

## MnROAD SEMI TRACTOR TRAILER

### MnROAD Operations – General Description

MnROAD uses a 5-axle semi to provide the loadings to its low volume road (LVR) and provide a known dynamic load to test the dynamic sensor instrumentation. MnROAD’s LVR is a 2-lane, 2 ½-mile closed loop that contains many different types of pavements.

Traffic on the LVR is restricted to a MnROAD operated vehicle, which is an 18-wheel, 5-axle, tractor trailer. MnDOT employed driver operates the MnROAD truck during his normal 8 hour working day averaging around 6 hours of driving or 80 laps a day. Laps are documented by the operator and entered into the MnROAD database. MnROAD does have the ability to track the truck using GPS antennas, which is typically used when collecting dynamic sensor data when location accuracy is required.



The LVR loading vehicle originally started operation on June 16, 1994. MnROAD originally utilized two different loading configurations. Originally from 1994-2008 we operated a "heavy" load configuration results in a gross vehicle weight of 102 kips (102K configuration) in the outside lane 1 day a week and a "legal" load configuration has a gross vehicle weight of 80 kips (80K configuration) 4 days a week in the inside lane. This results in a similar number of ESALs being delivered to both lanes even though the number of passes differs.

Since 2008 MnROAD runs a "legal" 80 kips loading configuration 5 days a week in the inside lane and leaves the outside lane to only receive environmental loadings with no traffic to help meet the research plans for many of the test cells built in 2007-2008. Here is a summary of the traffic loadings and equipment used over the years at MnROAD.

Year	Inside Lane	Outside Lane	Tractor	Trailer
1994 – 2008	80K 4 days/week	102K 1 day/week	Mack (93406) 1994 - 2011	Fruehauf (93410) 1994 – 2012
			Navistar (95167) 1997 - 2011	Fruehauf (97288) 1997 – 2010
2008 – 2011	80K 5 days/week	No Traffic	Mack (93406) 1994 – 2011 Navistar (95167) 1997 - 2011	Fruehauf (93410) 1994 – 2012
2012 - Current			WorkStar (211308) 2012 - Current	Towmaster (211309) 2012 - Current



This document is broken into the following to help document the equipment used at MnROAD

- International WorkStar Tractor Unit 211308, Model 7600 SBA 6X4 2010, License Number ET-5530, VIN: 1HSGSSJT8CJ536729, and Towmaster Trailer, Model T-100DTG G-Neck, Unit 211309, License Number EY-4977, VIN: M1021GO (BL161021)
- Mack Tractor Model No. RD600S, Unit 93406, License Number ET-2151, VIN: 2M1P296Y3PC016562,
- Navistar Tractor Model No. 9400 6X4, Unit 95167, License Number ET-0026, VIN: 2HSFHRDR8NC058428,
- Fruehauf 50 Ton rated Flatbed Trailers, Unit 93410, License Number EY-0111, VIN: 2P04522RW002401, with IMT Crane, and Unit 97288, License Number EY-2199, VIN: 1JJF452F9VS439570 used with the Mack and Navistar Tractors

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## International WorkStar Tractor and Towmaster T-100DTG Trailer

The following is the weights and description of the International WorkStar tractor and trailer configuration used at MnROAD starting December 8, 2011.



International Tractor (211308) with Towmaster Trailer (211309)

### International WorkStar Tractor (211308 - License Plate ET-5530)

2011 International WorkStar Model 7600 SBA 6X4 2010 fifth wheel tractor VIN: 1HSGSSJT8CJ536729 Manufactured 2011-04-26 is powered by a MaxxForce 13 L engine, which generates 475 HP @ 1700 RPM, 1700lb-ft Torque @1000 RPM. The Allison 4000\_RDS\_P close ratio 6-Speed, with double overdrive. This automatic Allison transmission delivers power to the tandem drive axles fitted with Eight Michelin XDN2 275/80R22.5 tires set to 100 psi (689 kPa). The steer axle was fitted with Two Continental 315/80R22.5 HSU tires with tire pressure set to 100 psi (689 kPa). Fuel is stored in two 100-gallon (756 L Total) Top Draw Aluminum D Style fuel tanks. The fifth wheel is air controlled, allowing the trailer to be slid in either direction. The environmentally controlled cab is fitted with two National 2000 Hi-Back seats with integral Headrest that can be positioned pneumatically. Fully fueled empty weight is 19,300 lbs. The aluminum Cab protector manufactured by ProTech was purchased and installed from Truck Utilities, Inc. under PO T7901-3000020851 in October, 2011.



