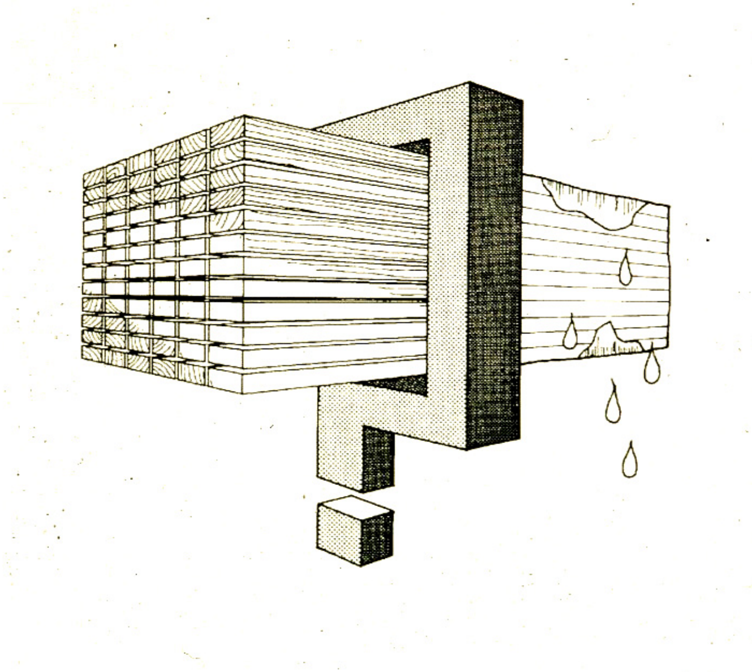
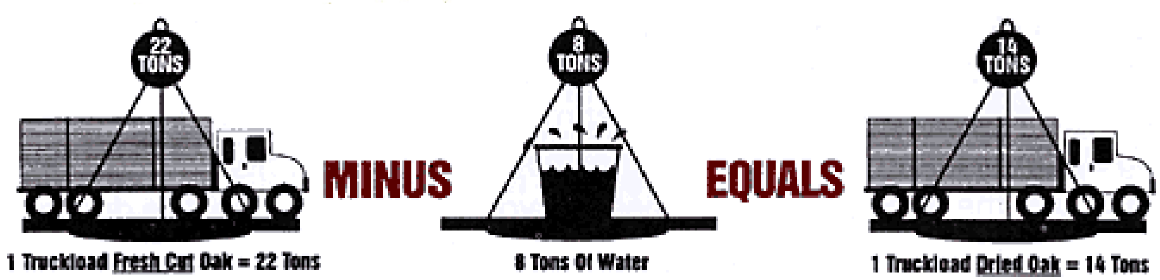
Wood Drying

Why dry wood?



1. transportation cost ↓
2. stability ↑
3. strength ↑
4. biodegradation ↓
5. gluing/finishing ↑
6. impregnation with liquids ↑



Timber Drying Methods

NATURAL

AIR DRYING

- cheap
- slow
- dangerous for wood

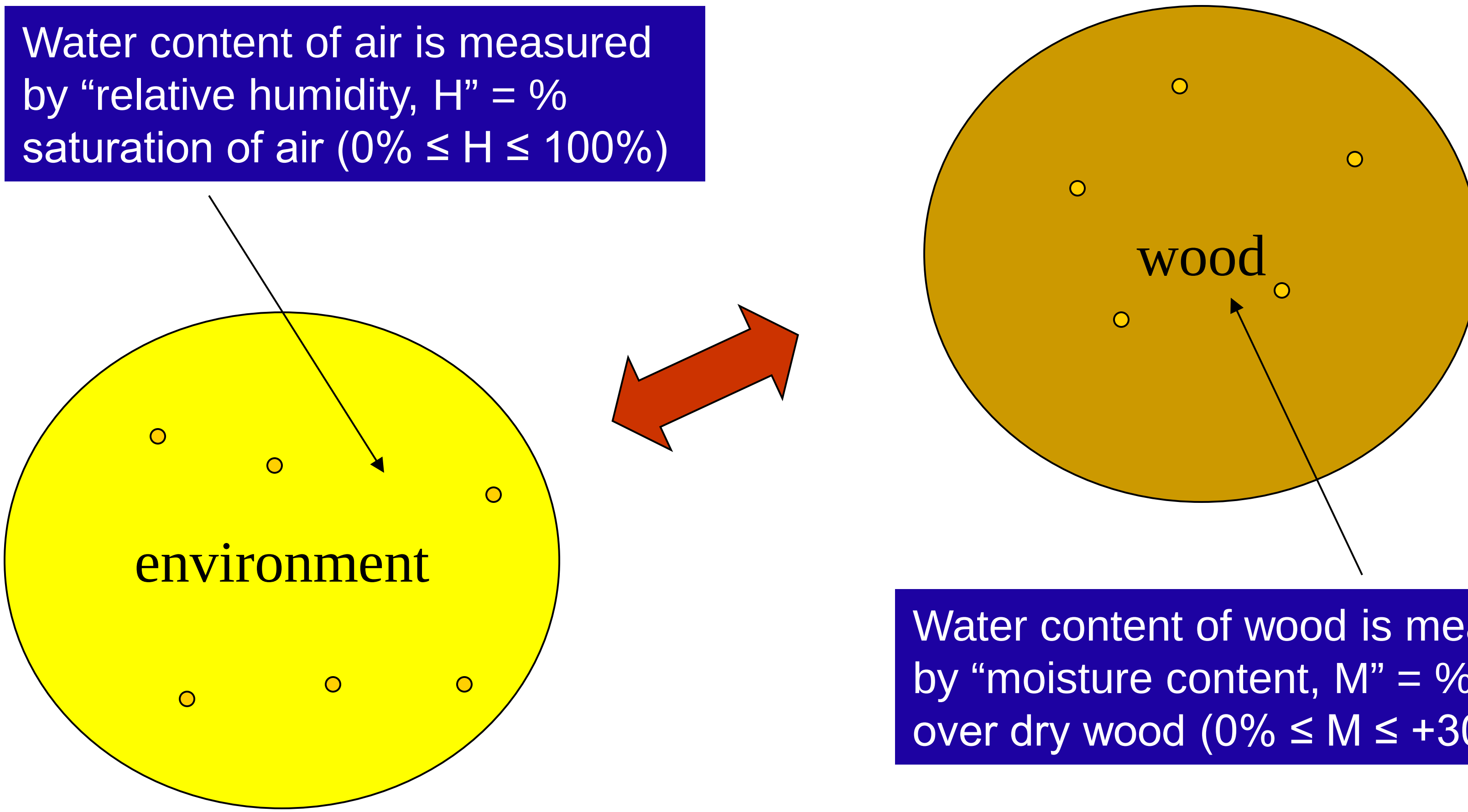
ARTIFICIAL

KILN DRYING (convective, vacuum, dielectric)

