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STAC

Certification process for self-wetting continuous friction measuring equipment used for construction and maintenance purposes on French airports

Technical information

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Certification process for self-wetting continuous friction measuring equipment used for construction and maintenance purposes on French airports

Technical information

Service technique de l'aviation civile
Département Infrastructures aéroportuaires

Civil aviation technical center
Airport infrastructure branch

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1. Introduction

In accordance with ICAO standards, the French rules (see reference 3) require aerodrome operators to assess regularly (at least one assessment every two years) runway friction characteristics using a self-wetting continuous friction-measuring equipment (CFME).

French rules define a minimum friction level for several friction-measuring equipments, below which the runway is considered as slippery, corrective actions have to be taken to improve runway friction characteristics and to inform pilots of such conditions.

French rules also require all self-wetting CFME, whatever their type or manufacturer, used for construction and maintenance purposes on French airports to be certified by the State.

2. Scope

This document presents the certification process for self-wetting continuous friction-measuring equipments (CFME) used for construction and maintenance purposes on French airports. Only devices are concerned by the certification. Operators are out of the scope of the certification.

The certification intends to ensure aerodrome operator that the CFME performs with reliability and consistency. It also harmonizes friction values between different devices and ensures a uniform acceptance of the minimum friction level.

The certification process consists in correlation trials between the applicant device and the reference device, owned by the French Civil Aviation Technical Centre (STAC). Results are analysed to:

- Assess the existence of a relationship between the applicant device and the reference device,
- Determine the relevance of this relationship,
- Check the performances of the applicant device in terms of repeatability and consistency of friction measurements.

A device reaching requirements for certification is then correlated to the reference device of the same type, in conformity with reference 3. It is then delivered with a certificate quoting:

- The relationship between the device and the reference device of the same type,
- The range of friction values covered by this relationship,
- The minimum friction level for this particular device.

The certificate is valid for two years and must be renewed at the end of this period. The equipment has also to be maintained and calibrated during this period.

3. References

The following documents contain reference material for this procedure.

1. Arrêté du 10 juillet 2006 relatif aux caractéristiques physiques des aérodromes civils utilisés par les aéronefs à voilure fixe (decree of 10 July 2006 relative to physical characteristics of civil aerodromes used by fixed wing aircraft)

2. International Standards and Recommended Practices: Annex 14 to the Convention on International Civil Aviation, Aerodromes
3. Airport Service Manual, Part 2, Pavement Surface Conditions

The following documents contain complementary material for this procedure.

- AC No. 150/5320-12C: US Department of Transportation; Federal Aviation Administration; Advisory Circular: Measurement, construction and maintenance of skid-resistant airport pavement surfaces.
- CROW report 06-05: Qualification Protocol for Candidate Self-wetting Friction-measuring Devices on Dutch Airfields
- CAP 683 – The assessment of Runway Surface Friction Characteristics

4. Definitions and abbreviations

4.1. Definitions

Accuracy: Accuracy is the degree of conformity of a measured or calculated quantity to its actual, nominal, standard, absolute, or some other reference, value.

Bivariate adjustment: Determination of relationship between two variables.

Friction coefficient: Friction coefficient is the measured and reported value expressing the resistance to relative motion between two bodies in contact, the frictional force being the force which acts tangentially in the contact area. The friction coefficient is also termed friction value.

Friction measurement: Friction measurement refers to the measurement of the friction coefficient.

Macro-texture: Macro-texture is the deviation of a pavement from a true planar pavement with characteristic dimensions along the pavement of 0,5 mm to 50 mm, corresponding to texture wavelengths with one third octave bands including the range 0,63 mm to 50 mm centre wavelengths

Micro-texture: Micro-texture is the deviation of a pavement from a true planar pavement with characteristic dimensions along the pavement of less than 0,5 mm, corresponding to texture wavelengths with one third octave bands and up to 0,5 mm centre wavelengths

R&r study: Study of repeatability and reproducibility of a measuring system to determine and check causes for measurement variations.

Reference device: The reference device is a particular measurement device selected as a reference for the correlation of other CFME.

Repeatability: Repeatability is the maximum difference expected between two measurements made by the same machine, with the same tyre, operated by the same crew on the same test section in a short space of time, with a probability of 95 %.

Reproducibility: Reproducibility is the maximum difference expected between two measurements made by different machines with different tyres using different crews on the same section of road in a short space of time, with a probability of 95 %

Outlier value: A data from a set that differs significantly from other data of the same set.

Univariate analysis: Analysis focusing on one criterion.

4.2. Abbreviations

ASFT: Airport Surface Friction Tester

CFME: Continuous friction-measuring equipment

IFSTTAR: Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux

IMAG: Instrument de Mesure Automatique de Glissance

ICAO: International Civil Aviation Organisation

STAC: Service Technique de l'Aviation civile (French Civil Aviation Technical Centre)

STFT: Surface Trailer Friction Tester

5. Equipments concerned by certification

According to reference 3, every self-wetting CFME used for construction and maintenance purposes on French airport has to be certified. Participants at certification campaigns are:

- The reference device, owned by the STAC,
- At least one applicant device to be certified.

5.1. Presentation of the reference device

The reference device is of IMAG (Instrument de Mesure Automatique de Glissance) type. This device has been chosen as reference because numerous participations to international correlation trials (Tire/Runway friction Workshop at NASA WALLOPS flight facility and Joint Winter Runway Friction Measurement Programme) have proved:

- It is repeatable,
- Its results correlate well with other CFME results.

To minimise causes for deviations from one campaign to another, it is:

- Well maintained and calibrated according to procedures set up by the STAC,
- Only used for certification of other devices,
- Coupled with its own towing vehicle and can only be used with that vehicle,
- Checked before and after every campaign.

