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Project Report
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7100—Engineering Operations

San Dimas, CA

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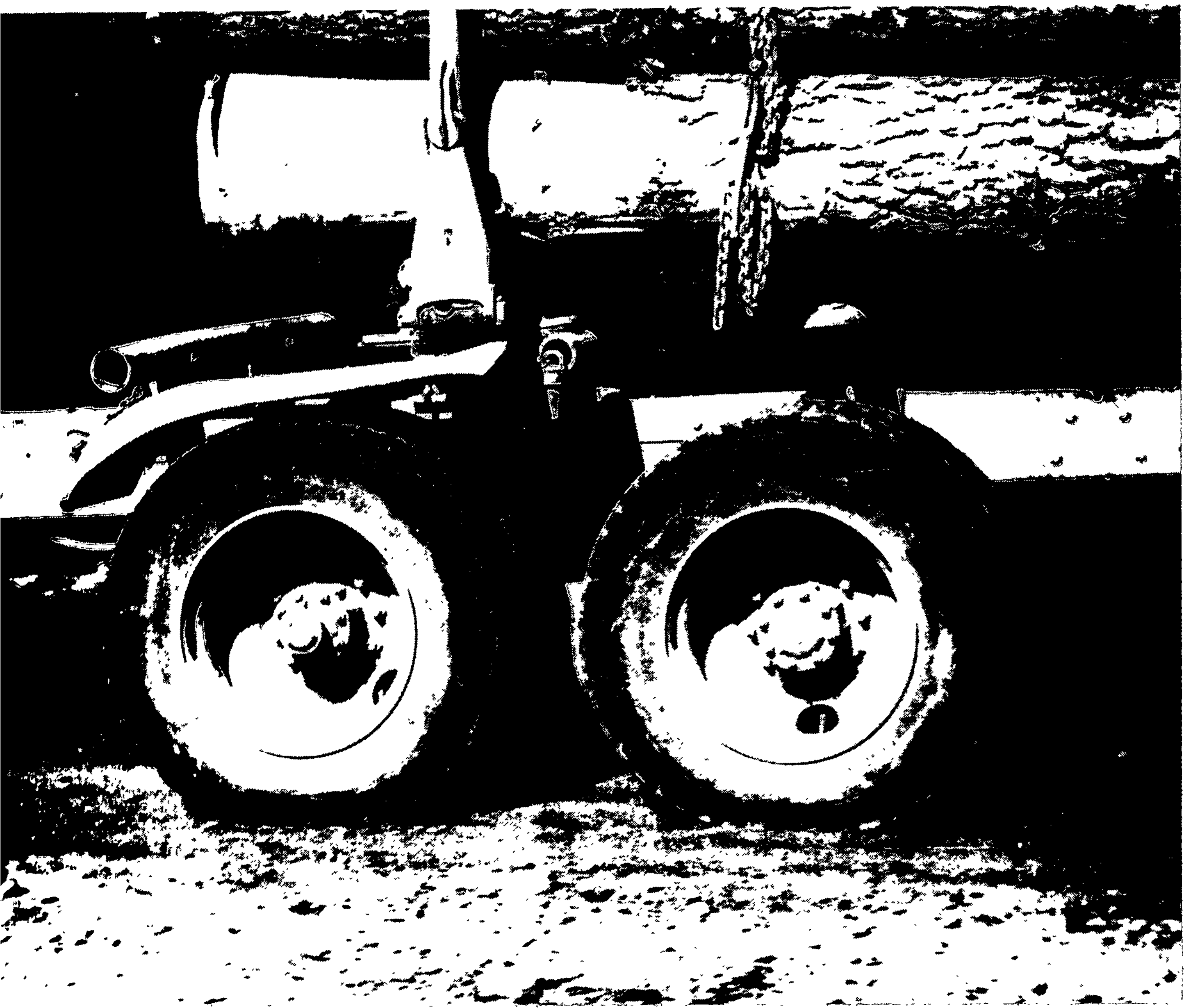
National Central Tire Inflation Program--Boise National Forest Field Operational Tests



National Central Tire Inflation Program--Boise National Forest Field Operational Tests

by

Deborah J. Taylor
Civil Engineer

Forest Service—USDA
Equipment Development Center
San Dimas, CA 91773

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ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

The Forest Service is conducting a two-part test program to evaluate the benefits and effects of lowered tire pressures on the cost of both road construction and maintenance and timber product hauling. A field operational test conducted during the Moores Creek timber sale on the Boise National Forest was the first use of lowered tire pressures on an actual timber operation. From September to November 1986, four 18-wheel logging trucks hauled 1.7 MMBF of timber over 5 miles of aggregate-surfaced County road and 6 miles of native-surfaced Forest Service road.

During this timber sale, 1.0 MMBF was hauled with the steering, driving, and trailer axle tire pressures determined appropriate for the speeds, loads, and weather conditions of the sale; i.e., between 25 and 54 pounds per square inch (psi). The airing and de-airing of these tires was performed manually, using automatic deflator valves and an airing station at the landing. For the remaining 0.7 MMBF of the haul, the trucks operated at their normal tire pressures of 100 psi.

Limited quantitative measurements were made throughout the course of the test program. The following test results (dependent largely upon opinions and observations regarding the effects of lowered tire pressure on the interrelationship between the road, the vehicle, and the driver) indicate that central tire inflation (CTI) technology can be beneficial in timber operations:

- No tire failures occurred with lowered tire pressure. One tire was damaged from a rock caught between the duals during a high tire pressure haul.

- Drivers expressed a unanimous liking for the smoother ride of the trucks when lowered tire pressure was in use.

- Some handling problems in the curves were experienced by the drivers. This was checked, and later attributed to the initial condition of the trailer bunk pads, which were worn badly and, in one case, worn completely through.

- No road maintenance was required while hauling the 1.0 MMBF using lowered tire pressures; the previous year maintenance had to be continual during timber hauling over the same roads. Minor rutting (3- to 4-inch depths) occurred in some wet spots, but never reached the 16-inch depths experienced the previous year. A healing effect from lowered tire pressure operation was observed as the road dried out.

- Lowered tire pressure improved truck traction and lessened road damage during wet and snowy road conditions. For both conditions, the haul would have been shut down by the District had the trucks not been operating with lowered tire pressure.

INTRODUCTION

Road Technology

Currently, the Forest Service maintains over 340,000 miles of roads to transport forest products from National Forests. Approximately 95 percent of these roads are unpaved. The cost of transporting forest products includes not only the actual cost of transportation, but also the cost of constructing and maintaining the roads. When faced with budgetary cuts, "doing the most with what you have" becomes the direction. Efforts to save dollars resulted in a need to investigate methods to reduce costs in all phases of existing road technology. Much of the direction for the current Forest Service effort is set by the Road Technology Improvement Program (RTIP).

Truck Tires, the Road, and the Vehicle

As recommended in RTIP, the San Dimas Equipment Development Center (SDEDC) is investigating the effects of tire pressure on the cost of transporting forest products over Forest Service roads. An initial report on this effort can be found in *Engineering Field Notes,* volume 15, January-March 1983, in an article by Leonard B. Della-Moretta on systems to decrease vehicular damage to forest roads. (A summary of this Project Report on the Boise National Forest tests can be found in an article appearing in volume 19, May-June 1987.)

SDEDC engineers are looking not only at the effect of lowered tire pressures on haul truck tires, but also at the basic interrelationship between tires, the road, and the vehicle. Both the U.S. Army and SDEDC have already found that lowering tire pressures on low-speed, unpaved roads may result in the following benefits:

- Reduced road maintenance requirements
- Reduced road surfacing requirements
- Reduced driver fatigue and injury
- Reduced vehicle operating (tire replacement, fuel, truck maintenance, etc.) costs
- Increased vehicle mobility.

Lowered Tire Pressures

The appropriate tire pressure is dictated by vehicle speed, tire construction, loading, and road surface strength. The use of CTI systems enables a vehicle driver to adjust tire pressure to an appropriate level from inside the vehicle cab. Although preliminary work has convinced the Army to equip their 5-ton trucks with CTI systems for mobility purposes, no sufficient quantification of other benefits has yet been accomplished.

To begin to quantify the relationship between tire pressure and road and haul costs, and to familiarize the logging industry with the lowered tire pressure concept, the Forest Service is conducting a two-part test program. Part one consists of structured tests to quantify the interrelationship between tires, the road, and the vehicle and the associated benefits of appropriate tire pressures. Part two consists of a series of field tests that should (1) demonstrate to the logging industry the concept of lowered tire pressures on unpaved roads and (2) qualitatively evaluate the effectiveness of CTI systems under actual field conditions.

FIELD OPERATIONAL TEST PLAN

The Moores Creek timber sale on the Boise National Forest near Cascade, ID, was the first field test to use lowered tire pressure for actual timber hauling. This field activity was selected to demonstrate the concept and associated benefits of hauling logs with lowered tire pressures and to determine the effects on:

- Haul costs
- Driver comfort and fatigue
- Road maintenance requirements
- Length of haul season.

The entire 11-mile haul route (fig. 1) was over unpaved roads. 5 miles of aggregate-surfaced County road and 6 miles of native-surfaced Forest Service road with tight curves and grades up to 12 percent. An administrative closure, effective the first day of the test program, was placed on the Forest Service segment of the haul route, restricting the test area to logging traffic only.

