COMMISSION OF THE EUROPEAN COMMUNITIES

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HILLMAN

PROPOSAL FOR A COUNCIL DIRECTIVE

on the approximation of the laws of the Member States relating to
CHECK-WEIGHING AND GRADING MACHINES

(submitted to the Council by the Commission)

EXPLANATORY MEMORANDUM

This directive is adopted in application of Article 100 of the Treaty and Council Directive N°. 71/315/EEC of 26 July 1971 on the approximation of the laws of the Member States relating to common provisions for both measuring instruments and methods of metrological control (1).

The aim is to remove existing technical barriers to intra-Community trade in the check-weighing and grading machines sector which exist because of differences between the national laws governing these instruments in the various Member States.

The rules applicable in the Member States to check-weighing and grading machines differ fairly widely. These differences are not limited to technical design specifications but also concern the degree of precision required and the control techniques to which these weighing machines must be subjected before being put on the market.

At the trading level similar situations arise from the fact that manufacturers are obliged to diversify their production to take into account the laws in force in the Member State where the weighing machines are to be used, and the fact that they have to undergo repeated checks carried out in accordance with differing procedures.

As the existing national laws are justified by a legitimate wish to protect consumers and users, the only possible method of removing the inconvenience resulting from divergences between the laws would appear to be the harmonization of those laws and the creation of the conditions necessary for establishing the Common Market.

The term "weighing and grading machines" covers instruments which can - without the help of an operator - divide up a group of articles, also called "loads", into several subgroups according to the respective weights of these articles.
There are several types of "weighing and grading machine" ; of these, the check-weighing and grading machine divides up articles the weights of which vary on either side of a predetermined value called the nominal weight.

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(1) OJ of the European Communities N°. L 202 of 6 September 1971.

Check-weighing machines are used chiefly in filling and prepackaging works. They are used at the end of the process to check whether each prepackaged lot complies with the appropriate nominal quantity and where it does not, to eliminate any lot whose weight or volume falls short of this nominal value.

This application illustrates how important the instrument is both for the producer or packer and for the end consumer.

To some extent, correct prepackaging of products put on the market depends on the precision of this type of weighing machine.

This draft directive therefore acts as a complement to Directives on prepackaging submitted earlier and, together with them, forms a corpus which cannot but be beneficial to the consumer.

In addition, at the same time as bringing about harmonization between the different national laws concerning these machines, the directive would make it possible for them to circulate freely within the Community ; at present this is not the case.

Defining Community procedures on pattern approval and initial verification for these weighing machines, and the concomitant reciprocal recognition of controls, would simplify the formalities which producers and customers have to undergo. This Directive would mean one more measuring instruments sector harmonized at Community level.

CONSULTATION OF PARLIAMENT AND THE ECONOMIC AND SOCIAL COMMITEE

Pursuant to the provisions of the second paragraph of Article 100 of the Treaty, these two bodies must be consulted. Implementation of the provisions of the Directive would, in the case of some Member States, require amendments to their laws.

PROPOSAL FOR A COUNCIL DIRECTIVE
on the approximation of the laws of the Member States

relating to CHECK-WEIGHING AND GRADING MACHINES

(submitted by the Commission to the Council)

THE COUNCIL OF THE EUROPEAN COMMUNITIES,

Having regard to the Treaty establishing the European Economic Community, and in particular Article 100 thereof,

Having regard to the proposal from the Commission,

Having regard to the Opinion of the European Parliament,

Having regard to the Opinion of the Economic and Social Committee,

Whereas in the various Member States construction and testing methods for check-weighing and grading machines are subject to mandatory provisions which differ from one Member State to the next and therefore hinder trade in these instruments ; whereas it is therefore necessary to align these provisions,

Whereas the Council Directive of 26July 1971 on the approximation of the laws of the Member States relating to common provisions for both measuring instruments and methods of metrological control (1) defines the procedures for EEC pattern approval and EEC initial verification ; whereas, in accordance with this Directive, it would be appropriate to draw up technical design and operating specifications with which these check-weighing and grading machines have to comply if they are to be imported, marketed and freely used after undergoing tests and having the relevant marks and signs affixed,

Whereas, the abovementioned Directive also states that, where the conditions allow, the separate directives may specify the date by which each Member State shall annul the national provisions applicable to instruments similar to those which comply with the Community provisions ; whereas in this case it is not yet permissible to fix such a date,

HAS ADOPTED THIS DIRECTIVE :

(1) OJ of European Communities N°. L 202 of 6 September 1971

Article 1

This Directive shall apply to check-weighing and grading machines. These instruments are defined in point 1 of the Annex.

Article 2

Check-weighing and grading machines for which EEC signs and marks may be issued are described in the Annex. They shall be subject to EEC pattern approval and EEC initial verification.

Article 3

No Member State may prevent, prohibit or restrict the placing on the market or entry into service of check-weighing and grading machines bearing the sign certifying EEC pattern approval or the mark certifying EEC initial verification for reasons connected with their metrological characteristics.

Article 4

1. Member States shall put into force the laws, regulations and administrative provisions needed in order to comply with this Directive within eighteen months of its notification and shall forthwith inform the Commission thereof.

2. Member States shall communicate to the Commission the text of the provisions of national law which they adopt in the field covered by this Directive.