- costly
- fast
- better quality timber

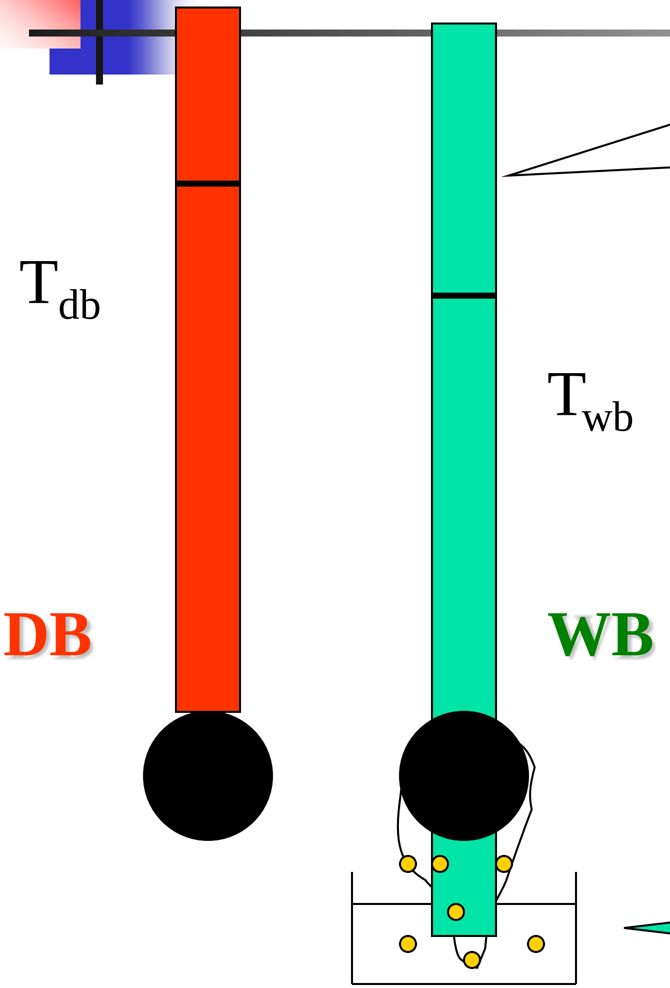
Water and wood

Water content of air is measured by “relative humidity, H” = % saturation of air (0% ≤ H ≤ 100%)



Water content of wood is measured by “moisture content, M” = % water over dry wood (0% ≤ M ≤ +300%)

Drying



reading lower than that of DB

$T_{db} – T_{wb}$ = wet-bulb depression (T_{wbd})

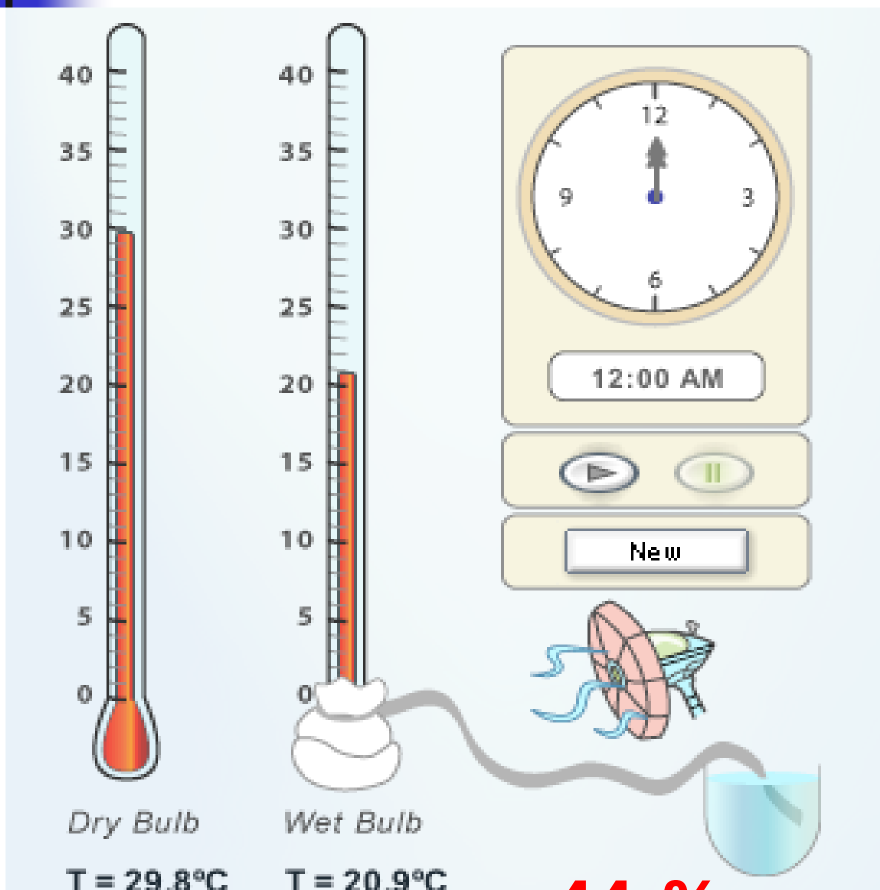
use T_{db} and T_{wbd} to calculate H

WB is temperature at wood surface

DB is air temperature

water

What is the approximate relative humidity in the situation shown below?

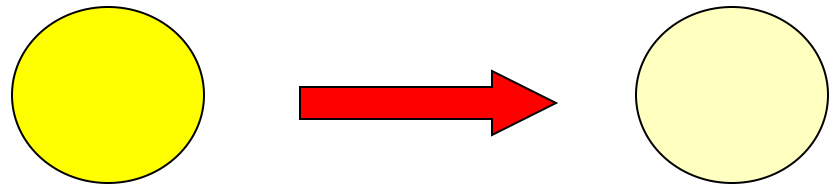


Temperature difference: 6 - 10 degrees

Dry-bulb reading (°C)	Difference between wet and dry-bulb reading (°C)				
	6	7	8	9	10
10	33	23	14	4	
12	38	29	20	11	3
14	42	33	25	17	9
16	45	37	29	22	14
18	48	41	33	26	19
20	51	44	37	30	24
22	53	46	40	34	27
24	55	49	43	37	31
26	57	51	45	39	34
28	59	53	47	42	37
30	61	55	49	44	39
32	62	56	51	46	41
34	63	58	53	48	43
36	64	59	54	50	45
38	65	60	56	51	47
40	66	62	57	52	48

