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TACOM PHASE II MICV/GT601/X-300 INTERIM TEST REPORT

CONTRACT NUMBER DAAK30-79-C-0139

APRIL 1982

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of the TACOM Phase II demonstration testing conducted at the General Motors proving grounds at Milford, Michigan from August 17 through November 5, 1981. The purpose of this program is to demonstrate the characteristics of a Garrett GT601 Gas Turbine Engine and Detroit Diesel Allison X-300 transmission without a torque converter installed in a Mechanized Combat Vehicle (MICV).

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TACOM PHASE II MICV/GT601/X-300
INTERIM TEST REPORT

INTRODUCTION

This report presents the results of TACOM Phase II demonstration testing conducted at the General Motors Proving Ground at Milford, Michigan, from August 17 through November 5, 1981, under the provisions of Contract DAAK30-79-C-0139. The purpose of this program is to demonstrate the characteristics of a Garrett GT601 Gas Turbine Engine mated with a Detroit Diesel Allison X-300 transmission without a torque converter installed in a Mechanized Infantry Combat Vehicle (MICV) loaded to 45,000 pounds GVW. Phase II program objectives successfully accomplished were:

- Section 1 - Determination of vibratory inputs to the engine mount system

- Section 2 - Determination of rolling resistance on level pavement and dirt

- Section 3 - Demonstration of adequate cooling system sizing (tractive effort)

- Section 4 - Demonstration of ability to maintain slow vehicle speeds without brake application (driveability)

- Section 5 - Determination of minimum acceleration times for 0 to 20 MPH, 0 to 30 MPH, and a 200-meter dash

- Section 6 - Determination of the effects on acceleration of inlet blockage simulating dirty air filters

- Section 7 - Determination of fuel consumption

- Section 8 - Determination of balance speed on various grades

- Section 9 - Demonstration for TACOM personnel

Included herein for each test section are summaries of test program results, discussions of testing, and conclusions and recommendations. Section 10 is a summary of testing along with a compilation of conclusions and recommendations. Test data sheets specified in various sections of this report are contained in Appendix A. Appendix B contains diesel-powered MICV test data obtained during testing performed in 1975 at Aberdeen Proving Ground, MD.

1- VIBRATION TEST RESULTS

1-1 Test Purpose

The purpose of these tests was to determine the level of vibratory inputs to the engine mount with new and worn vehicle track pads on various types of terrain.

1-2 Summary of Test Results

The vehicle vibration on both pavement and dirt and with both worn and new track pads appeared fairly random and spanned 0 to 800 Hz with a maximum level of 4.23 g to the vehicle side of the engine mount. Engine side mount vibration responses for the same conditions were limited to 81.5 Hz with a maximum level of 1.3 g.

1-3 Discussion

The test was conducted per Test Procedure 51-2640. The various peak vibration levels were analyzed and the resulting data are displayed in Tables 1 through 4, which identify each of the peaks on both sides of the mount. Figure 1 shows typical maximum vibration peaks on both sides of the mount with worn and new track pads. Figures 2 and 3 show the triaxial accelerometer system mounted on the engine side of the engine mount. Figure 4 shows a worn and new track pad installed showing that a worn pad allows metal-to-pavement contact.

A correlation between "5th wheel" speed and left driveshaft speed signals and vibration levels was attempted. However, due to superimposed noise interference, the speed signals could not be used. The peak vibration occurred at approximately 19 MPH with both new and worn pads.

1-4 Conclusions

Typical vibratory input information for engine and ancillary equipment mounting has been obtained.

TABLE 1. WORN TRACK PADS

MEASURED FROM THE TANK SIDE OF THE MOUNT

Direction	Pavement Run No. 1			Pavement Run No. 2			Dirt Run No. 1			Dirt Run No. 2		
	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)
Vertical	55. 57.5 62.5 63.7	4.74 6.42 5.9 4.85	0.82 1.08 1.18 1.005	49. 59.7 62.2 67.5 64.4	3.6 7.62 4.4 3.2 1.9	0.446 1.38 .87 .746 .42	52.2 69.4	2.56 1.8	0.356 0.45	56. 62.2	3.01 3.17	0.48 0.616
Horizontal	57.5 62.8 65.3 73.1	4.9 5.47 4.92 2.09	.84 1.1 1.07 .57	49 59.7 66.9 68.1 74	3.57 4.05 4.47 3.64 1.89	.438 .73 1.02 .87 .529	69.25 80 92.5 117.5 240	2.882 2.49 2.05 4.03 .821	.706 .816 .898 2.84 2.41	28 24.2	7.76 .946	.311 2.84
Axial	64.75 135 180 195 245 407.5	1.71 .938 1.16 1.12 .547 .316	.366 .87 1.92 2.18 1.61 2.68	90 105 180 317.5 415	2.42 2.33 1.177 .612 .481	1.0 1.31 1.95 3.15 4.23	25 107.5 122.5 210.0 217.5 247.5 317.5 390	7.29 2.35 2.16 1.168 1.118 .61 .59 .462	.233 1.388 1.657 2.63 2.7 1.91 3.03 2.36	102.5 182.5 190 212.5 225 315 397.5	1.83 1.398 1.323 1.83 1.049 .524 .494	.983 2.38 2.25 2.73 2.71 2.66 3.99

TABLE 2. NEW TRACK PADS

MEASURED FROM THE TANK SIDE OF THE MOUNT

Direction	Pavement Run No. 1			Pavement Run No. 2			Dirt Run No. 1			Dirt Run No. 2		
	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)
Vertical	52 53.25 67.5 70 72.25	3.46 3.86 1.97 2.26 2.03	0.48 0.56 0.45 0.566 0.541	47.5 52 71.25	2.71 2.22 0.84	0.31 0.306 0.216	58.75 52.75 58.75	1.38 2.08 1.45	0.24 0.296 0.264	4.5 6.25 47.75 52.5 75. 150	1.30 9.57 1.82 4.78 1.24 0.55	0.0135 0.0191 0.212 0.67 0.357 0.636
Horizontal	52 53.25 66.25	2.38 2.61 0.83	0.328 0.378 0.187	23.5 122.5	2.01 2.49	0.579 1.9	41 66.5 25 110	1.03 1.71 6.59 2.4	0.233 0.147 0.86 1.48	25 82.5 97.5 112.5	7.6 1.1 2.17 2.64	0.24 0.382 1.054 1.7
Axial	36.5	4.7	0.316	100 205 680	1.62 0.87 0.148	0.83 1.88 3.5	53.75 15 25 105 120 167.5 242.5 660	1.2 9.6 4.93 1.57 1.35 0.674 0.48 0.144	0.178 0.11 0.157 0.88 0.99 0.96 1.44 2.66	25 110 175 205 225 242.5 275	7.67 1.75 0.745 0.65 0.428 0.405 0.3	0.24 1.08 1.16 1.4 1.1 1.2 1.2

TABLE 3. WORN TRACK PADS

MEASURED FROM THE ENGINE SIDE ON THE MOUNT

Direction	Pavement Run No. 1			Pavement Run No. 2			Dirt Run No. 1			Dirt Run No. 2		
	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)
Vertical	24	6.36	0.187	21.2	4.9	0.11	54.7	4.42	0.676	25	7.32	0.234
	36.9	6.98	0.48	28.4	4.5	0.189	56.2	3.74	0.603	39	3.2	0.25
	43.1	6.62	0.63	41.9	4.6	0.416				43.5	3.06	0.296
	44	5	0.49	52.2	6.28	0.875						
	45.9	4.7	0.50	64	1.69	0.35						
	49.6	4.36	0.548									
	60.9	2.6	0.495									
	62.5	3.15	0.63									
Horizontal	37.25	11.3	0.80	17.5	5.45	0.085	27.75	8.78	0.33	31.25	7.14	0.356
	44.25	11.6	1.16	27.8	5.95	0.235	37.50	12.8	0.92	33.25	7.56	0.427
	45.75	8.25	0.86	37.8	9.34	0.68	49.75	5.7	0.72	36.25	7.25	0.487
	48.5	7.8	0.94	42.2	14.6	1.33	52.75	3.8	0.55	38.75	8.4	0.646
	58.75	4.8	0.848	50.3	6.83	0.88	81.50	1.77	0.60			
	60	5.08	0.935	53.7	1.14	0.993						
				55.6	4.35	0.687				42.2	4.5	0.41
				59.7	2.66	0.48						
				34.4	9.7	0.58						
				36.2	7.3	0.488						
Axial	36.9	11.3	0.79	64.4	2.27	0.48	36.9	7.3	0.51			
	40.3	9.08	0.75	42.2	7.16	0.65	37.8	8.08	0.59	55	2.43	0.3767
	43.1	7	0.666	44.1	3.03	0.30	43.1	4.1	0.39			
	45.9	4.92	0.53				47.5	3.08	0.355			
	48.4	4.07	0.488									
	60.9	2.3	0.44									

TABLE 4. NEW TRACK PADS

MEASURED FROM THE ENGINE SIDE OF THE MOUNT

Direction	Pavement Run No. 1			Pavement Run No. 2			Dirt Run No. 1			Dirt Run No. 2		
	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)	Frequency (Hz)	Displ (mils)	Accel (gs)
Vertical	25.5 29.75 43.0 44.5 47.5 25 60	5.44 5.76 2.45 3.82 1.84 6.27 2.7	0.18 0.26 0.23 0.386 0.211 0.2 0.496	15 20.25 20.25 39 46.5 54.5	10.6 6.83 10.5 4.22 2.66 1.86	0.12 0.143 0.342 0.328 0.29 0.282				20.5 24.5 57.5	7.17 6.4 3.79	0.154 0.196 0.64
Horizontal	32.25 34 43.25 44 66.5	5.39 7.16 3.56 6.13 1.6	0.286 0.423 0.34 0.62 0.38	17.5 34.5 40.75 43.75 44.75 46.5 48.25	6.67 7.23 3.54 4.9 4.66 5.25 4.4	0.104 0.44 0.30 0.48 0.476 0.58 0.523	31.25 33 43 46.5 26 37 39.75	3.56 3.64 4.33 4.06 2.92 3.49 2.89	0.177 0.202 0.41 0.448 0.1 0.244 0.233	33.50 35 42.25 44.5 45.5 54 38.75 42.25	7.64 8.63 3.9 4.53 4.07 2.38 5.07 2.74	0.438 0.54 0.355 0.458 0.43 0.606 0.389 0.25
Axial	34.5 43.5 44.75 42 61.25	1.6 3.18 3.04 1.15 1.24	0.09 0.307 0.311 0.10 0.23	48.5	2.66	0.319	43 33.25	2.5 1.94	0.236 0.11	38	4.25	0.314

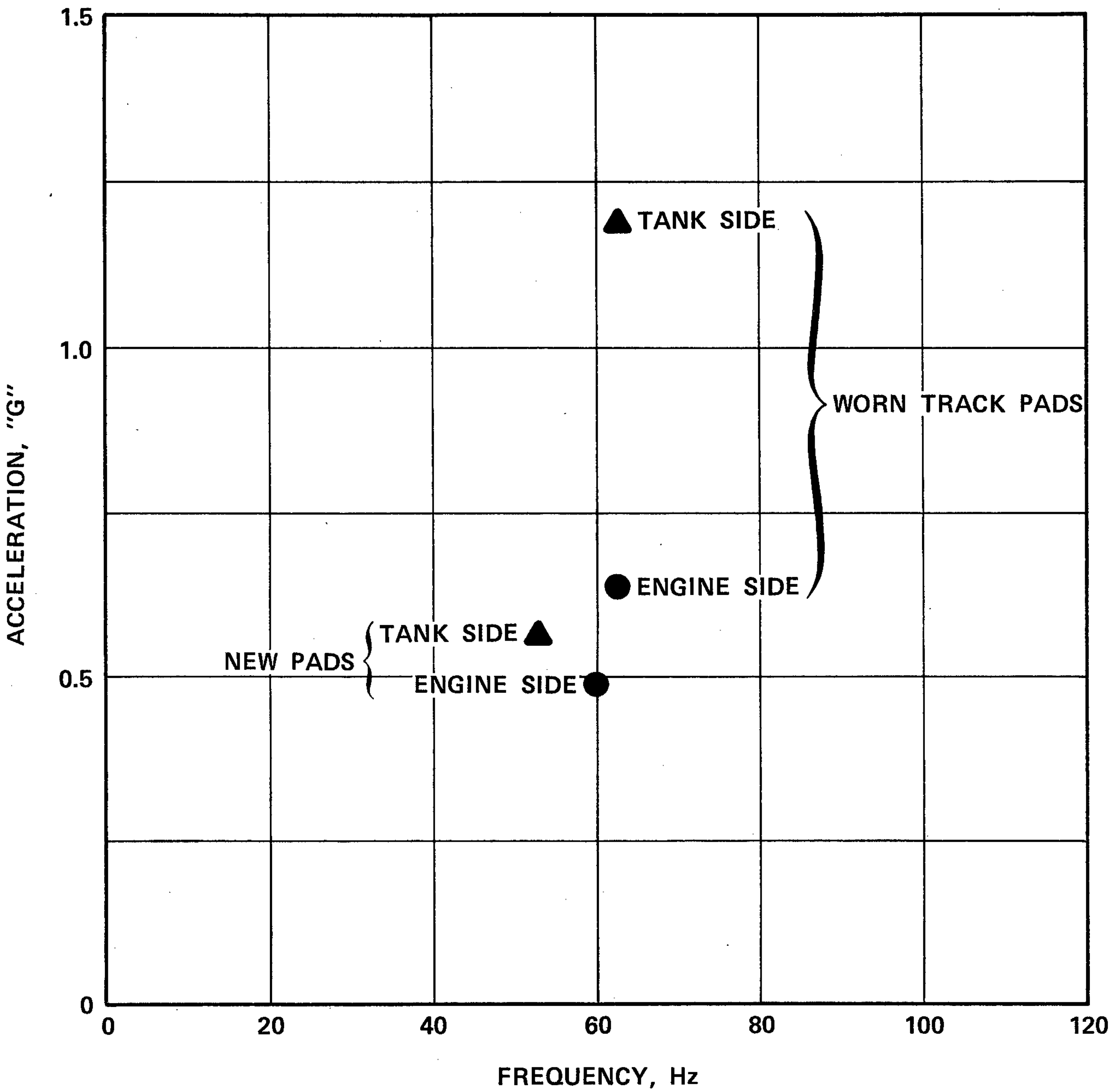

Figure 1. Typical Maximum Vibration Peaks with Worn and New Track Pads.