Article 5

This Directive is addressed to the Member States.

Done at Brussels,
For the Council
The President

CHAPTER 1

General considerations

1. General definition

A weighing and grading machine divides up, without the help of an operator, a group of articles, also called "loads", into several sub-groups according to the respective weights of these articles. A distinction is made between grading and checking machines and grading and classifying machines :

- a grading and checking machine divides up articles the weights of which vary on either side of a predetermined value called the nominal weight. The function of the grading machine is to divide the articles into two or more sub-groups according to the value of the difference between their weight and the nominal weight ;

- a grading and classifying machine divides articles of different weights for which there is no predetermined nominal weight. The function of the grading machine is to classify the articles into several sub-groups, each characterized by a fixed weight range.
This Directive only concerns checkweighing and grading machines.

2. Terminology

2.1. Classification of machines

2.1.1. according to their method of operation :

- weighing and grading machines with continous movement of the loads, or "continuous grading machines" : the movement of the loads on to the load receptor is continuous and the weight information is acquired during this movement;

- weighing and grading machines with discontinuous movement of the loads, or "discontinuous grading machines" : the movement of the loads on to the load receptor is discontinuous and the weight information is acquired when the load is at rest.

2.1.2. according to their method of grading :

The grading may take the form of :

- the appearance of physically distinct sub-groups leaving the machine ;

- the counting of these sub-groups by meters without any physical separation ;

- the stamping on each load of a distinctive mark for the subgroup to which it belongs ;

- several of the operations mentioned above.

2.2. Component equipment

2.2.1. Measuring train

2.2.1.1. Weigh cell

Non-automatic weighing instrument or part thereof designed to supply information relating to the weight of the loads to be graded.

It consists of a load receptor, a load-balancing device which may be automatic or non-automatic and possibly an indicating device showing either the value of the load-weight or the difference between it and a reference value, in units of weight.

2.2.1.2. Tripping device

Device that gives the order to acquire weight information.

2.2.1.3. Processing transducer

A device which converts the data from the weighing unit into an electrical or other signal and processes this signal to give a grading order.

2.2.1.4. Grading indicator

A device which gives at least one of the following items of information :

- the weight of the graded load;;

- the difference between this weight and a reference value ;

- the sub-group to which the graded load belongs.

2.2.2. Load Conveyor

Device designed to enable the loads to be moved on to the load recepter. It may form part of the weigh cell.

2.2.3. Presetting Device

Device for fixing the weight limits of the load sub-groups.

2.2.4. Grading Device

Device by which, where appropriate, the loads are divided into physically separate sub-groups.

2.2.5. Zeroing Device

Device which automatically corrects, in the light of the grading results, the setting of the machine making up the loads upstream from the grading machine.

2.2.6. Counters

Devices indicating the number of loads which have moved on to the load receptor (movement counter) or indicating the number of the loads in each of the sub-groups (division counters).

2.3. Grading characteristics

2.3.1. Grading Reference Setting

Value expressed as a unit of weight, set by the operator by means of the presetting device, in order to establish the limit between two consecutive load sub-groups.

2.3.2. Grading Point

Value in unit of weight in respect of which two different grading decisions may be taken, each having the same probability.

2.3.3. Grading Range

Weight interval within which the grading reference settings can be adjusted for a given nominal weight value of the loads.

2.3.4. Grading Interval

Range, expressed in units of weight between two consecutive grading reference settings.

2.3.5. Grading Error

Difference between the value of the grading reference setting and that of the grading point.

2.3.6. Weight Category

n grading reference settings divide the whole range of weights from zero to infinity into (n + 1) weight categories consisting of load sub-groups.

2.3.7. Drift

Variation in the value of the grading point per unit of time.

2.3.8. Zone of Indecision

Extent, expressed in units of weight, of the zone within which the machine may make two different decisions in respect of the same load.

2.3.9. Conventional Zone of Indecision

Zone in which the smallest ratio of distribution of the same load in two consecutive sub-groups is greater than or equal to 0,1 %.

2.3.10. Grading Rate

Number of loads graded per unit of time.

2.3.11. Load Length

Size of the load as measured in the direction in which it is moving.

2.3.12. Weighing Time

Time elapsed between the moment when the load is completely on the load receptor and the moment of acquisition of the weight information.

2.4. Metrological characteristics

2.4.1. Maximum Capacity (Max)

The design value of the maximum weight of the load which can be graded under normal conditions.

2.4.2. Nominal Zone of Indecision (U)

Value of the zone of indecision, expressed in a unit of weight, which is characteristic of the machine, fixed by the manufacturer and shown on the machine.

2.4.3. Response Time

Time elapsed between the moment when the load is completely on the load receptor and that following which the instantaneous response of the weigh cell differs from the final response by a quantity constantly less than 0.5U.

2.4.4. Scale Division of the Weigh cell

If the weigh cell has an indicating device, its actual or conventional scale and its verification scale shall be specified in accordance with the Annex to Directive N°. 73/360/EEC relating to non-automatic weighing machines.

3. Definition of the various machine precision classes

The machines are divided into three classes, according to their maximum capacity and their nominal zone of indecision.