MnDOT has additional information (M5MND Report Unit PD Cost History.pdf) for maintenance less the cost for tires and service. Located at MnROAD directory R:\MnROAD\Data - Collection\Traffic\Low Volume Road\Description\MnROAD Tractor Maintenance Cost.

### TOWMASTER Trailer used with WorkStar Tractor (211309 - License Plate EY-4977)

Towmaster Model T-100DTG (Detachable Goose Neck) drop deck (empty trailer weight is 16,300 pounds) with 24 feet long load carrying area. The 44 one thousand pound steel blocks which measure 1'X1'x2' each are centered between the third and fourth axles and secured to the deck with angled steel perimeter and tie down straps.

MnDOT has additional information (M5MND Report Unit PD Cost History.pdf) for maintenance less the cost for tires and service. Located at MnROAD directory R:\MnROAD\Data - Collection\Traffic\Low Volume Road\Description\MnROAD Tractor Maintenance Cost.

### WorkStar Tires and Tire Pressures

Starting December 8, 2011 the WorkStar Tractor was running (8) Michelin XDN2 275/80R22.5 radials inflated to 100 psi (689 kPa) on the drive axles and (2) Continental 315/80R22.5 HSU on the steer axle. New Michelin XZA1 275/80R22.5 were installed on the steer axle at 12,995 miles on (8/6/2012) and the tire pressures were inflated to 100 psi.

### Towmaster Trailer Tires and Fifth Wheel Positions

Starting December 8, 2011 this trailer ran with Eight Dunlop SP160 255/70R22.5 tires inflated to 110psi with a Meritor tire inflation system which is tapped into the tractor trailer air supply. On 8/6/2012 with tractor odometer reading 12995 miles, two Dunlop SP160 255/75R22.5 on wheel positions 17 & 18 were replaced with two Michelin XZE 255/70R22.5. On 9/6/2012 with Hub Odometer reading 13767, Bauer Built replaced two Dunlop SP160 255/75R22.5 on wheel positions 15 & 16 with two Michelin XZE 255/70R22.5.

### Workstar (Unloaded) Configuration

Weights measured using INTERCOMP scales on 11/17/2011 (without driver). Fifth wheel weight = 39%.

Timeframe	Total Weight (lbs)	Steering Axle	Front axle Tractor tandem	Back axle Tractor tandem	Front axle Trailer Tandem	Back axle Trailer Tandem
June 15, 2012 Present	35,600	10,850	7,850	7,000	4,900	5,000
			14,850		9,900	

