Guideline for

EN 252: Field test method for determining the relative protective effectiveness of wood preservatives in ground contact

Inspection and evaluation of the attack of stakes caused by micro-organisms

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CONTENTS

1. INTRODUCTION

This guide-line is elaborated as a deeper supplement to EN 252: "Field test method for determining the relative protective effectiveness of a wood preservative in ground contact". It can also be used for tests, which are initiated according to NWPC*) Standard No. 1.4.2.1./71: "NWPC Standard for testing of wood preservatives - Mycological test, Field test - A field test with stakes".

EN 252 can be used both for determining the relative protective effectiveness of a wood preservative in ground contact and for testing the natural durability of a wood species in ground contact.

Results from testing stakes according to EN 252 or related standards outside the CEN-region are very important for institutions involved in standardization in many parts of the world. It is therefore decisive to obtain results, which are as unambiguous and reproducible as possible.

Both EN 252 and NWPC Standard No 1.4.2.1./71 contain a five graded scale for describing the decay of a stake. The outer points "without attack by micro-organisms" (= sound) and "failed" - are easy to observe during evaluation.

Although the stake-test is an accelerated test in relation to wood of practical dimensions, it takes relatively many years in temperate regions to terminate the test and thereby obtain the service life for every retention.

Due to many reasons including price and environmental relations, institutions - like NWPC - require an evaluation of the protective effectiveness of preservatives before tests are completed. Registration of condition on the scale 2-4 thus gives an important significance and in practice may become decisive for a new preservative to come into production.

K.H. Henriksen (1989) showed in a report to NWPC concerning evaluation in Denmark, Finland, Norway and Sweden that this procedure was not as uniform as was desired. A calibration manual was therefore proposed.

NWPC has therefore had this guide-line elaborated. A draft was tested and commented during a meeting in Simlångsdalen 1990-06-19 (Bergman 1990).

*)NWPC = Nordic Wood Preservation Council

2. OBJECTIVE

This guide-line is elaborated in order to obtain a harmonized evaluation and registration of the condition of stakes exposed in ground contact in the Nordic countries.

3. AREA OF VALIDITY

This guide-line can be used in the Nordic countries as a support for evaluation and registration of the condition of stakes, which are tested according to EN 252 and NWPC Standard No. 1.4.2.1./71.

The guide-line only deals with the degradation of the stakes by fungi and bacteria.

The guide-line can be used by both trained inspectors in order to standardize evaluation and for the teaching of new inspectors.

4. WORKING PRINCIPLE

EN 252 and NWPC Standard 1.4.2.1./71 both outline a method for determining the protective effectiveness of wood preservatives in ground contact.

EN 252 point 3: "Wooden stakes are treated with preservative solutions to give a range of preservative retentions. After drying, and if necessary, an appropriate fixation period, the stakes are partially buried in soil in selected test fields in the open. A single site is regarded as adequate". However it is desirable to use more than one test field.

"The stakes are regularly inspected and their condition compared with that of untreated controls and that of a group of stakes treated with a reference preservative both of which indicate the aggressiveness of the individual field".

NWPC Standard No. 1.4.2.1./71 prescribes for each test at least two different test fields with different conditions regarding climate, type of soil etc.

In temperate regions - as in the Nordic countries - the stakes are examined annually during spring or autumn. Normally each test is inspected during the same month every year.

In section 6 - the instructions for inspection according to EN 252 are outlined in more detail and illustrations are provided. If any doubts arise, the text in EN 252 is decisive.

It is assumed that the inspector has good knowledge of EN 252.

It is desirable according to EN 252 that two persons with good knowledge and experience in wood decay cooperate during inspections. If possible, the same persons should be responsible for the yearly inspections of stakes for the same preservative test (section of the test area) in order to avoid test variations caused by different persons examining stakes. It is also desirable that the same person has responsibility for the tests for many years in succession.

5. EQUIPMENT

For inspection of the stakes in a field test the following equipment is used:

- a blunt scraper, which is used to remove attached soil from the stakes. Normally the upper part of the awl, mentioned later is used. The awl should not have sharp edges which would remove softened wood as well as soil.

- a blunt awl, which is used to find and demarcate softened wood and to examine attack by soft rot.

- a minute-book, which may contain experiment-and-stake-numbers but not earlier notes about decay rates.

- a battery tape recorder, which is firmly tied to the inspectors' belt and can be used for registration at the test field by recording data like experiment-number, stake-number and decay rate. The use of a tape recoder is very practical during inspections by one man. It can be used instead of a minute-book.

