CENTRAL TIRE INFLATION
LOGGING INDUSTRIES' EXPERIENCES

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BACKGROUND

Central Tire Inflation (CTI) Systems have been in use for 50 years primarily for military applications. Only within the last ten years has there been an interest in applying this technology to the commercial hauling industry and primarily log hauling. During the last few years most of the studies have been conducted by the U.S. Forest Service, the Forest Engineering Research Institute of Canada (FERIC), Weyerhaueser and the University of New Brunswick in Canada. This presentation is an overview of the results of these studies as well as actual experiences by log haulers using this equipment.

CTI is now standard issue on many U.S. Army vehicles. Military CTI systems are made by Rockwell and Eaton, and number in excess of 25,000 units. The U.S. Army estimates that they are able to access 10% more of North America's land area because of CTI systems. CTI systems (commercial and military) exist elsewhere in the world, but have only recently reached the commercial market in North America. Apart from the obvious mobility benefits, in the last 10 years some have begun to recognize many other benefits such as: reduced road maintenance and construction costs, improved traction; a smoother ride; and savings on truck and tire wear.

Realizing the potential of CTI systems to reduce costs associated with low volume forest roads, the U.S. Forest Service began to seek ways to use these systems on heavy forestry trucks. In 1984 the U.S. Forest Service's San Dimas Equipment Development Centre (SDEDC) investigated the effect of lowering a log truck's tire pressures on road surface damage and healing. The trial results indicated that low tire pressures provided a smoother ride, increased traction, eliminated washboard, and healed surface ruts like a rubber tired compactor (Della-Moretta 1984). A structured test at the Nevada Automotive Test Centre found that lowering tire pressures reduced traffic related road maintenance by up to 80% and healed existing ruts on unpaved roads. This test also found that truck

component damage was reduced by as much as 85% on a rough road course when using lowered tire pressures.

ALBERTA-PACIFIC'S CTI PROGRAM

Alberta-Pacific Forest Industries built a new pulpmill in northeastern Alberta, Canada, which produces 1,500 air dried metric tonnes of deciduous pulp daily. The government awarded Alberta-Pacific a Forest Management Agreement to harvest 2.5 million cubic metres annually. The area where harvesting was to be carried out had some roading and access problems that needed to be addressed. Traditionally the roads in this area were constructed and usually used only when the ground was frozen. Also, there is very little gravel in northern Alberta, therefore, material to upgrade roads to a summer hauling standard was at a premium.

CTI appeared to offer a solution to reducing the cost of road construction and extending the haul season. For this reason Alberta-Pacific has required that all log trucks contracted to Alberta-Pacific must have CTI installed on all axles. Although this practice highlighted some minor equipment problems that have, for the most part, been corrected, the benefits have met our expectations and confirmed our commitment to proceed with this program.

CENTRAL TIRE INFLATION SYSTEM PRINCIPLES

A pneumatic tire is specifically engineered to support load while rotating. Tire inflation pressures are generally specified to permit a vehicle to carry a full payload at highway speeds without overheating its tires. When the vehicle is partially loaded, unloaded, or traveling at reduced speeds, however, its tires are over inflated for their operating conditions. Over inflated tires cause a host of problems, including excessive vehicle vibration, increase tire wear and punctures, rock penetration and road surface damage. A Central Tire Inflation System permits a vehicle operator to optimize his tires' performance by varying their inflation pressures in response to changing operating conditions. Note that bias ply tires are generally not compatible with CTI Systems because when they are deflated, their sidewalls deflect excessively and their tread faces deform.

Figure 1 shows drive tire inflation pressure over a normal haul cycle for a log truck with CTI system. It starts with the truck leaving the pavement and starting on the forest road, then it inflates while being loaded, inflates to full pressure just before reaching the highway. Only about a quarter of the time do its tires require the full 90 psi. With that in mind, a normal log truck's tires are running in an over inflated condition for much of its haul cycle. Being over inflated means the tires wear out faster, provide less traction, and transmit more shocks between the road and the truck. However, before CTI there was no easy way to adjust pressures as operating conditions changed.

