

## Physics Lecture 19 - Oil vs Rules

### Introduction

There have been several requests in response to the January newsletter for a lecture regarding those race rules that don't have a basis in actual experience or otherwise just don't make sense. A good example is the rule that forbids using any sort of oil to lubricate between the wheel bore and axle. I first encountered this rule 17 years ago but it goes back considerably further than that. The original rule, according to Don Murphy's book *Pinewood*, in 1953 read "Rule 11 - Do not use any lubricants or graphite on wheels or axles". Since that day, lubricants have been allowed, primarily because they make the car go faster and their use can't be reliably determined through inspection.

Then one day, a few years later, somebody discovered that an oil that was used for lubrication softened the polystyrene plastic of the wheel in the wheel bore, causing friction rather than lubrication. Indeed, aromatic oils can attack polystyrene, but their use is now limited. An aromatic oil contains compounds that have an "ene" in the name, such as benzene, toluene, xylene, naphthalene, etc. But, because of eventual recognition of the carcinogenic nature of some aromatics, their use in oils is now rare. Nevertheless, the word went out, and the rumor mill in pinewood derby circles generated publicity that eventually led to a prohibition on the use of all oils for lubrication. Because of my background and training in chemistry and physics, I suspected such a rule was unwarranted, and in 1990 I immersed 10 wheels in various oils and have observed them occasionally over the years. The wheels will now be tested and reported according to scientific methodology.

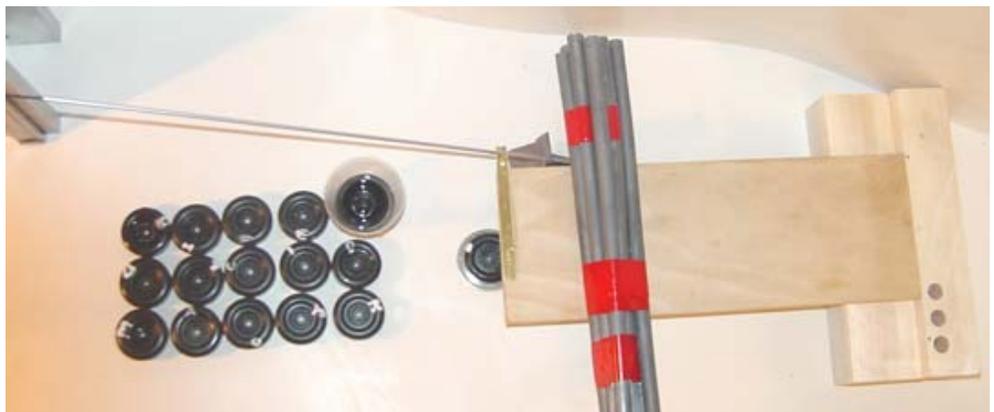
### Experimental Apparatus

A simple apparatus was built to compare the hardness of wheels that had been subjected to various lubricating oils. As shown in **Fig. 1** a sharp push pin attached to the underside of a pivoted cantilever board was allowed to rest on the side balloon part of a wheel. The vertical movement of the pin was magnified by a 10:1 lever movement and observed on a vertical caliper scale. A 1.5 kg weight (several 3/8" lead rods) was then placed on the cantilevered board and the deflection recorded. The amount of indicator deflection is given in **Table 1**. A deflection of 0.25" means the pin entered the plastic a distance of 0.025".

**Fig. 2** shows a top view of the apparatus and the assemblage of wheels being tested. **Table 1** shows the results of the tests.



