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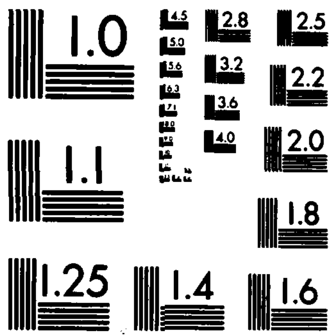

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TECHNICAL REPORT ARFSD-TR-86001

TEST OF NARROW TIRES ON M198 TOWED HOWITZER

CHARLES WIDMER

JULY 1986

US ARMY
ARMAMENT
MUNITIONS &
CHEMICAL COMMAND
ARMAMENT R&D CENTER

U. S. ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER
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This report is part of an overall study for an improved air loading procedure for the M198 howitzer, as applied to the C-130 aircraft. The intent of this study was to isolate and examine the effects imposed on the M198 system resulting from the replacement of the present wide (16.5 X 19.5) tires with narrower (10:00 - 20G) tires over various terrains for limited distances.

The value of this study lies in the understanding and knowledge gained about pneumatic tires and how their inflation pressures and widths affect weapons handling and road shock absorption.

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A

FOREWORD

The approved procedure for loading an M198 towed howitzer aboard a C-130 cargo aircraft was judged unacceptable by the United States Army Forces Command (FORSCOM). That procedure required 556 linear feet of rough cut, 2- by 12-inch lumber per howitzer to raise the weapon above the A/A 33H-A4 Low Altitude Parachute Extraction System (LAPES) rails attached to the floor of the aircraft.

On 21 July 1981, a loading technique using narrower tires and wheels was demonstrated at Fort Bragg, NC. The narrow tires reduced the overall width of the M198 by approximately 12 inches, allowing the howitzer to fit between the LAPES rails of the aircraft. This eliminated the need for the lumber.

The user expressed concern that it might not be practicable to replace the narrow tires with standard tires (for travel) immediately upon exiting the aircraft and requested authorization to tow the howitzer 10- to 15-km with the narrow tires installed. Without such additional operational testing, the narrow tires were not considered a complete solution.

CONTENTS

INTRODUCTION

The pneumatic tires of a towed artillery weapon are required to operate safely for sustained periods of time under a wide range of conditions. These conditions include temperatures ranging from -65°F to +140°F and maneuvers over various types of terrain while supporting heavy loads. Additionally, the tires must transmit the forces which guide and brake the vehicle, must maintain a constant axle height, and must have the flexibility required to absorb road rugosity. Thus, weapon stability, shock loads transmitted to the howitzer, and tire temperature are the principal operational elements subjected to the tests recorded in this report.

Weapon stability was monitored, at various speeds, over test courses at Aberdeen Proving Ground (APG), Maryland. These courses included 2-inch washboard, 6-inch washboard, Belgian block, 3-inch spaced bump, gravel, and cross-country tours of varying severity. Video cameras recorded the stability of the weapon and accelerometers mounted to the spindles recorded the g-loads transmitted through the tires. The g-loading was of concern to the scientific community primarily because of the inflation pressure required by the narrow tires. The recommended pressure was 100 psi compared to 45 psi for the standard tires.

Previous Army Research and Development Center (ARDC) studies indicated that the inflation pressure of standard tires (45 psi to 90 psi) did not significantly (.01 level of significance) affect weapon stability or g-loads recorded at the spindles when towed over Belgian block courses at 10 and 15 mph. (See reference 1 and appendix A.) As towing speed increased, weapon stability appeared to diminish with lower inflation pressure. Lowering the pressure did not significantly affect road shock. ARDC anticipated similar results with the narrow tires. "Hysteresis, which has been found to damp the verticle motion of the axle with a non-rotating wheel, appears to be practically absent with a rotating tire once the rate of rolling becomes high as compared to the rate of deflection. Instead, hysteresis produced rolling resistance," according to reference 2.

As a result of tire deformation and hysteresis, heat is generated within the tires. [High tire temperature directly affects the service life of tires (ref 3).] Literature warns that severe testing often results in tread separation from the cord body. This is caused by thermal degradation and high centrifugal force. Since the contact patch of a narrow tire is on the road surface for a longer period of time than the contact patch of a wide tire at the same inflation pressure (app A), the narrow tire runs hotter.

DISCUSSION

Comparison of Standard and Proposed Narrow Wheel Assemblies

Either wheel assembly must be capable of supporting the howitzer under various dynamic conditions. Since the howitzer weighs approximately 15,530 pounds, each tire must be capable of supporting 5,830 pounds when the weapon is stowed and 7,415 pounds when it is traveling. The dynamic loading the wheel assemblies see when the weapon is stowed is comparable to that seen during air transport; whereas, the load seen when the weapon is in travel position is comparable to that seen during towing exercises. Although each wheel assembly must function under the the same constraints, inherent differences in their components must be taken into consideration.

The standard wheel assembly consists of a 16.5 x 19.5 tubeless tire (16-ply rating) mounted to a one-piece rim. At an inflation pressure of 45 psi, as called for by the operator's manual (ref 3), the load carrying capability is approximately 5,360 pounds per tire. This under-inflated condition can result in weapon handling problems, premature tire failure, and rim damage resulting from bottoming out. Rim damage was recorded during earlier XM198 tests prior to the addition of two 0.625-inch-diameter rods welded to the rim for added strength.

The proposed wheel and tire assembly consists of a narrower (10.00-20G) tube-type tire (14-ply rating), mounted to a correspondingly narrow three-piece rim, and requires higher inflation pressure to achieve the same load carrying capability as the standard (larger) tire. (A tube is required because of the split rim design.) At an inflation pressure of 100 psi, the load carrying capability, per tire, is approximately 6,040 pounds; contact area is reduced, and ground contact pressure is incresed. Tube-type tires tend to increase tire operating temperature and, on occasion, the tube may shift within the tire. When a shift does occur, tire balance changes causing vibration and uneven tire wear. In extreme cases, the valve stem may tear, resulting in a flat tire.

Although the three-piece split rim permits more expedient mounting and dismounting of the tires, additional equipment and safety requirements are recommended to prevent injury resulting from possible explosive separation of rim components. Refer to appendix B and reference 4 for safety concerns associated with multi-rim wheels.

When the narrower tire assemblies are installed, there is a reduction in the width of the weapon from 111 inches to 99 inches at the wheel hub, and the location of the load center on the wheel hub moves inward toward the outer wheel bearing.

Ideally, the load center should be proportionally distributed between the wheel bearings. With the standard wheel assemblies, the load center is outward of the outer bearing, placing more load on the outer bearing and less on the inner bearing, as well as more leverage on the axle. Numerous equipment performance reports (EPR) relating to hub and bearing failures have been recorded. The reduction in overall width of the weapon is expected to result in less than 5 degrees maneuverability when traversing side slopes.

