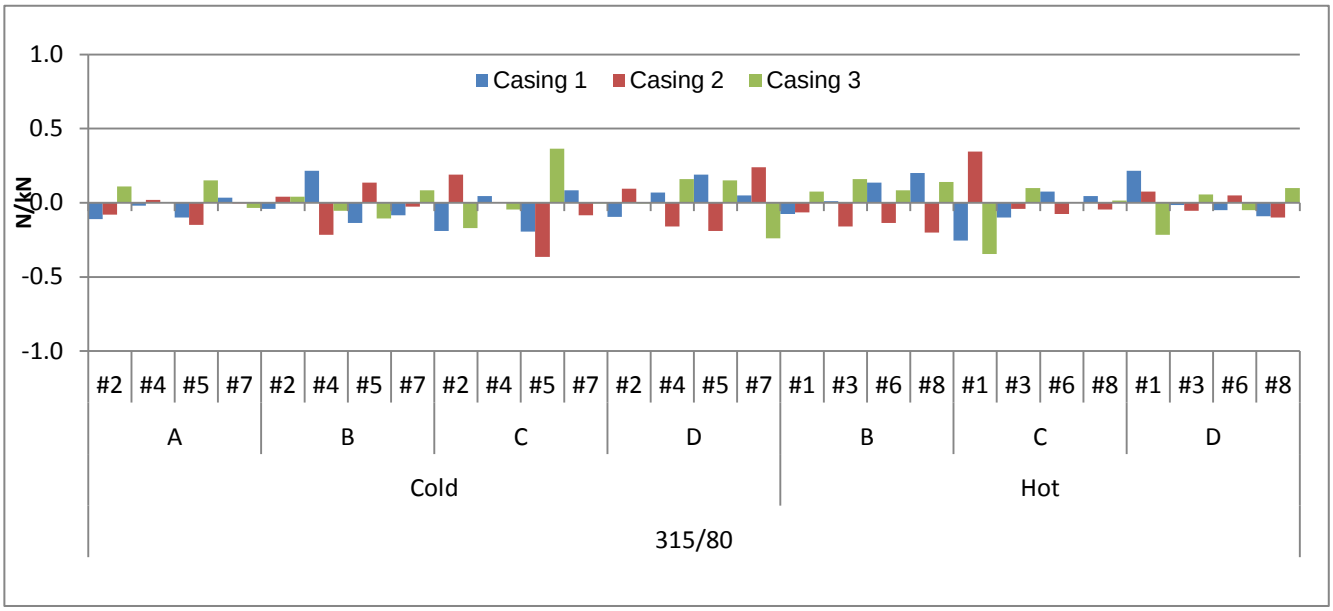
3.3.2. Impact of casing brand



Comparing the average of each casing brand to the central value, these data show that casing brand has a strong impact on the final result (range up to 0.55 N/kN)

3.3.3. Impact of casing unit

Comparison of individual casings, grouped by brand, history, retread parameters, then fully identical



These data show that among identical brand/history, the casing individuals have a strong impact on the final result :

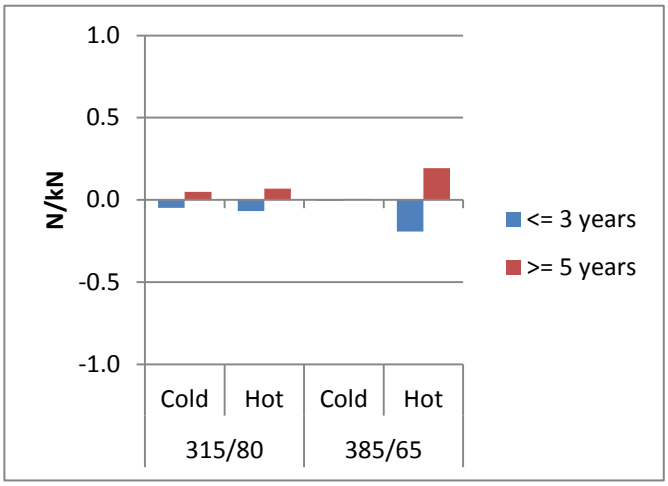
Max impact	0,73	Average impact	0,21	Impact standard deviation	0,17

With the same casing brand, history and retread process, variation can be summarized as follows:

Max variation :	0,73	Average variation :	0,21	standard deviation	0,17

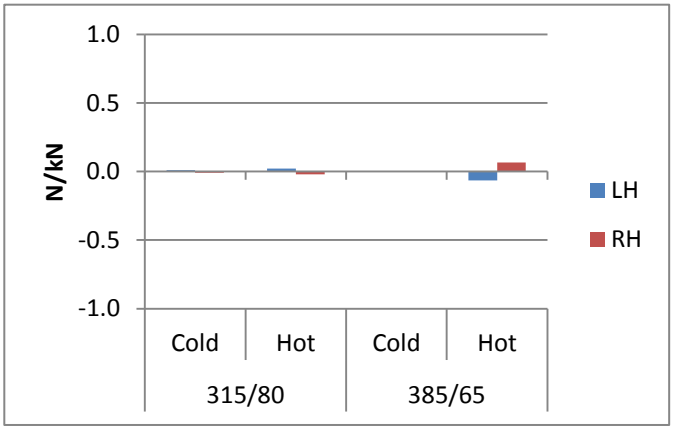
Conclusion is that Individual identical casing (coming from identical tyre model) have a strong impact.

3.3.4. Impact of casing age



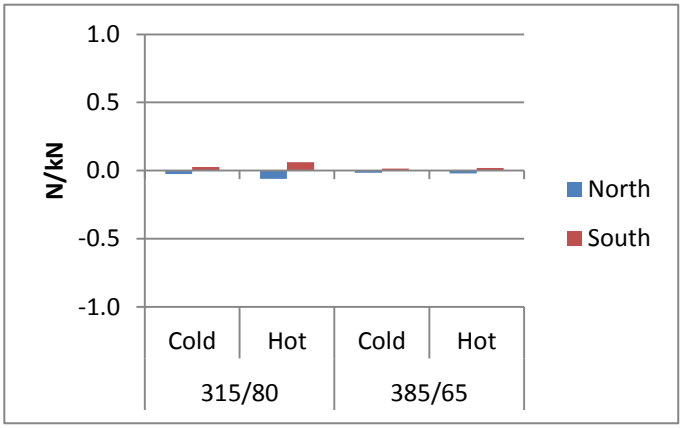
Comparing the average of each casing brand to the central value, these data show that casing age (lower or equal to 3 years, or superior or equal to 5 years), A slight trend of rolling resistance increasing with casing age can be observed, especially for 385/65R22.5 with hot retread. However, the possible impact seems low, and should be confirmed by an extensive survey.

3.3.5. Impact of casing usage (LH = Long Haul, RH = Regional Haul)



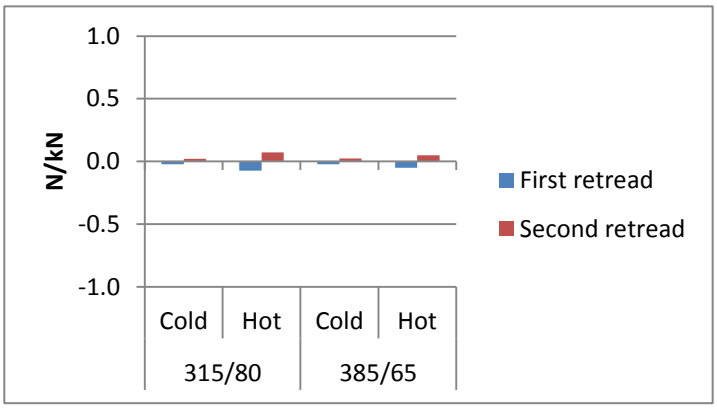
No significant impact can be observed by this survey

3.3.6. Impact of area of usage (North or South)



No significant impact can be observed, with a trend of higher RR for southern sourcing.

3.3.7. Impact of number of retread (first or second retread)



No significant impact can be observed for cold retread. However, for hot retread, a trend to increase of rolling resistance with number of retread can be observed. To be confirmed.

No significant impact can be observed for cold retread. However, for hot retread, a trend to increase of rolling resistance with number of retread can be observed. To be confirmed.

3.4. CONCLUSION ON CASING IMPACT ON ROLLING RESISTANCE OF RETREADED TYRE

The clearly relevant factors having an impact on retreaded tyre rolling resistance are **the brand** of the casing, and the casing variability among identical casings, causing the final retreaded tyre label spreading **on at least one label and up to 3 labels**. Other factors, individually considered, seem to have a low or non-significant impact. However, all the factors, considered together, could reach a significant level, potentially shifting a label from one class to another one.

4. IMPACT OF RETREADING PROCESS ON THE LABELLED TYRE PERFORMANCES

Retreaded tyres are built:

- by various sizes of companies, including small, medium and big enterprises,
- using various processes, machinery, components,
- using variable parameters, depending on regulations, on know-how and habits of retreaders, and on casing used for the retread.

ETRTO has considered it was essential to check the process parameters influence on the three performances labelled by European Union regulation 1222/2009 and 1235/2011.

4.1. RESULTS SUMMARY

The data show that some of the parameters used to build the retreaded tyre will impact the labelling of the retreaded tyre. However, since the parameters are chosen by the retreader, depending on his technologies, know-how and habits, the impact of the parameters on the labelling can be at least partially mastered.

