PROPOSAL: **ADD NEW AMC4 ADR.OPS.C.010(b)(4) Pavements, other ground surfaces and maintenance**

RUNWAY SURFACE FRICTION CHARACTERISTICS EVALUATION WITHOUT FRICTION MEASURING DEVICES

The aerodrome operator when conducting surface friction characteristics evaluation of the pavement should

(a) Inspect the full width and length of the pavement.
   a. Slopes
   b. Texture
   c. Drainage

(b) Inspect the area symmetrical from the centre line that is representative of the wheel span of the aeroplanes operating on the runway with special focus on

   a. Rubber deposits
   b. Polishing of aggregates

(c) Assess the amount of exposed texture.

RATIONALE: (text can be used in associated GMs.)

The objective of the runway surface friction characteristics evaluation should be to ensure that the runway pavement is able to create enough grip by the aircraft tyre to ensure adequate aeroplane stopping and crosswind capability for the desired operation on a wet runway.

The correct physics and mechanics should be applied. E.g. the physical and mechanical behavior of an aircraft tyre on a wet pavement providing grip on the pavement surface.

When a tyre is rolling on a wet pavement (free rolling without braking) the area of contact has a speed of 0 m/sec^2. **The area of contact does not move relative to the pavement. The texture of the pavement, both macro and micro, indent the rubber. These indenters cause the tyre to slip over them and thereby create horizontal forces without skidding.** The paradox is that a rolling aircraft tyre in the split second of contact with the pavement surface establish a grip at the area of contact. In order to establish grip there are micro movements in the rubber. **This micro movement is called slippage.**

On a dry surface there is in addition adhesive forces where the rubber and pavement are in direct contact. The adhesion phenomenon dominates in the dry and not in the wet regime. A wet pavement surface contributes almost no adhesion. That is why wet pavement surfaces may present a potential hazard to aeroplane operations. The wet pavement surface are very much dependent upon the surface friction characteristics.

In order to ensure adequate stopping and crosswind capability on a wet runway pavement there must be appropriate amount of indenters of adequate quality. These indenters are created through design and construction of the pavement and are related to the aggregates used in the pavements. Crushed aggregates exhibit a good microtexture, which is essential in obtaining good surface friction characteristics.

The horizontal forces can build up to but not exceed the static friction that can be generated in the contact area. If exceeding, there will be a macro movement relative to the pavement. **This macro movement is called skidding.**

Consequently, the pavement texture is fundamentally related to surface friction and focus should be on the **amount of exposed texture**. And in terms of friction coefficient; it is the static friction coefficient which is of interest.

Experience has shown that visual observations alone are insufficient for estimating degree of rubber accumulation or polishing. The microtexture is not apparent to the eye. The pavement surface itself must be touched by the hand to feel the amount of exposed texture left on the rubber coated surface. If the pavement does not feel "sandpapry" the aerodrome operator should conduct an extensive evaluation into the cause and extent of the reduction in exposed texture. The evaluation should cover

a) Microtexture aspects
b) Macrotexture aspects
c) Drainage aspects

Wet runway surface friction characteristics is closely related to the drainage characteristics of a runway pavement. For guidance on monitoring surface friction characteristics see NEW **GMX ADR.OPS.C.010 Pavements, other ground surfaces, and drainage.**

RATIONALE: (text used in the context of the proposal.)

There is obviously a need to have an AMC covering the situation where the airport operator does not have a friction measuring device.

The other way around is not that obvious. Do an airport operator need to have an continuous friction measuring device?

Discussion on the adequacy of using continuous friction measuring devices to assess the amount of exposed texture.

The continuous surface friction measuring devices does not measure the static friction coefficient. The friction measuring devices are designed to measure the dynamic friction within the skidding regime of a tyre. There are various measuring principles available. However, the basic idea has been to simulate a braking wheel close to where it can measure peak friction. From the dimensionless number generated by the device interpretations into the amount of exposed texture has been sought and its implication on aeroplane stopping performance.