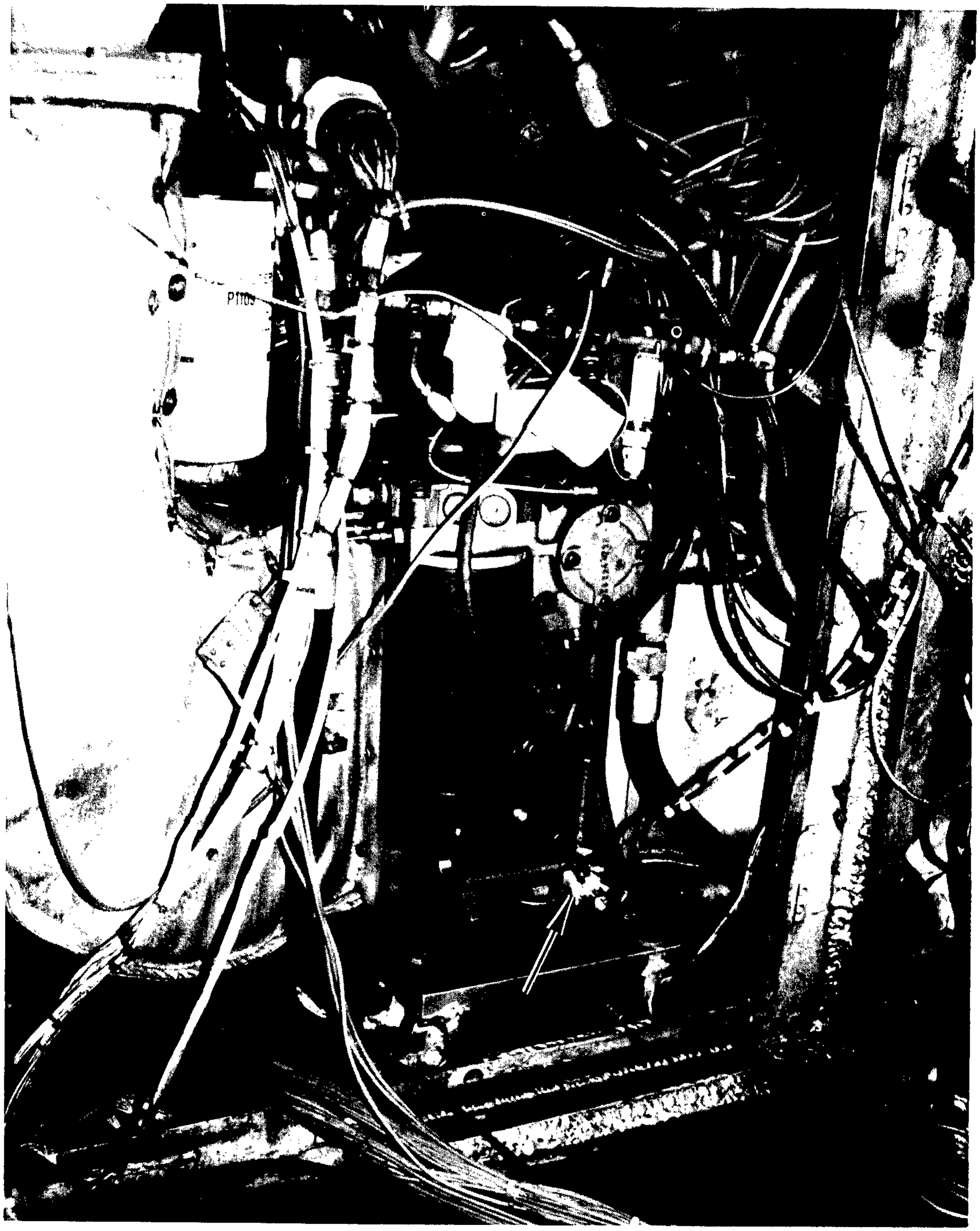

Figure 2. Triaxial Accelerometer Location on Engine Side of Engine Mount (See Arrow).

Figure 3. Close-Up of Triaxial Accelerometer System Located on Engine Side of Engine Mount.

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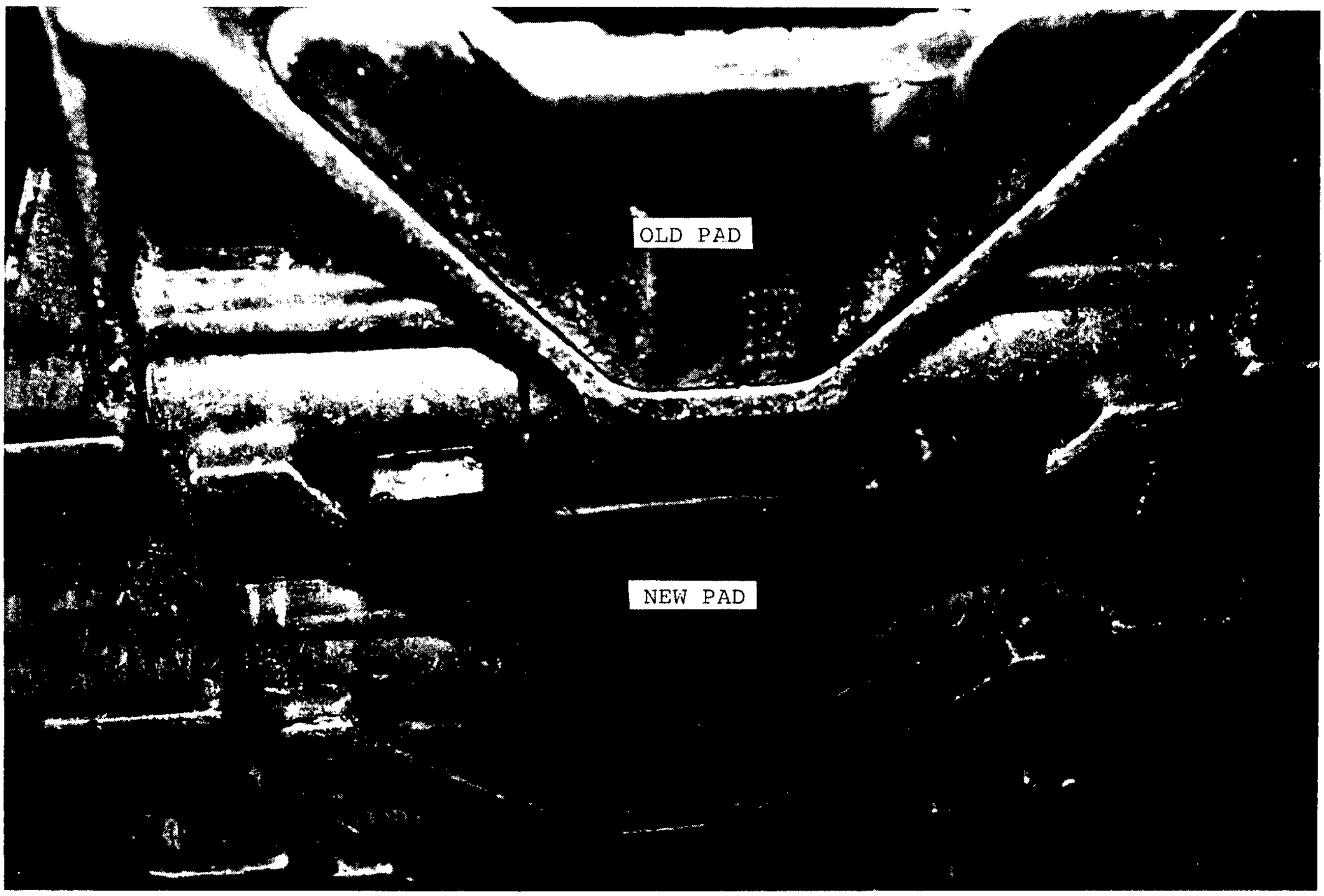


Figure 4. Close-Up of Worn and New Vehicle Track Pads Installed in Track.

2-0 ROLLING RESISTANCE TEST RESULTS

2-1. Test Purpose

The purpose of this test was to determine the MICV test vehicle rolling resistance on flat pavement and dirt. In addition, the force required to slide the vehicle on pavement was also obtained as requested by TACOM.

2-2 Summary of Test Results

The results of the rolling resistance tests on both flat pavement and dirt are shown in Figure 5. The tabulated data are presented below:

Vehicle Speed (mph)	Rolling Resistance		Road Surface
	(lbf)	(lbf/ton)	
5	1700	75.6	Pavement
7.5	1800	80	Pavement
10	1850	82.2	Pavement
12.5	1750	77.8	Pavement
14	1850	82.2	Pavement
15	1850	82.2	Pavement
16.5	1950	86.7	Pavement
17.5	2125	94.4	Pavement
20	2100	93.3	Pavement
5	1950	86.7	Dirt
7.5	2000	88.9	Dirt
10	2000	88.9	Dirt
12.5	2000	88.9	Dirt
15	2250	100	Dirt
17.5	2400	106.7	Dirt

The force required to slide the vehicle on asphalt pavement was 30,000 pounds. This is a coefficient of sliding friction (μ_f) of 0.67. The breakaway force was 37,500 pounds.

2-3 Discussion

The test was conducted per Test Procedure 51-2641A. Additional vehicle speeds were run to provide a more accurate plot. The maximum speed that the towing vehicle could maintain on dirt was 17.5 MPH.

Data are presented in Figure 5 and are tabulated on the "Rolling Resistance Test Data Sheets", DS-4373, Rev. A, Appendix A. Figures 6 through 9 are photographs of the test setup. The towing vehicle for the rolling resistance tests was a General Motors Proving Ground Heavy Duty Dynamometer weighing approximately 110,000 pounds and powered by two Detroit Diesel Model 6V71 engines rated at 235 horsepower each. The towing vehicle for the sliding test was a M60 tank.

On the days that the above rolling resistance tests were conducted, roadbed and track pad temperatures were not obtained. However, temperatures were obtained on a previous day and results show the track pad temperature increases approximately 20°F higher than the roadbed temperature. During the sliding test, the roadbed temperature was 99°F and the track pad temperature varied from 95°F at the rear of the sliding pads to 102°F at the front of the pads.

2-4 Conclusions and Recommendations

The vehicle rolling resistance has been determined up to 17.5 MPH on dirt and 20 MPH on pavement. Determination of rolling resistance at higher speeds will require a towing vehicle capable of higher speeds.

The force required to slide the vehicle on asphalt has also been determined.

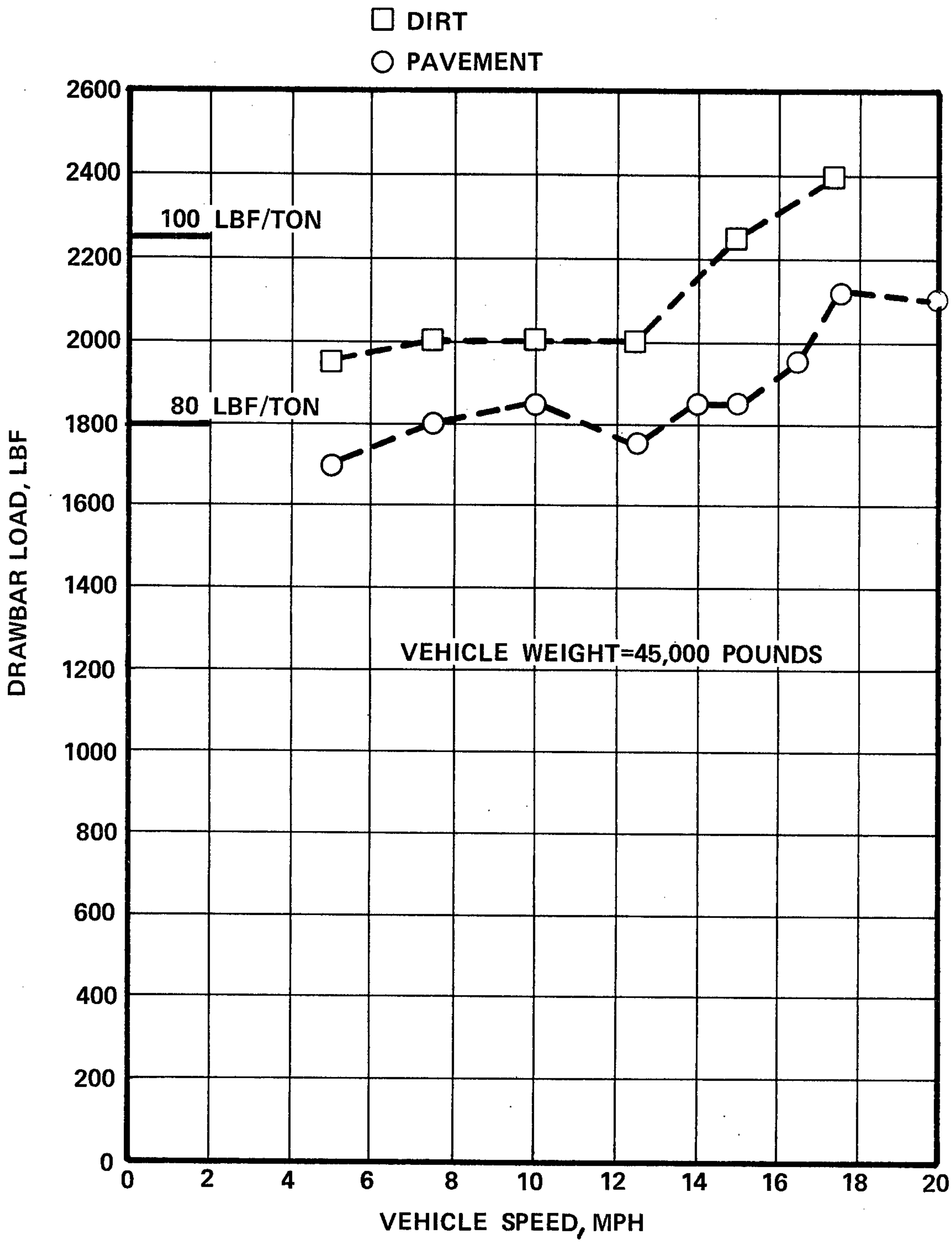


Figure 5. Rolling Resistance Test Results For Flat Pavement and Dirt.

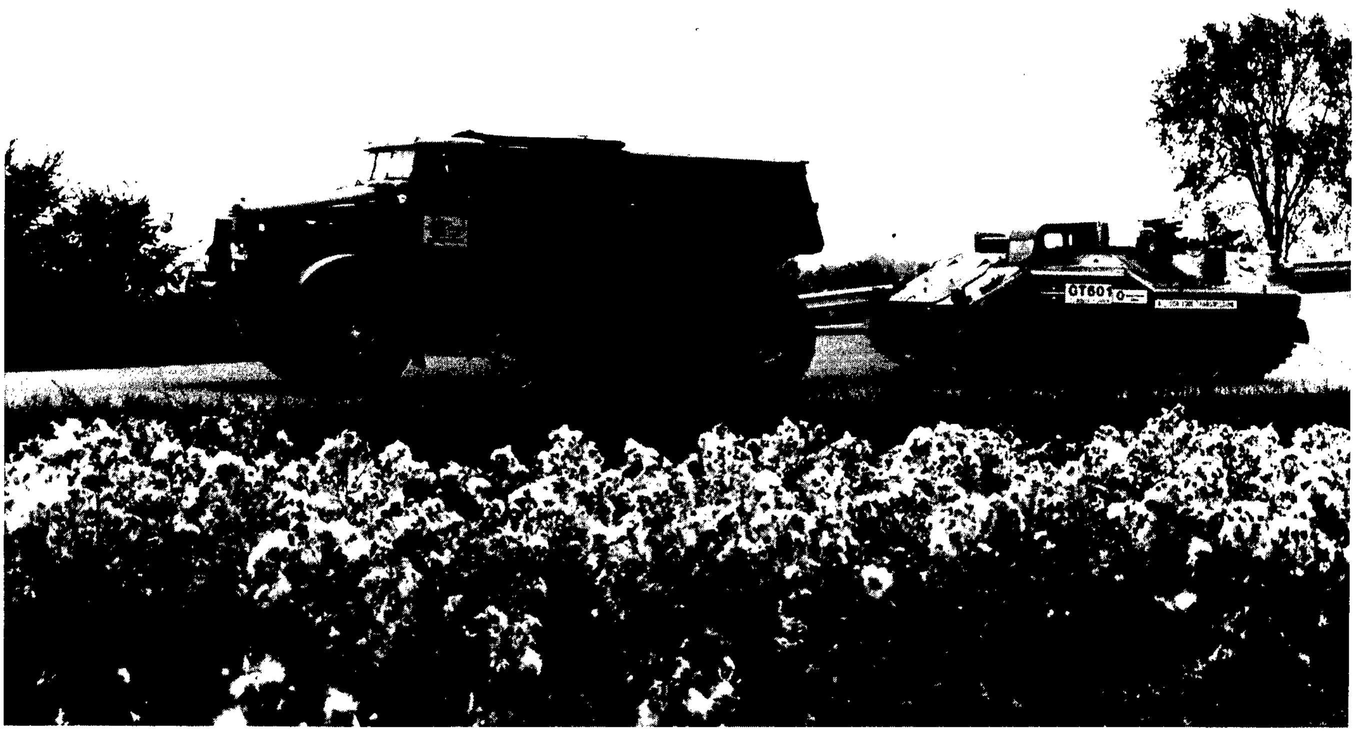


Figure 6. General Motors Dynamometer Truck Pulling MICV to Determine Vehicle Rolling Resistance.