The class is determined by the ratio of the nominal zone of indecision to the maximum capacity :

Class 0.05 : $\frac{U}{Max} \leqslant \frac{1}{1000}$

Class 0.2 : $\frac{1}{1000} < \frac{U}{Max} \leqslant \frac{1}{250}$

Class 1 $\frac{1}{250} < \frac{U}{Max} \leqslant \frac{1}{50}$

CHAPTER II

PROVISIONS CONCERNING THE OPERATION OF THE MACHINES

4. Metrological requirements

4.1. Minimum Value of a Grading Interval

This value is equal to twice the value of the nominal zone of indecision U.

5. Maximum permissible errors

5.1. On initial Verification

5.1.1. Weigh cell

When the weigh cell has its own indicating device it is a non-automatic weighing machine for the purposes of Directive N°. 73/360/EEC and must fulfil the requirements relating to the maximum permissible errors inherent in it and ascertained through static tests.

5.1.2. Zone of indecision

The zone of indecision determined during tests carried out in accordance with this Annex shall not exceed 0.8 times the nominal zone of indecision.

5.1.3. Grading Error

The grading error shall not exceed 0.8 times the nominal zone of indecision.

5.2. In Service

5.2.1. Weigh cell

When the weigh cell has its own indicating device, it is regarded as a non-automatic weighing machine for the purposes of Directive N°. 73/360/EEC and must fulfil the requirements relating to the maximum permissible errors inherent in it and ascertained through static tests.

5.2.2. Zone of indecision

The zone of indecision determined during tests carried out in accordance with this Annex shall not exceed the nominal zone of indecision.

5.2.3. Grading error

The grading error shall not exceed the nominal zone of indecision.

6. Conditions for the application of the maximum permissible errors

6.1. Normal Conditions of Use

6.1.1. Weight of loads

The weight of the graded loads shall be less than or equal to the maximum capacity of the machine.

6.1.2. Weighing time

This must be greater than or equal to the response time, and less than or equal to the time during which the load is completely on the load receptor.

Accordingly, for loads of a given length, there is a maximum conveyor speed and a maximum grading rate above which the normal conditions of use are no longer fulfilled.

For all speeds less than or equal to the maximum speed, the errors and the zone of indecision shall remain less than or equal to the values specified in point 5.

6.2. Influence Factors

6.2.1. Power supply

Variations in the voltage of the power supply source ranging from + 10% to - 15 % of its nominal value and frequency variations of ± 2 % of the nominal value shall not cause the grading point values to vary by more than 0.5 times the nominal zone of indecision.

6.2.2. Ambient temperature

If the identification plate carries no particular specification, the machines shall meet the requirements of items 5.1.2. and 5.2.2. between -10° and +40°C and the requirements of items 5.1.3. and 5.2.3. within a range of plus or minus x°C on either side of any ambient temperature at the time of adjustment, ranging between 0°C and 30°C.

Machines for which a specific temperature range of at least 30°C is given on the identification plate shall meet the abovementioned requirements only within the limits of this range.

However, when the identification plate specifies that the machine must be operated in an air-conditioned atmosphere the temperature range may be reduced to 10°C.

These provisions apply to stabilized temperatures and to fluctuations in ambient temperature not exceeding 5°C per hour.

6.2.3. Tilting

This relates only to machines which are not permanently fixed to one place. In relation to its reference setting position, a machine shall meet the requirements of Point 5 when tilted longitudinally or transversely in a slope of up to 2 per thousand.

6.2.4. Other factors of influence

The machines shall be protected as far as necessary in order to satisfy the provisions of Section 5, if, in normal conditions of use, they are affected by other factors of influence such as magnetic field, electrostatic force, vibrations, atmospheric conditions, restraints and mechanical stresses.

CHAPTER III

PROVISIONS CONCERNING THE CONSTRUCTION OF MACHINES

7.1. Suitability for use

Machines shall be so designed that they meet the purpose for which they are intended and shall be of careful and robust construction.

7.2. Reliability

Machines shall be so constructed that a maladjustment or operational failure cannot normally occur without the effect of the maladjustment or failure being clearly perceptible.

7.3. Oscillation damper

If the effectiveness of the oscillation dampers depends on temperature they shall be fitted with an automatic regulating device. If this device draws upon a source of power the using of such power must be clearly signalled. The damper regulating device must not be directly accessible to the user.

7.4. Conveyor

If the conveyor comprises a belt, tapes or chains intended to pass the loads on to the load receptor and if the tension of these belts, tapes or chains can affect the weight information received by the weigh cell it must not be possible for the user directly to operate the device for regulating the tension.

7.5. Levelling device level indicator

Machines to which item 6.2.3. applies shall have a levelling device and a level indicator fastened to the machine in such a way that they cannot be removed.

7.6. Operation of the load-balancer and presetting device

It must be possible to manipulate the control devices both of the load-balancer and of the presetting device, unladen or laden according to the type of machine, to within at least a quarter of the nominal zone of indecision.

7.7. Weight-Indicating devices

Indicating devices graduated in units of weight shall satisfy the requirements laid down for weight indicating devices on the non-automatic weighing machines referred to in Directive N°. 73/360/EEC.

7.8. Detachable weights and "Balancing weights"

The detachable weights used with the check grading machines must be in conformity with the EEC Directives N°. 71/317 and N°. 74/148, their accuracy class being that appropriate to the class of the grading machine.