Figure 1 is a picture of the reference device coupled with its towing vehicle.

Figure 1: Picture of the reference device coupled with its towing vehicle

5.2. Requirements for applicant devices

Participation to certification campaign requires CFME being in good operating conditions from a mechanical and a metrological point of view. It has to be checked and calibrated in accordance with the user manual provided by the manufacturer or in accordance with the procedures set up by the company. The CFME is equipped with a new and run tyre. The tyre is inflated in accordance with the manufacturer instructions. Participants must have a spare identical tyre in case of deterioration of the main tyre.

The test campaign requires tests to be performed at 95 km/h fully loaded. Participants must make sure the towing vehicle is in good working order (brake system, tyres…) to accelerate, maintain speed within a tolerance of ±5 km/h and decelerate in less than 400 m.

The operators are out of the scope of the certification. Therefore, they are not requested to justify neither training nor skills and are not delivered a certificate. Nevertheless, it is highly recommended that CFME are operated by trained and skilled staff.

For security reasons, two persons are required (a driver and a test operator) during the tests.

Figure 2 shows different pictures of friction measuring devices participating at certification campaigns.

Figure 2: Pictures of different devices participating at certification campaign (type ASFT on left and type Sarsys STFT on right)

6. Organisation of certification campaign

The STAC organizes every year one certification campaign at a fixed date. Another campaign can be organised on a company request. Certification campaigns are designed for both initial certification and renewal of certificates. Certification of CFME is subjected to the payment of fees.

6.1. Fixed date campaigns

One fixed date campaign is organised every year. It is generally organised at the end of August. Publicity is made on at the beginning of the year on the STAC website at the following link:

http://www.stac.aviation-civile.gouv.fr/chaussee

Every documents concerning certification of CFME can be found on the website:

- Registration form
- Procedure for registration
- Procedure for the test programme
- Procedure for the analysis of test results
- Model of test results form
- Procedure to issue a certificate.

6.2. Campaign on request

If a company requests to certify one (or several) equipments before the fixed date campaign, the STAC can organise an exceptional campaign.

Planning of such campaign depends on the STAC workload. It is organised in consent with the applicant and within the best time limit.

Friction measurements for construction and maintenance purposes can be performed only on dry pavements when temperatures are above 5 °C. Therefore, no campaign is organised between November and April.

6.3. Registration form

Electronic version of the registration form can be downloaded on the STAC website. A hard copy can also be sent on request. A copy of the registration can be found in appendix 1.

Registration forms must be postmarked at the latest 17 days before the beginning of the fixed date campaign. One form shall be sent per device.

Every written application (mail or e-mail) is examined for admissibility. Examination can lead STAC to ask for complementary information. Every field shall be filled, otherwise, the registration form is sent back to the applicant for complementary information. Request for complementary information or admissibility decision is sent under 15 days.

If the application is accepted, the applicant is asked to come to the trial campaign. An invoice is then sent.

If the examination of the registration form revealed the device does not comply with requirements set in reference 3, the applicant is not accepted. The device has then to be put in agreement with requirements set in reference 3, or, the applicant can ask for certification of another device.

6.4. Deontology

Operators participating to self-wetting CFME certification campaign have to show, whatever their qualification and function, objectivity and neutrality during the process of certification, from the acceptability of device to the issue of the certificate.

Operators participating to certification campaign have the duty to preserve secrecy. They are especially forbidden to spread documents, data or reports and to communicate information to either natural persons or legal entities.

The STAC ensures the confidentiality of information collected from its customers.

These information are, whatever their nature or medium, considered as confidential. In consequence, no information communicated to the STAC is spread to a natural person or legal entity outside the French Civil Aviation Authority (Direction Générale de l'Aviation Civile).

7. Test program

The certification campaign consists in friction measurement trials and statistical analysis of friction values.

7.1. Task planning

The STAC is responsible for the organisation of test campaign and for the analysis of experimental results. Each participant ensures the accomplishment of friction measurements.

The operators ensure that CFME is in full working conditions and calibrated in accordance with the manufacturer instructions or the instructions set up by the company. STAC staff can require evidence of calibration.

Staff operating at the test campaigns shall be the staff operating in routine friction assessment. The company applying for certification is responsible of providing two persons for the certification tests (a driver and a test operator).

7.2. Choice of test facilities

Certification tests are performed on specially prepared test facilities with a special test track (see figure 3), divided into five parts:

- The first part is the starting point. All participants wait here for departure.
- The second part is a semi-circle of 1400 m long and is used for acceleration.
- The third part is 500 m long and includes the track zone with 11 test surfaces covering a large range of friction values.
- The fourth part is 400 m long and is used for decelerating.
- The last part is the stopping point. All participants wait here before returning to the starting point.

The friction track has been designed for testing, calibration and certification of surface characteristics (texture and friction) measuring equipments.

Figure 3: IFSTTAR test facilities

7.3. Test surfaces

The friction track is constituted of 11 tests surfaces covering a large range of friction values. Disposition of test surfaces is presented on figure 4.

