

Precision Truck Training

Course III Heavy-Duty Models

By James E. Godfrey
and Robert J. Godfrey

First Edition — January, 2000



Career-builder training by
Truck Marketing Institute

PREVIOUSLY PUBLISHED BY TMI AS
Precision Truck Selling
Course III

**Precision
Truck
Training**
Course III
Heavy-Duty Models

First Edition—January 2000

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by

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Introduction

Preface

Welcome to Precision Truck Training: Course III. This course has now served students like you since it's first release in 1978. What a difference 20 years makes!

In 1978, the typical highway tractor here in North America was the cabover engine (COE) tilt with a sleeper. We strived to pull 45-foot trailers in 55-foot overall length. Achieving even 5 miles per gallon fuel consumption and a 500,000 mile overhaul point were remarkable. High tech communications consisted of the mobile telephone service.

Yes, what a difference. Today, our typical tractor is a conventional cab with sleeper—some so big they are called condos (short for condominium). Over 250,000 heavy trucks ply the American highways with onboard satellite communications systems. Million mile overhauls and 8 mpg fuel economy are achievable goals.

We are just beginning to witness a decade of electronics development for commercial vehicles. Today, there are vehicles in production with electronics packages that control the engine, transmission shifting, suspension ride, braking, cab environment and maintenance.

But, some things don't change. Trucks must still carry loads, be able to negotiate long uphill and downhill grades, and get in and out of tough job sites. Anyone with a gift of talk may be able to sell the truck that is sitting on the dealership lot.

But, the truck sales engineer is consulted by customers who want the professional assurance that the truck is going to carry the load and perform the way it is supposed to. Giving you the tools to do that is the basis for Precision Truck Training: Course III.

The opportunity to improve your skills is before you. Why not get started today and commit to a study program that will move you through this course in your shortest feasible time!



Robert J. Godfrey, Director

The Course Objectives

Whether you sell trucks or operate a fleet for a living, you will be more successful if you can listen to your customer, find out what their needs are, and then give them choices that reflect your professional expertise.

“Precision Truck Training: Course III” represents one of the most comprehensive self-study programs for persons entering the heavy duty truck sales engineering field. Selling skills courses are many and varied. Courses like this are usually found only in resident programs put on by the truck manufacturers at considerable expense. It would probably take you three 40-hour classes to equal the training that Course III provides.

As a graduate of this course, you will be expected to have the ability to analyze any commercial transportation objective and then to plan and propose equipment that will fulfill the transportation goal most efficiently and economically through the vehicle’s normal life cycle. That is the objective of Course III.

How We Get There

Ahead of you lies a 10 lesson course that will take you about 70 hours of study time to complete, including completion of an open book exam for each lesson. Take a moment to thumb through the textbook and look over the table of contents for each lesson to review the subject matter. Your other resources will be the Tables and Data information at the end of this book along with a component literature workbook in another binder. Last but not least, you will need the truck data book pertaining to one or more makes or (if you are not a truck dealer) the “Diesel Truck Index” publication which provides condensed heavy vehicle specifications.

To a certain extent, each lesson builds upon the other. You will start with Lesson 1, study it completely, do the test, submit it for corrections, and then move on. Submit a test after each lesson—do not send them in all at once. We strongly recommend that you do the lessons in the order they are presented.

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Truck Marketing Institute: A History

Truck Marketing Institute was founded in 1964 by James E. Godfrey to write specialized training courses for those who sell and operate trucks. Until TMI, this training was provided on a “catch as catch can” basis by truck manufacturer training personnel, area managers, advertising agencies, etcetera.

TMI is a privately owned school that operates in cooperation with the truck manufacturers and their suppliers. We strive to maintain up-to-date courses and manufacturers endorse them as “factory approved training.”

You can be assured that we meet and exceed distance education “best practices” of:

- Qualified faculty and staff
- Screening of applicants
- Reasonable tuitions
- Sound educational course content
- A fair tuition refund policy
- A history of student success and satisfaction
- The financial stability to ensure a quality educational service.



LESSON 1

Lesson Objectives

We shall take just a moment now to explain that a preview page precedes each lesson. In these previews we shall discuss the training objectives and briefly orient you to the subject matter as directed toward achieving the stated objectives. Thus, you will have a chance to warm up for the subjects ahead.

