Designation: F 1112 – 00

Standard Test Method for Static Testing of Tubeless Pneumatic Tires for Rate of Loss of Inflation Pressure[1]

This standard is issued under the fixed designation F 1112; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the rate of inflation pressure loss resulting from air diffusion through the structures of tubeless tires under constant temperature conditions. The testing is done under static conditions, that is, nonrotating, nonloaded tires.

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

1.3 *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:*

F 538 Terminology Relating to the Characteristics and Performance of Tires[2]

F 1082 Practice for Tires—Determining Precision for Test Method Standards[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *inflation pressure loss rate, n*—rate of change of normalized inflation pressure, determined from the slope of the linear portion of the log pressure versus time curve.

3.1.2 *measured inflation pressure, n*—gage pressure of a tire measured at a given time under ambient temperature and barometric pressure.

3.1.3 *normalized inflation pressure, n*— measured pressure of a tire adjusted, according to the ideal gas law, to the nominal test temperature and one atmosphere external barometric pressure.

4. Summary of Test Method

4.1 Test tires are mounted on rims, fitted with calibrated precision pressure gages, inflated to the desired pressure, and, after a period of stabilization, are monitored for inflation pressure as a function of time under static, constant temperature conditions.

4.2 Measured inflation pressures are normalized to the nominal test temperature and one atmosphere barometric pressure for calculation of pressure loss rates.

4.3 Two or more tires per construction are tested for pressure loss rate over a period of two to six months. High precision in the data may allow shortening the test. See 9.6, 10.5, and Section 12.

4.4 The pressure loss rate is calculated as percent loss per month at the nominal test temperature.

5. Significance and Use

5.1 Inflation pressure retention is an important property of tire performance because underinflation can adversely affect tire rolling resistance, handling, structural integrity, and tread life.

5.2 This test method is useful for research and development evaluation of the effects of tire component formulations and geometry on inflation pressure retention. Testing for rate of pressure loss under static conditions is practical because of the following:

5.2.1 Tires in normal use are predominantly at rest, and

5.2.2 Relative air diffusion rates of various tires in normal intermittent road service will correlate with static relative rates, to a first approximation. The relative air diffusion rates of different tires may not be quite the same under dynamic flexing as when tested statically, but the difference is believed to be small.

5.3 The results from this test method are not suitable for inferring tire inflation retention under severe service conditions, such as heavy cornering or impacts, that might cause significant air loss at the tire-rim seal.

6. Interferences

6.1 Ambient temperature excursions greater than ±3°C (±5°F) for several hours may significantly alter both the air diffusion rate through the tire and the driving force inflation pressure, thereby causing variability in the rate of tire pressure loss. Some temperature variations can result from inconsistent air currents around racked tires, or from spatial temperature gradients in static air spaces. The effects can be significant where heat generating tests such as laboratory road wheels are

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[1] This test method is under the jurisdiction of ASTM Committee F-9 on Tiresand is the direct responsibility of Subcommittee F09.30 on Laboratory (Non-Vehicular) Testing.

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[2] *Annual Book of ASTM Standards*, Vol 09.02.

operating intermittently in the same room.

6.2 Other causes for inconsistent results are minute leaks in the tire, rim, valve, or gage assembly; as well as varied service or other heat history of the test tires.

7. Sampling and Preparation of Test Tires

7.1 All of the tires in a sample should have the desired producing plant and date codes and similar storage and service temperature history.

7.2 Tires must be free of molding or other defects, particularly on the bead area and innerliner surfaces.

7.3 New tires should be used for evaluation of construction or compound variations.

7.4 Minimum recommended sample size is two tires for each type of tire or treatment being tested.

7.5 Mount test tires on T & RA-approved, painted steel rims in like-new condition. Rims must have clean, smooth surfaces in the bead seat areas, particularly in the vicinity of the weld. Rim flanges must be free of sharp edges or scuffs that could damage the tire during mounting. Both bead seats of test rims must be checked with a calibrated disc tape (ball tape) for proper diameter according to T & RA Year Book specifications.

7.6 A commercial bead-rim lubricant shall be applied to the tire bead areas and rim before mounting. Vegetable oil or soap-based lubricants are recommended.

7.7 Mount the tire on the rim according to the practice recommended by RMA. Do not exceed 275 kPa (40 psi) inflation pressure for seating beads. Use of sealants in the bead-flange area should be avoided since it can prevent proper seating.