A question to be asked; What are we trying to accomplish? If the intent is studying the actual skidding and stopping performance, then the dynamic coefficient of friction regime is relevant. However, if the intent is to determine the safety regime for tyre grip (non-skidding) than the static coefficient of friction is of interest.

In the reasoning below it is outlined how wet friction measuring evolved in the FAA Advisory Circular 150/5320-12 Methods for the design, construction, and maintenance of skid resistant airport pavement surfaces in the period from 1972 to 2016, starting with 2016, going back in time. It can be seen by these limited extracts how focus has changed from texture to friction and how visual inspections cannot be relied upon evaluating friction.

Question to be asked before and while reading through the selected historic extracts;

1. Have focus on the main subject been lost; The amount of exposed texture which can indent the rubber of the tyre and create horizontal forces – tyre grip?
2. Has focus on relating the measured coefficient of friction to aircraft stopping performance overshadowed the simplistic approach of touching the pavement ensuring that there is an adequate amount of exposed texture present?

<u>Selected</u> historic review from FAA AC

2016 Draft AC 150/5320-12D, May 2, 2016

> *"**3-16.** VEHICLE SPEED FOR CONDUCTING SURVEYS. All of the approved CFME in <u>APPENDIX E</u> can be used at either 40 mph (65 km/h) or 60 mph (95 km/h). The lower speed provides an indication of the overall microtexture/contaminant/drainage condition of the pavement surface. The higher speed provides an indication of the condition of the surface's macrotexture. A complete survey should include tests at both speeds."*

> *"**3-21**. RECOMMENDED TESTING. When friction values meet the criteria in paragraph 3-20.a, 3-20.b and 3.20.c., no texture depth measurements are necessary. When friction values do not meet these criteria and the cause is not obvious (e.g. rubber deposits), the airport operator should perform texture depth measurements.*

3-20.a, 3-20.b and 3-20.c refers to *maintenance planning friction level* and *minimum friction level.*

1997 The draft 12D version differs (role of the microtexture and macrotexture have changed) from the current 12C version of the document, dated 3/18/97:

> *"**3-16. VEHICLE SPEED FOR CONDUCTING SURVEYS.** All of the approved CFME in Appendix 4 can be used at either 40 mph (65 km/h) or 60 mph (95 km/h). The lower speed determines the overall macrotexture/contaminant/drainage condition of the pavement surface. The higher speed provides an indication of the condition of the surface's microtexture. A complete survey should include tests at both speeds."*

As can be seen from the statement an indication of the surface's microtexture can be given by the higher speed. However it is not explained how to assess this indication other that a complete survey should include tests at both speeds.

> *"**4-2.** ……..The effectiveness of rubber deposit removal procedures cannot be evaluated by visual inspection. It is highly recommended that rubber deposit removal contract base payment on final tests by CFME.*

Regarding visual evaluations it is argumented that visual evaluation of pavement friction is not reliable.

> *"3-4 SURVEYS WITHOUT CFME. Research has shown that visual evaluations of pavement friction are not reliable. An operator of an airport that does not support turbojet operations who suspect that a runway may have inadequate friction characteristics should arrange for testing by CFME. Visual inspections are essential, however, to note other surface condition inadequacies such as drainage problems, including ponding and groove deterioration, and structural deficiencies."*

1991 The 12B version of the document dated 11/12/91, gives following information:

> *"31. <u>Surveys Without CFME</u> – The FAA recommends that all airports serving a significant number of turbojet aircraft use CFME in accordance with section III of this chapter. CFME may be owned solely by the airport, borrowed from a nearby airport as needed, or owned by a pool for use at a number of airports. However, if CFME is not available, there are two basic methods of evaluating runway friction an airport operator should use to determine the need for corrective action. These two methods, systematic visual inspection of pavement surfaces and pavement texture measurement, are outlined in the following paragraphs: The frequency of conducting these surveys should be determined by reference to table 3-1 for each runway end.*