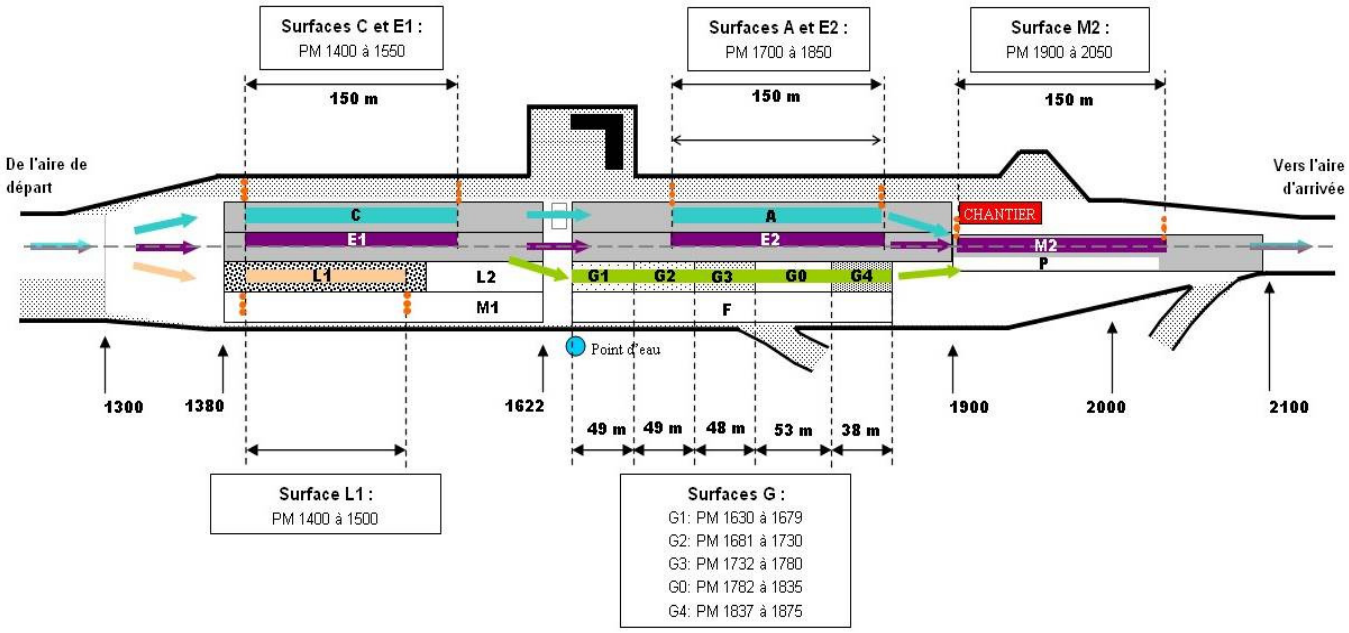


Figure 4: Disposition of test surfaces

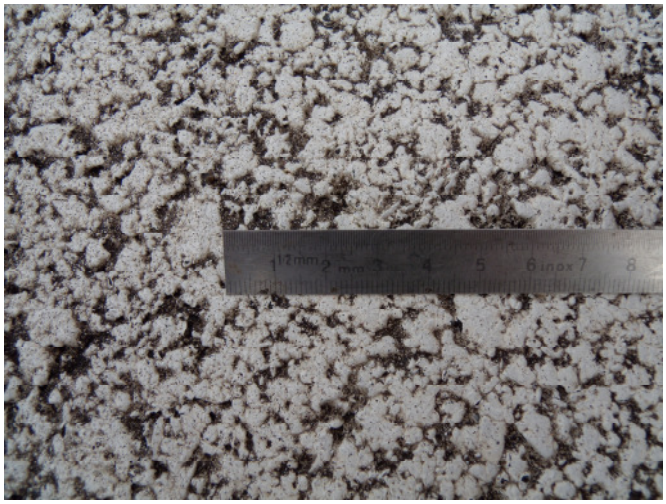
Surfaces A, E1, E2, and M2 are 150 m long and 2 m large and have medium to high friction levels. Surfaces G0 to G4 are 50 m long and 2 m large. Surface G1 to G4 have been painted to have low friction levels. Surface L1 is 100 m long and 2 large. It is covered with epoxy and presents very low friction values. The surface materials are presented in table 1 below:

Table 1: Surface materials

Test surface	Material
A	Porous asphalt concrete (0/6)
C	Surface dressing (0,8/1,5)
E1	Semi-granular bituminous concrete (0/10)
E2	Semi-granular bituminous concrete (0/10)
G0	Low friction asphalt concrete
G1	Slightly painted surface
G2	Painted surface +
G3	Painted surface ++
G4	Painted surface +++
L1	Epoxy
M2	Very thin bituminous concrete (0/6)

Figure 5 shows different surfaces of the track facility.

Surface E1: Semi-granular bituminous concrete (0/10)



Surface G4: Painted surface +++

Surface M2: Very thin bituminous concrete (0/6)

Surface G0: Asphalt “low friction”

Figure 5: Pictures of different surfaces

The beginning and the end of test surfaces are marked with construction site cones.

To limit certification test duration, measurements are performed on several test surfaces per run. For instance, surfaces C and A (or E1, E2 and M2, or G1, G2, G3, G0 and G4) can be tested on the same run.

7.4. Operating speed

Friction measurements can be performed at the following speeds:

- 40, 65 and 95 km/h on all surfaces except L1
- 20 km/h on surface L1.

The tolerance on speed is set at ± 5 km/h.

Surfaces A and C are porous asphalt concrete and surface dressing. They have high macro-texture and do not show high variation in friction values with speed. Therefore, it is generally not tested at high speed.

Surfaces G are painted surfaces and have low micro- and macro-texture. They are generally tested at 65 km/h and 95 km/h to have low or very low friction levels. These surfaces generally give friction values around the minimum friction level of the reference device, and thus are of primary importance for the success of certification campaign. A sweeper is generally used to help water to run off these surfaces. It has proved to improve repeatability and avoid apparition of aquaplaning conditions. Results cannot be exploited in aquaplaning conditions.

Surface L is covered with epoxy and presents very low friction values. It is generally used at 20 km/h because higher speeds lead to aquaplaning of the measuring wheel. It is usually used to check the offset of friction measuring equipments.

The STAC staff decides speeds and surfaces tested in order to ensure the achievement of requirements of the certification process.

7.5. Repetition

A repetition is defined as one run of one participant on one test surface. The test operator is responsible for the quality of the measures. Measures can be done again until the operator judges it in accordance with its operating mode.