7.8 The rim shall be outfitted with either two serviceable valves or a single valve to which is then attached a metal "T" adapter that permits permanent attachment of a pressure measuring device (gage) to one opening and inflation through the other.

7.9 A sealing tape such as TFE-fluorocarbon or a room–temperature curable epoxy shall be used on all threaded connections in the valve-adapter-gage assembly.

7.10 A pressure measuring device (gage) shall be permanently connected to the adapter (or valve) to continuously sense inflation pressure. The device should be selected so that the pressure will always be in its working range of 40 to 90 % of full scale. The device should be readable to 2 kPa (0.25 psi) and accurate to ±1 % of full scale. Devices shall be calibrated before and after each use with a reference device whose calibration is traceable to the National Institute of Standards and Technology (NIST). The pressure measuring device must maintain this accuracy over the duration of the test. Quality Bourdon tube gages[3] have been satisfactory. Stable, high–pressure electronic pressure transducer systems can be satisfactory, and they can be read remotely, avoiding entry to the test chamber.

7.11 Inflate the tire-rim assembly outfitted with the pressure gage to the desired starting pressure and test for leaks by submersion in a water tank, up to the base of the gage, for at least 30 min.

7.12 After confirming that the tire-rim assembly is free from leaks, fit the valve or adapter opening with a sealing cap, and keep the tire in the same orientation to avoid causing new leaks.

7.13 After the leakage check, condition the tires at the test room temperature for 48 h; then adjust to the starting test pressure. Replace the sealing cap on the valve or adapter. If a pressure drop of more than 3 kPa (0.5 psi) occurs over the conditioning period, recheck the assembly for leakage according to 7.11 and, if necessary, remount. Greater than 48 h conditioning may be necessary for some tires such as high–pressure compact spares, whose growth can affect early inflation loss results.

8. Test Chamber

8.1 The test chamber shall be controlled to provide a mean ambient temperature that is within ±0.6°C of the nominal test temperature and with overall variation within ±3°C (±5°F) over the course of the test.

8.2 Nominal test temperatures currently in use are: 21, 24, 30, and 38°C (70, 75, 86, and 100°F).

8.3 Air in the test chamber should be forcibly circulated to minimize spatial temperature gradients.

9. Procedure

9.1 Place the test tires in the test chamber so as to allow free air circulation around them and easy visual access to the pressure gages. The tires shall not be moved during the test.

9.2 Record inflation pressures, concurrent ambient temperatures, and barometric pressures daily for two weeks. Tap the gage lightly prior to each reading. Tires shall be considered to be satisfactorily conditioned when the slope of the logarithm of the normalized inflation pressure versus time relationship becomes constant.

9.3 The test shall be continued if replicate tires agree with each other within 6 kPa (approximately 1 psi) inflation pressure after two weeks. Otherwise, recheck the suspect assembly for leaks according to 7.11, and restart the test.

9.4 Inflation pressure readings and concurrent ambient temperature and barometric pressure readings shall be recorded at least once per week during the remaining test period. Continuous monitoring of ambient temperature is desirable to ensure that the tire is at equilibrium temperature when its pressure is measured.

9.5 Correct inflation pressure readings, P_1, to the nominal test temperature and one atmosphere barometric pressure (101.3 kPa, 14.69 psi) by using the equation in 10.1.

9.6 A commonly used test duration is 180 days. The test period may be shorter or longer depending on the precision level of the data. Twice per week measurements are recommended if shorter term projections of performance are intended. See also 4.3.

10. Calculation

10.1 Calculate normalized pressures from the formula:

$$P = (P_1 + B_1)(T_2/T_1) - B_2 \quad (1)$$

[3] Available from Ametek Corp., U.S. Gauge Division, 900 Clymer Ave., Sellersville, PA 18960. U.S. Gauge Dial model No. 37694 has been found satisfactory.

where:

P = normalized inflation pressure, kPa,
P_1 = measured inflation pressure, kPa,
B_1 = measured barometric pressure, kPa
B_2 = reference barometric pressure (one atmosphere = 101.3 kPa),
T_1 = measured temperature,°K, and
T_2 = nominal test temperature,°K.

NOTE 1—Temperature in kelvins equals celsius plus 273.15.

10.2 Fit the data to a model of the following form:

$$P = P_o e^{\beta t} \tag{2}$$

where:

P = normalized pressure, kPa,
P_o = initial pressure, kPa,
β = loss rate per day at the nominal test temperature, and
t = test time, days.