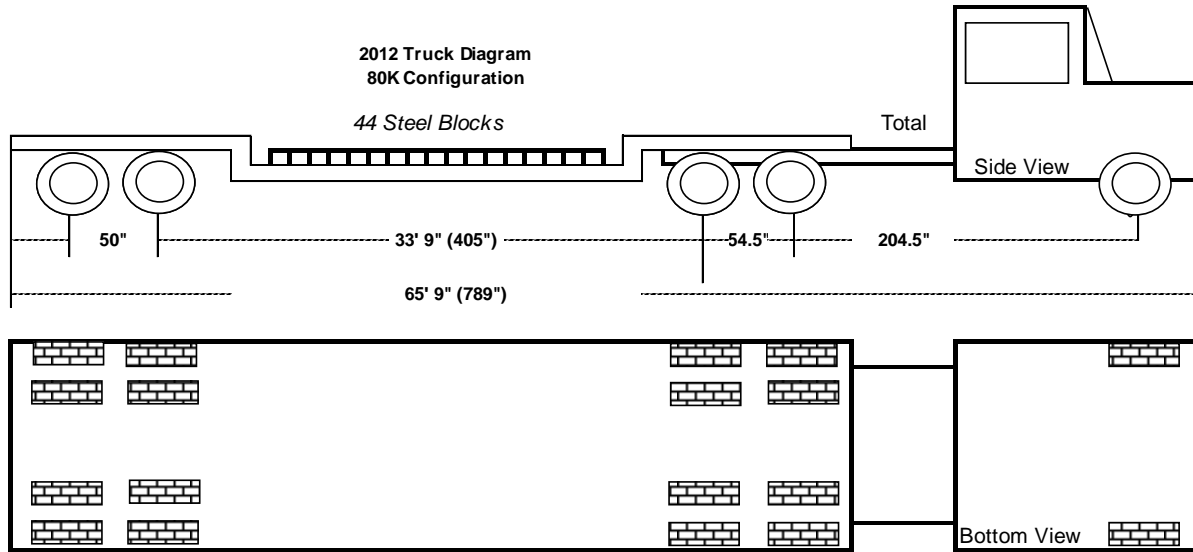
### Workstar 80K (Loaded) Configuration

Weights measured using INTERCOMP scales on 11/17/2011 (without driver). Fifth wheel weight = 44%. 44 of the steel blocks were used to achieve the 80K pound configuration.

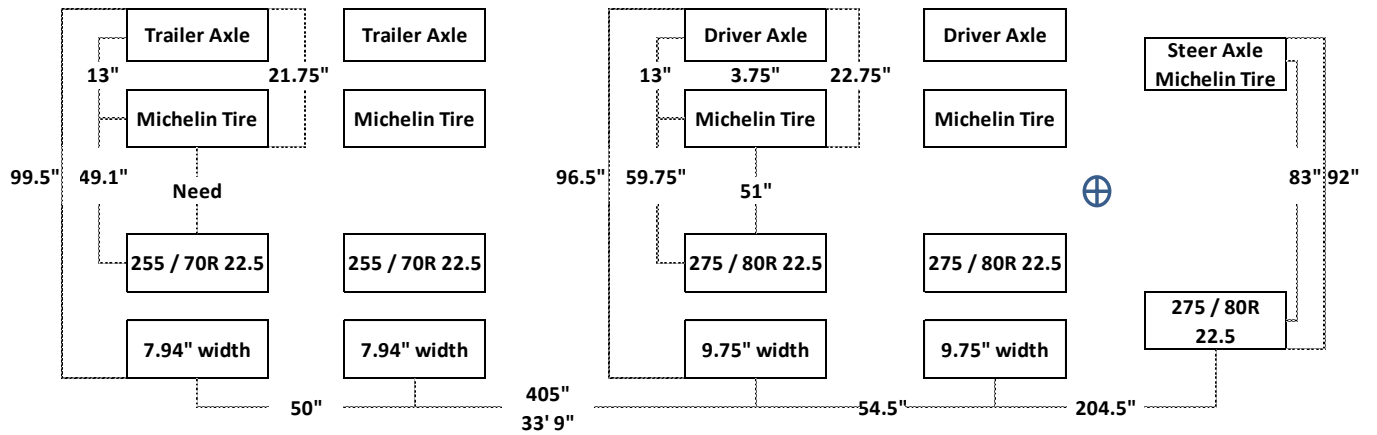
Timeframe	Total Weight (lbs)	Steering Axle	Front axle Tractor tandem	Back axle Tractor tandem	Front axle Trailer Tandem	Back axle Trailer Tandem
June 15, 2012 Present	79,700	11,700	17,650	16,450	16,800	17,100
			34,100		33,900	