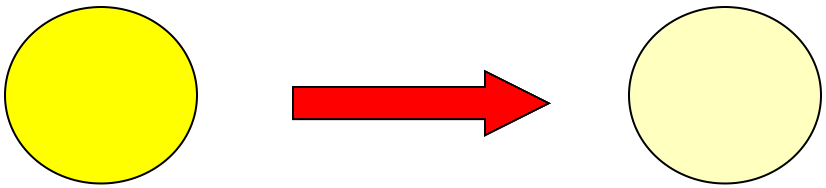
44 %

Drying



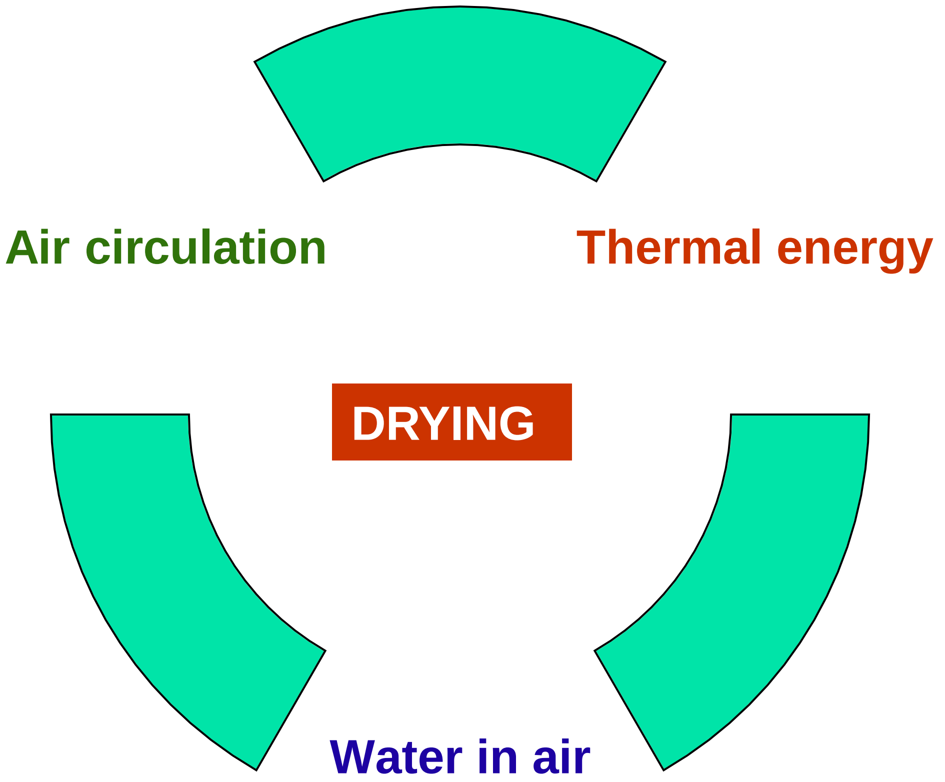
- Rate of drying is controlled by diffusion
- Diffusion occurs when water moves from region of high concentration to one of low concentration. (Gradient of moisture content or vapor pressure)
- Above FSP free water moves out of wood by surface drying, vapor diffusion and capillary forces.
- Initially surface evaporation controls rate of drying

Drying



- In the later stages the diffusion of water vapor (bound water) controls drying.
- In some species the wood structure prevents the mass movement of water (refractory wood)
- There are many types of drying (Conventional (<100°C - steam), High temperature (>100°C), Dehumidification, Vacuum, Vapour (hot organic liquid), RF or RF + vacuum, solar)

3 parameters of timber drying



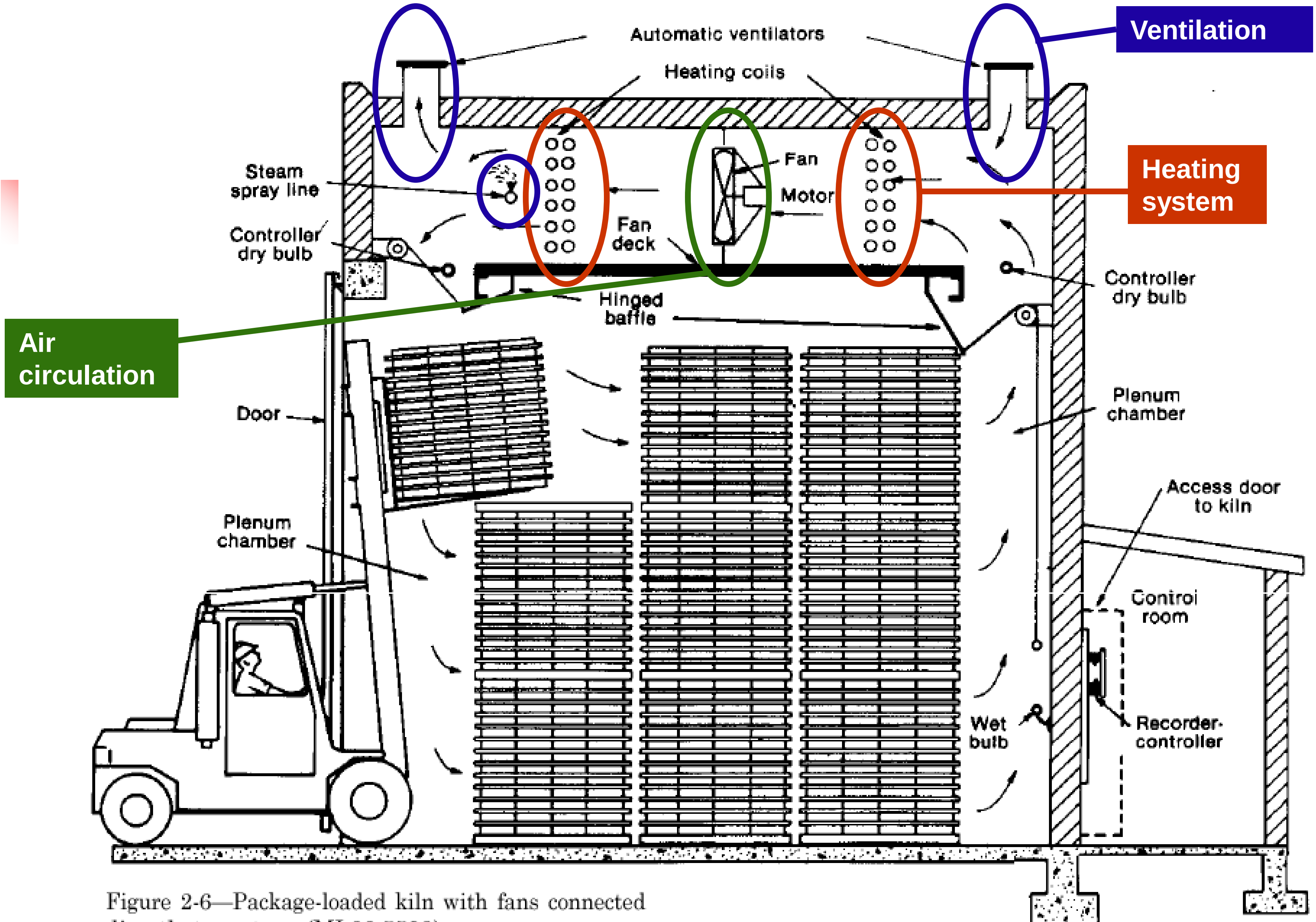
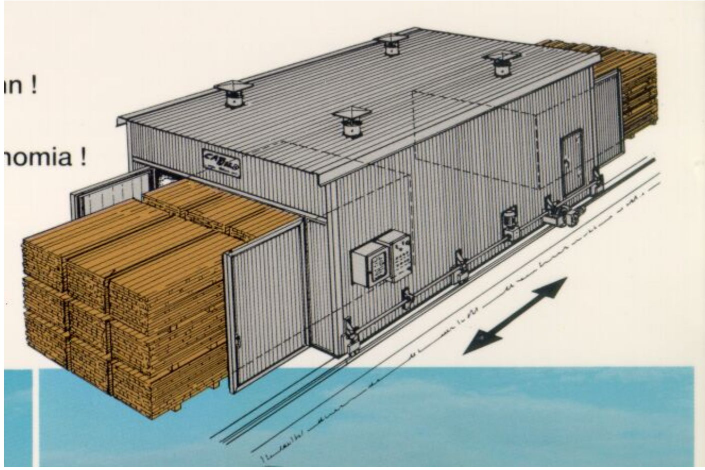


