TECHNICAL SPECIFICATION

ISO/TS 8611-4

First edition
2013-10-15

Pallets for materials handling — Flat pallets —

Part 4: Procedure for predicting creep responses in stiffness tests for plastic pallets using regression analyses

Palettes pour la manutention — Palettes plates —

Partie 4: Mode opératoire pour prédire les réponses au fluage lors des essais de rigidité des palettes en plastique en utilisant des analyses de régression

Reference number
ISO/TS 8611-4:2013(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 51, *Pallets for unit load method of materials handling*.

ISO 8611 consists of the following parts, under the general title *Pallets for materials handling — Flat pallets*:

— *Part 1: Test methods*

— *Part 2: Performance requirements and selection of tests*

— *Part 3: Maximum working loads*

— *Part 4: Procedure for predicting creep responses in stiffness tests for plastic pallets using regression analyses* [Technical Specification]

Pallets for materials handling — Flat pallets —

Part 4: Procedure for predicting creep responses in stiffness tests for plastic pallets using regression analyses

1 Scope

This part of ISO 8611 presents a procedure for predicting creep responses in stiffness tests for plastic pallets to shorten the test period. Based on regression analyses, deflections during full load and relaxation periods are predicted. This part of ISO 8611 is for use with the static stiffness tests such as tests 1b, 3b, 4b, 5b, and 7b referred to in ISO 8611-1:2011, and is for application at ambient temperature only. Annex A gives an informative example of this process.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 445, *Pallets for materials handling — Vocabulary*

ISO 8611-1:2011, *Pallets for materials handling — Flat pallets — Part 1: Test methods*

ISO 8611-2:2011, *Pallets for materials handling — Flat pallets — Part 2: Performance requirements and selection of tests*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 445 and the following apply.

3.1
regression analysis
statistical technique for modelling and analysing the relationship between several variables, where the focus is on the relationship between a dependent variable and one or more independent variables

3.2
least square method
statistical method of estimating the coefficients in the regression model such that the sum of squared residuals are minimized, where the residual is the difference between an observed value and the value provided by the model

3.3
test period
period required for the stiffness test of plastic pallets, which is divided into full test load period and relaxation period

3.4
full test load period
full period required for the stiffness test of plastic pallets under load, which lasts for 24 h or 48 h depending upon the type of tests

3.5
relaxation period
period required for the stiffness test of plastic pallets after releasing load, which lasts for 2 h from the outset of releasing

3.6
reduced test period
reduced period required for the stiffness test of plastic pallets under load, which lasts for 4 h

3.7
relaxation period of the full test
period required for the stiffness test of plastic pallets after releasing load, which lasts for 2 h from the end of the full test load period

3.8
relaxation period of the reduced test
period required for the reduced stiffness test of plastic pallets after releasing load, which lasts for 2 h from the end of reduced full load period

4 Symbols and abbreviated terms

b_0, b_1	regression coefficients
b_0*, b_1*	estimated regression coefficients
$Y(t)$*	deflection predicted at time t (mm)
$Y(t)$	deflection actually measured at time t (mm)
$e(t)$	regression error at time t
$\ln(t)$	natural logarithm of time t

5 Procedure for predicting creep responses

5.1 Purpose

Stiffness tests for plastic pallets, including tests 1b, 3b, 4b, 5b, and 7b in ISO 8611-1:2011, require test durations of 24 h to 48 h, depending on the type of test measurement. These test durations are essential because plastic pallets and pallet decks creep while placed in storage racks or stack storage. However, it is of great benefit in saving time and cost if creep deflections can be predicted for the entire test period from the test data of the first 4 h. Using the method described in this part of ISO 8611, test duration can be reduced while keeping the same time of relaxation as in ISO 8611-1:2011, as recommended in Table 1. This part of ISO 8611 shows how to conduct the stiffness tests based on the predicted value of creep responses during the loading and relaxation periods.