Table 3-1 is a table related to *Number of daily turbojet aircraft landings per runway end.*

"42. <u>Vehicle Speed for Conducting Surveys</u> - All of the approved CFME in Appendix 6 can be used at either 40 mph (65 km/h) or 60 mph (95 km/h). The lower speed is most often used and determines the overall macrotexture/contaminants/drainage condition of the pavement surface. If the airport operator suspects that the runway has microtexture problems (pavement does not feel "sandpapery" and/or aircraft report skidding only at higher speeds), measurements should also be made periodically at 60 mph (95 km/h)."

Table 3-2 Corrective action based on visual estimation of rubber deposits accumulated on runway

Description of rubber covering pavement texture in touchdown zone of runway as observed by evaluator	Classification of rubber deposit accumulation levels	Estimated range of MU values averaged 500 foot segments in touchdown zone	Suggested level of action to be taken by airport authority
Intermittent individual tire tracks. 95% of surface exposed	Very light	0.65 or greater	None
Individual tire tracks begin to overlap 80% to 94% surface texture exposed	Light	0.55 to 0.64	None
Central 20 foot traffic area covered 60% to 79% surface exposed	Light to Medium	0.50 to 0.54	Monitor deterioration closely
Central 40 foot traffic area covered 40% to 59% surface texture exposed	Medium	0,40 – 0,49	Schedule rubber removal within 120 days
Central 50 foot traffic are covered. 30% to 69% of rubber vulcanized and bonded to pavement surface. 20% to 39% surface texture exposed.	Medium to Dense	0.30 to 0.39	Schedule rubber removal within 90 days.
70 % to 95% of rubber vulcanized and bonded to pavement surface. Will be difficult to remove. Rubber has glossy or sheen look. 5% to 19% surface texture exposed	Dense	0,20 to 0,29	Schedule rubber removal within 60 days
Rubber completely vulcanized and bonded to surface. Will be very difficult to remove. Rubber has striations and glossy or sheen look. 0% to 4% surface texture exposed	Very dense	Less than 0.19	Schedule rubber removal within 30 days or as soon as possible.

1990 FAA correlated friction measuring devices with the Mu-Meter and introduced two new friction measuring tyres.

1986 The 12A version of the document dated 7/11/86, gives the following information under heading *"11. PROCEDURES FOR CONDUCTING FRICTION MEASUREMENTS."*:

"b <u>Visual Inspection.</u> Friction measurement surveys should include a visual inspection of the pavement surface condition according to the procedures given in paragraph 5. This information is used to supplement the data obtained from the friction measurements."

"e <u>Vehicle Speed for Conducting Friction Measurements.</u> The standard speed for conducting friction surveys is 40 mi/hr (65 km/hr). A higher speed of 60 mi/hr (97 km/hr), is needed to identify those pavements that have smooth surfaces (texture not apparent to the eye). Pavements with smooth surfaces are not easily identified at slower speeds and are known to be a problem for aircraft operating at high speeds (see paragraph 12d).

Paragraph 12d gives further information on how the measurement at higher speeds provide information:

> *"d. <u>Friction Deterioration at Higher Speeds.</u> When the difference between the averaged mu values over a distance of 500 feet (152 m) for speeds of 40 mph (65 kmh) and 60 mph (97 kmh) is greater than 10, the airport owner should conduct an extensive evaluation into the cause and extent of the friction deterioration and take corrective action to eliminate the situation.*

Paragraph 5 gives information relevant to visual inspection and the need for touching the pavement surface:

> *"5. <u>VISUAL INSPECTION OF RUNWAY PAVEMENT SURFACE CONDITION.</u> When conducting friction surveys on runways, a record of the pavement surface condition should be taken to note the extent and amount of rubber accumulation on the surface; type and condition of pavement texture; evidence of drainage problems; surface treatment condition; and any evidence of pavement structural deficiencies. The extent and degree of rubber accumulation should be rated on a scale from zero to nine (no rubber accumulation to pavement texture completely covered). Experience has shown that visual observations alone are insufficient for estimating the degree of rubber accumulation. The pavement surface itself must be touched by the hand to feel the amount of exposed texture left on the rubber coated surface. Table 1-2 contains a method for classifying the degree of rubber accumulation; table 1-3 a method for coding condition of grooves in pavements; and table 1-4 a method for coding pavement surface type."*

Table 1-2 classify the rubber accumulation by percentage covering of the texture and that corrective action should be taken when 70% is covered.

Table 1-3 classify the grooving condition and that corrective action should be taken when 50% of the depth remain.

Table 1-4 classify types of Asphalt concrete pavement and Portland cement concrete pavements and their macro and microtexture qualities including finishing methods.

1980 FAA conducted their National Runway Friction Measurement Program (1978-1980) involving 491 runways at 268 US airports gathered extensive texture and friction data. The report *National Runway Friction Measurement Program,* Report No. FAA-AAS-80-1, December 1980. Data from this program was used to update AC No: 150/5320-12.

1975 The first version of the document AC No: 150/5320-12, METHODS *FOR THE DESIGN, CONSTRUCTION, AND MAINTENANCE OF SKID RESISTANT AIRPORT PAVEMENT SURFACES,* dated June 30, 1975 refers only to the MU-meter friction measuring device operated at speed 40 mph.

1972 AC No: 150/5320-12 cancelled AC No: 150/5320-9, *USE OF A FRICTION MEASURING DEVICE IN ENGINEERING AND MAINTENANCE OF AIRPORT PAVEMENT SURFACES, dated 19 Sep 72.* The Advisory Circular refers only to the MU-Meter and contain no reference to vehicle speed.

RATIONALE: (text used in the context of the proposal.)

Aircraft tyre tread compound – variance aspects in tyre/pavement interface

1. When shifting the focus onto how an aircraft tyre produce grip there are some aspects with the conceptual approach that are in need of being further investigated.

2. A question to be asked: Do the Aviation sector have the right focus on identifying the variance in wet grip capability of aircraft tyres?

3. There is limited information in the public domain regarding the basic assumptions relevant to aircraft tyres and their grip performance. There is however a statement in the March 1977 Technical Report ASD-TR-77-7, *Tire Runway Interface Friction Prediction Subsystem*, prepared by Boeing under a USAF contract.

> *"1. TIRE TREAD COMPUND*
>
> *Pneumatic tires usually contain a variety of rubber compositions, each designed to contribute some particular factor to overall performance. Rubber compounds designed for a specific function will usually be similar but not identical in composition and properties, although in some cases there can be significant differences between compounds in tires of various types. The guiding principle in development of rubber compositions for tires is to achieve the best balance of properties for a particular type of tire service (ref. 8)*
>
> *8. Clark; S.K.; Editor: Mechanics of Pneumatic Tires, National Bureau of Standards Monograph 122, 1971.*
>
> *The manufacturers over the years have each developed their own tread compounding mixes and formulas and consider this as proprietary information. However, it is recognized that all aircraft tires are manufactured from natural rubber based polymers and their compounding from one manufacturer to the next one does not vary extensively. It will therefore not be considered as an independent variable for model formulation"*

4. From the above statement there are the following variance aspects identified:

   a. Tire manufacturers proprietary information on compounding mixes and formulas.
   b. Balance of properties for a particular type of service

5. Regarding balancing of properties for a particular type of service; this will also include the performance tradeoff taking place in the manufacturing process between grip, low rolling resistance and resistance to wear. It is recognized that care should be exercised when applying principles arrived at in the automotive sector to the Aviation sector regarding tyres and tyre performance. However, at the high level of concepts as identified it should be rather safe to tradeoff concept.