Figure 2-6—Package-loaded kiln with fans connected directly to motors. (ML88 5598)

Dry kiln types

compartment or batch kilns

(Preferred type)



moving kilns

Dry kiln types

Side loading

■ 13. *Tunnel kilns: ETR/M.*

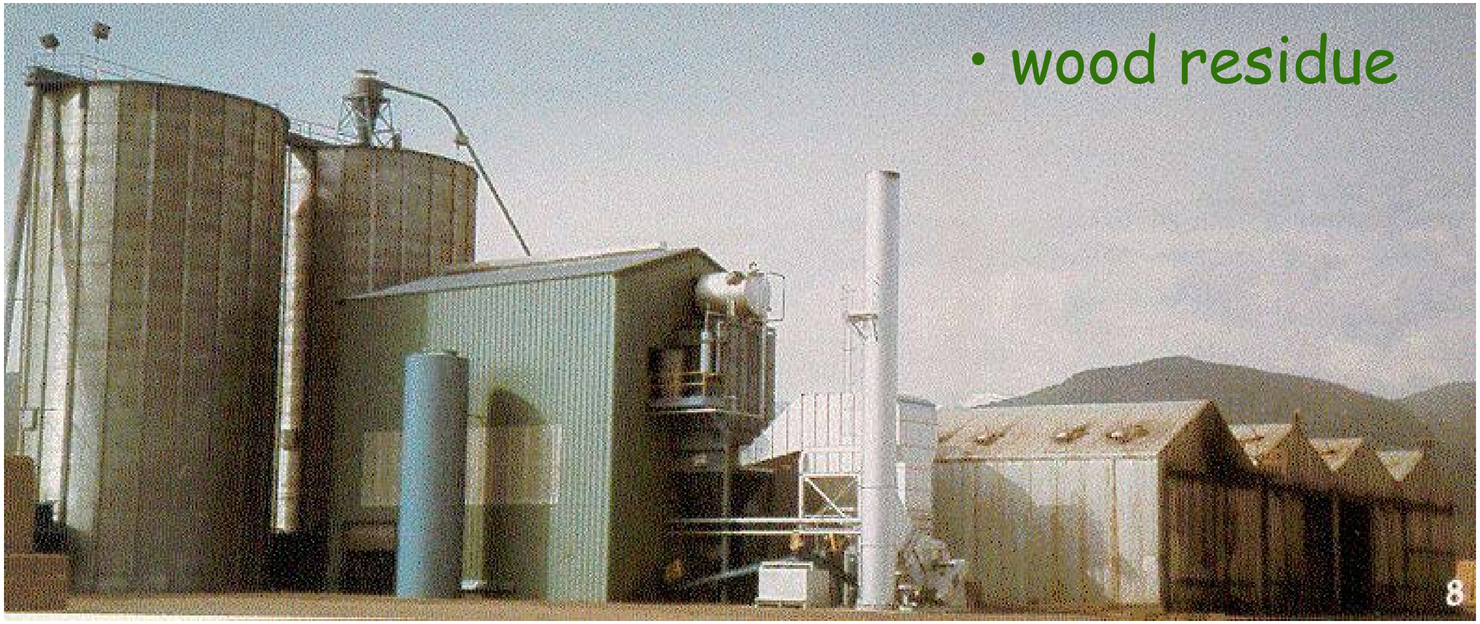
Tunnel kilns

■ 14. *Tunnel kilns: 2 double-track/double-door kilns adjoined.*

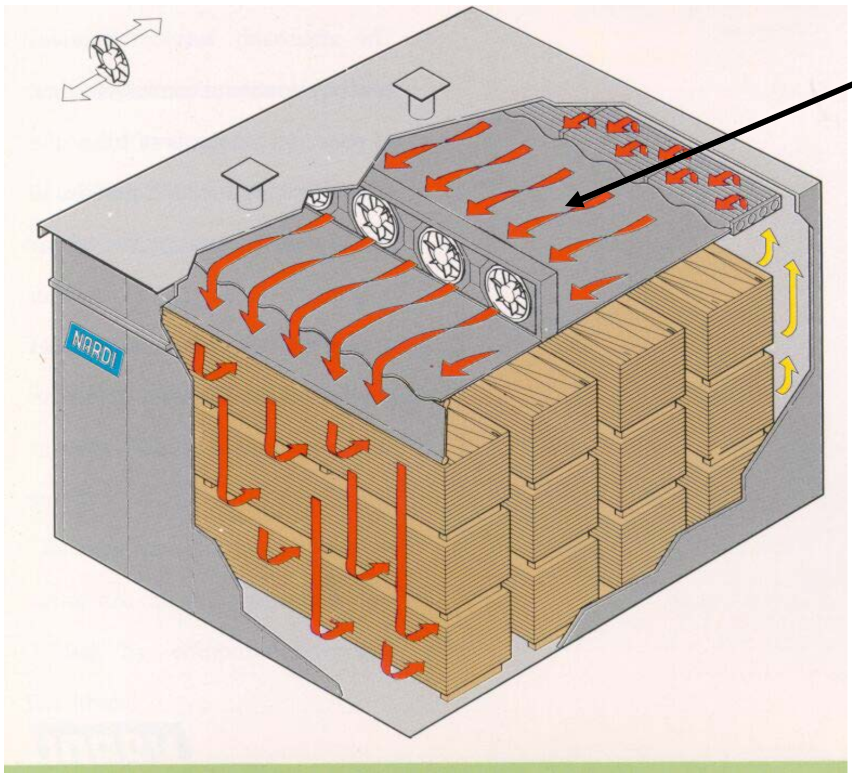
Kiln heating systems

Fuel for the boiler:

- oil
- natural gas
- wood residue

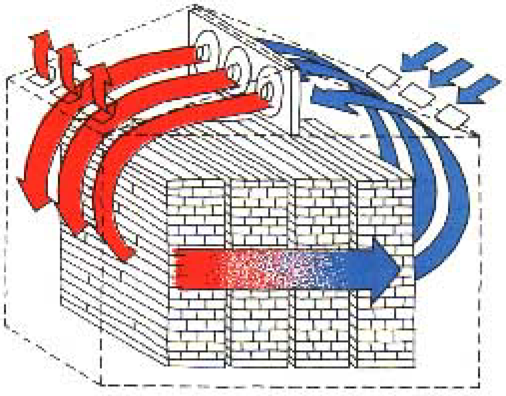


Air circulation systems



fans, normally located on the center-top part of the dry kiln

even air flow => even drying!