Although the proposed narrow tire inflated to 100 psi has similar load handling capabilities when compared to the standard tire inflated to 45 psi, increasing the inflation pressure of the standard tire increases its load handling capability to 8,440 pounds. Less tire deformation, lower tire operating temperature, and increased tire life are additional benefits (app A). However, this test did not specifically address these issues; and, for comparative purposes, the recommended inflation pressure (45 psi) called out in the operator's manual was used.

TEST RESULTS

The tests were conducted with weapon S/N 240 at Aberdeen Proving Ground, Maryland. Before and after the tests, a complete visual and physical examination of the howitzer, as well as other items under test, was conducted. The tests are summarized under the following headings:

Certification of g-Load Capabilities

Objective of Test. Satisfy air transportability requirements as specified by MIL-A-8421F.

Requirement. Demonstrate the capability of the proposed wheel and tire assemblies to withstand a downward vertical force of 1/2 g for duration of 0.1 second.

Test Procedure. Testing was accomplished by dropping the howitzer, in battery position, from a suspended quick-release mechanism. The severity of the test was increased by dropping the howitzer in battery position (axle wt. 14,830 lb) as opposed to dropping the howitzer in the stowed position (axle wt. 11,660 lb) as configured during air transportation aboard the C-130 aircraft. Accelerometers attached to the left and right spindles recorded g-loads. Oscillograph traces and high speed photography recorded the events. The height of the drop was gradually increased until the requirements were satisfied.

Results. See table 1.

Conclusion. The wheel and tire assemblies satisfactorily withstood the required 4.5 g-load for a duration of 0.1 second.

Table 1. Drop test

Event no.	Height of drop (in.)	Right spindle g-load	Right spindle Duration (sec)	Left spindle g-load	Left spindle Duration (sec)
1	6	3.6	.210	3.4	0.230
2	9	4.0	.230	3.8	0.240
3	12	4.6	.190	4.4	0.230
4	12	4.5	.220	4.3	0.210

Instrumented Towing

Objective of Test

1. Record g-loads at the spindles.

2. Compare performance of the standard and narrow tire.

Requirement. Tow at various speeds not inducing weapon instability or exceeding a vertical load of 6 g.

Test Procedure. Weapon stability and g-loads were monitored at various speeds and tire inflation pressures over terrains of varying severity. Test courses included 2-inch washboard, 6-inch washboard Belgian block, 3-inch spaced bump, gravel, and cross-country. Towing speeds were increased until the weapon became unstable, the 6-g limit was exceeded, or until reasonable speeds (as determined from previous tests) were reached.

Accelerometers were attached to the road arm spindles of each wheel assembly. The data recorded was transcribed onto oscillographs and analyzed to determine the ampitude distribution of the vibration levels recorded during the test. The proposed narrow tires were tested at inflation pressures of 80 and 100 psi; the standard tires were tested at 45 psi.

Vertical forces were limited to 6 g's based on previous testing experience as well as design criteria of other subassemblies located on the howitzer. (Typically, load factors used for initial chassis design are 5 g's for maximum speeds of less than 30 mph and 12 g's for maximum speeds of more than 30 mph (ref 5).

Results. No instance occurred in which the weapon became unstable or the 6-g design limit was exceeded. Although current maximum recommended operational towing speeds for both the Belgian block and cross-country courses were exceeded by 5 mph, the recorded vertical g-loads remained well below 6 g's.

Typical g-loads for each test course are listed in table 2. A 99% confidence level was used to eliminate the probability of noise. The g-loads listed in table 2 are not considered absolute values. Differences in values due to random variation are significant. The following findings were the result of a statistical analysis performed by Aberdeen Proving Ground.

1. There is no significant difference in g-loads between the high pressure narrow tires (100 psi) and the standard tires (45 psi). This is in agreement with previous ARDC finds (app A).

2. The low pressure narrow tires (80 psi) produce significantly higher g-loads than the standard tires (45 psi).

3. The low pressure narrow tires (80 psi) produce significantly higher g-loads than the high-pressure narrow tires (100 psi).

Conclusions. There are no significant differences in weapon handling and stability or g-loads between narrow tires, inflated to their recommended pressure of 100 psi, and standard tires inflated to 45 psi. Shock loads resulting from normal operational towing with the narrow tires installed are not critical. No instances occurred during testing in which the shock loading exceeded the 6-g maximum.

Table 2. Instrumented towing comparisons

g-loads recorded at spindles
(99% confidence level)

	Test no.	6-in. washboard 2 mph	6-in. washboard 2 1/2 mph	Belgian block 10 mph	Belgian block 15 mph	2-in. washboard 2 mph	2-in. washboard 5 mph	3-in. spaced bump 5 mph	3-in. spaced bump 10 mph	Gravel 10 mph	Gravel 25 mph	X-country 5 mph	X-country 10 mph
Wide tire (45 psi)	1	0.73	0.96	1.66	2.11	1.82	1.56	1.40	2.89	1.43	1.34	0.96	1.40
	2			1.68	2.55	3.07		2.31	3.14	1.38	2.30	0.79	1.82
	3												1.65
	4												1.69
Narrow tire (80 psi)		.73	1.15	1.85	3.08	1.83	2.25	1.73	3.07	0.86	1.81		
Narrow tire (100 psi)	1	1.20	1.09	3.23	3.43	1.33	2.75	1.41	5.14	1.06	0.94	0.82	1.82
	2			2.03	3.53	1.14	1.55		3.78	0.46	0.99	0.93	1.96

Temperature Test

Objective of Test. Monitor and record tire temperature at various towing speeds.

Requirement. Tire temperature must not exceed 250°F.

Test Procedure. Tests were conducted on a level, straight, and hard (macadam) surface. Inflation pressure was carefully checked prior to the start of each series of tests. Towing speeds were held constant until tire temperature stabilized.

Three methods of temperature measurement were utilized. The instruments used for these measurements included temperature indicator labels, infrared gun, and thermocouple needles. Each method has its advantages and disadvantages.

Temperature indicator labels were glued to the inner surface of the tires prior to the start of each test. Temperature was monitored by heat sensitive dots sealed under transparent windows on the labels. The dots turn from light grey to black at the temperature rating specified on the label. Accuracy is on the order of ± 1°F. Due to the heat, flexing of the tire, and the friction between the tire and the tube (in the instance of the narrow tires), loss of adhesion and readibility problems occurred. In some cases the original order, consisting of a series of temperature indicator labels bracketing each temperature range, had to be recreated due to the loss of adhesion. Friction between tire compounds caused material to adhere to the surface of the labels making readings extremely difficult. (Examination of the temperature indicator labels was time consuming because of their location inside the tires.)

More continuous monitoring could be accomplished using an infrared gun or thermocouple needles. An infrared gun was used for monitoring outside tire temperature. In this instance, temperature readings were immediate but not as accurate as either the temperature indicator label method or the thermocouple method. (Distance between the object being recorded and the gun must be held constant for accurate readings.) Surface debris on the tire may also affect readings. Outside tire temperature is known to be of a lower magnitude than internal tire temperature. The highest temperature occurs between the plies of the tire. Thermocouple needles provided the means to monitor between-ply temperature. Several small holes were drilled into the tires to permit insertion of the needles. (Temperature is affected by the insertion depth of the needles.) The tires were run at a constant speed until the temperature stabilized.