6. If we move the automotive industry these aspects are managed and thee exist an UN regulation. A table has been provided where both the automotive and aviation sector has been compared with regard to wet grip. It can be seen that within the automotive sector and approximately in the timeframe since the EASA came into being, EU has regulated **wet grip** of tyres and are proposing to regulate **Snow grip** and **Ice grip.**

7. What the comparison shows is the progress of identifying wet grip variance through UN and EU regulations in the automotive sector and the lack of progress within the Aviation sector.

Wet road vs. wet runway

<table>
<tr><td></td><td colspan="2">UN</td></tr>
<tr><td></td><td colspan="2">ECONOMIC AND SOCIAL COUNCIL (ECOSOC)</td></tr>
<tr><td></td><td>UNECE

Was set up in 1947 by ECOSOC as one of five regional commissions of the United Nations.

UNECE’s terms of reference have been defined by ECOSOC

Secretariat:
Genève, Switzerland</td><td>ICAO

Specialised agency and autonomous organization whose work is coordinated through ECOSOC.

Secretariat:
Montreal, Canada</td></tr>
<tr><td>Global</td><td>UN Vehicle Regulations

1958 – World Forum for Harmonization of Vehicle Regulations (WP.29)

• UN Regulations
• 56 Contracting Parties

1998 – Global Regulations

• GTR’s
• 38 Contracting Parties</td><td>ICAO Uniting Aviation

1944 - Chicago convention

Establish and maintain
• SARPs
• PANS

• Doc
• Circulars

192 Member States</td></tr>
<tr><td>Regulations SARPs and PANS</td><td>Available in the Public domain and full transparency as they are developed:

https://www.unece.org/trans/main/welcwp29.htm

l https://globalautoregs.com/</td><td>Payable documents

https://store.icao.int/</td></tr>
<tr><td rowspan="2">WET road/runway</td><td>UN R117 – Tyre Noise, Wet Adhesion, and Rolling Resistance
51 Contracting Parties
(US not included)

Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and/or to adhesion on wet surfaces and/or to rolling resistance.</td><td rowspan="2">Annex 8 –
• Airworthiness of Aircraft

Annex 6 –
• Operation of Aircraft, Part I – International Commercial Air Transport - Aeroplanes

Annex 14 Vol I –
• Aerodrome Design and Operations</td></tr>
<tr><td>UN GTR No. 16 – Global technical regulation on tyres

The objective is to establish provisions for new radial pneumatic tyres equipping passenger cars and light truck (commercial) vehicles up to and including 4,536 kg (10,000 pounds)</td></tr>
</table>

	The official bases of this harmonised set of requirements are Regulations Nos. 30, and 54 and 117 annexed to the 1958 Agreement, as well as Federal Motor Vehicle Safety Standard (FMVSS) 139 requirements established in the United States of America under the direction of the National Highway Traffic Safety Administration (NHTSA) The work on the GTR began informally in December of 2004 with a meeting in Paris. Regulation established 13 November 2014. Developed a method for ranging and labelling wet grip performance of tyres, using a few friction measuring devices and a standardised automobile tyre. In process of further reducing measuring devices. It has been proposed to declare wet grip performance on sections of roads	Annex 19 – • Safety Management Safety management functions related to, or in direct support of, the safe operation of aircraft ICAO FTF 2008 - present No SARPs regulating wet grip performance. Require States to set or agree standards for friction measuring devices.

EU Regulations	REGULATION (EC) **No 661/2009** OF THE EUROPEAN PARLIMENT AND OF THE COUNCIL of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor.
	
	Article 9
	
	• Wet grip requirements
	  o Wet grip index
	
	REGULATION (EC) **No 1222/2009** OF THE EUROPEAN PARLIMENT AND OF THE COUNCIL of 25 November 2009 on the labelling of tyres with respect to fuel efficiency and other essential parameters.
	