Figure 2 shows a comparison of tire footprint area at different pressures. When a radial tire's inflation pressure is reduced, its footprint gets longer but not wider. At the same time the tire's sidewalls deflect. These two changes lie behind most of the benefits offered by CTI. The longer footprint means more tread-to-ground contact area. Traction increases, wheel slip decreases, and rock damage to the tires decreases. Also, the combination of the softer sidewalls and the bigger footprint reduce the shock loading between the road and the truck. This means less damage to the road, the truck and to the driver.

CENTRAL TIRE INFLATION SYSTEM DESCRIPTION

A CTI System permits the vehicle operator to vary the tire inflation pressure from the cab, while the vehicle is moving. Normally the pressures are preset by the tire manufacturer and correspond to the vehicle's speed and tire loading. For example, a log truck typically has pressure settings corresponding to loaded travel on a bush road, loaded on the highway, empty in the bush and empty on the highway. The CTI Controller would have four settings and the driver would merely alternate between them. Table I indicates the typical tire pressure settings (psi) for vehicle speed and loaded or unloaded conditions.

Table I
Pressure Settings

PSI	Road Type	Loaded/ Empty	Max. Speed (km/h)
90	Hwy	Loaded	10
60/45	Bush	Loaded	60/30
60	Hwy	Empty	110
30	Bush	Empty	60

CTI systems generally consist of five component assemblies: a control device, which instigates tire pressure changes and warns the operator about system problems; air priority valves, which protect air brake system integrity; control air valves; air lines to and from the control valves; and axle end hardware to transmit air into and out of the rotating tires.

A schematic of the Eltek CTI System used by FERIC in its first CTI project is shown in Figure 3. This CTI system operates in a relatively simple manner. When an upcoming change in either truck loading or speed is anticipated, the vehicle operator selects an appropriate operating mode on the control device. In response to this selection, the control device signals either the inflate or the deflate control valve to open. Air from the wet tank is drawn into the CTI system when a tire inflation is initiated, while air from the tires is exhausted by the deflate valve when a tire deflation is initiated. Priority safety switches ensure that air is available for tire inflations only when wet tank pressure is above a safe level, eg., 6.2 bar (90 psi). Tire pressure is continuously monitored, with the inflate or deflate stopping when the selected mode's target pressure is reached.

Vehicle speed is also continuously monitored and, in the event of an over speed condition - which could lead to tire damage - the control device warns the operator to slow down or select a mode with a higher speed. The control device is also capable of being programmed to automatically select a mode with a higher speed, should an over speed condition persist.

There are two design concepts with respect to CTI systems. One system, which the Eltek system is an example, has air lines connected to the tires with the required air pressure in the lines at all times and basically becomes part of the tire inflation system. The second system, which the Eaton CTI system is a good example, provides air to the tires through the lines only on demand. Therefore, once the tire has reached the desired air pressure, the valve at the tire would close and the air line is isolated from the tire.
Both of these types of systems are installed on the trucks hauling for Alberta-Pacific and to date, both systems have operated with relatively the same performance and reliability.

The critical points that the log truck owners and CTI installers have experienced during the first year of operation at Alberta-Pacific have been:

Compressor Output: A rule of thumb for inflation times is that the tires should not be run under inflated for more than 10 minutes. For vehicles with 10 tires or less, a 15 or 16 CFM compressor is considered adequate. The CTI system controlling more than 10 tires, this generally necessitates increasing compressor capacity. For vehicles hauling for Alberta-Pacific with our load weights and speeds, this meant installing a 32 CFM compressor.

Proper dryer size and maintenance is very important to ensure the continued removal of harmful water and oil. The trucks hauling for Alberta-Pacific operate for a significant period in below freezing temperatures and the operators soon learned the importance of a moisture free air system.

The steering-axle air connector requires some protection if the vehicle is operated in harsh or frozen rut conditions. The action of the tire turning right or left and allowing the air line to come in contact with the hard abrasive edge to the rut may cause the line to break and thus deflate the tire. If you operate in these conditions, then a protective cover would be advisable.

