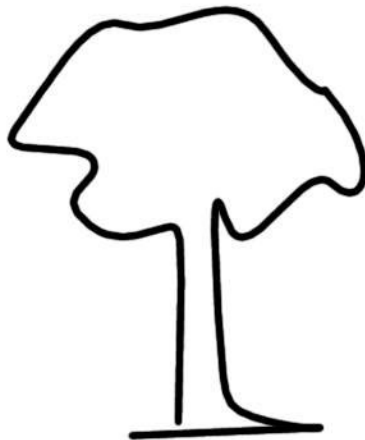# PORTABLE LUMBER GRADER
## Software and hardware guide
## Version 2.0

**FAKOPP**
**Enterprise**

**Introduction**

Structural lumber strength classes are determined by EN-338 norm. The Portable Lumber Grader is designed to grade lumber according to the above norm, that handles two different species classes like: deciduous (D) and coniferous (C) including poplar. Grading is based on the modulus of elasticity (MOE) and the average specific gravity of the lumber. Portable Lumber Grader system determines the MOE and specific gravity as quick as possible, 1 second/lumber.

The system components are: PC, balance, microphone and the Portable Lumber Grader software. The steps of the grading are:

1/ loading the balance
2/ hitting the end of the lumber by a hammer
3/ results appears on the screen and at the same time a voice message tells the result.

**Installation**

Installation of the software

1. Please check your PC or laptop computer. The following requirements are essential.

- operation system: Windows 95/98/ME/2000, XP, Win7
- processor speed: 100 MHz, (higher speed results quicker grading)
- monitor resolution: min. 600*800 pixel
- 16 bit (or higher) sound card installed properly, better resolution doesn't effects the grading process
- free USB port
- 1 Mbytes free space on your hard disk.

2. If your computer fulfils the above requirements, you need to install the Serial-USB converter first. If you alredy have an similar adaotor, please install our converter cable, because evaluation software working only with with the serial-USB converter cable enclosed. Simply copy the files from the "PLG software" directory of the PLG CD to your hard disk in a separate library. Portable Lumber Grader is not a free software. After coping the files, please run the „plg.exe" file.

**Hardware installation**

1. Connect the microphone jack to your soundcard's microphone connector,
2. Connect the RS-232 plug to your PC USB port, using the attached converter cable and the balance plug to the balance disply unit,
3. Connect the balance disply unit to the mains by adapter, or use battery. See separate balance guide.
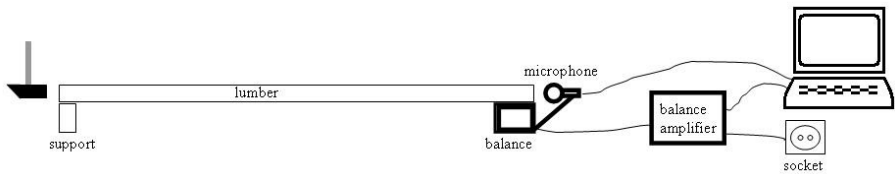4. Place the microphone near to the end of the lumber



Fig.1. The Portable Lumber Grader set-up

5. Run „plg.exe" and press balance button then select your balance comport. Usually serial mouse is using COM1 port, if you have a PS2 mouse or touch pad, COM1 is free. After a correct installation the proper read out of the balance appears on the screen. When balance is unloaded press the tara button and the readout turns to 0g.
6. Microphone settings are correct if the grading window shows the microphone wave in the left upper frame. If no signal, you need to activate the microphone input on your computer by following the instructions below:

    Start menu
     click Run
      type: sndvol32 and click OK
       select Settings/Options
        select Recording, check microphone if the check box is empty and click OK
         check microphone if the box is empty and apply maximum volume

Remark: Some sound card output channel is linked to recording. It disturbs the PLG software. In recording window please disabled "Line volume", "CD volume" "Stereo mixer" and other not necessary components

**The settings window**

Filling out the settings window is an important preparatory step of the grading process. Only the proper settings result correct grading!



Fig. 2. The settings window

Dimensions
Enter the nominal dimensions of your lumber using cm unit. (for special request we provide English unit software) Use decimal point for precise description of length, thickness and width.

Trigger level
  The software makes difference between the background noise and the grading signal. The trigger level set correctly if automatic evaluation starts only if the longitudinal vibration is generated by a hammer impact. The pre-set value of the trigger level is 50%. If you set 0%, continuous, and

4

meaningless test will be performed. If you set 100%, trigger function and grading is blocked. When the background noise is high, the recommended trigger level value is 80%.