10.3 A least squares fit can be obtained after transformation of the model equation to the following form:

$$\ln P = \alpha + \beta t \tag{3}$$

where:

α = $\ln P_o$

The model is derived from a relationship that expresses pressure loss as a function of pressure only:

$$dP/dt = \beta P \tag{4}$$

Thus, pressure loss in absolute units will vary as the actual nominal pressure changes, but a loss rate can be expressed by the constant, β.

10.4 The calculated loss rate constant, β, will be in units of 1/day. This number will typically be a very small decimal; it is convenient, and perhaps more intuitively meaningful, to express loss rate as a percent per month. This is done by multiplying β by 3000 (which is 100 % × 30 days/month).

10.5 Calculations of loss rate and predictions of future pressures can be made from any point in the test. The accuracy of such predictions will depend on the appropriate-ness of the model as well as the precision level of data obtained that, in turn, will depend on factors such as the following:

10.5.1 Care in reading pressure gages,

10.5.2 Resolution of pressure gages, and

10.5.3 Maintenance of a relatively constant temperature.

11. Report

11.1 For each test tire, report the loss rate as a percent per month (β × 3000) and other pertinent test parameters including:

11.1.1 Total test duration in days,

11.1.2 Projected inflation pressure, if applicable,

11.1.3 Average ambient temperature and range over test,

11.1.4 Initial inflation pressure,

11.1.5 Actual and "best fit" final inflation pressure, and

11.1.6 Starting date.

11.2 Also report the manufacturer, line, size, production plant, and date code for each tire.

11.3 An example treatment of test data is given in Appendix X1.

12. Precision and Bias [4]

12.1 The precision and bias section has been prepared in accordance with Practice F 1082. Refer to Practice F 1082 for terminology and other statistical calculation details.

12.2 An interlaboratory test was conducted in 1985 using a set of used uniform tire quality grading (UTQG) Course Monitoring Tires (CMT). This set of ten tires was furnished by one of the participating laboratories.

12.3 Five laboratories participated in the interlaboratory test. Each laboratory tested two tires following the test procedure as outlined in this standard. Thus, there are only 5 degrees of freedom (df) for repeatability (r) and four df for reproducibility (R). These low df for r and R are not optimum for a good reliable estimate of overall precision.

12.4 The tire air pressure loss rate was measured simultaneously for each of the two tires (per laboratory) at 22 ± 0.8°C. This loss rate, as specified by this test method, is expressed as ($B \times 3000$) in units of percent per month (or 30 days) at one atm (101 kPa) barometric pressure. A test result is the value obtained for ($B \times 3000$) for one tire and one test on that tire.

12.5 The precision results, given in Table 1, show that the repeatability is equal to the reproducibility. For this (small df) interlaboratory test, the variation among the five laboratories is no greater than the pooled tire-to-tire variation within the laboratories. The rather large relative repeatability of 35 % may be indicative of variations in the test samples themselves. There is no independent way to verify this due to the age dependency of diffusion rate measurements.

12.6 Table 2 lists the actual test results. Inspection of the table shows the lack of agreement between duplicate tire results within any one of the five laboratories. It also shows how the level of agreement among the laboratories substantially improves by taking averages. The within-laboratory single tire standard deviation, S_r, of 0.24 is twice the between-laboratory single tire standard deviation of 0.12 (adjusted for the "averages of two basis" by multiplication by $\sqrt{2}$).

12.7 *Repeatability*— The repeatability, r, of this test method has been established as 0.68. Two single test results, that is, loss rate in percent/month at 1 atm (101 kPa), obtained under normal test method procedures, that differ by more than this r must be considered as derived from different or nonidentical sample populations.

12.8 *Reproducibility*— The reproducibility, R, of this test method has been established as 0.68. Two single test results that is, loss in percent/month at 1 atm (101 kPa), obtained in two different laboratories, under normal test method procedures, that differ by more than R must be considered to have come from different or nonidentical sample populations.

12.9 Repeatability and reproducibility expressed as a percent of the mean level, (r) and (R), have equivalent application statements as above for r and R. For the (r) and (R) statements, the difference in the two single test results is expressed as a percent of the arithmetic mean of the two test results.

12.10 *Bias*—In test method terminology, bias is the difference between an average test value and the reference (or true)

[4] Supporting data are available from ASTM headquarters. Request RR: F09–1000.