Results. Tire temperature was directly affected by variations in towing speed. Initial testing of the narrow tires (100 psi), run at a constant speed of 50 mph, resulted in tire temperature exceeding the 250°F maximum. Measurements were recorded with temperature indicator labels. Ultimately the maximum allowable towing speeds for continuous operation would be controlled by tire temperature. The results from this initial test led to additional tests to determine what that maximum speed would be. Maximum speed was determined by running the narrow tires at 20, 30, 40, and 50 mph and recording tire temperature at each speed.

The results recorded with thermocouple needles are summarized in tables 3 and 4. Typical infrared gun readings taken at the tire's outside surface were 30° to 40°F below that of the readings recorded between the tire's plies with the termocouple needles. Part 2 of the test was run to assure that tire temperature stabilized.

Table 3. Narrow tire temperature test (part 1)

Velocity (mph)		Max temp (°F) (Recorded with thermocouple needle)	Approx max temp (°F recorded with IR gun)	Duration (hr)
Target	(Calc avg)			
50	45.0	223	195	1
40	38.7	208	171	1
30	30.5	188	158	1
20	20.3	193	150	1

Note: Inflation pressure 80 psi at start of test. Ambient temperature approximately 71°F.

Table 4. Narrow tire temperature test (part 2)

Velocity (mph)		Max temp (°F)	Duration (hr)
Target	(Calc avg)		
50	47.6	233	1
50	46.8	238	2

Note: Inflation pressure of 80 psi at start of test was estimated to be 110 psi at completion of test (max gauge reading 100 psi).

Based on the test data, an operational towing speed limitation of 40 mph was proposed. Typically, the operating temperature of automotive tires is 212°F. Tests at 50 mph using standard tires inflated to 45 psi revealed temperature of approximately 210°F. Accurate readings were difficult because of the damaged condition of the temperature indicator labels. Comparable temperatures resulted (i.e., 208°F) with narrow tires at 40 mph.

Conclusions. At 40 mph, the proposed narrow tires run at a temperature of approximately 210°F. Increasing the towing speed to 47 mph brings the operating temperature to 238°F, critically close to the 250°F maximum recommended by the tire industry.

Performance Test

Objective of Test. To determine the general performance capabilities of the proposed narrow tires in the following areas:

1. Braking
2. Towing over severe cross-country and mud courses
3. Traversing side slope
4. Turning diameter
5. Bead slip
6. Rolling distance

Requirements

1. The braking distance, at 20 mph, of the howitzer with narrow tires and M813 prime mover (5-ton truck) shall not exceed 40 feet.

2. The mobility characteristics of the howitzer when equipped with narrow tires shall not be degraded.

3. The truck coupled to the howitzer shall be capable of traversing a side slope of at least 30%.

4. The tires shall not slip on the rim at any time during testing.

Test Procedure

1. Braking distance was measured on a dry, high speed, paved road surface. First the truck was tested alone; then, with the howitzer equipped with narrow tires inflated to 80 psi and 100 psi.

2. The howitzer equipped with narrow tires was traversed over side slopes ranging from 10 to 40%. The tires were inflated to 80 psi (worst case).

3. Right- and left-turning diameters of the howitzer with narrow tires were measured when coupled to the truck.

4. Index lines were painted on the narrow tire and rim to test for bead slippage.

5. Rolling distance was determined by towing the howitzer forward one complete revolution of the wheel. Measurements were taken for both standard and narrow tires.

Results

1. Braking. Straight line tracking and weapon stability was demonstrated during braking. Braking distances are presented in table 5.

Table 5. M813 truck coupled to M198 howitzer* with proposed narrow tires installed--stopping distance

M813 truck				M813 truck/M198 howitzer combination			
Speed		Distance		551 kPa	(80 psi)	689 kPa	(100 psi)
km/hr	(mph)	(m)	(ft)	(m)	(ft)	(m)	(ft)
16.1	(10)	2.0	(6.6)	2.0	(6.6)	2.2	(7.2)
32.2	(20)	7.2	(23.7)	7.6	(24.9)	8.0	(26.2)
48.3	(30)	17.3	(56.6)	17.0	(55.7)	18.0	(59.1)
64.4	(40)	32.6	(107)	30.5	(100)	33.2	(109)

* M198 howitzer brake system life at time of measurement approximately 125 miles.

2. Side Slopes. Testing criteria in the past (DT II) has included 30% side slopes. The narrow tires were tested on side slopes up to an including 40%. The 30% requirement was exceeded, although some slippage was noted while traversing the 40% slope.

3. Bead Slip Test. Visual examination of index lines indicated that no slippage had occurred.

4. Turning Diameter. Turning diameters of the howitzer with narrow tires when coupled to the truck were as follows:

Left turn: 21.7 m (71.3 ft)

Right turn: 23 m (75.4 ft)

5. Rolling Distance. Mean rolling distances were as follows:

Standard tires at 310 kPa (45 psi)

3.082 m/rev (10.11 ft/rev)

Narrow tires at 551 kPa (80 psi)

3.152 m/rev (10.34 ft/rev)

Narrow tires at 689 kPa (100 psi)

3.179 m/rev (10.43 ft/rev)

6. Severe Cross-Country and Mud Course. The course was characterized by extremely rough terrain including marshy areas with swamp-type vegetation. Mud ranged from light (with free water) to cohesive. The variety of mud conditions, both in substance and depth, provided varying degrees of severity for testing.

Typical course profile was characterized by repetitive bumps spaced in a pattern. The horizontal distance from high to low averaged 13.75 feet and the vertical distance from low to high averaged 12.50 feet. An M548 tracked vehicle was required for this test. Tests were conducted with narrow tires inflated to 100 psi.

Mud mixed with water was visually observed reaching hub center lines while crossing test course hollows. No evidence of plowing (mud buildup forward of the wheels) was exhibited. The howitzer handled satisfactorily during all maneuvers. At no time did the howitzer restrict forward movement of the prime mover.

Conclusions. The proposed narrow tire meets all performance criteria and compares favorably with performance previously exhibited by the standard tire.

1. No appreciable difference in braking characteristics was demonstrated when comparing the stopping distance of the truck only with the truck/howitzer combination (narrow tires installed). This indicates that neither the truck nor the howitzer was braking excessively. A comparison of current test results with initial production tests revealed no degradation in stopping distance resulting from the proposed narrow tires. Braking distance was slightly decreased when using the lower tire pressure.

2. Although the turning diameter appeared to be reduced by approximately 9.5 feet compared to previous tests with standard tires, this is not a valid observation since the same truck was not used. (Variations in the turning diameter between trucks may be as much as 10 feet.)

3. Rolling distance was greater with the narrow tires than with the standard tires. Increasing the inflation pressure from 80 psi to 100 psi further increased rolling distance.

Endurance Test

Objective of Test. The objective of this test was to determine the handling characteristics of the howitzer over various road surfaces; to determine the endurance of the proposed tires and rims through resistance to wear; and to note any punctures or damage which might occur.