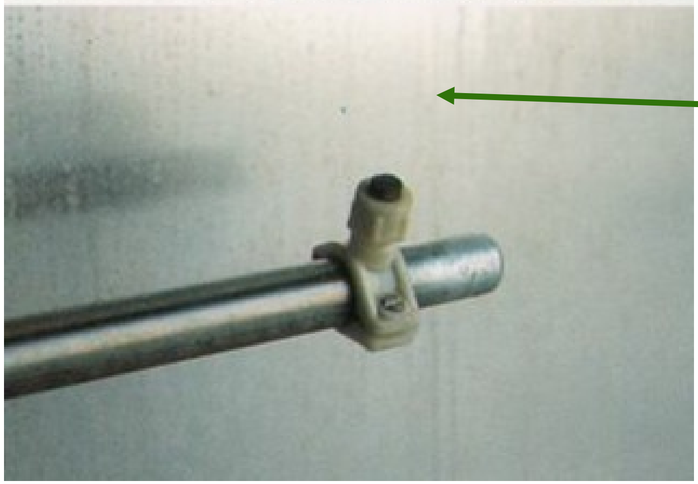
Air circulation systems

heat exchangers

cross-shaft fans

Kiln Humidity Systems

by opening vents, hot/humid air is released => H ⬇

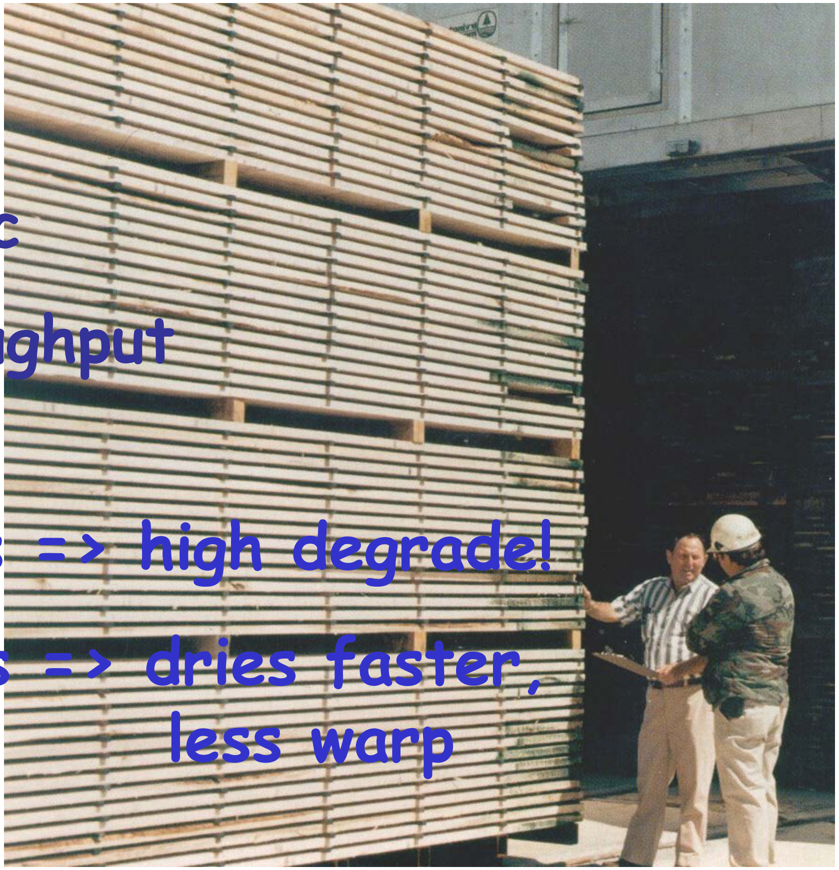


wet steam or cold atomized water spray system => H ⬆

Lumber preparation - handling

Objectives:

- minimize degrade
- obtain desired final mc
- maximize lumber throughput



- poor stacking practices => high degrade!
- good stacking practices => dries faster, less warp

Kiln schedule

Kiln schedule: a set of dry-bulb and wet-bulb temperatures as a function of time (time-based) or average moisture content (MC-based).

MC-based are the best schedules, but no reliable technology to monitor MC of the lumber population exists.

Kiln schedule

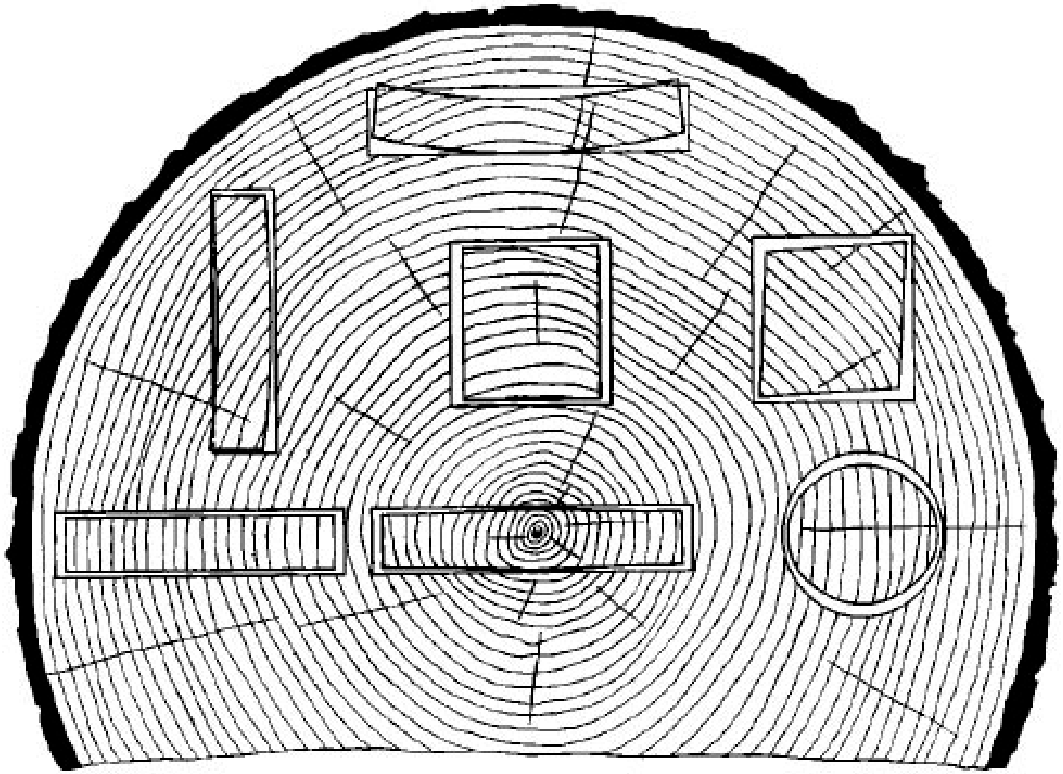
MC (%)	Temperature (°C)	Rel Humidity (%)
>60	71	58
50	71	31
40	71	21
35	71	21
30	77	24
25	77	24
20	82	26
15	82	26

