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Demonstration Of Forest Service Fire Engine Equipped With A Central Tire Inflation System

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James Bassel—Civil Engineer
Steve Raybould—Forestry Technician

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CTI for Fleet Equipment

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INTRODUCTION AND SCOPE

Central Tire Inflation (CTI) is a term used for a mechanical (electro-pnuematic) system, installed on a vehicle, that allows the driver to adjust tire pressures while the vehicle is moving. Controls in the cab are used to adjust and monitor tire pressures. The system utilizes an air brake compressor to maintain the tire pressure configuration selected by the driver. Pressure levels are changed for load, speed, road condition, and vehicle traction. Adjusting the tire pressure changes the deflection of the tire. Tire deflection is the change in tire section height from the freestanding height to the loaded height. Tire deflection varies with load and pressure. An increase in load increases tire deflection, while an increase in tire pressure decreases deflection. Increased tire deflection results in greater tire to road surface area or longer tire "footprints" that reduce stress applied to road surfaces, improve traction and reduce tire bouncing.

The longer tire footprint accounts for many of the benefits. Slip energy and dynamic loading reductions by the larger tire footprint play a significant role in reducing damage to the road and vehicle. The reasons for slip and bounce reduction are complex, but the improved behavior is easily observed and dependably reproducible.

The Forest Service has issued a Technology Application Plan, "Operation Bigfoot," for the application of Central Tire Inflation/Variable Tire Pressure (CTI/VTP). The plan calls for a continued effort to quantify and qualify the effects of CTI/VTP technology on roads and haul costs, and an increased effort to transfer this technology to the field. The San Dimas Technology and Development Center (SDTDC) contracted with Tire Inflation Systems Company (TISCO), Pomona, Calif., to install an internal CTI system on a Forest Service fire engine to determine the benefits of a CTI-equipped 4x2 fire engine.

OBJECTIVE

The objective of this demonstration was to compare, under similar operating conditions, a 4x2 fire engine equipped with a CTI system and nonlocking rear end to a 4x4 fire engine without a CTI system.

DEMONSTRATION PROGRAM

Location

The field demonstration was conducted June 9, 1992, on the Hunter Ligget Military Reservation in cooperation with SDTDC and the Pacific Southwest Region's Los Padres National Forest.

Procedure

The test was conducted in accordance with the *Model 61 Fire Engine Equipped with a TISCO CTI System on the Los Padres National Forest Test Plan*, written by SDTDC. Conditions were as identical as practical for the two engines. Both engine's water tanks were fully loaded.

Equipment

Los Padres National Forest (LPNF) Engine 54, a Model 61 4x2 engine equipped with a CTI system (fig. 1); and LPNF Engine 40, a Model 60 4x4 engine without a CTI system (fig. 2) were used in the demonstration. The Model 60 and 61 are similar, except for the cab configuration. The Model 60 is equipped with a six-position crew cab,

Figure 1. Engine 54, 4X2 Model 61 equipped with CTI system.

Figure 2. Engine 40, 4X4 Model 60 without CTI.

while the Model 61 has a conventional cab and four crew seats fabricated in the fire truck package. For this demonstration, these two models are considered to be equivalent.

The basic configuration of a TISCO CTI system is seen in figure 3 (page 3). To operate the CTI system, the driver simply selects among four tire pressure settings on the controller mounted in the cab (fig. 4). Both engines were equipped with 11R22.5 tires. All tire pressures were set to Tire and Rim Association standards, except for Adverse Trac. TISCO's operational manual states that Adverse Trac. should be used when speeds do not exceed 5 mph. Settings, tire pressures, and maximum speeds are as follows:

Setting	Tire pressure Steer axle (psi)	Tire pressure Drive axle (psi)	Max speed (mph)
Highway	70	70	55
Off-highway loaded	46	46	35
Off-highway unloaded	36	30	35
Adverse Trac. (traction)	36	20-25	5