# Workstar Dimensions

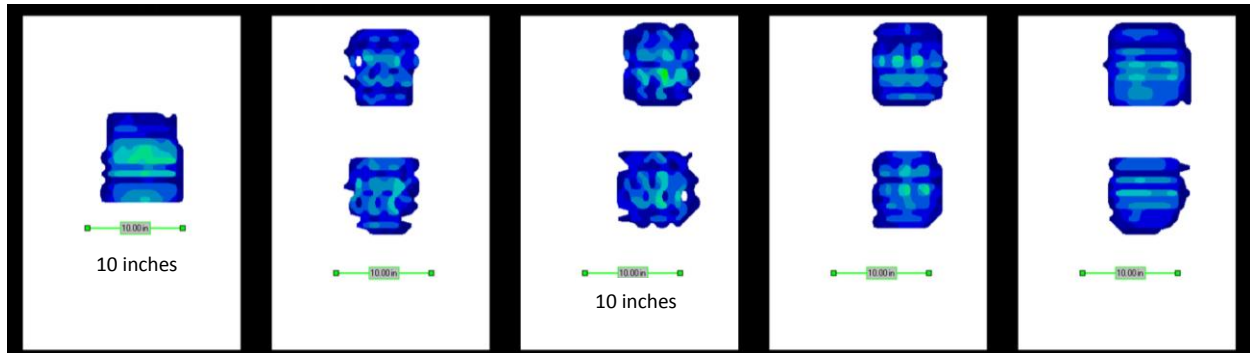


\*Diagrams not to scale



### TechScan Tire Measurements

MnROAD also has utilized a TECHSCAN system to measuring the tire pressures effect on the pavement. This was purchased and used for the 2007-2012 Farm Implements pooled fund study but MnROAD still has it for additional studies in the future as needed. The following set of pictures was taken from the MnROAD 5-axle semi starting on the front axle (left single axle) moving back (to the right) to the semi duels on tandem axles to the trailer duels on tandem axles (Green line = 10 inches). If you would like more information let us know.



### GPS Locations (Truck Offsets)

In 2008, the University of Minnesota's Department of Electrical and Computer Engineering began development of a Real Time Kinematic (RTK) GPS-based vehicle tracking system for the MnROAD facility. This measurements help analyze the dynamic seasonal truck testing done.

One of the more important tasks in the operation of a pavement research test track involves tracking the location of individual vehicles during load response testing. The location of a vehicle's tires has a profound effect on the values obtained from embedded pavement load response sensors. In an effort to improve the efficiency of load response testing both in the field and during analysis, a GPS-based vehicle tracking system (VTS) was developed for the MnROAD facility. Field trials to measure the accuracy of the VTS were conducted at the MnROAD facility.

The VTS demonstrated its capability of tracking vehicle motion with an accuracy of  $\pm 1$  inch (2.5 cm) at speeds up to 45 miles per hour (70 KH). These results matched or exceeded the accuracy obtained with the former high definition video camera used at MnROAD. Additional trials were conducted in greater Minnesota to determine the VTS operational area. Overall, the VTS received Real Time Kinematic (RTK) level signal correction in nearly 90% of the tested areas.

Two other modules were developed from the VTS. The Wireless Triggering System (WTS) provides the capability of triggering data acquisition as a test vehicle passes by an area containing pavement sensors. The Vehicle Guidance System (VGS) which is under development serves to guide test vehicle drivers through various predetermined paths. Both of these systems will significantly increase the efficiency of load response testing of pavement test sections in Minnesota.



### Instrumentation of Tractor/Trailer Axles

The overarching goal of this project was to instrument the new MnDOT International Tractor and Towmaster Detachable Goose Neck Trailer used primarily at MnROAD for dynamic loading on the MnROAD Low Volume Roadway and Instrumented Mainline for load testing during lane closures but also throughout the state for seasonal Weigh-In-Motion 40 ton five-axle base line adjustments.

A rugged data acquisition, data recording and wireless transmission system was established for collection of various sensor signals from the truck. The truck was instrumented with a suite of 20 accelerometers, with these accelerometers being located both on the five axles of the truck and on the tractor and trailer bodies. In addition, the truck was instrumented with a differential GPS system and an inertial measurement unit in the tractor cab. A CRIO-based data acquisition system, a rugged laptop and Lab View software together serve as a flexible platform to which other sensor suites could be interfaced in the future. A wireless communication system has been established to communicate trigger signals to roadside cabinets when the truck is at desired GPS locations on the road.