Figure 7. Drawbar System Used in Vehicle Rolling Resistance Test.

Figure 8. M-60 Tank Pulling MICV to Determine Sliding Friction Forces.

Figure 9. Sliding Friction Forces Testing.

3-0 TRACTIVE EFFORT TEST RESULTS

3-1 Test Purpose

The purpose of this test was to demonstrate adequate sizing of the engine and transmission lubrication systems by applying sustained maximum loads to the engine and transmission and observing oil temperatures.

3-2 Summary of Test Results

The vehicle was loaded to obtain maximum power operation both in first- and second-gears. In both cases the engine and transmission oil systems remained on thermostat control. Pertinent data obtained are tabulated below:

Gear	Vehicle Speed, MPH	Drawbar Load, lb	Transmission Oil In °F	Transmission Sump °F	Engine Oil In °F	Transmission Oil Cooler Oil In °F	Transmission Oil Cooler Oil Out °F	Engine Oil Cooler Oil In °F	Engine Oil Cooler Oil Out °F	Cooling Air In °F	Cooling Air Out °F
1st	7.6	16,000	172	186	160	188	164	129	58	88	166
2nd	16.6	6,300	152	176	158	178	141	126	59	87	149

3-3 Discussion

The test was conducted per Test Procedure 51-2642A. The complete list of data recorded are tabulated on the "Tractive Effort Test Data Sheet," DS-4374, Rev. A, Appendix A. Figures 10 and 11 show the cooler package installed in the test vehicle.

The engine oil-in temperature limit is 200°F, and the engine oil thermostat is set at 160°F. The transmission oil sump temperature limit is 250°F, and the transmission bypass cooler system controls at approximately 180°F.

The transmission oil cooler data recorded represent an average of the data observed. Although the load conditions were stabilized for several minutes, actual transmission oil temperature steady-state conditions were not achieved due to the cyclic characteristic of the external transmission oil cooler bypass control valve which allows temperatures to cycle a few degrees. In addition, the transmission oil cooler flow values observed are in conflict with predictions since the same value was observed during both the first-gear and second-gear testing. The transmission manufacturer's previous tests show that the heat rejection should decrease with higher number gear positions. This contention is supported by the data which show the transmission oil sump temperature was lower in second gear than in first gear. The transmission oil cooler ΔT was higher in second gear indicating a lower flow, and the cooling air ΔT was lower in second gear. All temperature data support the position that maximum transmission heat rejection occurs in first gear.

An apparent anomaly exists between the engine-oil-cooler recorded in and out temperatures and the engine oil-in and cooler air temperatures. Engine cooling requirements during this testing were such that the engine oil temperature was maintained with only a very small flow through the thermostat. This low flow in the engine oil cooler circuit allowed the oil to cool in the oil cooler supply and discharge lines. Since the engine-oil-cooler in and out temperatures are measured by thermocouples in these lines, these temperatures were actually lower than the oil temperatures at their respective supply points. This condition indicates the large excess capacity of the cooler at lower ambient conditions. Both the engine and transmission oil coolers were sized to provide more cooling capacity than is required on a hot day based upon the maximum heat rejection predicted by Garrett and Allison respectively.

3-4 Conclusions and Recommendations

The engine and transmission oil temperatures did not exceed thermostat control during full power loads in both first and second gears. First-gear operation generates higher transmission heat rejection than second-gear operation.

This data cannot be used to determine precise transmission cooler heat rejection, as a few degrees in cooler ΔT results in a sizable change in the heat rejection values, and the cooler oil flow values are unreliable.

The existing coolers are apparently adequate for hot-day operation. However, an actual hot-day test would provide additional substantiation.

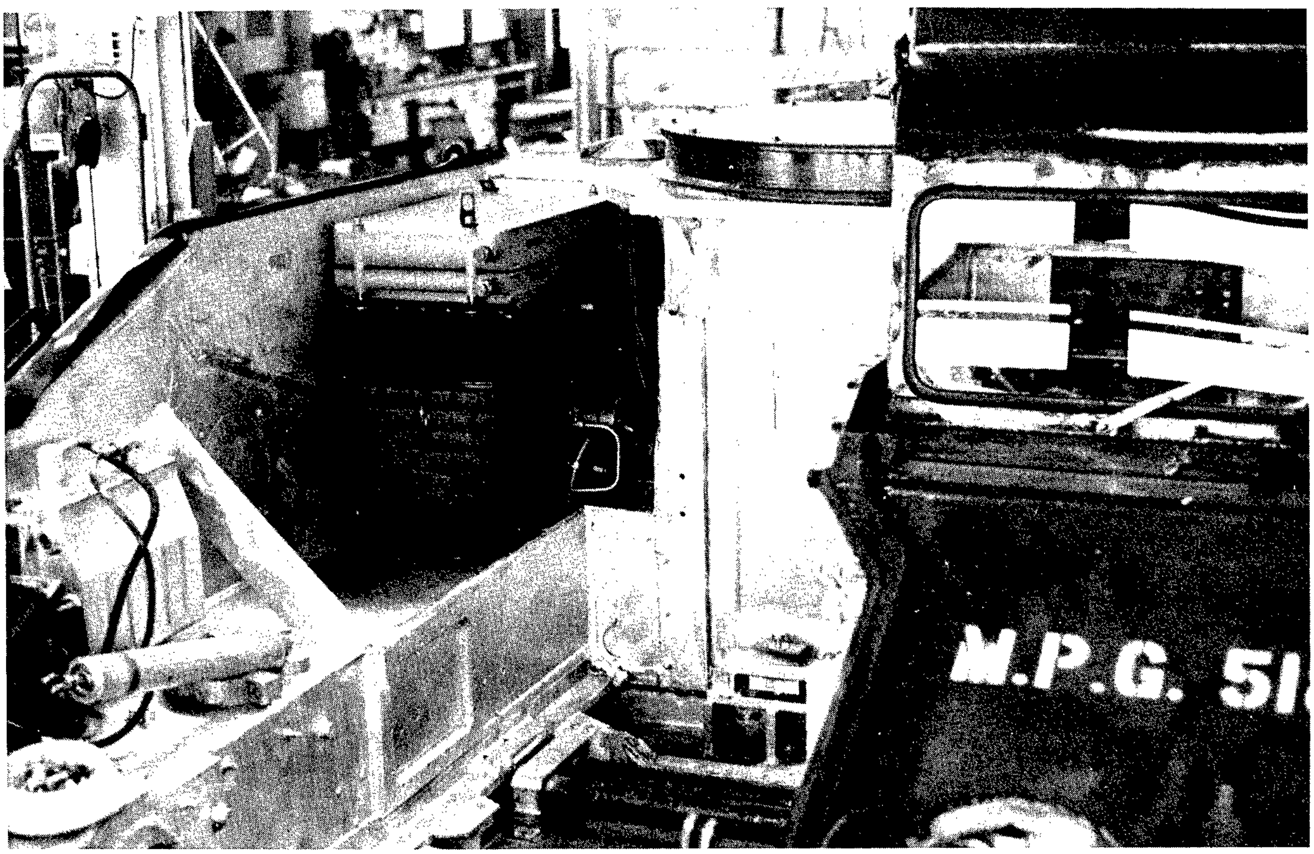


Figure 10. Cooler Package Placed in MICV Prior to Hook-Up.

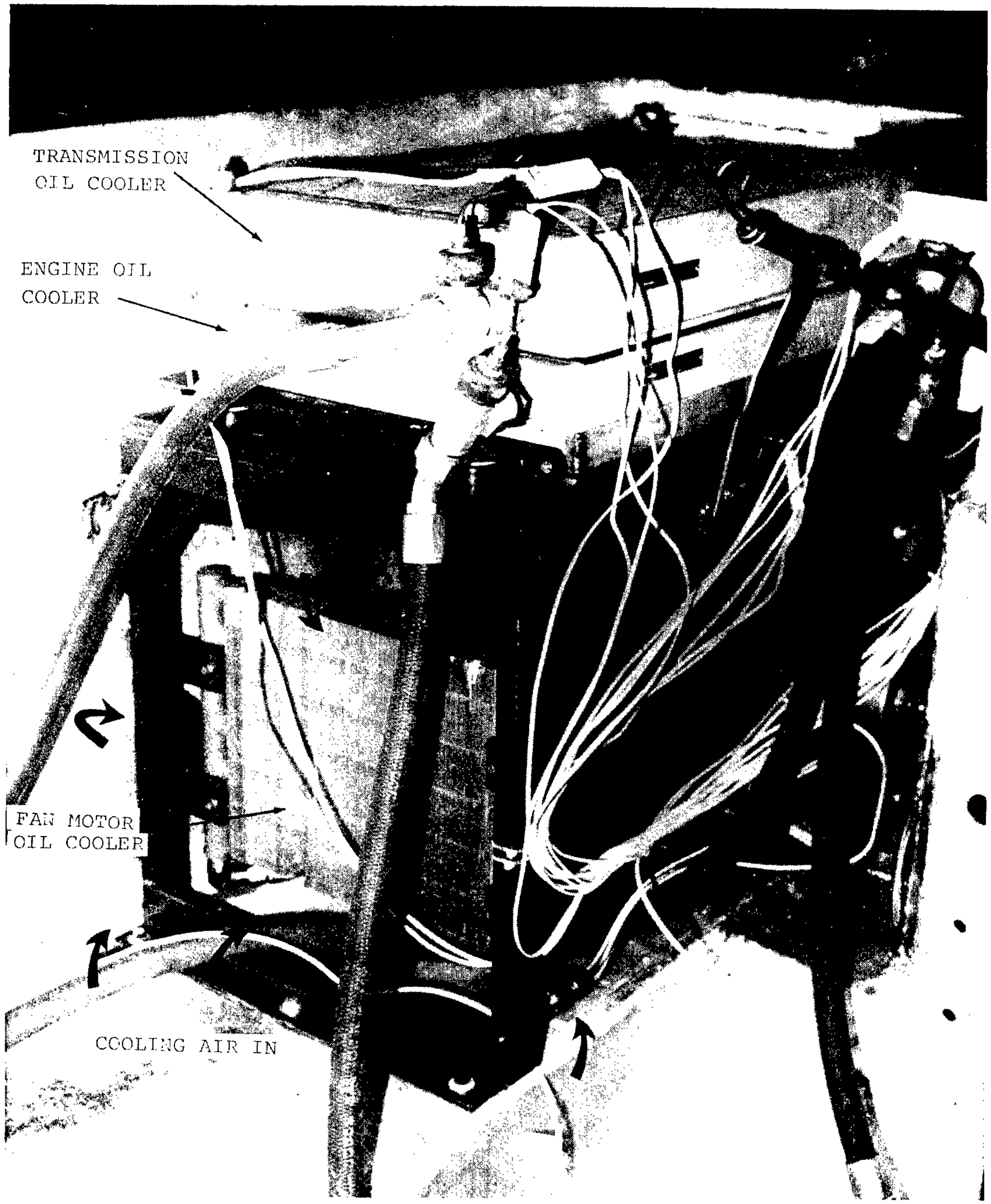


Figure 11. Instrumented Cooler Package Installed in MICV.

4- VEHICLE DRIVEABILITY TEST RESULTS

4-1 Test Purpose

The purpose of these tests was to determine at both 50- and 70-percent gas generator idle speeds the minimum level hard surface road speeds that can be maintained without brake application.

4-2 Summary of Test Results

4.2.a Variable Turbine Nozzle Vanes Controlling Automatically

50% idle - 1st gear - 1.9 MPH
- 2nd gear - 0 MPH

70% idle - 1st gear - 1.95 MPH
- 2nd gear - 3.9 MPH
- 3rd gear - 6.2 MPH

4.2.b Vanes Set at "Null"

50% idle - 1st gear - 2.05 MPH
- 2nd gear - 1.6 MPH
- 3rd gear - 0.87 MPH

70% idle - 1st gear - 4.9 MPH*
- 2nd gear - 8.7 MPH
- 3rd gear - 10.1 MPH

*For the 4.9 MPH point, the time to accelerate from 0 to 4.9 MPH was 10 seconds.

4-3 Discussion of Test

The test was conducted per Test Procedure 51-2643A. The complete list of data recorded is tabulated on the "Vehicle Driveability Test Data Sheet," DS-4375, Rev. A, Appendix A.

The GT601 control system allows the selection of either completely automatic operation in a choice of gas generator idle speeds or operation in a choice of gas generator idle speeds with "fixed position" power turbine nozzle vanes through the actuation of a "null" switch. The Section 2 summary shows that these choices allow a wide selection of vehicle idle speeds from 0 MPH to over 10 MPH. Steady-state conditions were maintained for over a minute in each configuration; in all cases, the accelerator was not depressed. Speeds in fourth gear could not be obtained since fourth range is actually automatic and the fourth gear can only be engaged at higher speeds.

When the GT601 control system is operating in the automatic mode, the variable geometry power turbine vanes control engine temperatures and power turbine speeds. When the vehicle accelerator is not depressed, the vanes attempt to maintain power turbine idle speed. Therefore, when the transmission is engaged in any gear and the accelerator is not depressed, the power turbine vanes close to accelerate the vehicle to that speed which matches power turbine idle speed. If the power turbine speed is higher than idle, as it would be on a downshift, the vanes go to a braking position, thereby slowing the vehicle down to a speed matching power turbine idle speed. This unique function provides positive vehicle braking during normal driving each time the foot is lifted from the accelerator, thereby enhancing vehicle driveability in all terrains. The vanes move to the braking position only when the accelerator is released. Therefore, no interference is experienced with normal driving. The vehicle can be driven without application of brakes, except for downgrade stopping.

Since power turbine idle speed is independent of gas generator idle speed, the vehicle speed in first gear with both 50-percent or "standby" idle and 70-percent or "mobility" idle are nearly identical. Since vehicle acceleration is enhanced by increasing gas generator idle speed (refer to Section 5, "Vehicle Acceleration"), operation at the higher idle will allow low vehicle speed operation and maintain higher acceleration capability. However, operation at the low idle point would provide the same low vehicle speed with reduced fuel consumption. In second gear at 50-percent idle, the power pack did not develop sufficient output to accelerate the vehicle.

Power turbine idle speed can be specified, depending upon the gear ratios present and the vehicle idle speeds desired. Idle speed can be changed by changing a resistor in the electronic control unit.

The "null" switch places the vanes in a fixed position that is slightly more open than the position the vanes automatically have at full power condition. The vehicle can be driven with the vanes locked in null, but normal driving fuel consumption is increased and the power turbine braking feature is lost. Therefore, if the null switch is used for obtaining a particular vehicle idle speed, it should be switched back to normal for other driving conditions. The logic for vane reversing during upshifts with the X-300 transmission will override the null switch logic for reduced clutch/gear loads.

4-4 Conclusions and Recommendations

The GT601/X-300 power pack allows a selection of 10 idle driving speeds from 0 MPH to over 10 MPH. Power turbine idle speed can be specified by the user if speeds different from those obtained in this testing are desired.

The same power turbine variable geometry that provides this capability also provides significant positive vehicle braking that enhances vehicle driveability. To quantify this braking capability, two additional tests are recommended:

Test No. 1 - <u>Vehicle Deceleration Rates</u> - On a level surface, determine vehicle deceleration times from maximum speed (approximately 40 MPH) to the intermediate speeds of 30, 20, and 10 MPH, first with the transmission in neutral and secondly in fourth range (automatic).