Requirements

1. The howitzer shall remain stable over all road surfaces.

2. The proposed rims shall be free of any damage following road operations.

3. The proposed tires shall not experience any abnormal wear, tread splitting, stone cutting, bead chaffing, or rubber separation.

Test Procedure

1. Tread depth, visual inspection of the tire, and magnetic particle inspection of the rims were performed prior to, during, and following the tests.

2. The prime mover was loaded with an equivalent of the high-density payload it is intended to carry. The howitzer, with narrow tires, was coupled to the truck and towed over the Munson and Perryman test courses.

Results

1. The howitzer equipped with the narrow tires remained stable over both courses. No discontinuities or indication of cracks or other defects were found. Visual examination of the tires indicated no splitting, cutting or rubber separation. Discussion with drivers who had towed M198 howitzers having standard tires revealed that they experienced no difference in handling when the narrow tires were installed.

2. Average tread wear for the narrow tires was 7.90 mm (0.311 in.) for tire no. 1 and 4.95 mm (0.195 in.) for tire no. 2. Comparison data for a standard tire taken from a similar test (howitzer S/N 287) revealed that tread wear of 1.27 mm (0.05 in.) was considered excessive. Based on this comparison, tread wear for the narrow tire is considered excessive. Some puckering of the tread was also noted. A summary of distance traveled with the narrow tires is given in table 6.

Conclusion. Although the narrow wheels were not damaged by the endurance test, the narrow tires were considered to have worn excessively. Further testing for durability is in order. No degradation in handling was observed.

Table 6. Summary of miles towed

Course	Narrow tire no. 1	Narrow tire no. 2	Narrow tire no. 3
Paved[a,b]	549	575	194
Munson vibration[b,c]	42	42	0
Perryman X-country no. 1,2,3[b,c]	115	100	15
Perryman X-country no. 4[d]	20	20	0
Gravel[c]	17	17	0
Total	743	554	209

[a] These figures include temperature and braking subtests.

[b] Video coverage was taken of howitzer's reaction while on this course.

[c] These figures include instrumentation subtests.

[d] M548 prime mover.

Human Factors

Objective of Test

1. Determine the most expedient method for changing wheels.

2. Determine manpower requirement to install the standard wheel assemblies to the side of a 5-ton truck.

Evaluation

1. The most expedient method for changing wheels requires 16 minutes each and consists of the following:

a. Leaving pintle attached to prime mover

b. Attaching baseplate to howitzer

c. Moving wheels to up position

2. To lift the standard wheel (approx 264 lb) to truck bed height requires four men. With difficulty, three men are capable of performing the same task.

Comments

Ground clearance with the narrow tires installed and inflated to 100 psi is approximately 19 inches.

Although the narrow tires when inflated to 100 psi are capable of carrying the load, the standard tires do so when inflated to 45 psi. However, both tires would be operating in an overloaded condition; by increasing the pressure of the standard tires to 90 psi, the load limit is returned to the safe zone. (See tables 7 and 8.)

Load and inflation pressure greatly affect the service life of tires. The percentage of total service life (percentage of service life due to inflation multiplied by the percentage of service life due to loading) is considerably worse for the proposed narrow tires than for the standard tires inflated to 90 psi (table 9).

Table 7. Percentage of loads

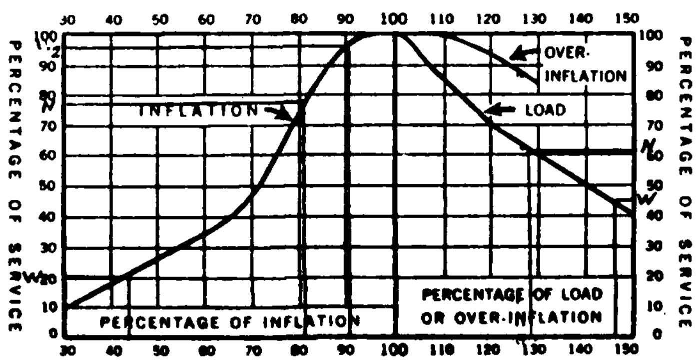
STD tire	STD tire	Narrow tire
(45 psi)	(90 psi)	(100 psi)
147%	92%	129%

Table 8. Percentage of inflation

STD tire	Narrow tire
(45 psi)	(100 psi)
45%	83%

Table 9. Tire service life

	Percentage of service due to percentage of inflation	Percentage of service due to percentage of overload	Percentage of total service
W(std tire at 45 psi)	0.21	0.45	9.5
W_2(std tire at 90 psi)	0.96	1.0 (no overloading)	96
N(narrow tire at 100 psi)	0.78	0.62	48.4



CONCLUSIONS

1. Narrow tires inflated to 100 psi are capable of sustaining a 4.5 vertical g-load for 0.1 second.

2. Vertical and horizontal g-loads, when measured at the spindles, are comparable to those experienced with standard tires.

3. The handling characteristics and mobility performance compare favorably with that of standard tires.

4. Tire carcass temperature may exceed 250°F when towing speeds exceed 40 mph.

5. Tread wear appears to be significantly greater than that experienced with standard tires in previous tests.

6. The most expedient method for changing from one tire to the other is to leave the howitzer attached to the truck and use the baseplate for support.

7. The physical performance and condition of the howitzer was not degraded as a result of substituting the narrow tires for the standard tires.

8. Additional care must be taken when changing wheels or inflating tires due to the three-piece split rim design.

9. Tire temperature and pressure may exceed maximum recommended operating levels when towing speeds exceed 40 mph.

10. The split ring may not seat properly when in line with the valve stem. The rim should be positioned approximately 180 degrees away from the valve stem prior to inflating the assembly.

11. Side and lock rings of different rim types are not interchangeable. Some rings are common to two types or sizes, but must be identified with the same size or type.

12. Acceptance of the narrow tires will require the user to carry additional material in the 5-ton truck which may be currently overloaded by approximately 5000 pounds.

13. The proposed rim assembly does not have as high a load rating as the standard reinforced rim.

RECOMMENDATIONS

1. The standard (wide) tires on the M198 howitzer are underinflated at 45 psi and are overloaded at that pressure. Excessive tire deflection due to underinflation may cause weapon handling problems and premature tire failure. It is recommended that the inflation pressure for the standard tire be increased from 45 psi to 90 psi. Although the narrow tire (100 psi) compared favorably to the standard tire (45 psi), the standard tire inflated to the proper pressure (90 psi) is believed to be superior to the narrow tire.

2. The narrow wheel assemblies are recommended for air transportability aboard the C-130 and for limited towing.

3. It is suggested that additional towing tests be conducted to address the assembly's durability and possible permanent replacement.

REFERENCES

1. "Malfunction Investigation of Howitzer," TECOM Project No. 2-WE-200-198-028, STEAP-MT-A, 14 July 1981.

