International Standard ISO 3324/II

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Aircraft tyres and rims — Part II : Test methods for tyres

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FOREWORD

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3324/II was developed by Technical Committee ISO/TC 31, *Tyres, rims and valves*, and was circulated to the member bodies in September 1977.

It has been approved by the member bodies of the following countries :

Australia	Israel	Spain
Austria	Japan	Sweden
Brazil	Korea, Rep. of	Switzerland
Bulgaria	Mexico	Turkey
Canada	Netherlands	USA
Czechoslovakia	Poland	USSR
Egypt, Arab Rep. of	Romania	
Germany, F.R.	South Africa, Rep. of	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

France
United Kingdom

Printed in Switzerland

Aircraft tyres and rims — Part II : Test methods for tyres

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies test methods for new and retreaded civil aircraft tyres in the following categories :

a) low-speed tyres : for ground speeds up to and including 104 knots;

b) high-speed tyres : for ground speeds above 104 knots.

NOTE — 1 knot = 1,85 km/h = 1.15 mile/h.

2 REFERENCE

ISO 3324/I, *Aircraft tyres and rims — Part I : Specifications.*

3 STATIC TESTS

3.1 Burst pressure (Pressure proof test)

Mount the tyre on a test wheel of adequate strength, and inflate it hydraulically at a slow rate to the minimum specified burst pressure.

Maintain the tyre at this pressure for 10 s without failure.

Burst pressure testing of tubeless tyres may be conducted with an inner tube fitted.

3.2 Bead seating pressure

Determine the bead seating pressure by a suitable method. Two procedures, currently adopted, which may be used are :

Procedure 1 — Carbon paper

The bead seating pressure is determined by placing a sheet of carbon paper between two sheets of thin paper and placing these sheets between the flanges of the wheel and the bead of the tyre. The tyre is inflated and the pressure at which the heel of the bead touches the vertical face of the rim flange, as shown on the thin paper, is considered as the bead seating pressure.

Procedure 2 — Electrical

The contact area of the wheel is cleaned to expose the metal surface.

Three pieces of shim copper or steel, 120° from each other, are fixed to one tyre bead. The shims are held in place with light gauge non-conducting adhesive tape (see figure 1). The tape insulates the shims from the top of the rim flange.

This procedure calls for the use of a battery, fitted with two leads, one of which is a fixed lead containing a lamp or ohmmeter, the other lead being used as the probe lead. The fixed lead is clipped to the wheel, and the probe lead is used to make contact with the three shims in turn.

The tyre is inflated in increments, and after each increment, the probe lead is placed on the shims in turn. When the lamp lights or the ohmmeter reading is zero, at all three shim locations, the bead is considered to be fully seated on the wheel at the recorded inflation pressure, and that pressure is considered to be the bead seating pressure.

Other procedures may be used if these are recognized and approved by the Certification or Airworthiness Authority.

In all procedures the test shall be conducted without the use of lubricant on the tyre bead or rim.

3.3 Air retention — Tubeless tyres

Inflate the tyre to the maximum rated inflation pressure and allow it to stand for a minimum of 12 h, after which time, make good the pressure reduction due to tyre stretch. Then allow the tyre to stand for a further 24 h, at the same ambient temperature, after which time measure the pressure and determine the pressure drop.

3.4 Tyre dimensions

Mount the tyre on the specified rim, inflate it to its maximum rated inflation pressure and allow it to stand for a minimum of 12 h at normal room temperature. After this lapse of time, readjust the inflation to the original value.

Following the pressure adjustment, measure and record the following tyre dimensions :

- overall diameter;
- overall width;
- shoulder diameter;
- shoulder width.

Where a tyre does not have a readily identifiable shoulder point, measure the shoulder width at the maximum specified shoulder diameter.

3.5 Load-deflection curves

Mount the tyre and inflate as specified in 3.4.

Install the tyre and wheel in the testing machine. Make every attempt to remove all the looseness (slop) between the wheel, axle, bushings etc., so that an accurate zero point can be determined.

Break in the tyre before plotting the curves, by loading the tyre three times at three different locations to a deflection greater than 50 % but not bottomed.