TABLE 1 Precision: Air Pressure Loss Rate (B × 3000)

Tire Type	Average Loss Rate[A]	Within Laboratory[B]			Between Laboratory[B]		
		S_r	r	(r)	S_R	R	(R)
UTQG CMT P19575R14 Uniroyal	1.91	0.24	0.68	35.4	0.24	0.68	35.4

[A] Units = percent per month (101 kPa).
[B] S_r = repeatability standard deviation.
r = repeatability (in measurement units) (= 2.83 S_r).
(r) = repeatability (relative or percent).
S_R = reproducibility standard deviation.
R = reproducibility (in measure units) (= 2.83 S_R).
(R) = reproducibility (relative or percent)

TABLE 2 Actual (B × 3000) Values for Five Laboratories[A]

Laboratory	Tire	$B \times 3000$	Tire	$B \times 3000$	Average (2 Tire)
1	1	1.74	6	1.94	1.84
2	2	2.25	7	1.70	1.98
3	3	1.95	8	1.88	1.92
4	4	1.61	9	2.02	1.82
5	5	2.14	10	1.90	2.02
					1.91

[A]

S_r = 0.24.
S_R = (among laboratory) standard deviation (2 tire average) = 0.086.
S_R = (among laboratory) standard deviation (single tires) = 0.086 $\sqrt{2}$ = 0.12.

test property value. Reference values do not exist for this test method since the value (of the test property) is exclusively defined by the test method. Bias, therefore, cannot be determined.

13. Keywords

13.1 inflation pressure; pneumatic tires; rate of loss; static testing

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE OF DATA ANALYSIS FOR RATE OF PRESSURE LOSS IN TIRES

X1.1 This example shows typical input data and analyses for obtaining the rate of pressure loss of a tire according to this test method.

X1.2 Table X1.1 presents measured data for a single tire over the 195 day test duration, the normalized inflation pressures calculated with the equation in 10.1, and the natural logarithms of the normalized pressures.

X1.3 Normalized inflation pressure as a function of time is plotted in Fig. X1.1. Fig. X1.2 is a plot of ln(P) versus time. In each case, the least squares regression of the data excluded the first 30 days to avoid the initial nonlinear inflation pressure change due to tire growth (evident in the first few data points).

X1.4 Computation of inflation pressure loss rate over the test duration employed a computer program to fit the model equation (10.2) to the data by conducting a simple linear regression of the ln(P) vs time data. The intercept is ln(P_0), and the slope is β. Inflation pressure loss rate is (the absolute value of) $\beta \times 3000$. The calculation is repeated at successive times to get an increasingly precise estimate of the true loss rate. Results are reported in Table X1.2. Again, the first thirty days of data were excluded from the analysis because they would not be expected to fit the model due to the nonlinear effects in this portion of the data set (noted earlier).

X1.5 Fig. X1.3 presents a format for the test data summary, in accordance with 10.5 of the standard test method. Results for two tires tested at the same time are presented.

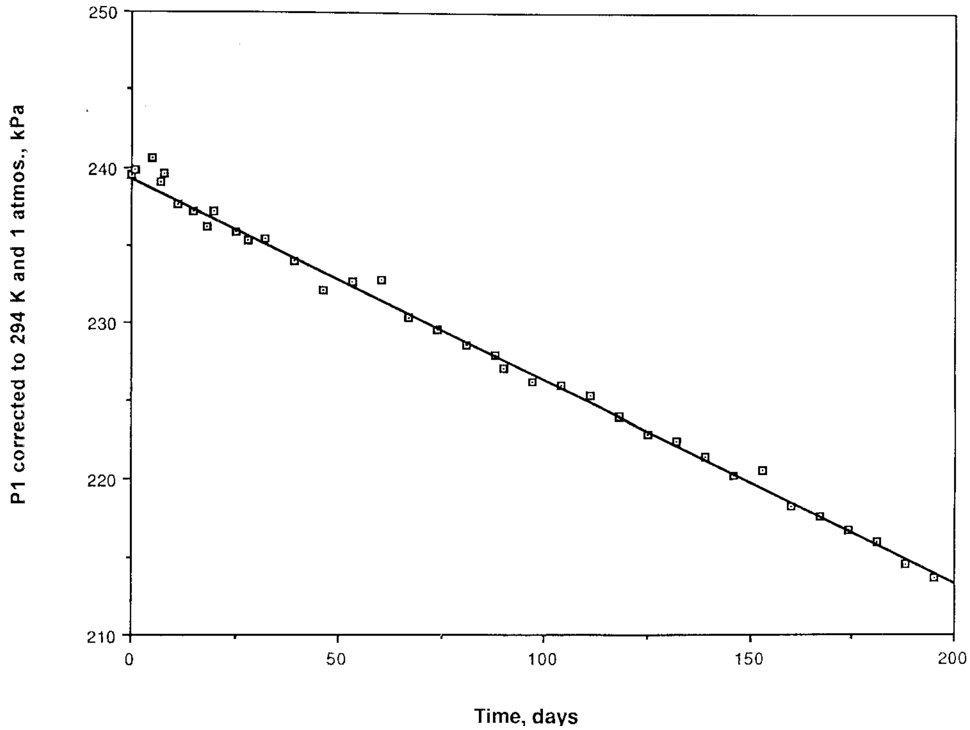
TABLE X1.1 Tire Inflation Pressure Loss Rate Test Example: Raw Input Data, Normalized Pressure and ln (Pressure)[A]