BENEFITS TO THE COMPANY OR ROAD OWNER

There are five areas where the Company benefits as a result of using vehicles with CTI equipment. These are:

- reduced road construction costs
- savings in road maintenance
- reduced cycle time
- reduced environmental impact
- extended hauling season

REDUCED ROAD CONSTRUCTION COSTS

A model was developed by the U.S. Army Corps of Engineers, Waterways Experimental Station, Mississippi, to predict the influence of tire pressure on required road thickness. The model predicted that by lowering tire pressure from 90 psi (620 kpa) to 60 psi (414 kpa), almost 25% can be saved in graveling requirements. A further reduction of pressure to 30 psi (210 kpa) could result in savings of almost 50% of graveling costs.

Weyerhaueser constructed a road 1,100 metres long, with eight sections - each surfaced with either 9", 13.5" or 18" (the usual thickness) of gravel in an area near Vail, Washington. Only CTI trucks were used on this road. Table II summarizes the economic benefits in U.S. $ of using CTI versus expected costs from hauling using high tire pressure. Weyerhaueser concluded that although the 50% sections (i.e., 9") held up, they would feel quite comfortable in using 25% less gravel in all CTI applications.

Table II
Weyerhaeuser's Test
First Location, Estimated Benefits for Block Entry Road [a,b] (Keller, 1992)

Cost Item	High Pres. Tires	Low Pres. Tires	Savings
Surface Gravel	$10,640.	$7,800.	$22,940.
Patch Gravel	800.	200.	600.
Grading	600.	300.	300.
Assist Vehicle	19,800.	600.	19,200.
	$31,840.	$8,900.	$42,040.

[a] Assuming block entry road constructed with 34 cm of gravel per 100 m station

[b] Estimated in U.S. $

FERIC are presently analyzing data collected from trials in Whitecourt, Alberta, using a Super-B configuration chip van equipped with CTI. The results should be published by this fall, however, all indications appear to confirm the results reported in the Weyerhaueser study.

Robert Douglas, Associate Professor at the University of New Brunswick, is working on a project to determine the road engineering specifications for roads built for use only by CTI equipped vehicles. This research will be carried out at the Transport Research Laboratory in Crowthorne, Berkshire, England, during 1994. It is hoped that his results will be available by mid-1995.

SAVINGS IN ROAD MAINTENANCE

In another trial near Raymond, Washington, Weyerhaueser compared the actual costs of high and low pressure hauling operations. Test results confirmed that CTI lessened road damage, reduced road maintenance, and helped heal ruts on the access road left by the high pressure trucks. The added traction afforded by reducing tire pressures also eliminated the need for an assist vehicle. This trial concluded that road maintenance could be reduced by 80 percent plus with CTI. Another example of eliminating assist vehicles is reported at Weldwood

Canada, in Hinton, Alberta. An off road heavy haul truck grossing 84,000 kg., on a conventional tractor trailer, has migrated from using an assist vehicle at most landing sites to using no assist vehicles since equipped with CTI.

Alberta-Pacific has documented similar reductions particularly with bush access roads. A section of road with loose sand prevented logging trucks with high tire pressure from hauling while the trucks with CTI hauled without the need of any assist vehicles.

REDUCED CYCLE TIME

Vehicles operating with CTI reduce ruts and eliminate wash boarding. This fact, plus the effect of greater shock absorption with tire are deflated to a lower pressure allows trucks to drive faster than they would with poor roads. Reduced cycle times have been identified as a significant benefit.

FERIC conducted a test on a logging truck equipped with CTI in Lumby, British Columbia. The owner of that truck reported a 20 minute reduction in cycle time for a 4.5 hour haul. The main reason for the reduction was the reduced time to return to the bush when empty.

LOWER ENVIRONMENTAL IMPACT ON FOREST ROADS

CTI provides vehicles with significantly more traction and mobility, therefore, the trucks can haul on block access roads that require less cut work, therefore, reduced disturbance. As well, lower tire pressure results in less raveling of surface gravel onto road shoulders and into ditches. The compaction effect of lower tire pressure reduced the problem of shoulders breaking when roads are newly built or "green".

EXTENDED HAULING SEASON

Lower tire pressures result in the ability to travel over poorer quality roads, thereby extending the number of operations days that log hauling can occur. Alberta Newsprint Corp. in Whitecourt, Alberta, and Alberta-Pacific Forest Industries in Athabasca are two companies that have extended their hauling approximately 25 percent as a result of using CTI equipped vehicles.

BENEFITS TO THE OWNER/ OPERATOR

In addition to the advantages mentioned above, the truck owner also benefits from reduced truck maintenance and improved tire life.