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APPENDIX A

MECHANICS OF PNEUMATIC TIRES

TIRE FUNCTION

1. The function of the M198 tires is to transmit the forces which brake, guide and carry the load of the vehicle. It is also recognized that the tires are to absorb local road surface irregularities over a wide range of road conditions. Consistency in tire dimensions is necessary for straight-line motion, and constant axle height, whereas flexibility is required for the absorption of road rugosity.

SOLID TIRES vs. PNEUMATIC TIRES

2. A solid tire carries a load by using only a small fraction of the tot tire volume. The volume made up of the tire cross-sectional area times the length of the contact patch may be used for a first approximation. To carry a greater load at no greater tire stress requires a wider and heavier tire. With a pneumatic tire, the above approximation is not applicable since load carrying ability is controlled by contact patch area and inflation pressure. Ground contact pressure within the contact patch is primarily determined by the pressure of the gas inflating the tire structure. Therefore with pneumatic tires by increasing the tire inflation pressure greater loads may be carried with a negligible increa in tire weight.

PRINCIPLES OF PNEUMATIC TIRES

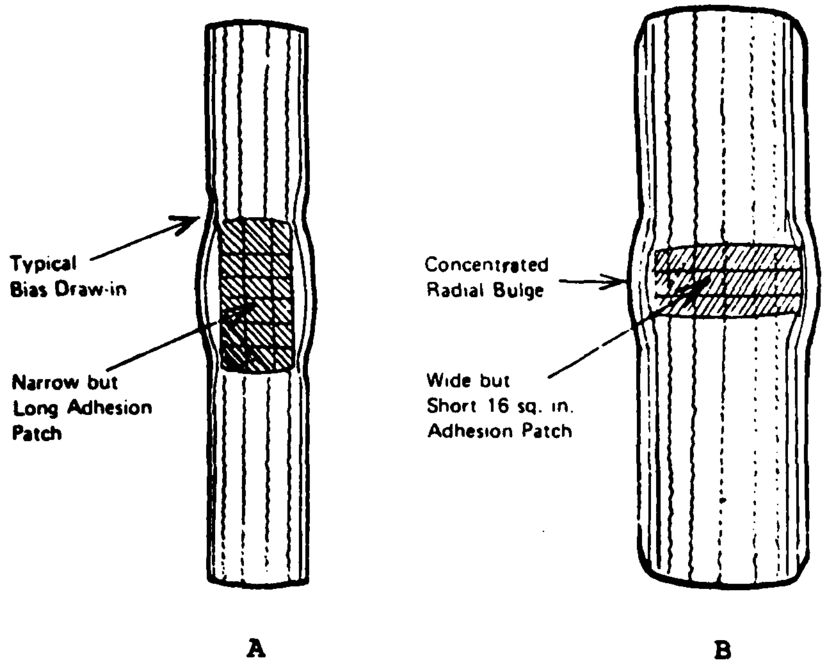
3. Pneumatic tires transmit their normal load predominately by the formation of a finite contact area 'A', which enables the internal air

pressure, P_i, to remain in equilibrium, with the external vertical contact pressure, P_z. Therefore, for a thin membrane, normal load 'W' is approximately equal to the inflation pressure multiplied by the contact area. The effective area may be defined as $A_e = W/P_i$.

However, the tire tread-band in automobile tires and trucks cannot be considered thin and often their footprints show up nearly rectangular in form. The tension force in the side wall, caused by the air pressure has an upward component which reduces the resulting pneumatic force. Experiments of various investigators indicate that the rigidity of the tire side wall and tread-band causes a noticeable contribution to the force transmission. For cross-ply automobile tires, according to these references, in underrated inflation pressure conditions, the carcass carries about 15 percent of the verticle load.

WIDE TIRES vs. NARROW TIRES

4. The tire patch size in square inches will be the same for any given vehicle weight and tire pressure. It makes no difference whether the tires are wide, narrow, large diameter or small. A tire adhesion patch continues to enlarge as the vehicle sinks down, until the adhesion patches are large enough so that the internal tire pressure against the patches equal the weight of the vehicle (Newton's Law: equal and opposite reaction).



The above illustrates tire patches of 16 square inches, one on a 4 inch wide tread and the other on an 8 inch wide tread.

CONDITION	COMPARISON	
	A. Narrow Tire	B. Wide Tire
1. Four inch wide hole	Adhesion momentarily lost	Four inch tread remains in contact with road
2. Four inch wide bump	Tire completely affected (i.e. bounce over object)	Wide tire is more likely to absorb the object
3. Emergency braking and acceleration	Rubber in contact with road twice as long as wide tire resulting in heating of tire compound and less friction	Cooler running tires during braking and acceleration
4. Sand	-	Less tendency to dig into sand
5. Wet weather	-	Higher tendency to aquaplane

In order to have sufficient rim clearance above the road, the narrow tire must have high side walls. High side walls generate more sidewall flex and more cornering distortion. The wide tire can develop the same patch area with far less sidewall flex, and less heat buildup.

ADVANTAGES AND DISADVANTAGES OF NARROW AND WIDE WHEELS AS THEY APPLY TO THE M198 HOWITZER

5. Load Limits.

5.1 - The wide tire currently used on the M198 has a load limit of 8440 lbs at inflation pressures of 90psi. However the operator's manual specifies an inflation pressure of 45psi. The tires are severely overloaded at these inflation pressures. At 55psi, load limit is specified at 6030 lbs (Incl 1).

5.2 - The load limit of the narrow tire in question, inflated to 105psi, is 6040 lbs (Incl 2), which is an improvement over the present tire inflated to 55psi.

5.3 - The load ranges, as indicated above, are maximum limits under highway conditions. Increases in the load carrying capacity may be increased as much as 32% for vehicle speeds under 20 mph (Incl 3).

6. Reducing the present width of the weapon from 111 inches to 99 inches is expected to result in a reduction of less than 5^{o} maneuverability on side slopes.

7. Wheel assemblies should be designed such that the load is proportionally distributed between the wheel bearings. With our present wide wheel(s), the load center is located outwards of the outer bearing, thus, placing more load on the outer bearing and less on the inner bearing as well as more leverage on the axle. (Refer to the numerous EPRs on M198 Hub and Bearing Failures). The narrow wheels will improve an already undesirable situation.

8. Although the wider tires have a lesser tendency to dig into sand; the accumulation of sand and other road materials tend to create obstacles in front of the present M198 tires.

8.1 - The Final Developmental Test, dated September 1977, reported the following: "During towing of the XM198, the tires accumulated large mounds of grassy bog in front of them. These mounds became obstacles which blocked the tires, and the Howitzer slid through muskeg without the wheels turning".

8.2 - A similar situation occurred recently during mud deflector tests at Aberdeen Proving Ground.

EFFECTS TIRE PRESSURE HAS ON THE TOWING CHARACTERISTICS

9. Increasing the tire pressure from 45psi to 90psi does not significantly (.01 level of significance) affect the g's recorded at the right and left spindles when towing over APG Belgian Block courses at 10 and 15 mph (Incl 4).