Test No. 2 - <u>Vehicle Balance Speed on Downgrade</u> - Determine the vehicle balance speed in both neutral and in gear on various downgrades.

5- VEHICLE ACCELERATION TEST

5-1 Test Purpose

The purpose of these tests was to determine full power vehicle acceleration times over a level, hard surface.

5-2 Summary of Test Results

The test was conducted per Test Procedure 51-2644A on smooth, flat pavement at an altitude of approximately 1,000 feet with the engine inlet air temperatures listed. The loaded vehicle weight was 45,000 pounds.

Acceleration Performance					
Engine Inlet Air Temp-T_2, °F	0-20 MPH, sec	0-30 MPH, sec	200 Meters		Shifting Sequence (Automatic)
			Time, sec	Speed, MPH	
74	7.1	14.1	19.4	35.2	2nd through 4th Gear
68	7.35	14.7	19.8	34.65	1st through 4th Gear

Figures 12 and 13 are overlays of vehicle speed versus time traces for these two runs.

Figure 14 shows these actual test results plotted as vehicle speed versus acceleration time using the 20 and 30 MPH and 200 meter data points. Also shown in Figure 14 are the same data points normalized to standard day conditions. The performance model of test engine GT601, S/N 008, was utilized to normalize the engine performance. The predicted first through fourth gear standard day accelerations for S/N 008 engine have also been included. The normalized acceleration data closely approximate the predicted accelerations for the same conditions. Detailed test data is included in the "Vehicle Acceleration Test Data Sheet" DS-4376, Rev. A, Appendix A.

Acceleration testing was conducted with two different transmission shift quadrants. With one quadrant, when the gear selector is engaged in fourth range with the vehicle stopped, the transmission automatically engages first gear and shifts to second, third, and fourth gear with increasing vehicle speed. With the other shift quadrant, when the vehicle is stopped and the operator moves the gear selector to fourth-range the transmission automatically engages second gear, bypassing first gear. Several advantages exist with this second- through fourth-quadrant. As can be seen in the test results, maximum acceleration is enhanced by starting in second-gear. This is because the engine power turbine is accelerated one less time. In first-gear, the power turbine inertia effect is relatively large. Driving comfort is also enhanced by starting in second-gear since the two-to-one gear ratio change encountered in upshifting and downshifting is avoided. Driveline loads also are reduced by eliminating first-gear in automatic operation. If conditions exist that require first-gear operation, such as a steep grade, it can still be manually selected with the quadrant. Figures 12 and 13 show the respective shift points with the two quadrants.

The engine control system can be configured to provide three separate gas generator idle speeds; a 50-percent or "standby" idle is used for engine starting and "standby" operation. It also can be used for low speed movement as discussed in Section 4, Driveability. Although all other driving could be performed from this standby idle, performance and driveability are enhanced by selecting the 70-percent or "mobility" idle setting. Most normal driving would be done with the mobility idle setting. Engine starts also can be made with this idle setting. For maximum vehicle acceleration, a maximum gas generator speed "tactical" idle can be provided. This option enhances acceleration by minimizing the time to achieve full engine power conditions. The acceleration testing was done both with the "mobility" idle and a simulated "tactical" idle setting.

Maximum N_{GG} (gas generator speed) "tactical" idle accelerations were done with an initial N_{GG} of approximately 88-percent. If gas generator speed were increased to 100-percent prior to test initiation, the resultant accelerations are predicted to be approximately 0.5 second faster.

5-4 Conclusions and Recommendations

The GT601/X-300 powered MICV loaded to 45,000 pounds GVW has demonstrated good acceleration time to 20 and 30 MPH and during a 200-meter dash to cover. The accelerations can be further improved by raising the initial gas generator tactical idle speed. Additional testing is required to verify the predicted improvement. Additional testing is also required to establish the benefits of operating the GT601 to 100-percent power turbine speed. Operation with higher power turbine speeds will result in faster balance speeds on grades (refer to Section 8, Gradeability).

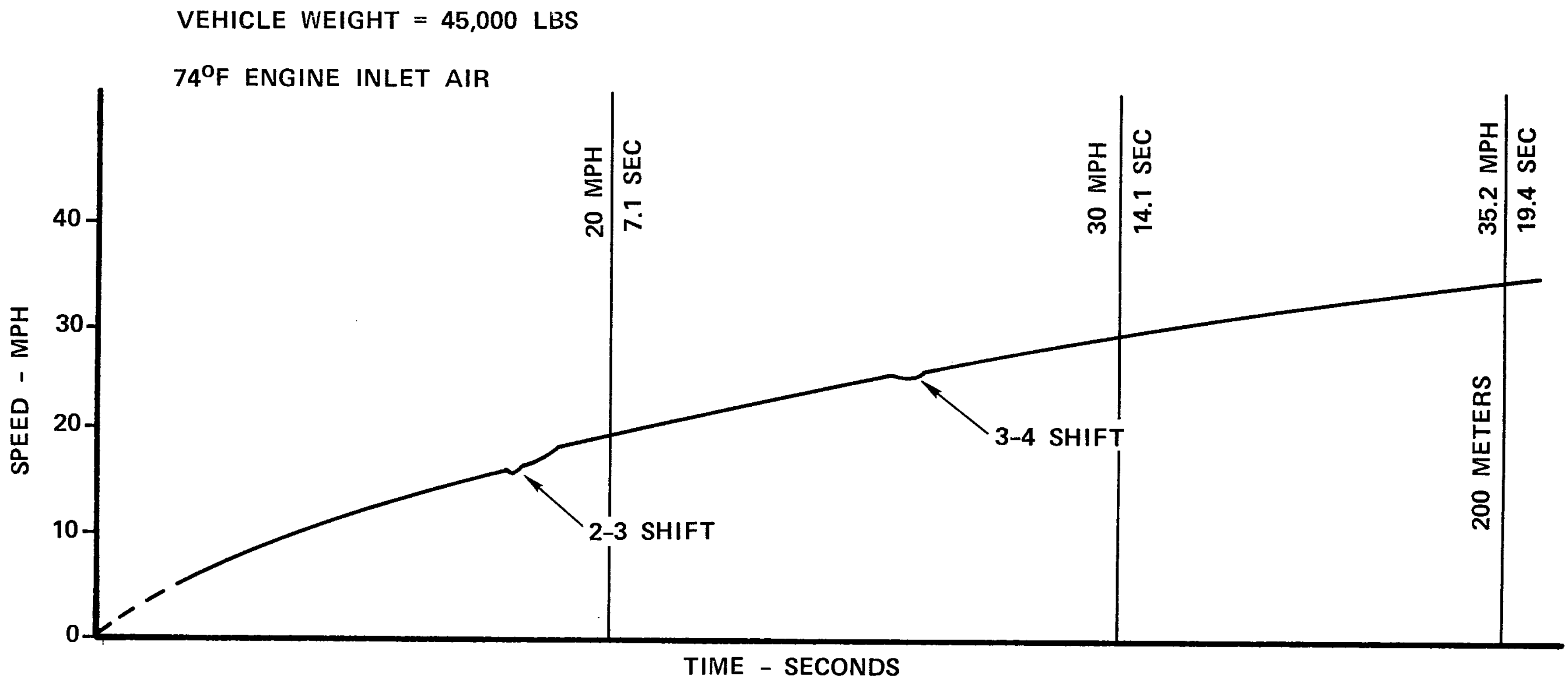


Figure 12. Acceleration Performance for 2nd through 4th Automatic Gear Shifting.

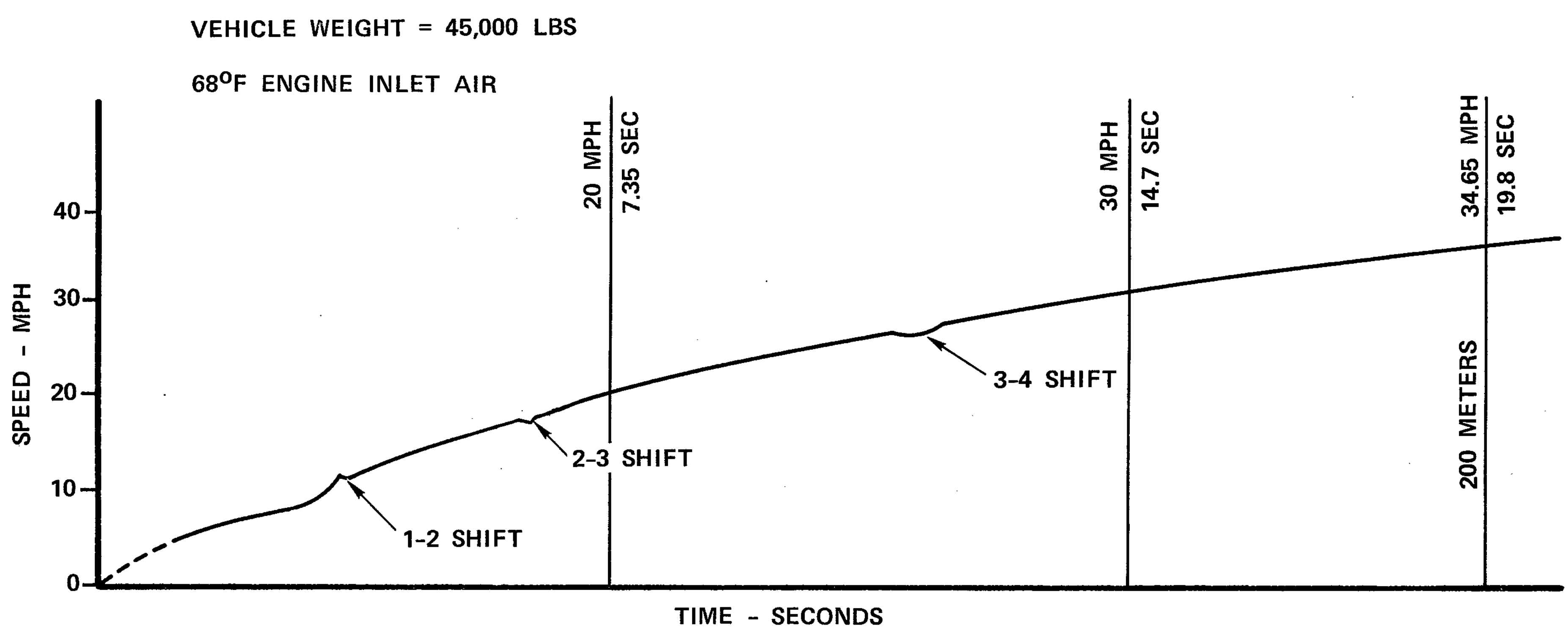


Figure 13. Acceleration Performance for 1st through 4th Automatic Gear Shifting.

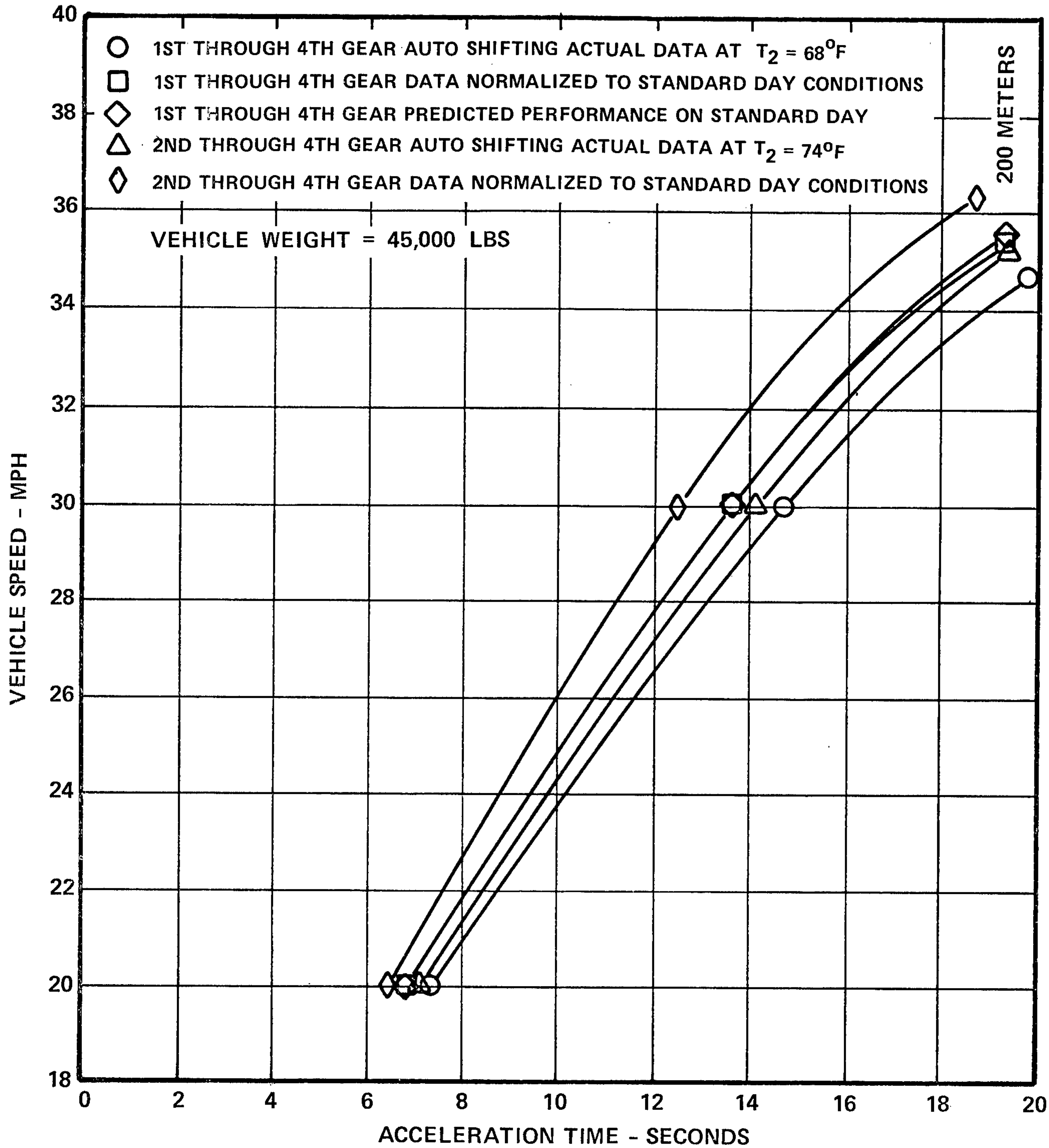


Figure 14. Speed versus Acceleration Time for 20 and 30 mph and the 200-Meter Data Points.

6- INLET BLOCKAGE EFFECTS

6-1 Test Purpose

The purpose of these tests was to determine the effect a clogged engine air filtration system has upon vehicle acceleration.

6-2 Summary of Test Results

The vehicle loaded to 45,000 pounds GVW demonstrated the following effects of inlet blockage:

Inlet Configuration	ΔP at 100%, in-H_2O	0-20 MPH, sec	0-30 MPH, sec	200 Meters, sec	Inlet Air Temp - °F
Open	12.6	7.1	14.1	19.4	74
Blocked	22.0	8.05	15.8	20.4	73

The above results are presented in Figure 15. The effect of the tested inlet blockage is an increase of the vehicle acceleration time of approximately 5-percent to cover 200 meters.

6-3 Discussion

The test was conducted per Test Procedure 51-2645A. Figure 16 is a photograph of the inlet blockage. Data is tabulated on the "Inlet Blockage Effects Test Data Sheets" DS 4378, Rev. A, Appendix A. The blockage tests were run in conjunction with the vehicle acceleration tests.

The blockage tested represents a typical field blockage over a time period. However, since the M1 tank allows up to 26 in-H_2O blockage of just the filters, additional testing is recommended at higher blockages.