To test the effect of lowered tire pressures, the Forest Service, the Boise Cascade Corporation, and Hanson Logging of Horseshoe Bend, ID, agreed to change the operating plan for the Moores Creek timber sale for the 1986 fall operating season. From September to November 1986, four 18-wheel western logging trucks were operated with lowered tire pressures and hauled timber from this sale area during the test program. Approximately two-thirds of the haul was to

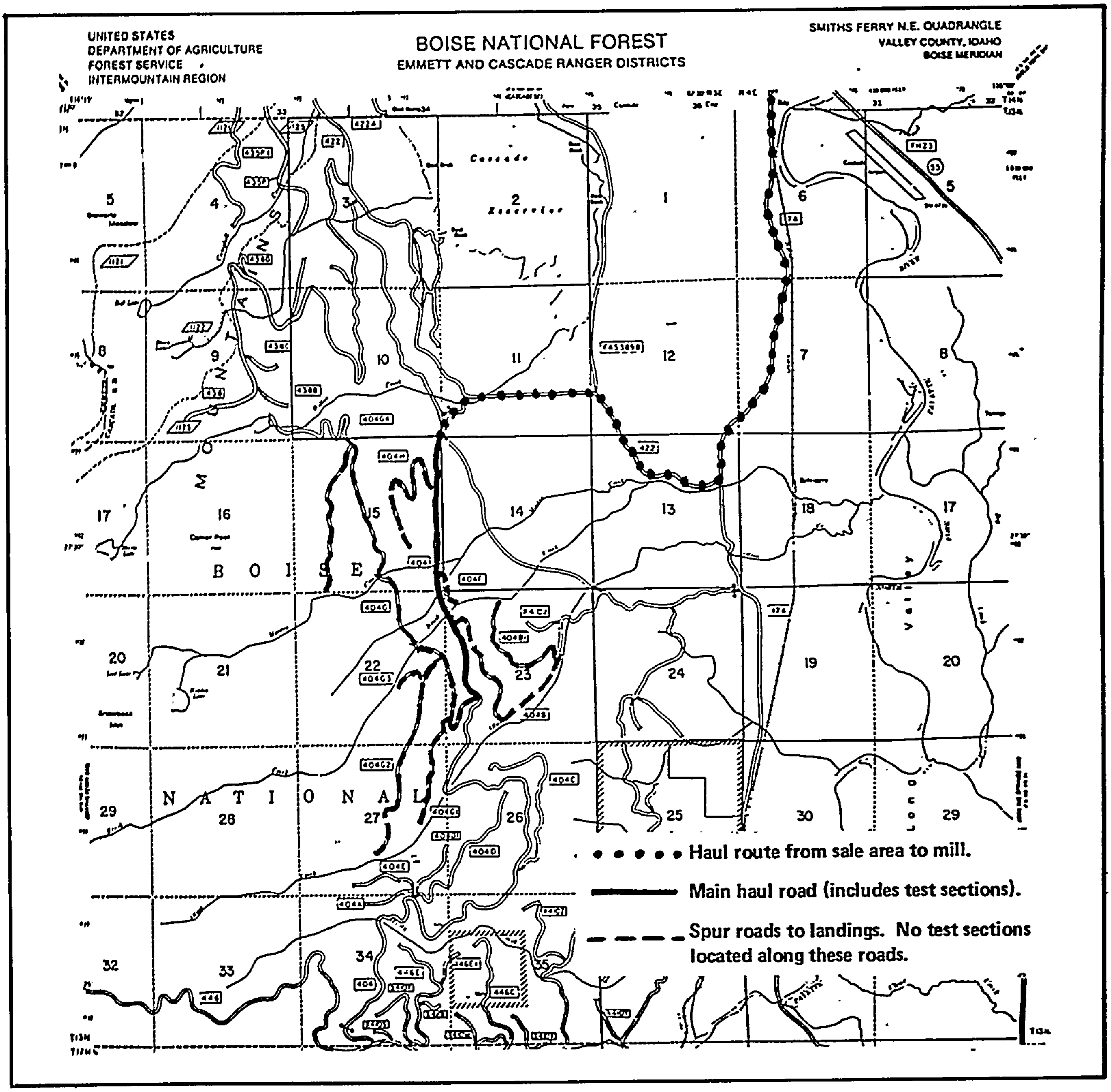


Figure 1. Layout of field operational test haul route.

be operated at a tire pressure determined to be safe for the speeds, loads, and weather conditions encountered. Appendix A presents the original test plan; appendix B presents the contract (Memorandum of Understanding) between the logging company and the agency. It details the terms and conditions for conducting the field operational tests.

TEST PROCEDURES

On September 12, 1986, the four logging trucks designated to participate in this test were each equipped with 18 new 11R24.5 tubeless-type Michelin radial tires. Five working days after termination of the field tests, the tires were removed from the trucks. Both the tire mounting and dismounting were performed by a local shop selected by the contractor.

Radial tires perform more effectively if run at pressures appropriate for the particular load, speed, and road conditions. The tires were to be kept in their original positions, as initially mounted at the beginning of the test program. Trailer axle tires were set at 38 psi for the entire lowered pressure test, since they were carried (or "piggy-backed") on the return trip. Steering axle tires were set at 54 psi for the entire lowered tire pressure phase.

Since CTI systems were not yet fully developed and available for this test, tire pressure adjustments were made manually. A compressor at the landing was used to inflate the driving axle tires when a truck was loaded with harvested logs. The airing station control panel used to regulate air pressures, and the tires equipped with hardware used to inflate the driving axle tires at the landing, can be seen in figures 2 and 3. The driving axle tires were set at 41 psi for the loaded condition.

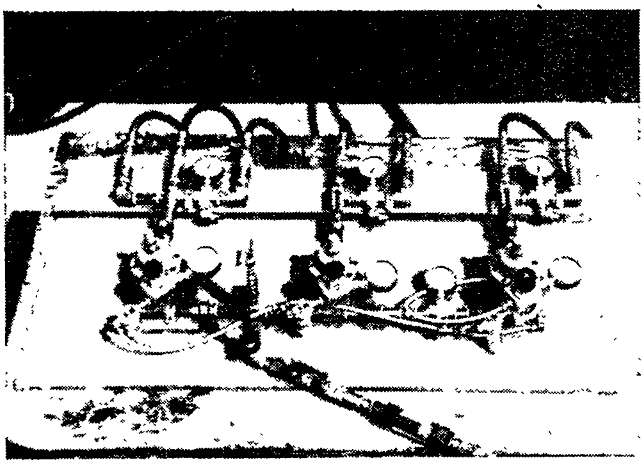


Figure 2. Airing station control panel.

When the trucks were unloaded at the Boise Cascade mill, the drivers deflated the driving axle tires to 25 psi by using automatic deflation valves that plugged onto the tire valve stems. By using various pressures, tire footprint length and deflection (change of tire section height) were kept constant for the different axle loads during the lowered pressure phase. Constant deflection and footprint length were important to ensure consistent results during lowered pressure testing. For an unloaded logging truck, a decrease in the tire pressure in the driving axle tires from the normal 100 psi to 25 psi increases the length of the tire footprint, while the tire width

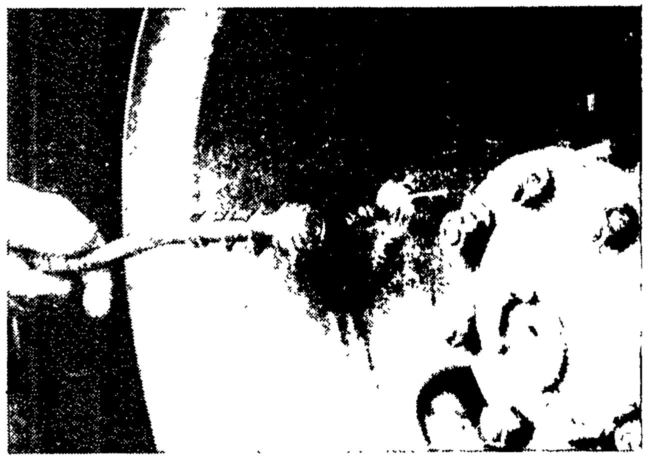


Figure 3. Hardware for manual tire inflation.

remains relatively constant (fig. 4). Table 1 illustrates that for the tire footprints shown in figure 4, a 90 percent increase in contact area was obtained by decreasing tire pressures from 100 to 25 psi.

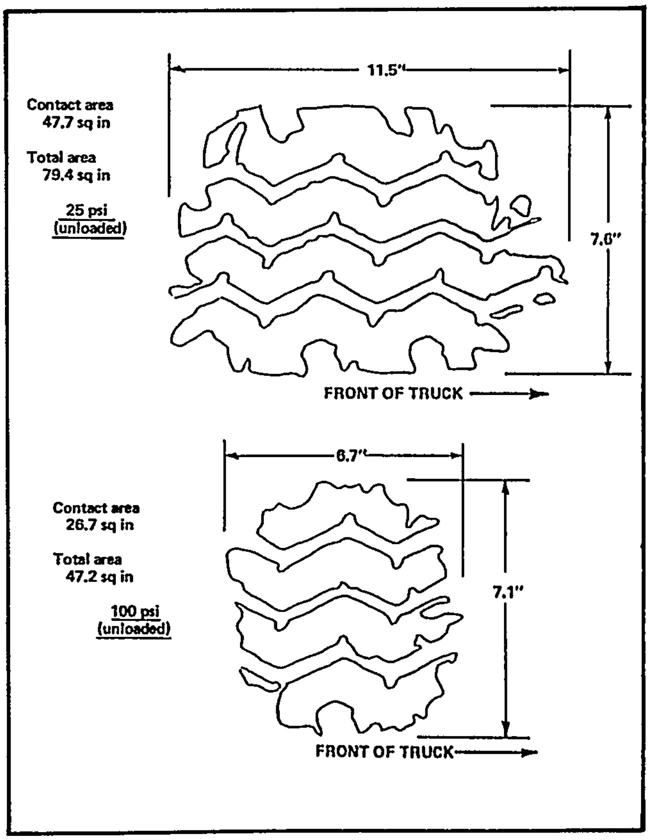


Figure 4. Comparison of length of driving axle tire footprints at 25 and 100 psi.

Table 1. Comparison of contact areas for unloaded third-axle dual tires

Tire pressures (psi)	Footprint dimensions: Length (in)	Width (in)	Contact area (sq in)*	Total load per tire (lb)	Average static ground contract pressure (psi)
25	10.8	7.6	45.5	1,300	28.6
100	6.2	7.1	24.0	1,300	54.2

*Area of general purpose tread that was contacting ground.