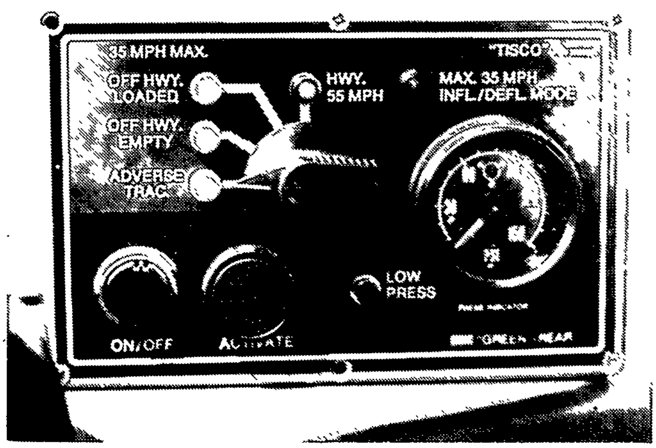

Figure 4. Engine 54's cab-mounted CTI system controller.

Personnel

Bonnie Stevens-Mortier was the Engine 54 captain and Mark Aguire was the operator for Engine 54; Berry Garten was the operator for Engine 40. The two operators received instructions to drive the vehicles at a maximum speed of 5 mph and to minimize acceleration on the courses.

Test Courses

Four driving courses were located in an area where fire crews had responded to a fire on May 29, 1992. The courses were selected because the crews were familiar with the area and previous performance of the engines. The courses were as follows:

Course No. 1

35-percent slope—a long, straight grassy grade that engines had traversed during the fire, not graded by a dozer.

Course No. 2

37-percent slope—a trail that had been graded by a dozer during the fire, very loose native surface, a curve at the bottom preventing the engine from accelerating before the climb. During the fire, 4x2 engines were not able to climb this grade.

Course No. 3

32-percent slope—4x2 engines required dozer assistance during the fire.

Course No. 4

52-percent slope—was off-road, and selected for a "no-go" situation for 4x4 engines. In fire situations, fire engines should not drive this steep a grade.

DEMONSTRATION RESULTS

Course No. 1

Engine 40 with highway tire pressure and all-wheel drive climbed the entire grade.

Engine 54 at CTI Highway setting was not able to climb the grade, the wheels spun and dug into the course.

Engine 54 at CTI Adverse Trac. setting climbed the entire grade.

Course No. 2

Engine 40 with highway tire pressure and all wheel drive made the entire grade with only slight tire slip.