  N.B. Registration by tape recorder implies a strict discipline conceming the working-method. It must be turned on before each recording and turned off immediately after.

- two pencils or other writing materials, which are used for the minute-book.

- a memorandum-block, which is used for unanticipated test stake details, that cannot be written in the minute-book or recorded on tape.

6. INSPECTION

Stakes in the same trial should be set out at random within the section of the test field to be used.

The stakes in each trial are inspected once a year, and if possible during the same month.

To facilitate evaluation of the condition of stakes, the inspection should be carried out at a time when it may be expected that the part of the stake in the soil is moist (above the fibre saturation point for stakes which are possible to moisten). However, inspections in rainy weather should be avoided, since a very wet wood-surface makes evaluation of the attack more difficult.

The inspection is started with a light blow on one of the 50 mm wide faces of the stake when still in the ground. If it breaks, then condition rate 4 (= decay rate 4 = failure) is reached. If the stake does not break it is carefully withdrawn from the ground. Adhering soil is carefully removed with the scraper without removing any softened wood. Examine all sides of the stake for evidence of changes of the wood, e.g. alterations in colour, form or texture and presence of fungi (e.g. mycelium, strands, sporophores, etc.). Notice colour changes that do not only arise from moistening or uneven moistening, but also in the wood preservative and this in relation to moistening and discolouration by the soil.

To determine any change in surface hardness of the wood, a blunt pointed instrument can be used for probing. However, the stake should be inspected without undue mutilation or removal of softened wood as this would destroy the surface of the wood and alter test conditions.

It is acceptable to examine wood strength at the stake surface by probing with an awl and by applying weak pressure against the wood fibres ("pick test") without making a fracture. Note for springwood with wide annual rings that a fracture like in soft rot attacked wood can often be obtained, although the wood is not attacked. See Figure 1.

If the inspection results in decay rate 3 and with widespread attack in decay rate 2, then the stake should be tested in the bending apparatus (see appendix 1) to test for decay rate 4. This is due to a suspicion of extensive soft rot attack. The test is carried out cautiously.

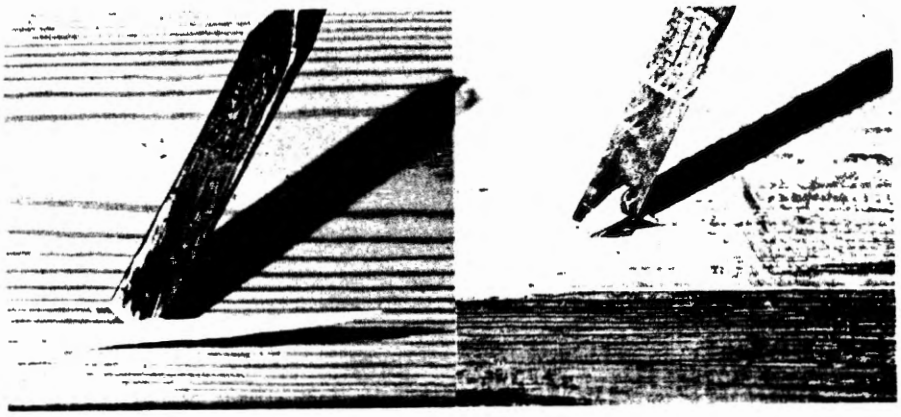


Figure 1. Use of "pick test" for control of short or abrupt fractures (soft rot) (Evans and Klem, 1992).

After the inspection the stake is re-installed into its original hole to the same depth as that before inspection and with the number-plate in the original direction. The soil is carefully pressed against the stake so that good contact is assured between the soil and the surface of the buried part of the stake. A template can be used for re-installation of the stake to the correct depth, which is important, as the most severe attack usually occurs at the ground line. Too deep, or too high re-installation in the hole can cause the ground line zone along the stake to become larger than provided in the method. If the soil at the test site is frozen in the winter period the stakes should be pressed to the correct depth in early spring.