Cold process	Buffing radius	Curing temperature	Curing time	Remaining rubber	Cushion gauge
Rolling resistance	medium	Low	Low	Low	Low
Sound emission	Low	Low	Low	Low	Low
Wet adherence	Low	Low	Low	Low	Low

Hot process	Buffing radius	Curing temperature	Curing time	Remaining rubber	Cushion gauge
Rolling resistance	High	High	Low	Low	Low/High[1]
Sound emission	Low	Low	Low	Low	Low
Wet adherence	Low	Low	Low	Low	Low

[1] 385/65 has low impact and 315/80 has a high impact. Reason to be confirmed

The only really impacting process parameters for rolling resistance which can be precisely measured are:

- the curing temperature for hot retread, with up to 1.5 label of variation,
- the buffing radius, especially for “narrow” tyres (315/80)

For other parameters, the impacts are low or very low, sometimes medium, especially after considering the precision of the test methods used for wet adherence and sound emission measurements. However, total impact of process, when adding the impacts, can become noticeable.

In order to be able to master the 3 labelled performances of a retreaded tyre, it will then be necessary to master the retreading parameters. This is possible for most of the parameters (curing time and temperature, cushion gauge…). However, some parameters have to be tuned depending on the casing geometry, which could require different buffing radius or remaining rubber… The mastering level of retreading process will then be lower for retreaded tyres than for new tyres.

Note:
For noise performance, “low” means less than 0.5 dB(A), “medium” means less than 1 dB(A)
For wet performance, “low” means less than 5 WGI, “medium” means less than 10 WGI
For rolling resistance, “low” means less than 0.3 N/kN, “medium” means less than 0.6 N/kN

4.2. DESIGN OF EXPERIMENT DESCRIPTION

In order to understand and measure the impact of the parameters used to build a retreaded tyre on it's rolling resistance, wet adherence and sound emission, which are the three performances labelled under the European Union 1222/2009 regulation, ETRTO has designed and performed a second design of experiment.

Based on each member experience, the design of experiment, run in 2015, has been set as follows:

- Five major companies participated in the study,
- The experiments were conducted on two very popular sizes
  - 315/80 R 22.5 Drive or 385/65 R 22.5 Trailer
- Five parameters have been surveyed, each of them with 2 different values:
  - Buffing radius, with values 800 and 2000mm,
  - Remaining rubber after buffing, with values 1 and 4 mm,
  - Cushion gauge, with values 1.5 and 3 mm,
  - Curing temperature, with values 95 and 125 for cold retread, 135 and 160 for hot retread
  - Curing time, with values 4 and 8 hours for cold retread, 110 and 145 minutes for hot retread
- Four repetitions were made for each experiment, 3 being measured for rolling resistance using ISO 28580 conditions, the fourth one being only use to allow wet adherence and sound emission measurements.
- The same casing (coming from new tyres of the same brand manufactured during the same period) have been used for each size,
- The same precured treads have been used for cold retreads,
- The same compound for all hot retread has been used, as well as the same mold,
- All the retreads were made in the same factory at approximately the same time
- One casing of each set was measured for RR using the ISO 28580 conditions before retreading operation
- Each set of 4 identical retreaded tyres have been measured for wet adherence and noise following the method requested by EU regulation 1222-2009

The resulting data are available in

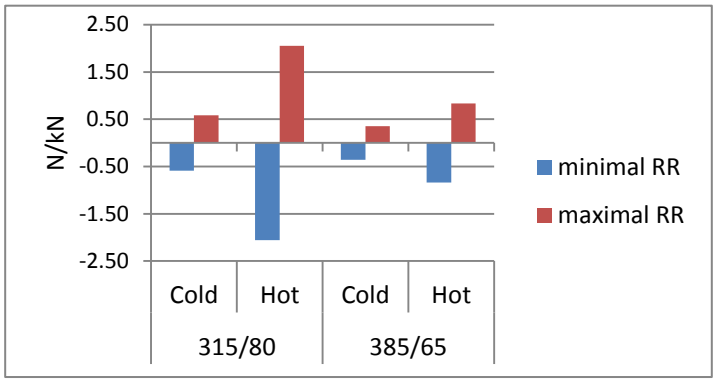
- § 8.2 Design of Experiment "Process Impact" data for rolling resistance
- § 8.3 Design of Experiment "Process Impact" data for sound emission and wet adherence

4.3. DETAILED RESULTS FOR ROLLING RESISTANCE

This section will study and compare impact of all the chosen parameters.

Except for the global impact, each factor is presented with the same scale, to allow a comparison of impact.

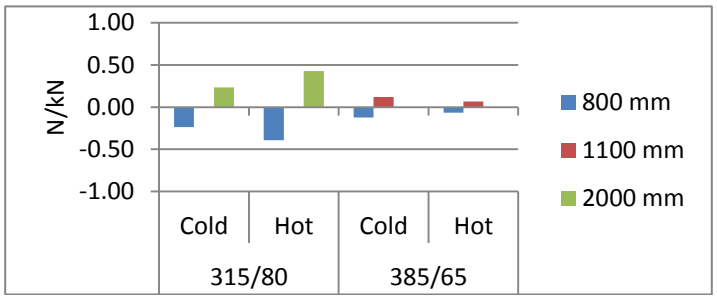
4.3.1. Global parameters impact



Globally, process parameters can change the rolling resistance value by up to 4 N/kN, which represents 4 labels.

It must be observed that new tyres have been used for retreading, in order to make sure to have identical casings. Casing obtained from new tyres having a smaller diameter than worn tyres casing, the variation obtained for hot tyres may be higher than the variation which could be observed when retreading worn tyres.

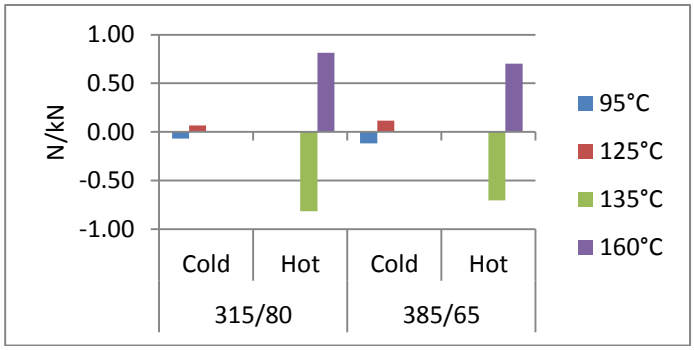
4.3.1. Buffing Radius impact



Impact of buffing radius is high.

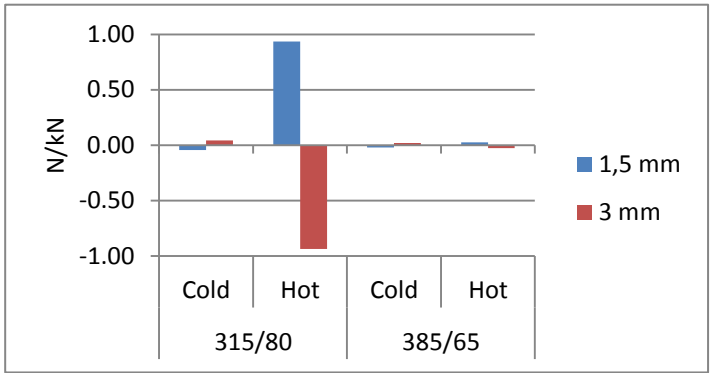
It should be noted that buffing radius has sometimes to be tuned depending on the shape of the casing. For the same process and the same component, the retreader can choose different buffing radius, depending on the casing geometry.

4.3.2. Curing temperature impact



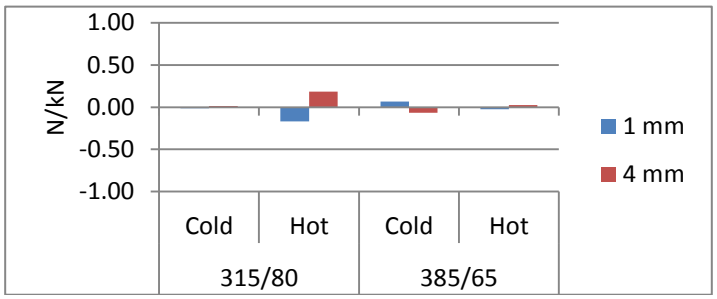
Impact of curing temperature is high for hot retread, whatever is the size, and lower for cold retread

4.3.3. Cushion Gauge impact



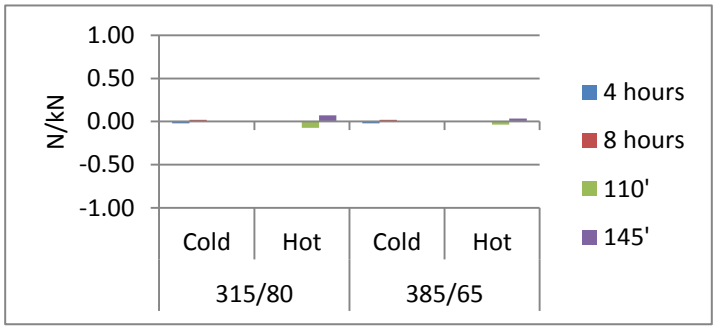
Impact of cushion gauge is low, except for 315/80R22.5 with hot retread, where the data should be further analyzed, since more rubber left surprisingly decreases the rolling resistance

4.3.4. Remaining Rubber impact



Impact of remaining rubber is low, reaching up to 0.35 N/kN for the 315/80R22.5 hot retread, but lower for other configuration