Especially, a test needs to be performed again:

- If test speed is not maintained (above tolerance set in 6.4),
- If the participants veers off the centreline of the test surface,
- If the measuring wheel was in aquaplaning conditions,
- If any event happened during friction measurements made the test not conform to the operating mode of the participant,
- If there is any reason to question the measured value.

For each combination (participant, surface, speed), a minimum of five valid repetitions is required. Repetitions are needed to assess repeatability and reproducibility of the CFME.

7.6. Meteorological conditions

Tests are performed only on dry pavement. Temperatures shall be above 5 °C. In a case of rain, tests are adjourned until pavement is dry again.

7.7. Test courses

Depending on the number of applicant devices, the trial duration varies but cannot exceed 3 days and a half of tests. Each participant has a design of experiment specifying number of runs and tested surfaces.

Starts and returns to the starting point are coordinated by STAC staff. Frequency of starts is usually every minute.

For instance, first run:

- Reference device: start at 9h00 – surfaces C and A
- Participant 1: start at 9h01 – surfaces E1, E2 and M2
- Participant 2: start at 9h02 – surfaces G1, G2, G3, G0 and G4

When all partiicpants have joined the stopping point, they are allowed to go back to the starting point.

Second run:

- Reference device: start at 9h10 – surfaces E1, E2 and M2
- Participant 1: start at 9h11 – surfaces G1, G2, G3, G0 and G4
- Participant 2 start at 9h12 – surfaces C and A

Water tanks are filled every four or five runs, depending on their water capacity.

7.8. Test results

At the end of each testing day, each participant gives his results under electronic format before leaving the test facility. This is required to ensure enough data have been collected and to decide which tests have to be performed the next days. Results are given as mean friction value per surface with the time of the measure.

After the certification week, each participant gives analysed results to the STAC using the form for test results. A copy of the form can be found in appendix 2.

The participant is fully responsible for the friction values[1] given to the STAC. They can be sent either by mail, e-mail or fax. The analysis of the test results is based on data communicated by the participants and therefore can start only from the reception of the form.

7.9. Safety conditions and practical details

All participants shall stay in the starting area and wait for the signal before going on the track. For safety reasons, only one participant can use the track at the time. At the end of the run, the participants wait at the stopping point for other participants. All participants go back to the starting point together.

When participants drive for other reasons than tests, they must limit their speed to 40 km/h.

Operators shall wear a reflective suit on the site.

The location of the facility is:

IFSTTAR Centre de Nantes

Route de Bouaye

BP 4129

44341 Bouguenais CEDEX

France

[1] Friction value is the arithmetical value of longitudinal friction coefficient measured on one test surface at one speed. It should be averaged on 100 m for surfaces A, C, E1, E2 and M2, and on 30 m for surfaces G1, G2, G3, G0 and G4.

An uncovered car park is offered on the test facility. A water supply point is available on the test track (blue mark on figure 2). Water tanks can be filled there. Water tanks need to be filled in the morning before beginning of any test. When a participant needs to fill water tank, all tests are suspended.

A petrol station is 5 minutes away from the facility. All participants have to fill up with petrol in the morning before the beginning of the tests.

8. Analysis of test results

Test results analysis is based on friction coefficient measured during the certification campaign. It consists in a statistical analysis, using the software JMP 8.0.1 specialised in statistical treatment of data. Explanations relative to the validation of JMP application can be found at: http://www.jmp.com/software/qualitystatement.shtml

8.1. Data formating

Test data are formatted so as data from the applicant device are paired with data from the reference device.

The pairing consists in joining data from both devices realised in similar test conditions and over a short period of time.

8.2. Pre-analysis

A pre-analysis is realised to detect inconsistent values. These values may be caused by a non-controlled variation of one test parameters, the technology of the equipment, surface characteristics or meteorological conditions.

Inconsistent values are systematically moved away from the statistical analysis. The report details justifications for moving away these values.

8.3. Graphic representation

For both applicant and reference equipments, friction values and standard deviations are plotted against test surfaces and test speeds. These graphs aim to observe all measurements per device and to assess the accuracy.

First, all friction values are plotted, per device, against the speed and the surface. It allows observing the range of individual values variation. Figure 6 is an example of plots obtained for one device. Then, standard deviations are calculated per device, speed and surface. The values are plotted with the boundaries of the 95 % confidence interval of standard deviation. Figure 7 is an example of standard deviations obtained for one device.

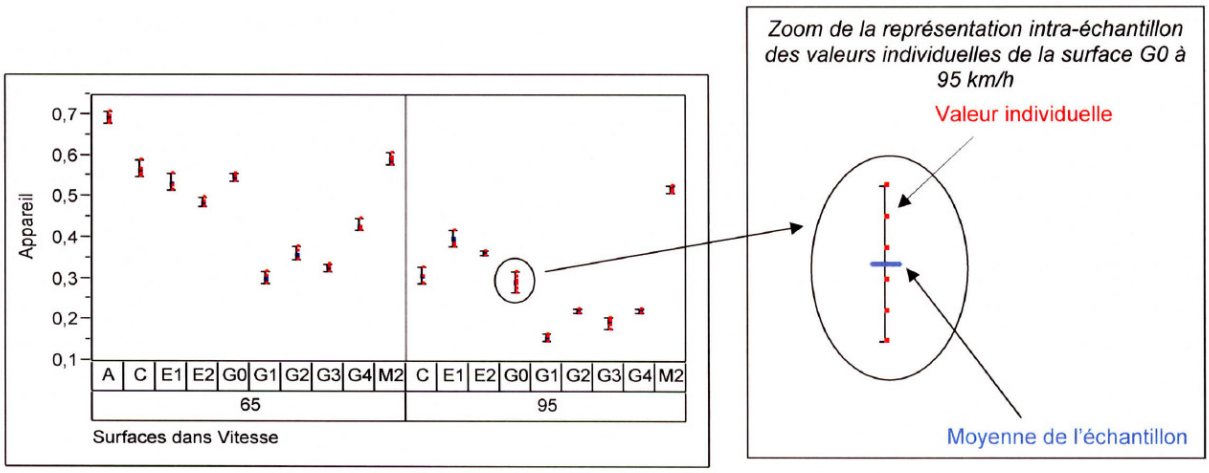


Figure 6: Plots of individual friction values against speed and surface for one device