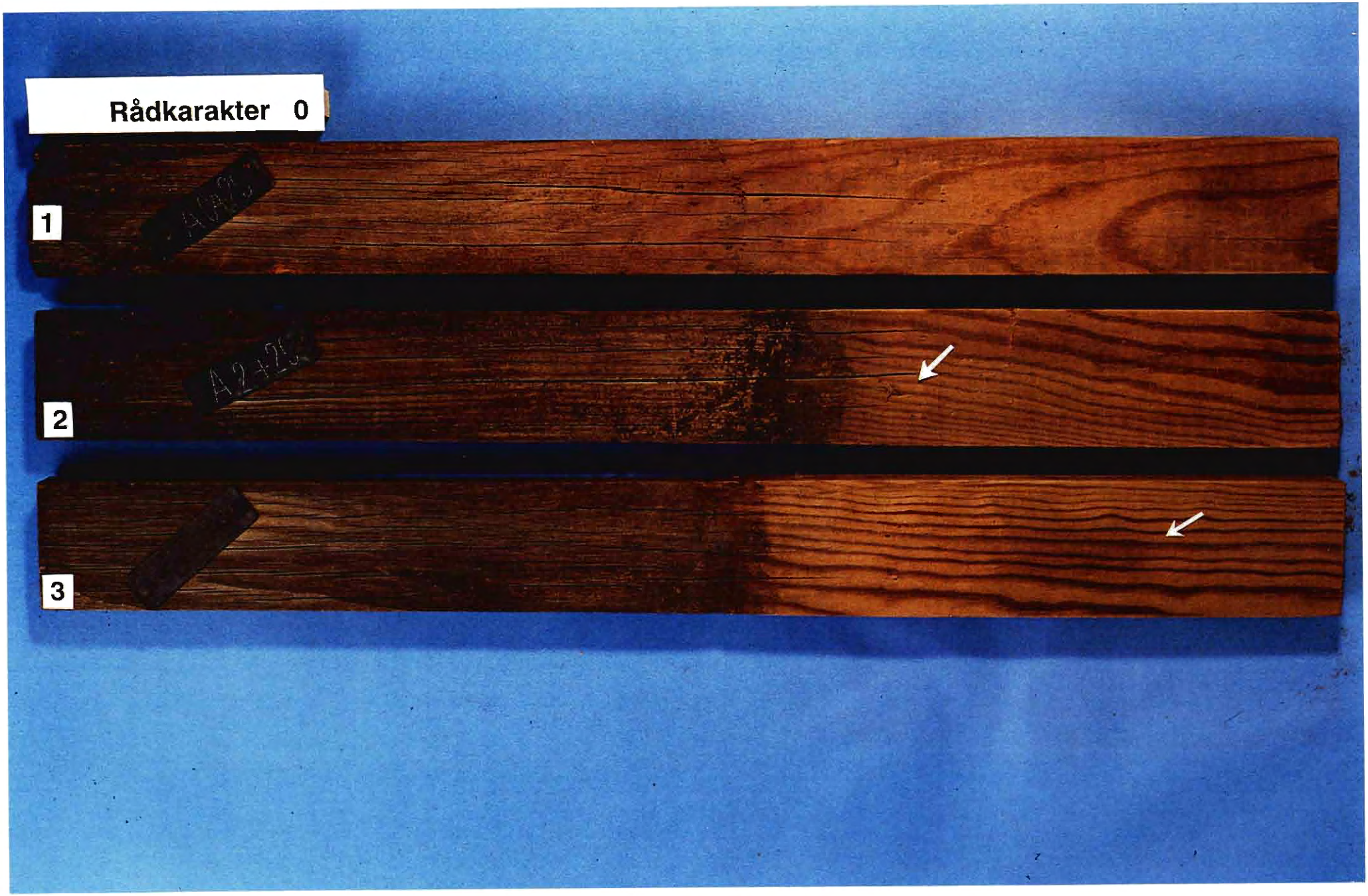
7. REGISTRATION

The evaluation of the extent of attack is based on a number of observations which cannot be measured in absolute terms. In addition, the apparent condition of an individual stake may vary slightly from time to time depending on the climatic conditions before and during the inspection. It is therefore important not to make the rating procedure too elaborate.

N.B. If there is any uncertainty whether an individual stake should be given one of two ratings, it is strongly recommended that the lower-numbered rating be used.

7.1. Attack by micro-organisms

Usually fungi are the most destructive micro-organisms of wood in ground contact. The following grading system should be used to evaluate the extent of attack of stakes caused by micro-organisms.


Rådkarakter 0
1
2
3

Decay rate	Definition of condition
0	EN 252. No change perceptible by the means at the disposal of the inspector in the field. Comments: Notice colour changes from moistening, uneven moistening, the wood preservative and this in relation to moistening and discolouration from the soil. Test the fibre strength by inspection for attack by soft rot. Springwood with wide annual rings has poor strength and can break without being decayed. Traces remaining from stickers must be particularly checked for, because surfaces bearing such traces can diverge from other surfaces in respect to decay. Notes:

Figure 2. Decay rate (Rådkarakter) 0: The range only comprises original colour differences and discolouration from the soil - seldom colour changes.