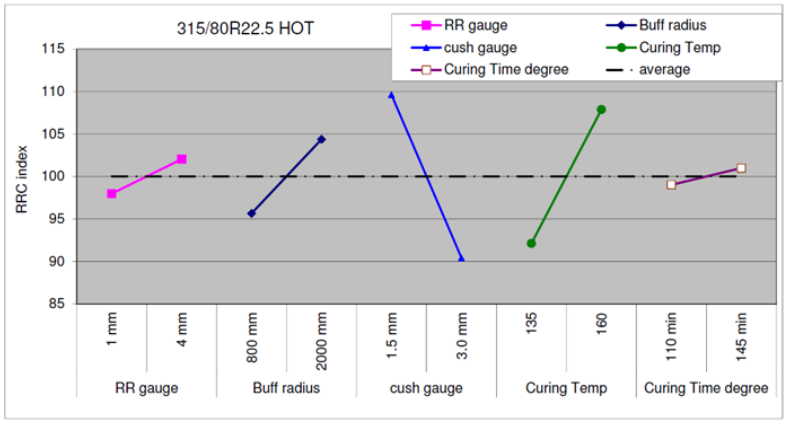
4.3.5. Curing time impact



Impact of curing temperature is high for hot retread, whatever is the size, and lower for cold retread

4.3.6. Comparison of parameters impact

4.3.6.1. 315/80R22.5 HOT retread, Taguchi method analysis

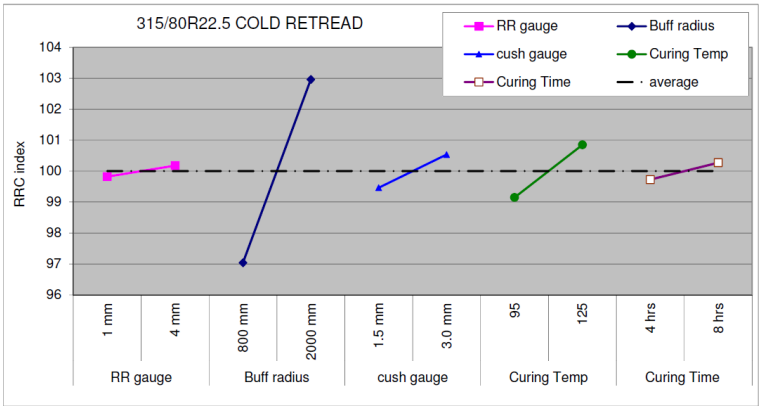


From most influent to less:

- Cushion gauge
- Curing temperature
- Buffing radius
- Remaining Rubber
- Curing time

The cushion gauge impact, indicating more rolling resistance for less material is to be further analyzed.

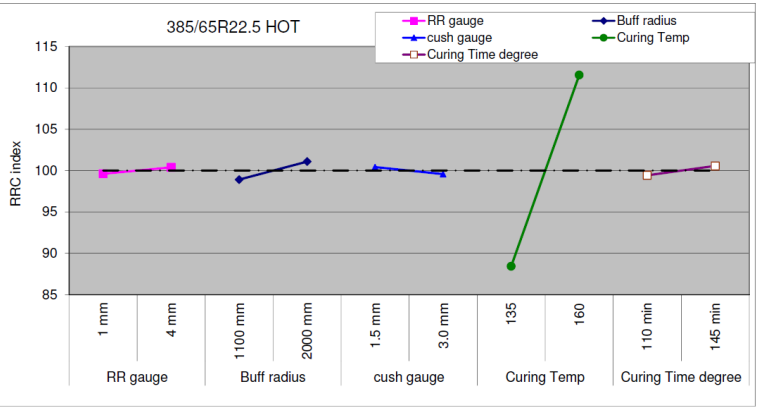
4.3.6.2. 315/80R22.5 COLD retread, Taguchi method analysis



From most influent to less:

- Buffing radius
- Curing temperature
- Cushion gauge
- Curing time
- Remaining Rubber
-

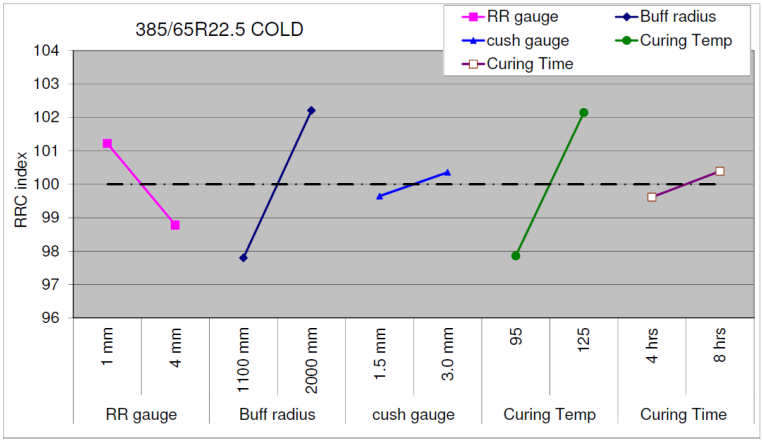
4.3.6.3. 385/65R22.5 HOT retread, Taguchi method analysis



From most influent to less:

- Curing temperature
- Buffing radius
- Curing time
- Remaining Rubber
- Cushion gauge

4.3.6.4. 385/65R22.5 COLD retread, Taguchi method analysis



From most influent to less:

- Buffing radius
- Curing temperature
- Cushion gauge
- Remaining Rubber
- Curing time

4.4. CONCLUSION ON PROCESS IMPACT ON ROLLING RESISTANCE OF RETREADED TYRE

The clearly relevant process parameters having an impact on retreaded tyre rolling resistance are **the curing temperature** of the retreaded tyre and the **buffing radius** of the casing, other parameters having less impact (cushion gauge impact for hot 315/80 to be confirmed). Other factors, globally considered, could have a noticeable impact on rolling resistance, potentially shifting the label by one class. In opposition with the casing situation, most retreading parameters can be mastered by the retreader, allowing to have a certain level of control on the rolling resistance of the retreaded tyre.

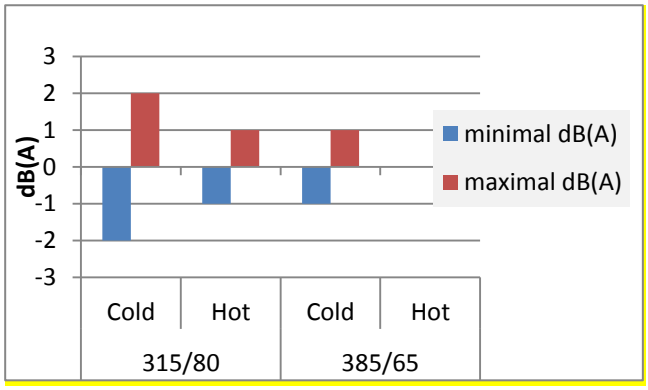
5. RETREADING PROCESS IMPACT ON RETREADED TYRE ROLLING SOUND EMISSION

5.1. DETAILED RESULTS FOR RETREADED TYRE ROLLING SOUND EMISSION

This section will examine then compare impact of all the chosen parameters.

All the graphs are presented with the same scale +/- 3dB(A), so that impacts can be compared. It must be observed that the tyre/road rolling sound emission measurement are always given without decimal number, linked to the measurement precision.

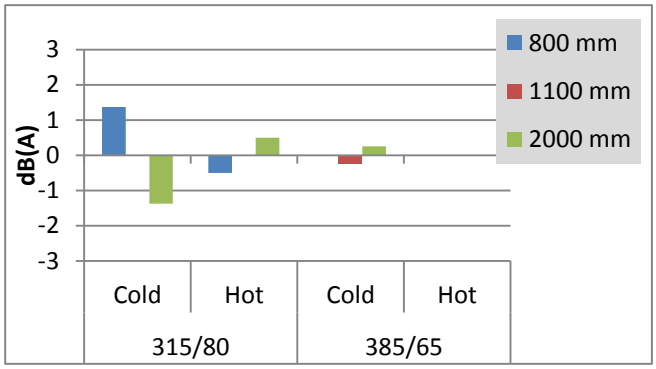
5.1.1. Global parameters impact



Globally, process parameters can change the sound emission value by 4 dB(A).

However, considering the parameters has been chosen with values surrounding the usual parameters in order to show evidence of potential impact, and considering the parameters can be mastered during production process, the conclusion is that process parameters do not show a significant effect on retreaded tyres sound emission

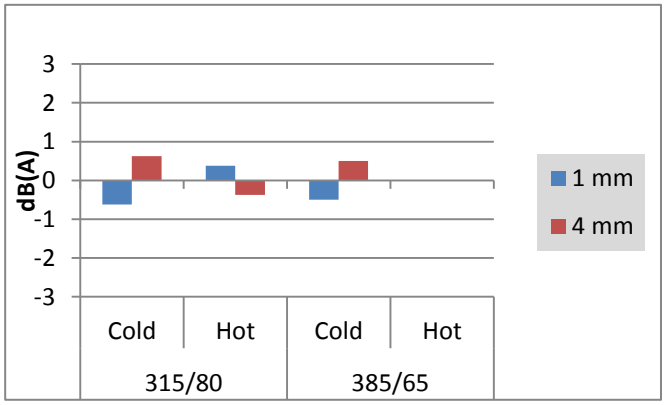
5.1.2. Buffing Radius impact



Buffing radius impact is low, but higher for the 315/80R22.5 retreaded with cold process,.