Operating log trucks with softer, low tire pressures when off-highway, reduces the amount of shock and vibration felt by tractor and trailer frames and components. Studies suggest that the rear drive axle is responsible for much of the vibration (i.e., "beaming") of the tractor frame which in turn influences cab and engine component life, and driver backslap. During the course of the FERIC trial at Lumby, British Columbia, the CTI truck

had 30% fewer repairs than the control fleet. The average monthly repair time for vibration related damaged (eg., loosened bolts and nuts, broken scale pads and lights, damaged cab components, frame cracks) was 19% less. The most significant improvement was in the reduction in severity and number of frame cracks. Overall, it is estimated that the truck owner saved $2,700. Canadian per year in truck and drive tire maintenance. The drivers also indicated during this test that back problems were virtually eliminated.

FERIC is monitoring the performance of a CTI equipped truck to determine the impact of tire life when CTI is used to improve ride and traction. For the CTI equipped truck, eight original drive tires achieved 90% less wear than the drive tires on the five truck control fleet operated by the same contractor. Two of the original tires were dissected for structural analysis by Toyo Tire and no defects were found. The remaining six tires were recapped. The first recaps achieved a 25% decrease in wear and the second set of recaps were fitted with a different off-road tread and they achieved 40% longer tire life. This test is ongoing and currently on their sixth set of recaps. In all instances the casings were 100% acceptable.

CONCLUSION

Central Tire Inflation has performed well for the log haul companies that have implemented or tested this equipment. The benefits are:

- reduced road construction
- less road maintenance
- reduced truck maintenance
- improved tire life
- reduced driver fatigue
- improved access

Tests are still ongoing, however, the list of proven benefits to date indicate that Central Tire Inflation will gain in acceptance, particularly as road infrastructure and truck repair costs increase.