Kiln defects

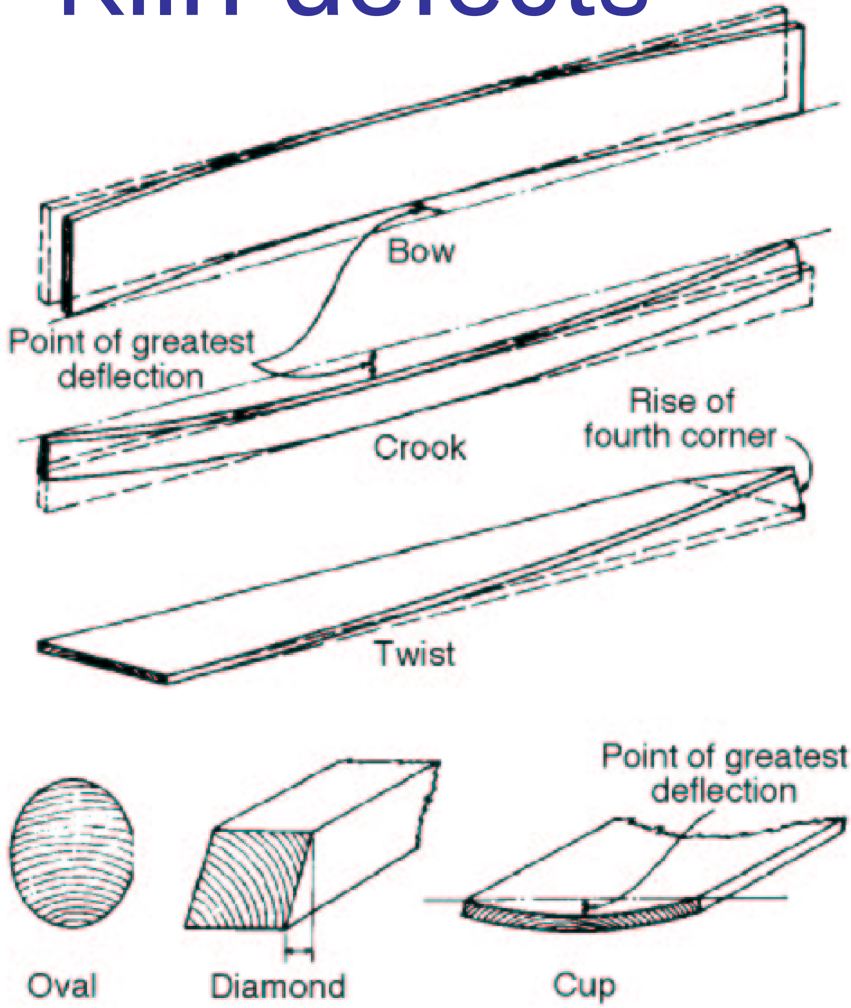
- shape distortions due to wood characteristics
- shape distortion defects due to inappropriate kiln schedules

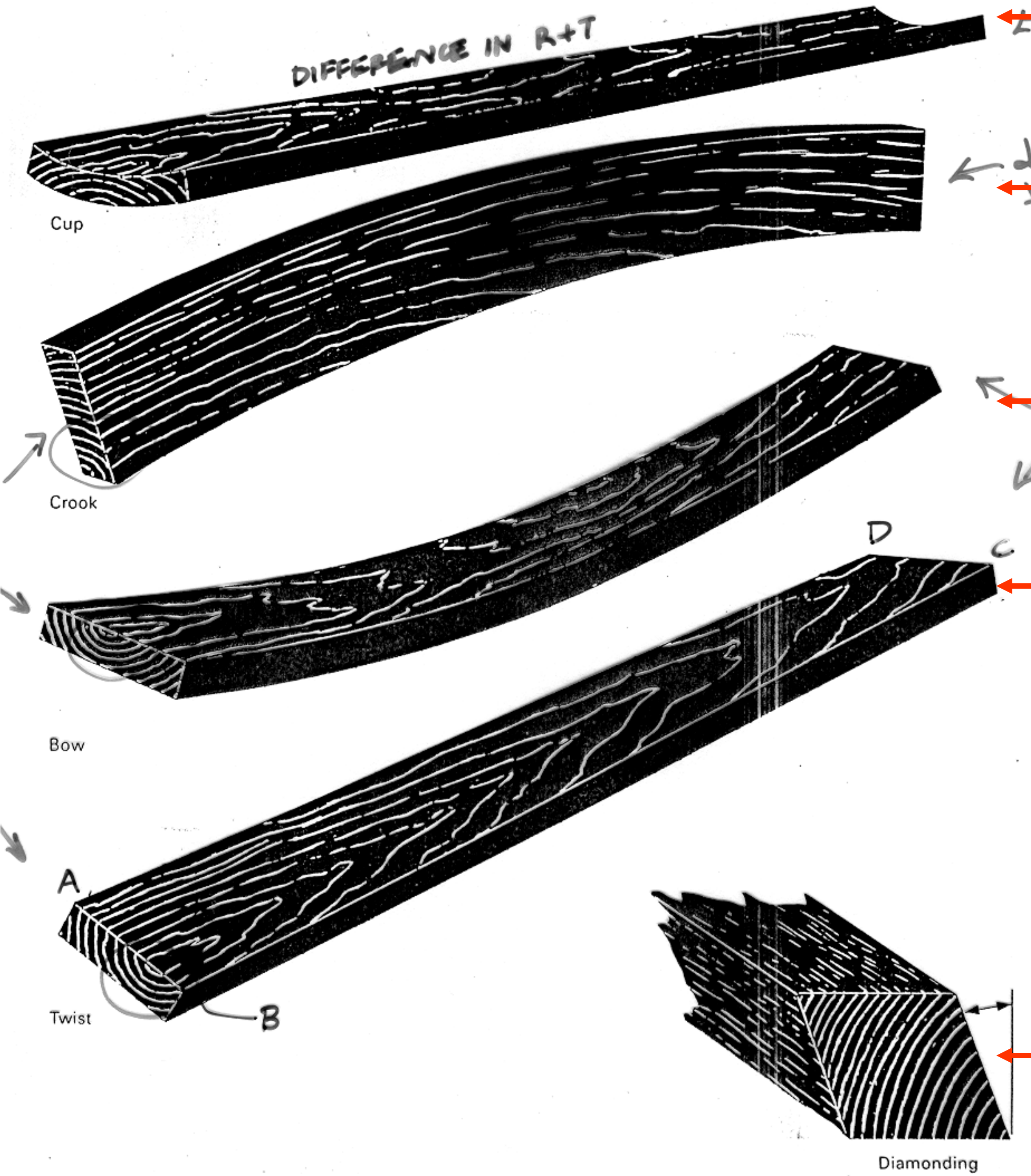
= loss in value

Drying defects



Kiln defects





deviation flatwise due to T vs. R shrinkage differences – pressure will keep them flat