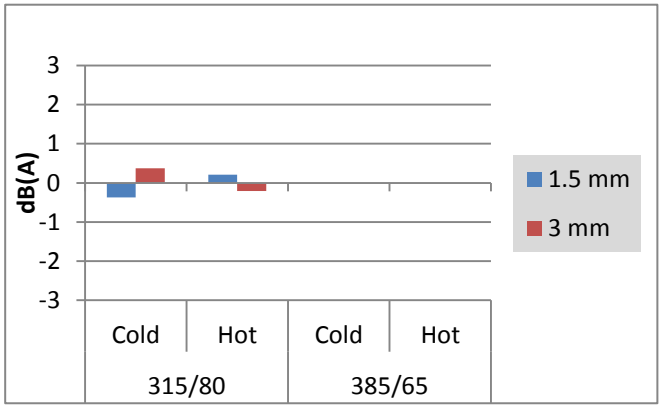
For the 315/80R22.5 Cold, the impact will be reduced by mastering process parameters.

5.1.3. Remaining Rubber impact



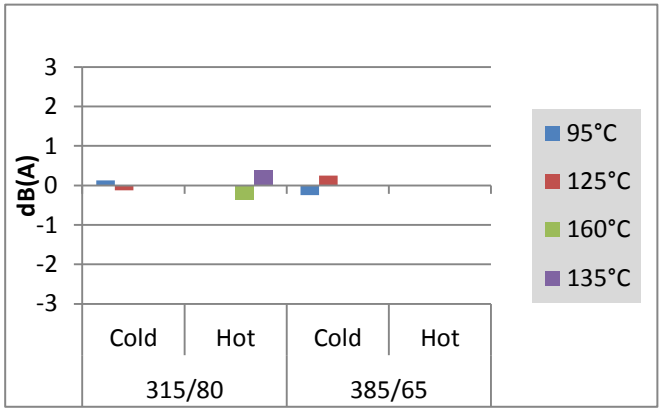
Remaining rubber impact of is low, reaching up to 1.3 dB(A) for the 315/80R22.5 hot retread, but lower for other configuration

5.1.4. Cushion Gauge impact



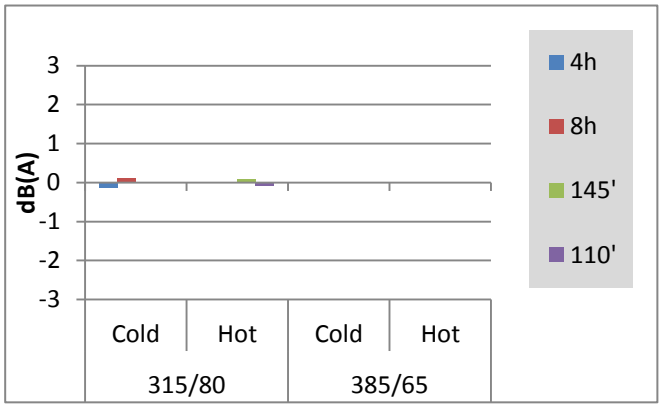
Cushion gauge impact is low

5.1.5. Curing temperature impact



Curing temperature impact is very low

5.1.6. Curing time impact



Curing time impact is very low

5.2. CONCLUSION ON PROCESS IMPACT ON SOUND EMISSION OF RETREADED TYRE

Globally, process parameters can change the sound emission value by 4 dB(A).

However, considering that:

- the chosen parameters surround the usual values, to show evidence of the impacts,
- the parameters can be mastered during production process,
- the precision of tyre rolling sound emission measurement method,

Conclusion is that process parameters do not show a significant effect on retreaded tyres sound emission.

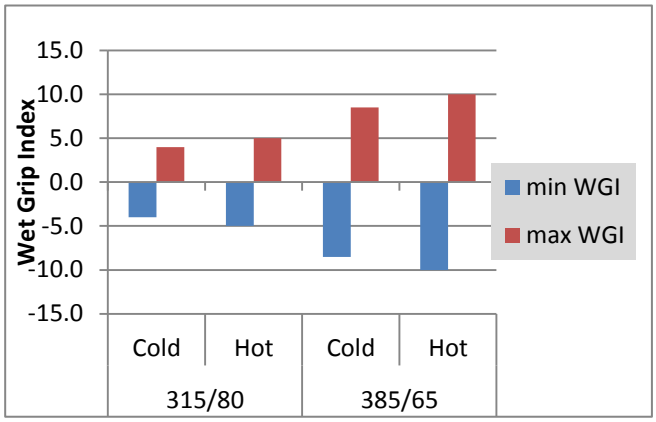
6. RETREADING PROCESS IMPACT ON RETREADED TYRE WET ADHERENCE

6.1. DETAILED RESULTS FOR RETREADED TYRE WET ADHERENCE

This section will examine then compare impact of all the chosen parameters.

All the graphs are presented with the same scale +/- 15 point of wet grip index, so that impacts can be compared.

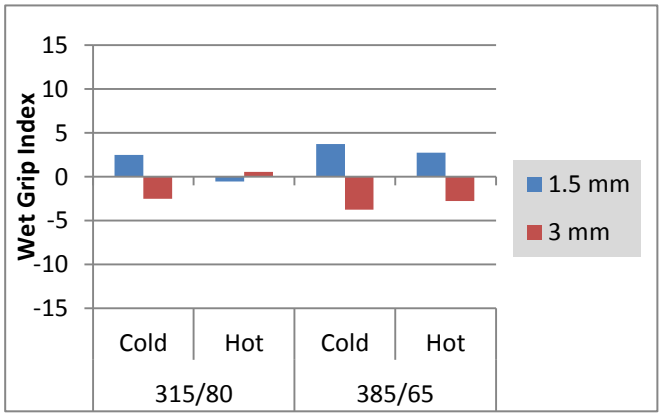
6.1.1. Global parameters impact



Globally, process parameters can change the wet grip index value by 20 points.

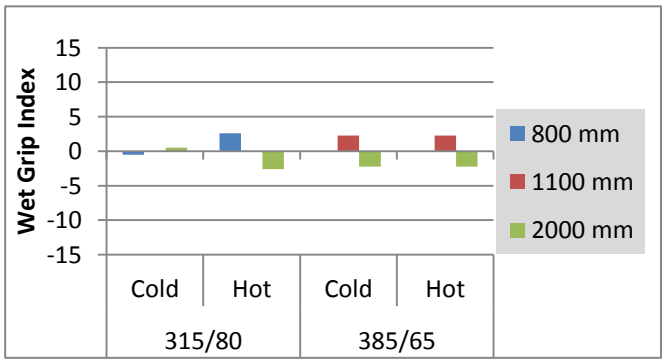
However, considering the parameters has been chosen with values surrounding the usual parameters in order to show evidence of potential impact, and considering the parameters can be mastered during production process, the conclusion is that process parameters do not show a significant effect on retreaded tyres wet adherence

6.1.1. Cushion Gauge impact



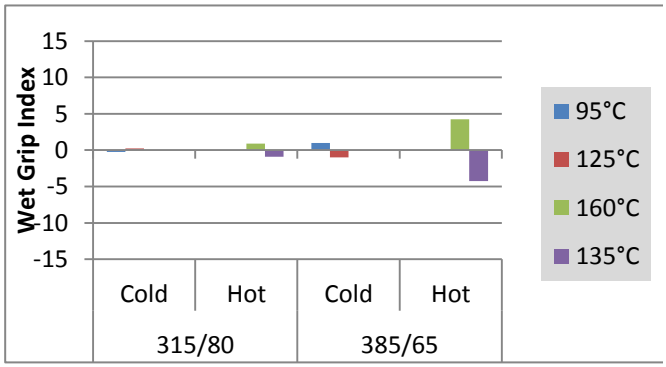
Cushion gauge impact is low

6.1.2. Buffing Radius impact



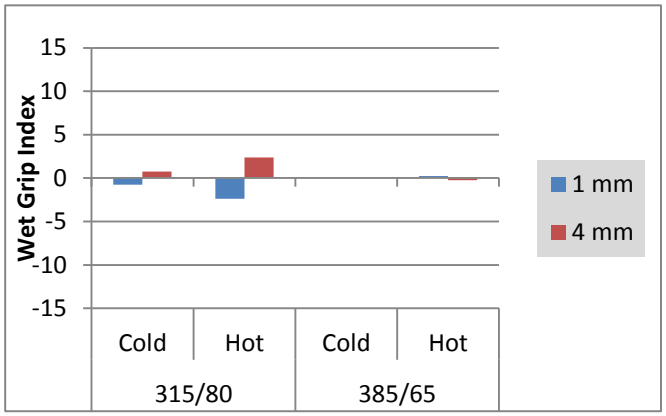
Buffing radius impact is low.

6.1.1. Curing temperature impact



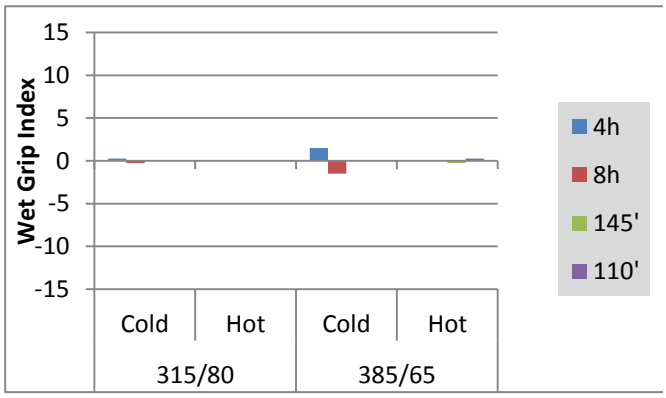
Curing temperature impact is very low, but for 385/65R22.5 with hot process, where impact is low

6.1.2. Remaining Rubber impact



Remaining rubber impact is very low

6.1.3. Curing time impact



Curing time impact is very low

6.2. CONCLUSION ON PROCESS IMPACT ON WET ADHERENCE OF RETREADED TYRE

Globally, process parameters can change wet grip index value by 20 points.