When, from a technical point of view, it is absolutely necessary, these weights may be replaced by "balancing weights" which meet the following requirements :

- the shape must be different from that of the detachable weights ;

- they must bear the following indications : number of the grading machine and conventional identification of the weight.

7.9. Identification

Machines must bear the following data, in the order given :

7.9.1. Data expressed in plain language :

- identification of the manufacturer ;
  if applicable, identification of the importer ;

- year and number of manufacture ;

- identification mark on each component of machines comprising separate connected components.

7.9.2. Data expressed in code :

- EEC pattern approval mark ;

- accuracy class in the following form :

  for class 0.05 : CL 0.05
  for class 0.2 : CL 0.2
  for class 1 : CL 1

- maximum capacity, in the following form : Max .....

- nominal zone of indecision, in the following form : U = ...

- response time, in the following : t = ...

- where appropriate, accuracy class and scale interval of the weigh cell, in the form provided for in Directive N°. 73/360 EEC ;

- if necessary, an indication of the temperature range, as laid down in item 6.2.2., in the following form : ... °C/.... °C ;

- voltage and frequency of the electricity supply circuit, in the following form : V

..... H_z

7.9.3. Other data

Data other than those laid down in this Annex may be required or authorized by EEC pattern approval.

7.9.4. Appearance of identification data

Identification data must be indelible and be of such size, shape and clarity as to be easily legible.

They must be arranged on an identification plate fixed in a clearly visible manner close to the adjustment controls.

It must be possible to seal the mounting for the data except if it is such that it would be destroyed by removal.

CHAPTER IV

EEC PATTERN APPROVAL

EEC pattern approval of check grading machines shall be carried out in accordance with the requirements of Council Directive N°. 71/316/EEC of 26 July 1971 on the approximation of the laws of the Member States relating to common provisions for both measuring instruments and methods of metrological control. Certain of these requirements are specified in this Chapter.

8. Application for pettern approval

The application for EEC pattern approval shall comprise the following information and special documents :

8.1. Characteristics

- some of the data specified in item 7.9. ;
- for continuous grading machines, table showing the maximum operating rates in keeping with the conveyor-belt speed and the load length ;
- electrical characteristics of the measuring train components.

8.2. Descriptive documents

These shall include schematic diagrams enabling the working of the machine to be easily understood, diagrams of electrical circuits relating to supply, pick-up and measurement, and photographs.

9. Limited EEC pattern approval

Limited EEC pattern approval decisions may be made, after prior consultation with the other Member States, in order to permit the performance of tests under normal conditions of use.

The validity of these decisions shall be limited to five years at the most and the places of installation of the machines must be notified to the competent authorities.

10. Examination for EEC pattern approval

10.1. Place of testing

Machines being considered for approval may be installed :

- either on the premises of the Metrology Service with which the application has been lodged ;

- or in any place judged suitable by agreement between the Metrology Service concerned and the applicant.

10.2. Provision of the means of checking

The means of checking which the Metrology Service may require from the applicant are the test loads, the means of handling and the qualified staff which the performance of the tests demands and the requisite checking instruments.

10.3. Checking that the construction complies with legal requirements

Machines shall meet the construction requirements specified in Chapter III.

10.4. EEC pattern approval tests

Machines which may bear several grading reference settings shall be submitted for testing with at least two grading reference settings. In the utilization zone the machines shall meet the operating requirements specified in Chapter II. The operational tests shall take into account the conditions for use specific to the machines tested.

10.4.1. Static tests

10.4.1.1. Tests with eccentric loads

Under a load equal to one third of the maximum capacity, the extreme difference between the values of the standard weights corresponding to the equilibrium position when these weights are placed on any different points on the load receptor shall not exceed 0.5 U.

10.4.1.2. Special tests for machines the weigh cell of which is a self-contained non-automatic weighing machine

The non-automatic weighing machine shall undergo the sensitivity, mobility and accuracy tests specified in Directive N°. 73/360/EEC of 19 November 1973.

The permissible reading errors shall be the same as those for non-automatic weighing machines in keeping with their scale division and accuracy class.

10.4.1.3. Variation of the grading point under the effect of influence factors

The purpose of these tests is to determine statically the variation of the grading points for different loads not greater than the maximum capacity, under the effect of the various influence factors listed in item 6.2.

The variations obtained under the effect of each influence factor must be compatible with the provisions of item 6.2.

10.4.2. Measurement of response time

The response time shall be measured under conditions free of influence factors. The values obtained must be less than or equal to the value shown on the identification plate.

The data referred to in item 8.1. concerning the maximum operating rates as a function of the belt speed and the load length must be compatible with the values obtained for the response time.

10.4.3. Tests under normal conditions of use

10.4.3.1. Zone of indecision and grading error

The tests, under normal conditions of use, shall be carried out in accordance with the method described in item 12.3.1. (Reference method), with the machine operating either on a production line or on a load circuit simulating a production line, the test loads, of various weights above and below a mean value, being themselves quite numerous.

10.4.3.2. Drift of the grading point

These tests, carried out with loads of the same nominal weight without altering the machine settings and without varying the factors of influence, shall be repeated several times during a period of at least eight hours. The grading errors must conform to the provisions of item 5.1.3. without the difference between the extreme values exceeding 0.5 U.