Stake 1. The surface is of uniform colour and hard on all sides.

Stake 2. The surface is hard. The arrow shows that the outermost fibers have a long break. Algal growth does not affect the decay rate.

Stake 3. The arrow indicates a dark surface colour, which is not the result of decay.


Rådkarakter 1
1
2
3
4

Decay rate	Definition of condition
1	EN 252. Perceptible changes, but very limited in their intensity, and localization: - changes which only reveal themselves externally by a change in colour or by very superficial degradation, softening of the wood being the most common symptom to an apparent depth of the order of one millimetre (corresponding to a greater actual depth affected). Comments: Decay rate 1 ranges from wood where an attack is not apparent to wood with certain colour changes and softened wood up to a depth of 1.5 mm everywhere. Notes:

Figure 3. Decay rate 1. Stake no 1 and no 4 illustrate the range - of weak to heavy attack - for decay rate 1.

Stake 1. Fibres with a short fracture (cross-fracture). This is usually the first sign of attack and is characteristic for the edges of the stakes (i.e. the radial surfaces).

Stake 2. Point attacks with dark colour up to a depth of 2 mm. The other part of the surface is free from decay.

Stake 3. Superficial decay in the zone between soil and air. The attack seems to have stopped, because the surface is hard.

Stake 4. Edges with slight attack. This is often the first sign of attack.


Rådkarakter 2
1
2
3
4

Decay rate	Definition of condition
2	EN 252. Clear changes to a moderate seriousness according to the apparent symptoms: - changes which reveal themselves by softening of the wood to an apparent depth of approximately 2 to 3 mm over all or part of the test piece from the ground level zone and below. Comments: Decay rate 2 ranges from softened wood with a depth of more than 1.5 mm to a depth of 2 mm over more than 1 cm^2. Notes:

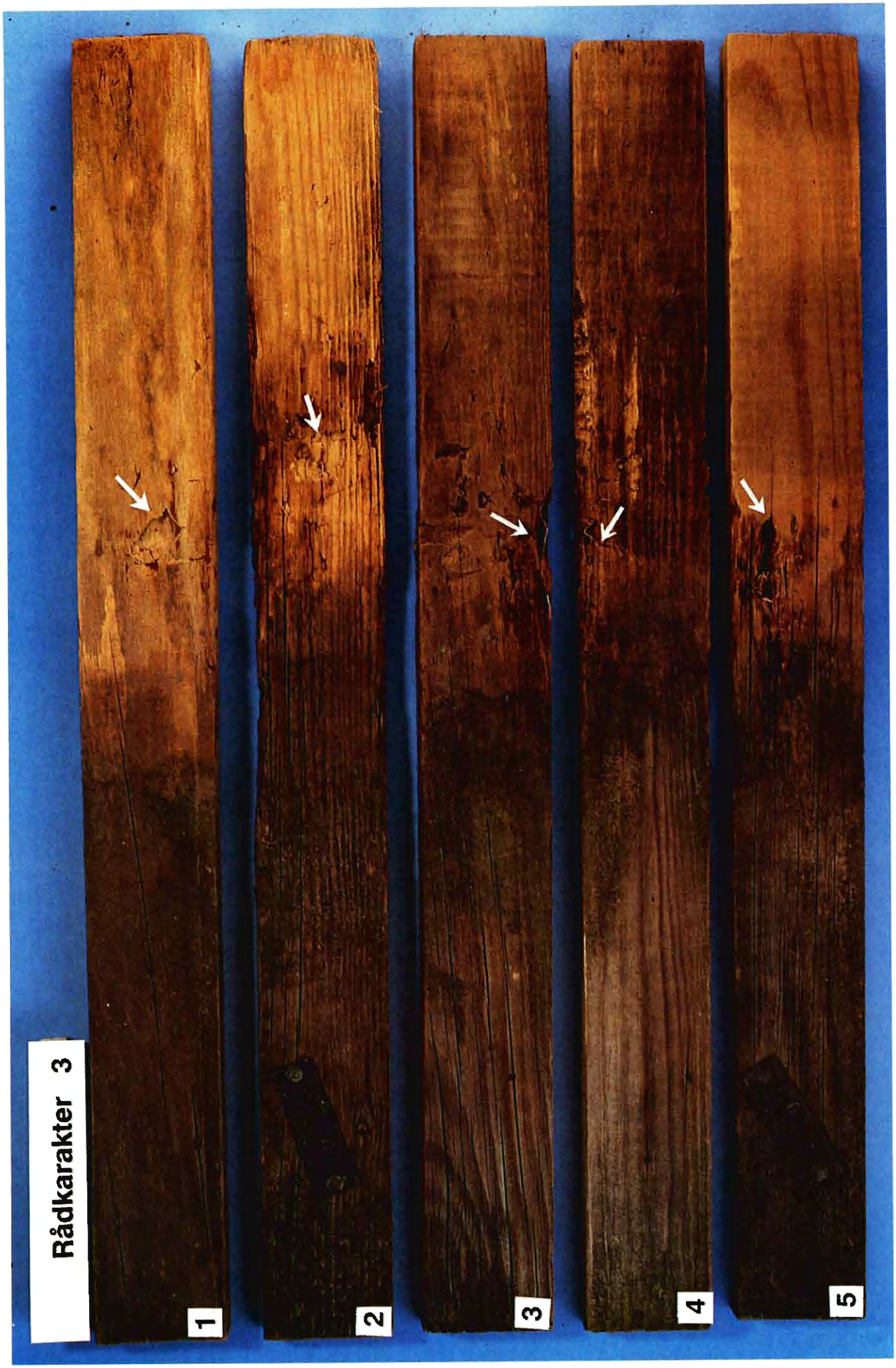
Figure 4. Decay rate 2. Stake no 1 shows the weakest and stakes no 3 and 4 the heaviest attack within decay rate 2.

