Standard Practice for
Calculating the International Runway Friction Index[1]

1. Scope

1.1 This practice covers the calculation of the International Runway Friction Index, IRFI, from measurements obtained by local friction-measurement devices[2] on movement areas under winter conditions.

1.2 The IRFI is the international friction index to be used for reporting the friction characteristics of airport movement areas.

1.3 The IRFI reported by this practice is a harmonized value of the pavement friction characteristics.

1.4 The IRFI obtained by using this practice has not been extended to address the braking performance of an aircraft.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 524 Specification for Standard Smooth Tire for Pavement Skid-Resistance Tests[3]

E 867 Terminology Relating to Vehicle-Pavement Systems[3]

E 1551 Specification for Special Purpose, Smooth-Tread Tire, Operated on Fixed Braking Slip Continuous Friction Measuring Equipment[3]

E 1844 Specification for a Size 10×4-5 Smooth-Tread Friction Test Tire[3]

E 1859 Test Method for Friction Coefficient Measurements between Tire and Pavement Using a Variable Slip Technique[3]

E 1960 Practice for Calculating International Friction Index of a Pavement Surface[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *base surface*, *n*—the type of surface evaluated; there are four classes (1) bare pavement dry, (2) bare pavement wet, (3) bare compacted snow and (4) bare ice.

3.1.2 *compacted snow*, *n*—a compressed solid mass of snow, which is sufficiently strong to prevent a normally loaded tire operating in a rolling mode from penetrating to the pavement or breaking up the surface.

3.1.3 *device configuration*, *n*—a term used to designate the entire test system as used for any friction measurement; it includes type of device (force or torque measurements), tire type, size and inflation pressure, slip ratio, normal load and braking system control mode.

3.1.4 *harmonization*, *n*—the adjustment of the outputs of different devices used for measurement of a specific phenomenon so that all devices report the same value.

3.1.5 *ice*, *n*—water with or without contaminants frozen into a continuous solid body with or without cracks.

3.1.6 *IRFI reference device*, *n*—a particular friction measuring device selected as a benchmark or reference; it is used to calibrate any local friction device to permit master or local friction device values to be converted to IRFI values for selected base surfaces.

3.1.7 *local friction device*, *n*—a particular friction testing device used at a given location to measure the friction level of selected base surfaces; the friction values evaluated with this device may be harmonized to IRFI values.

3.1.8 *master friction device*, *n*—a particular friction measuring device selected as a secondary reference that has been calibrated with the IRFI reference device; it is used to calibrate any local friction device to permit local friction device values to be converted to IRFI values for selected base surfaces.

3.1.9 *movement area*, *n*—that part of the airport (aerodrome) used for take-off, landing and taxiing of aircraft, consisting of the maneuvering area and the apron(s).

3.1.10 For additional definitions, see Terminology E 867.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *international runway friction index (IRFI)*—a unified index of friction that is harmonized to the value measured by the IRFI reference device.

4. Summary of Practice

4.1 This practice outlines the procedure for calculating a value designated as the International Runway Friction Index, IRFI. This index is related to the available friction level of the

surface. The IRFI for a local friction device is calculated by converting the measured friction value by means of a pre-established empirical relationship using the linear regression method.

4.2 The procedure as contained in this practice is applicable to base surfaces with no more than 25 mm of loose snow or 12 mm of slush.

NOTE 1—Some devices may not be able to measure at these depths.

4.3 The details of the IRFI reference device are given in Appendix X2.1.

4.4 A master friction device shall be a dedicated device used for calibration of local devices and shall not be used in ordinary friction measurement service except when not practical.

5. Significance and Use

5.1 This practice defines and prescribes how to calculate IRFI on aircraft movement areas in winter.

5.2 The local device is calibrated directly or indirectly to the reference device, thereby achieving harmonization of local friction devices to a common unit of measure regardless of the local friction device used.

5.3 The IRFI can be used by airport maintenance staff to monitor the winter frictional characteristics for surface maintenance actions.

6. Measurement Requirements

6.1 The local friction device shall be harmonized by conducting field-testing with the IRFI reference device (see Section 7). The field test shall collect friction data for each surface class for which the local device can be used. When a local friction device has different selectable modes of operation (for example: fixed or variable slip measurement) each mode of operation shall be treated separately.