**Figure 1** - The apparatus for testing the hardness of polystyrene pinewood derby wheels.



**Figure 2** - The apparatus of **Fig. 1**, top view.

As can be seen from **Table 1**, there are 2 types of wheels. Towards the end of 1990 a new improved wheel was produced that became commonly used in 1991. For this reason the wheel is referred to as the 1991 type. Then in 1999 this wheel was modified slightly and is called the 1999 wheel, which, as of this writing, is still in use. There is no substantial difference in hardness between the fresh (unoiled) 1991 wheels and the 1999

**Table 1 - Data on the effect of oils on pinewood derby wheels**

WHEEL	TYPE	OIL	TIME IN OIL	HARDNESS (IN X 10)	BORE RUB	NAIL SCRATCH
A	1999	NONE	0	0.21	NO RESIDUE	NONE
B	1999	NONE	0	0.21	NO RESIDUE	NONE
C	1991	NONE	0	0.23	NO RESIDUE	NONE
D	1991	MARVEL MYSTERY	17 YRS	0.23	NO RESIDUE	NONE
E	1991	SHELL ROTELLA	17 YRS	0.24	NO RESIDUE	NONE
F	1991	ROYAL PURPLE	17 YRS	0.26	NO RESIDUE	NONE
G	1991	USP MINERAL	17 YRS	0.25	NO RESIDUE	NONE
H	1991	WD-40	17 YRS	0.24	NO RESIDUE	NONE
I	1991	3-IN-ONE	17 YRS	0.27	NO RESIDUE	NONE
J	1991	NAPA SILICONE	17 YRS	0.27	NO RESIDUE	NONE
K	1991	TEXACO 10W-40	17 YRS	0.24	NO RESIDUE	NONE
L	1991	SLICK 50 GEAR LUBE	17 YRS	0.26	NO RESIDUE	NONE
M	1991	CASTROL HYPOY C	17 YRS	0.26	NO RESIDUE	NONE
X	1999	NONE	0	0.25	NO RESIDUE	NONE
X	1999	PLUS 5% TOLUENE IN 3-IN-ONE	1 HR	0.29	SLIGHT	SLIGHT
A	1999	PLUS 25% TOLUENE IN 3-IN-ONE	1 DAY	0.30	MEDIUM	MEDIUM
B	1999	100% TOLUENE	1 MIN	0.32	SUBSTANTIAL	SUBSTANTIAL

wheels. Moreover, it can be seen that after approximately 17 years there is no substantial change in hardness from continual oil contact on the 10 wheels labeled D through M. When the 1999 wheel X was inserted into 5% toluene in oil there was a hint of softening (0.29"). Other tests included a bore rub and a fingernail scratch. The bore rub consisted of rolling the wheel on a white cardboard rod axle as in **Lecture 17, Figure 6**. The finger nail scratch test does not leave a mark on the surface of an oiled wheel except where the oil contains aromatics, similar to the bore rub test. Whereas the hardness test measures bulk softening rather deep inside a wheel the bore rub and nail scratch are more sensitive to surface softening. Thus, even though pure toluene produced a gooey sticky layer a few mils thick on the wheel surface, this only allowed the sharp probe to penetrate a few mils deeper giving a hardness of 0.32". For those of you unfamiliar with toluene, it is a benzene compound with a methyl (CH<sub>3</sub>) group attached. Some higher octane gasolines may contain a substantial amount of toluene (in the past, up to 50%).

## Rules

**Table 2 - Comparing two rules**

	Rule	Reasoning	Truth	Small Amount Inspectable ?
1	No oil allowed	May damage the wheels causing greater friction	Not True	No
2	No wheel misalignment allowed	May rub the center strip causing greater friction	True	No

So many of us are faced with a decision on whether or not to use an oil lubricant in a PWD race. Consider **Table 2** carefully and suppose 1) that the "no oil allowed" rule is based on trying to prevent damage to the wheels, and 2) that we also have another rule introduced that says "no wheel misalignment allowed". Both these rules have as a reason protection, for the sake of the car builder, from having a sloppy race. But rule 1 is based on fiction and superstition while rule 2 reasoning is actually true. Now at least about 50% of builders may have some degree of misalignment but they will take their chances and just ignore rule 2. So why not ignore rule 1 which is even more ridiculous than rule 2? The first step in rule setting or law making is that it must be inspectable to be enforceable. How can a traffic policeman give a ticket for speeding to an invisible (and stealth coated) car? Is it a matter of retaining honor vs. the thrill of a winning trophy? Perhaps. But should honor apply to an uninspectable rule set by someone who believes in an old wives' tale and doesn't understand the race dynamics? Only you can answer this, but whatever the answer, I hope it makes sense to the kids.