Stake 1. A deeper attack (2-5 mm) of a smaller area. The rest of the surface is without decay.

Stake 2. A larger area, where the surface is decayed everywhere to a depth of 2-3 mm.

Stake 3. Area with attack up to a depth of 3 mm.

Stake 4. The surface of the stake in the soil is decayed everywhere to a depth of 2-3 mm. In spots, deeper attacks (3-4 mm) are present.


Rådkarakter 3
1
2
3
4
5

Decay rate	Definition of condition
3	EN 252. Severe changes. - significant decay in the wood to an apparent depth of 3-5 mm over a wide surface (for example soft rot or other type of decay over all the circumference of the specimen at the ground line zone or below) or by deep decay of a relatively limited surface area (for example white rot 10-15 mm deep over a few square centimetres). Comments: Decay rate 3 ranges from softened wood with more than 2 mm depth over more than 1 cm^2 to a fracture of the wood after an easy blow before the stake is removed from the ground for evaluation or fractured in the bending apparatus. Notes:

Figure 5. Decay rate 3. The figure illustrates the range of decay rate 3 with stake 1 and stakes 3 and 4, respectively as limits. The stakes have been tested in a bending apparatus without being broken, however (see Figure 6).

Stake 1. Softened wood to a 3-4 mm depth. The colour reveals that the whole surface of the stake is attacked.

Stake 2. Decay in a larger area to a depth of 3-5 mm.

Stakes 3 and 4. Decay everywhere. At the edges to a depth of 10-15 mm.

Stake 5. A small hole through the stake is always evaluated to at least decay rate 3.


Rådkarakter 4
1
2
3

Decay rate	Definition of condition
4	EN 252. Impact failure of the stake in the field. Comments: Failure means that the remaining bending strength is less than about 25 % of the original strength. Notes:

Figure 6. Decay rate 4. The figure shows that a small blow to the top of a stake before taking it out of the ground does not always lead to fracture even if the stake has been evaluated to decay rate 4.

Stake 1. The stake is not broken. It is tough and will bend in the bending apparatus (indicates white rot).

Stakes 2 and 3 Stakes broken with a characteristic short fracture (abrupt fracture) in the bending apparatus (indicates soft rot).

7.2. Attack by insects

Attack by insects - in this case termites - are not considered in Nordic field tests. The section in EN 252 about evaluation of attack by termites is therefore not referred to in this guide-line.

8. TEST RECORD

After recording the condition of the stakes at the test field in a minute book or on a tape recorder the records are transferred in the laboratory to a list with the stake numbers in running order to control the number of recorded stakes.

From the number-lists the records are transferred to the test record - this is a file with recording cards (see Fig. 7) - for every series with a place to record 10 stakes for 16 years. When required the card of the series can be supplied with a new card. The test records can be replaced by a computor. In this case a copy is printed - with back-up - for every record of a test series.

In the Nordic countries a copy of the record card or of the print copy is sent after every yearly inspection to the Department of Forest Products at the Swedish University of Agricultural Sciences, which has the NWPC's central archives of the field tests.

START YEAR:

Test site:

No.	kg/m^3																	$\bar{x}$ year

Figure 7. Card of test record

9. EVALUATION

A test series comprises all stakes exposed at the same time at the test field of one species, which is treated with one preservative to the same retention. It also comprises the untreated control stakes and the treated reference stakes.