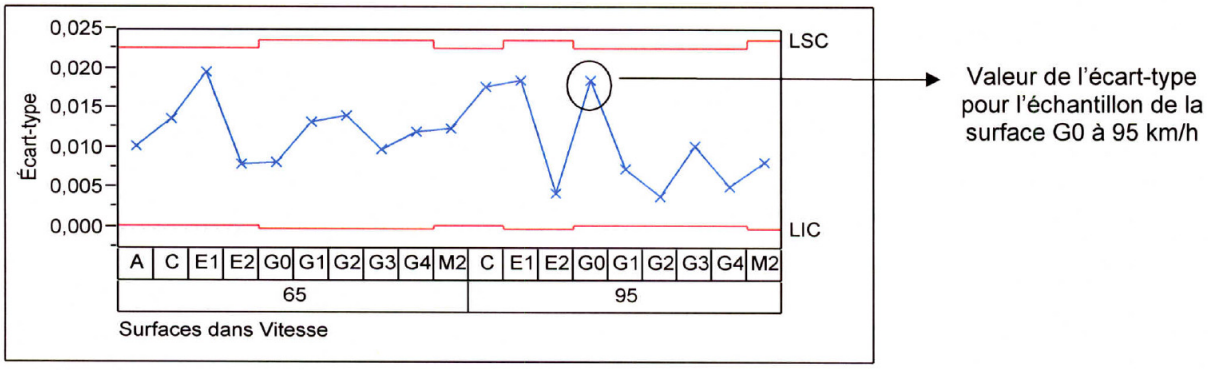


Figure 7: Plots of standard deviations and boundaries of 95 % confidence interval against speeds and surfaces for one device

The 95 % confidence interval, plotted on the standard deviation chart, represents the variability of standard deviation around the mean value. Boundaries of the confidence interval are calculated by the Student law. If one value of standard deviation is out of these boundaries, it means that friction values for this test configuration present high variability compared to the other test configurations. Friction values corresponding to this test configuration are marked and identified for the next part of the analysis.

No value is ejected at this stage of the analysis.

8.4. Outlier detection

A simple linear regression (Y=aX+b) is performed on the whole data set, without inconsistent values identified in part 8.2. Data of the reference device are considered as the explanatory variable (X) and thus are plotted on the abscissa axis, while data of the applicant device are considered as the response variable (Y) and thus are plotted on the ordinate axis.

The 95 % confidence interval of individual values is plotted. This interval means that, if the reference device measures a friction value x, there is 95 % chance that the friction value of the applicant device is between these boundaries.

All values out of this interval are therefore considered as outliers and ejected of the data set for the rest of the analysis. Causes for the removal of data are searched to ensure no data is removed abusively.

This operation is performed only one time.

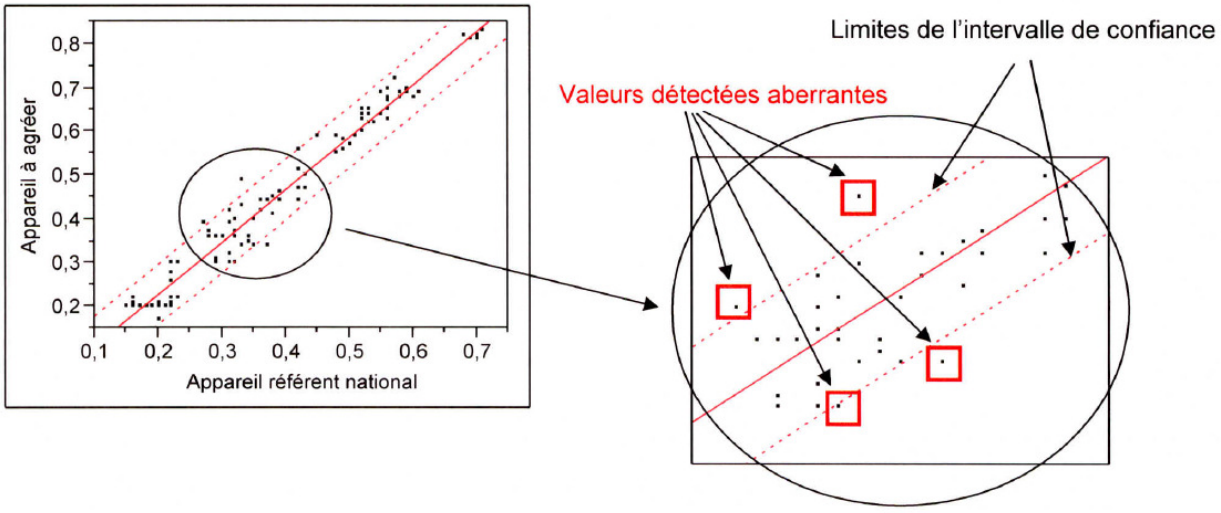


Figure 8: Simple linear regression and identification of outlier values

8.5. Final simple linear regression

Finally, a new simple linear regression is performed on the new set of data (without inconsistent and outlier values). This type of regression allows describing the relation existing between the measures of the applicant device against the measures of the reference device. The coefficient of determination (R^2) is used to estimate the quality of the relation between the measures. The graphs of residuals are plotted to estimate the quality of the linear regression model.