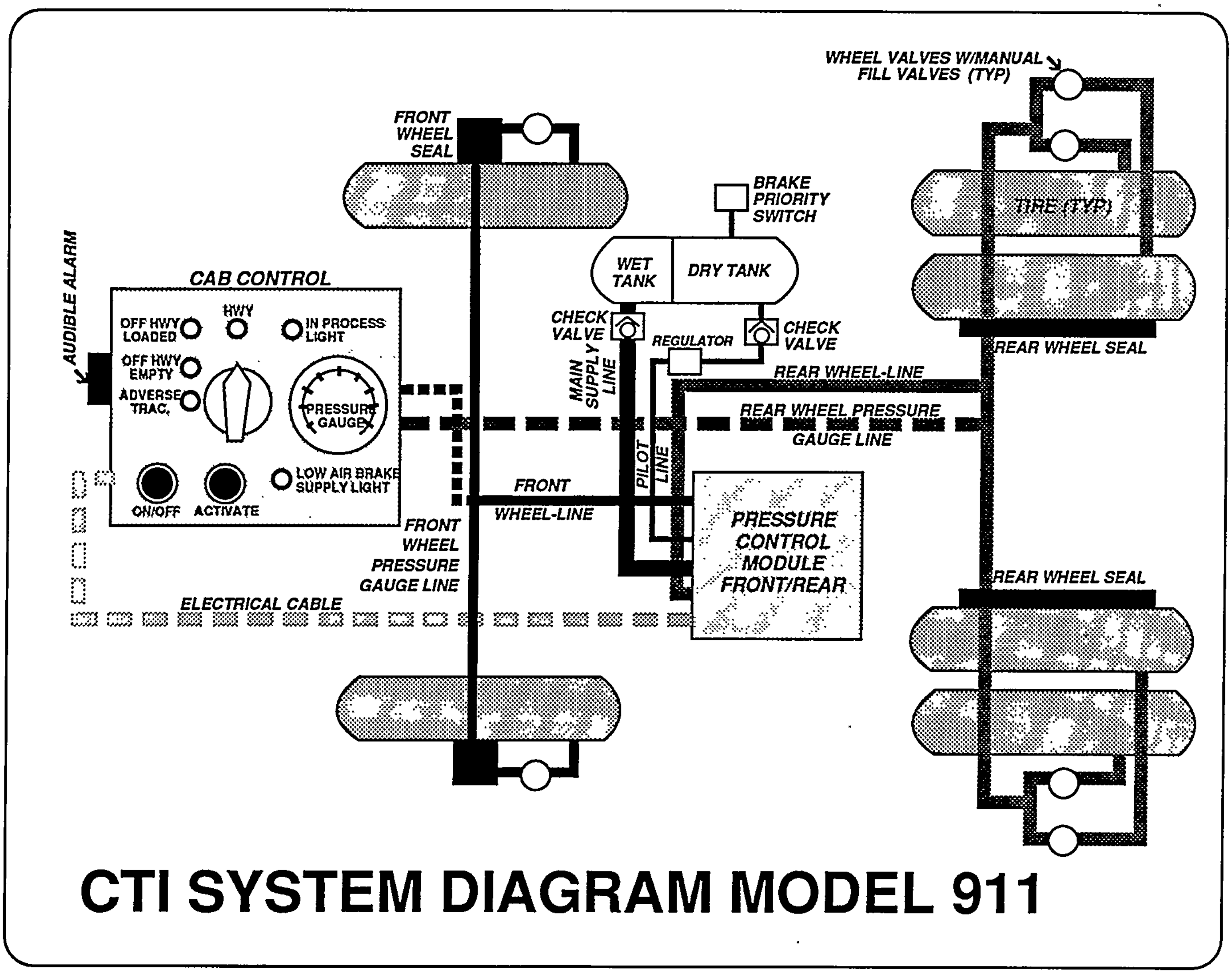

Figure 3. Basic configuration of Engine 54's CTI system.

Engine 54 at CTI Highway setting stopped after 20 feet. Both wheels were digging into the surface.

Engine 54 at CTI Adverse Trac. setting made three different runs and the following observations were recorded:

1st run—climbed the entire grade.

2nd run—the vehicle stopped at midpoint (to determine if it could make the grade from a full stop) and climbed the remaining grade.

3rd run—the driver from Engine 40 (the 4x4) drove Engine 54 to determine the effects of driver variability. As in the first run, the engine climbed the entire grade. While descending the slope, the driver was told to brake hard two or three times at the places where the road was the softest to determine vehicle stability. The engine was able to stop without any problems.

Engine 40 with highway tire pressure and in all wheel drive made the same additional runs and the following observations were recorded:

1st run—the vehicle stopped at midpoint and climbed the remaining grade.

2nd run—while descending, the driver stopped about the same place as the 4x2, and the engine was able to stop without any problems.

Course No. 3

This run was made to compare Engine 54 to the other 4x2 engines that had tried to climb the grade during the fire. Engine 54 at CTI Adverse Trac. setting climbed the grade with no trouble. During the fire, the other 4x2 engines had required dozer assistance.

Course No. 4

Engine 40 with highway tire pressure and all wheel drive was able to climb only 30 feet before spinning out.

Engine 54 at CTI Adverse Trac. setting climbed approximately 18 feet further than Engine 40.

Engine 40, with very low tire pressure that had been set manually with an auxiliary air compressor, climbed the grade with no problem. Climbing this grade is not recommended for fire situations.