Table 1 — Full load duration and reduced duration recommended for static stiffness tests

Pallet material and tests		Test period (h)	Reduced test period (h)	Relaxation time (h)
Where plastics or plastic parts dictate overall performance	tests 1b, 3b, 5b, and 7b	24	4	2
	test 4b	48	4	2

5.2 Test procedure

At least three plastic pallets for each test shall be used as specified in Clause 5 of ISO 8611-2:2011. Deflections at the specified locations on the pallet shall be recorded continuously during the creep test. The frequency of 1 observation per 30 s is recommended for the first hour of testing, and the recommended frequency for the remainder of the creep test is 1 every 10 min interval. The recommended extraction interval for relaxation is 1 observation every 30 s. The following steps shall be used to predict the creep responses.

1) Test the first pallet for both the full load period (24 h; 48 h for test 4b) and the relaxation period (2 h). Deflections at specified intervals shall be measured while pallet creeps. If the deflection measured at the end of the full load or the relaxation period exceeds the standard performance limits specified in Table 1 of ISO 8611-2:2011, stop the test. The pallets in the lot shall be declared as failed for the stiffness test. Otherwise, proceed with step 2.

2) Test the second pallet for the reduced test duration with 4 h load. Use Formula (1) to estimate the regression coefficients for the loading test period. Then predict the deflections for the remainder beyond the reduced test duration, which span from 4 h to 24 h (or 48 h), based on Formula (1). If the deflection predicted at the end of the full load period exceeds the standard performance limit specified in Table 1 of ISO 8611-2:2011, stop the test. The pallet shall be declared as failed for the stiffness test. Otherwise, proceed to step 3 to test for the relaxation period. The performance limit test shall be done based on *t*-test procedure.

3) Test the second pallet for the 2 h relaxation period of the reduced test and obtain the data. Use Formula (2) to estimate the regression coefficients for the relaxation period. Then predict the deflections in the relaxation period of the full test, which cover from 24 h to 26 h (or 48 h to 50 h), based on Formula (2). If the deflection predicted at the end of the relaxation period of the full test exceeds the standard performance limit specified in Table 1 of ISO 8611-2:2011, stop the test. The pallet shall be declared as failed for the stiffness test. Otherwise, proceed to step 4. The performance limit test shall be done based on *t*-test procedure.

4) Test the third pallet and repeat steps 2 to step 3.

5.3 Specification of regression models

The regression model in Formula (1) shall be used for fitting sample data from the loading period.

$$Y(t) = b_0 + b_1[\ln(t)] + e(t) \quad (1)$$

where

$Y(t)$ is the pallet deflection occurred at time t (mm);

t is the time in minutes;

b_0, b_1 is the set of regression coefficients;

$e(t)$ is the error at time t, independently and identically distributed as normal.

Formula (2) shall be used for fitting sample data from the relaxation period for $0 \le t \le 2$ h.

$$R(t) = b_0 + b_1[\ln(t)] + e(t) \tag{2}$$

where

$R(t)$ is the ratio of deflections at the relaxation period, $Z(t)$ divided by $Z_p(t)$;

$Z(t)$ is the deflection in t minutes relaxation from the full test pallet;

$Z_p(t)$ is the deflection in t minutes relaxation from the reduced test pallet;

$e(t)$ is the error at time t, independently and identically distributed as normal.

5.4 Predicting the deflections under the test load and during the relaxation time

5.4.1 Purpose

Two performance requirements shall be measured in order to evaluate the bending stiffness of pallets. The first requirement is the bending deflection for the test load period and the second is the bending deflection for the relaxation time.

5.4.2 Predicting the deflections during the full test load period

5.4.2.1 Measuring the actual deflections

The first pallet shall be tested as specified in 5.2 for both the full test load period and the relaxation period, and the deflection shall be measured at the end of the full test load period.

5.4.2.2 Calculating the predicted deflections

For the second pallet, the test duration shall be 4 h as specified in Table 1. Regression coefficients are estimated based on the least squares method, and then the deflections at the end of full duration are predicted. The deflections in the full load period for the partially tested pallet shall be predicted using the estimations from Formula (3).

$$Y(t)^* = b_0^* + b_1^*[\ln(t)] \tag{3}$$

where

$Y(t)^*$ is the pallet deflection estimated at time t (mm);

t is the time in minutes;

b_0^*, b_1^* is the set of estimated regression coefficients.