deviation along the fiber due to juvenile or reaction wood shrinkage differences – impossible to control

same as crook

control with pressure

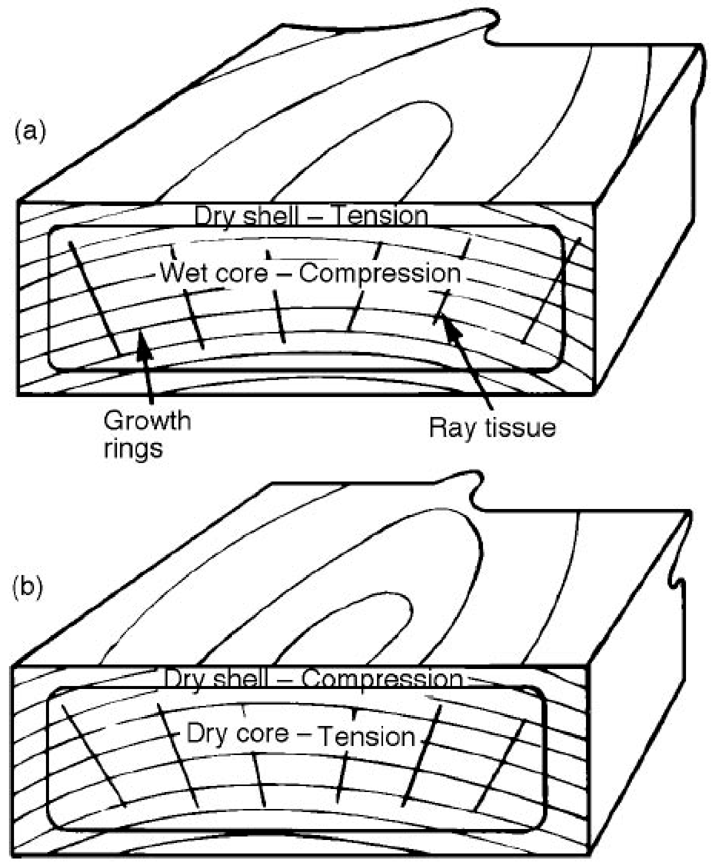
due to spiral, wavy or diagonal grain - control with pressure