Concentrated Knot Diameter Ratio (CKDR)
The knot diameter is a distance between the two tangential lines parallel to arises (longitudinal direction) of a lumber surface in which the knot exists. If a knot diameter not less than 2.5 times as much as its smallest diameter, it shall be considered to have one half of its actual measured diameter. The knot diameter ratio (KDR) is a percentage of the diameter of a knot to the width of a lumber surface in which it exists. The concentrated KDR (CKDR) is the sum of KDR concerning the knots existing in any 15 cm length of a piece of the lumber. The highest - considering 4 faces - CKDR represents the piece of lumber. The CKDR value is between 0 and 1.

Moisture difference
Sometimes the moisture content of the lumber at the grading process is different from the moisture content in service condition. We call moisture difference the following term:

moisture difference = actual moisture content – future moisture content in service condition

The unit is %. The best case if no moisture difference between actual a service condition is.

Species group
Select the appropriate wood species group (deciduous or coniferous) by the check box. Poplar species belongs to the coniferous group.

Write to file
If the "Write to file" box is checked, report file is created automatically. The measured MOE, density and dimensions is saved after each hammer impact. The file name is given automatically, like:
**moe2002_12_10_08_45.txt**
After "moe" actual year_month_day_hour_minutes is given automaticaly. File is created when the Portable Lumber Grader software has started. You can read the report file in excel. The structure of the report file: MOE[Gpa] density[kg/m$^3$]  widtw[cm]  thicknes[cm]  length[cm]

At the bottom of the settings window you find two buttons: Balance and Grading buttons.

**<u>Balance window</u>**

<u>COM port selection</u>
Please select your com port. In case of proper setting, the actual weight appears in the centre of the window (if the balance disply unit is connected to the mains via adapter and serial-USB cable installed and in use.), other case you get "COM error" message. The default port is COM1. In case of all cable connected and no balance data, please change com port number, check all the four. **Before using the sytem press <u>TARA</u> or Zero at the display unit while balance is empty!**
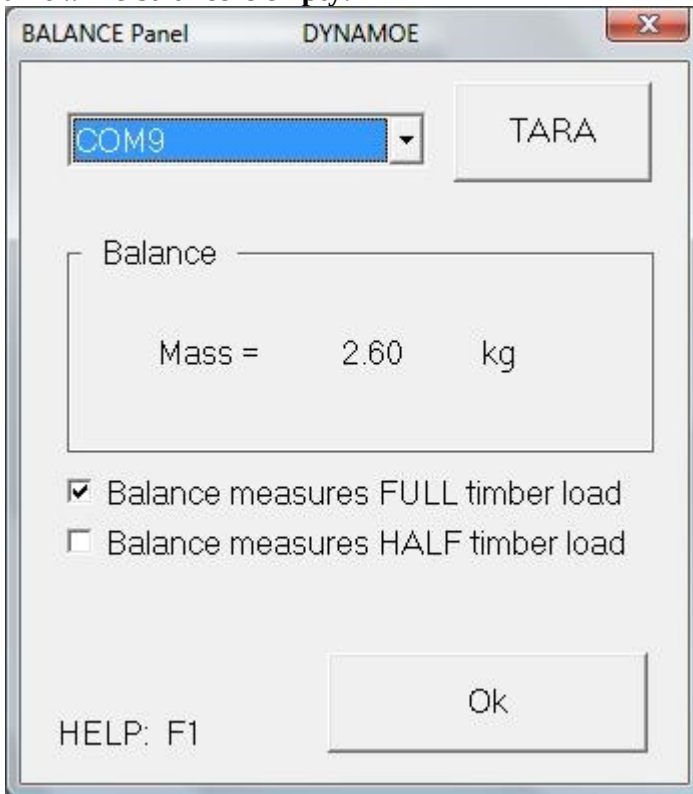


*Fig. 3. The Balance window.*

Balance mode

Here you can select the full weight or the half weight mode. In half weight mode, one end of the lumber is placed on the balance, other end is placed on a support. This set-up is shown on figure 5. and photo below. Precise mass determination possible only if the lumber lies horizontally on the balance. In the full weight mode, the full lumber is placed on the balance. This mode is recommended for light and short lumber or specimen, See figure 4.



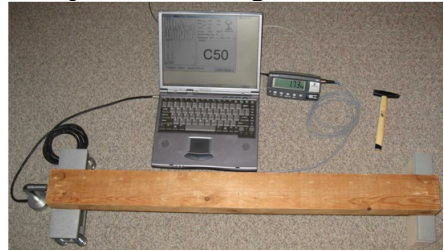*Fig. 4. The balance measures full timber load. Recommended setup for short (bellow 2m) lumber.*

*Fig. 5. The balance measures half timber load. This setup is demonstration only, recommended for long (l > 2m) lumber.*

Tara

At the centre of the balance window the actual weight appears in g unit. Please check the balance. If the unloaded balance shows some weight (this is normal) please press tara button (top right corner of the window). After pressing the tara button the read out turns to zero. The same function is available on the balance display unit as well.