6-4 Conclusions and Recommendations

A blockage which resulted in an additional 9.4 in-H_2O pressure drop in the engine inlet system resulted in only a 5-percent increase in the elapsed time required for the 200-meter dash to cover. Additional testing is recommended with larger blockages to determine the practical engine inlet blockage limit and to provide comparisons with the M1 vehicle.

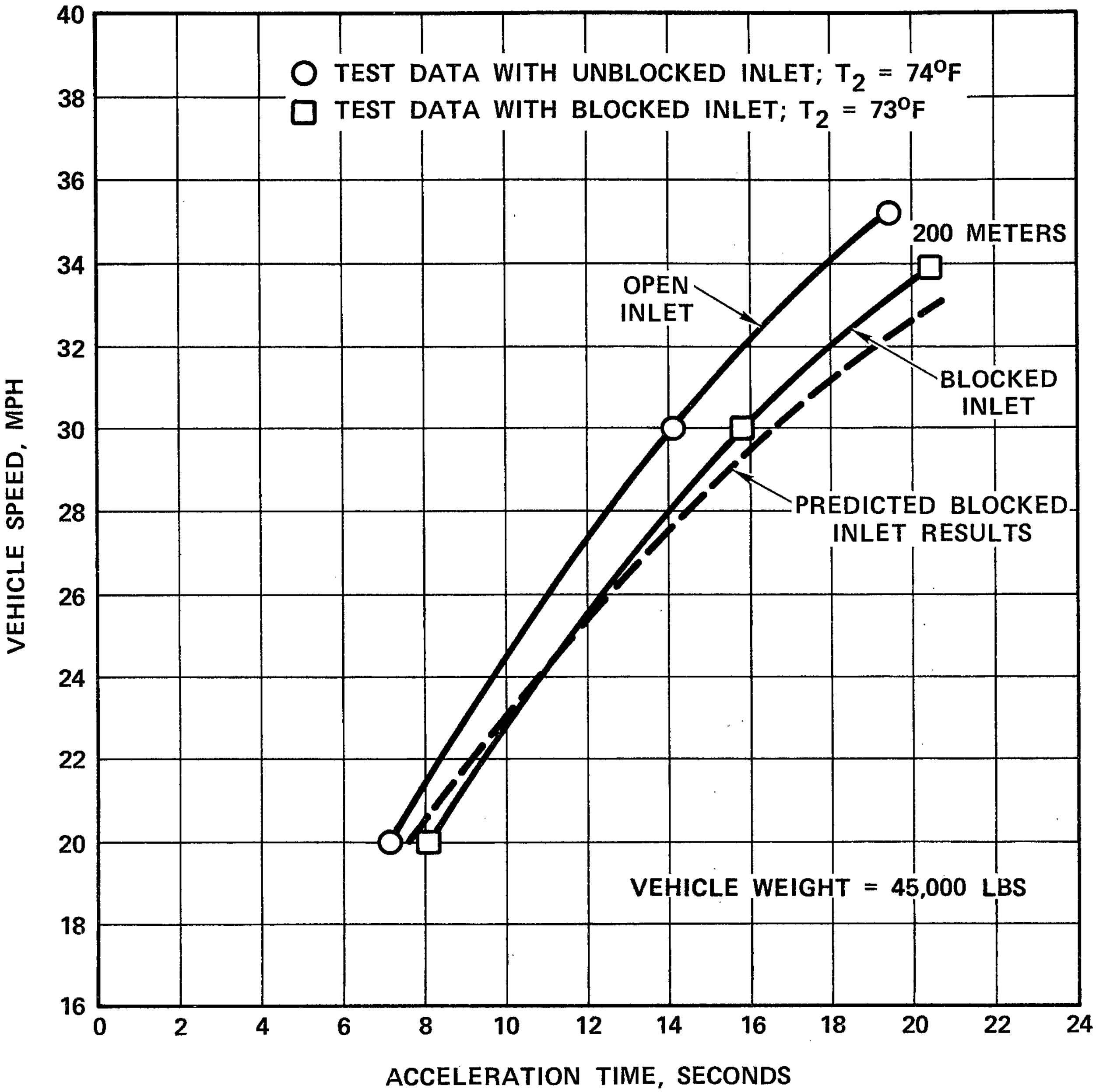


Figure 15. Inlet Blockage Test Results.

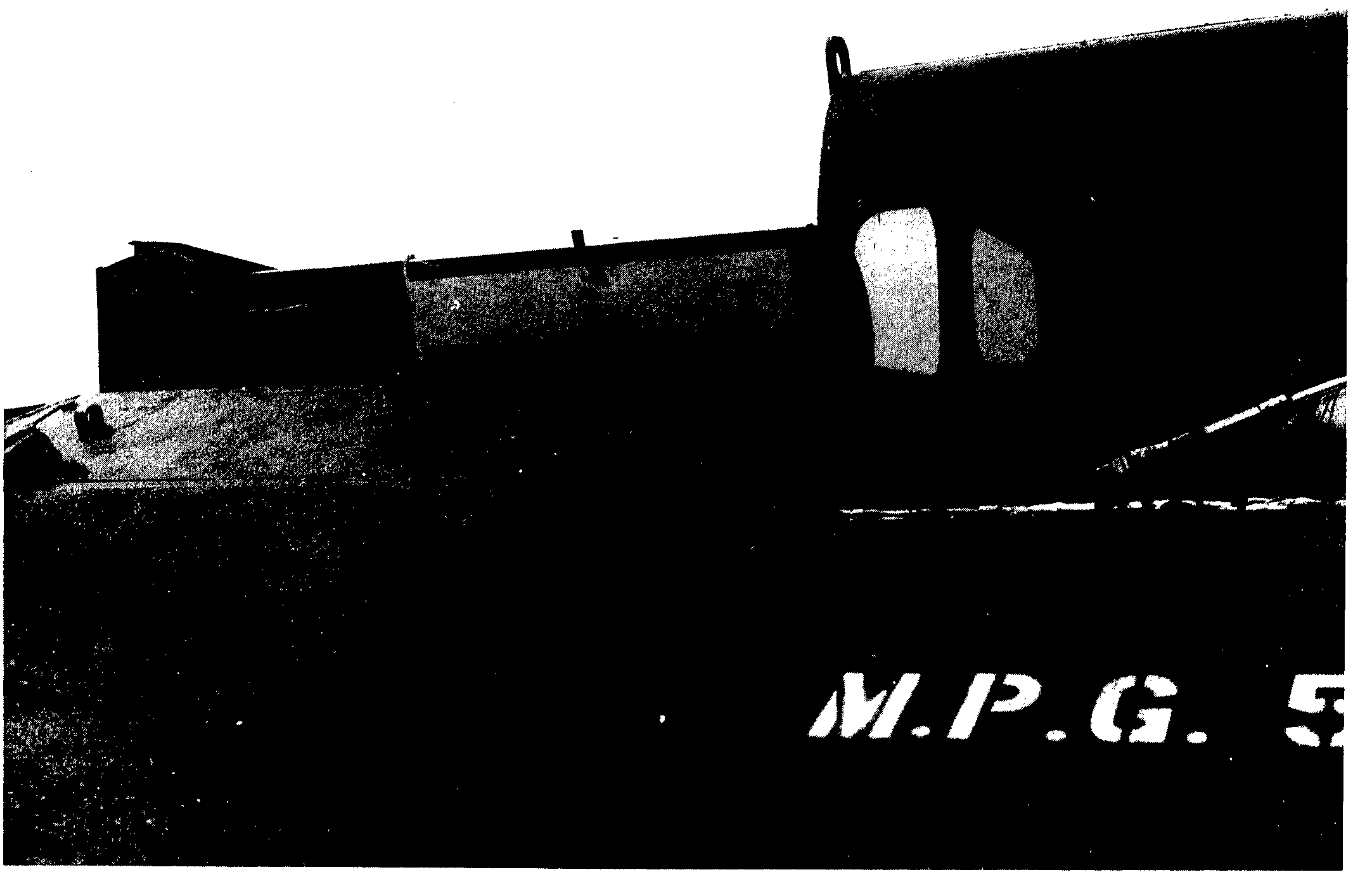


Figure 16. Inlet-Air Grill Blockage (Arrow).

7- FUEL CONSUMPTION TEST

7-1 Test Purpose

The purpose of these tests was to determine the vehicle fuel consumption over flat, hard terrain.

7-2 Summary of Test Results

The vehicle demonstrated the following fuel consumption rates on a level, paved straightaway:

Avg MPH	Actual MPG	*TMPG	Engine Inlet Air Temp °F	Average Turbine Inlet Temp - °F
12.2	1.04	23.4	74	1550
22.2	1.72	38.7	68	1700
31.0	1.91	43	74	1700
40.0	1.82	41	84	1800

*TMPG = Ton Miles Per Gallon

The above results are presented in Figure 17. Also included in Figure 17 are curves showing the above data normalized to 59°F, sea-level conditions and the computer predicted mileage for 59°F, sea-level conditions.

7-3 Discussion

The test was conducted per Test Procedure 51-2646A. The data is tabulated on the "Fuel Consumption Test Data Sheet" DS 4379, Rev. A, Appendix A. Figures 18 through 20 are photographs of the test setup.

Figure 17 shows that the mileage achieved approximates the computer predictions. Computer predictions indicate that an 11-percent increase in mileage would have resulted at the 12.2 MPH point if third gear had been selected instead of second gear in which that point was conducted.

This test was also used to establish the ratio between the left output shaft speed and vehicle speed. The constant is left output shaft speed ÷ MPH = 69.25 and is used for determining vehicle speed in other Phase II tests where output shaft speed is known.

7-4 Conclusions and Recommendations

The MICV vehicle powered by the Garrett GT601 engine and loaded to 45,000 pounds GVW has demonstrated mileage on flat, hard terrain of up to 43 ton-miles per gallon.

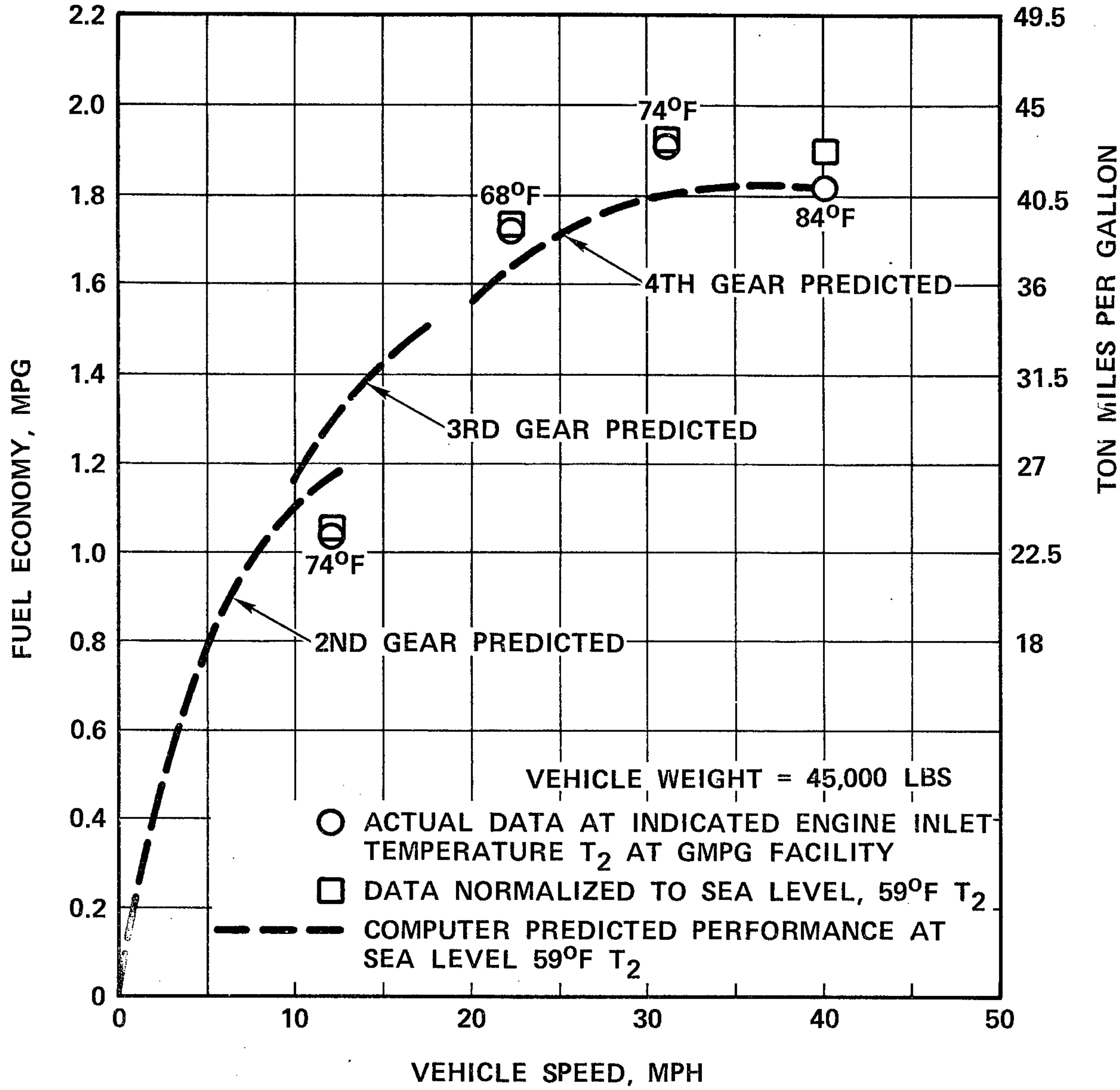


Figure 17. Fuel Consumption Test Results for a Level Paved Straightaway.

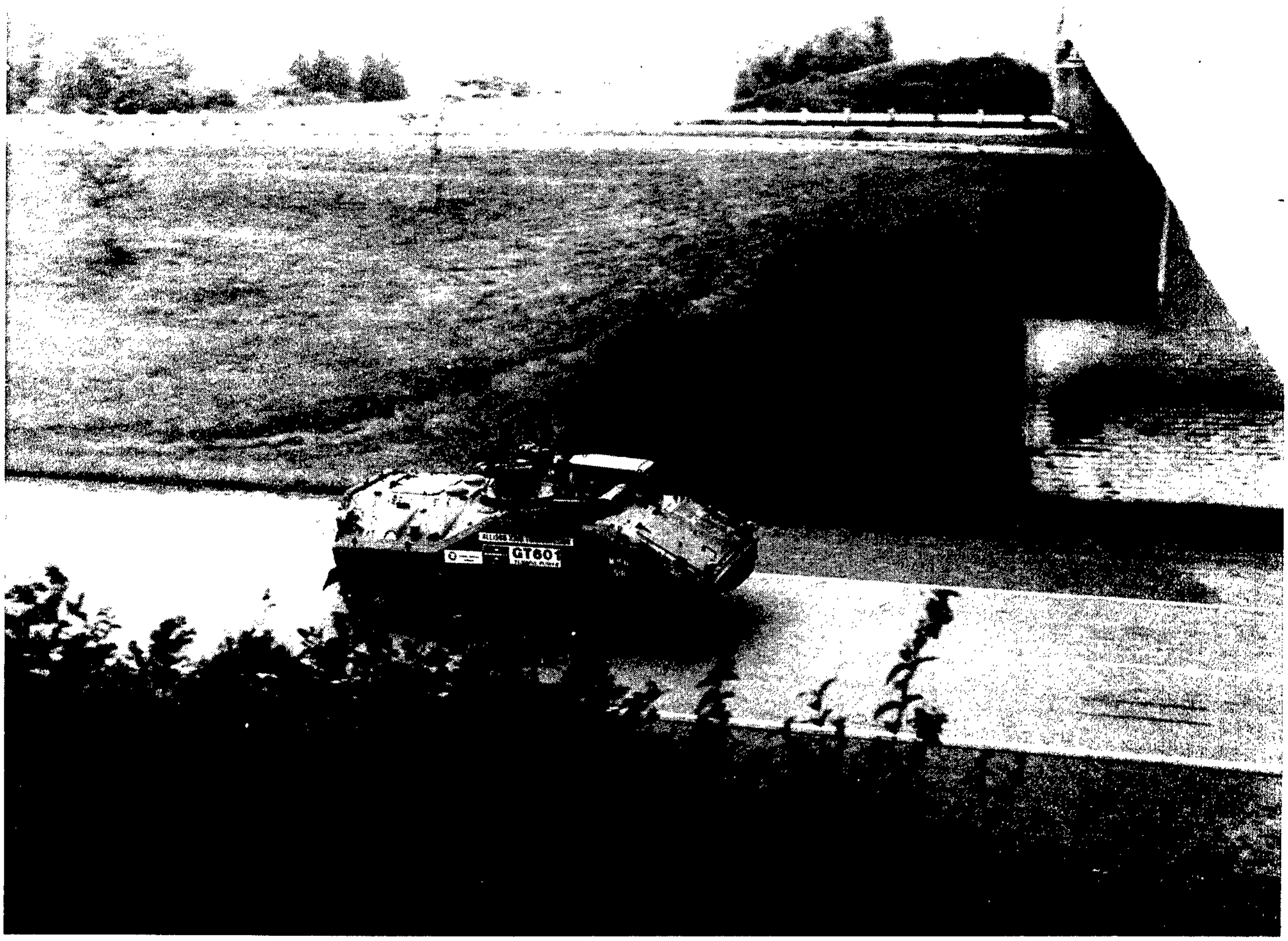


Figure 18. MICV Running Fuel Consumption Test. Note External Fuel Tank on Turret Cover.