The average decay rate or average decay rating of a test series is calculated as the sum of the single decay rates divided by the number of stakes. The standard deviation for every series is also calculated.

The calculation can be performed after 5 years of exposure or later, when the average decay rate of the reference stakes with the lowest retention is at least 1.0.

When all the stakes in a test series have failed (i.e. decay rate 4) the average life is calculated as the sum of the life of each stake divided by the number of stakes. The average life is reported in years together with the standard deviation.

The biological reference value (b.r.v.) in EN 252 is defined in prEN 599-1, note 19 (CEN 1991) with an advised method of calculation (see Fig. 8);

B.r.v. in EN 252. The b.r.v. shall be determined separately for each of the 2 or more different sites. The b.r.v.'s shall be derived by plotting decay index (di) against retention of preservative (r) for both the reference preservative (R) and the product under test (P) for each site. The upper notional retention of the product (unrP) is that retention which has a di = di of the highest retention of reference (hrR). The lower notional retention of the product (lnrP) is that with a di = di of the lowest retention of reference (lrR).

The upper biological test value shall be unrP/0.6 and the lower biological test value shall be lnrP/0.14. The b.r.v. shall be the higher of the 2 means of the upper and lower biological test values at each site.

It corresponds to the retention of the preservative in kg/m^3, which in point of principle shall have the same durability as the nominal amount of reference preservative. For example, 9 $kg/m^3/0.6 = 15\ kg/m^3$ for reference preservative No 1.

Example in year x:

Preservative in test	
Retention, kg/m^3	Decay index, $\bar{x}$ (di)
4.5	3.0
7.0	2.5
10.0	2.0
14.0	1.5
20.0	0.9
Reference preservative No. 1	
9	1.1
2	3.2

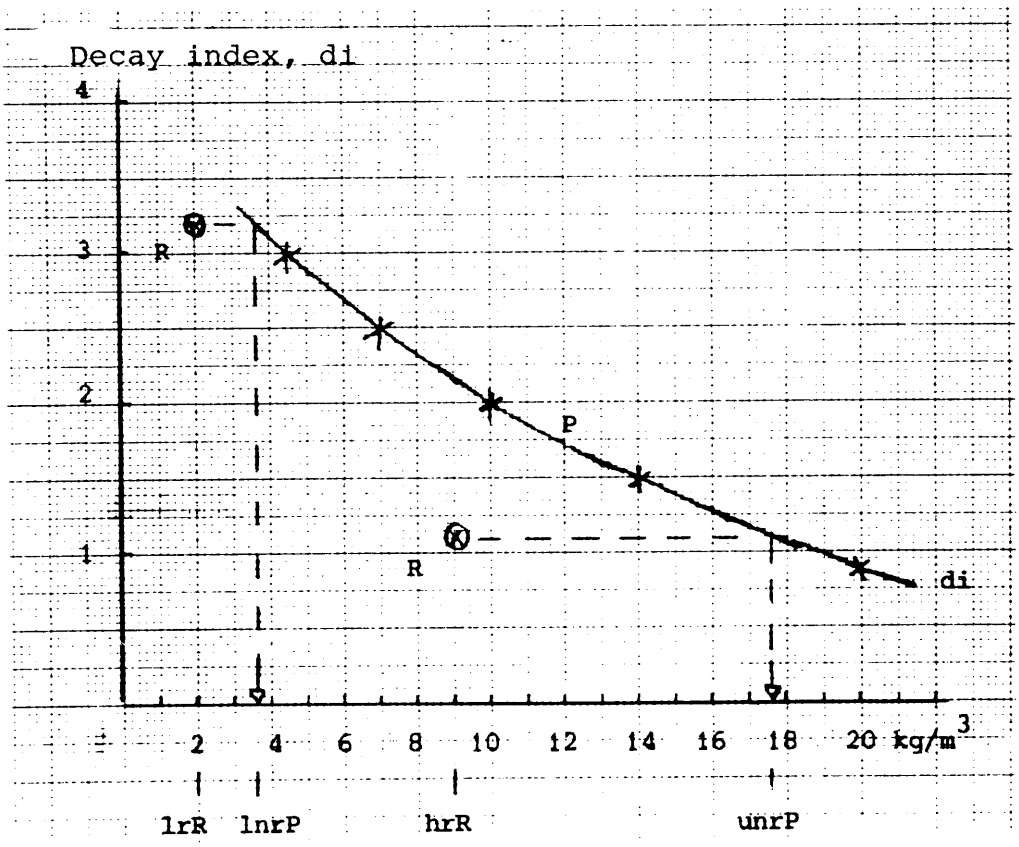


Figure 8. Diagram illustrating the example above.