10. Test observers and vehicle operators have reported that by inflating the present tires to 90psi the stability of the weapon is noticeably improved. Refer to APG Malfunction Investigation Report dated 14 July 81. "The Howitzer was more stable and handled better when tires were pressurized to 90psi".

INFLATION PRESSURES

11. Initial inflation pressure: When new or used fabric cord bias ply tires are mounted and inflated, the inflation pressure may drop as much as 10psi in 24 hours due to "inflation growth" of the tire (stretch) and the cooling of warm compressor air. After being mounted on the vehicle, the tire may stretch further due to heat from running and tire deflection. After cooling, the tire may show a further 6 to 10psi loss in air pressure.

12. Under normal operating conditions, increases in tire pressure of 10 to 15psi are considered normal. Higher pressures may be signs of overloading, underinflation, excessive speed, improper tire size or any combination of these.

13. Inflation pressures should be checked and corrected when the tire is cool.

14. Underinflation.

14.1 - Lower air pressure can result in excessive heat generation and cause tire failure.

14.2 - Heat buildup can cause the tire body to deteriorate and result in separation of the tread from the body or belt ply.

14.3 - A soft tire over deflects causing fatique breaks in the body cords and under high load conditions handling problems will result. This continued over-deflection causes breaks in the body cord construction to progress through the tire, causing a sudden loss of air.

14.4 - Bottoming out, causing damage to rims may result.

14.5 - With underinflated tires, during cornering the rim of the wheel moves outward so that it no longer is directly over the adhesion patch. This throws more of the weight and cornering force onto the outer side of the tire as it greatly distorts the shape of the adhesion patch, possibly creating an unstable condition.

15. Overinflation.

15.1 - Road shocks not absorbed well.

15.2 - Body breaks can occur when impacting an object or chuck-hole and can overstress rim.

15.3 - Overinflated tires are more likely to cut, snag or puncture.

HEAT INDUCED TIRE FAILURE

16. Tire cord fabrics lose strength at temperatures above 250°F. Permanent damage may have been done to the cord fabric even though failure may not have occurred. The original strength does not fully return to the damaged cords when the tire is cooled. Additional trips wil promote further weakening until a heat blow-out occurs. Under severe operating conditions, the tires may reach such high temperatures that the cords actually scorch and lose strength. High tire temperatures result in the tread being more susceptible to snagging and tearing.

17. An incident of heat blow-out did occur during prototype tesing in Australia. The present (wide) tires were inflated to 45psi when the incident occurred. The replacement tires were inflated to 60psi. No additional incidents were reported.

MOISTURE DAMAGE

18. Excessive moisture trapped on the inside surface of a steel radial tire, prior to or during the mounting of the tire on a rim or wheel, can permeate through the tire and may cause deterioration of the tire's structural integrity and possibly lead to tire failure.

SUMMARY AND RECOMMENDATIONS

19. The present (wide) tires used on the M198 Howitzer are underinflated at 45psi and are severely overloaded at that pressure. Excessive tire deflection due to underinflation may cause weapon handling problems and premature tire failure. It is recommended that the inflation pressures for the present tires be increased from 45psi to 90psi.

20. Initial ARRADCOM Tests have indicated that increasing the tire pressure from 45psi to 90psi does not significantly (at the .01 level of significance) affect the g's recorded at the right and left spindles

when towing over Belgian Block courses.

21. With the proposed narrow tires inflated to 90psi, the weapon handling characteristics should not be significantly different than the tests performed with the present (wide) tires inflated to 90psi.

22. The proposed narrow tires with inflation pressures of 90-100psi are rated at higher load handling capacities than our present tires inflated to 45psi.

23. Improvements in weapon turning diameters, maneuverability and a reduced tendency to aquaplane are some benefits which may be achieved with the acceptance of the narrow wheels. Although there is a greater tendency for the narrow wheels to dig into sand, the chances of sand building up, creating obstacles, in front of the tires, may be reduced (verification required). The narrow wheels will move the load center closer to the outer bearing, improving an already undesirable situation. The total weight of the weapon system will be reduced with the narrow tires installed.

24. Reduction in side slope tests of less than 5° should occur with the narrow wheels.

25. The present tires, inflated to the proper (i.e. 90psi) pressure are believed to be superior to the proposed narrow tires. The narrow tires are not meant to be used as a substitute for the present tires but merely used for air transportability in the C-130 and limited towing.

26. The acceptance of the narrow wheels will require the user to carry additional materials in the 5-ton prime mover he claims is already overloaded by 5000 lbs.

27. It is suggested that additional towing tests be conducted using the

proposed narrow tires. The benefits achieved, if the narrow tires could be used as a permanent substitue may outweight the towing restrictions imposed.

WIDE BASE TIRES FOR TRUCKS, BUSSES AND TRAILERS USED IN NORMAL HIGHWAY SERVICE

BIAS PLY TIRES MOUNTED ON 15° DROP CENTER RIMS

TABLE WBTB-1B

DUAL (D) SINGLE (S)

BIAS PLY

TIRE SIZE DESIGNATION		TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES														
		30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
14-17.5	D	2820(C)	3080	3340	3570(D)	3800	4020	4220(E)	4430	4620	4810(F)	5000	5180	5360(G)		
	S			3210(C)	3500	3790	4060(D)	4320	4570	4800(E)	5030	5255	5470(F)	5680	5890	6090(G)
15-19.5	D	3600(D)	3930	4250	4560(E)	4850	5120	5390(F)	5650	5900	6150(G)					
	S			4090(D)	4470	4830	5180(E)	5510	5820	6130(F)	6420	6710	6980(G)			
15-22.5	D				5000(E)	5320	5620	5910(F)	6200	6480	6740(G)	7000	7250	7500(H)		
	S						5680(E)	6040	6390	6720(F)	7040	7360	7660(G)	7950	8240	8520(H)
16.5-19.5	D				5310	5640	5970	6270	6580	6870	7150	7430(H)				
	S						6030	6410	6780	7130	7480	7810	8130	8440(H)		
16.5-22.5	D				5800	6170	6520	6860	7190	7520	7820	8120(H)				
	S						6590	7010	7410	7790	8170	8540	8890	9230(H)		
18-19.5	D				5900	6270	6640	6980(G)	7310	7640	7960(H)	8260	8560	8850(J)		
	S						6700	7130	7540	7930(G)	8310	8680	9040(H)	9390	9730	10080(J)
18-22.5	D				6430	6850	7230	7610(G)	7980	8330	8680(H)	9010	9340	9650(J)		
	S						7310	7780	8220	8650(G)	9070	9470	9880(H)	10240	10610	10870(J)
19.5-19.5	D				6950	7390	7820	8230	8620	9010	9370(J)					
	S						7900	8400	8890	9350	9800	10240	10650(J)			

1. Letters in parentheses indicate Load Range for which **BOLD FACE** Loads are maximum. (See Load Range—Ply Rating Conversion Table)
2. For tire loads at various maximum speeds other than 60 mph and special operating conditions, see page 35.

