

# RESULTS

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## Five million km covered in CTI project

Mechanical reliability, low repair costs, improved driver environment, reduced tyre wear, lower fuel consumption — these are just some of the findings from a three-year CTI-evaluation project for Swedish conditions. Twelve roundwood haulage rigs were equipped with a central tyre inflation system (CTI). The rigs together covered more than five million kilometres during the project period.

It cost between US\$25,000 and 30,000 to install a CTI system. Average repair costs were 2 cents per km, and the level of technical utilization for the system was 95.5%.

The increase in fuel consumption due to CTI, measured in litres/km, was only marginal, but because the vehicles could carry heavier payloads on roads having a low bearing capacity, fuel consumption per cubic metre of timber transported was actually reduced.

Driver comfort was improved thanks to the reduced vibration experienced with CTI. This was because the integral damping in the tyres was effective even when the vehicle was unladen. On a round trip, vibration was some 8% lower than normal.

Road studies found that lower tyre pressures meant lower ground pressure,

and thus lower stress in the road structure — down to a depth of approximately 200 mm. At a greater depth, the reduction in stress was either marginal or nonexistent.

Accumulated knowledge from studies in North America and Sweden indicate that CTI technology helps to increase mobility on both public and private-road networks, facilitates access to timber during the spring thaw, and reduces haulage costs on roads with reduced passability.

The project findings clearly demonstrate that it is feasible to introduce CTI on a wide scale in Sweden.



**Implementation ready**  
Read more on back page  
Paul Granlund

"The technology works well — so get going!" says Paul Granlund.



**Picture above:** One of the twelve haulage rigs used in the three-year trials. This one clocked up some 420,000 km with CTI installed.

## Broad collaboration

### Background

Central Tyre Inflation (CTI) is a system that enables tyre pressures to be varied whilst the vehicle is under way. Reducing the tyre pressures results in a greater contact area between the tyre and the road — thus reducing the ground pressure.

CTI increases the mobility of vehicles on soft ground, such as on forest roads during the spring thaw, and also makes it possible to increase the payload on roads with reduced passability.

The technology is already being used on an operational scale, particularly

in North America, where some 2,500 haulage rigs are equipped with CTI.

### The project

Skogforsk has collaborated on a three-year, CTI-implementation project with a number of industrial forest enterprises, haulage companies, commercial vehicle manufacturers, the Swedish Road Administration, and others. About 50 people have been involved in the study, some as drivers and others in reference groups and working parties. Some of the larger forest enterprises and forestry cooperatives acted as hosts

for the project. The aim of the project was to obtain information to determine the feasibility of using CTI on a wide scale in Sweden. To this end, twelve haulage rigs, operating in various parts of the country, were equipped with CTI for the trials.

There are five suppliers of CTI systems in the world. The system used in this project was Tireboss, from the TPC company, which is well established in the USA and Canada.



## Experience over five million kilometres

During the three-year project period, the twelve haulage rigs clocked up an aggregate of five million km (3.1 million miles). The following is a summary of some of the knowledge we acquired during the trials:

### Technical utilization

The level of technical utilization for the CTI system was 95.5%. The two best results were actually 100% utilization, and the two worst, 80% utilization.

In severe cold weather, some of the vehicles experienced problems with freezing in the valve assembly.

The swivels had proved problematic in previous tests, with a useful life of only 20,000 km in the mid-1990s. In the current trials, however, the swivels

on the driving axles had a useful life of 280,000–350,000 km. Swivels fitted to steering and trailer axles, which are better protected from the ingress of salt and dirt, lasted — with one exception — throughout the trials, having covered an average of 600,000 km.

Some of the vehicles encountered problems with changing from summer to winter tyres. The tyres were difficult to remove without breaking either the hoses to the swivels or the valves in the tyres.

### Low repair costs

Repair costs ranged widely, from zero to eight cents per km, with the average being two cents per km.

### Improved driver conditions

The drivers who took part in the trials found the ride smoother and more comfortable thanks to CTI. Without CTI, the tyre pressures in vehicles are always set to be appropriate for a fully laden vehicle travelling along main roads. This makes good use of the tyres' damping effect, but the pressures are otherwise too high for other driving conditions.

To verify the drivers' findings in this respect, readings were taken on one of the vehicles. From this we found that vibration in the vertical plane — which

is most relevant to driver comfort — was between 5 and 10% lower when the CTI system was activated. The greatest improvement occurred when the vehicle was driven unladen on substandard roads, and at slow speeds when laden.