Upper b.r.v.
unrP/0.6 = 17.6/0.6 = 29.3 kg/m^3

Lower b.r.v.
lnrP/0.14 = 3.6/0.14 = 25.7 kg/m^3
55.0 kg/m^3

In this case the b.r.v. in year x = 55.0 / 2 = 27.5 kg/m^3

Approved retention of a preservative (critical value, c.v.) is according to prEN 599-2 equivalent to the highest b.r.v. derived in the biological tests specified for any given hazard class.

10. LITERATURE

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Norwegian Institute for Wood Technology, Oslo.

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NTR Feltforsøg - Sammenligning af rådfaktorvurdering i Danmark, Norge, Sverige og Finland. Teknologisk Institut/Træteknik, DK-2630 Tåstrup. (NWPC Field tests - Comparison of decay rate evaluation in Denmark, Norway, Sweden and Finland. Danish Technological Institute/Wood Technology, DK 2630 Taastrup).

Nordic Wood Preservation Council (1971)
NWPC Standard No. 1.4.2.1./71: Standard for Testing of Wood Preservatives - Mycological Test - Field Test - A Field Test with stakes. Helsinki.

Appendix 1. Calibration and operation of the bending apparatus (Holmgren model)

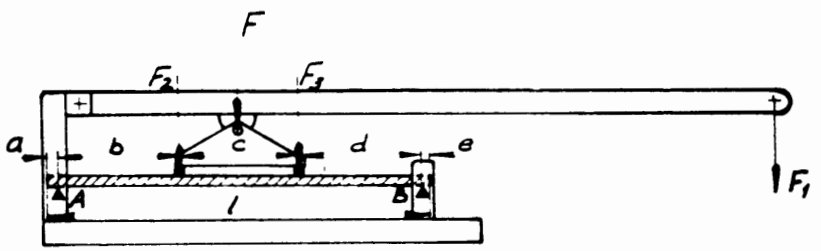

Figure 9. Schematic diagram of the bending apparatus.

The following factors affect the bending of the test stake (Fig. 9)

1. Force F
2. Distance b, c and d
3. Dimensions of the test stake
4. Installation and position of the stake
5. Different strength properties of the test stake

During the test, the variables 1 to 4 should be kept constant.

<u>NWPC - stakes: 20 x 50 x 500 mm</u>

1. The force F is kept constant by means of a fixed load F_1 at a given distance on the lever arm.

   For Scots pine (*Pinus sylvestris*) the force F should be 780 N and F_1 should be 100 N.

The bending apparatus can be calibrated as follows, see Figure 10:

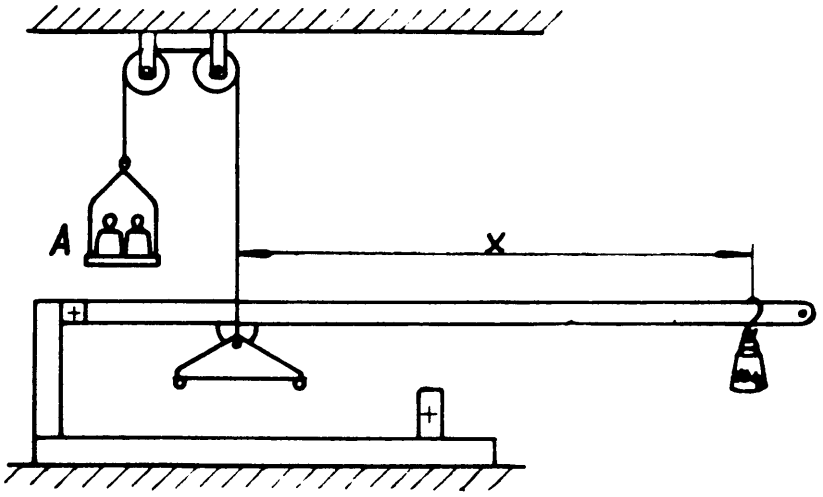

Figure 10. Calibration

1. The bending apparatus (Fig. 10) is fastened in such a manner that only the lever arm is free. A 78-kg weight is then placed in the scale A and a 10-kg load is placed on the lever arm at such a distance, X that the arm is in equilibrium. This point on the lever arm is marked and the load is always kept at the same point during the test. The lever arm should be lowered slowly in order to avoid any possible impact failure on the stake.