Observation	Day	T_1	P_1	B_1	P	ln (P)
1	0	294.4	241.0	29.57	239.533	5.47869
2	1	293.9	240.8	29.57	239.913	5.48028
3	5	294.4	240.1	30.17	240.663	5.48340
4	7	294.4	238.8	30.08	239.059	5.47671
5	8	293.9	239.7	29.82	239.659	5.47922
6	11	294.4	239.3	29.51	237.631	5.47072
7	15	294.4	235.9	30.40	237.243	5.46909
8	18	294.4	238.6	29.30	236.222	5.46477
9	20	294.1	236.7	30.07	237.272	5.46921
10	25	294.4	238.2	29.31	235.856	5.46322
11	28	294.4	234.6	30.21	235.302	5.46087
12	32	294.4	234.5	30.27	235.405	5.46131
13	39	295.0	234.5	30.06	234.011	5.45537
14	46	295.5	234.0	29.81	232.104	5.44718
15	53	294.4	233.5	29.76	232.681	5.44967
16	60	294.7	233.5	29.90	232.814	5.45024
17	67	294.4	230.0	30.12	230.401	5.43982
18	74	295.5	230.0	30.25	229.604	5.43635
19	81	295.8	299.5	30.22	228.670	5.43228
20	88	294.7	228.0	30.10	227.999	5.42934
21	90	294.9	227.5	30.05	227.108	5.42542
22	97	295.0	227.0	29.95	226.160	5.42124
23	104	294.1	226.0	29.91	226.027	5.42065
24	111	294.5	225.5	29.98	225.319	5.41752
25	118	295.5	225.0	30.05	223.952	5.41143
26	125	295.0	224.0	29.86	222.865	5.40656
27	132	295.0	222.0	30.33	222.456	5.40473
28	139	294.4	222.0	29.83	221.425	5.40009
29	146	295.0	221.0	29.97	220.244	5.39474
30	153	294.4	219.5	30.32	220.584	5.39628
31	160	295.0	219.0	29.98	218.283	5.38579
32	167	295.1	218.0	30.10	217.583	5.38258
33	174	295.0	216.5	30.24	216.667	5.37836
34	181	294.7	217.0	29.77	215.902	5.37483
35	188	295.2	215.5	30.00	214.539	5.36849
36	195	295.5	214.5	30.09	213.633	5.36426

[A]