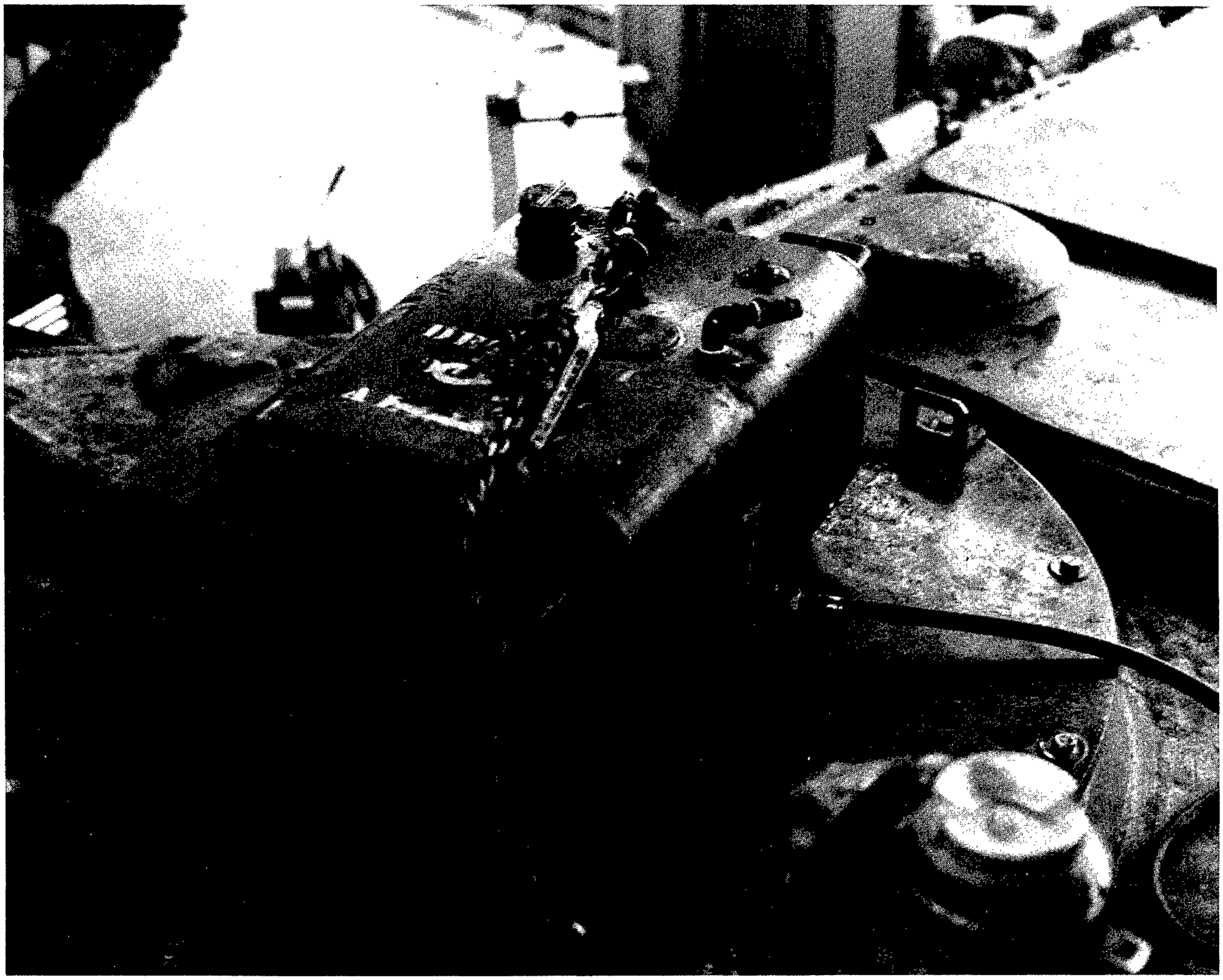


Figure 19. Close-Up of External Fuel Tank Used for Fuel Consumption Tests.

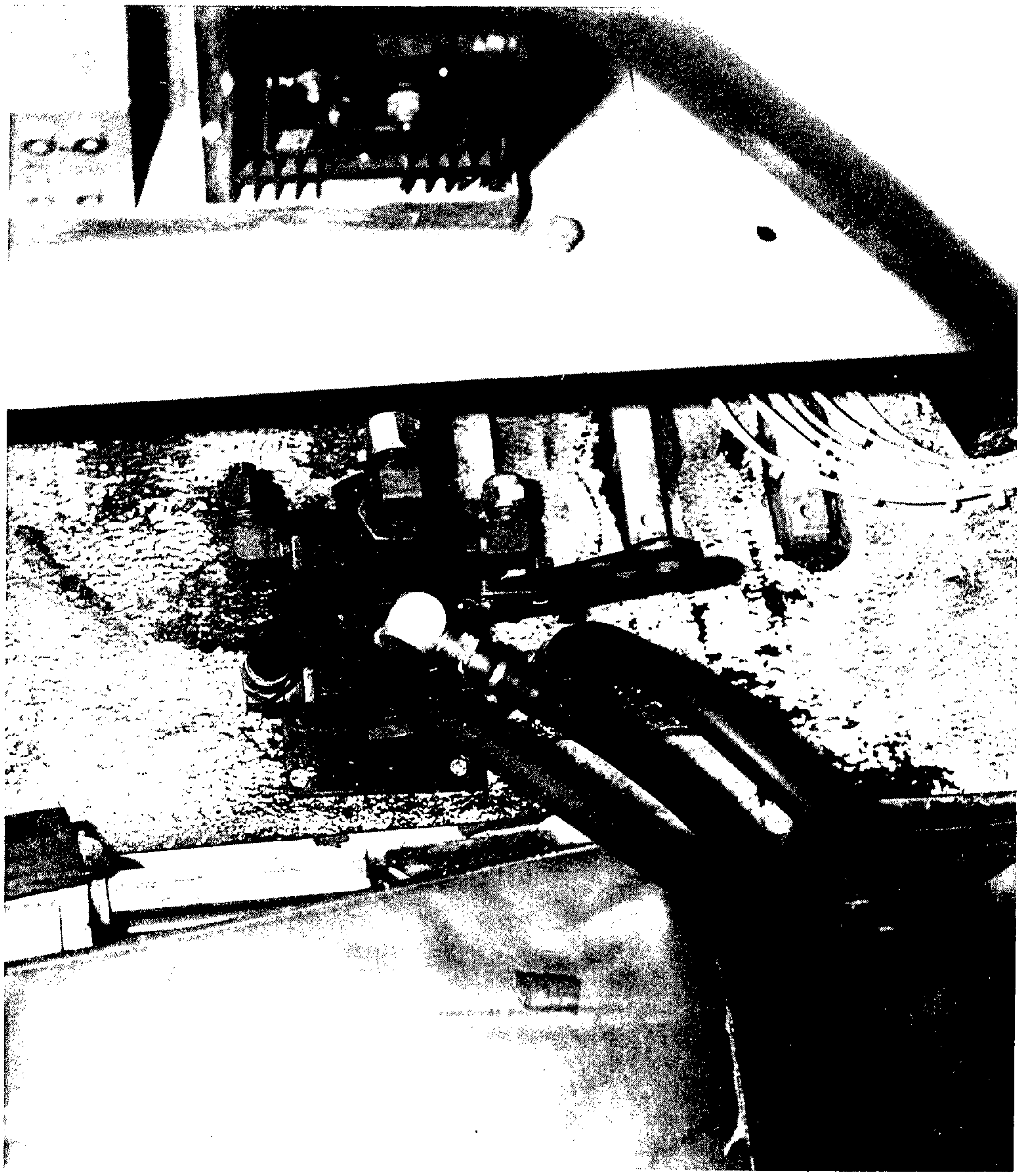


Figure 20. Closeup of 3-Way Valve Used in Fuel Consumption Testing to Switch From Internal Fuel Tanks to External Test Tanks.

8- GRADEABILITY TESTS

8-1 Test Purpose

The purpose of these tests was to determine the vehicle balance speed on various grades.

8-2 Summary of Test Results

The vehicle at 45,000 pounds GVW demonstrated the following balance speeds on various grades:

Percent Grade	Balance Speed, MPH	Engine Inlet Air Temperature (T_2) - °F
4	35.8	66
6	28.2	73
10	21.0	72
33	7.8	75

The above results are presented in Figure 21. Also included are points showing the above data normalized to 59°F, sea level conditions and the computer-predicted balance speeds for 59°F, sea level conditions.

The 60-percent grade test was not completed due to wet test facility grade conditions which could not provide sufficient vehicle traction.

8-3 Discussion

The test was conducted per Test Procedure 51-2647A. The data is tabulated on the "Vehicle Gradeability Test Data Sheet" DS 4380, Rev. A, Appendix A.

Figure 21 shows that the normalized test data closely matches the predicted gradeability for the same conditions. It is also seen that the actual and normalized points for the 33-percent grade are at the same speed. The reason that the normalized data are identical to the actual data obtained at the existing engine inlet air temperature is that the vehicle speed was limited by the maximum allowable transmission input shaft speed. If the maximum allowable power turbine speed were increased by changing the offset gearbox ratio, the vehicle speed is predicted to be approximately 1.4 MPH faster on the 33-percent grade in the next lower gear. Operation on the 33-percent grade in the next lower gear in this test yielded the same speed as the higher gear because the power turbine speed was low and, therefore, the engine was operating at a relatively low power match point. The flat spot in the predicted curve from 33-percent to 38-percent grades is created by the fact that the power turbine is not presently allowed to operate up to 100-percent speed. Noted on the curve is the standard day computer predicted balance speed on the 33-percent grade if the gear ratio in the offset gearbox were changed to allow the power turbine speed to go to 100 percent. As discussed in the acceleration section of this report, vehicle acceleration may also be enhanced by allowing higher power turbine speeds.

8-4 Conclusions and Recommendations

The MICV loaded to 45,000 pounds and powered by a GT601 engine demonstrated the ability to negotiate grades up to 33-percent at speeds closely matching the computer predictions. The 60-percent grade can also be negotiated once the grade conditions provide enough traction. Retesting gradeability with higher power turbine speeds accomplished through an offset gearbox gear ratio change is recommended to demonstrate the higher balance speeds that would be achieved.

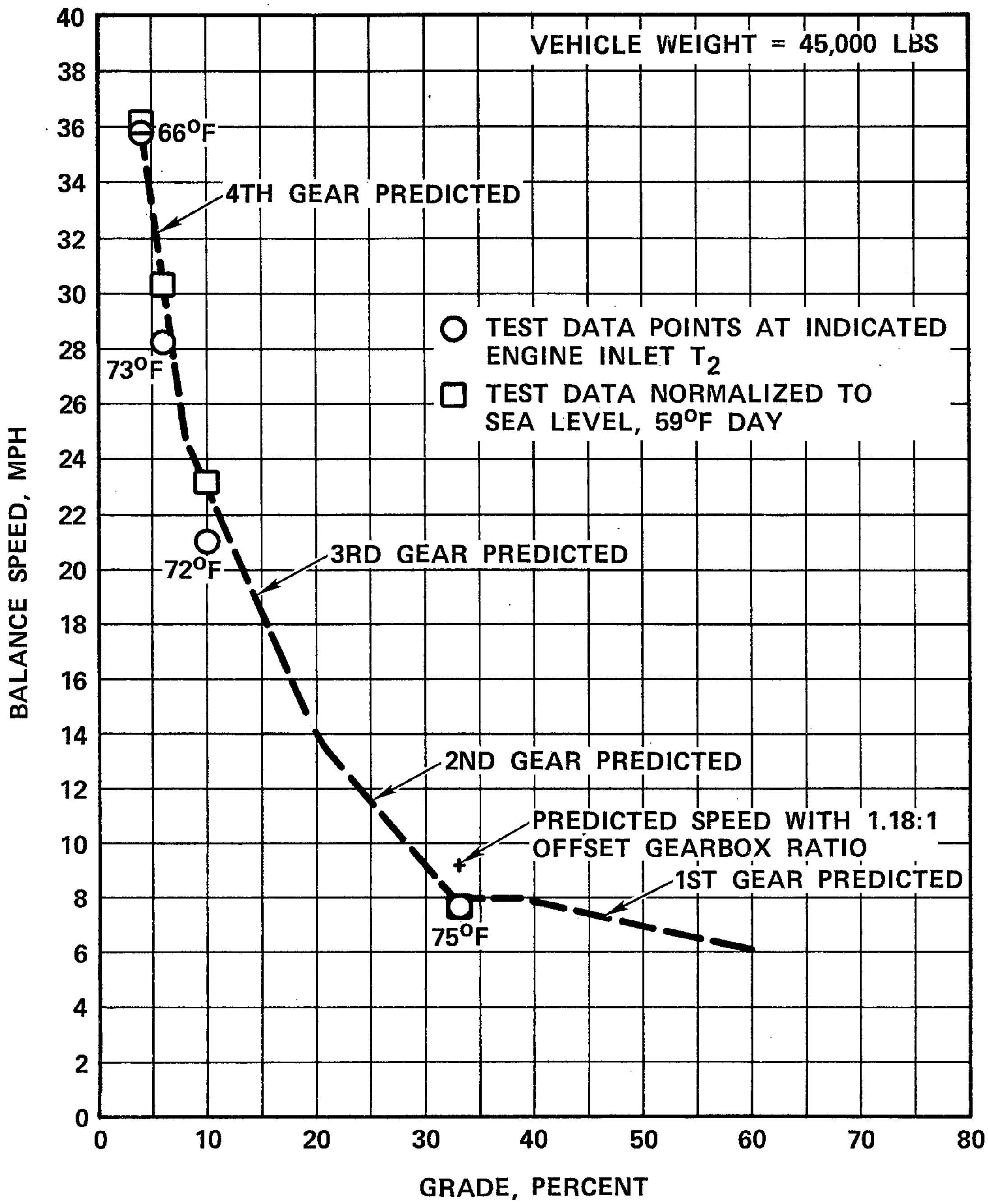


Figure 21. Gradeability Test Results.