Measure and record tyre overall diameter for each curve.

To obtain the zero load and deflection point, move the tyre until it barely touches the flat plate. Do not pre-load.

Run the testing machine to plot the load-deflection curves as the following crosshead speeds :

7,6 mm/min (max.) for tyres up to 762 mm diameter;

25,4 mm/min (max.) for tyres over 762 mm diameter.

Load the tyre until bottoming starts or until the machine limit is reached.

Obtain the load-deflection curves by starting at the lowest inflation pressure first, and allow 10 min between each curve run at a different inflation pressure.

Do not pause at rated loads to determine data points.

4 DYNAMOMETER TESTS

4.1 General

Tyres shall be tested by means of one of the following test procedures :

- low-speed tyres shall be tested either in accordance with 4.3 or as prescribed for high-speed tyres in 4.5;
- high-speed tyres shall be tested in accordance with 4.4 or in accordance with 4.5.

Unless otherwise specified, the time between test cycles shall be chosen to provide a contained air or carcass temperature, at the start of at least 80 % of the test cycles, of 41 ± 3 °C. The carcass temperature shall be measured in the tyre bead above the rim flange.

4.2 Pressure correction

In order to compensate for the curvature of the flywheel, the tyre inflation pressure shall be adjusted in accordance with one of the following :

a) the test inflation pressure shall be that pressure which is necessary to provide the same deflection, when the tyre is loaded againt the curved surface of the dynamometer flywheel at its rated load, as when the tyre is loaded against a flat surface at its rated tyre load and rated inflation pressure (see ISO 3324/I);

b) by adjustment of the rated inflation pressure by application of the appropriate ratio obtained from figure 2 or 3.

4.3 Dynamometer test procedure for low-speed tyres for which load/speed/time/distance data are not specified

4.3.1 *Dynamometer characteristics*

The tyres shall be tested on a dynamometer having a stored kinetic energy, E_k, at a flywheel peripheral speed of 104 knots computed as follows :

$$E_k = 485\ L_r$$

where L_r is the rated tyre load, in kilograms, for the ply rating.

The kinetic energy is expressed in joules.

4.3.2 *Tyre load*

Throughout all test cycles, the tyre shall be loaded against the flywheel at its rated tyre load, L_r.

4.3.3 *Test speeds*

The total number of dynamometer test cycles shall be divided into two equal parts having speed ranges as follows :

a) In the first series of cycles, the tyre shall be loaded ("landed") against the flywheel at 78 knots and the tyre unloaded ("unlanded") at zero speed. The speed at "landing" shall be decreased as necessary (see 4.3.4) to ensure that 56 % of the calculated kinetic energy is absorbed by the tyre during each cycle.

b) In the second series of cycles, the tyre shall be loaded ("landed") against the flywheel at 104 knots and the tyre unloaded ("unlanded") at 78 knots. The speed of "unlanding" shall be increased as necessary (see 4.3.4) to ensure that 44 % of the calculated kinetic energy is absorbed by the tyre during each cycle. (All speeds shall be expressed in knots.)

4.3.4 *Flywheel kinetic energy*

If the correct number of flywheel plates cannot be used to obtain the computed kinetic energy value (see 4.3.1), a greater number of plates shall be selected and the dynamometer test cycle speed adjusted to obtain the required kinetic energy for each series of test cycles. If this results in landing speeds of less than 70 knots, the following shall apply :

- landing speed shall be determined by adding 28 % of the test E_k to the flywheel E_k at 55.6 knots;
- unlanding speed shall then be determined by subtracting 28 % of the test E_k from the flywheel E_k at 55.6 knots.

4.3.5 *Alternative dynamometer test*

Dynamic tests may also be run on a test drum which is of fixed mass, provided that the load, speed, time and roll distance are identical to those to which the tyre would be subjected if run on an inertia type dynamometer.