Limited field measurements were taken during the test program since the test was to be a demonstration with primarily subjective evaluations. Truck drivers were responsible for keeping a daily record of fuel consumption, round trip times, and total loads hauled. Records were made of any tire or rim damage—including conditions causing the damage, the type of damage, tire mileage, tire pressure, and position of the tire on the vehicle. Maximum load limits were set at 81,000 lb GVW. A radar gun was used to determine the speed of each vehicle through the test segments and other designated segments of the haul route. For test purposes, the trucks were kept to a maximum speed of 35 mph, which was considered appropriate for the loads, tire pressures, and road conditions.

During the test program, vehicles were run exclusively on unpaved roads. Five test sections were selected along the haul route to record the effects of changing tire pressures under a variety of road conditions including curves, grades, surface soil types, and moisture changes. Table 2 characterizes the soil properties of each test section.

Table 2. Test section descriptions

Test section No.	1	2	3	4	5
Description	Level	4% grade, 60° curve	Adverse curve w/ tangent	Tangent haul	Long tangent, soft soil
Location (from No. 404/No. 422)	0.25 mi (No. 404)	0.75 mi (No. 404)	1.5 mi (No. 404B)	2.0 mi (No. 404G)	2.5 mi (No. 404G/ No. 404G1)
Specific gravity (20° C) (-No. 4)	2.71	2.71	2.79	2.75	2.71
Atterberg limits	NP	NP	NP	NP	NP
R-value	70	79	64	61	61
Classifications— AASHO Unified	A-2-4 SM	2-1-b SM	A-2-4 SM	A-2-4 SM	A-4 (0) SM
Capillary rise potential	Mod.	Mod.	Mod	Mod.	High
Frost susceptibility	L-Med.	L-Med.	L-Med.	L-Med.	Med.

NOTE: Laboratory analysis is based upon representative soil samples, which were sampled on 7/10/86 and received for testing on 10/6/86.

At the beginning and end of each phase of testing, nuclear moisture/density readings (to be verified with an oven dry sample) were recorded, and documentation photographs were taken, at each test section.

Measurements of road rutting and related strain were taken at a designated location by Dan Salm from the Forest Service Graduate Program, Oregon State University. (Results of this data gathering effort will be available in a report published by the University.) Once truck drivers or test personnel observed washboard corrugation or road rutting, depth measurements were recorded and photographs taken to document the progression. A rain gauge was installed to record daily precipitation.

TEST RESULTS

This test program is just one of many projects to be conducted throughout the United States so as to involve a wide variety of regional conditions. Many of the comments and observations made during this test program are dependent upon the conditions particular to this sale area.

Tire Pressures

According to the original test plan, the first 1.0 MMBF of timber was to be hauled using lowered tire pressure, the second 1.0 MMBF with high tire pressure, and a final 1.0 MMBF of timber again with lowered tire pressure. Lowered tire pressure phases run during the test program were as discussed in "Test Procedures." These phases were run with the tire pressures shown in table 3 for the axle loads indicated. High pressure phases were run with tire pressures at 100 psi.

During the test program, 1.0 MMBF (205 loads) of timber were hauled with lowered tire pressures, and a remaining 0.7 MMBF (142 loads) with high tire pressures. The original procedure outlined in the test plan was modified to accommodate changes in road and weather conditions. After the first 4 days of haul with lowered tire pressure, weather conditions changed and the road surface became so wet in test sections 2.0 and 2.5 (greater than 23 percent surface moisture) that the haul was temporarily shut down. Subsequent hauls were accomplished by alternating high and lowered tire pressures, as road and weather conditions changed during the period of 9/12/86 through 11/6/86 (table 4).

There was a period of the haul (10/27 to 11/6) when road and weather conditions remained relatively constant. In fact, the first lowered pressure phase set the road up so hard and smooth that the high pressure runs did not appear to impact the road surface conditions. The opportunity arose to haul with a series of lowered pressure combinations other than those originally defined in the test plan. Approximately 0.4 MMBF (72 loads) of the total 1.0 MMBF hauled with lowered tire pressure (those listed at the tail end of table 4 under "Variety of . . .") was hauled using the tire pressure combinations shown in table 5.

Table 3. Lowered tire pressures defined for typical axle loads and vehicle speeds

Axle		*Axle loads (lb)*		*Tire pressures (psi)*	
		Empty	*Loaded*	*Empty*	*Loaded*
Steering		8,900	9,500	54	54
Driving	front:	6,000*	19,500	25	41
	rear:	5,200*	18,800	25	41
Trailer	front:	3,500	15,800	38	38
	rear:	2,500	16,700	38	38
	Totals:	26,100	80,300		

**NOTE:* The empty weight of the driving axles does not include the weight of the trailer that is carried on the unloaded haul. When the empty weight of the trailer is added in, the front driving axle carried approximately 9,500 lb, while the rear axle carried approximately 8,500 lb.

Table 4. Test period road and weather conditions

Date	Weather conditions: Precip. (in)	Weather conditions: Temp. (wet/dry) (° F)	Road conditions: Descript. (if any)	Road conditions: Surface moisture (%) (per nuclear densitometer)
Lowered Tire Pressure Runs (Steers at 54 psi/drivers loaded at 41 psi; unloaded at 25 psi/trailers at 38 psi)				
9/12/86	–	–/–		
9/15/86	0.02	–/–		21/21/10/17 for test section 0.75/1.5/2.0/2.5
9/16/86	0.00	45/56		
9/17/86	0.01	42/44		
9/18/86	0.29	43/45		
9/19/86	0.05	43/48		
9/22/86	0.50	39/41		
9/23/86	0.00	42/49		
9/24/86	0.25	40/43		
9/26/86	1.08	35/37		14/14/22/23 for test section 0.75/1.5/2.0/2.5
10/6/86	1.08	50/55		
10/7/86	0.00	–/–		
High Tire Pressure Runs (all at 100 psi)				
10/8/86	0.00	48/56		
10/9/86	0.00	–/–		
10/10/86	0.00	–/–		
10/13/86	0.00	–/–		
10/14/86	0.00	47/55		
10/15/86	0.00	–/–		
10/16/86	0.00	43/50	Center of sect. 2.5, average rut depth 3 in; Center of sect. 2.0, average rut depth 8 in (left lane); 10 in (right lane); pot holes forming	10/10/15/16 for test section 0.75/1.5/2.0/2.5
10/17/86	0.00	45/53		
10/20/86	0.00	–/–		
10/21/86	0.00	–/–	2 trucks (also 2 trucks at low pressure)	
10/22/86	0.00	56/63	"	
10/23/86	0.00	47/55	"	
10/24/86	0.00	–/–	"	
Variety of Lowered Tire Pressure Combinations				
10/27/86 thru 11/6/86	0.00 / 0.00	–/– / –/–		11/25/24/21 for test section 0.75/1.5/2.0/2.5 (as of 11/3/86)

Table 5. Lowered tire pressure combinations tested

For drivers at 70 psi (loaded):

Drivers (unloaded) . . . . .43 psi
Trailers . . . . .65 psi
Steers . . . . .75 psi

For drivers at 60 psi (loaded):

Drivers (unloaded) . . . . .37 psi
Trailers . . . . .56 psi
Steers . . . . .65 psi

For drivers at 50 psi (loaded):

Drivers (unloaded) . . . . .31 psi
Trailers . . . . .47 psi
Steers . . . . .54, 65 or 75 psi—depending upon driver response

Mileage

Based upon an average round-trip haul of 22 miles between the mill and the landings, the average of the total miles hauled by each truck during testing was approximately 2,000 miles. The average total miles hauled by each truck at lowered pressure was 1,030 miles and at high pressure was 770 miles. Table 6 summarizes the actual loads and miles hauled by each of the four trucks for both the lowered and high tire pressure runs during the period 9/15 to 11/6/86.

Table 6. Summary of total loads and miles hauled

Truck No.	Pressure:	Total loads: High	Total loads: Low	Total loads: New low**	Total miles*: High	Total miles*: Low	Total miles*: New low**
1		52	22	21	1,144	484	462
2		34	48	22	748	1,056	484
3		27	26	11	594	572	242
4		29	37	18	594	572	242
	Total:	142	133	72	3,080	2,684	1,430
	Average:	36	33	18	770	670	360

*Based upon an average round-trip of 22 miles.
**Includes lowered pressure combinations as defined in table 5.

Reduced Haul Costs

Truck Maintenance. Costs associated with truck maintenance and repair are a significant portion of the overall haul costs. Condition surveys of the vehicles prior to and at the conclusion of the test program indicated that no additional maintenance or repair was required on the vehicles after hauling the 1.7 MMBF. (Refer to appendix C for truck condition surveys.) The truck drivers agreed that over an extended time period, overall truck maintenance and repair efforts would be decreased by the use of lowered tire pressures.

Fuel Consumption. Table 7 indicates that vehicles consumed approximately 10 percent more fuel on lower pressure (anywhere from 3 to 5 gallons a day), depending upon the particular vehicle. During this test program, the initial lowered pressure runs were over a wet, slippery native road surface. After 140 passes with lowered tire pressures, the road surface was dry and compacted, responding as if it were paved.

Other, more closely controlled tests indicate that, for high tire pressures, additional fuel use occurs only when logging trucks are sinking into the road surface or are experiencing a lot of slip. In this instance, additional footprint length actually improves fuel consumption. In our test, road roughness was decreased, and the road damage common to high tire pressures did not occur, possibly explaining why fuel economy improved for high tire pressures.

Table 7. Comparison of average fuel consumption for lowered and high tire pressures

Driver No.	Fuel consumption (miles per gallon): Lowered pressure	Fuel consumption (miles per gallon): High pressure
1	2.30	2.65
2	2.37	2.26
3	2.37	3.09

Note: Fuel consumption is based upon an average round trip of 20 miles.

Tire Damage. One of the largest haul cost factors is tire replacement. Bruises, breaks, and cuts are currently the predominent cause of premature tire failure on logging trucks. With a longer tire footprint, the lowered pressure tires actually rolled over large, sharp rocks that protruded above the road surface on low-speed roads, without the tire damage commonly seen. Also, the increased deflection in the tire sidewalls eliminates the tendency for rocks to get caught between the duals and cause blowouts.

During the course of the field operational tests the only blowout resulted from a rock caught between the duals during high pressure operation. The only flat from a puncture occurred during high pressure operation when a nail was picked up. Upon completion of the test program, the trademark designs molded within the tire tread area by the tire manufacturer were still evident, indicating limited tire wear.