The results are shown in the following tabular format:

Course No.	Slope %	Engine No.	Pressure	Pass/Fail
1	35	40	Highway	Pass
		54	CTI-highway	Fail
		54	CTI-Adv. Trac	Pass
2	37	40	Highway	Pass
		54	CTI-highway	Fail
		54	CTI-Adv. Trac	Pass
3	32	54	CTI-Adv. Trac	Pass
4	52	40	Highway	Fail
		40	Reduced	Pass
		54	CTI-Adv. Trac	Fail

DEMONSTRATION OBSERVATIONS

The demonstration took place when a fire school training session was being held. The attendees at the session had the opportunity to observe the CTI demonstration. Everyone observing or involved with the demonstration was impressed by how well the CTI-equipped fire engine performed compared to the 4x4 engine on these courses. Arriving at Course No. 2, many observers were saying that the CTI engine would not make it to the top of the grade. When the CTI engine did make it, there were yells of excitement. When the CTI engine stopped mid-grade to start again, no one thought it would make it to the top. The drivers and observers were indeed excited when it did make it.

Mark Aguire, the driver of Engine 54, and Berry Garten, the driver of Engine 40, had the following responses to questions after the test runs:

Q. Was CTI effective?
A. Yes, soft tires were obviously better than hard tires, and being able to control the pressure from the cab was great.

Q. Was the ride easier on the driver?
A. It was hard to tell on these short runs but it felt like it.

Q. Was the ride easier on the truck?
A. Could not tell.

Q. Was the hardware easy to use?
A. Yes, after we learned how to use it. The only problem was the time it took to air up the tires.

Q. How much would you use CTI?
A. On almost every fire where we would have to go off of the pavement.

Q. Would you recommend CTI on fire engines?
A. Yes, it works well and four-wheel drives are more expensive to operate.

Q. General thoughts?
A. They liked what they had seen. From Berry, "I am still concerned about safely descending steep hills with soft tires, but I would like to have one."

CONCLUSIONS

The objective of this demonstration was to compare qualitatively a 4x2 fire engine equipped with a CTI system to a 4x4 fire engine without CTI. The results are that the 4x2 fire engine with CTI is comparatively the same as the 4x4 fire engine with no CTI. Comparing Course Nos. 1 and 2, Engine 54 at CTI Adverse Trac. setting performed the same as Engine 40 in all wheel drive. On Course No. 4, the CTI engine even out-performed the 4x4 engine at highway tire pressure, but not at reduced tire pressure. An engine with CTI has the same mobility for short, steep grades as an engine with all wheel drive. This does not mean that a CTI system replaces all wheel drive.

A 4x4 engine generally costs more to purchase, operate, and maintain than a 4x2 engine. The results of this demonstration should provide preliminary information to help determine the practicality of replacing some 4x4 engines with 4x2 CTI models.

The test was videographed by Los Padres personnel. Subsequently, SDTDC edited this field footage and narration and produced the *CTI Fire Engine Demonstration* video.

RECOMMENDATIONS

Draw bar tests should be done with the assistance from tire manufactures and/or the Tire and Rim Association to help determine tire pressures that would be suitable and safe for CTI fire engines climbing/descending steep slopes and side hill driving. Continued field testing is recommended to determine safety issues, operating constraints, and performance in other types of material.

ACKNOWLEDGMENTS

SDTDC would like to thank the Los Padres National Forest for providing the location, crews, engines, mechanic with tools, supplies, compressor, and videographer (see appendix A).

APPENDIX A

Personnel Attending Demonstration

Los Padres National Forest	Phone/FS electronic mail
Thom Myall Forest FMO	805/683-6711 DG:RO5FO7A
Lonnie Briggs Forest AFMO	805/683-6711 DG:RO5F07A
John McKenzie Fleet Manager	805/925-3140 DG:R05F07D53A
Carl Stephens Mechanic	805/646-3943
Ray Roethler Mechanic	805/683-6711
Ron Bassett District Ranger Ojai Ranger District	805/646-4348 DG:R05F07D55A
Bob Becker District AFMO Ojai Ranger District	805/646-4348 DG:R05F07D55A
Bonnie Stevens-Mortier Engine Captain Oak Flats Station	805/646-4348 DG:R05F07D55A
Juan Lopez District AFMO Monterey Ranger District	408/385-5434 DG:R05F07D51A
Earl Clayton PAO	408/683-6711 DG:R05F07A

San Dimas Technology and Development Center

LaMoure Besse Mechanical Engineer	909/599-1267 DG:W07A
Steve Raybould Forestry Technician	909/599-1267 DG:W07A