The fixed mass flywheel shall be decelerated at a constant rate over a time period calculated to make the tyre absorb the required kinetic energy. This time is calculated from the relationship of the energy required to the energy available from the fixed mass flywheel. Power may be added to or subtracted from the flywheel to obtain the desired programme time, t_c, as calculated from the following equation :

$$t_c = \frac{E_{kc}}{\dfrac{E_{kw(UL)} - E_{kw(LL)}}{t_{L(UL)} - t_{L(LL)}} - \dfrac{E_{kw(UL)} - E_{kw(LL)}}{t_{w(UL)} - t_{w(LL)}}}$$

where

E_{kc} is the kinetic energy calculated to be absorbed during landing;

E_{kw} is the kinetic energy of the flywheel at a given peripherical speed;

t_c is the programme time required for calculated kinetic energy;

t_L is the coast-down time with load on wheel (no power);

t_w is the coast-down time for windage and friction loss of wheel;

(UL) refers to the upper speed limit;

(LL) refers to the lower speed limit.

This equation reduces to the following for 78 knots to zero :

$$t_c = \frac{E_{kc}}{\dfrac{E_{kw(UL)}}{t_{L(UL)}} - \dfrac{E_{kw(UL)}}{t_{w(UL)}}}$$

4.4 Dynamometer test procedure — High-speed tyres for which load/speed/time/distance data are specified by the aircraft manufacturer in the form of total sortie test cycles

4.4.1 The tyre test shall realistically simulate tyre performance for the most critical combination of aircraft mass and centre of gravity position for the total sortie cycle from taxi-out to taxi-in.

Provision shall be made, in determining the total test sequence, for the following :

a) increased speeds and distances resulting from operation at high-altitude airports;

b) increased speeds and distances resulting from operation at high ambient temperature;

c) in-flight heating;

d) increased distances resulting from reduced acceleration required for operation of the aircraft.

4.4.2 Representative load/speed/time/distance data, compiled by the aircraft manufacturer, shall be the basis for establishing the applicable dynamometer test conditions, including data in respect of :

a) the probable incidence of the exceptional conditions stated in 4.4.1a), b), c) or d) in order to determine the percentage of the test cycles which shall include these conditions;

b) tyre heat soak temperature and time data relevant to 4.4.1c).

4.4.3 A typical total test cycle sequence is shown schematically in figure 4. The curves and the sequence shall be adjusted, for the purpose of establishing the full and precise test cycle, according to the data supplied by the aircraft manufacturer.

In the interests of efficient utilization of testing equipment, it is permissible to remove the tyre assembly from the dynamometer, to carry out the tyre in-flight heating or cooling phase, provided that the heating or cooling conditions laid down are respected and no interruption to the continuity of the test cycle results.

4.5 Dynamometer test procedure for high-speed tyres or for low-speed tyres for which load/speed/time/distance data are specified by the aircraft manufacturer not in the form of sortie test cycles

4.5.1 *Basic conditions for test*

Representative load/speed/time/distance data, compiled by the aircraft designer, shall be the basis for establishing the dynamometer tests.

The test procedure to be used shall be in accordance with 4.5.1.1, 4.5.1.2 and 4.5.1.3.

4.5.1.1 The high-speed series of test cycles shall be in accordance with either 4.5.1.1.1 or 4.5.1.1.2 as specified by the aircraft manufacturer, the test speed being in accordance with 4.6.

4.5.1.1.1 The dynamometer test cycles shall realistically simulate actual aircraft takeoff performance on the runway. A load/speed/time/distance schedule is adopted wherein the dynamometer flywheel is accelerated to the applicable conditions as shown graphically in figure 5.

4.5.1.1.2 The dynamometer test cycles shall consist of a load/speed/time/distance deceleration (reverse takeoff) type test as shown graphically in figure 6.

4.5.1.2 The low-speed series of test cycles shall be in accordance with either 4.5.1.2.1 or 4.5.1.2.2 as outlined below.

4.5.1.2.1 The tyre shall be loaded ("landed") against the flywheel at 78 knots and the tyre unloaded ("unlanded") at zero speed. The speed at "landing" shall be decreased as necessary (see 4.3.4) to ensure that 56 % of the calculated kinetic energy is absorbed by the tyre during each cycle.