A detailed summary of the tire incidents evidenced at high and lowered pressures during this test program is presented in appendix D. The incidents detailed in appendix D are all the flat tires reported during the test. They show damage was done to tires only at high pressure. The incidents show bead unseating of tires at lowered pressure when severely impacted from the side, but not from normal operations and maneuvering in tight curves, ruts, turn arounds, etc.

Following an examination of nine of the tires by Bandag, Inc., Muscatine, IA, for possible tire damage and feasibility of full-use retreading, evidence of heavy lubrication along the tire bead was noted. Beads of lubricant were also found within the tire carcass. Heavy use of this unauthorized lubricant when mounting the tires may have contributed to the bead unseating experienced from side impacts. Refer to appendix E for a summary of the results of the Bandag inspections. Cross-reference of the field reports on the tires in appendix D with the laboratory results presented in appendix E indicates that the only tire rejected for retread (No. 5R0B2 on truck No. 2) was damaged at high pressure.

Increased Driver Comfort

By lowering tire pressures, tire deflection increases and the tire footprint is subsequently lengthened. Hence, the tire is in contact with the road surface for a longer period of time. The drivers noticed less bouncing and rattling of their trucks and less discomfort to their backs. Drivers agreed that overall stability was improved and felt that a truck rollover was avoided because the truck had lowered tire pressure.

Nevertheless, the effect of lowered tire pressure on overall truck handling and stability raised some concerns. Because of the short duration of lowered pressure operation, the drivers did not get use to the feel of handling and stability associated with lowered pressure. Power steering would have helped with the handling, since the longer footprint requires more power to turn the steering tires. Three of the four drivers felt some instability in the curves. However, subsequent tests and inspection found this to be a problem with the bunk pads on the trailer that only happened to be highlighted by lowered tire pressure.

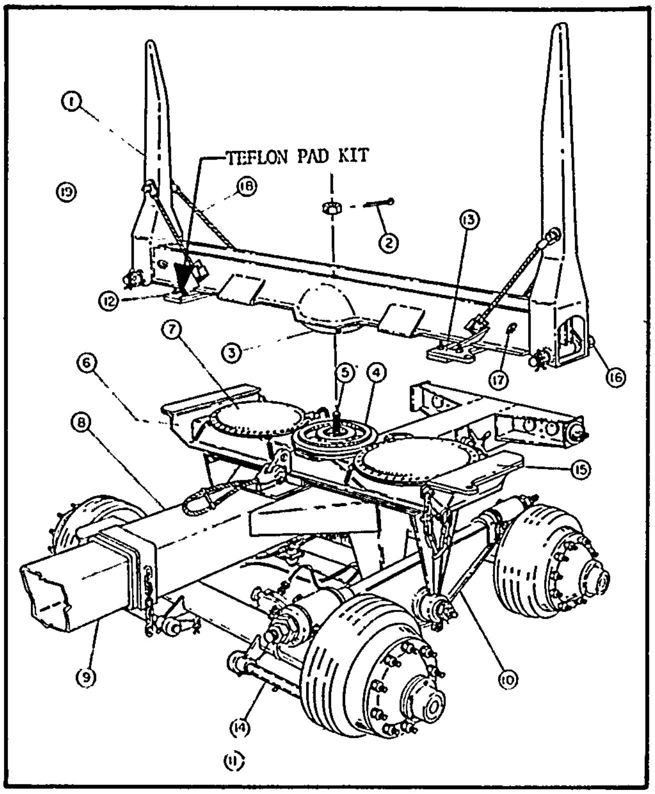
In fact, shortly after the conclusion of this test program, similar concerns were expressed by the truck drivers during structured tests at the Nevada Automotive Test Center (NATC). Even with power steering, the drivers in the NATC test program also felt a similar wobbling of the trailer—most noticeable going into the curves. Further investigation found that any excessive wear of the rub pads on the bunk assembly could have caused the bunk to bind as the load shifted and the truck began into a curve, pulling the trailer to the inside of the curve.

This was checked on the trucks in the Moores Creek field tests, and it was found that the bunk pads on the three trucks which had the problem were worn badly and, in one case, had worn completely through (fig. 5). The truck which did not experience the problem had bunk pads which were in relatively good condition. Teflon pad kits can be purchased to reduce the friction and the tendency for bunk binding (fig. 6). In general, excessive wear of the rub pads will increase the clearance between the bunk and bolster assembly, accentuating the rocking motion of the bunk assembly. Further tests on the use of lowered tire pressure will require that this clearance be adjusted to meet truck maintenance specifications.

Figure 5. Excessive wear of rub pads on bunk assembly.

Reduced Road Maintenance

It was evident to both the logging truck drivers and the Forest Service that changing tire pressures improved the road surface conditions and decreased overall road maintenance requirements. According to Al Noyes, engineering technician on the Cascade Ranger District,



Item	No. req.	Part No.	Description
1	1		Hassell L4C bunk assembly
2	1		¼" x 4" cotter pin
3	1	MM 1026-3	14" saucer air scales
4	1	MM 1027-3	14" hub air scales
5	1	MM 1031-4	Bunk bolt and nut
6	1	MM 1125	Bolster assembly
7	1		Scale pad assembly.
8	1	MM 1200-2	Frame assembly
9	1	MM 1201	Reach tube 7" x 9"
10	1	MM 1351	Walking beam assembly
11	2		Axle assembly—optional
12	2	MM 1160	Teflon pad kit, left & right
13	1	MM 1148	Bracket—pin side
14	4		Cam shaft cover
15	1	MM 1147	Wear plate with bar
16	2	MM 4115	Stake bolt
17	2		3/8" grab hook
18	2 (pair)	4200D	Stake cable
19	2	4210C	Stake cable pin

Figure 6. Teflon pad kit installed in bunk and bolster assembly.

road deterioration did not occur during either the lowered (fig. 7) or high (fig. 8) pressure phases. (This was dramatically different than the previous year, when the road had required continual maintenance; see final paragraph in this subsection.) The roads in this sale area became "greasy" when wet.

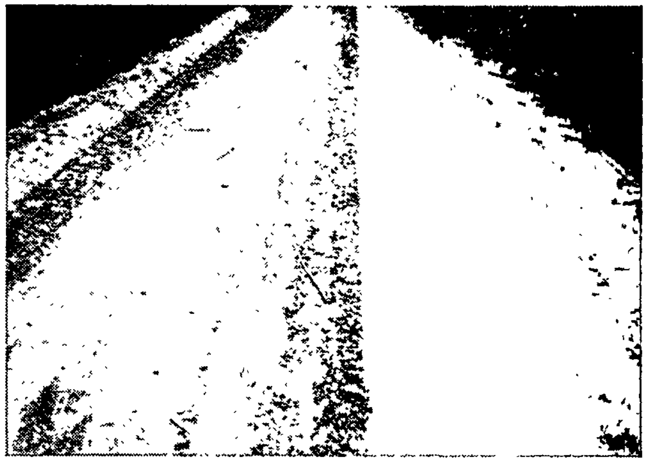


Figure 7. Road test section after 140 lowered tire pressure runs.

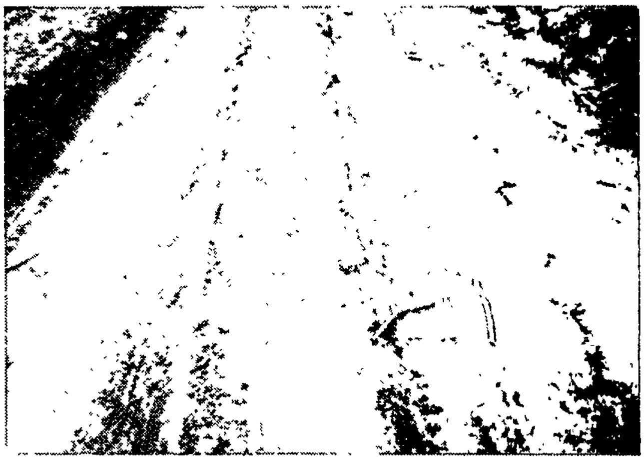


Figure 8. Road test section, seen in figure 7, after 284 high tire pressure runs.

Figure 7 shows road test section 2.0 after the first phase of lowered tire pressure runs that occurred from 9/12 through 9/26, 1986. Figure 8 is the same section after the first phase of high tire pressure runs, 10/8 through 10/17, 1986. The first lowered pressure test phase set the road surface up so hard and smooth that only in areas of excessive subsurface water did the road surface break down under high pressure. The repairing effect of lowered pressure became apparent early on in the test program. During the first lowered pressure phase, when the roads became saturated and so slick that the haul operation was temporarily shut down (23 percent surface moisture in test sections 2.0 and 2.5), logging traffic other than the logging trucks had rutted and damaged the road surface with high pressure tires (fig. 9).

Figure 9. Road test section rutted and damaged, but not by logging trucks.

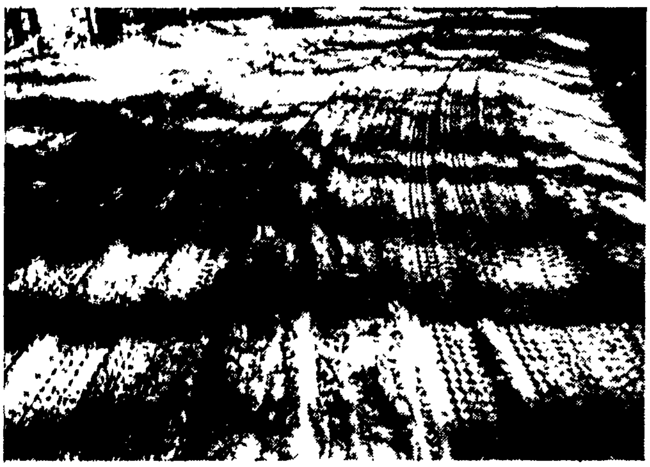


Figure 10. Road test section, seen in figure 9, after 54 lowered tire pressure runs.