How much do you know right now about putting trucks together? (In this context we are referring not to the plant assembly line, but rather to the whole procedure of fitting just the right truck to the job at hand.) It's all to the good if you hold experience with light- or medium-duty trucks. If not, and you're here to take the plunge directly into heavy-duty trucks, fret not—this course will accommodate you.

But, regardless of the extent of your truck experience, do be assured that a substantial body of new knowledge will unfold in this and the other nine lessons. Consider, if you will, the most fundamental concepts relating to heavy trucks and high-tonnage trucking: **Measurements**, **economics**, and **productivity**. Very simply, your understanding of measurements, economics and productivity will be essential to your success in “putting heavy trucks together.”

Let us touch briefly on each of those three key words: **Measurements** are implicit to all aspects of selecting the right truck for the job, for you are dealing in weights and sizes of loads, constantly relating these to truck sizes and load ratings. **Economic** considerations prevail also, for the constant objective is lowest cost over the truck's life span, consistent however with **productivity**, which takes into account the amount of load, distance carried, and time span. Lesson 1 will enlarge upon these fundamental concepts.

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Depreciating Initial Cost Differences

Initial differences in purchase price must be viewed in a long range perspective. But what are we talking about in the way of initial cost differences? It could be any of numerous considerations in the vehicle specification: Will it be gasoline- or diesel-powered? Can extra cost lightweight equipment be justified? Or are you just underbid by a competitive truck of lesser quality and specifications? Suppose, for example, that the truck operator depreciates his linehaul tractors in three years and your quotation is \$2,000 over the competition. What would be your response?

First of all, consider long range value. What will be the worth of each tractor three years hence? Used truck purchasers seek out quality equipment, and their demands are reflected in higher resale prices. But placing residual worth aside, it may be strategically sound to underplay your case by using a theoretical 25% salvage value for each unit. When applied to the \$2,000 price difference, the 25% salvage leaves \$1,500 extra depreciation on your unit over the three-year span, so using the straight line procedure you could indicate an average extra fixed cost of \$500 per year for three years. A first class piece of equipment can generate profits far in excess of any modest difference in fixed cost — profits that come both from extra revenue and savings in operating costs.

Apply this same depreciation procedure when evaluating power plants or lightweight options, but go the one next step to calculate projected savings from fuel costs, maintenance, payload gains, or whatever. Your proposal will then have the validation of a demonstrated cost savings or profit increase, over and above the extra yearly fixed cost.

Productivity Cost Measurement

Can a big \$90,000 tractor-trailer rig move goods at less expense than two drivers wheeling two middleweight straight trucks with van bodies? Unless drivers' wages plummet, it would look offhand as though the betting money should go with the big rig. There is a method of comparing, should we choose to do so. Earlier, we discussed productivity and how it may be measured in ton-miles per hour. And later we

LESSON 2

Lesson Objectives

We begin with our usual preview, yes, but before looking into Lesson 2, a bit of reflection about Lesson 1 may well be in order. Measurements, economics and productivity factors dominate all heavy equipment job applications. Having laid that foundation, stick with us as we move into the many interesting technical challenges of legal-limit truck applications.

In several respects, since we still have more groundwork to lay, Lesson 2 continues an introductory phase of this training course. Because terminology varies by region and country, and because we want to be positive that we understand each other, we'll define heavy truck types and terms as well as tractor-trailer terms and dimensions. After that there will be a general discussion of vehicle size and weight limits, and you'll have a look at the multitude of vehicle combinations allowed on the highways — many types to suit the peculiarities of patchwork state and provincial limitations of vehicle types, sizes and weights. Our objective is to give you a broad understanding of industry conditions on a national level. Armed with this background, you will be in a position to make sound judgments for optimum vehicle applications anywhere on the continent.

Your work in Lesson 2 will then continue as you refer to size and weight summaries covering all jurisdictions of the United States and Canada. As you progress through Lesson 2, it will become evident that heavy trucks are molded to the size and shape of prevailing laws, molded under the pressure of economic and productivity goals. Understand these factors and you will grasp the true concepts of heavy duty truck applications.