Data recording by in-pavement sensors is triggered by this system. Further, a time stamp signal is communicated so that the time values of recordings of the in-pavement sensors and of the sensors on the truck can be synchronized. Software has also been set up for automatic downloading of data from the truck to a server on the network at MnROAD.

The experimental performance of the developed system has been verified by multiple tests conducted by the research team. This report provides samples of some recorded data and also includes a user-manual for use of the data recording software on the truck.

The above instrumentation of the truck will enable data collection on truck vibrations, enable analysis of correlations between truck vibrations and variations in in-pavement weigh-in-motion sensors, and enable recording of truck movements and pavement loads at MnROAD.

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### Mack Tractor Trailer

The following is the weights and description of the Mack tractor trailer configurations used at MnROAD from June 1994 till December 2011. Two similar model Fruehauf 50 Ton capacity four foot dock height trailers except the original trailer (Unit 93410) was equipped with an IMT hydraulic crane for configuring 1K steel blocks, both were used with the Mack and Navistar tractors, Unit 93410 from June 1994 thru December 2011 and Unit 97288 from November 1997 thru August 2010 at MnROAD.



Mack Tractor (93406) with Fruehauf Trailer (97288)



### **Mack Tractor (Unit 93406)**

Mack Model RD600S is powered by an E7-300 engine, which generates 300 h.p. @ 1950 r.p.m. The HT750DR 5-speed Allison transmission delivers power to the tandem drive axles fitted with dual 11R24.5 tires inflated to 100 psi (689 kPa). Fuel is stored in two 110-gallon (416 L) Steel fuel tanks. The Holland fifth wheel is air controlled, allowing the trailer to be slid in either direction at + or -250 pounds per notch to the steer axle. The environmentally controlled cab is fitted with two Air-Bostrom 914 Hi-Back seats that can be positioned pneumatically. Another driver-oriented feature is the Model 2406 Collimator Sight. The sight provided the operator a virtual image at a target point, combining the image and field view by utilizing a light source, a lens and a reflector plate. Unit 93406 was removed from service November, 2011

MnDOT has additional information (M5MND Report Unit PD Cost History.pdf) for maintenance less the cost for tires and service. Located at MnROAD directory R:\MnROAD\Data - Collection\Traffic\Low Volume Road\Description\MnROAD Tractor Maintenance Cost.

### **Mack Fruehauf Trailer (Unit 93410)**

This trailer is a Fruehauf 50 ton (445 KN) rated flatbed which is 45' (13.7 m) long and 96" (2.43 m) wide. It is fabricated of steel framework with apitong wood floor and has a sliding rear tandem, which are also fitted with dual recapped Michelin XZY 11R24.5 tires. The trailer is equipped with an IMT Model 4825 hydraulic crane, which facilitates loading and movement of the 1,000-lb (4.448 KN) steel weights used to ballast the vehicle. The crane can be operated either manually or with a wireless remote unit.



Mack Tractor (93406) with Fruehauf Trailer (93410)

The trailer tandem wheel hub and drum assemblies were changed in November, 1998 from stud piloted to hub piloted wheels in order for using one set of rims for both trailers running recapped Michelin XZY 11R24.5 tires and the Mack Tractor running Michelin XDA 11R24.5 MS drive tires. All flange lugs were tightened to 450 Foot pounds after each tire service. This trailer was sand blasted and repainted with Nason Ful-poxy Xon sanding primer and Nason Ful-thane 2K urethane paint in July, 2002 due to the harsh environment in which it operated.

In November of 2010 the IMT Crane was inspected by American Testing Center and found several shims and bushings that needed to be replaced but Central Shop decided that it was too costly to repair due to the uncertainties of how long this trailer would remain in service and as a safety concern tagged the crane out of service for the remainder of this trailers use. Unit 93410 was removed from service April 2011 with 245,361 recorded miles on the LVR.