6.2 The local friction device shall be operated according to the standard test method of the device and the manufacturer's instructions for the device.

6.3 The minimum length of the surface segment that shall be used for producing a friction value shall be equal to 100 m.

6.4 Average surface temperature shall be measured and reported (for runways each third).

6.5 The friction values shall be reported digitally (with separate data series for each segment) in one file for the runway. The file shall have record(s) ordered by segments.

6.6 The operator shall report the surface classes of the segments.

6.7 The local friction device shall be run within the range of speeds for which it was harmonized.

7. Harmonization

7.1 The local device shall be harmonized to report an IRFI by conducting parallel friction measurements on surfaces with the reference device or a master device on surfaces similar to those used to calibrate the master with the reference device. A minimum of 10 surfaces covering a range of 0.1 to 0.7 as measured by the master device shall be included. Harmonization constants shall be determined for the speed at which the device normally operates.

7.2 The master device shall be harmonized by conducting parallel friction tests with the IRFI reference device. All types

of surfaces shall be included. A minimum of 35 segments covering a friction range of 0.1 to 0.7 as measured by the IRFI reference device shall be included. The harmonization constants shall be determined at speeds at which the device normally operates. Maintain test speeds within ± 3 km/h (1.6 knots, 1.5 mph).

7.3 The measurements with the local friction device and the IRFI reference device or a master reference device shall be taken on a segment within 2 min of each other.

7.4 Linear regressions shall be of the following form (see Eq 1 and Eq 2):

$$FR_{ref} = A + B \times FR_{master} \qquad (1)$$

$$FR_{master} = a + b \times FR_{local} \qquad (2)$$

where:
FR_{ref} = the friction value reported by the reference device,
FR_{local} = the local device measured value, and
A, B = harmonization constants for the master device, and
a, b = harmonization constants for the local device.

The correlation coefficient of the regression and the standard error of estimate shall be reported. Typical values for devices that have been harmonized are given in Appendix X1. These results were for specific local devices that were harmonized during the Joint Winter Runway Friction Program. They are not applicable to other local friction devices or to other test speeds.

7.5 Subsequent measurements made by the local friction device can be harmonized using the regression constants of the device (see Eq 3):

$$IRFI = A + B \times a + B \times b \, FR_{local} \qquad (3)$$

7.6 Any time the local friction device is recalibrated, new harmonization constants shall be determined. Harmonization of master devices and local devices shall be conducted as frequently as the time stability of the devices mandates.

8. Calculation

8.1 The runway is divided into segments (see Fig. 1). The minimum length of the segment is 100 m and the maximum is one third of the runway length. The harmonized friction value for an individual segment is designated, *irfi* (that is, by italics and lower case). The value, IRFI, for each third of the runway or base surface is computed as a weighted average of *irfi* values as given by Eq 4.
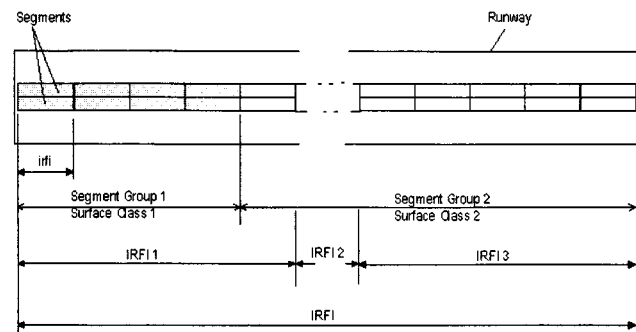

FIG. 1 Illustration of a Segmented Runway

$$IRFI = \frac{1}{L} \Sigma(l_i \times irfi_i) \qquad (4)$$

where:
L = total length of the one-third distance, m, and
l_i = the length of segment i, m.

8.2 When all segment lengths are equal, simple averaging will give the value for IRFI.

8.3 IRFI for other movement areas are computed the same way except they are not divided into thirds.

9. Report

9.1 *Field Friction Report*—The field report for each runway test shall contain data on the following items:

9.1.1 Airport and designation of runway or taxiway,

9.1.2 Date and time of day,

9.1.3 Reference to runway condition report,

9.1.4 Distance from centerline tested,

9.1.5 Achieved measuring speed,

9.1.6 The average surface temperature for each third of the runway (optional),

9.1.7 The friction value of each segment group computed as the International Runway Friction Index, IRFI, and

9.1.8 The local friction device type and test configuration.

9.2 *Summary Report*—Test results are entered in forms specified by the civil aviation authorities.