After the road surface had dried out enough to resume haul, it was planned to begin the first high tire pressure phase. However, based upon the suggestion of the logging contractor and truck drivers, 2 days of haul were run using lowered tire pressure in lieu of grading the road surface. The lowered tire pressures smoothed the road surface and grader maintenance was not required. Figure 10 illustrates how this particular test section responded to the use of lowered tire pressure as a maintenance method.

For the remainder of the test program, the road surface remained dry. The decision was made to diverge from the original test plan and try a number of different lowered tire pressure settings (refer to the section "Tire Pressures" under "Test Results"). The opportunity did not arise to haul on wet roads using high tire pressures. However, this same haul road—when it had been used a year earlier using tire pressures of 90 to 115 psi—showed ruts as deep as 16 inches. Road maintenance had been continual. This same haul road was never maintained throughout the course of this test program. Some minor rutting was experienced in wet spots; these were never more than 3 to 4 inches deep. According to the Cascade Ranger District staff, it was almost too much to believe that 1.7 MMBF of timber were hauled with no maintenance to the road.

Extended Haul Season

Because of its road healing characteristics, the use of lowered tire pressures could extend the actual haul season, particularly for wet or snow-covered road conditions. On steep grades, truck traction was improved by the use of lowered tire pressure. In the case of adverse haul over a wet road surface, the use of lowered tire pressure prolonged the haul and delayed a temporary shut down. Several days of hauling were allowed that would not have been possible with high pressure.

The truck drivers recognized the possible advantage of using lowered tire pressure under snowy conditions. During the first heavy snowfall—when the road surface became slick and icy, but was still warm enough to melt the snow—tires on all four trucks were inflated to normal pressures so that chains could be used. However, the drivers asked to have their tires deflated to lowered pressures—claiming that the road surface was not yet slick enough for chains, but recognizing that high pressure tires would not provide enough traction. Hauling resumed with all drivers using lowered tire pressures. By using lowered pressure rather than chains, the road surface was not damaged and hauling resumed the following day with chains on a 2- to 3-inch layer of frozen snow. Although the use of chains on November 7, 1987, terminated the test program, hauling continued with chains through mid-December until all the sale had been logged. The haul would have been shut down by the woods boss or the District had the trucks not operated with lowered tire pressures.

CONCLUSIONS

The field testing on the Moores Creek timber sale demonstrated that CTI technology can be beneficial in timber operations. On this active timber sale, four 18-wheel logging trucks hauled a total of 1.7 MMBF of timber over 11 miles of native-surfaced local road and graveled County road. Approximately 1.0 MMBF of timber were hauled with lowered tire pressures.

Throughout the course of this field test, opinions and observations regarding the effects of lowered tire pressures on the interrelationship between the road, the vehicle, and the driver were obtained. Limited quantitative measurements were made. Based upon the field test results reported herein, the following conclusions can be drawn:

1. No tire wear or failure was observed with lowered pressures. One tire was ruined during the high-pressure phase when a rock caught between the duals.

2. Drivers expressed a unanimous liking for the ride of the trucks with lowered pressures. The smoother ride resulted in less discomfort to their backs.

3. Drivers expressed some concern about the handling in curves. This was attributed mainly to the condition of the bunk pads. The initial truck condition survey found that bunk pads were worn badly and, in one case, worn completely through.

4. Road maintenance was dramatically reduced using lowered pressures. No road maintenance was required during field testing. Rutting developed only in wet spots and never over 3 to 4 inches deep, as compared to previous years when rut depths of up to 16 inches were reported. A healing effect was demonstrated when lowered tire pressure was used as the road surface dried out.

5. The haul season was extended by use of lowered tire pressures. In wet conditions, traction improved and road damage was decreased. The use of chains was delayed by hauling with lowered tire pressure under snowy conditions. The use of lowered tire pressure prevented a shut-down of the haul by the District and the wood's boss.

The use of CTI systems in logging operations will enable vehicle drivers to haul using the appropriate tire pressures for particular vehicle speeds, loads, and road surface strength.

RECOMMENDATIONS

This field operational test was only one of a series of tests designed to determine the feasibility of using CTI systems to allow the use of appropriate tire pressures for load, speed, and road conditions. The effects of lowered tire pressures on overall tire life and on vehicle fuel consumption are still to be addressed, for tires running under actual field operational conditions. Additional field operational tests are necessary to evaluate the benefits of lowered tire pressures over a wider range of soil, climate, and road design conditions.

Additional field operational tests need to define the goal of the test to be performed. Everyone involved in the field test must agree upon whether the goal of the project is to conduct a quantitative or qualitative evaluation of test results. If the goal is a qualitative evaluation, quantitative measurements should be limited. The following is a list of additional suggestions for conducting successful field operational tests:

1. Record all factory stamped serial numbers, corresponding tire locations, and vehicle identification numbers prior to mounting of tires on the vehicles.

2. Record the initial odometer readings of all vehicles immediately following mounting of tires and at the beginning of the field test. Record the odometer reading and the tire serial numbers, corresponding locations, and total mileage at the change of test phases and the conclusion of testing.

3. To enable drivers to adjust to any differences in vehicle handling due to lowered pressure, hauling should begin at normal pressures and be gradually dropped to the lowered pressures to be used during the field testing. There may be some drivers who have not hauled using radial tires and they should be given the opportunity to first adjust to any differences in handling due to the switch from bias ply tires before lowering tire pressures.

4. Periodically check and collect daily log sheets kept by each driver to be certain that records are up to date. Records of any tire or vehicle damage should be made at the time of the occurrence. Whenever possible, vehicle and tire damage should also be recorded by the Project Engineer to insure that records are accurate.

5. Field notes should be kept daily by the Project Engineer. This journal will prove to be helpful when drafting the final project report.

6. Be flexible. These are field tests subject to variable field conditions. Do not hesitate to make amendments to the original test plan. It may be necessary to add new test sections or change the recommended lowered tire pressures to accommodate changes in weather and/or road conditions.

CENTRAL TIRE INFLATION UNSTRUCTURED TEST PLAN

Moore's Creek Timber Sale
Cascade Ranger District
Boise National Forest, Idaho

INTRODUCTION and SCOPE

Commercial hauling trucks are traditionally operated with tire pressures of 90 to 110 psi. The design of those heavy vehicles, and roads to carry them, has long been dictated by those high inflation pressures needed for loaded tires to survive. Damage to roads and structural design required should be reduced when trucks are operated with lowered tire pressure.

The scope of this test is to subjectively evaluate the effect of tire pressure on road surface deterioration, road maintenance, timber haul costs (i.e., truck maintenance, fuel consumption, round trip time, and tire life), and driver fatigue and injury. Limited measuring will be done to quantify these effects.

OBJECTIVES

The objectives for this test program are:

1. Demonstrate CTI technology and benefits to timber industry in the West:
   - As broad a scope of application as possible.
   - Visible, to broad group of industry people.
2. Determine subjective benefits of lowered tire pressure on:
   - Road surfacing
   - Road Maintenance (washboard, dust, surf. replacement, etc.)
   - Haul cost (fuel, round trip time, tire cost, truck maintenance).
   - Driver fatigue and injury.

TEST PROCEDURE

The test will consist of operating typical western logging trucks on this timber sale with varying tire pressures during the period from September to November 1986, to determine benefits of lowered tire pressure. Four trucks will be used to haul approximately 3.0 MMBF of timber from this sale area. This will require approximately 600 round-trip truck passes. Approximately 1/3 of these passes will be operated at a low tire pressure as determined to be safe by the project engineer and timber operator for speeds, loads, and other conditions encountered.

TEST PROCEDURE (con't)

The next 1/3 of the passes will be operated with a tire pressure more commonly used (90-110 psi). The final 1/3 of the passes shall be at the lowered tire pressure determined appropriate for the first passes. The trucks shall be equipped with new radial truck tires immediately prior to testing.

Tire pressure shall be adjusted manually to that appropriate for each phase of testing. The road deterioration, haul cost effects, driver comfort, and vehicle handling characteristics will be determined for each of the three testing phases. Drivers will be interviewed at the conclusion of each testing phase to record their perception of operational efficiency. Tests will be videotaped. Tires shall be removed from the trucks at the conclusion of the test for further tire testing. Airing stations will be used at the landing and at the mill to ensure the driving axle tires are operated at constant deflection for the loaded and unloaded conditions (i.e., 45 psi loaded, 20 ± psi empty). Steering axle tires will be maintained at 55 psi for all operation during low pressure test phases. Trailer axle tires will be maintained at approximately 45 psi during low pressure phases without variation for loaded and unloaded conditions.

SPECIFICS

Three specific test sections will be observed on Roads 404 and 404G throughout the test. They will vary in horizontal and vertical alignment and surfacing type. Moisture content of surfacing materials will be measured throughout the tests.

Test Road - The test roads shall consist of the entire length of Road 404 on the sale area and a portion of Road 404G.

Segment - Portions of the test roads that the test truck will travel at prescribed tire pressure with speeds monitored. Segments are designated by stations and road number.

Section - The portion of the road where the specific measurements/observations will be taken throughout the test. Sections are selected for gradient and surface type. Sections are identified by letters. Five to seven test sections are anticipated.

Failure - Defined as the condition at which maintenance is required to continue haul.

I. Truck

I.A. Axle loads:

-Trucks will be fully loaded with logs to approximately legal highway load limits.

-At the beginning of the test, loaded trucks will be weighed on platform scales at Cascade, Idaho.

-Trucks will be weighed so that each axle load can be determined.

-Weights will be recorded to nearest 100 lb.

DEFINITIONS - Truck (con't)

-Axle loads will be measured during test at discretion of Project Engineer (approximately once per week).

-Axle loads shall be recorded.

I-B. Tire pressure (Cold):

-At the beginning of the test cold rear axle tire pressures will be set as directed by Project Engineer (45 psi anticipated for loaded; 20 psi for unloaded).

-Tire pressure will be checked during test as directed by Project Engineer (daily or more frequently for the first 2 weeks, less frequently thereafter).

-Tire pressure will be recorded to the nearest psi once for each phase of testing. Significant deviations will also be recorded by tire location, truck number, and tire serial number.