The quality of the relation is higher when R^2 is close to 1 and lower when R^2 is close to 0.

Acceptable value for R^2 has been set to 0,90. This value means that 90 % of variability of applicant device friction values is explained by the variability of reference device friction values.

When this criteria is reached, a complementary analysis is performed to check the relevance of coefficients a and b of the regression. This complementary analysis is explained in part 8.6. Otherwise, a simple linear regression is determined for each test speed. The acceptation criteria is in this case R^2 greater than 0,95. When this criteria is reached, a complementary analysis is performed to check the relevance of coefficients a and b.

If no one of these criteria is reached, the device cannot be certified.

8.6. R&r analysis

A complementary analysis is realised to check the relevance of coefficient a and b of the relationship between the applicant device and the reference device. ANOVA gauge R&r (repeatability and reproducibility) is applied. R&r method measures the amount of variation due to the measuring system and compares it to the total variation observed. It determines the viability of the measurement system.

The linear regression determined in part 8.5 is applied to individual values (after removal of inconsistent and outlier values) of the applicant device, to relate them to the same scale of values than the reference device. Values of the applicant device can then be compared to values of the reference device.

Acceptation criteria are summarized in the table below:

Table 2: Acceptation criteria for R&r analysis

R&r value	Meaning	Conclusion
R&r ≤ 30 %	Both devices are close in their behaviour for some levels of friction coefficients.	The device is acceptable.
R&r > 30 %	The applicant device has significantly different behaviour against the levels of friction coefficients measured on the test surfaces.	The device is not capable of measuring.

If R&r is lower than or equal to 30 %, the device is certified. A certificate is then delivered to the applicant device.

If R&r is greater than 30 %, the device is rejected and a repeatability check is performed for both applicant and reference devices. It aims to ensure reference device has better repeatability than the applicant device. This repeatability analysis consists in an analysis of variance on individual values, without removal of inconsistent or outlier values.

NB: The R&r analysis aims to check the relevance of a and b coefficients of the relationship between the applicant and the reference devices. Results of this analysis do not justify the performances of the applicant device and must not be used by its owner.

9. Issue of certificate

A device is granted with a certificate if the following requirements are satisfied:

- The relationship between the applicant and the reference device is of good enough quality (R^2 greater than 0,90) and R&r is lower than 30%, or
- The relationship by speed is of good enough quality (R^2 greater than 0,95 per speed) and R&r is lower than 30%.

The certificate contains the following information:

- Reference of the certificate,
- Name and address of the applicant,
- Identification of the device
- Relationship between the applicant and the reference device of the same type,
- Validity domain of the relationship,
- The minimum friction level for the reference device of the same type.

The certificate is valid for two year and must then be renewed.

The model of certificate can be found in appendix 4.

APPENDIX 1

Model of registration form

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Registration form

Certification campaign for self-wetting continuous friction-measuring equipments

Please address one registration form per equipment.

Frame reserved for administration

Réf : FOR/STAC/IA/SAC/PR2/….-.....

Requester:

Company name: _____

Adress: _____

_____

Your request concerns:

☐ Fixed date certification campaign

☐ Exceptional certification campaign

Wished date(s): _____

_____

Motive for request:

☐ Initial certification

☐ Renewal of certification

(Precise the reference of last valid certificate)

_____

On behalf of:

☐ Applicant

☐ Another company

Name: _____

Adress: _____

_____

Continuous friction-measuring equipment

	Frame reserved for administration	
	Administrative admissibility	Identification of product
Trailed version ☐ *Precise the model of towing vehicle:* _____ On board version ☐ *Precise the model of vehicle :* _____		
Commercial name: _____ Type (or model) : _____ Serial number: _____ Starting date: _____		
Wetting system: ☐ yes ☐ no Test tyre type: _____ Inflation pressure: _____ Slip rate: ____ % Device uncertainties given by the manufacturer: _____		

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TSVP →

31, avenue du Maréchal Leclerc
94381 Bonneuil-sur-Marne CEDEX
Tél: 01 49 56 80 00 - Fax: 01 49 56 82 19
www.stac.aviation-civile.gouv.fr

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Modèle version v2 du 19/05/2010
Disponible sur T:\Ia\17-SAC\unité-Adhérence\PR2_Agrément (Nantes)\Procédures Générales

Registration form

Certification campaign for self-wetting continuous friction-measuring equipments

Procedure(s) or manual(s) applied for device metrological monitoring

Document(s) supplied by the manufacturer:

Document(s) drawn up by the company:

Checking/calibration performed before certification campaign:

Frame reserved for administration

Proof of checking/calibration quoted above presented at the certification campaign:

The applicant claims to know and to accept regulation applying to aerodrome operators. The applicant claims to know and to accept procedures set up by the service technique de l'Aviation civile for continuous friction-measuring equipments certification campaign. These procedures can be downloaded from the STAC website, indicated at the bottom right of this form. The applicant commits himself to respect these procedures.

Date and signature of the legal representative of the company:

31, avenue du Maréchal Leclerc
94381 Bonneuil-sur-Marne CEDEX
Tél: 01 49 56 80 00 - Fax: 01 49 56 82 19
www.stac.aviation-civile.gouv.fr

APPENDIX 2

Model of result form

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Form for test results
Certification campaign
for self-wetting continuous friction-measuring equipment
Please sent one form per test speed

Frame reserved for administration

Réf : FOR/STAC/IA/SAC/PR2/....-.....

TESTS : ☐ **Realised** ☐ **Complemenary**

Date _____ 20___.

Measuring device: _____.

