

# **IMPROVE LUMBER DRYING PROGRAM**

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IMPROVE is a package of tools under development to measure and improve processing efficiency and product quality in sawmills, veneer mills, and plywood plants. Data collection procedures and computer software combine recovery improvement programs with many of the latest technological and research developments. IMPROVE gives primary processors an easily used system to analyze how effectively logs are being converted into end products, to identify opportunities to increase product yield and value, and to predict the results of proposed improvements.

The IMPROVE system consists of eight major programs, each capable of evaluating specific processes in primary manufacture. The eight areas are log processing at the mill, green lumber manufacture, lumber drying, lumber dry-end practices including planing, green veneer manufacture, veneer drying, plywood manufacture, and storage and shipping. Each program basically consists of a test procedure to measure current practices and a computer analysis to identify potential areas for improvement and simulate the effects of changing practices.

IMPROVE is being developed by the USDA Forest Service, Forest Products Laboratory, State and Private Forestry, and several cooperating universities, currently Oregon State University and the University of Wisconsin. IMPROVE is being offered as a service from State and Private Forestry and the computer programs will be available at no charge to mill operators.

## **THE IMPROVE LUMBER DRYING PROGRAM**

The Lumber Drying Program portion of IMPROVE is being developed to help mills improve lumber drying quality and identify sources of drying losses, both grade and volume. What happens in the dry kiln is only one factor that determines lumber drying quality. Each process from the time logs are felled in the woods until the lumber leaves the unstacker after drying affects lumber drying quality. The Lumber Drying Program is designed to systematically identify the areas that contribute to poor drying quality; therefore, the causes can be corrected at the source, rather than trying to compensate for them in the kiln.

To accomplish this, the Lumber Drying Program is divided into three broad areas, green lumber assessment, dry kiln practices, and dry lumber evaluation. The green lumber assessment evaluates the condition of the lumber before it goes into the kiln. The dry kiln practices considers two areas, preparation of the kiln charge, mainly stacking and stickering practices, and operation of the kiln, primarily dry- and wet-bulb temperatures and air velocity. The dry lumber evaluation determines how well the lumber was dried. Each of these areas is described as they relate to how the team developing the program does a complete Lumber Drying Program study.

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Our studies are large and detailed. In addition to assessing kiln operation and evaluating drying quality, we collect information to make the program more valuable to kiln operators and managers. We measure and grade about one-third of the boards in a kiln charge to learn more about lumber quality as it enters the kiln and the effects of lumber drying conditions on final moisture content and defect development.

When the Lumber Drying Program is available for mill operators to use, it will not be necessary to do as large or as detailed a study as we are now doing. The program will be organized so that you will use only the area required for your operation, and you will need to sample far fewer boards.

### **GREEN LUMBER ASSESSMENT**

The purpose of the green lumber assessment is to identify existing defects or potential degrade in green lumber that could be confused with drying defects. It also identifies conditions that could lead to drying degrade or moisture content variation. The grading line is often the first place in production that the lumber is looked at one piece at a time; therefore, most mills do not have a way of systematically identifying the source of what is broadly lumped as "drying defects." Kiln operators cannot correct existing lumber damage or completely overcome the effects of natural variability in wood. The Lumber Drying Program is designed to distinguish what kiln operators can and cannot control.

Many defects attributed to kiln drying may actually be in the lumber before it enters the kiln. Shear damage or stump pull in felling the logs can cause end splits. Leaving logs in the woods when logging is stopped as a result of fire danger or some other reason can cause the ends to dry out and check. Old logs may have dried and checked in storage because sprinklers did not keep them wet. Mechanical damage can occur at any point starting from when the logs are loaded in the woods to the sawmill where lumber hits stops to change direction or is banged around in the unscrambler.

Some of these "drying defects" occur naturally in logs. Wind shake, for example, may be in the tree. Again, this may not be recognized unless the green lumber is inspected.

Lumber manufacturing practices may improve drying quality or they may be part of the problem. Thickness variation is probably the most common sawmill-induced drying problem. Thick and thin lumber dries at different rates, contributing to variations in final moisture content. Excessive thickness variation also contributes to warp and cupping, because the thin pieces are not restrained by the stickers.