TIRES FOR TRUCKS, BUSSES AND TRAILERS USED IN NORMAL HIGHWAY SERVICE

BIAS PLY TIRES MOUNTED ON TYPE I, II, AND III RIMS

TABLE TB-1B (Con't)
DUAL (D) SINGLE (S)

BIAS PLY

(CONTINUED FROM PRECEDING PAGE)

TIRE SIZE DESIGNATION		TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES															
		40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115
10.00-15 TR	D			3140	3320	3490	3660	3830	3980(F)	4130	4280	4430(G)	4570	4710	4880(H)		
	S					3580	3780	3980	4170	4370	4540(F)	4710	4880	5050(G)	5210	5370	5530(H)
10.00-20	D			3760	3970	4180	4380	4580	4760(F)	4950	5120	5300(G)	5470	5630	5800(H)		
	S					4290	4530	4770	4990	5220	5430(F)	5640	5840	6040(G)	6240	6430	6610(H)
10.00-22	D			4000	4230	4450	4660	4870	5070(F)	5260	5450	5640(G)	5820	6000	6170(H)		
	S					4560	4820	5070	5310	5550	5780(F)	6000	6210	6430(G)	6630	6840	7030(H)
11.00-15 TR	D			3430	3630	3820	4000	4180	4350	4520	4680	4840(G)	5000	5150	5300(H)		
	S					3910	4140	4350	4560	4770	4960	5150	5340	5520(G)	5700	5870	6040(H)
11.00-20	D			4100	4330	4560	4780	4990	5190(F)	5390	5590	5780(G)	5960	6150	6320(H)		
	S					4670	4940	5200	5450	5690	5820(F)	6140	6370	6580(G)	6790	7010	7200(H)
11.00-22	D			4350	4600	4840	5080	5300	5520(F)	5730	5940	6140(G)	6330	6530	6720(H)		
	S					4960	5240	5520	5790	6040	6290(F)	6530	6770	7000(G)	7220	7440	7660(H)
11.00-24	D			4620	4890	5140	5390	5630	5860(F)	6090	6310	6520(G)	6730	6930	7130(H)		
	S					5270	5570	5860	6140	6420	6680(F)	6940	7190	7430(G)	7670	7900	8130(H)
11.50-20	D			4180	4420	4650	4870	5090	5290(F)	5500	5700	5890(G)	6080	6260	6440(H)		
	S					4770	5040	5300	5550	5800	6030(F)	6270	6500	6710(G)	6930	7140	7340(H)
11.50-22	D			4440	4700	4940	5180	5410	5630(F)	5850	6060	6270(G)	6560	6760	6960(H)		
	S					5060	5360	5630	5910	6170	6420(F)	6670	6910	7150(G)	7380	7600	7820(H)
12.00-20	D				4930	5190	5440	5680	5910	6140(G)	6360	6580	6790(H)	7000	7200(J)		
	S						5620	5920	6200	6480	6740	7000(G)	7250	7500	7740(H)	7980	8210(J)
12.00-24	D				5550	5840	6120	6390	6650	6910(G)	7160	7410	7640(H)	7870	8100(J)		
	S						6330	6660	6980	7280	7580	7880(G)	8160	8450	8710(H)	8970	9230(J)

1. Letters in parentheses indicate Load Range for which **BOLD FACE** Loads are maximum. (See Load Range—Ply Rating Conversion Table)
2. For tire loads at various maximum speeds other than 60 mph and special operating conditions, see page 35.

LOAD LIMITS AT VARIOUS SPEEDS
FOR BIAS AND RADIAL PLY TRUCK TIRES USED ON IMPROVED SURFACES

IMPROVED SURFACE — An improved surface is one which is relatively smooth and intended to handle any vehicle manufactured primarily for use on the public streets, roads and highways.

(These Tables do not apply to Rims or Wheels)

For Tires Shown in Tables LT-1B, LT-1R, T-1B, T-1R, TLT-1B, TLT-1R, WBLT-1B, WBLT-1R, WBLT-2B, WBLT-2R

The service load and inflation must comply with the following limitations:

SPEED RANGE (MPH)	INFLATION PRESSURE INCREASE	% INCREASE (+) OR DECREASE (—) IN LOADS
75 thru 84	+ 10 PSI	—10%
65 thru 74	+ 10 PSI	None
55 thru 64	No increase	None
45 thru 54	No increase	+ 9%
35 thru 44	No increase	+16%
25 thru 34	No increase	+24%
15 thru 24	No increase	+32%

For special operating conditions, cold inflation pressures may be increased up to 10 PSI above those shown in the referenced tables with no increase in loads (not to exceed the maximum rim capacity). The total increase in cold inflation pressure shall not exceed 10 PSI above those specified in the above referenced tables for the load being carried.

For Tires Shown in Tables TB-1B, TB-1R, TTB-1B, TTB-1R, WBTB-1B and WBTB-1R

The service load and inflation must comply with the following limitations:

SPEED RANGE (MPH)	INFLATION PRESSURE INCREASE		% INCREASE (+) OR DECREASE (—) IN LOADS	
	BIAS TIRES	RADIAL TIRES	CONVENTIONAL	WIDE BASE
71 thru 75	+ 10 PSI	+ 10 PSI	—10%	—10%
61 thru 70	+ 10 PSI	+ 10 PSI	None	None
51 thru 60	No increase	No increase	None	None
41 thru 50	No increase	No increase	+ 9%	+ 7%
31 thru 40	No increase	No increase	+16%	+ 9%
21 thru 30	No increase	+ 10 PSI	+24%	+12%
11 thru 20	No increase	+ 15 PSI	+32%	+17%

For special operating conditions, cold inflation pressures may be further increased up to 10 PSI (not to exceed the maximum rim capacity) with no increase in loads.

LOAD LIMITS FOR REDUCED SPEEDS FOR TIRES SHOWN IN TABLES HTB-1B AND FOR HTB-1R

SPEED RANGE (MPH)	INFLATION PRESSURE INCREASE		% INCREASE IN LOADS
	BIAS TIRES	RADIAL TIRES	
41 thru 50	No increase	No increase	No increase
31 thru 40	No increase	No increase	+ 7%
21 thru 30	No increase	+ 10 PSI	+ 13%
11 thru 20	No increase	+ 15 PSI	+ 21%

SUBJECT: Effects Tire Pressure has on the Towing characteristics of the M198 Howitzer

INTRODUCTION: The intent of this study was to determine if increasing the tire pressure from 45 psi to 90 psi had any significant effect on the towing characteristicsof the M198 Howitzer.

DATA ACQUISITION PROCEDURE: Tests were conducted with the 155mm Towed Howitzer, M198, serial no. 10 at Aberdeen Proving Ground. Two accelerometers, positioned vertically, were located on the outside of the right and left spindles. Peak g's were recorded, at each location, for each lap over the Munson Belgium Block course.

EXPERIMENTAL PROCEDURE: An analysis of variance was used to determine if there was a difference in g's recorded at spindle locations, due to random variation alone or if there was also a contribution from systematic variation attributed to changes in tire pressure. This procedure essentially separates the total variability into the following two components.