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### **Navistar Tractor (Unit 95167)**

The second Tractor employed for applying loads on the MnROAD Low Volume Roadway was a 1992 Navistar 9400 Eagle VIN No.2HSFHRDR8NC058428. This Tractor was contributed by Navistar Corporation to a mutual partnership between MnDOT, University of Minnesota Dept. of Mechanical Engineering, and Navistar for the development of autonomous controls of heavy duty trucks. Navistar's other partners in this program included Caterpillar Heavy Duty Truck Engines and Allison Transmission, a Division of GM Corporation. This tractor was modified as a test bed for the development of autonomous controls. The 1992 chassis Number: NC058428 was powered by a model 3406B PEEC Cat Engine serial number 2EK01718 producing 425 HP @ 2000 RPM-PEEC 50ST H-T-1991. The Allison HD4560PR provides power to Int. N400 40KLB Tandem SGL-RED axle drivers running on Michelin XDA11R24.5 retreads on Aluminum Alloy wheels. The steer axle is an Int. I-140S 14K LB running on Michelin XZA1+ LRG 11R24.5 on Aluminum Alloy wheels. This unit equipped with 300 gallon Dual polished aluminum fuel tanks. The Fontaine fifth wheel is air controlled, allowing the trailer to be slid in either direction at + or -250 pounds per notch to the steer axle. Unit 95167 was removed from service December, 2012 with 198700 recorded miles on the LVR.

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### **Navistar Fruehauf Trailer (Unit 97288)**

This is the second trailer and also a Fruehauf 50 ton (445 KN) rated flatbed which is 45' (13.7 m) long and 96" (2.43 m) wide. It is fabricated of steel framework with a wood floor and has sliding rear tandem, which are also fitted with dual recapped Michelin XZY 11R24.5 tires. A cab protector (Also known as Headache Rack) was fabricated, welded to the leading edge of this trailer and painted with matching paint by Abbott Welding on March 26, 1998.



Navistar Tractor (95167) with Fruehauf Trailer (93410)

After PM and CVI on August 9, 2010 we found cracks in driver's side I-Beam (while attempting to slide the dolly) at a location above the tandem dolly and Central Shop decided to remove this trailer from service and disposed of it on September 22, 2010.





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### **Mack and Navistar Tires and Tire Pressures**

Starting in June 1994, the **Mack** was running Michelin radials at 115 psi. New Michelin radials were installed at 16788 miles (12/30/94) and the tire pressures were changed to 100 psi. Recapped Michelin radials were installed at 27567 miles (7/27/95) and continued with a tire pressure of 100 psi. The **Navistar** truck started running at the LVR facility on September 26, 1994 with an assumed initial tire pressure of 115 psi. On December 30, 1994, the tire pressure switched to 100 psi on the Navistar as well as the Mack. The Mack last ran with Michelin XDA 11R24.5 MS drive tires and XZA 11R24.5 steer tires.