Figure 1. Log Truck Duty Cycle

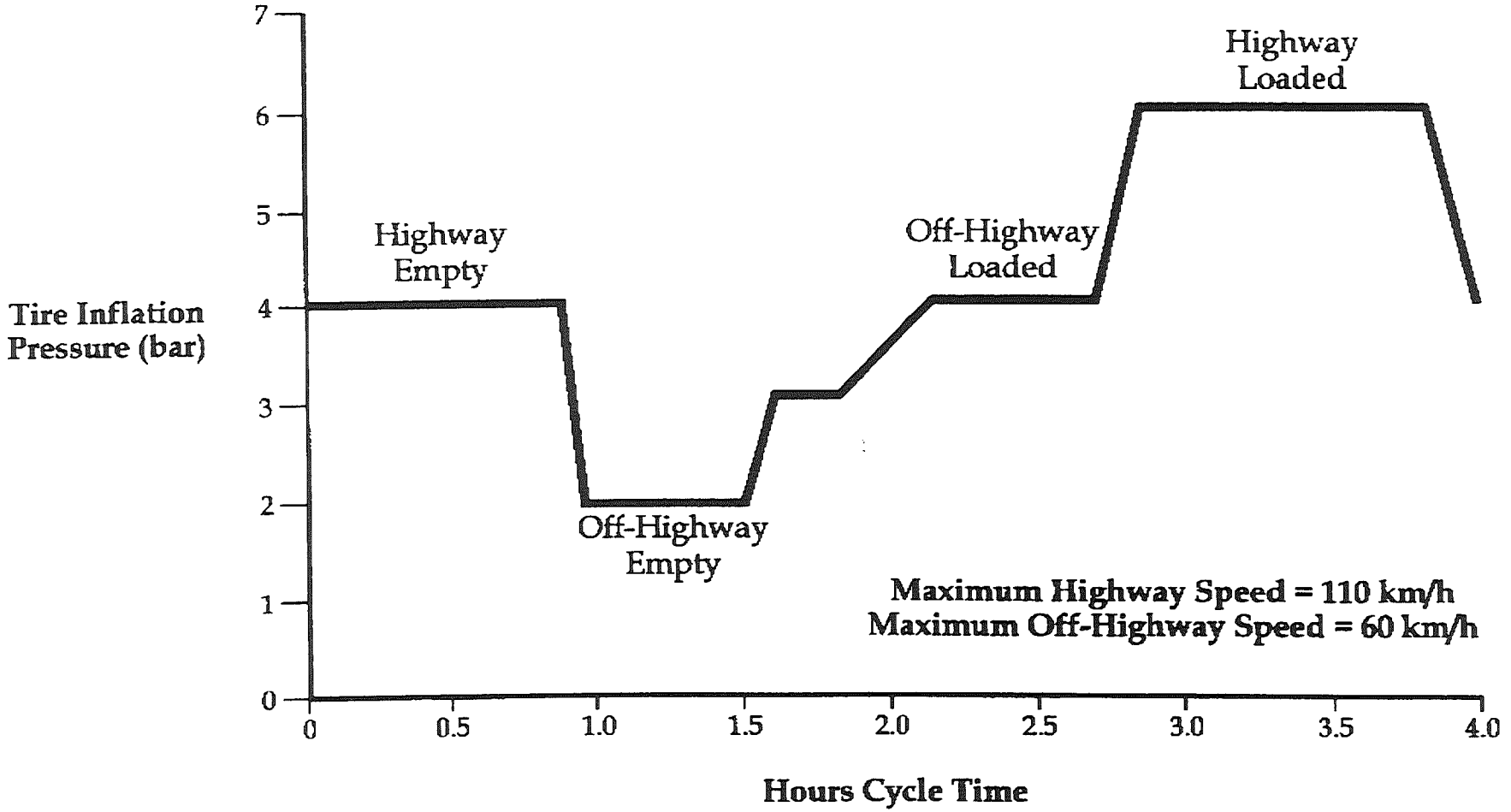
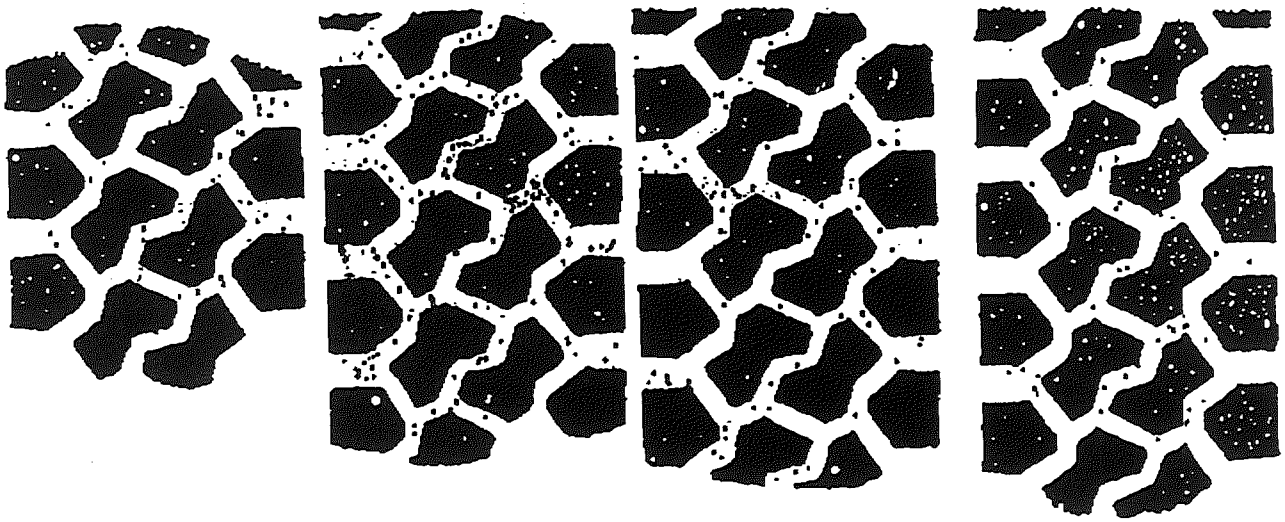


Figure 2. Footprint Comparison for Various Pressures with a Tire Load of 2410 kg



Pressure	6.2 bar	4.1 bar	3.1 bar	2.1 bar
Print Length	25.8 cm	32.0 cm	33.8 cm	36.3 cm
% Deflection	8.5	15	23	30

Based on Information from Toyo Tire Canada

Figure 3. Eltek CTI System for Drive Tires