APPENDIXES

(Nonmandatory Information)

X1. TABLE OF TYPICAL HARMONIZATION RESULTS FROM 1998-1999 JOINT WINTER RUNWAY MEASUREMENT PROGRAM

X1.1 Table X1.1 illustrates typical harmonization results with the IRFI reference device only.

TABLE X1.1 Table of Typical Harmonization Results from 1998–1999 Joint Winter Runway Measurement Program

Harmonization Constant A	Harmonization Constant B	Correlation Coefficient R	Standard Error of Estimate
0.0565	0.4264	0.78	0.023
0.0445	0.7635	0.83	0.052
0.0879	0.8814	0.73	0.045
0.0001	1.1109	0.82	0.042
0.0907	1.0231	0.92	0.048
0.0226	0.7262	0.98	0.034
0.0504	0.3923	0.77	0.030
0.0598	0.7589	0.92	0.034
0.1261	0.6727	0.67	0.044

X2. DESCRIPTION OF THE IRFI REFERENCE DEVICE

X2.1 General

X2.1.1 The IRFI reference device is a trailer (see Fig. X2.1) towed by a vehicle. It consists of a principal frame with two wheels fitted on articulated arms. This frame supports an articulated measuring frame equipped with a loaded measuring wheel and a hydraulically controlled braking system.

X2.1.2 The measuring wheel can be equipped with various tires. The standard tire is generally a smooth PIARC tire (165 × 380). A ribbed tire or an aircraft tire of the same size can also be used. The wheel is loaded at a nominal load of 1800 N and a nominal inflation pressure of 150 KPa. The device is towed at a constant speed (0 to 130 km/h) and the measuring wheel is braked at a slip that can be set between 0 (free rolling) and 100 % (locked wheel).

X2.2 Braking System

X2.2.1 The measurement wheel drives a hydraulic pump through a system of pulleys and a belt. The flow of oil is returned to the oil tank by the pump. A servo value on the discharge side of the pump controls the oil outflow. The servo

valve is controlled by a signal coming from an electronic controller. The electronic controller compares signals (rotational speed) given by reference wheels (pulse generator) and the measurement wheel (tachometer).

X2.2.2 A computer, controlled by the operator, sets the slip ratio that the controller transforms to a signal to drive the servo valve that controls the outflow of the pump. In this way, the operator can set the slip ratio for the measuring wheel at any time.

X2.2.3 The computer software allows a manual or automatic control of the braking action of the measuring wheel.

X2.3 Measuring System

X2.3.1 The combined signals given by the pulse generators, which are parts of the braking control system, are used for time and distance related acquisition of measuring signals given by the sensors installed on the device.