10.5. EEC pattern approval test report

The EEC pattern approval test report shall include the results of the tests specified in item 10.4. and any relevant data arising from the various tests, especially from those on the operating safety devices.

In its conclusion, the report shall contain an opinion for or against EEC pattern approval.

10.6. Special conditions required by EEC pattern approval

When EEC pattern approval requires the machines to comply with special conditions, these must be shown on the pattern approval certificate.

CHAPTER V

EEC INITIAL VERIFICATION

EEC initial verification of weighing and grading machines shall be carried out in accordance with the requirements of Council Directive N°. 71/316/EEC of 26 July 1971 on the approximation of the laws of the Member States relating to common provisions for both measuring instruments and methods of metrological control.

These requirements shall be supplemented and rendered specific by the following special provisions :

11. Place of EEC initial verification

EEC initial verification shall be carried out in two stages :

First stage - at the choice of the Metrology Service concerned :

at the verification office or

on the premises of the manufacturer or his agent or at the place of installation.

The second stage shall be accomplished at the place of installation by the competent local Metrology Service.

12. Methods of testing

12.1. Provision of means of testing

The material means which the metrology service may demand from the applicant are, in particular : the test loads, the handling equipment and qualified staff required to perform the tests, and the requisite testing instruments.

12.2. Tests during the first stage

These tests are the static tests specified in item 10.4.1.

12.3. Tests during the second stage

These tests may be carried out either by one of the methods hereinafter described or by any other method offering equivalent security.

12.3.1. Reference method (see item 14.2.)

In respect of the nominal set point the machine shall be caused to check test weights at 7 points spanning the zone of indecision.

Assuming that the approximate values of the set point and of the zone of indecision are already known or are determined by means of preliminary tests, the mass of the test weights to be used is obtained as follows :

$$m_{1,7} = A \pm 1.645 \frac{B}{6} \quad m_{2,6} = A \pm 1.282 \frac{B}{6} \quad m_{3,5} = A \pm 0.842 \frac{B}{6} \quad m_4 = A$$

where :

$$A = \frac{H + L}{2} \qquad B = H - L$$

H and L are the approximate values of the mass at the limits of the zone of indecision.

The test weights shall be similar in shape to the articles which the machine is designed to checkweigh.

Each test weight shall be passed over the machine 50 times, except in the case of the two (2) lightest and two heaviest weights, which shall be passed 200 times each.

The test weights shall be passed in random order. However, the test weights at the opposite extremes of the zone of indecision should follow each other consecutively, separated by a time interval which corresponds to the maximum rate of checkweighing.

The results logged for the various tests shall be set out in a table as shown under item 14.2. From these results it will be possible to calculate the zone of indecision and the set point in the prescribed manner.

12.3.2. Method A

A load is employed the weight of which is equal to the minimum desired load.

Adjust the "minimum" operating reference setting so that a "minimum signal always appears during "n" weighings.

Make certain that when the load in increased by a value approximately one tenth of the nominal zone of indecision the "normal" signal appears at least once during "n" weighings.

Continue the test by increasing the test load by low values until the "normal" signal is obtained constantly in the course of "n" weighings.

The difference between the two extreme values found is an estimate of the zone of indecision, the difference between the grading reference setting and the middle of this zone being the estimate of the grading error.

12.3.3. Method B (see item 14.3.)

If the machine has at least two grading reference settings both must be adjusted until a load distribution in the three weight categories is obtained, the grading interval being approximately 1.5. to 3 times the nominal zone of indecision.

Once the machine is working normally, separate from the other loads the first 200 loads classed in the abovementioned grading interval, weigh them on a suitable checking instrument, eliminate the two extreme values found and note the penultimate values.

The discrepancy between the difference between the penultimate values and the grading interval is an estimate of the zone of indecision ; half the sum of the penultimate values minus half the sum of the grading reference settings is th e estimate of the grading error.

If the machine has only one grading reference setting, adjust it so as to obtain a virtually equal distribution between the two categories. Weigh the first 200 loads of each category, noting the penultimate values, the heaviest of the light category and the lightest of the heavy category ; the difference between these two values is the estimate of the zone of indecision, the estimated grading point being equal to half the sum of these two values.

12.3.4. Method C (see item 14.4.)

This is derived from method A and requires calculation, but it presupposes that the distributions around a grading point obey the normal law.

Adjust the test load to a value x_1 such that a "minimum" signal appears almost constantly and the "normal" signal appears only k_1 times, k_1 being very small compared with the number "N" of times this load passes among the others of the batch to be checked.

The test load shall then be adjusted to a value x_2 such that k_2, the number of times when the "normal" signal appears, approximates very closely to "N", the number of times the load passes.

As the ratios $\frac{k_1}{N}$ and $\frac{k_2}{N}$ are respectively equal to $P_1\%$ and $P_2\%$, the tables of the normal law make the reduced normal variables u_1 and u_2 correspond, to P_1 and P_2.

Now $u = \frac{x - m}{\sigma}$ and knowledge of the values x_1, x_2, u_1 and u_2 gives the values for m (grading point) and σ (standard deviation of the zone of indecision). Where $N = 100\sigma$ and m can be satisfactorily determined.

CHAPTER VI

IN-SERVICE VERIFICATION

13. In-Service tests

In-service checks shall be made under the same conditions as the second-stage tests of the initial verification and carried out under normal conditions of use, the maximum permissible errors provided for in item 5.2. being applied.