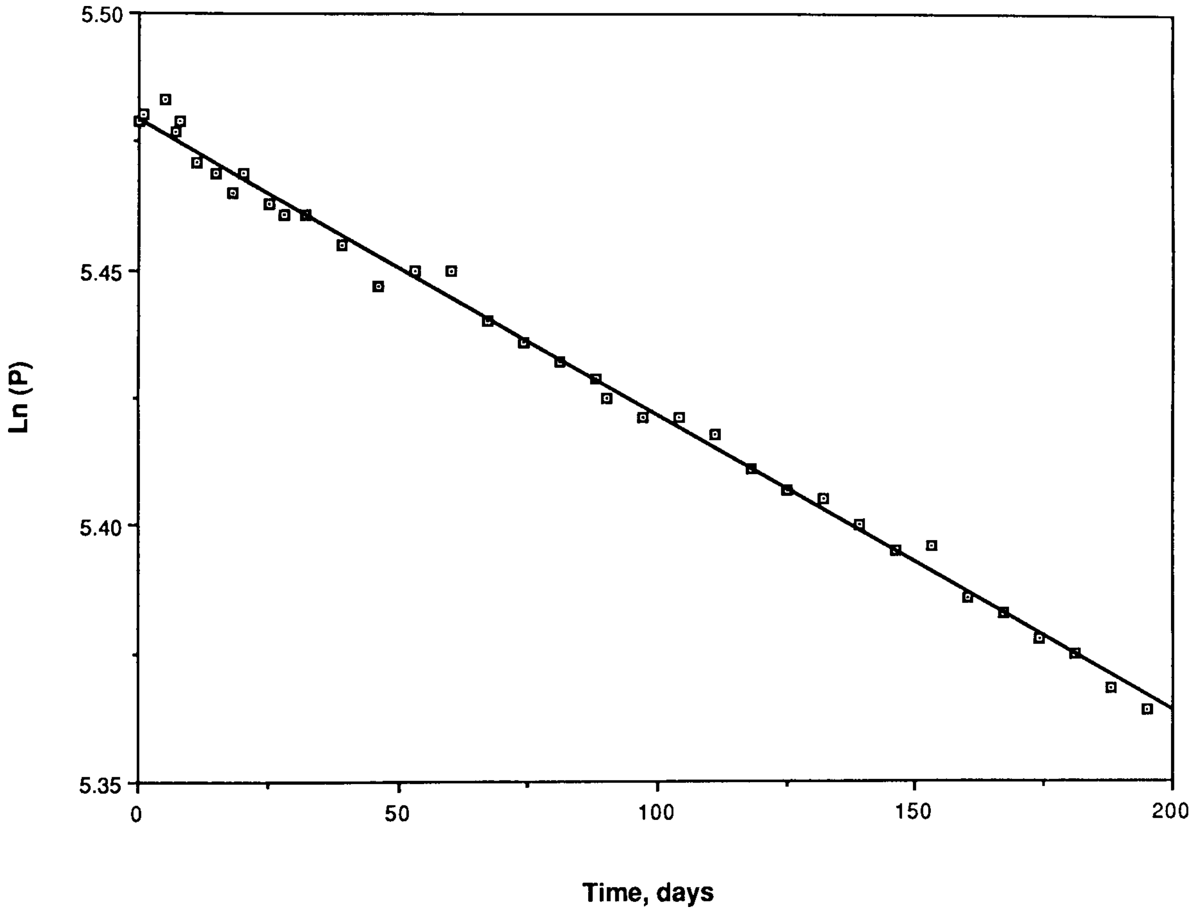
where:

T_1 = measured temperature, K,
P_1 = measured inflation pressure, kPa,
B_1 = measured barometric pressure, kPa,
T_2 = 294 K (assumed),
P = normalized inflation pressure,
$ln(P)$ = $Log_n(P)$, and
B_2 = 101.3 kPa (assumed).



NOTE 1—Calculation of regression line excluded the data that occurred in the first 30 days.

FIG. X1.1 Typical-Change in Tire Inflation Pressure With Time



NOTE 1—Calculation of regression line excluded the data that occurred in the first 30 days.

FIG. X1.2 Typical Change in Tire Ln(P) With Time

TABLE X1.2 Results of Loss Rate Calculation[A]

Observation	Day	Loss Rate, % per month
1	46	3.026
2	53	1.847
3	60	1.193
4	67	1.473
5	74	1.575
6	81	1.631
7	88	1.633
8	90	1.694
9	97	1.738
10	104	1.706
11	111	1.673
12	118	1.681
13	125	1.697
14	132	1.686
15	139	1.684
16	146	1.695
17	153	1.663
18	160	1.683
19	167	1.693
20	174	1.702
21	181	1.707
22	188	1.721
23	195	1.733

[A]First 30 days of data were deleted due to obvious nonlinearity in initial data of this set that would not fit the model in 10.2.

Tire: Manufacturer, Line, Size:	(Example Only)		
Serial Numbers:	______	______	
Features:	______		
Test Temperature, °C:	Nominal 21.0 Average 21.5 Range 20.7 - 22.6		
Test Start Date:	1/2/86	Duration: 195 days	
Normalized P's, kPa:			
Initial:	239.5	239.5	
Final:	213.6	213.6	
Best Fit:	214.0	213.7	(First 30 days excluded from the regression)
Inflation Pressure Loss Rate, %/Month (at 101 days):	1.71	1.73	Average: 1.72

FIG. X1.3 Test Report on Rate of Loss of Inflation Pressure