X2.3.2 *Vertical load on measuring wheel (F_V)*—A load sensor is located on the rear of the device, at the top of the shock absorber between the oil tank frame and the end of the
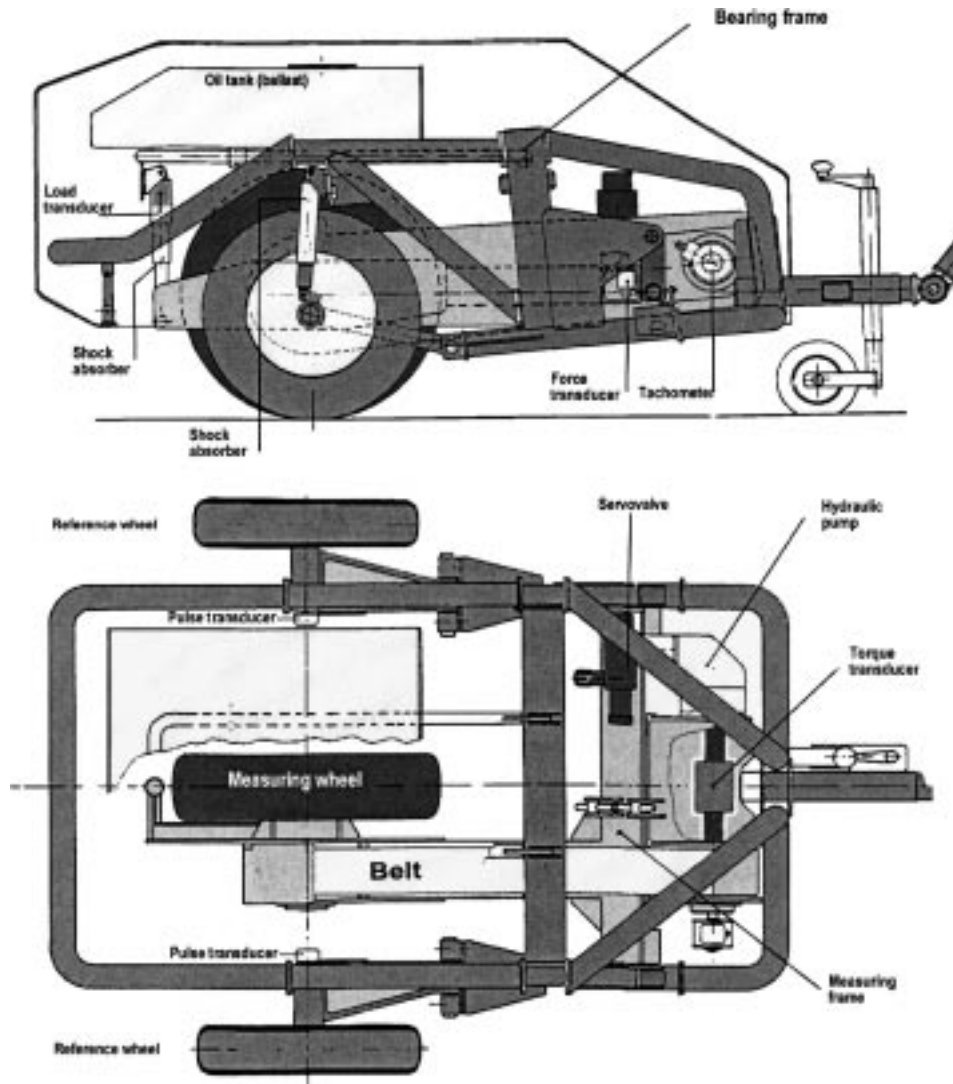

FIG. X2.1 IRFI reference device as designed, built, and operated by the French Civil Aviation Administration, S.T.B.A. Airports and Air Force Bases Engineering.

measuring frame. This sensor captures 70 % of the dynamic load on the wheel. This signal is used for real time calculation of friction coefficient and a global drag coefficient.

X2.3.3 *Friction coefficient, Mu_T*—A torque transducer is located between the front pulley receiving the driving belt and the hydraulic pump. This transducer senses the braking torque, T, developed by the friction in the contact area between tire and pavement. The friction coefficient is computed in real time as $Mu_T = (T/r)/F_V$.

X2.3.4 *Drag coefficient, Mu_D*—Two force transducers are located on each side of the bearing frame of the device. They sense the horizontal force T_D produced by the measuring frame that is linked by axles and small rods to the bearing frame. The drag coefficient is computed in real time as $Mu_D = T_D/F_V$.

X2.4 Conditioning, Control and Acquisition System

X2.4.1 An electronic system is located on the device for pre-conditioning the sensors and interfacing the servo valve. The servo control of the braking system, the final-conditioning system, and the microcomputer are located in the towing vehicle.

X2.4.2 The software includes all the functions required for the control, the setup of the device, and the acquisition system.

X2.4.3 Measurements are displayed in real time and recorded in ASCII format. In operational conditions, the results are displayed at the end of the measurements and hardcopy is produced for immediate use by the airport authorities. Software is available for special studies.

X2.5 Dimensions and Weights

Overall width	1600 mm
Overall length	1950 mm + 1050 mm (shaft)
Height	1080 mm
Wheel track distance	1340 mm
Length from tongue to axle	2260 mm
Trailer weight	480 kg
Weight on tongue	80 kg
Weight on main tires	110 kg + 110 kg
Weight on test tire	180 kg