However, considering that:

- the chosen parameters surround the usual values, to show evidence of the impacts,
- the parameters can be mastered during production process,
- the precision of tyre wet adherence measurement method,

Conclusion is that process parameters do not show a significant effect on retreaded tyres wet adherence.

7. CONCLUSIONS

7.1. CONCLUSION ON CASING IMPACT ON ROLLING RESISTANCE OF RETREADED TYRE

The data show that the casing used to build the retreaded tyre strongly impacts the rolling resistance of the retreaded tyre, since a retreaded tyre built with the same process, material and parameters but different casing could cover up to 3 labels depending of the casing used for the retread.

The clearly relevant factors having an impact on retreaded tyre rolling resistance are **the brand** of the casing, and the casing variability among identical casings, causing the final retreaded tyre label spreading **on at least one label and up to 4 labels**. Other factors (age, type of use, region of use and number of retreadings), individually considered, seem to have a low or non-significant impact. However, all the factors, considered together, could reach a significant level, potentially shifting a label from one class to another one.

The retreader, not mastering the incoming casing rolling resistance, will not be able to master the retreaded tyre rolling resistance, unless measuring each casing, which is not industrially and economically feasible.

It will then not be possible to predict with any reasonable accuracy what will be the final class of a retreaded tyre, using the current labelling scheme.

7.2. CONCLUSION ON PROCESS IMPACT ON ROLLING RESISTANCE OF RETREADED TYRE

The clearly relevant process parameters having an impact on retreaded tyre rolling resistance are **the curing temperature** of the retreaded tyre and the **buffing radius** of the casing, other parameters having less impact (cushion gauge impact for hot 315/80 to be confirmed). Other factors, globally considered, could have a noticeable impact on rolling resistance, potentially shifting the label by one class. However, in opposition with the casing situation, most retreading parameters can be mastered by the retreader, allowing to have a certain level of control on the rolling resistance of the retreaded tyre.

7.3. CONCLUSION ON PROCESS IMPACT ON SOUND EMISSION OF RETREADED TYRE

Globally, process parameters can change the sound emission value by 4 dB(A).

However, considering that the chosen parameters surround the usual values (to show evidence of the impacts), that the parameters can be mastered during production process and the precision of tyre rolling sound emission measurement method, the conclusion is that process parameters do not show a significant effect on retreaded tyres sound emission.

7.4. CONCLUSION ON PROCESS IMPACT ON WET ADHERENCE OF RETREADED TYRE

Globally, process parameters can change wet grip index value by 20 points.

However, considering that the chosen parameters surround the usual values, to show evidence of the impacts, that the parameters can be mastered during production process and the precision of tyre wet adherence measurement method, the conclusion is that process parameters do not show a significant effect on retreaded tyres wet adherence.

7.5. CONCLUSION ON LABEL FEASIBILITY

About wet adherence and sound emission, the experiment has proven that the manufacturing process impacts, hence being noticeable, should most probably be mastered by retread industry, in a manner which could be sustainable, applying the current labelling scheme for C3 tyres.

About rolling resistance, the experiments have proven that casing impact and manufacturing process have a big impact, which can be partially mastered for manufacturing process, but cannot be mastered for the casing impact. Then, with current retreading operations, rolling resistance retreading labelling scheme same as new tyre is not feasible, unless every single retreaded tyres is tested individually, which is not sustainable for the retreading industry.

In order to find if any suitable scheme for rolling resistance performance could be available and sustainable for retread industry, further experiment should be organized, before making a decision.

8. ANNEX

8.1. DESIGN OF EXPERIMENT "CASING IMPACT" DATA

Size	Retread Type	DOE. Nr	Casing #	Id. nr.	Brand code	Use	Area	Retread(s)	AgeType	DOT	RRC casing (N/kN)	RRC tire (N/kN)
315/80	COLD	2	1	A2-1	B	LH	N	1	<= 3 years	3710	**3,86**	**7,28**
315/80	COLD	2	2	A2-2	B	LH	N	1	<= 3 years	1111		**7,31**
315/80	COLD	2	3	A2-3	B	LH	N	1	<= 3 years	111		**7,50**
315/80	COLD	4	1	A4-1	B	RH	S	1	<= 3 years	4110	**3,55**	**7,36**
315/80	COLD	4	2	A4-2	B	RH	S	1	<= 3 years	4010		**7,40**
315/80	COLD	4	3	A4-3	B	RH	S	1	<= 3 years	4110		**7,38**
315/80	COLD	5	1	A5-1	B	LH	S	0	<= 3 years	3710	**3,76**	**7,22**
315/80	COLD	5	2	A5-2	B	LH	S	0	<= 3 years	3810		**7,17**
315/80	COLD	5	3	A5-3	B	LH	S	0	<= 3 years	3610		**7,47**
315/80	COLD	7	1	A7-1	B	RH	N	0	>= 5 years	3208	**4,01**	**7,47**
315/80	COLD	7	2	A7-2	B	RH	N	0	>= 5 years	3308		**7,43**
315/80	COLD	7	3	A7-3	B	RH	N	0	>= 5 years	3308		**7,40**
315/80	COLD	2	1	B2-1	C	LH	N	1	<= 3 years	5009	**4,82**	**7,87**
315/80	COLD	2	2	B2-2	C	LH	N	1	<= 3 years	1810		**7,95**
315/80	COLD	2	3	B2-3	C	LH	N	1	<= 3 years	1910		**7,95**
315/80	COLD	4	1	B4-1	C	RH	S	1	<= 3 years	3010	**4,71**	**8,27**
315/80	COLD	4	2	B4-2	C	RH	S	1	<= 3 years	5110		**7,84**
315/80	COLD	4	3	B4-3	C	RH	S	1	<= 3 years	710		**8,00**
315/80	COLD	5	1	B5-1	C	LH	S	0	>= 5 years	4907	**4,37**	**7,61**
315/80	COLD	5	2	B5-2	C	LH	S	0	>= 5 years	3807		**7,88**
315/80	COLD	5	3	B5-3	C	LH	S	0	>= 5 years	4907		**7,64**
315/80	COLD	7	1	B7-1	C	RH	N	0	>= 5 years	4807	**4,46**	**7,63**
315/80	COLD	7	2	B7-2	C	RH	N	0	>= 5 years	307		**7,69**
315/80	COLD	7	3	B7-3	C	RH	N	0	>= 5 years	4707		**7,80**
315/80	COLD	2	1	C2-1	D	LH	N	1	<= 3 years	2111	**4,51**	**7,62**
315/80	COLD	2	2	C2-2	D	LH	N	1	<= 3 years	4510		**8,00**
315/80	COLD	2	3	C2-3	D	LH	N	1	<= 3 years	3310		**7,64**
315/80	COLD	4	1	C4-1	D	RH	S	1	>= 5 years	3308	**4,91**	**7,80**
315/80	COLD	4	3	C4-3	D	RH	S	1	>= 5 years	4208		**7,71**
315/80	COLD	5	2	C5-2	D	LH	S	0	>= 5 years	407	**4,40**	**7,60**
315/80	COLD	5	3	C5-3	D	LH	S	0	>= 5 years	3407		**8,33**
315/80	COLD	5	1	C5-1	D	LH	S	0	>= 5 years	3906		**7,77**
315/80	COLD	7	1	C7-1	D	RH	N	0	>= 5 years	3207	**4,33**	**7,50**
315/80	COLD	7	2	C7-2	D	RH	N	0	>= 5 years	3607		**7,33**
315/80	COLD	7	3	C7-3	D	RH	N	0	>= 5 years	1107		**7,41**
315/80	COLD	2	1	D2-1	A	LH	N	1	<= 3 years	2811	**3,65**	**7,10**
315/80	COLD	2	2	D2-2	A	LH	N	1	<= 3 years	2210		**7,29**
315/80	COLD	2	3	D2-3	A	LH	N	1	<= 3 years	4609		**7,19**
315/80	COLD	4	1	D4-1	A	RH	S	1	<= 3 years	711	**3,75**	**7,30**
315/80	COLD	4	2	D4-2	A	RH	S	1	<= 3 years	2511		**7,07**
315/80	COLD	4	3	D4-3	A	RH	S	1	<= 3 years	3810		**7,39**
315/80	COLD	5	1	D5-1	A	LH	S	0	>= 5 years	2106	**4,11**	**7,51**
315/80	COLD	5	3	D5-3	A	LH	S	0	>= 5 years	1307		**7,47**
315/80	COLD	5	2	D5-2	A	LH	S	0	<= 3 years	711		**7,13**
315/80	COLD	7	1	D7-1	A	RH	N	0	>= 5 years	3406	**4,17**	**7,47**
315/80	COLD	7	2	D7-2	A	RH	N	0	>= 5 years	907		**7,66**
315/80	COLD	7	3	D7-3	A	RH	N	0	>= 5 years	708		**7,18**

