TECHNICAL NOTE NUMBER 213
FOREST PRODUCTS LABORATORY - U. S. FOREST SERVICE - MADISON, WISCONSIN

THE DETECTION AND RELIEF OF CASEHARDENING

The successful dry kiln operator must be able to produce from his kiln lumber which is free from visible defects such as checking, honeycombing, warping and twist. Two additional things which he must be able to prove at the end of a kiln run are that the moisture content of his lumber is right and that the lumber is free from invisible seasoning stresses which would cause warping when the wood is resawed and shaped into furniture or other products. Neither of these points can be proved by examination of the outside of the lumber. They are easily determined, however, by the following tests devised by the Forest Products Laboratory.

Before the lumber is removed from the kiln, choose a fairly representative board from each truck load of stock. Cut four cross-sections (A, B, C, D) at least 2 feet from the end of the board.

Test for Moisture Content

Use section A to find the average moisture content of the dried stock. To do this, weigh the section immediately after cutting, on a balance accurate to 1/10 of 1 per cent, and then dry it in an oven at 212 degrees F., or on a steam pipe, until it reaches constant weight. The weight lost during this drying is the weight of the moisture which was in the section. Divide the weight of the moisture by the weight of the oven-dry section and multiply by 100. This will give the percentage of moisture in the section and also in the stock in that part of the kiln in which the sample was taken.

Example:

Wt. of section when cut	27 grams
Wt. of section dry	25 grams
Wt. of water evaporated	2 grams

M. C. $\frac{2}{25} \times 100 = 8$ per cent

For furniture manufacture and other high grade uses, the moisture content of any board in the kiln should not vary by more than one and one-half per cent from the final moisture content specified.

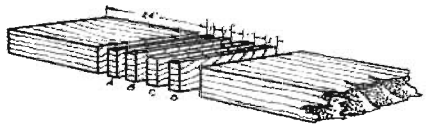
Use section B to find out whether the stock is uniformly dry. In order to do this the section must be cut and the moisture content of the core and the shells found separately. If the stock is one and one-half inches or more in thickness, cut the section parallel to its edges to get an outer shell of material one quarter inch thick. Trim the block that remains equally on all four sides to leave a core one half inch thick. If the stock is less than one and one-half inches thick, cut section B so as to get an outer shell and inner core each one-fifth the total thickness of the section. Find the moisture content of each piece by the method used for finding the moisture content of section A. If the core is more than two or three per cent above the desired moisture content, the drying should be continued.

Test for Casehardening

Use the third and fourth sections, C and D, for casehardening tests. Saw section C parallel to the wide faces of the original board to form tongues or prongs, leaving about one-half inch of solid wood at one end of the section. If the stock is one inch thick, make two saw cuts; if it is more than one inch thick, make a greater number of saw cuts. In section D, saw one central saw kerf, so that the section will represent resawed stock. Then stand the sections on end in some convenient, warm place in the shop to dry, leaving them there for about twenty-four hours.

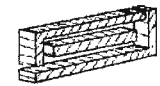
Observe carefully the action of the prongs from the moment of sawing. Do they bow in or out or remain straight on the saw? Do they change shape after drying in a warm room (not in an oven) to a uniform moisture content?

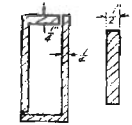
MOISTURE CONTENT SECTIONS



METHODS OF CUTTING TEST SECTIONS FROM PLANK

SEC. "A"
MOISTURE CONTENT SECTION
To be weighed, oven dried & reweighed to determine moisture content.





SEC. "B"
MOISTURE DISTRIBUTION SECTION
Outer margin sawed off as shown Outer & center portions weighed dried & re-weighed separately to determine moisture content.

CASE HARDENING SECTIONS

SECTIONS TO BE ROOM DRIED BEFORE CONCLUSION AS TO CASE HARDENING IS MADE

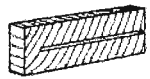
SEC. "C"
Thick stock sawed as shown for "Case Hardening" test. Prongs 2 & 3 to be broken out

Not "Case Hardened"

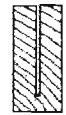
"Case Hardened" Permissible

"Case Hardened" Not Permissible

Effect of over steaming Not Permissible



SEC. "D"
Reserved test for "Case Hardening" One Saw Kerf



Not "Case Hardened"

Case Hardened Permissible

"Case Hardened" Not Permissible

Effect of over-steaming Not Permissible

TEST SECTIONS FOR MOISTURE CONTENT & CASE HARDENING

If the prongs remain straight both on the saw and after room drying, the lumber is perfectly seasoned, being free from stresses and uniformly dry throughout.

If prongs which remain straight on the saw bow in or out during room drying, or if the amount of bowing in curved prongs changes during room drying, the lumber is not uniformly dry.

If the prongs are bowed in after room-drying, the lumber is case hardened.

Cause of Casehardening

The term "casehardening" is sometimes used to describe lumber which is very dry on the surface and still moist in the center. But casehardening as here used means that the lumber when uniformly dry is stressed because the center is attempting to shrink more than the surface.

When lumber dries, the surface becomes dry first but cannot shrink fully because the center does not shrink until later. The surface layers of the lumber therefore become set in an expanded condition and when the center of the lumber does become dry and tries to shrink fully, stresses are set up.

Relief of Casehardening

Casehardening can be relieved by giving the lumber a conditioning treatment at temperatures of 160° F. or higher and at relative humidities which will iron out the difference in moisture content between the center and the surface of each board.

As the moisture distribution in each board becomes uniform, stresses due to difference in set are fully developed. At the high temperature of the conditioning treatment the wood becomes so plastic that it yields to the stresses, thereby relieving them, and the lumber is

freed from casehardening. Treatments for the relief of casehardening in dry 1-inch lumber must be given for a period of 20 to 30 hours in order to be effective to the center of the lumber. Longer periods may be necessary if the casehardening is unusually severe. Thicker stock will require longer treatments.

The temperatures and humidities for the relief of casehardening are as follows:

Moisture Content of Lumber (per cent)	*Temperature (degrees F.)*		*Relative Humidity (per cent)*
	Hardwoods	*Softwoods*	
15-18	160°-180°	180° and up	90-95
10-12	160°-180°	180° and up	80-85
6-8	160°-180°	180° and up	65-75

Steaming at 100 per cent relative humidity for a short time is often used to relieve casehardening, but such practice is not recommended for it produces reverse casehardening, and the stock will still cup and warp when resawed or worked into furniture. Another effect of steaming at high humidities is to reopen surface checks which had closed as the lumber became dry.

After any treatment to relieve casehardening a high humidity should be maintained while the lumber is cooling.

Casehardening stresses are also reduced when lumber is bulk-piled for some time, but they are reduced so slowly that when kiln-dried lumber is bulk-piled for a period of two weeks to a month, the lumber is still liable to cup and warp upon resawing. Bulk-piling is beneficial, however, because it permits the moisture distribution to become more uniform.