Surface			TEST SPEED _____ (km/h)										
			Time	Starting MP	Ending MP	Av. speed	σ speed	Av. flow rate	σ flow rate	Av. G%	σ G%	Av. LFC	σ LFC
C	Repetitions	1											
		2											
		3											
		4											
		5											
A	Repetitions	1											
		2											
		3											
		4											
		5											
E1	Repetitions	1											
		2											
		3											
		4											
		5											
E2	Repetitions	1											
		2											
		3											
		4											
		5											
M2	Repetitions	1											
		2											
		3											
		4											
		5											
G1	Repetitions	1											
		2											
		3											
		4											
		5											
G2	Repetitions	1											
		2											
		3											
		4											
		5											
G3	Repetitions	1											
		2											
		3											
		4											
		5											
G0	Repetitions	1											
		2											
		3											
		4											
		5											
G4	Repetitions	1											
		2											
		3											
		4											
		5											

The longitudinal friction coefficient value communicated to the STAC is the arithmetical average of measured friction coefficient on the test surface for one run at one speed. The value is contained between 0 and 1, and is given with 2 significant digits

If all parameters in this table cannot be transmitted, the applicant takes responsability for giving LFC based on validated test parameters (test speed, water flow rate regulated, slip rate, measured area...).

Date :	Company seal:
In charge of tests: Last name: First name:	

Turn please

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www.stac.aviation-civile.gouv.fr

dgac STAC

LEGEND:

Starting MP
Metric point where exploitation of data started

Ending MP:
Metric point where exploitation of data ended

Av. speed:
Average speed on the length of measured surface

σ speed:
Standard deviation of speed on the length of measured surface

Av. flow rate:
Average water flow rate on the length of measured surface

σ flow rate:
standard deviation of water flow rate on the length of measured surface

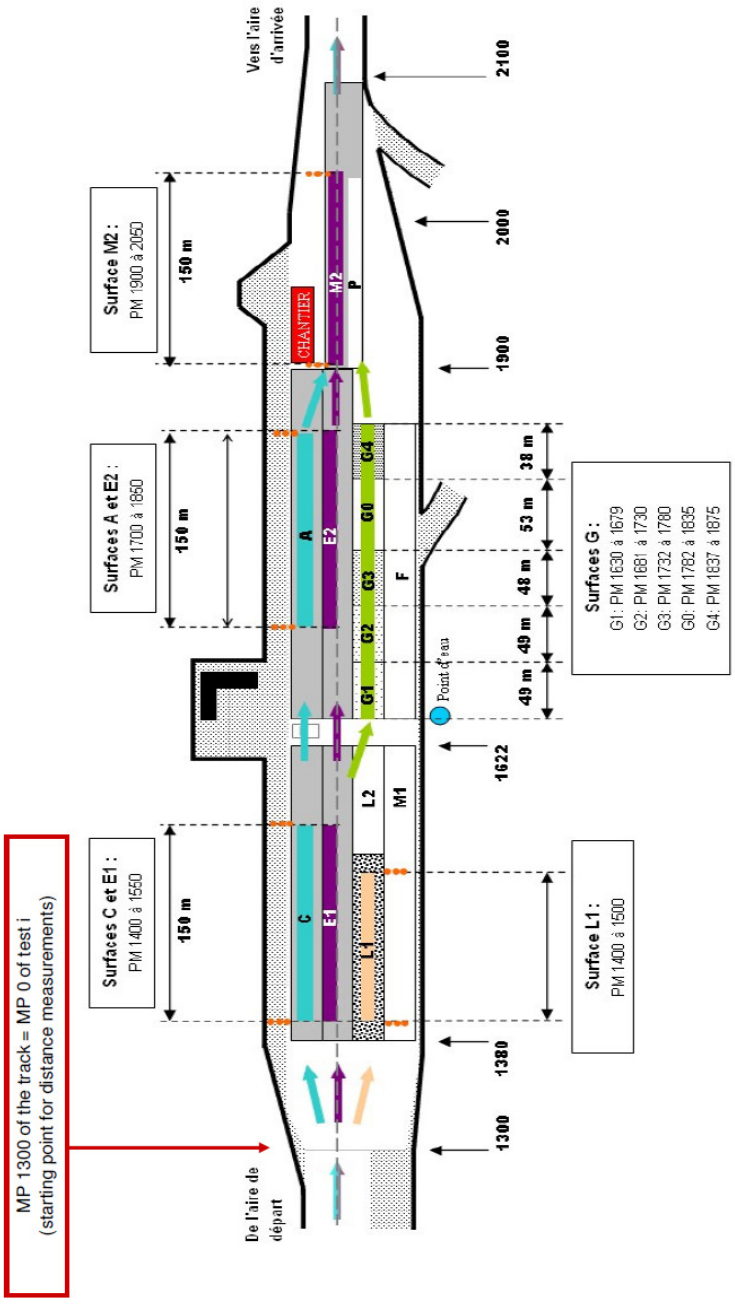
Av. G%:
Average slip rate on the length of measured surface

σ G% :
Standard deviation of slip rate on the length of measured surface

Av. LFC:
Average friction coefficient on the length of measured surface

σ CFL :
Standard deviation of friction coefficient on the length of measured surface