4.5.1.2.2 The dynamometer test cycles shall consist of a load/speed/time/distance deceleration schedule as supplied by the aircraft manufacturer and as shown graphically in figure 7. The test load and speed shall be reduced to simulate actual aircraft landing conditions.

4.5.1.3 The tyre shall be subjected to a taxi type test in accordance with 4.5.1.3.1 and 4.5.1.3.2 as outlined below.

4.5.1.3.1 The tyre shall be tested on the dynamometer under the following conditions :

Peripheral speed :	30 knots
Tyre load	rated tyre load, L_r
Inflation pressure :	as specified in 4.2
Roll distance :	10 700 m

4.5.1.3.2 The tyre shall be heated so that at the start of each of the taxi test cycles, the contained air or carcass temperature is 50 ± 3 °C. No adjustment shall be made in the inflation pressure to compensate for increases in air pressure due to temperature rise. Rolling the tyre on the dynamometer is acceptable in obtaining the 50 °C tyre temperature.

4.6 Dynamometer test speeds

Applicable dynamometer test speeds for corresponding maximum operational ground speeds shall be as follows :

Maximum operational ground speed of aircraft knots		**Dynamometer test speed** knots
above	to	
–	104	
104	140	140
140	165	165
165	183	183
183	195	195
195	204	204
204	213	213
213		Consult the tyre manufacturer