2. The distances marked by b. and c. should be 150 mm each and the distance a. should be equal with e., namely 25 mm. F points to the centre point of the stake (Fig. 9).

3. The size of the stake should be 20 x 50 x 500 mm.

4. The stakes should always be placed in the apparatus flat wise, so that the number plate is on the upper side of the stake and the end of the stake which has been buried in the ground points to B (see Fig. 9).

<u>EN 252 - Stake: 25 x 50 x 500 mm</u>

The above bending apparatus can after calibration be also used for EN 252-stakes.

The calibration can be carried out as shown for NWPC-stakes.

For a stake of Scots pine (*Pinus sylvestris*) it is proportionately calculated that the load (F_1) on the lever arm in the same hole as for the NWPC-stakes should be increased from 100 N to 156.3 N ~ 15.9 kg ~ 16 kg.

Calibration for other wood species

The bending apparatus can be calibrated for stakes of other wood species after calculation if the impact bending strength of the species is known - or after measuring.

Measuring can be carried out in the same way as shown in Figure 10. The load is replaced by a dynamometer. For extra stakes with the standard dimensions the cross-section is reduced by 25 %. The stakes are then moistened to at least the fibre saturation point and tested one by one in the bending apparatus. The dynamometer is loaded slowly and is read when the stake breaks. The average load is then calculated. It is the same as F_1 and is made steady as a load in the hole of F_1. The apparatus is then calibrated for the species in question. Instead of a dynamometer a bucket can be fastened in the F_1-hole into which water is slowly poured until the stake breaks. The force F_1 can then be measured as the weight of the bucket and water.

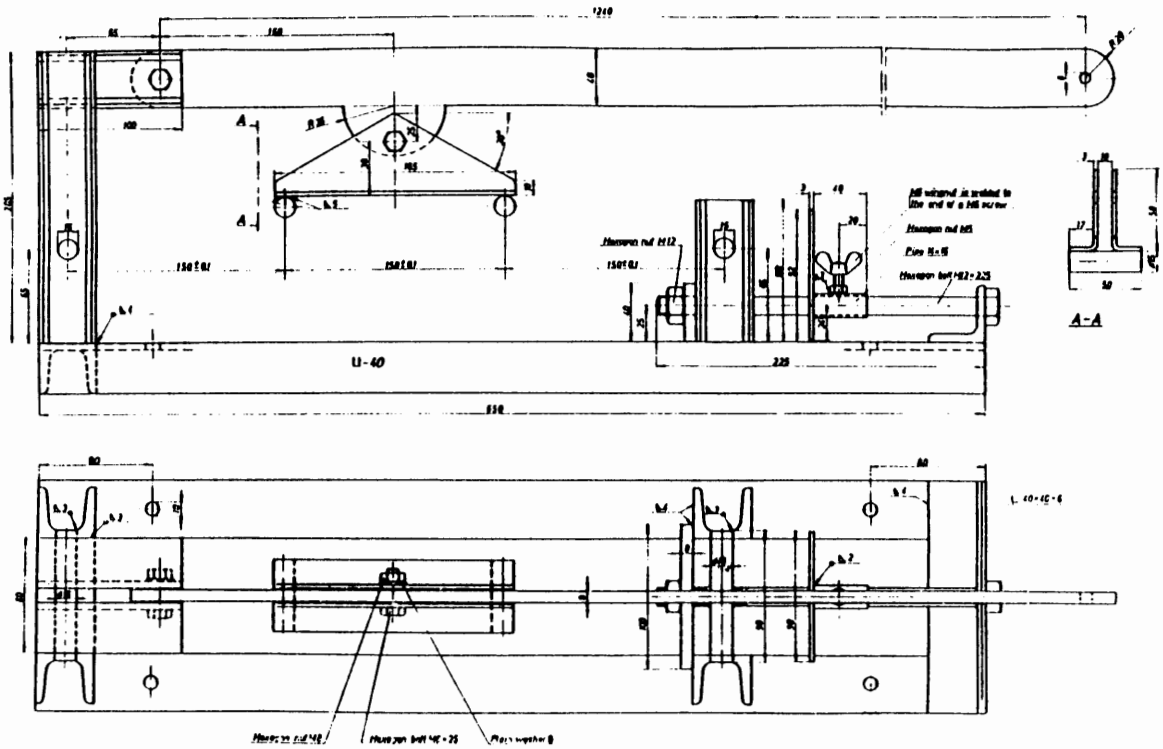

Figure 11. A detailed drawing of the bending apparatus.