Size	Retread Type	DOE. Nr	Casing #	Id. nr.	Brand code	Use	Area	Retread(s)	AgeType	DOT	RRC casing (N/kN)	RRC tire (N/kN)
315/80	HOT	1	1	B1-1	C	LH	N	0	<= 3 years	4709	**3,57**	**8,04**
315/80	HOT	1	2	B1-2	C	LH	N	0	>= 5 years	709		**8,05**
315/80	HOT	1	3	B1-3	C	LH	N	0	<= 3 years	4709		**8,19**
315/80	HOT	3	1	B3-1	C	RH	S	0	>= 5 years	1709	**3,67**	**8,31**
315/80	HOT	3	2	B3-2	C	RH	S	0	>= 5 years	1709		**8,14**
315/80	HOT	3	3	B3-3	C	RH	S	0	>= 5 years	1609		**8,46**
315/80	HOT	6	1	B6-1	C	LH	S	1	>= 5 years	209	**4,04**	**8,49**
315/80	HOT	6	2	B6-2	C	LH	S	1	<= 3 years	1810		**8,22**
315/80	HOT	6	3	B6-3	C	LH	S	1	<= 3 years	1710		**8,44**
315/80	HOT	8	1	B8-1	C	RH	N	1	<= 3 years	1510	**4,12**	**8,20**
315/80	HOT	8	2	B8-2	C	RH	N	1	<= 3 years	911		**7,80**
315/80	HOT	8	3	B8-3	C	RH	N	1	<= 3 years	911		**8,14**
315/80	HOT	1	1	C1-1	D	LH	N	0	<= 3 years	2710	**3,74**	**7,99**
315/80	HOT	1	2	C1-2	D	LH	N	0	<= 3 years	3509		**8,59**
315/80	HOT	1	3	C1-3	D	LH	N	0	<= 3 years	2410		**7,90**
315/80	HOT	3	1	C3-1	D	RH	S	0	<= 3 years	711	**3,51**	**8,03**
315/80	HOT	3	2	C3-2	D	RH	S	0	<= 3 years	1011		**8,09**
315/80	HOT	3	3	C3-3	D	RH	S	0	<= 3 years	2410		**8,23**
315/80	HOT	6	1	C6-1	D	LH	S	1	<= 3 years	4809	**4,15**	**8,49**
315/80	HOT	6	2	C6-2	D	LH	S	1	<= 3 years	2510		**8,34**
315/80	HOT	6	3	C6-3	D	LH	S	1	<= 3 years	2110		**8,42**
315/80	HOT	8	1	C8-1	D	RH	N	1	>= 5 years	2107	**4,25**	**8,43**
315/80	HOT	8	2	C8-2	D	RH	N	1	>= 5 years	2507		**8,34**
315/80	HOT	8	3	C8-3	D	RH	N	1	>= 5 years	3506		**8,40**
315/80	HOT	1	1	D1-1	A	LH	N	0	<= 3 years	3010	**3,62**	**8,18**
315/80	HOT	1	2	D1-2	A	LH	N	0	<= 3 years	4510		**8,04**
315/80	HOT	1	3	D1-3	A	LH	N	0	<= 3 years	2411		**7,75**
315/80	HOT	3	1	D3-1	A	RH	S	0	<= 3 years	2811	**3,31**	**8,06**
315/80	HOT	3	2	D3-2	A	RH	S	0	<= 3 years	4710		**8,02**
315/80	HOT	3	3	D3-3	A	RH	S	0	<= 3 years	4710		**8,13**
315/80	HOT	6	1	D6-1	A	LH	S	1	>= 5 years	4606	**4,22**	**8,21**
315/80	HOT	6	3	D6-3	A	LH	S	1	>= 5 years	4108		**8,21**
315/80	HOT	6	2	D6-2	A	LH	S	1	>= 5 years	2507		**8,31**
315/80	HOT	8	1	D8-1	A	RH	N	1	>= 5 years	1707	**3,69**	**8,06**
315/80	HOT	8	2	D8-2	A	RH	N	1	<= 3 years	3409		**8,05**
315/80	HOT	8	3	D8-3	A	RH	N	1	>= 5 years	4406		**8,25**

Size	Retread Type	DOE. Nr	Casing #	Id. nr.	Brand code	Use	Area	Retread(s)	AgeType	DOT	RRC casing (N/kN)	RRC tire (N/kN)
385/65	COLD	2	1	A2-1	B	LH	N	1	<= 3 years	4509	**3,39**	**5,50**
385/65	COLD	2	2	A2-2	B	LH	N	1	<= 3 years	4409		**5,51**
385/65	COLD	2	3	A2-3	B	LH	N	1	<= 3 years	2411		**5,56**
385/65	COLD	4	1	A4-1	B	RH	S	1	<= 3 years	311	**3,33**	**5,60**
385/65	COLD	4	2	A4-2	B	RH	S	1	<= 3 years	3411		**5,59**
385/65	COLD	4	3	A4-3	B	RH	S	1	<= 3 years	310		**5,49**
385/65	COLD	5	1	A5-1	B	LH	S	0	>= 5 years	3107	**3,42**	**5,60**
385/65	COLD	5	2	A5-2	B	LH	S	0	>= 5 years	4607		**5,51**
385/65	COLD	5	3	A5-3	B	LH	S	0	>= 5 years	4107		**5,54**
385/65	COLD	7	1	A7-1	B	RH	N	0	>= 5 years	4108	**3,49**	**5,49**
385/65	COLD	7	2	A7-2	B	RH	N	0	>= 5 years	1508		**5,47**
385/65	COLD	7	3	A7-3	B	RH	N	0	>= 5 years	3608		**5,44**
385/65	COLD	2	1	B2-1	C	LH	N	1	>= 5 years	3508	**3,57**	**5,43**
385/65	COLD	2	2	B2-2	C	LH	N	1	<= 3 years	1011		**5,84**
385/65	COLD	2	3	B2-3	C	LH	N	1	>= 5 years	2007		**5,64**
385/65	COLD	4	1	B4-1	C	RH	S	1	<= 3 years	4809	**3,71**	**5,61**
385/65	COLD	4	2	B4-2	C	RH	S	1	<= 3 years	3810		**5,61**
385/65	COLD	4	3	B4-3	C	RH	S	1	<= 3 years	4010		**5,87**
385/65	COLD	5	1	B5-1	C	LH	S	0	>= 5 years	4906	**3,72**	**5,50**
385/65	COLD	5	2	B5-2	C	LH	S	0	>= 5 years	4607		**5,65**
385/65	COLD	5	3	B5-3	C	LH	S	0	>= 5 years	4805		**5,66**
385/65	COLD	7	1	B7-1	C	RH	N	0	>= 5 years	3007	**3,88**	**5,59**
385/65	COLD	7	2	B7-2	C	RH	N	0	>= 5 years	1306		**5,67**
385/65	COLD	7	3	B7-3	C	RH	N	0	>= 5 years	1707		**5,91**
385/65	COLD	2	1	C2-1	D	LH	N	1	<= 3 years	2910	**3,82**	**5,56**
385/65	COLD	2	2	C2-2	D	LH	N	1	<= 3 years	2911		**5,62**
385/65	COLD	2	3	C2-3	D	LH	N	1	<= 3 years	3310		**5,63**
385/65	COLD	4	1	C4-1	D	LH	S	1	<= 3 years	2111	**3,52**	**5,49**
385/65	COLD	4	2	C4-2	D	RH	S	1	<= 3 years	5211		**5,59**
385/65	COLD	4	3	C4-3	D	RH	S	1	<= 3 years	4610		**5,65**
385/65	COLD	5	1	C5-1	D	LH	S	0	>= 5 years	4807	**3,47**	**5,51**
385/65	COLD	5	2	C5-2	D	LH	S	0	>= 5 years	3207		**5,36**
385/65	COLD	5	3	C5-3	D	LH	S	0	>= 5 years	207		**5,39**
385/65	COLD	7	1	C7-1	D	RH	N	0	>= 5 years	4907	**3,44**	**5,45**
385/65	COLD	7	2	C7-2	D	RH	N	0	>= 5 years	3807		**5,41**
385/65	COLD	7	3	C7-3	D	RH	N	0	>= 5 years	1607		**5,43**
385/65	COLD	2	1	D2-1	A	LH	N	1	<= 3 years	4309	**3,45**	**5,36**
385/65	COLD	2	2	D2-2	A	LH	N	1	<= 3 years	410		**5,32**
385/65	COLD	2	3	D2-3	A	LH	N	1	<= 3 years	911		**5,43**
385/65	COLD	4	1	D4-1	A	RH	S	1	<= 3 years	511	**3,34**	**5,37**
385/65	COLD	4	2	D4-2	A	RH	S	1	<= 3 years	4009		**5,41**
385/65	COLD	4	3	D4-3	A	RH	S	1	>= 5 years	909		**5,40**
385/65	COLD	5	1	D5-1	A	LH	S	0	>= 5 years	3307	**3,95**	**5,60**
385/65	COLD	5	2	D5-2	A	LH	S	0	>= 5 years	4508		**5,48**
385/65	COLD	5	3	D5-3	A	LH	S	0	<= 3 years	2510		**5,41**
385/65	COLD	7	1	D7-1	A	RH	N	0	<= 3 years	4510	**3,46**	**5,34**
385/65	COLD	7	2	D7-2	A	RH	N	0	<= 3 years	211		**5,18**
385/65	COLD	7	3	D7-3	A	RH	N	0	<= 3 years	1911		**5,39**