### Reduced puncture risk

According to the hauliers and drivers, the incidence of punctured tyres was lower than normal on vehicles taking part in the trials.

The danger of tyres bursting due to overheating is eliminated, as the system monitors the tyre pressures continuously, releasing air when the pressure increases. Over the five million kilometres covered, only two tyre bursts were recorded. Both of these were due to defects in the tyres and had nothing to do with the CTI system.

The Swedish Motor Vehicle Inspection Company inspected tyres thoroughly during its routine testing, and was unable to identify any adverse effects from the use of CTI. On the contrary, the authority found that tyre wear was more even than normal over the entire tread area.

Weak point where the hose screws onto to the wheel valve.



## A driver's opinion

One of the vehicles used in the trials was a Scania truck owned by a Swedish company, Fermgruppen. The Scania rig operated mostly on short runs, hauling 5–8 loads a day. The CTI system was used on all the runs, which means that tyre pressures were altered 20–30 times during the day. The rig was new when the CTI system was installed, and it clocked up 350,000 km between June 2003 and February 2006. Technical utilization for the CTI system was 99%.

### Driver's findings:

- Better comfort ("If I forgot to activate the CTI system, I would notice it straight away")
- Fewer tears in the tyres
- Tyre wear more even
- Fewer punctures
- Tyres lasted longer



Photo: Ingemar Lundgren

Six settings were used in the project: two for the rig unladen, and four for rig laden. After consultation with the tyre manufacturers, suitable tyre pressures were specified for each vehicle based on the tyre configuration and axle loads. The table shows the tyre pressures used during the summer by the Fermgruppen driver.

| Company: SCA1 |                              | Tireboss™ Tyre Pressure Control |        |         |      |       |
|---------------|------------------------------|---------------------------------|--------|---------|------|-------|
| Setting       |                              | Steered                         | Driven | Trailer | Max  | Max   |
| Description   |                              | kPa                             | kPa    | kPa     | km/h | Time  |
| 1             | Main road, unladen           | 570                             | 500    | 500     | —    | —     |
| 2             | Gravel road, unladen         | 550                             | 350    | 350     | 66   | —     |
| 3             | Low-grade gravel road, laden | 770                             | 400    | 550     | 50   | —     |
| 4             | Gravel road, laden           | 775                             | 450    | 650     | 66   | —     |
| 5             | Main road, laden             | 800                             | 690    | 780     | —    | —     |
| 6             | Emergency pressure           | 550                             | 220    | 400     | 16   | 5 min |

## Reduced fuel consumption per ton-kilometre

Accurate metering of fuel consumption on one of the vehicles was carried out in the project. With CTI, fuel consumption rose — albeit by less than 1% per ton-kilometre — but given that the rig could carry a heavier payload on roads having a low bearing capacity, the fuel consumption, expressed in terms of per unit tonne of timber transported, actually fell.

Fuel consumption was also metered on a haulage rig driven with varying payloads and tyre pressures on Scania's test track near Stockholm. The outcome for a laden rig with reduced tyre pressures was a 3.6% rise in fuel consumption. Conversely, when the rig was unladen, the reduced tyre pressures

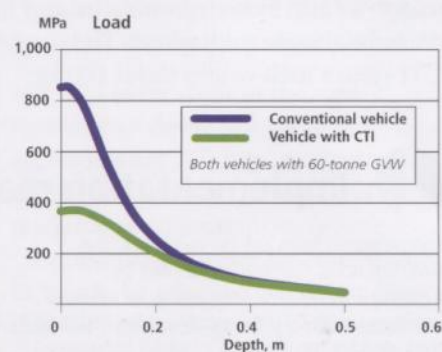
had no effect on fuel consumption. On a normal run with CTI, the distance covered when the vehicle is laden and the tyre pressures have been reduced is fairly short: just 6–7% of the total distance. Thus, the practical effect on fuel consumption is negligible.

The project also included an environmental impact analysis for CTI. This revealed that the system itself had no environmental impact, but when CTI-equipped rigs can operate with a heavier payload on roads having a low bearing capacity, the distance covered to deliver a total shipment will often be shorter, and the fuel consumption lower — which is beneficial to the environment.