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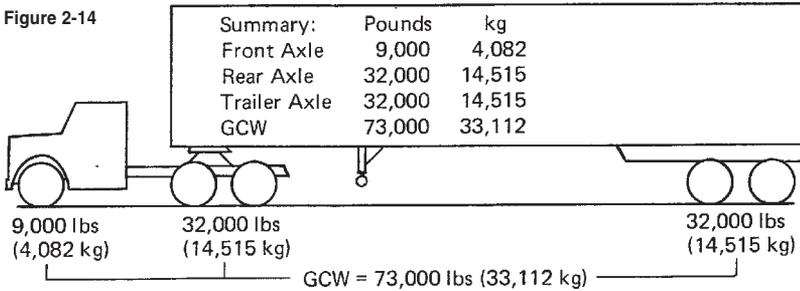
Illustration Acknowledgments

FIGURE: COURTESY OF:
2-16, 2-17, 2-17A Trailmobile Trailer Corporation
2-17B Brown Trailer Div., Clark Equipment Co.

Gross Combination Weight

In Gross Combination Weight (GCW) we have the *actual* gross weight of the tractor, trailer and cargo. If driven over a weight scale, the sum of the axle loads would be the Gross Combination Weight, as shown by this next illustration:

Figure 2-14



Trailer Types and Terms

Having reviewed truck types and terms, it would be appropriate to take a similar look at the cargo-carrying member of the tractor trailer team. What is a trailer? And what is a semitrailer? There is a distinct difference between these two vehicles, but it would be well to establish the understanding that the term trailer commonly is used in the broad sense to include *semitrailers* as well as trailers. (This paragraph heading, in fact, implies semitrailers and trailers in common.) These vehicles are defined as follows:

Trailer (full-trailer or “pup” trailer, as it also may be called) is a trailing load carrier which is supported by its own axles (two or more). A drawbar connects the trailer to a pintle hook on the towing vehicle.

Semitrailer is a form of trailer having the axle (or axles) only at the rear. The front of the trailer is supported by the fifthwheel coupling of the towing tractor. The semitrailer kingpin engages with locking jaws at the center of the tractor fifthwheel. Before uncoupling from the tractor, a movable landing gear is lowered to support the front of the semitrailer.

LESSON 3

Define the objective; identify any relevant problems; then reach the objective through the orderly solution of each specific problem.

Solving Problems and Reaching Objectives

At this point in your studies it seems timely to reflect on the basic techniques for problem-solving and goal-reaching. While the above thoughts were assembled to fit the occasion (and *italicized* to impart an aura of gospel truth), it would be presumptuous to claim originality. Such fundamental concepts probably trace back to the age of chiseled commentaries on tablets of stone.

The true motive here is to stir an awareness that success in dealing with heavy-duty trucks will hinge on your ability to define the objectives at hand, and then solve the related problems. But in a field as diverse as trucking, no training course can begin to formulate a solution for every imaginable situation. Instead, your strength will come through an understanding of the procedures. Thus, you are expected to build upon this given base of experience — training being a synthetic form of experience. So add a measure of resourcefulness to the teachings of this course and rarely will you be at a loss to cope with a truck application.

Lesson Objectives

Thinking in terms of broad objectives, the basic objective of heavy trucking was defined in Lesson 1: maximum productivity at lowest cost. After that, Lesson 2 addressed the problems of confinement — the laws defining the sizes and weights of vehicles, in turn setting constraints on load sizes. This next phase begins the process of learning to shape trucks for greatest efficiency and productivity within the legal parameters.

In Lesson 2 we touched on legal axle loads, practical front axle loads and allowable gross weights. As you may well appreciate, it is necessary to carefully plan the distribution of weight between the axles of a rig to achieve the allowed weight maximums. This leads up to the need for a good understanding of weight distribution principles. This subject has to do with the proportioning of weight between the axles of a truck, tractor or trailer. The placement of fifthwheel on a tractor can be critical, just as the relationship of body length and wheelbase are important to proper weight distribution of the loaded truck.

As it applies to heavy trucks and tractors, weight distribution is a subject of considerable scope—enough to merit two full lessons—so Lesson 3 will be confined to truck and tractor weight distributions; tractor-trailer combinations will be covered in Lesson 4. The final result will be the shaping of your talent for getting the weight where it belongs in legal-limit rigs.