	Article 7
	
	Harmonised testing methods
	• Wet grip class of tyres
	  o Determined on the basis of the wet grip index according to a specified ‘A’ to ‘G’ scale
		REGULATION (EC) **No 216/2008** OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing CCouncil Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC
		
		EASA
		
		ED Decision 2012/009/R 28/06/2012
		Annex II
		
		European Technical Standard Order

<table>
<tr><td></td><td></td><td>ETSO-C62e

Subject: Aircraft Tyres
ETSO marking
Skid depth
Size and load ratings, established and identified in a timely manner in the TRA Aircraft Year Book, latest edition or in the ETRTO Aircraft tyre and Rim Data Book, latest revision.</td></tr>
<tr><td>EU Proposal

COM(2018) 296 final

17.5.2018</td><td>Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the labelling of tyres with respect to fuel efficiency and other essential parameters and repealing Regulation (EC) No 1222/2009

Updating the tyre label and allowing for its revision.

Improving enforcement by creating an obligation to register tyres in the product database established under Regulation (EU) 2017/1369:

The database for products covered by energy labelling regulations will be operational as of 1 January 2019. From that date on tyre suppliers will be obliged to enter into the database the information set out in Annex 1 to Regulation (EU) 2017/1369 (suppliers identification, model of tyre, label, parameter classes and product information sheet).

It is appropriate to replace Regulation (EC) No 1222/2009 by a new Regulation which incorporates amendments made in 2011 and modifies and enhances some of its provisions to improve its effectiveness.

Tyres are characterised by a number of interrelated parameters. Improving one parameter such as rolling resistance may have an adverse impact on other such as wet grip, while improving wet grip may have an adverse impact on external rolling noise. Tyre manufacturers should be encouraged to optimise all parameters beyond the standards already achieved.

WET grip classes
Calculated in accordance with point 2 and measured in accordance with Annex 5 to UNECE Regulation 117.
Calculation of wet grip index (G).
The measured value shall not be greater than the lower limit (the lowest value of G) of the declared class
SNOW grip</td><td></td></tr>
</table>

	The snow performance shall be tested in accordance with Annex 7 to **UNECE Regulation No 117**. • The measured value shall not be lower than the minimum snow performance index ICE grip The ice performance shall be tested in accordance with ISO 19447 • The measured value shall not be lower than the minimum ice performance index.	
ETRTO The European Tyre and Rim Technical Organisation	ETRTO More than 50 years of standardisation https://www.etrto.org/getattachment/About-us/History/ETRTO-MORE-THAN-50-YEARS-OF-STANDARDISATION-2015-03-25.pdf?lang=en-US	Standards Manual Aircraft Tyres Design Guide – Aircraft tyres
European Tyre Labelling review: The first five years October 2018	ETRMA – European Tyre & Rubber manufacturers' association http://www.etrma.org/uploads/Modules/Documentsmanager/etrma-lizeo-report-2018-v9-web.pdf Conclusion The findings of the analysis indicate there is still room for improvement to obtain the full potential of the European tyre label. Firstly, the data analysis shows that the tyre label is still a relatively new tool and that consumers are still in the process of gaining better awareness and understanding of its benefits. Furthermore, the labeling tool is confronted with an evolving market: recent years showed an increasing number of new brands on the market (+20%), especially in the budget segment, which increased by 134% in volume. This is a clear indication that, at present, consumers still choose their tyres mainly on the basis of price. Furthermore, improvements can be made in relation to the reliability of the label: a considerable amount of tyres contain incorrect labelling, which shows the importance of the Market Surveillance as a key element in ensuring the effectiveness of the tyre label.	
In Europa Road/ Runway	The same standards apply when designing, procuring, constructing roads and runways CEN standards related to construction products. Harmonised standards for aggregates in concrete and bituminous mix.	

Parameter	Wet grip index and tyre labelling *[Snow grip]* *[Ice grip]* *[Labelling sections of roads]*	Aircraft Anti skid efficiency Skid depth *[Declare physical characteristics of runways in AIP]*