-Tire pressure will be adjusted daily to appropriate level for testing in progress.

I-C. Contact Length, Deflection, and Tire Print:

-After the tire pressure has been set at each pressure to be tested, contact length, deflection, and tire print will be taken and recorded (one drive tire, one steering axle tire, and one trailer tire will be jacked up, inked, and set down on paper) for the loaded and unloaded conditions and pressures.

-Contact length shall be measured to the nearest 1/2-in.

-Tire print will be taken by the Project Engineer in cooperation with the truck owner or driver.

I-D. Driver Impacts:

-The Ride Meter developed by the U.S. Army Corps of Engineers Waterway Experiment Station will be used to measure ride quality (driver comfort and injury). Each test segment will be measured after each 50 loaded passes. The Ride Meter will be operated using the recommended procedure. Each segment will also be measured immediately prior to beginning of testing and again immediately following the last trip for each phase of testing.

I-E. Truck Maintenance and Repair:

-Accurate records will be kept of truck maintenance and repairs. Records will be made of any parts that fail including type of failure, mileage of vehicle, miles of low pressure (including pressure) running, and operating conditions at failure. Downtime for repairs will also be recorded. A detailed history for test will be kept for each truck.

Truck Maintenance and Repair (con't)

Historical records will be kept daily to record operating conditions, tire pressure, mileage, and other notable occurrences during the day. Any tire changes are to be recorded on the log sheet, including the location of changed tires by the tire serial number. A thorough condition survey of each vehicle immediately prior to the test and at the end of each phase of testing will be made. If vehicles are used off the project, record will be made of conditions, tire pressure, maintenance, etc. for the period of use off site.

I-F. Fuel Consumption:

-Fuel consumption will be measured for each vehicle. This will consist of recording the gallons and 1/10th gallons and mileage each time the vehicle is refueled.

I-G. Tires:

-Tires will be kept in original position as initially mounted at the beginning of testing. Record shall be made of any tire or rim damage including conditions causing damage, type of damage, tire mileage, tire pressure, and other pertinent facts.

I-H. Vehicle Speed:

-A radar gun (correlated with vehicle speedometer) will be used to determine the speed of each vehicle through test segments and other designated segments of the haul route. During the first two weeks of the tests, measurements will be made daily for each vehicle to determine average speeds for each vehicle/driver. This should be repeated each time the tire pressure used on any road segment is changed. During the remainder of the tests, the speed will be spot checked as necessary when the driver or project engineer detects a change in average operating speeds for any segment (such as slow downs for increased road roughness, increased speeds with low pressure and road familiarity, etc.). The measurements must be adequate to establish operating speeds (average) for each vehicle on each road segment and to establish variations in those average speeds. Conditions causing slower or faster speeds should be subjectively determined by both driver and project engineer and recorded with information on speed. Round-trip-times should be measured for each vehicle. The driver should record clock time departing the landing, arriving at the mill, departing the mill, and arriving at the landing for each trip.

II. Road

II-A.Nuclear Moisture/Density Reading:

-One reading per test section.

-Location of readings will be taken on wheel rut and at a set location between cross sections.

II-A. Nuclear Moisture/Density Reading (con't)

-Moisture readings will be recorded at the beginning and end of each phase of testing (verify with an oven dry sample).

-Density readings will be taken on surface and 4-in depth increments to a depth of 12 in at the beginning of the test and at the end of each test phase.

II-B. Washboard Pitch and Depth:

-Once truck drivers or test personnel observes washboard corrugation, crest to crest pitch distance (nearest 10th of a foot) and total depth of washboarding corrugation (nearest 100th of a foot) will be measured from a straight edge or taut string stretched across the crests. Measurements will commence when washboard appears and will be taken at the discretion of the Project Engineer.

II-C. Trip Counts:

-Driver's log will indicate number of trips daily.

II-D. Road Maintenance:

-Accurate records will be kept of amount and type of road maintenance required, if any, as well as cost of these activities. Records will include number of passes incurred at each tire pressure to require maintenance, soil type (surfacing and subgrade), soil moisture, precipitation prior to maintenance.

II-E. Road Materials:

Soil tests will be made for each test segment prior to testing. Tests will include R-value, sieve analysis, Atterburg limits, and proctor (T99) for soils.

II-F. Road Rutting:

-Measurements of road rutting and related strain will be taken by Dan Salm from the Forest Service Graduate Program at Oregon State University.

III. General

III-A. Weather:

-Precipitation will be taken from daily weather observation.

III-B. Video:

-A color record of the test and its effect upon the road will be made with video tapes.

III-B. Video (con't)

-The footage will be selected to show road effects and observable truck effects, such as headlights flickering at dusk or dawn on road corrugation. Successive footage at the same location will be used, when effective, to depict significant road and truck changes.

III-C. Photographs:

-All photographs taken of roads will include photo date and road location test section or milepost.

III-D. Subjective Evaluations:

-At the time tire pressures are changed and at the end of test the drivers and project engineer separately will fill out a questionnaire to subjectively evaluate the effect of tire pressure on:

Truck Handling and Stability	Tire Life
Fuel Economy	Driver Comfort
Road Deterioration and/or Improvement	Washboarding
Use of Jake Brake	Use of Differential Lock Out
Vehicle Speed	Truck Maintenance
Round-Trip-Time	Overall Effectiveness
Performance on Grade (±)	Performance of Curves

MEMORANDUM OF UNDERSTANDING
between
HANSON LOGGING CO. OF HORSHESHOE BEND, IDAHO
and the
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
for
CONDUCTING AN UNSTRUCTURED TEST OF THE CENTRAL TIRE INFLATION TESTING PROGRAM

IDENTIFICATION OF PARTIES

This Memorandum of Understanding is entered into between Dale Hanson Logging Company of Horseshoe Bend, Idaho, hereinafter referred to as the Logging Contractor and the San Dimas Equipment Development Center (SDEDC) and Intermountain Region of the Forest Service, U.S. Department of Agriculture, hereinafter referred to as the Forest Service.

BACKGROUND

Recent developments in tire designs, and central tire inflation (CTI) systems innovated by the military, should allow a driver to vary the inflation pressure of a vehicle's tires while the vehicle is moving down any type of road. This could mean that logging trucks, fire engines, etc. can be operated on Forest roads at necessary low speeds with tire pressures of approximately 45 pounds per square inch (psi).

Tire deflections of 20 to 30 percent of the section height and pressure ranges from 45 to 90 psi have become feasible. Tires can thus be adjusted to alleviate vehicular road damage problems at the tire/road interface, where destructive forces are applied to roads.

To investigate the effects of tire pressure and deflections on road surface depth; road material loss; road maintenance; haul cost; vehicle stability; and driver control, comfort, and physical well being, the SDEDC and Forest Service Region 4 have entered into an unstructured tire inflation testing program on the Moore's Creek Timber Sale on the Boise National Forest.

PURPOSE

The purpose of this agreement is to gain the cooperation of a logging contractor to assist in the testing procedures as outlined in the Central Tire Inflation Test Plan which is attached to and made a part of this memorandum of understanding.

AGREEMENT

1. It is agreed that the Forest Service and the Logging Contractor will use the CTI unstructured test plan for the Moore's Creek Timber Sale as the basic framework for the testing procedures.

2. In completing the testing procedures the Forest Service will:

a. Equip four (4) 18-wheel log trucks of the logging contractor with new 11R24.5 tires immediately prior to the commencement of hauling (on or about September 15, 1986). Each truck will be furnished with two spare tires. All tires are to be mounted by the Forest Service on rims supplied on the truck or by the contractor. This may be accomplished with a purchase order issued by the Forest Service to the logging contractor. All tire repairs during testing will be the responsibility of the Forest Service.

b. In the event damage occurs to a rim of the four logging trucks fitted with test tires, the Forest Service will repair or replace said rim.

c. Take every practical precaution not to interfere with or delay normal logging or haul operations. Measurements and recordings required to be taken by Forest Serice which might interfere with truck traffic will be done at normal truck shutdown time (lunch, end of shift, etc.)

d. Monitor tire pressure and truck speeds and require adjustments as stated in sections I-B and I-H of this test plan.

e. Provide ten (10) deflator valves for the drivers in each of the test trucks.

f. Maintain and operate an airing station at or near the landing.

g. Adjust tire pressures on drive axle tires each time the truck is loaded to maintain test pressures as specified in the test procedures in section I-B of this test plan. The trailer and steering axle will be checked and adjusted daily.

h. Remove test tires at the end of the test and remount tires originally furnished on the trucks by the logging contractor. This may be accomplished with a purchase order issued by the Forest Service to the logging contractor.

i. Take and record all measurements except as specifically stated in the Test Plan requirements.

j. Furnish daily log sheets to each truck driver for recording required information.

k. Maintain confidentiality of any truck maintenance records made available by the logging contractor for testing purposes.

l. Indemnify the logging contractor for damages or injuries resulting to Forest Service personnel riding in trucks for authorized CTI testing purposes.

3. The logging contractor will:

a. Follow procedure as outlined in the scope, objective, and test procedures stated in the test plan.

b. Maintain a daily driver's log for each truck giving all information as required on the log sheet furnished by the Forest Service.

c. Strictly limit driver's speed to 35 mph or less for all portions of haul while using lowered tire pressure.

d. Maintain the positioning of tires as initially mounted at the onset of testing in section I-G.

e. Limit loads to approximately 81,000 lb. GVW.

f. Require each driver to complete the Government-furnished questionnaire, at the end of testing, section III-D.

g. Make trucks available to the Forest Service for periodic condition inspections and tire measurement inspection of log trucks during nonuse times such as lunch, breaks, end of shift, etc., section I-E.

h. Store tires replaced by test tires until the completion of the test and remounting by the Forest Service.

i. Make at least one driver available for a video-taped interview (approximately 2 hours) at the conclusion of testing.

j. Prohibit trucks with test tires from being driven outside the designated haul route (Moore's Creek Timber Sale Area and the road leading directly to the mill in Cascade) except under specific direction by the Forest Service.

k. Allow the ride meter developed by the U. S. Army Corps of Engineers to be placed in the same truck for 1 day each week.

l. In the event that a tire needs or requires repair during the course of testing, remove the tire and give it to the Project Inspector or Project Engineer.

m. Park logging trucks at a trailer park in Cascade, Idaho, for overnight and during periods of nonuse.