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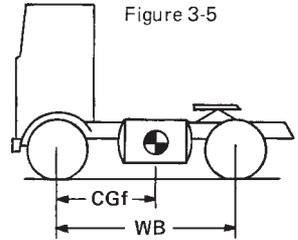
Weight Distribution of Chassis Equipment

Wherever the objective is maximum payload, chassis weight of the truck or tractor assumes critical importance. Some truck operators even demand a guarantee of actual road-ready weight upon delivery; in that circumstance you simply cannot afford to underestimate the vehicle weight with all its many options and accessories — nor should you jeopardize your competitive position by overestimating the weight. Therefore, it is beneficial to understand the mechanics of chassis weight distribution.

Of all the optional equipment for any heavy-duty truck or tractor, fuel tanks and their fuel content often constitute the greatest single weight addition to the base chassis weight. As an example, consider the weight imposed by this diesel fuel tank.

Weights and essential dimensions are as follows:

Model	WB	CGf
T420C (in)	120	63
T420M (mm)	3050	1600



Tank Data	Customary	Metric
Nominal Size	100 U.S. gal.	380 litres
Fill Capacity	95 U.S. gal.	360 litres
Fuel Density	7.0 lb/gal.	.84 kg/litre
Fuel Weight*	665 lb	302 kg
Tank Weight	<u>95 lb</u>	<u>43 kg</u>
Total Weight	760 lb	345 kg

*Calculations: $7.0 \text{ lb/gal.} \times 95 \text{ gal.} = 665 \text{ lb}$
 $665 + 95 = 760 \text{ lb Total Weight}$

Incidentally, in computing fuel tank weight, be sure to use the actual fill capacity, after determining whether the published tank volume is nominal or actual — the difference being an allowance of five percent for fuel expansion.

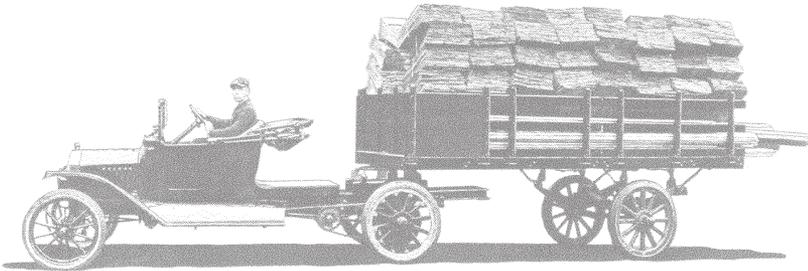
LESSON 4

Lesson Objectives

In earlier years of trucking, the Fruehauf Trailer Company promoted the payload advantages of tractor-trailers over trucks through the analogy that by pulling a wagon, a horse can haul more than it can carry. From the dawning of the wheel to the Westward-Ho Conestogas, history supported the wagon/trailer concept. And over the decades of trucking, the trailer idea has spawned multitudes of sophisticated and specialized semitrailers and trailers. Lesson 4 examines the representative contemporary trailer types, along with the tractors that pull them.

Ah, but this is a “truck” course, and perhaps your direct responsibility ends at the tractor fifthwheel. Nonetheless, one cannot escape the consequences of the tractor-trailer relationship. In plain fact, tractors and trailers must be planned together as a working unit. The state or provincial vehicle inspector typically measures trailer length and the overall length from tractor bumper to rear of the trailer. And at the weight scales, excessive or improper trailer loading may show up as an overweight tractor drive axle. These, then, are but two of many facets of the interrelationship existing between tractors and trailers.

From topic to topic in Lesson 4, you will be learning principles of trailer weight distribution, how to get maximum payload on tractors, dimensional and weight compatibility of tractors and trailers, and other subjects that will provide you with a full understanding of the tractor-trailer rig as a working team. As you become more expert in the broader scope of heavy-duty trucks, then it may seem more appropriate to look upon your role as a **trucking** specialist rather than the more narrowly defined **truck** specialist. Lesson 4 will help to shape the subtle but substantial distinction between trucks and trucking.



Detroit, 1914: Building Materials on the First Fruehauf Trailer.