Size	Retread Type	DOE. Nr	Casing #	Id. nr.	Brand code	Use	Area	Retread(s)	AgeType	DOT	**RRC casing (N/kN)**	**RRC tire (N/kN)**
385/65	HOT	1	1	B1-1	C	LH	N	0	<= 3 years	2810	**3,20**	**5,79**
385/65	HOT	1	2	B1-2	C	LH	N	0	<= 3 years	1010		**5,75**
385/65	HOT	1	3	B1-3	C	LH	N	0	<= 3 years	5010		**5,78**
385/65	HOT	3	1	B3-1	C	RH	S	0	<= 3 years	4110	**3,72**	**5,94**
385/65	HOT	3	2	B3-2	C	RH	S	0	<= 3 years	711		**6,10**
385/65	HOT	3	3	B3-3	C	RH	S	0	>= 5 years	1409		**5,95**
385/65	HOT	6	1	B6-1	C	LH	S	1	>= 5 years	2007	**3,91**	**5,93**
385/65	HOT	6	2	B6-2	C	LH	S	1	<= 3 years	4610		**5,49**
385/65	HOT	6	3	B6-3	C	LH	S	1	>= 5 years	2007		**6,17**
385/65	HOT	8	1	B8-1	C	RH	N	1	<= 3 years	1210	**3,99**	**6,01**
385/65	HOT	8	2	B8-2	C	RH	N	1	>= 5 years	608		**6,14**
385/65	HOT	8	3	B8-3	C	RH	N	1	>= 5 years	2407		**6,03**
385/65	HOT	1	2	C1-2	D	LH	N	0	<= 3 years	4310		**5,16**
385/65	HOT	1	3	C1-3	D	LH	N	0	<= 3 years	2010		**5,28**
385/65	HOT	1	1	C1-1	D	LH	N	0	<= 3 years	4710	**3,04**	**5,13**
385/65	HOT	3	1	C3-1	D	RH	S	0	<= 3 years	510	**3,36**	**5,28**
385/65	HOT	3	2	C3-2	D	RH	S	0	<= 3 years	910		**5,5**
385/65	HOT	3	3	C3-3	D	RH	S	0	<= 3 years	4210		**5,3**
385/65	HOT	6	1	C6-1	D	LH	S	1	<= 3 years	3710	**3,46**	**5,42**
385/65	HOT	6	2	C6-2	D	LH	S	1	<= 3 years	4910		**5,68**
385/65	HOT	6	3	C6-3	D	LH	S	1	<= 3 years	910		**5,39**
385/65	HOT	8	1	C8-1	D	RH	N	1	<= 3 years	4109	**3,41**	**5,36**
385/65	HOT	8	2	C8-2	D	RH	N	1	<= 3 years	4109		**5,56**
385/65	HOT	8	3	C8-3	D	RH	N	1	<= 3 years	910		**5,4**
385/65	HOT	1	1	D1-1	A	LH	N	0	<= 3 years	1111	**2,99**	**5,53**
385/65	HOT	1	2	D1-2	A	LH	N	0	<= 3 years	1711		**5,74**
385/65	HOT	1	3	D1-3	A	LH	N	0	<= 3 years	1211		**5,63**
385/65	HOT	3	1	D3-1	A	RH	S	0	<= 3 years	3109	**3,31**	**5,72**
385/65	HOT	3	2	D3-2	A	RH	S	0	>= 5 years	2908		**5,8**
385/65	HOT	3	3	D3-3	A	RH	S	0	<= 3 years	3509		**5,75**
385/65	HOT	6	1	D6-1	A	LH	S	1	<= 3 years	1010	**3,11**	**5,53**
385/65	HOT	6	2	D6-2	A	LH	S	1	<= 3 years	211		**5,78**
385/65	HOT	6	3	D6-3	A	LH	S	1	<= 3 years	3509		**5,68**
385/65	HOT	8	2	D8-2	A	RH	N	1	>= 5 years	3007		**5,87**
385/65	HOT	8	3	D8-3	A	RH	N	1	>= 5 years	3608		**5,85**
385/65	HOT	8	1	D8-1	A	RH	N	1	<= 3 years	5009	**3,30**	**5,66**

8.2. DESIGN OF EXPERIMENT "PROCESS IMPACT" DATA FOR ROLLING RESISTANCE

Size	DOT CASING	L.I./S.I.	Original M+S (Y/N)	Process	HSE	P1 (remaining rubber)	P2 (Buffing radius)	P3 cushion gauge (mm	P4 curing t° (°C)	P5 curing time (min)	Tyre weight (kg)	RRC Tire	RRC casing
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	1	800	1.5	95	240	72.0	7.7	
315/80R22.5	2415	156/150L (154/150M)	N	Cold	21	1	800	1.5	95	240	73.0	7.5	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	1	800	1.5	95	240	73.5	7.7	
315/80R22.5	1915	156/150L (154/150M)	N	Cold	21	1	800	1.5	125	480	73.5	7.7	3.22
315/80R22.5	2415	156/150L (154/150M)	N	Cold	21	1	800	1.5	125	480	73.5	7.7	
315/80R22.5	2415	156/150L (154/150M)	N	Cold	21	1	800	1.5	125	480	73.0	7.5	
315/80R22.5	1915	156/150L (154/150M)	N	Cold	21	1	2000	3	95	240	76.0	8.1	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	1	2000	3	95	240	76.0	8.0	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	1	2000	3	95	240	76.0	8.0	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	1	2000	3	125	480	76.0	8.2	3.56
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	1	2000	3	125	480	76.0	8.2	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	1	2000	3	125	480	76.0	8.6	
315/80R22.5	1815	156/150L (154/150M)	N	Cold	21	4	800	3	95	480	75.0	7.7	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	4	800	3	95	480	74.5	7.9	
315/80R22.5	2415	156/150L (154/150M)	N	Cold	21	4	800	3	95	480	75.5	7.7	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	4	800	3	125	240	75.0	7.7	3.12
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	4	800	3	125	240	76.0	7.7	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	4	800	3	125	240	75.0	7.8	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	4	2000	1.5	95	480	75.0	8.0	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	4	2000	1.5	95	480	76.0	8.1	
315/80R22.5	1815	156/150L (154/150M)	N	Cold	21	4	2000	1.5	95	480	75.0	8.0	
315/80R22.5	1815	156/150L (154/150M)	N	Cold	21	4	2000	1.5	125	240	76.0	8.2	3.51
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	4	2000	1.5	125	240	75.0	8.2	
315/80R22.5	2315	156/150L (154/150M)	N	Cold	21	4	2000	1.5	125	240	76.0	8.3	

Size	DOT CASING	L.I./S.I.	Original M+S (Y/N)	Process	HSE	P1 (remaining rubber)	P2 (Buffing radius)	P3 cushion gauge (mm	P4 curing t° (°C)	P5 curing time (min)	Tyre weight (kg)	RRC Tire	RRC casing
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	1	800	1,5	135	110	77,5	8,9	
315/80R22.5	2415	156/150L (154/150M)	N	Hot	22	1	800	1,5	135	110	77,5	8,9	
315/80R22.5	1815	156/150L (154/150M)	N	Hot	22	1	800	1,5	135	110	79,5	8,9	3,22
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	1	800	1,5	160	145	78,0	10,9	
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	1	800	1,5	160	145	77,0	10,7	
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	1	800	1,5	160	145	78,0	11,0	
315/80R22.5	1815	156/150L (154/150M)	N	Hot	22	1	2000	3	135	110	79,0	8,2	
315/80R22.5	1915	156/150L (154/150M)	N	Hot	22	1	2000	3	135	110	79,0	8,1	
315/80R22.5	1815	156/150L (154/150M)	N	Hot	22	1	2000	3	135	110	80,5	8,2	
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	1	2000	3	160	145	79,5	9,7	3,56
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	1	2000	3	160	145	79,5	9,4	
315/80R22.5	2415	156/150L (154/150M)	N	Hot	22	1	2000	3	160	145	79,5	9,7	
315/80R22.5	2415	156/150L (154/150M)	N	Hot	22	4	800	3	135	145	78,0	8,0	
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	4	800	3	135	145	78,0	8,0	
315/80R22.5	1815	156/150L (154/150M)	N	Hot	22	4	800	3	135	145	79,5	8,2	
315/80R22.5	1815	156/150L (154/150M)	N	Hot	22	4	800	3	160	110	78,0	8,8	3,12
315/80R22.5	2515	156/150L (154/150M)	N	Hot	22	4	800	3	160	110	78,0	8,8	
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	4	800	3	160	110	78,5	8,8	
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	4	2000	1,5	135	145	80,5	10,2	
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	4	2000	1,5	135	145	79,5	10,1	
315/80R22.5	1815	156/150L (154/150M)	N	Hot	22	4	2000	1,5	160	110	82,0	12,1	3,51
315/80R22.5	1815	156/150L (154/150M)	N	Hot	22	4	2000	1,5	160	110	82,0	12,1	
315/80R22.5	2315	156/150L (154/150M)	N	Hot	22	4	2000	1,5	160	110	81,0	12,1	