Map of test surfaces



APPENDIX 3

Analysis of test results flow chart

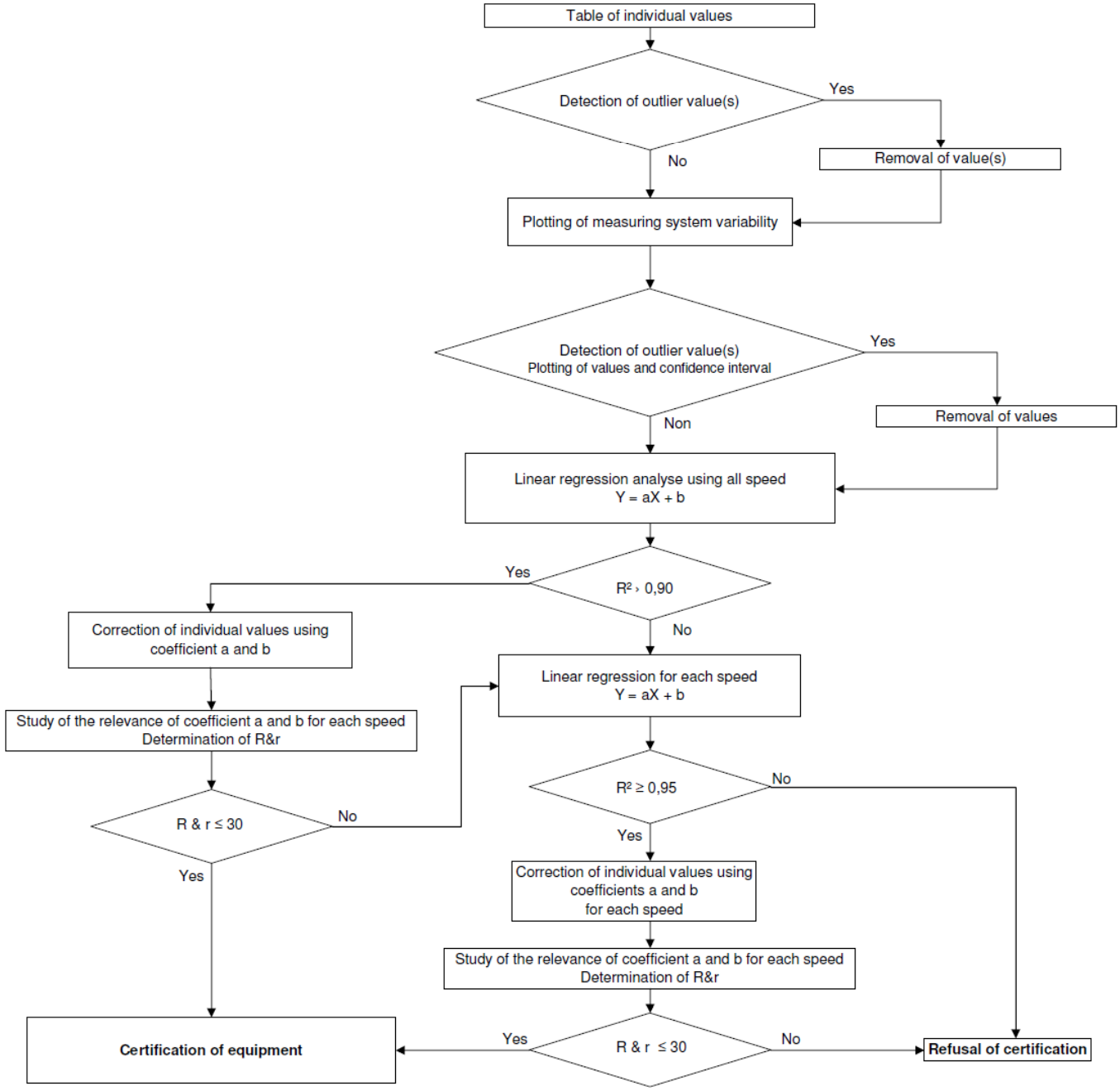


Table of individual values
Detection of outlier value(s)
Yes
Removal of value(s)
No
Plotting of measuring system variability
Detection of outlier value(s)
Plotting of values and confidence interval
Yes
Removal of values
Non
Linear regression analyse using all speed
Y = aX + b
Yes
R² › 0,90
No
Correction of individual values using coefficient a and b
Linear regression for each speed
Y = aX + b
Study of the relevance of coefficient a and b for each speed
Determination of R&r
R² ≥ 0,95
No
R & r ≤ 30
No
Yes
Yes
Correction of individual values using coefficients a and b for each speed
Study of the relevance of coefficient a and b for each speed
Determination of R&r
Certification of equipment
Yes
R & r ≤ 30
No
Refusal of certification

APPENDIX 4

Model of certificate

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DES TRANSPORTS ET DU LOGEMENT

Direction générale de l'Aviation civile

Service technique de l'Aviation civile

Département Infrastructures Aéroportuaires

CERTIFICATE OF SELF-WETTING CONTINOUS FRICTION MEASURING EQUIPMENT

DAD/STAC/IA/SAC/PR2/**XX-XXX**

This certificate, established in accordance with the decree of 10 July 2006 relative to physical characteristics of civil aerodromes used by fixed wing aircraft (TAC), is delivered to:

Company name
Address

It certifies that, the measuring device identified below:

Commercial name of the device
Type or model
Serial number
Equipped with test tyre xxx

is in compliance with applicable technical and metrological requirements. The coefficients of the linear regression existing between the longitudinal friction coefficient (LFC) measured by this device and those measured by the reference device of the same type are:

$$LFC_{\text{(measuring device of the same type)}}{}^{1} = A\ LFC_{\text{(certified device)}} + B$$

Range of friction values where this relationship applies is from xx to xx.

This relationship aims to adjust measures performed by the certified device in order to compare them to minimum friction values specified in table 1 of technical appendice of decree TAC. These values are reminded below:

Measuring device	Test tyre		Test speed (km/h)	Theoritical test water film thickness (mm)	Minimum friction level
	Type	Pressure (kPa)			
Measuring device of the same type	X X	X X	65 95	1,0 1,0	X X

This certificate is valid until « year Y+2 after the date of delivery »,
It cancels and replaces the certificate referenced: « reference of the previous certificate »

Delivered: « date of delivery »

Signed: The Director of Civil Aviation Technical Centre

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