The same procedure shall be applied to the third pallet.

5.4.3 Predicting the deflections during the relaxation period

5.4.3.1 Measuring the actual deflections

The deflections during the relaxation period, after unloading, shall be measured at both the full test period and the reduced period.

5.4.3.2 Calculating the predicted deflections

The deflections for the relaxation period of reduced test shall be estimated using the deflection ratio of fully tested pallet to partially tested pallet as specified in Formula (2) and (3).

The deflections in the relaxation period of the partially tested pallet shall be predicted using the estimated Formula (4) as follows.

$$Z(t)^* = Z_p(t)\{b_0^* + b_1^*[\ln(t)]\} \tag{4}$$

where

$Z(t)^*$ is the hypothetical deflection in t minutes relaxation, if the partially-tested pallet is put to full test, of which deflections shall be predicted using the regression model;

b_0^*, b_1^* is the set of estimated regression coefficients based on Formula (2).

The same procedure shall be applied to the third pallet.

5.5 Statistical testing for the standard performance limit

5.5.1 Purpose

Using t-test procedure, the predicted deflections for the hypothetical full period of pallets shall be tested if the predicted deflection of the pallet falls within the standard performance limit.

5.5.2 *t*-test procedure for the loading period

The t-test procedure is formulated as follows. Set up the null hypothesis "predicted deflection is above the standard limit, C." That is, the null hypothesis is that the pallet fails the performance test. Then the alternative hypothesis is that predicted deflection is not above standard limit. Under the null hypothesis, T-stat is computed as T-stat = $(Y^*_{24\text{ h or }48\text{ h}} - C)/SE(Y^*_{24\text{ h or }48\text{ h}})$. T-stat is approximately distributed as t-distribution with $(n - 2)$ degrees of freedom, where $Y^*_{24\text{ h or }48\text{ h}}$ is the deflection predicted at 24 h or 48 h; C is the standard performance limit for the loading period according to ISO 8611-2:2011; $SE(Y^*_{24\text{ h or }48\text{ h}})$ is the standard error of predicted deflection at 24 h or 48 h; n denotes the number of observations in the regression. The standard error $SE(Y^*_{24\text{ h or }48\text{ h}})$ can be computed following Formula (5).

$$SE(Y^*_{24\text{h or }48\text{h}}) = \sqrt{\sum_{t=1}^{n} \frac{(Y_t - Y_t^*)^2}{n-2}} \sqrt{\left(1 + \frac{1}{n} + \frac{(X_{24\text{h or }48\text{h}} - \bar{X})^2}{\sum_{t=1}^{n}(X_t - \bar{X})^2}\right)} \tag{5}$$

where

n is 138;

X_t is $\ln(t)$;

$X_{24\text{ h or }48\text{ h}}$ is ln(1 440 min) or ln(2 880 min);

$\bar{X}$ is the mean of X;

Y_t^* is the estimate of Y_t .

The *t*-test statistic shall be compared to $t(5\ \%, n-2)$, which is the critical value at $n-2$ degrees of freedom and 5 % significance level in the one-sided test for the left tail. The critical value corresponding to $t(5\ \%, n-2)$ can be referred in the Student-T distribution table. If T-stat < $t(5\ \%, n-2)$, the pallet passes the performance test.