4. This agreement may be revised as necessary, by mutual consent of all parties, by the issuance of a written amendment, signed and dated by all parties.

5. Barring any unplanned complications, haul operations will begin approximately September 15, 1986.

6. This agreement may be terminated by either party upon 15 days written notice to the other. The termination of this agreement will automatically terminate all subsidary agreements. Project Engineers will be allowed reasonable time to remove equipment from logging trucks.

7. Stop haul during the period October 1 to 4 for hunting season.

EFFECTIVE DATE

IN WITNESS WHEREOF, the parties hereto have executed this agreement as of the last written date below.

FOREST SERVICE
Department of Agriculture

HANSON LOGGING COMPANY

____
Director
San Dimas Equipment Development Center

____
Date

____
Owner
Hanson Logging Company

____
Date

____
Regional Forester
Intermountain Region

____
Date

Appendix C

Truck Condition Surveys

Owner: Art Hansen Logging Trucks
Truck No.: 3

Make:	Kenworth
Model:	W-900
Year:	1970
S/N:	118442

Hose to the blower appears to be leaking; not severely. Has a leak on the rear cylinder rocker arm cover. Fan shroud on the right side is broke out. Transmission leak on the rear part of the transmission the shaft outlet seal. Leak in the top of the auxiliary transmission and, also, the inlet shaft seal in the auxiliary transmission. Center crossmember below bunk on the truck frame is cracked both sides; also, front and rear plates (picture will be taken).

Brake pads on tractor appear to be between 40 and 60 percent. Trailer brakes front axle between 50 and 70 percent on the driver's side front axle and 70 percent on the right side front axle. Brakes on rear axle of trailer about 50 percent on right and 70 percent on left. Has a weld crack on the rear section of the bunk left side—the bolt tiedown area holding the rear section of the bunk down (picture taken). Has a ½-inch crack on the support bar to the walking beam on the rear trailer right side (picture will be taken). Several cracks to the underside of the trailer, one to the suspension (picture will be taken). Crack on cab lower section just below and in front of the driver's side door.

Owner: Art Hansen Logging Trucks
Truck No.: 16

Make: Kenworth
Model: W-900
Year: 1976
S/N: 10453857

Steering appears to be fairly tight. Driver's side front brake canister has release problems. Left front axle spring–one U bolt missing off of the spring clamps on the left. Slight oil leak on the top of the injector pump compressor unit. Oil leak on top and top front of transmission where shift rods go in. Leak on the back plate gasket. Oil leak, little more than slight; appears to have a exhaust leak condition (picture taken). (Also, picture taken of bottom side of transmission. Picture taken of left front spring, axle spring and steering arm connection.)

Left side tractor–back side of walking beam rubber mount plate is broken (picture taken). Cross beam on frame below front bunk on tractor right side (on the lower part) is cracked all the way around (pictures taken). Rear axle on tractor, brakes on right side appear to be about 30 percent left, and left side approximately 30 percent also. Front dual axle brakes about 70 percent good, both sides. Front axle brakes of the trailer appear between 70 and 90 percent. Rear brake on rear axle of trailer about 40 percent on right and 80 percent on left. Left side of trailer bunk approximate 2 inch crack on support rail on rear bunk on left side right beside spring. Engine looks fairly good. Hood of truck has left front fender damage to the fiberglass (picture taken).

Owner: Art Hansen Logging Trucks
Truck No.: 17

Make: Kenworth
Model: W-900
Year: 1969
S/N: 114238

Both front windshields cracked from rocks; hood and fenders are okay. Crack on the lower driver's side of grill (no picture needs to be taken). Steering drag link is worn approximately half through, and shows the hollow pipe, could bend quite easily. Oil leaks around engine are minimal; looks pretty good. Main transmission looks good—no leaks. Auxiliary transmission has a pretty good leak on the input shaft seal in front of the transmission. Front differential looks good; rear differential has a slight seep in the front input shaft seal.

Center crossmeber has crack on the lower plate on the front section one crack on the bolt on the back side of driver's side. Two cracks are both on the driver's side. We have one repaired crack on the right hand side of the back part of the crossmember—side of the crossmember on the plate. Support platform on the rear part of the walking beam on the driver's side is cracked, and one section of it broke away. That's the rear support on the walking just below the rubber pad. Slight crack on the driver's side front crossmember of the tractor frame; this is on the lower left hand side—it's a well crack.

Front axle brakes less than 30 percent—approximately 20 percent on the right side front axle. Brakes on the left side front are approximately 50 percent; brakes on right rear axle approximately 50 to 70 percent; left rear 40 to 50 percent. Right side rear section walking beam rubber pad is disintegrating. Crack on the upper part of the rear of the walking beam plate mounted to the frame is cracked (picture taken). Brakes on front axle of trailer driver's side 60 percent, right side 50 to 60 percent. Rear axle of trailer brakes 50 to 60 percent, both sides. There is a crack on the clamp of the walking beacm axle, left side of the trailer.

Owner: Art Hansen Logging Trucks
Truck No.: 19

Make:	Kenworth
Model:	W-900
Year:	1974
S/N:	1313449GL

Truck has crack on right fender approximately 2½ to 3 feet; also has crack on left fender approximately 8 inches (pictures taken). Engine has oil leak on the front head section—appears to be seeping. Also a leak in front of the engine, possibly from seep. Crack on the bottom of the crossmember holding the right side of the auxiliary transmission up; this is on the bottom right side. Also, an output shaft housing seal leaking on the auxiliary transmission. Pinion seal on front differential leaking; appears it's throwing oil all the way to the back differential or it's possibly leaking also.

Center crossmember under the bunk has crack on the left hand side on the bottom plate, both front and back; also, has crack on the right hand side near the bolt on the back side. Brakes on front axle of tractor unit right side approximately 30 to 40 percent, left side the same. Rear axle brakes 40 to 50 percent. Brakes on trailer front axle 45 to 50 percent both sides. Rear axle of trailer brakes 50 to 70 percent.

Appendix D
Truck Incidents Summary

The following notes summarize the incidents to tires, on the four 18-wheel logging trucks, that occurred in the course of the field operational tests (September 15 to November 6, 1986) during the Moores Creek Timber Sale on the Boise National Forest.

Truck #1 (Note: This driver had only 4 months experience driving logging trucks)

Front trailer axle, right outside tire (10/06/86): Driver drove off the road into the cut bank, impacting the sidewall with enough force to unseat the bead. The tire suffered no apparent damage and was aired up off the truck and put on as a spare. Tire location at test conclusion: front trailer axle, left side of vehicle, outside dual. LOWERED PRESSURE. Mileage at incident: 400 mi. Additional miles to final dismount at test conclusion: 1,600 mi.

Rear driving axle, left outside tirm (11/03/86): Driver came out of the landing, skipped a gear, lost control, and slid into the ditch. The rim was badly bent; consequently, bead unseating resulted. A spare replaced the tire until the rim was repaired and the tire remounted in its original position on the truck. LOWERED PRESSURE. Mileage at incident: 1,900 mi. Additional mileage to test conclusion: 200 mi.

Second axle, right outside tire (10/06/86): Driver ran over a log and into the ditch on his way up to the landing. The rim was bent; this resulted in the bead unseating. A spare replaced the original tire. The damaged rim was repaired and the tire aired up and put on the truck as a spare. LOWERED PRESSURE. Mileage at incident: 400 mi. Additional mileage: 0 mi. (Mounted as spare and not run.)

Truck #2

Front trailer axle, right outside tire (09/17/86): This truck (loaded) and truck #1 (unloaded) met on a blind curve. The driver of this truck was on the inside of the curve and swerved into the cut bank to avoid a collision. Looking at the vertical scrape marks on a rock projecting from the cut bank, it appeared that the tire rim was caught on the rock; consequently, there was bead unseating. A spare was mounted. The tire was aired up and put back on the truck as a spare. The tire was remounted on 10/21/86 as the second driving axle, left side of vehicle, inside dual; it remained there until test conclusion. LOWERED PRESSURE. Mileage at incident: 200 mi. Additional mileage: 1,300 mi.

Front driving axle, right inside tire (11/11/86): The driver was running at high pressure with chains. The tire went flat but there was no evidence of punctures, although there was minimal evidence of cuts. Reason for flat is unknown--may possibly have been due to a slow leak in the valve core. Aired up on truck (not dismounted). HIGH PRESSURE. Mileage at incident: 2,400 mi. Additional miles: 100 mi.

Rear trailer axle, right outside tire (11/12/86): The driver was running with high tire pressure and chains. A rock was caught between the rear trailer duals, causing massive sidewall damage and a blowout. The rock was picked up on the haul road over a section normally hauled. No rocks were picked up and caught between the duals when using low tire pressure on this haul. Tire was not remounted. HIGH PRESSURE. Mileage at incident: 2,400 mi. Additional mileage: 0 mi.

Truck #3

Front driving axle, left outside tire (09/18/86): Type of damage best described as bead unseating due to intense impact to the sidewall area. Road conditions were extremely wet and slippery. The driver claimed that when he went to take the curve of section 0.75 (known to get very greasy and soft when wet) with a full load of logs, his truck slipped and pulled toward the outside of the curve. He was able to pull himself back in toward the cut bank and, after coming to a standstill on the straight away, the truck seemed to lay over onto its left side into the cut bank. Neither the cab nor the frame were damaged or even touched the ground. The truck was supported at a 45-degree angle by both the load and the steering axle. According to the driver and those who observed the spill, the truck impact and damage may have been more extensive had the tires been at full pressure. In this case, a major advantage offered by lowered pressures was the extra ground contact of the tires which may have helped to cushion the fall. The tire was aired up on the truck. LOWERED PRESSURE. Mileage at incident: 264 mi. Additional mileage to test conclusion: 1,144 mi.