## Grading window

The grading window is an information window, where the vibration, the Fourier spectra, the measured and calculated MOE, concentrated knot diameter ratio, specific gravity, dimensions and the grade appears on the screen. The spectra consist of 512 points. The only button is the "Back to settings"

## Grading process

The grading process is simple. The appropriate grade appears on the screen after the end of the lumber hit by hammer. The evaluation time depends on the length of the lumber and the speed of your computer, but usually 1

second only. In the practice most of the grading time goes by loading and unloading the balance manually. The result is available via voice message. If no voice message please check the volume of your speaker and sound card settings.

**INI file**

You can change some parameter in the "dynamoe.ini" file. If the measured data is starange instead of grade number a "STRANGE" message will appear on the screen. The first 4 parameters sets the "strange" parameters. Next parameter is related to the clarity of the spectra. The last two parameters sets the region of interest in the spectra. The content of the file is:

strange_c_moe=25.0
strange_c_den=1100.0
strange_d_moe=28.0
strange_d_den=1500.0
hitagain=8
winlow=51
winhigh=250

| Parameter | Explanation |
|---|---|
| strange_c_moe | If coniferous MOE[Gpa] is higher than the given value evaluation is strange |
| strange_c_den | If coniferous density[kg/m$^3$] is higher than the given value evaluation is strange |
| strange_d_moe | If deciduous MOE[Gpa] is higher than the given value evaluation is strange |
| strange_d_den | If coniferous density[kg/m$^3$] is higher than the given value evaluation is strange |
| hitagain | The evaluation is done only, if the spectra is clear. Clarity of the spectra is measured by the following parameter called „hitagain" = amplitude of the tallest peak divided by the average amplitude of the whole specta. If the measured hit again parameter is less than the given value, |

| | |
|---|---|
| | the result will be HIT AGAIN. If you are working in a noisy environment please set lower value. You can eliminate this function by setting value 1. |
| winlow | Only part of the spectra is used for the longitudinal vibration frequency determination. The spectra consist of 512 points. In this range you found the peaks of the longitudinal vibration, mode number 1 and 2 (sometimes 3). Software selects the highest peak automatically. For the proper MOE measurement we need to select the peak of the mode number 1. The tallest is not always the mode number 1. The "winlow" parameter sets the low value of the region of interest. Lowest possible value is 10, highest value is "winhigh" -2. |
| winhigh | The "winhigh" parameter sets the high value of the region of interest. Lowest possible value is "winlow"+2, highest value is 511. In the spectra window, two vertcal lines- hanging from the top - indicates the region of interest. |
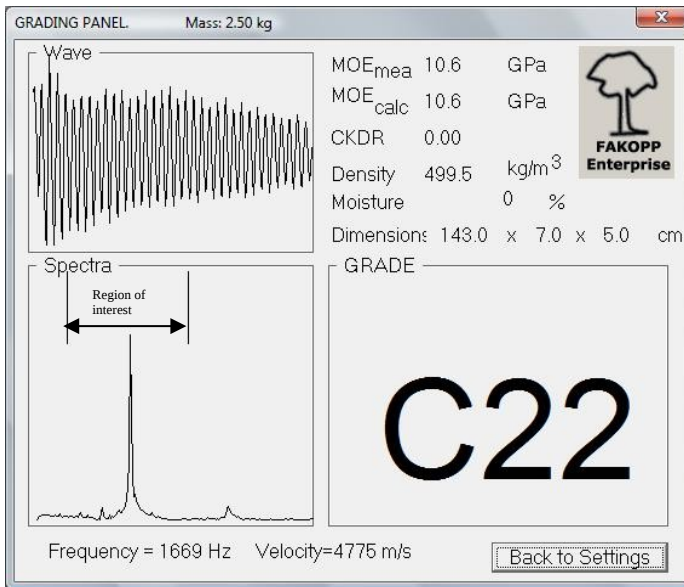
*fig. 4. The grading window*

**File structure**

| | |
|---|---|
| dynamoe.doc | Software and hardware guide |
| plg.exe | Grading software |
| dynamoe.ini | Ini file for setting 7 basic grading parameter |
| logo.bmp | image |
| vol Directory: | |
| c14 wav | sound file representing the grade in file name |
| c16.wav | sound file representing the grade in file name |
| c18.wav | sound file representing the grade in file name |
| c22.wav | sound file representing the grade in file name |
| c24.wav | sound file representing the grade in file name |
| c27.wav | sound file representing the grade in file name |
| c30.wav | sound file representing the grade in file name |
| c35.wav | sound file representing the grade in file name |
| c40.wav | sound file representing the grade in file name |

| | |
|---|---|
| d30.wav | sound file representing the grade in file name |
| d35.wav | sound file representing the grade in file name |
| d40.wav | sound file representing the grade in file name |
| d50.wav | sound file representing the grade in file name |
| d60.wav | sound file representing the grade in file name |
| d70.wav | sound file representing the grade in file name |
| hitagain.wav | sound file representing "hit again" |
| oog.wav | sound file representing "out of grade" |
| strange | sound file representing "starnge" |

Hitting mode

1/ the power

The read out is not sensitive to the power of the hit, but the weak hit makes low signal, below the trigger level and this case no grade result. Extremely powerful hit accelerates the lumber and may hit or destroy the microphone. Please find your optimum hitting power in between.