5.5.3 *t*-test procedure for the relaxation period

The *t*-test procedure for the relaxation period is almost identical to that for the loading period. The only differences are the preset standard performance limit (C) for the relaxation stage and the standard error of the deflection estimate at time 26 h, $Z^*_{26\text{ h}}$, or at time 50 h, $Z^*_{50\text{ h}}$. The standard error of $Z^*_{26\text{ h}}$ or $Z^*_{50\text{ h}}$ can be computed as follows.

$$SE(Z^*_{26\text{h or }50\text{h}}) = Z_{6\text{h}} \sqrt{\sum_{t=1}^{n} \frac{\left(R_t - R_t^*\right)^2}{n-2}} \sqrt{\left(1 + \frac{1}{n} + \frac{(X_{6\text{h}} - \bar{X})^2}{\sum_{t=1}^{n}(X_t - \bar{X})^2}\right)} \quad (6)$$

where

n is 69;

X_t is $\ln(t)$;

$X_{6\text{h}}$ is ln(360 min);

R_t is Z_t / Z_{pt};

R_t^* is the estimate of Z_t/Z_{pt};

$\bar{X}$ is the mean of X;

$Z_{6\text{h}}$ is the actual deflection of partially-tested pallet at the end of relaxation period (i.e. 6 h).

6 Test report

The test report shall list at least the following:

a) a reference to this International Standard (i.e. ISO/TS 8611-4:2013);

b) the type of tests and the number of pallets used for the regression method;

c) the reduction in test duration;

d) the regression results from 24 h (or 48 h) and 4 h, with coefficients for full load test period;

e) the regression results with coefficients for relaxation period;

f) the results from the *t*-test for standard performance limit for full and relaxation periods.

Annex A
(informative)

An example of predicting creep responses in order to reduce the full test load duration

A.1 General

This annex is for information only and cannot be used to evaluate the performance of plastic pallets.

A.2 Procedure

The sample deflection data in every step are from the testing of plastic pallets. These data are presented here only for the demonstration of how the deflections could be predicted in test durations shorter than required for the stiffness tests of pallets. The test has been performed in accordance with the procedure provided in 5.2.

Step 1: The first pallet is subjected to test 1b to determine the stiffness of the pallet. The test is performed during 24 h of the full test load period and for 2 h of the relaxation period as specified in Table 1. The deflections are measured in accordance with 5.2. Now we have the deflections at both 24 h and 26 h at the relaxation time, and the accompanying actual deflection curve, as shown in Figure A.1. The standard performance limits (C) are calculated according to the prescription in Table 1. In this sample test, the performance limits are 2 % and 0,7 % of the span of pallets, respectively. Thus, since the sample pallet is 1 100 × 1 100 × 150 mm^3 of which span is 1 100 − 2 × 75 = 950 mm, the performance limits should be 19 mm under load and 6,65 mm in relaxation.

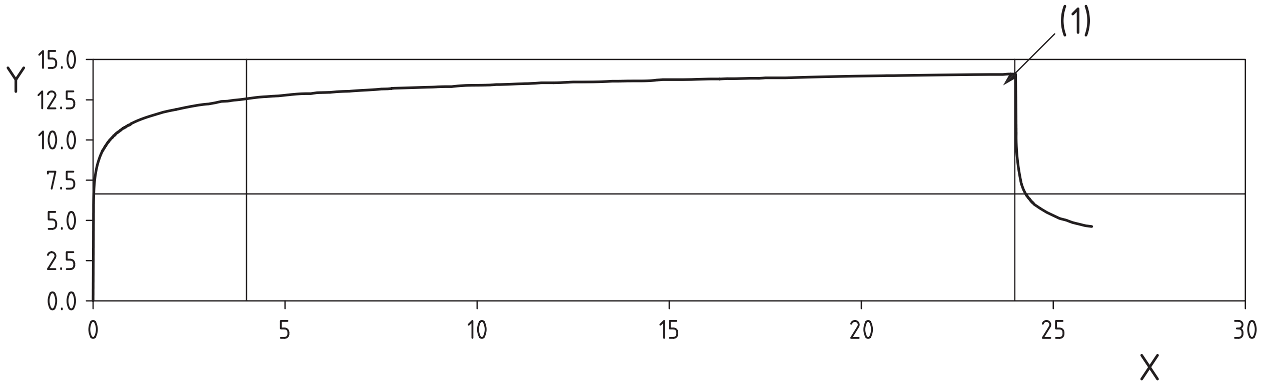
a) The deflection actually measured at 24 h, Y(24 h) = 14,1 mm; Standard limit for the loading period = 19 mm.