9- VEHICLE DEMONSTRATION

A demonstration for TACOM and M1 Tank Office personnel was successfully conducted on November 5, 1981. All interested parties who desired to drive the vehicle did so on the level durability course. Favorable comments were received on many aspects including positive engine braking as discussed in Section 4, Vehicle Driveability, the relatively cool environment next to the engine compared to the M1, and the relatively cool exhaust compared to the M1 tank. The vehicle often was driven without using the brakes on level terrain. After the engine slowed the vehicle with power turbine vane braking, stops could be made by simply shifting to neutral. The M1 tank engine does not have power turbine vane braking and, therefore, brake application is required for normal deceleration from speed.

10- PHASE II SUMMARY

The TACOM Phase II demonstration testing was conducted at the GM Proving Ground at Milford, Michigan, from August 17 through November 5, 1981. The test vehicle was a MICV loaded to 45,000 pounds GVW. The power pack consisted of a Garrett GT601 gas turbine engine mated with a Detroit Diesel Allison X-300 transmission without a torque converter.

Referenced to the preceding report sections, the following nine Phase II program objectives were successfully accomplished:

- Section 1 - Determination of vibratory inputs to the engine mount system
- Section 2 - Determination of rolling resistance on level pavement and dirt
- Section 3 - Demonstration of adequate cooling system sizing (tractive effort)
- Section 4 - Demonstration of ability to maintain slow vehicle speeds without brake application (driveability)
- Section 5 - Determination of minimum acceleration times for 0 - 20 and 0 - 30 MPH, and a 200-meter dash
- Section 6 - Determination of the effects on acceleration of inlet blockage to simulate dirty air filters
- Section 7 - Determination of fuel consumption

- Section 8 - Determination of balance speed on various grades

- Section 9 - Vehicle demonstration

During the Phase II period, the GT601 accrued 114 starts, 40:11 hours, and 593 miles. No mechanical power pack problems were experienced during Phase II.

Since being installed in the MICV, the unit has accrued 245 starts, 78 hours and 1,076 miles.

The conclusions and recommendations for each of the Phase II objectives are summarized below.

Section 1 - VIBRATION

Typical vibratory input information required for the mounting of the engine and ancillary equipment has been obtained.

Section 2 - ROLLING RESISTANCE

The vehicle rolling resistance up to 20 MPH on pavement and 17.5 MPH on dirt has been determined. The force required to slide the vehicle on asphalt has also been determined.

Section 3 - TRACTIVE EFFORT

The existing engine oil and transmission oil coolers are apparently sized adequately for hot-day operation. An actual hot-day test would provide additional substantiation.

Section 4 - VEHICLE DRIVEABILITY

Any of 10 idle driving speeds from 0 MPH to over 10 MPH can be selected. The same engine power turbine variable geometry that provides this capability also provides significant positive vehicle braking that enhances vehicle driveability. To quantify this braking capability, two tests are recommended; determination of vehicle deceleration rates without brake application on a level surface, and determination of vehicle balance speed on various downgrades.

Section 5 - VEHICLE ACCELERATION

The GT601/X-300-powered MICV demonstrated good acceleration times. The accelerations can be further improved by raising the initial gas generator tactical idle speed from the 88-percent tested. Higher allowable power turbine speeds achieved through an offset gearbox gear ratio change may also enhance acceleration, and Garrett recommends testing to determine these differences.

Section 6 - INLET BLOCKAGE EFFECTS

A blockage which resulted in an additional 9.4 inches of water pressure drop in the engine inlet system resulted in only a 5-percent increase in the elapsed time required for the 200-meter dash to cover. Additional testing is recommended with larger blockages to define the practical limit for blockage and to provide comparisons with the M1 tank.

Section 7 - FUEL CONSUMPTION

A high level of mileage, up to 43 ton-miles per gallon, was demonstrated.

Section 8 - GRADEABILITY

The GT601-powered vehicle demonstrated the ability to maintain balance speeds closely matching computer predictions on grades up to 33-percent. The 60-percent grade can also be negotiated once the grade conditions provide enough traction. It is recommended that this test be performed as well as a repeat of the various grades with higher power turbine speeds achieved through an offset gearbox gear ratio change.

Section 9 - VEHICLE DEMONSTRATION

A vehicle demonstration was conducted on November 5, 1981.

It should be noted at this time that the high levels of vehicle performance obtained in Phase II testing were achieved with an early development configuration engine that did not meet the GT601 performance specifications. The GT601 bare engine nominal ratings on a standard day are 638 shaft horsepower and a specific fuel consumption (sfc) of 0.393 pounds per horsepower-hour. The actual bare engine performance of S/N 008 prior to installation in the MICV was 583 shaft horsepower and an sfc of 0.415. Garrett desires the opportunity to demonstrate the additional levels of vehicle performance obtainable with an engine of specification performance. Improvements in fuel consumption, acceleration, and gradeability are to be expected. The additional desired/recommended testing discussed in this report could also be performed at that time.

In conclusion, the following additional efforts are recommended:

- Install a GT601 engine meeting specification performance in the vehicle

- Repeat the fuel consumption, acceleration, and gradeability testing to demonstrate the improvements with a specification engine

- Demonstrate the vehicle braking obtained with the power turbine variable geometry by running the vehicle deceleration and downgrade balance speed tests described in Section 4

- Run additional vehicle acceleration testing with higher gas generator and power turbine speeds as described in Section 5

- Run inlet blockage tests with larger blockages to provide comparisons with the M1 vehicle and determine practical limits

- Run additional gradeability testing to demonstrate 60-percent gradeability and the effect of higher power turbine speeds as described in Section 8

- Examine the engine/transmission interface parameters with an engine upgraded to full performance capability

- Perform maximum braking effort and forward-reverse-forward tests to evaluate the impact of these tests on the GT601/X-300 system

Phase II testing was successfully completed on schedule and within budget.

TACOM PHASE II DEMONSTRATION
VEHICLE ROLLING RESISTANCE TEST
DATA SHEET

DS-4373, Rev A

Date 10/15/81 10/30/81 Engine S/N 008 Transmission S/N 13 Fuel Type ________

Technician J. Hess Engineer P. D. Olivier TACOM Rep ________

Item		Unit	Flat Pavement * (mph) 10-15-81						Flat Dirt ** (mph) 10-30-81					
			5	10	12.5	15	17.5	20	5	10	12.5	15	17.5	20
Ambient Air Temperature (Dry Bulb)		°F	55						54					
Relative Humidity		%	100						96					
Barometric Pressure		in Hg A	29.02						29.31					
Wind Speed and Direction		mph	WSW 6-7						ESE 6					
Drawbar Load		lbf	1700	1850	1750	1850	2125	2100	1950	2000	2000	2250	2400	--
Road Bed Temperature	Before Test	°F												
	After Test	°F												
Track Pad Temperature	Before Test	°F												
	After Test	°F												

*Additional Points:	MPH	Drawbar Load (lbf)
	7.5	1800
	14.0	1850
	16.5	1950
**Additional Point:	7.5	2000

TACOM PHASE II DEMONSTRATION
TRACTIVE EFFORT
TEST DATA SHEET

DS-4374, Rev A

Date 10/1/81 Engine S/N 008 Transmission S/N 13 Type Fuel DF2

Technician J. Hess Engineer P. Olivier TACOM Rep

Item	Units	Pre-Test Conditions	Test Runs					
			First Gear			Second Gear		
Ambient Air Temperature (Dry Bulb)	°F		53			53		
Relative Humidity	%		87			87		
Barometric Pressure	in Hg A		28.61			28.61		
Wind Speed and Direction	mph		11 W			11 W		
Vehicle Inlet Grill Air Temperature	°F		54			53		
Engine Inlet Air Temperature	°F		66			66		
Engine Compartment Air Temperature (3 Locations)	°F		172	174	131	118	89	80
Cooling Fan Inlet Temperature	°F		---			---		
Oil Cooler Inlet Air Temperature*	°F		88			87		
Oil Cooler Outlet Air Temperature*	°F		166			149		
Vehicle Outlet Grill Exhaust Temperature	°F		701			645		
Transmission Sump Oil Temperature	°F		186			176		
Transmission Oil Cooler, Oil Inlet Temperature*	°F		188			178		
Transmission Oil Cooler, Oil Outlet Temperature*	°F		164			141		
Engine Oil Cooler, Oil Inlet Temperature*	°F		129			126		
Engine Oil Cooler, Oil Outlet Temperature*	°F		58			59		
Fan Drive Reservoir Oil Temperature	°F		158			147		
Fuel Temperature into Engine	°F		---			---		
Engine Oil Temperature	°F		160			158		
Oil Temperature into Transmission	°F		172			152		
Gas Generator Speed*	rpm		37,500			37,000		
Power Turbine Speed*	rpm		24,000			25,800		
Cooling Fan Speed	rpm		1500			1450		
Left Output Shaft (Vehicle Speed)*	rpm/mph		525/7.6			1150/16.6		
Transmission Oil Flow to Cooler*	gpm		45-50			45-50		
Left Output Shaft Torque*	lb-ft		---			---		
Variable Turbine Nozzle Vane Position	vdc		2.8			2.9		
Throttle Position	vdc		Full			Full		
Turbine Inlet Temperature*	°F		1900			1880		
Drawbar Load*	lbf		16,800			6300		
Recuperator Gas Inlet Temperature**	°F		--- out			--- out		
Elapsed Time (1-second marker)*	√		10 minutes			7 minutes		

*Items to be continuously recorded.
**Power turbine exit

TACOM PHASE II DEMONSTRATION
VEHICLE DRIVEABILITY
TEST DATA SHEET
(PARAGRAPH 4.2.1)

DS-4375, Rev A

Date 8/27/81 Engine S/N 008 Transmission S/N ______ Fuel Type DF2

Technician J. Hess Engineer A. Eckstat TACOM Rep Notified

Item	Unit	50-Percent Minimum Speed in Gears				70-Percent Minimum Speed in Gears			
		1	2	3	4**	1	2	3	4 **
Ambient Air Temperature (Dry Bulb)	°F	72				70	70	70	
Relative Humidity	%	86				98	98	98	
Barometric Pressure	in Hg A	28.98				28.98	28.98	28.98	
Wind Speed and Direction	mph	SE 7-8				E 3-5	E 3-5	E 3-5	
Vehicle Inlet Grill Air Temperature	°F	83				69	69	69	
Engine Inlet Air Temperature	°F	86				74	74	74	
Engine Oil Temperature	°F	156				156	155	155	
Oil Temperature into Transmission	°F	166				168	165	168	
Gas Generator Speed*	rpm	20,530				27,470	27,450	27,280	
Power Turbine Speed*	rpm	5950				6170	5980	6060	
Left Output Shaft* (Vehicle Speed)	rpm	130				135	272	430	
	mph	1.9				1.95	3.9	6.2	
Variable Turbine Nozzle Vane Position*	vdc	Auto 2.3				Auto 0.7	Auto 1.1	Auto 1.85	
Throttle Position* (NGG ref)	vdc	Off 1.4				Off 2.35	Off 2.35	Off 2.35	
Turbine Inlet Temperature*	°F	1070				1040	960	1000	
*Elapsed Time on Condition (1 second marker)	Seconds	150				100	100	70	

*Items to be continuously recorded
**Gear selection in fourth range is automatic

TACOM PHASE II DEMONSTRATION
VEHICLE DRIVEABILITY
TEST DATA SHEET
(PARAGRAPH 4.2.2)

DS-4375, Rev A

Date 8/27/81 Engine S/N 008 Transmission S/N 13 Fuel Type DF2

Technician J. Hess Engineer A. Eckstat TACOM Rep Notified

Item	Unit	50-Percent Minimum Speed in Gears				70-Percent Minimum Speed in Gears			
		1	2	3	4**	1	2	3	4**
Ambient Air Temperature (Dry Bulb)	°F	70	70	70		70	70	70	
Relative Humidity	%	98	98	98		98	98	98	
Barometric Pressure	in Hg A	28.98	28.98	28.98		28.98	28.98	28.98	
Wind Speed and Direction	mph	E 3-5	E 3-5	E 3-5		E 3-5	E 3-5	E 3-5	
Vehicle Inlet Grill Air Temperature	°F	76	75	75		72	70	69	
Engine Inlet Air Temperature	°F	80	79	80		77	76	75	
Engine Oil Temperature	°F	156	155	154		157	156	156	
Oil Temperature into Transmission	°F	143	144	147		161	166	169	
Gas Generator Speed*	rpm	20,370	20,310	20,220		27,250	27,040	27,000	
Power Turbine Speed*	rpm	6500	2400	800		15,400	13,220	9900	
Left Output Shaft* (Vehicle Speed)	rpm	142	110	60		337	600	700	
	mph	2.05	1.6	0.87		4.9	8.7	10.1	
Variable Turbine Nozzle Vane Position*	vdc	Null 2.8	Null 2.8	Null 2.8		Null 2.8	Null 2.8	Null 2.8	
Throttle Position* (NGG ref)	vdc	Off 1.4	Off 1.4	Off 1.4		Off 2.35	Off 2.35	Off 2.35	
Turbine Inlet Temperature*	°F	1140	1160	1160		920	1070	1140	
*Elapsed Time on Condition (1 second marker)	Seconds	110	190	140		120	90	110	

*Items to be continuously recorded
**The gear selection in 4th range is automatic

TACOM PHASE II DEMONSTRATION
VEHICLE ACCELERATION
TEST DATA SHEET

DS-4376, Rev A

Date Sept. 9-10, 1981 Engine S/N 008 Transmission S/N 13 Fuel Type DF2

Technician J. Hess Engineer D. L. Starr TACOM Rep

Item	Unit	1st-4th Gears Acceleration with High Idle			2nd-4th Gears Acceleration with High Idle			1st-4th Gears Acceleration with Maximum N_{GG}			2nd-4th Gears Acceleration with Maximum N_{GG}		
		20 mph	30 mph	200 Meters	20 mph	30 mph	200 Meters	20 mph	30 mph	200 Meters	20 mph	30 mph	200 Meters
Ambient Air Temperature (Dry Bulb)	°F	61			64			61			64		
Relative Humidity	%	100			43			100			43		
Barometric Pressure	in Hg A	28.76			28.93			28.76			28.93		
Wind Speed and Direction	mph	8 SW			6 WSW			8 SW			6 WSW		
Vehicle Inlet Grill Air Temperature	°F	63			67			63			67		
Engine Inlet Air Temperature	°F	67			74			68			74		
Engine Oil Temperature	°F	156			162			158			160		
Oil Temperature into Transmission	°F	159			158			157			157		
ΔP Inlet Grill to Engine Inlet (1)	in H_2O ΔP	12.4	11.2	12.5	12.0	10.6	11.8	12.4	11.7	12.5	12.6	11.4	12.4
Gas Generator Speed* (1)	rpm	36,700	36,200	38,000	37,100	36,300	37,600	36,800	36,350	37,800	37,500	36,400	37,700
Power Turbine Speed* (1)	rpm	19,500	19,300	22,600	19,300	19,300	22,400	14,700	19,200	22,300	19,200	19,300	22,800
Left Output Shaft* (Vehicle Speed)	rpm	1,385	2078	2,430 35.1 mph	1,385	2,078	2,405 34.7 mph	1,385	2,078	2,400 34.65 mph	1,385	2,078	2,440 35.2 mph
Variable Turbine Nozzle Vane Position* (1)	vdc	3.2	3	2.85	3.1	3	2.8	3.1	2.95	2.9	3.1	3	2.9
Elapsed Time (1-second marker)*	√	8.35	15.2	---	8.5	15.8	---	7.35	14.7	---	7.1	14.1	---
Elapsed Time (Stopwatch)	seconds	---	---	20.5	---	---	20.9	---	---	19.8	---	---	19.4
Turbine Inlet Temperature* (1)	°F	1870	1920	1910	1880	1925	1910	1870	1915	1910	1880	1920	1900
Recuperator Inlet Gas Temperature** (1)	°F	1190	1200	1190	1175	1175	1175	1210	1210	1200	1225	1215	1210
Throttle Position*	vdc	Full			Full			Full			Full		