Size	DOT CASING	L.I./S.I.	Original M+S (Y/N)	Process	HSE	P1 (remaining rubber)	P2 (Buffing radius)	P3 cushion gauge (mm	P4 curing t° (°C)	P5 curing time (min)	Tyre weight (kg)	RRC Tire	RRC casing
385/65R22.5	2315	160K (158L)	N	Cold	15.5	1	1100	1.5	95	240	77.5	5.26	2.95
385/65R22.5	2715	160K (158L)	N	Cold	15.5	1	1100	1.5	95	240	74.5	5.18	
385/65R22.5	1915	160K (158L)	N	Cold	15.5	1	1100	1.5	95	240	80.0	5.31	
385/65R22.5	1715	160K (158L)	N	Cold	15.5	1	1100	1.5	125	480	79.0	5.55	
385/65R22.5	2615	160K (158L)	N	Cold	15.5	1	1100	1.5	125	480	79.0	5.58	
385/65R22.5	2815	160K (158L)	N	Cold	15.5	1	1100	1.5	125	480	80.0	5.65	
385/65R22.5	1215	160K (158L)	N	Cold	15.5	1	2000	3	95	240	80.5	5.56	3.45
385/65R22.5	1715	160K (158L)	N	Cold	15.5	1	2000	3	95	240	81.0	5.63	
385/65R22.5	1415	160K (158L)	N	Cold	15.5	1	2000	3	95	240	81.0	5.6	
385/65R22.5	1915	160K (158L)	N	Cold	15.5	1	2000	3	125	480	80.5	5.73	
385/65R22.5	1715	160K (158L)	N	Cold	15.5	1	2000	3	125	480	80.5	5.89	
385/65R22.5	1715	160K (158L)	N	Cold	15.5	1	2000	3	125	480	80.0	5.81	
385/65R22.5	2315	160K (158L)	N	Cold	15.5	4	1100	3	95	480	79.5	5.25	2.95
385/65R22.5	1415	160K (158L)	N	Cold	15.5	4	1100	3	95	480	80.5	5.29	
385/65R22.5	2715	160K (158L)	N	Cold	15.5	4	1100	3	95	480	76.5	5.19	
385/65R22.5	1915	160K (158L)	N	Cold	15.5	4	1100	3	125	240	81.0	5.41	
385/65R22.5	2315	160K (158L)	N	Cold	15.5	4	1100	3	125	240		5.39	
385/65R22.5	1715	160K (158L)	N	Cold	15.5	4	1100	3	125	240		5.43	
385/65R22.5	2215	160K (158L)	N	Cold	15.5	4	2000	1.5	95	480	80.0	5.44	3.36
385/65R22.5	1715	160K (158L)	N	Cold	15.5	4	2000	1.5	95	480	80.5	5.56	
385/65R22.5	2715	160K (158L)	N	Cold	15.5	4	2000	1.5	95	480		5.26	
385/65R22.5	2215	160K (158L)	N	Cold	15.5	4	2000	1.5	125	240		5.67	
385/65R22.5	2215	160K (158L)	N	Cold	15.5	4	2000	1.5	125	240		5.63	
385/65R22.5	1715	160K (158L)	N	Cold	15.5	4	2000	1.5	125	240		5.62	

Size	DOT CASING	L.I./S.I.	Original M+S (Y/N)	Process	HSE	P1 (remaining rubber)	P2 (Buffing radius)	P3 cushion gauge (mm	P4 curing t° (°C)	P5 curing time (min)	Tyre weight (kg)	RRC Tire	RRC casing
385/65R22.5	2315	160 K (158 L)	N	Hot	15,5	1	1100	1,5	135	110	78,0	5,3	
385/65R22.5	2215	160 K (158 L)	N	Hot	15,5	1	1100	1,5	135	110	77,5	5,4	
385/65R22.5	2315	160 K (158 L)	N	Hot	15,5	1	1100	1,5	135	110	78,0	5,3	
385/65R22.5	1715	160 K (158 L)	N	Hot	15,5	1	1100	1,5	160	145	78,0	6,7	2,95
385/65R22.5	1715	160 K (158 L)	N	Hot	15,5	1	1100	1,5	160	145	77,5	6,8	
385/65R22.5	1715	160 K (158 L)	N	Hot	15,5	1	1100	1,5	160	145	77,5	6,8	
385/65R22.5	2215	160 K (158 L)	N	Hot	15,5	1	2000	3	135	110	79,0	5,2	
385/65R22.5	2615	160 K (158 L)	N	Hot	15,5	1	2000	3	135	110	79,0	5,3	
385/65R22.5	1415	160 K (158 L)	N	Hot	15,5	1	2000	3	135	110	79,5	5,4	
385/65R22.5	1715	160 K (158 L)	N	Hot	15,5	1	2000	3	160	145	80,5	6,9	3,45
385/65R22.5	1915	160 K (158 L)	N	Hot	15,5	1	2000	3	160	145	80,5	6,9	
385/65R22.5	1915	160 K (158 L)	N	Hot	15,5	1	2000	3	160	145	80,0	6,8	
385/65R22.5	2215	160 K (158 L)	N	Hot	15,5	4	1100	3	135	145	77,5	5,3	
385/65R22.5	2815	160 K (158 L)	N	Hot	15,5	4	1100	3	135	145	77,5	5,4	
385/65R22.5	2615	160 K (158 L)	N	Hot	15,5	4	1100	3	135	145	79,0	5,4	
385/65R22.5	2615	160 K (158 L)	N	Hot	15,5	4	1100	3	160	110	76,5	6,6	2,95
385/65R22.5	1915	160 K (158 L)	N	Hot	15,5	4	1100	3	160	110	77,5	6,8	
385/65R22.5	1715	160 K (158 L)	N	Hot	15,5	4	1100	3	160	110	77,5	6,7	
385/65R22.5	2315	160 K (158 L)	N	Hot	15,5	4	2000	1,5	135	145	81,0	5,6	
385/65R22.5	2215	160 K (158 L)	N	Hot	15,5	4	2000	1,5	135	145	81,0	5,4	
385/65R22.5	2215	160 K (158 L)	N	Hot	15,5	4	2000	1,5	135	145	80,7	5,5	
385/65R22.5	1915	160 K (158 L)	N	Hot	15,5	4	2000	1,5	160	110	81,5	6,8	3,36
385/65R22.5	1715	160 K (158 L)	N	Hot	15,5	4	2000	1,5	160	110	81,5	6,9	
385/65R22.5	1915	160 K (158 L)	N	Hot	15,5	4	2000	1,5	160	110	81,0	6,9	

8.3. DESIGN OF EXPERIMENT "PROCESS IMPACT" DATA FOR SOUND EMISSION AND WET ADHERENCE

	Experiment	Process	Size	WGI	WET grade	Noise	Noise label waves	HSE	Pattern	P1 (remaining rubber)	P2 (Buffing radius)	P3 cushion gauge (mm)	P4 curing t° (°C)	P5 curing time (min)	Tyre weight (kg)
1	Cold	315/80R22.5	92	D	76	3	21	1	1	800	1.5	95	240	72	
2	Cold	315/80R22.5	90	D	76	3	21	1	1	800	1.5	125	480	73.5	
3	Cold	315/80R22.5	86	D	74	2	21	1	1	2000	3	95	240	76	
4	Cold	315/80R22.5	88	D	74	2	21	1	1	2000	3	125	480	76	
5	Cold	315/80R22.5	87	D	78	3	21	1	4	800	3	95	480	75	
6	Cold	315/80R22.5	88	D	78	3	21	1	4	800	3	125	250	75	
7	Cold	315/80R22.5	93	D	75	2	21	1	4	2000	1.5	95	480	75	
8	Cold	315/80R22.5	94	D	74	2	21	1	4	2000	1.5	125	240	76	
1	Hot	315/80R22.5	112	B	77	3	22	2	1	800	1.5	135	110	77.5	
2	Hot	315/80R22.5	114	B	76	3	22	2	1	800	1.5	160	145	78	
3	Hot	315/80R22.5	109	B	77	3	22	2	1	2000	3	135	110	79	
4	Hot	315/80R22.5	110	B	77	3	22	2	1	2000	3	160	145	79.5	
5	Hot	315/80R22.5	117	B	76	3	22	2	4	800	3	135	145	78	
6	Hot	315/80R22.5	119	B	75	2	22	2	4	800	3	160	110	78	
7	Hot	315/80R22.5	112	B	77	3	22	2	4	2000	1.5	135	145	0	
8	Hot	315/80R22.5	Not tested. Damaged				22	2	4	2000	1.5	160	110	82	
1	Cold	385/65R22.5	128	A	68	1	15.5	3	1	1100	1.5	95	240	77.5	
2	Cold	385/65R22.5	125	A	69	1	15.5	3	1	1100	1.5	125	480	79	
3	Cold	385/65R22.5	118	B	69	1	15.5	3	1	2000	3	95	240	80.5	
4	Cold	385/65R22.5	111	B	69	1	15.5	3	1	2000	3	125	480	80.5	
5	Cold	385/65R22.5	120	B	69	1	15.5	3	4	1100	3	95	480	79.5	
6	Cold	385/65R22.5	118	B	70	1	15.5	3	4	1100	3	125	240	81	
7	Cold	385/65R22.5	120	B	70	1	15.5	3	4	2000	1.5	95	480	80	
8	Cold	385/65R22.5	124	B	70	1	15.5	3	4	2000	1.5	125	240	0	
1	Hot	385/65R22.5	131	A	71	2	15.5	4	1	1100	1.5	135	110	78	
2	Hot	385/65R22.5	130	A	71	2	15.5	4	1	1100	1.5	160	145	78	
3	Hot	385/65R22.5	112	B	71	2	15.5	4	1	2000	3	135	110	79	
4	Hot	385/65R22.5	129	A	71	2	15.5	4	1	2000	3	160	145	80.5	
5	Hot	385/65R22.5	122	B	71	2	15.5	4	4	1100	3	135	145	77.5	
6	Hot	385/65R22.5	127	A	71	2	15.5	4	4	1100	3	160	110	0	
7	Hot	385/65R22.5	119	B	71	2	15.5	4	4	2000	1.5	135	145	81	
8	Hot	385/65R22.5	132	A	71	2	15.5	4	4	2000	1.5	160	110	81.5	