    The first pallet passes the loading test since Y(24 h) < 19 mm.

b) The deflection actually measured at 26 h during the relaxation period of 2 h, Y(120 min) = 4,6 mm.; Standard limit for the relaxation period = 6,65 mm.

    The first pallet passes the relaxation test since Y(120 min) < 6,65 mm.

c) The actual deflection curve during the loading period is as follows.



Key

X time (h)

Y deflection (mm)

Figure A.1 — Actual deflection curve measurement

Step 2: The second pallet is tested for the reduced test duration. The test is performed for 4 h of the full test load period, as recommended in Table 1. The deflection at 24 h based on the 4 h of deflection data can be calculated and predicted using Formula (1) in Clause 5.3. The predicted deflection curve is presented as shown in Figure A.2.

a) The predicted deflection at 24 h using 4 h of data:

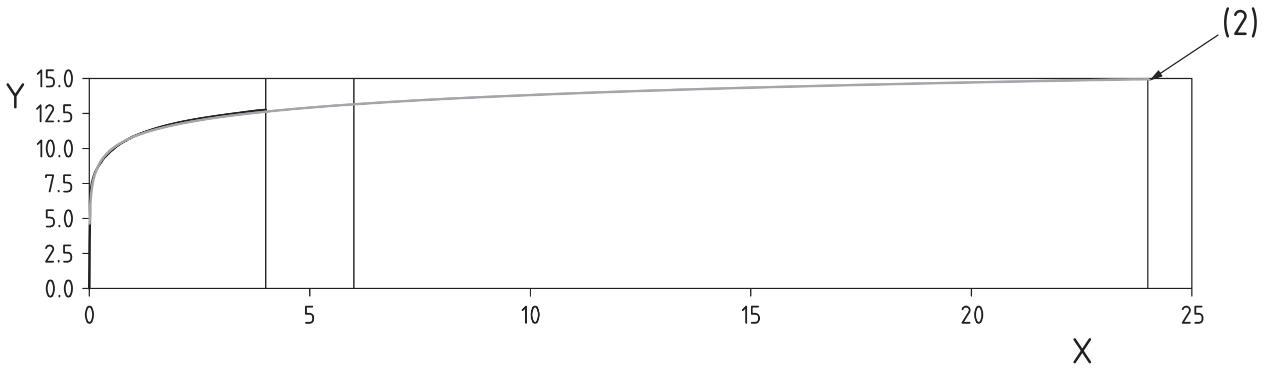
Y*(24 h) = 6,069 + 1,206 [log(24 h)] = 14,953 mm

b) *t*-test if the deflection of the pallet in the loading period is within the standard performance limit, 19 mm:

T-stat = (14,953 − 19)/0,171 = −23,58 vs. −1,65 at 5 % significance level

The t value at 5 % significance level, $t(5\ \%, n-2)$ is approximately equal to $t(5\ \%, 136) = -1{,}65$.

The 2nd pallet passes the loading test since T-stat < −1,65.



Key

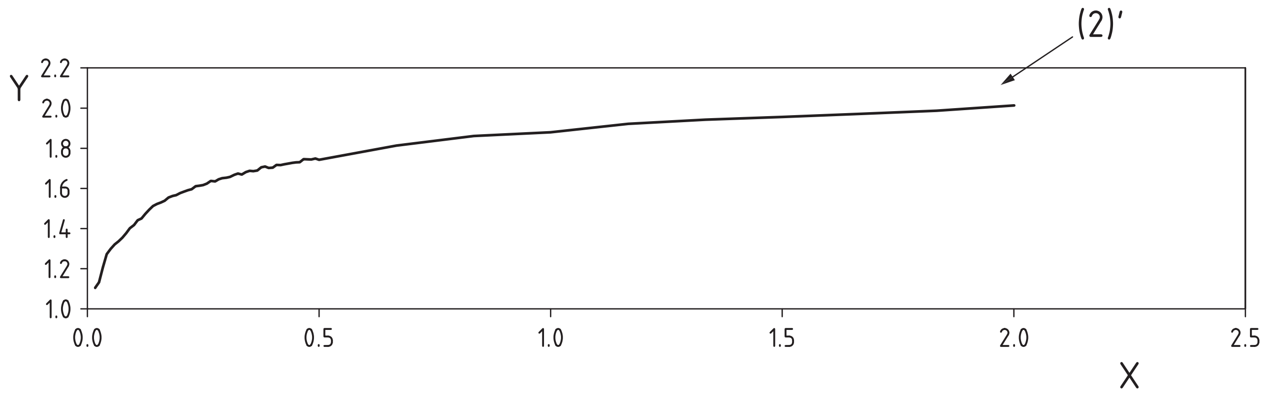
X time (h)