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Tractor-Trailer Weight Distribution Compatibility

Through the previous tank semitrailer examples, you have seen the kind of balancing act that is needed at times to gain maximum payload. In a basic sense, compatibility is the object of it all — maximum weight distribution compatibility of tractor and semitrailer as a working team. When a semitrailer is built, weight distribution can be modified to a limited extent by a choice of optional kingpin locations, but that practice is generally discouraged in favor of standardizing the kingpin position. Shifting the axle fore or aft, however, can cause a marked change of payload distribution. In fact, some semitrailers have a provision for *sliding* the entire running gears back and forth in specific increments (12 inches being common). Consider such a trailer—a 40 ft grain semitrailer—and how its tandem suspension would be located for use with two-axle or three-axle tractors:

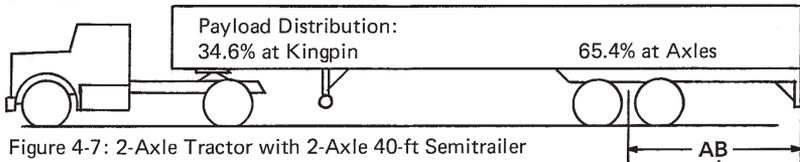


Figure 4-7: 2-Axle Tractor with 2-Axle 40-ft Semitrailer

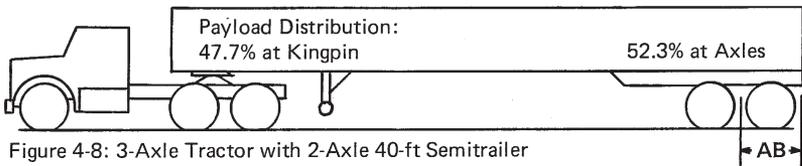


Figure 4-8: 3-Axle Tractor with 2-Axle 40-ft Semitrailer

Semitrailer Payload Distribution:

AB Dimension	KP %	% Axle
132 in (3353 mm)	34.6%	65.4%
54 in (1372 mm)	47.7%	52.3%

Where: TL = 40 ft (12192 mm)
 KP = 36 in (914 mm)
 KP to CG = 204 in (5182 mm)

When in a forward position, the semitrailer axle takes on a high percentage of body weight, as well as payload weight, thus reducing the load at the kingpin. But when positioned at the extreme rear of the body, the axle suspension shares the body and payload weight almost equally with the kingpin.

LESSON 5

Lesson Objectives

So far, major attention has been focused on the loading aspects of the truck or tractor-trailer rig—size and weight limits and distributions of weight to achieve maximum allowed loads within all legal constraints. Now it's time to examine the truck itself, starting with the load-carrying components.

Your Lesson 5 studies will begin with the frame—the central load-carrying member of the truck or tractor. You'll want to know about frame types and materials, shapes of side rails and crossmembers, and measures of relative frame strength.

From frames, your studies will move on to suspension systems—front and rear axles plus their related components (springs, wheels and tires). All will be covered thoroughly except rear axles, which get nodding attention in Lesson 5. Presently, the focus is on load-carrying, so we'll come back to rear axles later in conjunction with performance calculations and power train selections.

Determinations of required size and capacity are fundamental in the truck selection process, of course, but after that comes the need for choosing between alternate components. Which design characteristic will best suit the job at hand? What, for example, are the most probable applications for radial-ply, tubeless or wide-single tires? Or for soft-ride front springs, auxiliary rear springs, or rubber-biscuit mounting of a tandem axle suspension? The aim here is to broaden your knowledge of these many components, their attributes and limitations. On that basis, you can function with self-assurance and make well-reasoned recommendations.

Perhaps you have already scanned through the volume of component literature as provided with this training course. At any rate, from here on, make a point of referring to the component studies assignment

sheet after you finish each lesson. As you may realize, heavy-duty trucks are built with proprietary components (truck manufacturer's own parts) plus numerous components from outside suppliers—engines by Caterpillar, Cummins or Detroit Diesel, transmissions by Fuller, Rockwell, Spicer and Allison, axles by Spicer or Meritor. These and other component manufacturers are always ready to help, and we gratefully acknowledge the cooperation of those companies whose brochures are furnished for your present study and future reference.

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Low Profile Radials

During the mid-1980s, a new generation of metric sized tires was developed. TMI Tables 7C and 7M provide a handy source of capacities for these ‘new tires. If you were to compare a low profile 275/80R24.5 tire (275 is the width in millimetres while 80 is the aspect ratio) with an 11R24.5/G size, the metric tire would offer certain benefits, along with affects on axle ratios and braking, including:

1. Lower weight, for lower tire tax and more payload.
2. Firmer sidewall construction—less squirming, more life.
3. Less rolling resistance; better fuel economy.
4. Smaller rolling radius, calling for change of axle ratio.
5. Increased braking torque at the ground, sometimes requiring brake design changes for balanced braking.