## Impact on road surface

As part of the project, the Swedish Road Administration ran a number of theoretical calculations for different combinations of load and contact pressure on the road surface. These showed that lower tyre pressures caused reduced stress in the uppermost 200 mm or so of the road structure. At a greater depth it is the axle load that governs the structural stress.



Field trials conducted in 2005 found that lower tyre pressures resulted in much reduced rutting on ten out of twelve road tests. The effect was most pronounced on roads having a low bearing capacity. The two stretches of road on which the effect did not occur were of a good standard. Lower tyre pressures also reduced bulging or swelling, thus diminishing the ruts that hamper mobility in private cars.

## Economics

Installing the CTI system (including assembly and downtime) on the vehicles included in the project cost between \$24,900 and 38,800 per rig. This was a higher figure than expected — both for purchase and installation. It should be possible to bring down the cost, however, if the manufacturers were to make provision for the system in conjunction with assembly of the haulage rig. For instance, predrilling the holes on the trailer could be done in the axle factory, while the CTI system on the trailer could be fitted by the trailer manufacturer. It seems unlikely that the entire system could be factory fitted, as this would probably be too costly given the limited production series.

### An investment calculation

A simple calculation of the investment required has shown that a CTI system would cost approximately \$5,500 per year, or 23 cents per tonne, over a period of five years and with an average haulage distance of 100 km.

Using an interest rate of 4%, we calculated that the cost of the system including fitting would be \$15,500 for the tractor unit and \$9,160 for the trailer. We also reckoned with a reduction of 400 kg in the payload. The CTI system itself weighs about 100 kg,

added to which we allowed 300 kg for replacing aluminium rims with steel rims, which better withstand the stresses caused by different tyre pressures.

Such an investment would be profitable if an additional revenue of \$5,500 could be found through a higher number of operating hours, particularly during the spring thaw, and/or by increasing the payload on roads having a low bearing capacity.

A number of other factors could be included in a more refined calculation:

- CTI reduces vibration and shaking when a vehicle is driven unladen. Because there is less wear and tear on the rig, a higher estimated residual value could be justified, together with lower costs for servicing and repairs. One could also reckon on a somewhat faster road speed.
- Tyres last longer with less wheelspin. Also, the vehicle always operates with the right tyre pressures, which results in even wear.
- A one per cent or more reduction in fuel consumption per ton-kilometre.
- In any system in which air is compressed, there is a potential problem with water freezing. Allowance should therefore be made either for the cost of a higher-capacity drying system or for more frequent service intervals.



Road closed to all heavy vehicles — except those fitted with CTI!

#### Further reading:

Granlund P, Eliasson T, Ersson, B. 1999. Significant benefits of CTI-equipped timber trucks. *Resultat nr 4 1999*. Skogforsk.

Granlund, P & Andersson, G. 1998. Looking forward to spring with CTI. *Redogörelse nr 2 1998*. Skogforsk.

Granlund, P. 2004. Roundwood rigs with CTI—less vibration and a smoother ride. *Resultat nr 22 2004*. Skogforsk.

The publications listed are in Swedish with a summary in English.

The project was financed jointly by Skogforsk's framework programme, the forest enterprises involved, and the Swedish Road Administration. We would like to offer our warmest thanks to all those who have contributed their time, their involvement and their financial resources to the project.

Paul Granlund



## Implementation ready

Following on from the project work, the Swedish Road Administration will be offering a new set of conditions for vehicles equipped with CTI. It is possible, for instance, that vehicles having a GVW of 60 tonnes will be allowed to operate on roads that, owing to a poor bearing capacity and/or an inadequate wearing course, would normally be restricted to traffic having a GVW of 52 or 38 tonnes. The Administration will also be giving dispensations (under certain conditions) to CTI-equipped rigs with a GVW of 60 tonnes,

whereby they will be allowed to operate on roads that would normally be closed during the spring thaw. A likely consequence of this will be a breakthrough for CTI technology on Swedish roads, particularly in central and northern parts of the country.

The basic idea behind the project was to involve, right from the initial planning stage, all the interested parties — the users of haulage services, the hauliers, the manufacturers of vehicles and equipment, the Swedish Road Administration, others involved in highway

engineering, and researchers — all the way through to implementation and analysis. We believe that this project stands as an ideal example of how a project can be constituted for the purpose of finding out whether research results or new technology can be translated into practical applications. What's more, this project, focusing on a specific branch of forestry, can serve as a model for other implementation projects.