Y deflection (mm)

NOTE Regression curve follows $Y = b_0 + b_1 \ln(t) + e$; std limit at 24 h = 19 mm.

Figure A.2 — Deflection curve predicted (4 h ~ 24 h) during the full load duration using 4 h of data

Step 3: The deflection for the relaxation period is predicted using the regression curve (2)', which depicts the ratio of the full-test deflection (Z) to the partial-test deflection (Z_p), $R = Z/Z_p$.



Key

X time (h)

Y $R = Z/Z_p$

Figure A.3 — Deflection ratio curve during relaxation

a) The predicted deflection for the relaxation time (t = 26 h) can be computed using Formula (2) in 5.3 as follows. Using Z_p(360 min) = 2,3, b_0* = 1,081, and b_1* = 0,196,

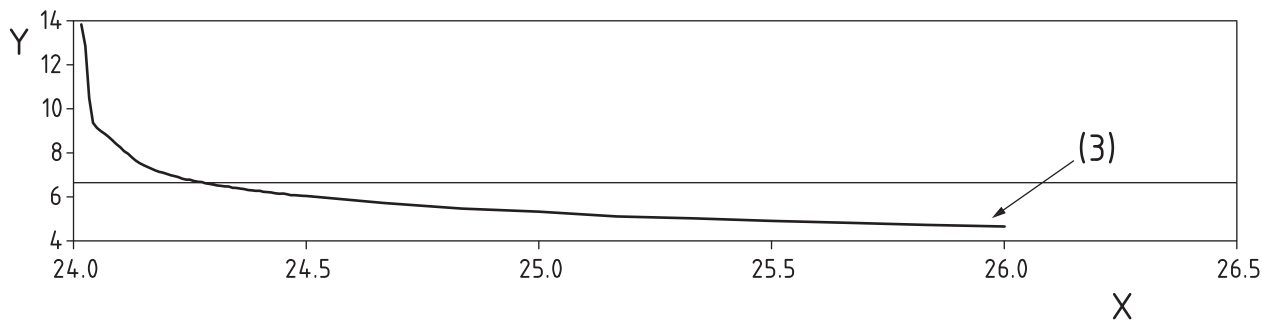
Z*(120 min) = 2,3 × {1,081 + 0,196 [ln(120 min)]} = 4,65 mm

SE[Z*(120)] = 0,024

b) t-test for the standard performance limit

T-stat = (4,65 − 6,65)/0,024 = −83,1 vs. −1,67 at 5 % significance level. The t value at 5 % significance level, t(5 %, n − 2) is approximately equal to t(5 %, 67) = −1,67.

The 2nd pallet passes the relaxation test since T-stat < −1,67.



Key

X time (h)

Y deflection (mm)

NOTE Regression curve for the relaxation period $R = b_0 + b_1\ln(t) + e$; $R = Z/Z_p$; $Z^* = Z_p[b_0^* + b_1^*\ln(t)]$;std limit at 26 h = 6,65 mm.

Figure A.4 — Deflections predicted during the relaxation period (24 h ~ 26 h)

Step 4: The third pallet is tested. Repeat steps 2 and 3.

Step 5: If all three pallets pass all the tests specified above, the production lot is judged to have passed.

Bibliography

[1] ISO 8611-3, *Pallets for materials handling — Flat pallets — Part 3: Maximum working loads*

ICS 55.180.20
Price based on 10 pages