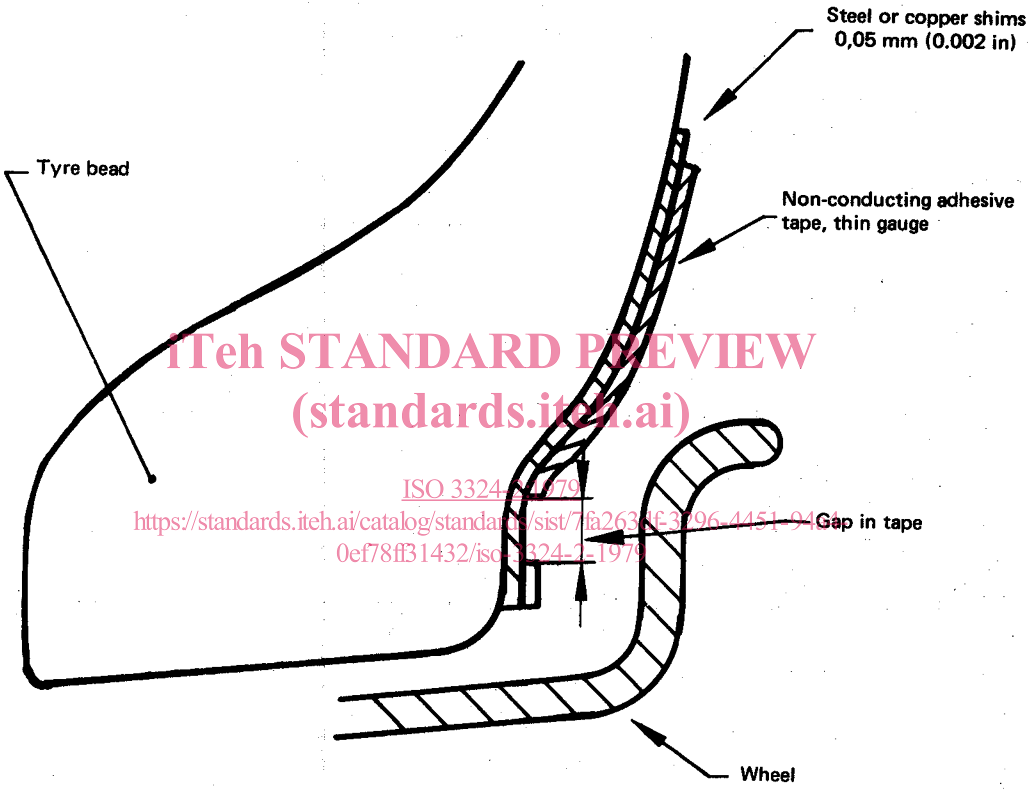

FIGURE 1 — **Bead seating pressure — Electrical method**

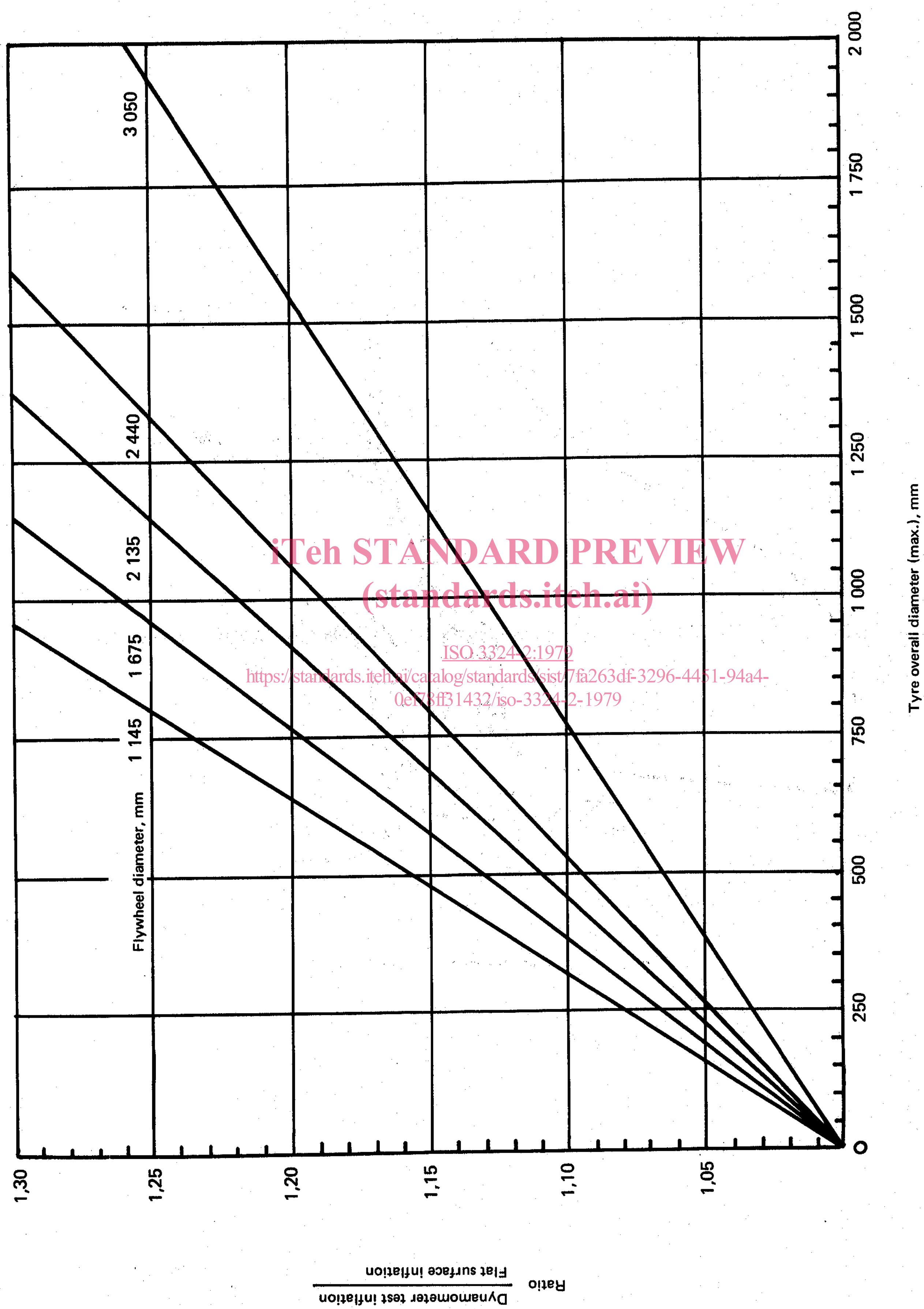

FIGURE 2 — Chart for adjusting aircraft tyre test inflation pressure for flywheel curvature — Values in millimetres