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CHAPTER VII

14.1. ZONE OF INDECISION

As the loads are distributed in a random fashion around a grading point, experience shows that the zone of indecision does not have precise boundaries and it is thus necessary to take as a value for this zone the difference between the two loads, the smallest ratio of distribution of which in each of the sub-groups is lower than a determined percentage which is the same for each of the loads.

Therefore the zone of indecision could be defined as follows :

The zone of indecision is the zone in which the smallest ratio of distribution of a given load in two consecutive sub-groups is greater than or equal to $\frac{0,002}{2}$

14.2. REFERENCE METHOD

Procedure in logging the test results and calculating the zone of indecision and the set point.

M_o is the mass of the test weight to which incremental masses x_i are added. If a particular test mass $(M_o + x_i)$ is passed over the machine n_i times and is accepted r_i times, then r_i/n_i will vary from 0 to 1 as i varies from 1 to k. k is thus the number of different test masses which are used to span the zone of indecision (ie from i = 2 to i = k-1, $0 < r_i/n_i < 1$).

The test result values of x_i, r_i and n_i are entered into the table below. The values for nw and nwy are found from tables 2 and 3 for n = 50 and n = 200 respectively.

The values of $n_i w_i x_i$, $n_i w_i x_i^2$ and $n_i w_i x_i y_i$ are then calculated and columns 5, 6, 7, 8 and 9 are summed to give respectively

$$\sum_{i=1} n_i w_i, \quad \sum_{i=1} n_i w_i y_i, \quad \sum_{i} n_i w_i x_i, \quad \sum_{i} n_i w_i x_i^2 \quad \sum_{i} n_i w_i x_i y_i,$$

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TABLE 1

Col.1	Col.2	Col.3	Col.4	Col.5	Col.6	Col.7	Col.8	Col.9
x	n	r	i	nw	nwy	nwx	nwx^2	$nwxy$
x_1	n_1	r_1	1	n_1w_1	$n_1w_1y_1$	$n_1w_1x_1$	$n_1w_1x^2_1$	$n_1w_1x_1y_1$
•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•
x_i	n_i	r_i	i	n_iw_i	$n_iw_iy_i$	$n_iw_ix_i$	$n_iw_ix_i^2$	$n_iw_ix_iy_i$
•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•
x_k	n_k	r_k	k	n_kw_k	$n_kw_ky_k$	$n_kw_kx_k$	$n_kw_kx^2_k$	$n_kw_kx_ky_k$
				$\sum_1^k n_iw_i$	$\sum_1^k n_iw_iy_i$	$\sum_1^k n_iw_ix_i$	$\sum_1^k n_iw_ix^2_i$	$\sum_1^k n_iw_ix_iy_i$

The following quantities are calculated from the summations given in Table 1.

$$\bar{x} = \frac{\sum n_i w_i x_i}{\sum n_i w_i}$$

$$\bar{y} = \frac{\sum n_i w_i y_i}{\sum n_i w_i}$$

$$S(nwxx) = \sum n_i w_i x_i^2 - \frac{(\sum n_i x_i x_i)^2}{\sum n_i w_i}$$

$$S(nwxy) = \sum n_i w_i x_i y_i - \frac{(\sum n_i w_i x_i)\ (\sum n_i w_i y_i)}{\sum n_i w_i}$$

and $$b = \frac{S(nwxy)}{S(nwxx)}$$

Then the estimate $\hat{M}$ of the set point M is given by

$$\hat{M} = M_o + \hat{m} \text{ where } \hat{m} = \bar{x} - \frac{1}{b}\bar{y}$$

The estimate $\hat{V}(\hat{m})$ of the variance of $\hat{m}$ is given by

$$\hat{V}(\hat{m}) = \frac{1}{b^2}\left[\frac{1}{\sum n_i w_i} + \frac{\bar{y}^2}{b^2 S(nwxx)}\right]$$

The estimate $\hat{Z}$ of the zone of indecision Z is given by

$$\hat{Z} = \frac{6}{b}$$

The estimate $\hat{V}(\hat{Z})$ of the variance of $\hat{Z}$ is given by

$$\hat{V}(\hat{Z}) = \frac{36}{b^4 S(nwxx)}$$

The interval of confidence at $100\left(1 - \frac{1}{C2}\right)$ % which straddles the true value of the characteristic, in other words the interval for which the probability that it straddles the true value is at least $\left(1 - \frac{1}{C2}\right)$, is obtained by applying Tchebycheff's inequality which states that

$$P(|E - T| < C\sqrt{V}) \geq 1 - \frac{1}{C^2}$$

Where C is chosen to give the required minimum probability

E is the estimate of the value of the characteristic obtained from the test data

T is the true value of the characteristic

V is the variance of the estimate E obtained from the test data

Using this formula the limits to a double-sided 95 % confidence interval on the set point M are :

$$\hat{M} - \sqrt{20}\,\hat{V}(\hat{m}) \text{ and } \hat{M} + \sqrt{20}\,\hat{V}(\hat{m})$$

and the limits to a double-sided 95 % confidence interval on the zone of indecision Z are :

$$\hat{Z} - \sqrt{20}\,\hat{V}(\hat{Z}) \text{ and } \hat{Z} + \sqrt{20}\,\hat{V}(\hat{Z})$$

The values for nw, and nwy are showon in tables 2 and 3 for n = 50 and n = 200 respectiv[illegible].