Front driving axle, right inside tire (10/06/86): This was the first day that the truck had hauled since the spill of 9/18/86 described above. The driver noticed a flat tire on his first trip of the day. A spare replaced the tire. The reason for the flat is unknown. LOWERED PRESSURE. Tire remounted same day after airing up off of truck. Mileage at incident: 418 mi. Additional mileage: 990 mi.

Truck #4

Rear trailer axle, left inside tire (09/15/86): This was the first truck on the first day of haul. This truck left the landing with a load without being aired up to the low pressures designated for the loaded condition. The driver was stopped approximately 0.5 mile from the landing to be aired up. Before reairing, the truck pulled out of the ditch, and the sidewalls of the tires on the left side of the trailer impacted the ditchline. Bead unseating occurred for the rear left inside dual. The tire was aired up off of the truck the same day. LOWERED PRESSURE. Mileage at incident: 12 mi. Additional mileage: 1,396 mi.

Same tire as above (10/06/86): The driver found this tire flat at the trailer park in the morning but was able to air the tire up on the truck before heading out to haul. The driver had left his deflator valves on his tires overnight, causing a slow leak of air in the tire. Aired up on truck same day. LOWERED PRESSURE. Mileage at incident: 352 mi. Additional mileage: 756 mi.

Front trailer axle, right outside tire (09/15/86): The rim of this tire was bent, but no bead unseating or other damage to the tire was reported. The damage occurred during the incident described above when the tires impacted the ditchline. LOWERED PRESSURE. Mileage at incident: 12 mi. Additional mileage: 1,396 mi.

Appendix E

Tire Inspections Summary

(by Bandag, Inc., Muscatine, IA and indication of tires which were retreadable)

Truck No. 1: Front trailer axle, right outside tire (4R0B1)

Fleet/Owner Forest Service **Date:** 2/10/87

Tire/Casing Information:

Brand: Michelin **Series:** XZY **Size:** 11R24.5

Serial No.: P0031145A **DOT:** HN4F1CCX256 **Load range:** G

Fleet or Customer No.: 4R0B1 **Tire Mfg. Country/Origin:** Canada

Tread Depth Remaining: Shoulder 18 **Center** 18 **Shoulder** 18

Condition of Casing/Components:

Condition of Beads: OK **Malwear and Type:** None

Shoulder/Sidewall Condition: Serial number side requires four spot repairs

Tread Surface Condition: Very good

Cuts: Minimal **Punctures:** None **Repairs Required:** None

NDI(R) Grade: Accept **Retreadable— Yes** X **No** ______

Additional Comments: Tires retreaded with No. 8 Lug Logger.

Truck No. 1: Rear driving axle, left outside tire (3L0B1)

Fleet/Owner Forest Service Date: 2/10/87

Tire/Casing Information:

Brand: Michelin Series: XZY Size: 11R24.5

Serial No.: P0031221A DOT: HN4F1CCX256 Load range: G

Fleet or Customer No.: 3L0B1 Tire Mfg. Country/Origin: Canada

Tread Depth Remaining: Shoulder 17 Center 17 Shoulder 17

Condition of Casing/Components:

Condition of Beads: OK Malwear and Type: Rounding of tread elements

Shoulder/Sidewall Condition: OK

Tread Surface Condition: Rounding of elements and indication of spinning; also marks of chains.

Cuts: Minimal Punctures: None Repairs Required: None

NDI(m) Grade: Accept Retreadable— Yes X No

Additional Comments: Tire had experienced loss of air due to bead losing seal to rim;* no evident damage occurred. Tire has been retreated with No. 8 lug logger.

**Note: Rim had been bent.*

Truck No. 1: Front driving axle, right outside tire (2R0B1)

Fleet/Owner Forest Service Date: 2/10/87

Tire/Casing Information:

Brand: Michelin Series: XZY Size: 11R24.5

Serial No.: P0030032A DOT: HN4F1CCX236 Load range: G

Fleet or Customer No.: 2R0B1 Tire Mfg. Country/Origin: Canada

Tread Depth Remaining: Shoulder ? Center ? Shoulder ?

Condition of Casing/Components:

Condition of Beads: Good–OK Malwear and Type: ______

Shoulder/Sidewall Condition: OK

Tread Surface Condition: ______

Cuts: ______ Punctures: None Repairs Required: None

NDI(R) Grade: Accept Retreadable– Yes X No ______

Additional Comments: The tire has experienced air loss due to seal lost at bead*–no indication of any resulting damage. This tire was buffed prior to arrival of Forest Service personnel. No notes taken concerning tread wear/condition. Tire was retreated with No. 8 Lug Logger.

**Note: Rim had been bent.*

Truck No. 2: Front trailer axle, right outside tire (4R0B2)

Fleet/Owner Forest Service Date: 2/10/87

Tire/Casing Information:

Brand: Michelin Series: XZY Size: 11R24.5

Serial No.: P0030030A DOT: HN3F1CCX236 Load range: G

Fleet or Customer No.: 4R0B2 Tire Mfg. Country/Origin: Canada

Tread Depth Remaining: Shoulder 18 Center 18 Shoulder 18

Condition of Casing/Components:

Condition of Beads: OK Malwear and Type: ______

Shoulder/Sidewall Condition: Very minor scuff serial no. side and scruff on DOT side requiring spot repair.

Tread Surface Condition: Excellent

Cuts: Minimal Punctures: None Repairs Required: None

NDI(R) Grade: Accept Retreadable– Yes X No ______

Additional Comments: Absence of any detectable scruff/rounding of tread elements. One bead has lost seal to rim during operation; beads not damaged. Tire has been retreaded with No. 8 Lug Logger.

Truck No. 2: Front driving axle, right inside tire (2RIB2)

Fleet/Owner Forest Service Date: 2/10/87

Tire/Casing Information:

Brand: Michelin Series: XZY Size: 11R24.5

Serial No.: P0030572A DOT: HN4F1CCX246 Load range: G

Fleet or Customer No.: 2RIB2 Tire Mfg. Country/Origin: Canada

Tread Depth Remaining: Shoulder 17 Center 17 Shoulder 17

Condition of Casing/Components:

Condition of Beads: Good–OK Malwear and Type: None

Shoulder/Sidewall Condition: OK

Tread Surface Condition: Evidence of chains used. Light evidence of wheel spin.

Cuts: Minimal Punctures: None Repairs Required: None

NDI® Grade: Accept Retreadable– Yes X No ____

Additional Comments: Tire was retreaded with No. 8 Lug Logger.

Truck No. 2: Rear trailer axle, right outside tire (5R0B2)

Fleet/Owner Forest Service Date: 2/10/87

Tire/Casing Information:

Brand: Michelin Series: XZY Size: 11R24.5

Serial No.: P0030585 DOT: HN4F1CCX246 Load range: G

Fleet or Customer No.: 5R0B2 Tire Mfg. Country/Origin: Canada

Tread Depth Remaining: Shoulder 17 Center 17-18 Shoulder 17

Condition of Casing/Components:

Condition of Beads: OK Malwear and Type: Moderate leading edge wear in shoulders; slight amount in central ribs.

Shoulder/Sidewall Condition: Large hole in sidewall due to stone between duals.

Tread Surface Condition: Good

Cuts: Minimal Punctures: Sidewall Repairs Required: None—too large

NDI(R) Grade: ______ Retreadable— Yes ____ No X

Additional Comments: Massive sidewall injury—reject for retread.

Truck No. 3: Front driving axle, left outside tire (2L0B3)

Fleet/Owner: Forest Service   Date: 2/10/87

Tire/Casing Information:

Brand: Michelin   Series: XZY   Size: 11R24.5

Serial No.: P0030067A   DOT: HN4F1CCX236   Load range: G

Fleet or Customer No.: 2L0B3   Tire Mfg. Country/Origin: Canada

Tread Depth Remaining: Shoulder ?   Center ?   Shoulder ?

Condition of Casing/Components:

Condition of Beads: OK   Malwear and Type: ____

Shoulder/Sidewall Condition: Good

Tread Surface Condition: –

Cuts: –   Punctures: None   Repairs Required: –

NDI® Grade: Accept   Retreadable— Yes X No ____

Additional Comments: During buffing, a cable was snagged in No. 3 belt; cable was removed and fitted. The tire was buffed prior to arrival of Forest Service personnel. No notes taken concerning tread wear and condition. Tire retreaded with No. 8 Lug Logger.

Truck No. 3: Front driving axle, right inside tire (2RIB3)

Fleet/Owner Forest Service Date: 2/10/87

Tire/Casing Information:

Brand: Michelin Series: XZY Size: 11R24.5

Serial No.: P00043557A DOT: HN4F1CCX156 Load range: G

Fleet or Customer No.: 2RIB3 Tire Mfg. Country/Origin: Canada

Tread Depth Remaining: Shoulder 18 Center 18 Shoulder 18

Condition of Casing/Components:

Condition of Beads: OK Malwear and Type: Less shoulder lug rounding serial no. side. Shoulder lugs DOT side slightly rounding.

Shoulder/Sidewall Condition: OK

Tread Surface Condition: Chain marks visible in three spots around tread, otherwise good.

Cuts: Minimal Punctures: None Repairs Required: None

NDI(tm) Grade: Accept Retreadable— Yes X No

Additional Comments: Very light evidence of tire spin. Tire has been retreaded with No. 8 Lug Logger.

Truck No. 4: Rear trailer axle, left inside tire (5LIB4)

Fleet/Owner Forest Service Date: 1/ 2/10/87

Tire/Casing Information:

Brand: Michelin Series: XZY Size: 11R24.5

Serial No.: P00044790A DOT: HN4F1CCX166 Load range: G

Fleet or Customer No.: 5LIB4 Tire Mfg. Country/Origin: Canada

Tread Depth Remaining: Shoulder 18 Center 18 Shoulder 18

Condition of Casing/Components:

Condition of Beads: OK Malwear and Type: Rounding tread elements; also evidence of running in ruts on shoulder lugs.

Shoulder/Sidewall Condition:

Tread Surface Condition: Good

Cuts: Minimal Punctures: 2 nails, not thru Repairs Required: 2 nail hole repairs

NDI® Grade: Accept Retreadable— Yes X No

Additional Comments: Tire retreaded with No. 8 Lug Logger.