1. Variability between tire pressures, measuring systematic and random variation.

2. Variability within tire pressure, measuring only random variation.

Equal sample sizes were chosen for the following reasons:

1. The f ratio is insensitive to slight departures from the assumption of equal variances for the k populations when the samples are of equal size.

2. Equal sample size minimizes the probability of committing a type II error (ie. Accepting the null hypothesis when it is false).

The null hypothesis Ho is rejected at the α level of significance when-

$f > f_{\alpha}[k-1,\ k(n-1)]$

Preferred computational formulas for SST, SSA and SSE are as follows:

$$SST = \sum_{i=1}^{k} \sum_{j=1}^{n} y_{ij}^2 - \frac{T^2}{nk}$$

$$SSA = \sum_{i=1}^{k} \frac{T_i^2}{n} - \frac{T^2}{nk}$$

$$SSE = SST - SSA$$

RESULTS:

1. Test the hypothesis that the mean verticle g's on the right outside spindle and left outside spindle are the same at the .01 level of significance.

Tire pressure: 45 psi
Course speed: 10 mph

Peak g's

	Right	Left	
	1.97	1.52	
	3.88	1.77	
	2.22	1.61	
	2.95	1.92	
	3.72	2.92	
	3.12	1.95	
TOTAL	17.86	11.69	29.55
MEAN	2.97	1.94	

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	COMPUTED f
LOCATION	3.17	1	3.17	7.65
ERROR	4.14	10	.414	
TOTAL	7.31	11		

CRITICAL REGION: $F > 10.04$ with $\nu_1 = 1$ and $\nu_2 = 10$ degrees of freedom.

CONCLUSION: Right and left vertical accelerometers see the same mean g loadings.

2. Test the hypothesis that the variations in mean g's is the same regardless of changes in tire pressure at 10 mph at the .01 significance level.

(R) Designates right spindle location

(L) Designates left spindle location

Peak g's	TIRE PRESSURE 45 psi	TIRE PRESSURE 90 psi	
	1.97 (R)	2.58 (R)	
	1.52 (L)	2.30 (L)	
	3.88 (R)	3.10 (R)	
	1.77 (L)	2.68 (L)	
	2.22 (R)	4.26 (R)	
	1.61 (L)	3.15 (L)	
	2.95 (R)	2.55 (R)	
	1.92 (L)	3.28 (L)	
	3.72 (R)	3.90 (R)	
	2.92 (L)	3.21 (L)	
TOTAL	24.48	31.01	55.49
MEAN	2.44	3.10	

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	COMPUTED f
TIRE PRESSURE	2.13	1	2.13	3.80
ERROR	10.15	18	.56	
TOTAL	12.28	19		

Critical Region: $F > 8.29$ with $\nu_1 = 1$ and $\nu_2 = 18$ degrees of freedom.

CONCLUSION: Tire pressure does not make a significant difference in g's recorded at the spindles, at 10 mph.

3. Test the hypothesis that the variations in mean g's is the same regardless of changes in tire pressure at 15 mph at the .01 significance level

(R) Designates Right Spindle location.

(L) Designates Left Spindle location.

TIRE PRESSURES

Peak g's	45 psi	90 psi	
	4.29 (R)	5.14 (R)	
	4.66 (L)	3.57 (L)	
	4.29 (R)	5.46 (R)	
	4.66 (L)	3.57 (L)	
TOTAL	17.9	17.74	35.64
MEAN	4.47	4.43	

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	COMPUTED f
TIRE PRESSURE	0.0	1	0.0	0
ERROR	3.19	6	.53	
TOTAL	3.19	7		

CRITICAL REGION: $F > 13.75$ with $\nu_1 = 1$ and $\nu_2 = 6$

CONCLUSION: Tire pressure does not make a significant difference in g's, recorded at the spindles, at 15 mph.

CONCLUSIONS:

Increasing the tire pressure from 45 psi to 90 psi does not significantly affect the g's recorded at the right and left spindles, when towing over Belgium Block courses at 10 and 15 mph.

APPENDIX B

SAFETY CONCERNS FOR NARROW WHEELS KIT

Safety Precautions and Concerns

As a result of narrow wheel testing numerous concerns and cautions were noted which should be followed to provide for the safety and personal welfare of both equipment and manpower. These concerns address the initial inspection of the equipment, the proper assembly of wheel assemblies and recommended towing restrictions.

Prior to the installation of new wheel assemblies on a howitzer, the rim, inner tube, inner flap, and the inside of the tire should be visually inspected for evidence of damage. Visual inspection of the tire should include examination for tread splitting, rubber separation, unusual wear, and servicability of the valve stem.

During the assembly of the tires and rims, inflation should only occur when wheel assemblies are contained by a restraining device, such as a safety cage or safety straps, except when the wheels are on the vehicle and contain more than 80 psi. Positioning of the split rim is critical in the assembly process and if not set properly can create a safety hazard, as a result of explosive disassembly. The split rim may not seat properly when in line with the valve stem and should be positioned approximately 180° away from the valve stem, prior to the inflation of the assembly after tire inflation, the tire, rim, and rings should be inspected while still within the restraining device, to assure a proper seat. A 1/16 to 1/4 inch gap should still remain between the ends of the split ring. Compatibility of rim components is critical to proper functioning. Side and lock rings of different types are not interchangeable. Some rings are common to two types or sizes, but must be identified with the same size and type. This information is described in detail in the U.S. Department of Transportation, National Highway Traffic Administration's Multipiece Rim/Wheel Matching Chart.

When assembling the wheel assemblies to a howitzer the howitzers handbrakes should be engaged prior to installing wheel assemblies and the torquing of lug nuts. The lug nuts should be torqued to 450 + 50 ft. lbs. Bolt hole chambers should be examined prior to each installation for burrs or disc cracks. Damage of this nature may be associated with overtorquing. Lug nuts should be checked periodically for looseness.

Inflation pressures are critical to the safe operation of the narrow tires. Tires should be inflated to 100 psi (cold) for normal weapon maneuvers. "Cold" inflation pressures refer to tires which have not travelled a distance greater than one mile for a duration of 30 minutes minimum. Air should never be bled from a hot tire during towing maneuvers. The tires should be allowed to cool prior to making inflation adjustments. Inflation pressures may drop initially, with a new tire, due to "inflation growth" of the tire (stretch) and the cooling of warm compressor air. A break-in period is recommended where tires are towed at low speeds, (i.e., 5 mph) for several miles.

The following towing restrictions are critical to safe towing operations of the M198 howitzer. Maximum recommended towing speeds are five mph max on cross-country terrain; 30 mph max on secondary roads, and 40 mph max (continuous) on improved roads. Continuous towing at speeds exceeding 40 mph for distances greater than 100 miles may cause premature tire failure. Towing distances should be limited to 100 miles at a time, followed by a rest period. Exceeding the above requirements for towing speeds and distances results in increased heat generation in the tire. The effects include reduced tire life, rubber deterioration, fatigue life shortened, strength properties lowered, tread wear increased, a reduction in tensil strength of body cords, and a reduction in aging qualities.

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