Extreme variations in green moisture content between boards in a kiln charge can also contribute to final moisture content variation. Logs from different growing sites can have different initial moisture contents. Trees growing on low, moist sites can have a much higher moisture content than trees growing on the dry side of a mountain. When these are mixed in the sawmill, the resulting lumber will also vary considerably. The time logs spent in storage and the time lumber spent in in-process inventory can also contribute to green moisture content variation. The time to accumulate a kiln charge of low-volume sizes, for example, allows the part of the charge sawn first to partially air dry.

The green lumber assessment part of the Lumber Drying Program is structured to give a systematic means of looking at the green lumber to identify both natural or manufacturing-related conditions that contribute to drying difficulties.

We grade the green lumber as though it had been dried with no drying defects or degrade and, at the same time, mark any defects that could be confused with drying defects on the boards. This gives a means of isolating only the defects and degrade that occur in the kiln.

We measure green lumber thickness at a minimum of four places, two on each edge, and we may measure at more places if thickness variation appears to be a problem. If shrinkage information is needed, the measurement locations are marked so the same spots can be measured after drying. The IMPROVE system contains computer programs to calculate the average lumber thickness and the amount of sawing variation so this can be quantified. These programs can also be used to help the sawmill reduce the amount of variation. At this time, we cannot quantify the effect of sawing variation on final moisture content variation, but a computer model to do this is being developed.

Width of the green lumber is also measured. This is used in addition to the dry measurements to calculate shrinkage and specific gravity.

We also weigh the green boards. The weight is used with final moisture content and dry weight to calculate green moisture content.

### DRY KILN PRACTICES

The dry kiln practices portion of the Lumber Drying Program evaluates preparation of the kiln charge and operation of the kiln system. The kiln charge preparation section looks primarily at stacking and stickering practices. The kiln operation section monitors dry- and wet-bulb temperatures and air velocity in the kiln. It also provides checklists for evaluating overall condition of the kiln.

We check stickers for alignment, missing or broken stickers, stickers skewed or on edge, and stickers not lined up over the bolsters or kiln bunks. Variation in sticker thickness is also checked. All these factors can reduce the efficiency of airflow through the sticker spaces and may contribute to warp and sticker kink.

We also check even-ending the loads. We count the number of boards sticking out from the ends of each package and record the distance. Attempts to push these boards back into the package can dislodge, misalign, or break stickers, and cutting ends off the boards to make packages fit in the kiln wastes lumber. Even when the overhang is not enough to keep the packages from fitting in the kiln, it can create openings between package ends that allow air to bypass the sticker spaces.

Dry- and wet-bulb temperatures are monitored throughout the drying cycle. We use a system with 96 dry-bulb thermocouples placed on both sides of the load and up to 8 wet-bulb thermocouples and wicks. In double-track kilns, we are presently studying only one side. The thermocouples are attached to a portable computer so temperature can be recorded as often as once a minute. The computer continuously displays plots of the readings and lists the temperature read by each thermocouple. That way, we can view the entire cycle and see the changes in temperature distribution when valves open and close or the fans reverse.

The dry-bulb thermocouples are located in a grid 4 high by 12 long on each side of the load. Opposite pairs of thermocouples are placed in the same sticker space. In that way, we can measure both entering and leaving air temperature and calculate temperature drop across the load.

This dense spacing of the dry-bulb thermocouples gives valuable information about temperature distribution throughout the kiln. First, it tells if the kiln dry-bulbs are calibrated and if all of them are working properly. Hot and cold areas are identified and we can see if these areas change with fan reversal or when valves open or close. The difference in entering air temperature on each side of the

load before and after fan reversal measures the effectiveness of the reheat coils in double-track kilns.

We also put wet-bulb thermocouples and wicks at four or more locations along the length of the kiln with dry-bulb thermocouples at the same locations. This provides a check on calibration of the kiln wet bulb. We use these multiple wet-bulb thermocouples as a research project to study the variability of wet-bulb temperature throughout the kiln. We have observed some differences, but we need to learn more about the practical significance.

After the kiln is loaded and the baffles put in place, all doors and vents are closed and the fans turned on. We measure air velocity on the exiting-air side of the load at each of the thermocouple locations, in the bolster spaces, at the ends of the load, and in any openings in the load with the fans running forward and then, after fan reversal. From this, we can calculate what percent of the air is actually drying lumber and how much is bypassing the sticker spaces. These measurements show places where airflow is blocked or diverted due to poor baffling, openings in the load or between packages, or extraneous material blocking airflow.