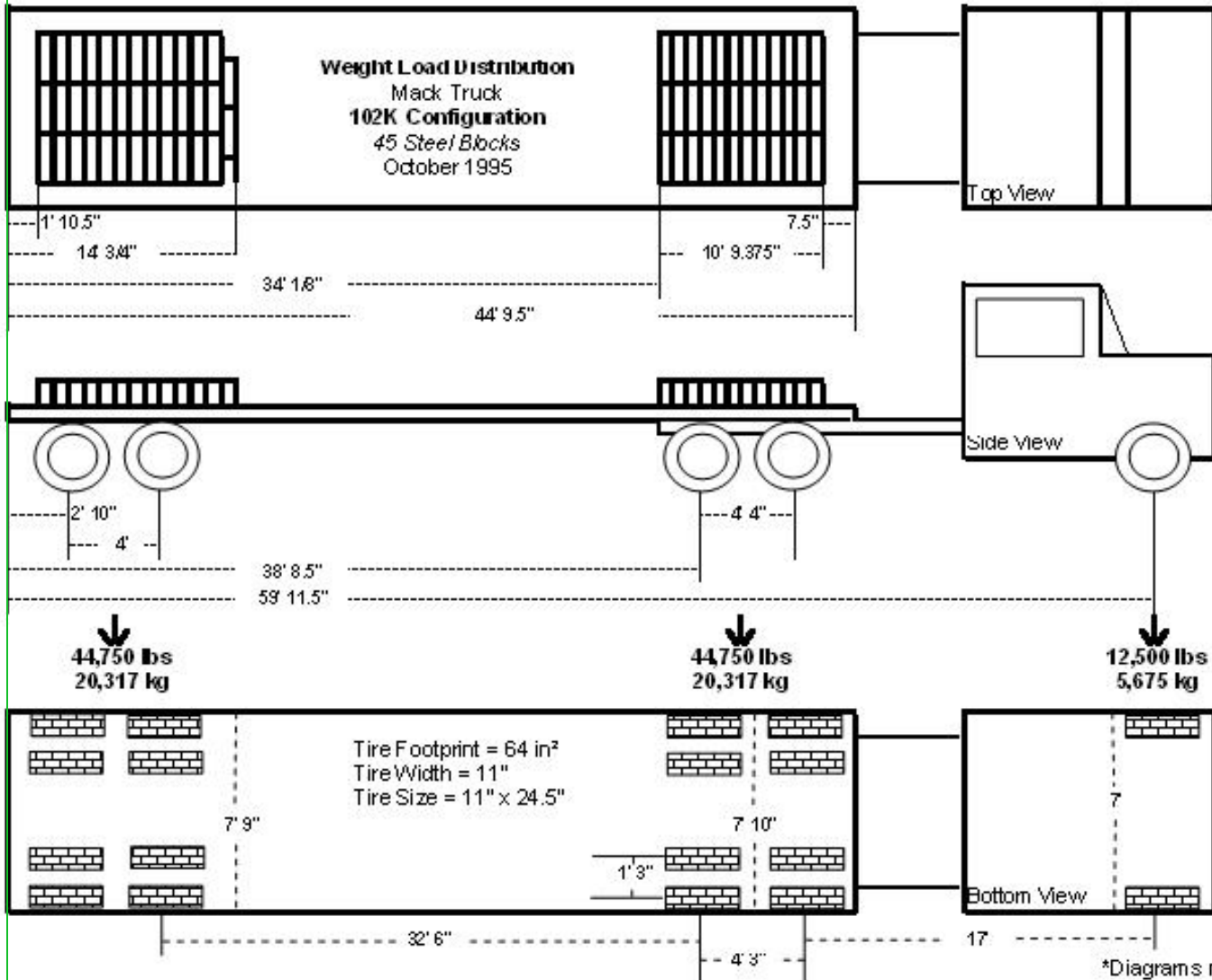
### **Fruehauf Trailer Tandem Dolly and Mack Fifth Wheel Positions**

There are 10 positions to which the trailer tandem dolly can be adjusted. For the purposes of this document, the most rearward position is referred to as position #1 and most forward position is referred to as position #10. The "yellow" position is marked with yellow paint, position #3. The "white" position is marked with white paint, position #2. The holes used to position the trailer tandem dolly are 6 inches on center. The Mack fifth wheel has always been in the same position, position #4.