TABLE 2 n = 50

r	nw	nwy	r	nw	nwy
0*	3.588	- 8.346	35	28.784	15.094
1	5.981	- 12.282	36	28.104	16.380
2	9.669	- 16.928	37	27.342	17.591
3	12.580	- 19.559	38	26.492	18.711
4	15.015	- 21.097	39	25.546	19.726
5	17.111	- 21.929	40	24.494	20.614
6	18.947	- 22.263	41	23.325	21.351
7	20.574	- 22.226	42	22.024	21.902
8	22.024	- 21.902	43	20.574	22.226
9	23.325	- 21.351	44	18.947	22.263
10	24.494	- 20.614	45	17.111	21.929
11	25.546	- 19.726	46	15.015	21.097
12	26.492	- 18.711	47	12.580	19.559
13	27.342	- 17.591	48	9.669	16.928
14	28.104	- 16.380	49	5.981	12.282
15	28.784	- 15.094	50*	3.588	8.346
16	29.386	- 13.744			
17	29.915	- 12.339			
18	30.374	- 10.888			
19	30.767	- 9.399			
20	31.096	- 7.878			
21	31.363	- 6.332			
22	31.569	- 4.766			
23	31.715	- 3.185			
24	31.802	- 1.595			
25	31.831	0			
26	31.802	1.595			
27	31.715	3.185			
28	31.569	4.766			
29	31.363	6.332			
30	31.096	7.878			
31	30.767	9.399			
32	30.374	10.888			
33	29.915	12.339			
34	29.386	13.744			

* The values of nw, and nwy in this line should only be used for the highest value of x when r = o or the lowest value of x when r = 50.

r	nw	nwy	r	nw	nwy
0*	4.831	- 13.560	40	97.974	- 82.456
1	8.406	- 21.650	41	99.086	- 81.620
2	14.350	- 33.384	42	100.132	- 80.750
3	19.414	- 42.128	43	101.170	- 79.842
4	23.922	- 49.128	44	102.182	- 78.904
5	28.028	- 54.932	45	103.166	- 77.932
6	31.820	- 59.846	46	104.124	- 76.932
7	35.356	- 64.062	47	105.058	- 75.902
8	38.676	- 67.710	48	105.968	- 74.844
9	41.812	- 70.890	49	106.852	- 73.762
10	44.788	- 73.668	50	107.714	- 72.652
11	47.618	- 76.102	51	108.552	- 71.518
12	50.320	- 78.236	52	109.368	- 70.362
13	52.906	- 80.104	53	110.162	- 69.182
14	55.386	- 81.736	54	110.936	- 67.982
15	57.768	- 83.158	55	111.686	- 66.762
16	60.058	- 84.386	56	112.416	- 65.520
17	62.268	- 85.444	57	113.126	- 64.262
18	64.398	- 86.342	58	113.814	- 62.984
19	66.454	- 87.094	59	114.484	- 61.688
20	68.444	- 87.714	60	115.134	- 60.376
21	70.368	- 88.212	61	115.764	- 59.048
22	72.232	- 88.594	62	116.376	- 57.704
23	74.038	- 88.872	63	116.968	- 56.346
24	75.788	- 89.050	64	117.542	- 54.974
25	77.486	- 89.138	65	118.098	- 53.588
26	79.136	- 89.138	66	118.636	- 52.190
27	80.738	- 89.058	67	119.156	- 50.778
28	82.294	- 88.902	68	119.658	- 49.354
29	83.806	- 88.676	69	120.144	- 47.920
30	85.276	- 88.382	70	120.612	- 46.474
31	86.706	- 88.024	71	121.062	- 45.018
32	88.096	- 87.608	72	121.496	- 43.552
33	89.450	- 87.134	73	121.914	- 42.076
34	90.766	- 86.606	74	122.316	- 40.590
35	92.050	- 86.028	75	122.700	- 39.098
36	93.298	- 85.402	76	123.068	- 37.596
37	94.514	- 84.728	77	123.422	- 36.086
38	95.698	- 84.012	78	123.758	- 34.568
39	96.850	- 83.254	79	124.078	- 33.044