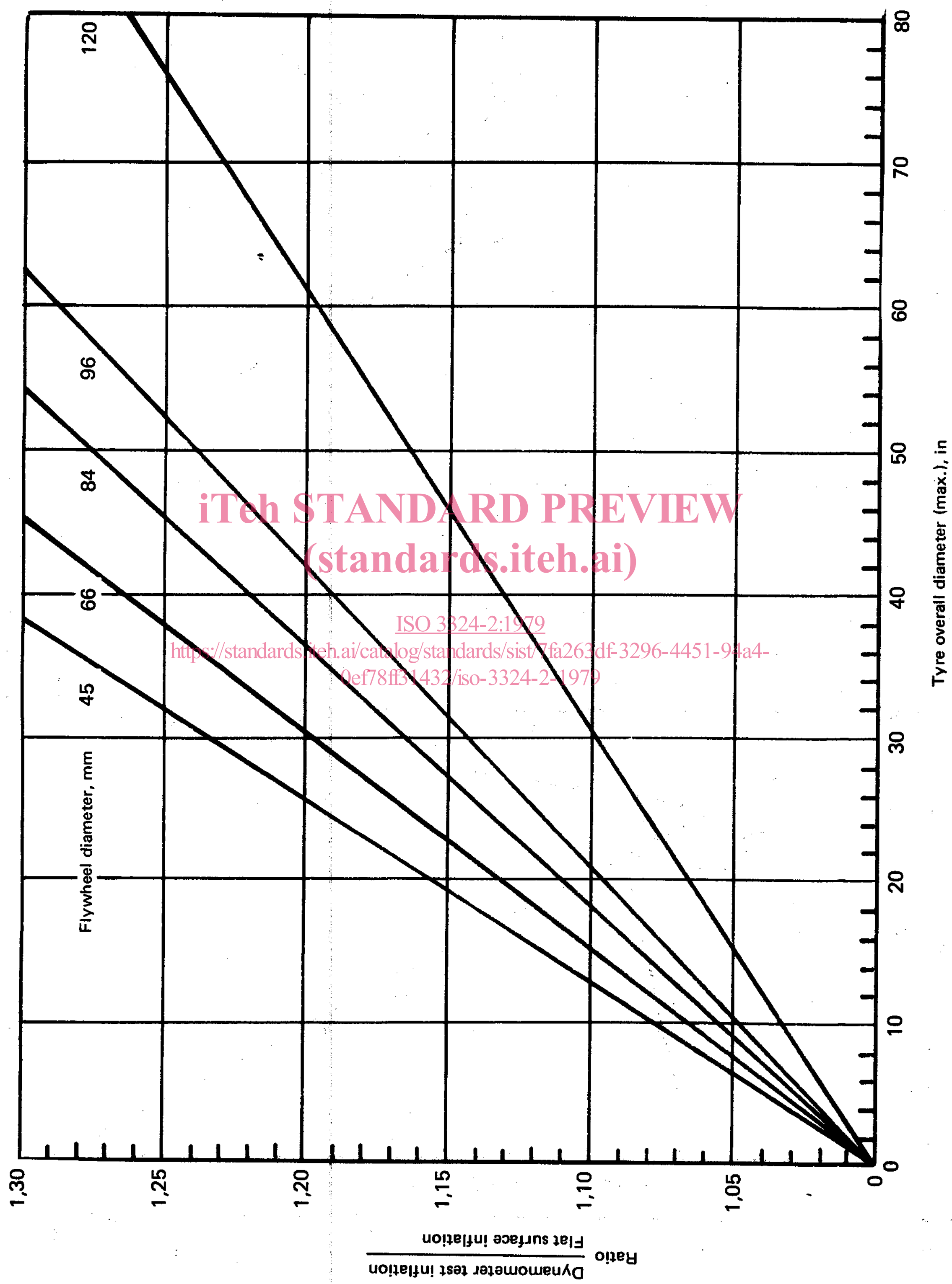

FIGURE 3 — Chart for adjusting aircraft tyre test inflation pressure for flywheel curvature — Values in inches