We also thoroughly check the condition of the kiln. Steam traps are checked for waterlogging. Steam leaks are noted if they are seen. Baffles are checked for proper placement. Doors are checked for air leaks.

All of these items contribute to the condition of the dry lumber as it leaves the kiln. Overdried lumber or wet lumber can be related to hot or cold areas measured by the thermocouples. Uneven air velocity may contribute to variations in final moisture content, depending on whether there are hot or cold air spots. We are also working on correlating defects and degrade to this temperature and velocity data.

## **DRY LUMBER EVALUATION**

The dry lumber evaluation looks at the lumber as it comes out of the kiln, primarily to evaluate moisture content distribution and defects or degrade.

As the packages are broken down, the location of each of our test boards in the package is recorded. From knowing the location of the packages in the kiln, we are trying to develop ways to correlate the board moisture content and defects with the temperature and air velocity information collected in the dry kiln practices part of the study.

The moisture content of each test board is measured with a dielectric meter. Currently, we are taking three measurements with a moisture meter and averaging them, because there is some variability of moisture content within the boards. From this information, we calculate the average moisture content of the entire load, the average of each package, and the amount of variation, both in total and by package. The overall average and variation tell how well the load meets the grading rules or specifications. The package averages and within- and between-package variation give additional information on how efficiently the kiln is operating and how to find the trouble spots.

We also weigh the dry boards. The dry weight is used along with the green weight and dry moisture content to calculate green moisture content. A large amount of variation in green moisture content can be one cause of variability in dry moisture content. It can also point out a need to better rotate the log supply or to get lumber in the kiln more quickly.

The boards are then regraded and any drying defects recorded. We tabulate how much degrade occurred, what defects were noted, and how many defects occurred by each final moisture content class. This program is still under

development, and at this time we are not able to track the boards through the planer to measure roller split and other defects that might not appear until after planing. We can run that kiln load through the planer as a batch to get an overall estimate of how much degrade occurred in the planer. This becomes especially important when a large number of boards were overdried and tend to roller split.

If shrinkage information is needed, thickness and width of the dry boards are measured.

## **USING THE LUMBER DRYING PROGRAM**

The Lumber Drying Program is being developed for use on IBM<sup>2</sup>-compatible personal computers. The programs will be offered at no cost as a service from State and Private Forestry and will be available from them or from the state forester. We also plan to make the temperature and air velocity recording equipment available as a service from State and Private Forestry.

The program is being developed so that you do not need to do a complete study in as much detail as I have described. You will use only those portions of the program that apply to your problem. We are working to learn more about variability of all the factors in kiln drying, so we can tell you how to obtain information about what is happening and still measure the minimum number of boards.

For example, suppose your sawmill is receiving a mixture of old and fresh logs, and you are starting to have more variation in final moisture content than you like. You use only the parts of the Lumber Drying Program relating green and dry moisture content to see if this could be part of your problem. This would mean weighing a sample of green boards, scattering them throughout the kiln load, then reweighing them, and measuring the moisture content after drying. The programs will calculate the green moisture content and you can see if, in fact, the wet boards entering the kiln were also the wettest after drying.

If you are interested in grade falldown in drying, you can grade and mark a sample of green boards, dry them, and regrade them after drying, and if possible, after planing. The programs will calculate the amount of degrade and show by board the type of degrade that occurred. With a little more effort, place your sample boards throughout the kiln in such a way that some are in the parts of the kiln that you suspect cause drying degrade, while others are in the parts that dry better. This will give you a better idea of drying quality throughout the kiln.

## **PRESENT STATUS OF THE PROGRAM**

The Lumber Drying Program (IMPROVE) is still under development. We do have computer programs available so that the people involved in the development team can do an effective study. We are in the process of getting the programs ready for distribution and writing the instruction manuals.

The computer programs will be available for you to use. It is probably not practical for an individual mill operator to buy a system for measuring temperature that is as complex as ours. We are working to make this system available through State and Private Forestry or the state foresters' offices, so their forest products utilization specialists can do the temperature monitoring for you.

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<sup>2</sup>The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

We are continuing to run studies in mills to get additional background information for development of the program. We need to learn much more about how the variations in temperature and air velocity in the kiln affect drying quality and about the interactions of green moisture content, specific gravity, and drying conditions on final moisture content and degrade.