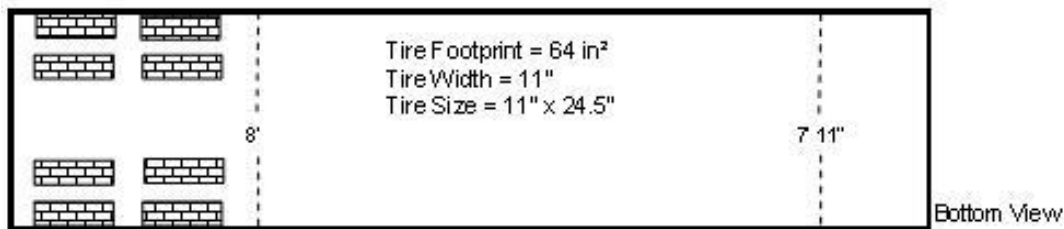
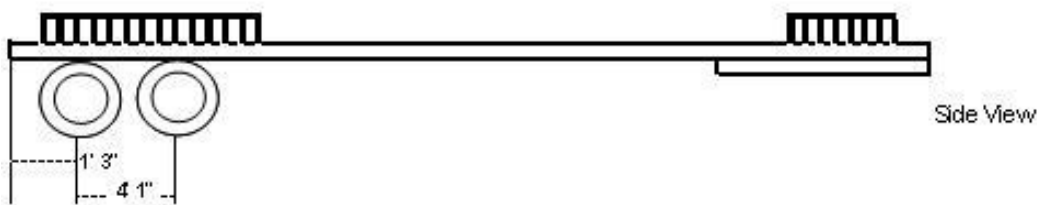
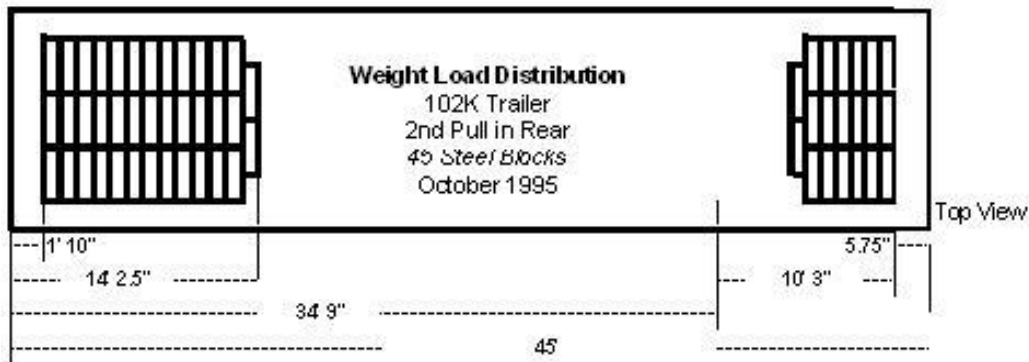
## Mack in the 80K Configuration

Timeframe	Total Weight (lbs)	Steering Axle	Front axle Tractor tandem	Back axle Tractor tandem	Front axle Trailer Tandem	Back axle Trailer Tandem
June 15, 1994 Present	79,500	12,000	16,900	16,600	15,600	18,400
			33,500		34,000	



## Mack in 102K Configuration

Timeframe	Total Weight (lbs)	Steering Axle	Front axle Tractor tandem	Back axle Tractor tandem	Front axle Trailer Tandem	Back axle Trailer Tandem
June 15, 1994 March 29, 1995	102,600	13,200	21,000	20,600	22,700	25,100
			41,600		47,800	
June 15, 1994 March 29, 1995	102,800	13,600	22,300	21,400	23,900	21,600
			43,700		45,500	
March 30, 1995	102,600	12,400	22,900	22,200	21,200	23,900
			45,100		45,100	



\*Diagrams not to scale



### Navistar Tires and Tire Pressures

The Navistar truck started running at the LVR facility on September 26, 1994 with an assumed initial tire pressure of 115 psi. On December 30, 1994, the tire pressure switched to 100 psi on the Navistar as well as the Mack. The Navistar ran through one set of Goodyear radials and afterwards changed to Michelins.

### Navistar Trailer Tandem Dolly and Fifth Wheel Positions

There are 12 positions for the Navistar fifth wheel. The "yellow" position is marked with yellow paint and is in position #6, if we call the most reward position, position #1. The "white" position is marked with white paint and is in position #5. Included herewith are schematics of the weight configurations to be used in the 80 kip and 102 kip configurations. These configurations have been used with the exceptions of the trailer tandem dolly position (changed at the October 6, 1995 weighing), and the movement of the weights which was implemented at the March 28, 1995 weighing.

### Navistar in the legal configuration

Timeframe	Total Weight (lbs)	Steering Axle	Front axle Tractor tandem	Back axle Tractor tandem	Front axle Trailer Tandem	Back axle Trailer Tandem
June 15, 1994	79,100	11,500	16,900	16,600	16,500	17,600
Present			33,500		34,100	

### Navistar in the heavy configuration

Timeframe	Total Weight (lbs)	Steering Axle	Front axle Tractor tandem	Back axle Tractor tandem	Front axle Trailer Tandem	Back axle Trailer Tandem
June 15, 1994	102,400	12,400	21,400	23,400	22,100	23,100
Present			44,800		45,200	

### For more information:

For more information about MnROAD and the Road Research program at MnDOT:

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