*Continuously recorded
**Power turbine exit
(1) Noisy trace. readings are best estimate

TACOM PHASE II DEMONSTRATION
INLET BLOCKAGE EFFECTS
TEST DATA SHEET

DS-4378, Rev A

Date 9-11-81 Engine S/N 008 Transmission S/N 13 Fuel Type DF2

Technician J. Hess Engineer D. L. Starr TACOM Rep

Item	Unit	Test Conditions		Test Points With Blockage			Test Points With Blockage Removed		
		Without Blockage	20-24 In H2OΔP	20 MPH	30 MPH	200 Meters	20 MPH	30 MPH	200 Meters
Ambient Air Temperature (Dry Bulb)	°F			68			64		
Relative Humidity	%			100			43		
Barometric Pressure	in Hg A			28.90			28.93		
Wind Speed and Direction	mph			5 WSW			6 WSW		
Vehicle Inlet Grill Air Temperature	°F			67			67		
Engine Inlet Air Temperature	°F			73			74		
Engine Oil Temperature	°F			157			160		
Oil Temperature into Transmission	°F			155			157		
ΔP Inlet Grill to Engine Inlet*	in $H_2O\Delta P$			21.8	20.6	22	12.6	11.4	12.4
Gas Generator Speed* (1)	rpm			36,900	36,600	37,800	37,500	36,400	37,700
Power Turbine Speed* (1)	rpm			19,800	19,300	22,000	19,300	19,300	22,800
Left Output Shaft* (Vehicle Speed)	rpm			1385	2078	2350 33.9 mph	1385	2078	2440 35.2 mph
Variable Turbine Nozzle Vane Position* (1)	vdc			3.1	2.95	2.9	3.1	3	2.9
Throttle Position*	vdc			Full			Full		
Turbine Inlet Temperature* (1)	°F			1870	1925	1905	1880	1920	1900
Recuperator Gas Inlet Temperature** (1)	°F			1195	1195	1190	1225	1215	1210
Elapsed Time* (1 second marker)	minutes			8.05	15.8	20.4	7.1	14.1	19.4

*Items to be continuously recorded
**Power turbine exit
(1)Noisy trace. readings are best estimate

TACOM PHASE II DEMONSTRATION
FUEL CONSUMPTION TEST DATA SHEET

DS-4379, Rev. A

Date 9/1-2/81 Engine S/N 008 Transmission S/N 13

Fuel Type DF-2 Technician Jack Hess

Engineer P.D. Olivier Tacom Rep

Item	Units	Level Hard Surface Test Speeds			
		12.2 mph	22.2 mph	31.0 mph	40 mph
Ambient Air Temperature (Dry Bulb)	°F	64	64	70	80
Relative Humidity	%	100	100	100	80
Vehicle Inlet Grill Air Temperature	°F	65	63	70	79
Engine Inlet Air Temperature	°F	74	68	74	84
Barometric Pressure	In-HgA	28.88	28.86	28.78	28.73
Fuel Consumption [Ref. Par. 5.3(C)]	MPG	1.04	1.72	1.91	1.82
	TMPG	23.4	38.7	43	41
Engine Compartment Air Temperature (3 locations)	°F	118 143 114	88 109 105	115 151 125	121 148 127
Engine Inlet Fuel Temperature	°F	64	62	69	78
Engine Oil Temperature	°F	159	155	157	162
Transmission Inlet Oil Temperature	°F	151	162	154	163
Wind Speed and Direction	mph	4-5 NE	3-4 NNE	5 SW	4-8 SSW
*Gas Generator Speed	rpm (avg)	25,000	28,000	29,500	31,500
*Power Turbine Speed	rpm (avg)	18,500	21,500	20,000	25,500
*Left Output Shaft (Vehicle Speed)	rpm (avg)	846	1535	2150	2770
*Fuel flow	lb/hr (avg)	73	88	125	165
*Throttle Position	vdc (avg)	2.45	2.75	2.85	3.7
*Turbine Inlet Temperature	°F (avg)	1550	1700	1700	1800
Elapsed Time (Stopwatch)	minutes	24:33	27:04	19:20	15:00
*Recuperator Gas Inlet Temperature (Power Turbine Exit)	°F (avg)	1240	1220	1210	1230

*Continuously Recorded

TACOM PHASE II DEMONSTRATION
VEHICLE GRADEABILITY
TEST DATA SHEET

DS-4380, Rev. A

Date 9/15/81 Engine S/N 008 Transmission S/N 13 Type Fuel DF2

Technician J. Hess Engineer A. G. Eckstat TACOM Rep

Item	Unit	Test Points			
		4-Percent Grade	6-Percent Grade	10-Percent Grade	33-Percent Grade
Ambient Air Temperature (Dry Bulb)	°F	59	67	67	70
Relative Humidity	%	90	41	41	100
Barometric Pressure	in. Hg A	28.97	28.66	28.66	29.07
Wind Speed and Direction	mph	8 NNE	8-11 NNE	8-11 NNE	Calm
Vehicle Inlet Grill Air Temperature	°F	61	66	66	70
Engine Inlet Air Temperature	°F	66	73	72	75
Engine Oil Temperature	°F	160	157	158	160
Oil Temperature into Transmission	°F	175	175	176	163
Gas Generator Speed*	rpm	36,000	36,500	37,300	35,000
Power Turbine Speed*	rpm	23,400	18,000	20,600	26,200
Left Output Shaft* (Vehicle Speed)	rpm/mph	2480/35.8	1954/28.2	1455/21.0	540/7.8
Variable Turbine Nozzle Vane Position	vdc	3.2	2.85	2.9	3.5
Throttle Position	vdc	Full	Full	Full	Full
Turbine Inlet Temperature*	°F	1900	1880	1880	1800
Recuperator Gas Inlet Temperature**	°F	1165	1150	1130	Out
Elapsed Time (1 second marker)	seconds	13	6	4	5

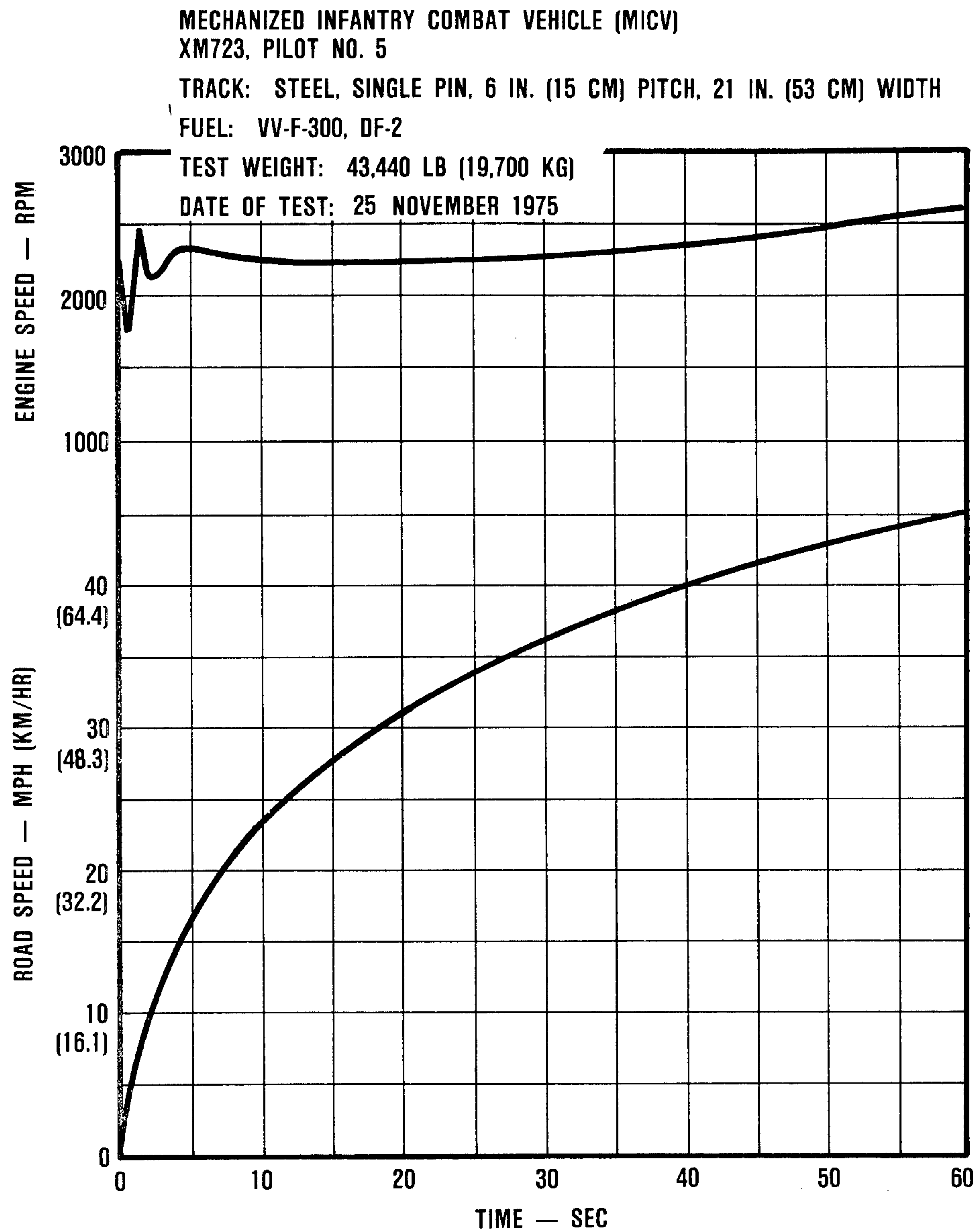
*Items to be continuously recorded.
**Power turbine exit

APPENDIX B

The data contained in Appendix B were obtained from diesel-powered MICV testing conducted at Aberdeen Proving Ground MD, in 1975. It is included for information purposes only and is not intended as a direct comparison to GT601/X-300 MICV test data due to differences in test conditions.

Test Parameter	GT601 Test	Diesel Test
Vehicle Weight (lbs)	45,000	43,400
Test Site	GM Proving Ground	Aberdeen Proving Ground
Test Data	September, 1981	November-December, 1975
Fuel Consumption	Steady-State	Munson Standard Fuel and Modified Standard Fuel Courses
Gradeability	Hard Dirt	Hard Surface

CONTENTS:


MECHANIZED INFANTRY COMBAT VEHICLE (MICV)
XM723, PILOT NO. 5
TRACK: STEEL, SINGLE PIN, 6 IN. (15 CM) PITCH, 21 IN. (53 CM) WIDTH
FUEL: VV-F-300, DF-2
TEST WEIGHT: 43,440 LB (19,700 KG)
DATE OF TEST: 25 NOVEMBER 1975
ENGINE SPEED — RPM
3000
2000
1000
ROAD SPEED — MPH (KM/HR)
40
(64.4)
30
(48.3)
20
(32.2)
10
(16.1)
0
0
10
20
30
40
50
60
TIME — SEC

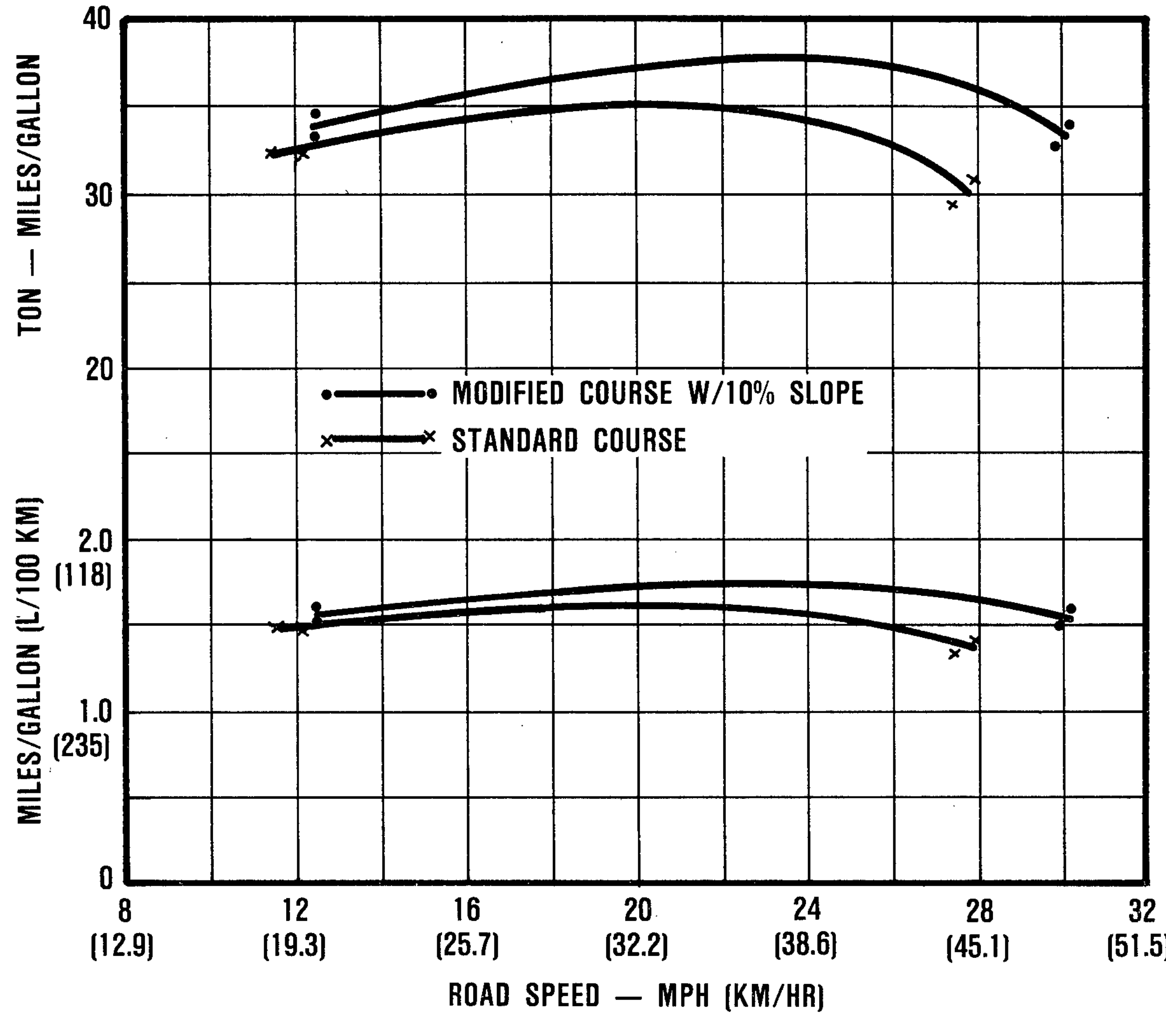
MECHANIZED INFANTRY COMBAT VEHICLE (MICV)
XM723, PILOT NO. 6

TRACK: STEEL, SINGLE PIN, 6 IN. (15 CM) PITCH, 21 IN. (53 CM) WIDTH

FUEL: VV-F-300, DF-2

TEST WEIGHT: 43,440 LB (19,700 KG)

DATE OF TEST: NOVEMBER 1975



MECHANIZED INFANTRY COMBAT VEHICLE (MICV)
XM723, PILOT NO. 6

LONGITUDINAL SLOPE PERFORMANCE — HARD SURFACE

TRACK: STEEL, SINGLE PIN, 6 IN. (15 CM) PITCH, 21 IN. (53 CM) WIDTH

FUEL: VV-F-300, DF-2

TEST WEIGHT: 43,440 LB (19,700 KG)

DATE OF TEST: 3 DECEMBER 1975

NOTE: 50% AND 60% SLOPE DATA WERE COMPUTED. DURING ACTUAL TESTS VEHICLE LOST TRACTION ON THESE SLOPES.