2/ the direction

Grader evaluates the longitudinal vibration, so we need to generate longitudinal wave. The proper hitting direction is parallel to the long axes of the lumber.

3/ the technique

There is no special hitting technique. Do not press the lumber, let the hammer spring back. Do not apply double hit like first testing the direction by a small then a normal hit.

4/ the hammer weight

The hammer weight is important. Usually the lighter is better, but for larger lumber we need heavier hammer. Roughly 0.1 – 3 % of the lumber weight is the proper hammer weight.

5/ which end

We can select which end of the lumber will be hit. When we hit the microphone end, special attention need to pay to the microphone integrity.

Technical data

Balance:
    dimensions, 250 x 75 x 90 mm
    capacity: 30 kg
    resolution: 10g, histeresis max. 90g
    output: RS232 signal
    powered by 12 V adapter or 4 AA size batteries
Microphone:
    unidirectional
    sensitivity: -56 dB (0dB = 1V/mbar at 1000 Hz)
    frequency range: 100-15000 Hz
    operational temperature $5 - 40$ C$^\circ$
Hammer weight:
    $0.1 - 3\%$ of the lumber weight
Grading principle:
    mass, CKDR and MOE determination,
    grading table identical to EN-338 norm
    grading time is about 1 second
    Grading software is a windows based software
    The PC or lap-top is not a part of the Portable Lumber Grader package
The requirements for the PC or laptop
-      operation system: Windows 95/98/ME/(2000)
-      processor speed: 100 MHz, (higher speed results quicker grading)
-      monitor resolution: min. 600*800 pixel
-      16 bit (or higher) sound card installed properly, better resolution doesn't effects the grading process
-      free RS-232 serial port (if you have only USB port a converter is necessary, enclosed)
-      1 Mbytes free space on your hard disk
Limitations:
-      The actual lumber dimension have to be within the nominal (given in settings panel) +/-2% interval.
-      Lumber mass is less than the balance capacity *2.
-      Lumber length: 0,5m – 10 m.
-      Automatic grade marking system is under development, not available at the moment, marking of the lumber is the duty of the operator.

**Principle**

Specific gravity determination
Nominal dimensions are given via key board, mass is measured by the balance. Specific gravity is determined by the following term:

$$\rho = \frac{m}{l * w * h * (1 + u/100)}$$

where  $\rho$:   specific gravity
        l:   length
        w:   width
        h:   height
        u:   moisture difference in %

The measured Modulus Of Elasticity ($MOE_{mea}$) determination

The EN-338 norm is dealing with static MOE. The Portable Lumber Grader software determine the dynamic MOE first then apply a correction factor to calculate the static MOE. The following term defines the MOE:

$$MOE_{mea} = \frac{m}{l * w * h}(2lf)^2 0.92(1 + u/50)$$

where  $f$:   frequency of the longitudinal vibration
        u:   moisture difference in %. If u > 18 than u=18.

The calculated Modulus Of Elasticity (MOE) determination
The calculated MOE takes into account the effect of knots using the highest concentrated knot diameter ratio CKDR.

$$MOE = MOE_{mea} - 6.2CKDR$$

**The grading algorithm**

Grade decision is made by the following tables. Values are the lower limit of a given grade. Grade evaluation is done according to MOE and specific gravity separate, and the final grade becomes the lower one.

For coniferous species group the following table is used:

| Grade | C14 | C16 | C18 | C20 | C22 | C24 | C27 | C30 | C35 | C40 | C45 | C50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MOE(GPa) | 7 | 8 | 9 | 9,5 | 10 | 11 | 11,5 | 12 | 13 | 14 | 15 | 16 |
| ρ (kg/m³) | 290 | 310 | 320 | 330 | 340 | 350 | 370 | 380 | 400 | 420 | 440 | 460 |

For deciduous species group the following table is used:

| Grade | D30 | D35 | D40 | D50 | D60 | D70 |
|---|---|---|---|---|---|---|
| MOE (GPa) | 10 | 10 | 11 | 14 | 17 | 20 |
| ρ (kg/m³) | 530 | 560 | 590 | 650 | 700 | 900 |

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Grading soft wood lumber in a lumber yard.


The balance and the microphone

# Box arrangement