due to R & T shrinkage differences in square timbers

Drying stresses

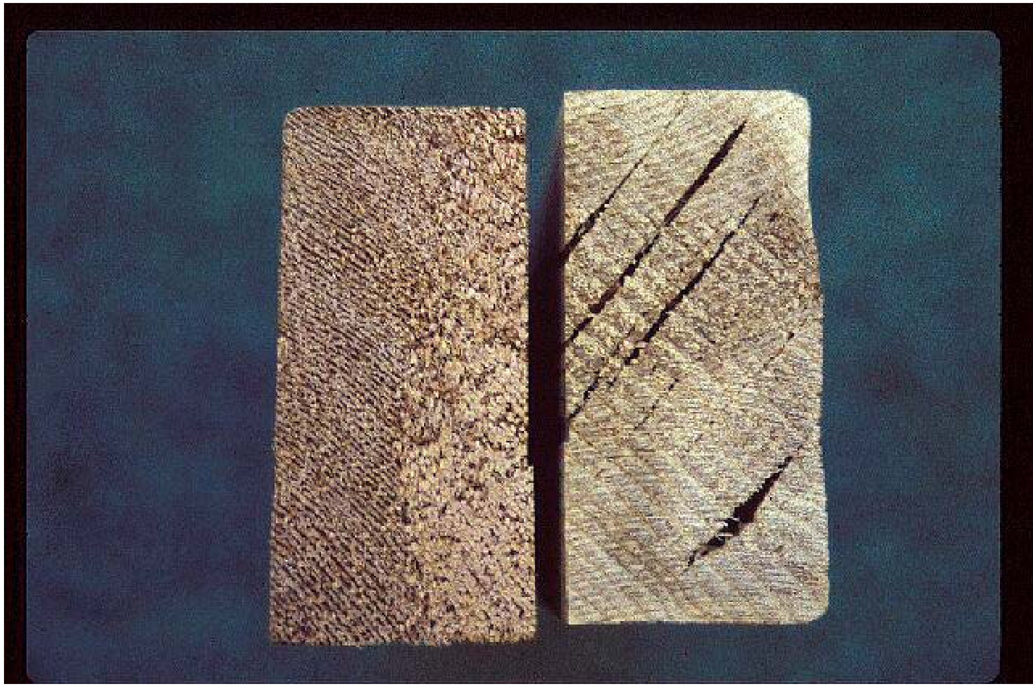
Initial drying

Final drying

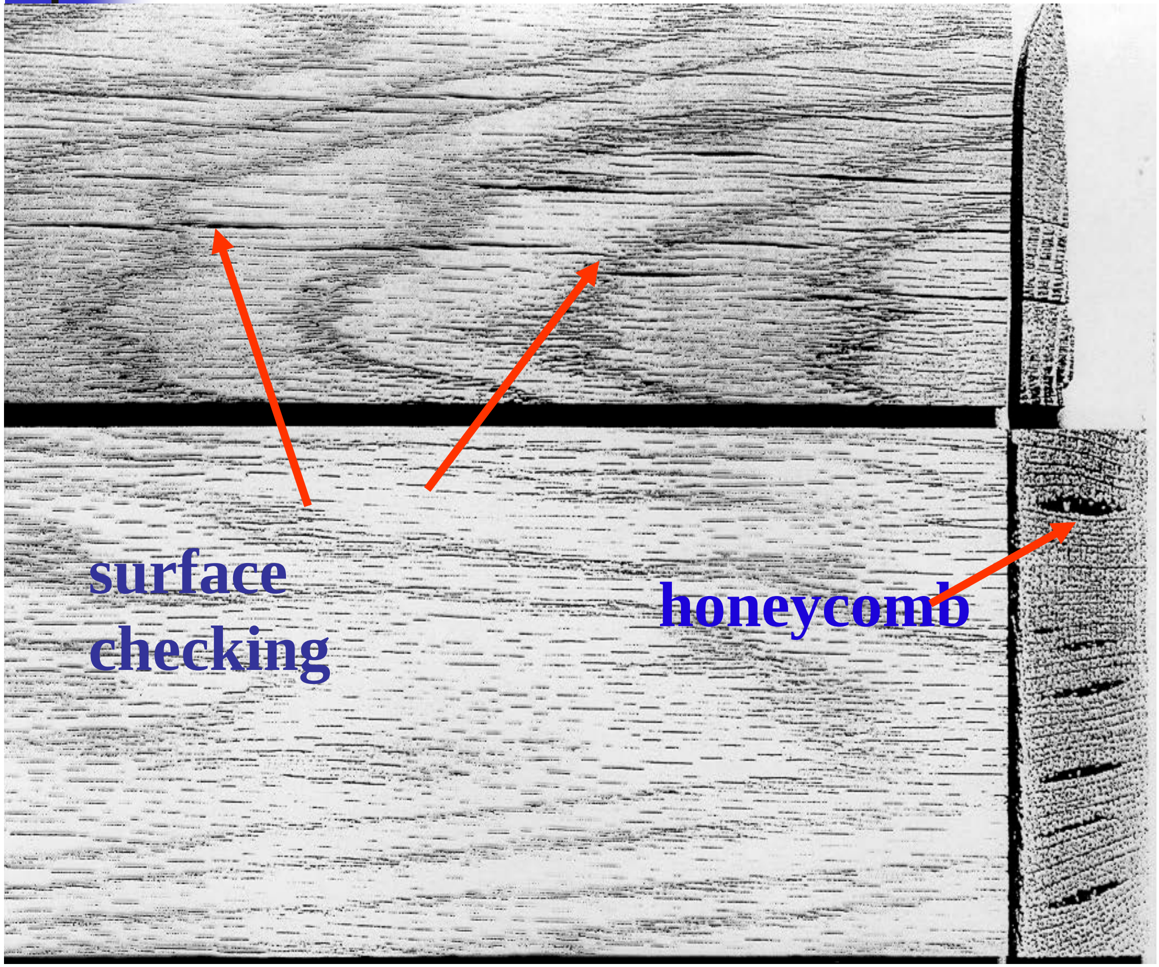


Kiln defects

honeycomb (internal checking due to high internal pressures)



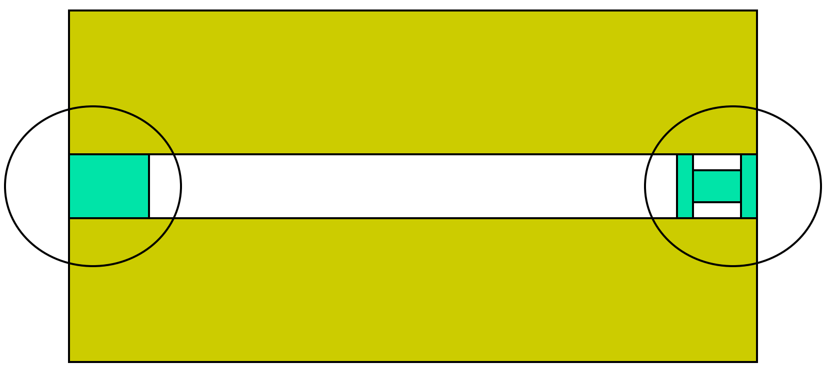
Kiln drying defects

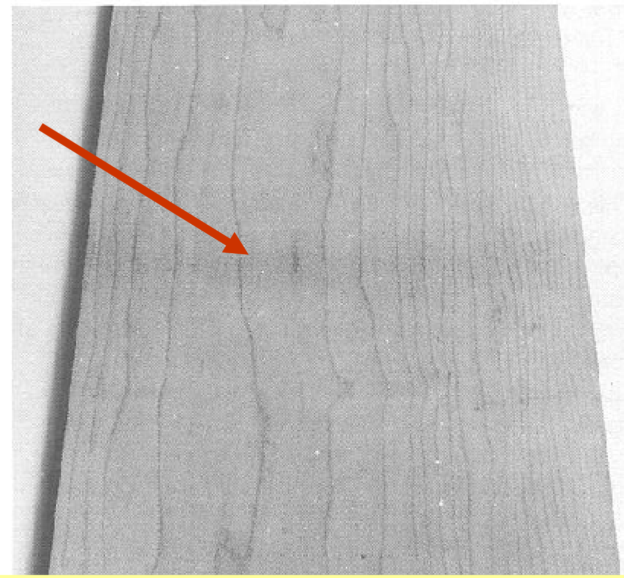


End checking

Drying defects

stickers can react with wood at the contact surface and leave a mark called "**sticker stain**" that sometimes is quite deep and cannot be removed in the planer mill

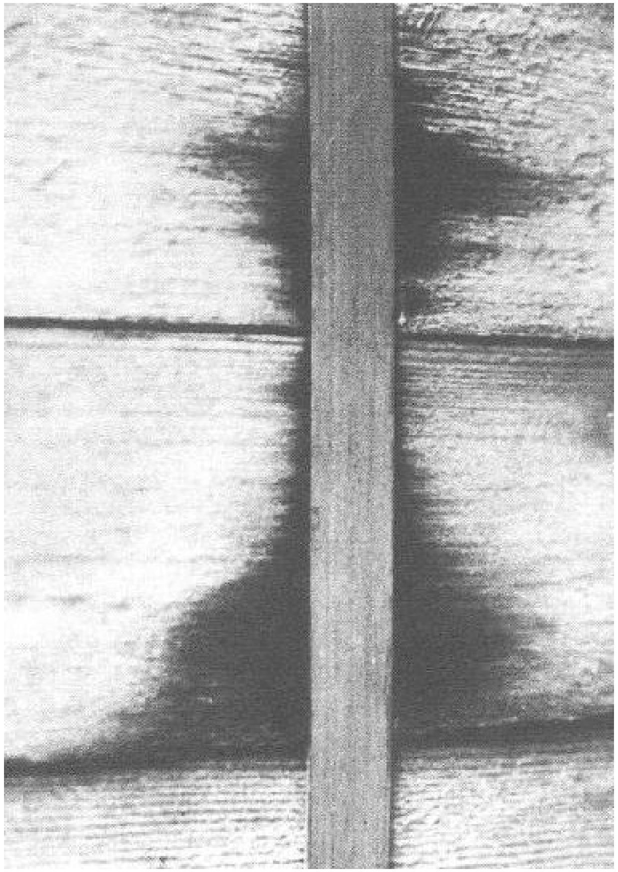




reduce contact area between wood and sticker => fast drying

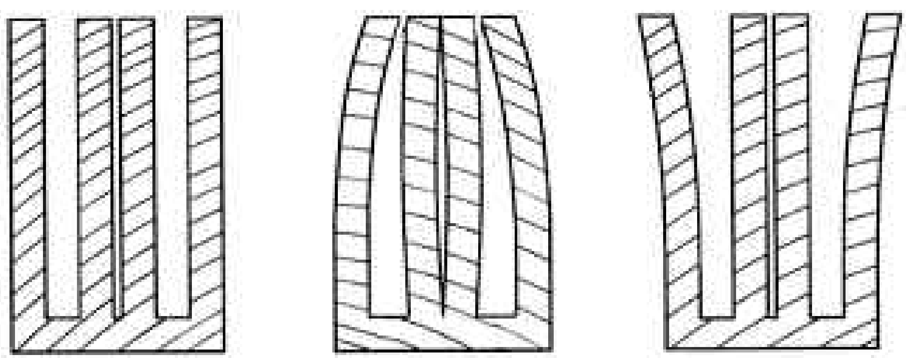
Drying defects

Iron stain in green hemlock from zinc – epoxy coated bands



Drying defects

casehardening: typical defect due to shell vs. core MC differences



No Casehardening   Caseharding   Reverse Caseharding

internal stresses