TABLE 3 (contd) n = 200

r	nw	nwy	r	nw	nwy
80	124.384	- 31.512	120	124.384	31.512
81	124.674	- 29.974	121	124.078	33.044
82	124.948	- 28.432	122	123.758	34.568
83	125.206	- 26.882	123	123.422	36.086
84	125.450	- 25.328	124	123.068	37.596
85	125.678	- 23.768	125	122.700	39.098
86	125.892	- 22.040	126	122.316	40.590
87	126.090	- 20.636	127	121.914	42.076
88	126.274	- 19.064	128	121.496	43.552
89	126.442	- 17.488	129	121.062	45.018
90	126.596	- 15.908	130	120.612	46.474
91	126.734	- 14.326	131	120.144	47.920
92	126.858	- 12.740	132	119.658	49.354
93	126.968	- 11.154	133	119.156	50.778
94	127.062	- 9.564	134	118.636	52.190
95	127.142	- 7.972	135	118.098	53.588
96	127.208	- 6.380	136	117.542	54.974
97	127.258	- 4.786	137	116.968	56.346
98	127.294	- 3.192	138	116.376	57.704
99	127.316	- 1.596	139	115.764	59.048
100	127.324	- 0	140	115.135	60.376
101	127.316	1.596	141	114.484	61.688
102	127.294	3.192	142	113.814	62.984
103	127.258	4.786	143	113.126	64.262
104	127.208	6.380	144	112.416	65.520
105	127.142	7.972	145	111.686	66.762
106	127.062	9.564	146	110.936	67.982
107	126.968	11.154	147	110.162	69.182
108	126.858	12.740	148	109.368	70.382
109	126.734	14.326	149	108.552	71.518
110	126.596	15.908	150	107.714	72.652
111	126.442	17.488	151	106.852	73.762
112	126.274	19.064	152	105.968	74.844
113	126.090	20.636	153	105.058	75.902
114	125.892	22.040	154	104.124	76.932
115	125.678	23.768	155	103.166	77.932
116	125.450	25.328	156	102.182	78.904
117	125.206	26.882	157	101.170	79.842
118	124.948	28.432	158	100.132	80.750
119	124.674	29.974	159	99.086	81.620

r	nw	nwy
160	97.974	82.456
161	96.860	83.254
162	95.698	84.012
163	94.514	84.728
164	93.298	85.402
165	92.050	86.028
166	90.766	86.606
167	89.450	87.134
168	88.096	87.608
169	86.706	88.024
170	85.276	88.382
171	83.806	88.676
172	82.294	88.902
173	80.738	89.058
174	79.136	89.138
175	77.486	89.138
176	75.788	89.050
177	74.038	88.872
178	72.232	88.594
179	70.368	88.212
180	68.444	87.714
181	66.454	87.094
182	64.398	86.342
183	62.268	85.444
184	60.058	84.386
185	57.768	83.158
186	55.386	81.736
187	52.906	80.104
188	50.320	78.236
189	47.618	76.102
190	44.788	73.668
191	41.812	70.890
192	38.676	67.710
193	35.356	64.062
194	31.820	59.846
195	28.028	54.932
196	23.922	49.128
197	19.414	42.128
198	14.350	33.384
199	8.406	21.560
200*	4.831	13.560

* The values of nw and nwy in this line should only be used for the highest value of x when r = 0 or the lowest value of x when r = 200

14.3. METHOD B

Let it be assumed, therefore, that a percentage q_1 of loads outside the limits of the zone of indecision which it is desired to determine can be placed within this zone, and let $(1 - \alpha)$ be the probability that this hypothesis can be accepted without there being a probability β that a certain percentage q_2 ($q_2 > q_1$) will be exceeded.

From these values (α, q_1 - β, q_2) it is possible to determine the size n of the sample to be achieved and the acceptable number c of loads which may be eliminated in order to determine the value of the zone of indecision.

n and c having been fixed, the mean percentage $q = \frac{c}{n}$ is determined with a confidence interval equal to $1 - (\alpha + \beta)$. It should be observed that, as c and n must be whole numbers, those which are calculated are to be considered as approximate values.

Assuming that the percentage of the loads abnormally placed in the zone of indecision is q_1, elimination of "c" extreme loads, corresponding to the mean percentage $q > q_1$, only leads to a result with negative deviation, i.e. at the most equal to the true value of the zone of indecision and therefore to the nominal zone of indecision with which it is desired to compare it.

Moreover, as the grading point is defined as the value of the loads likely to be placed, with a probability of 0.5, in one or other of the sub-groups which it separates, the half sum of the extreme values selected constitutes an estimate which will be proportionately better where the grading reference setting or setting are closer to the mean value of the population to be graded and the size of the sample is larger.

If one selects, $q_1 = 0.002$ and $q_2 = 0.05$ in respect of n = 200 and c = 2 the zone of indecision is determined with a confidence interval practically equal to 0.99 (see table 4).

It should be observed that this method appears to be more particularly applicable when the initial and periodical verifications are carried out, i.e. when it is a question of ensuring that the nominal zone of indecision is not smaller than the experimental zone of indecision, the value of which is only a result with negative deviation.

TABLE 4 n = 200

c \ q	0,001	0,002	0,005	0,0083	0,01	0,0133	0,02	0,05
	0,9825	0,9386	0,7358	0,5	0,4044		0,0908	0,0004
	0,9988	0,9921	0,9202		0,6766	0,5	0,2357	0,0023

Probability of finding in a sample of size "n" a number at most equal to "c" defective loads where the percentage of defective loads in the batch is "q".

14.4. METHOD C

This method appears to be better suited for determining the zone of indecision since it produces the standard deviation of the distribution.

What is more, it may be accepted where N is large, that the experimental standard deviation "s" approximately obeys a normal law with mean σ and standard deviation $\frac{\sigma}{\sqrt{2N}}$, which when a specific confidence interval is adopted enables the uncertainty of the measurement to be found.

This, in the case of a confidence interval approximating to 0.99 the limits of σ are $s \pm 2.5 \frac{s}{\sqrt{2N}}$, roughly therefore, where N = 100,

$$\frac{7}{6} s \geqslant \sigma \geqslant \frac{5}{6} s$$

The position of the grading point is determined, in the case of the same confidence interval, with a similar uncertainty.