Wide-Base Single Tires provide high load capacity along with superior flotation capability—two very appropriate qualities for construction trucks, given their off-road usage and typically heavy front axle loads. This wide-single tire offers an indication of capacity per tire and per axle.

Tire Size: 425/65R22.5/J:

Load Limit (lbs)	per Tire	per Axle
Front or Single Rear Axle	10500	21000
Tandem Rear Axle	10500	42000

As you may have guessed from its 22.5-inch rim diameter, the wide-base single tire is tubeless. Like conventional tubeless tires, the 22.5-inch rim has flanges to mount on 20-inch cast spoke wheels. Here is a cross-section of a wide-base single tire superimposed over a set of dual tires. The wheel design centers the wide tire over the wheel bearings. Axle track width and hubs are special. Weight savings of wide-base single tires can be significant, as indicated by this comparison using a tandem axle:

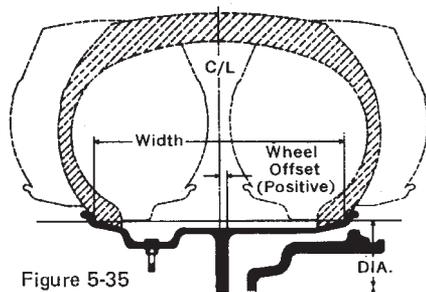


Figure 5-35

LESSON 6

Lesson Objectives

At this point of your progress through the truck selection process, you have planned for maximum productivity within the legal size and weight maximums. Load-support components have been carefully chosen for capacity and applicability to the job at hand. With all these aspects in order, it is time to think about making the wheels turn—time to plan for performance traits to get the job done most efficiently in terms of time and money.

The subject of vehicle performance takes in a rather wide range of considerations, all of which must be investigated and evaluated for possible effects on power plant and driveline recommendations. As a matter of fact, the subject is too broad to treat adequately in a single lesson, so your work in Lesson 6 will concentrate on principles of performance and performance calculation; Lesson 7 will carry on with driveline and rear axle gearing as major performance considerations.

As a prelude to any deep study of heavy-truck vehicle power requirements, it is inevitable that we must touch briefly on the relationship of torque, power and tractive effort. (If you understand those fundamentals, bear with us.) We say, “deep study” advisedly, for numerous subtle factors can affect performance ability, and an ill-chosen power train will cause the truck to be unfit for its intended purpose.

Subject headings in the Contents listing will provide a good indication of the nature and extent of your Lesson 6 studies. After that, the Achievement Test offers an opportunity for you to evaluate performance characteristics and to compute power requirements for a full range of heavy truck or tractor operating conditions. The results of this work should leave you with a thorough understanding of heavy vehicle performance characteristics and what it takes to make the vehicle run as intended.

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Drive Wheel Power Requirements

So far, it has been loss, loss, loss — engine accessories, perhaps altitude or hot thin air, and of course there are the driveline power parasites at work. A few pages back we saw 230 gross horsepower diminish to 193.5 horsepower at the rear wheels. But how much of that horsepower might be needed? And for what purposes? It all depends upon factors such as gross weight, frontal area, vehicle speed, road surface quality and possible grade conditions. Here are the basic elements that make up the power requirement at the drive wheels:

1. Rolling Resistance;
2. Air and Wind Resistance;
3. Grade Resistance;
4. Adverse Surface Resistance.

One by one, we shall discuss when, where, and why these resistances occur, their amounts and how the amounts can be predicted reliably from table references and from simple calculations on your part.

Rolling Resistance Power Demand

Just like taxes, rolling resistance takes its share of the action whenever truck wheels roll. Tires are round, yes, except when each tire flattens to put its footprint on the road. That tire flat spot at the road is the primary ingredient of rolling resistance, augmented by churning wheels and wheel bearings. On a hard, smooth road surface such as new concrete, rolling resistance traditionally has been pegged at 10 pounds for each thousand pounds of gross weight. However, various road test data show that rolling resistance does deviate from the 10-pound mark, and vehicle speed causes a variance too. Table 18C/18M provides you with full data on rolling resistance demand power, based on contemporary vehicle test results. From Table 18C, we give you the rolling resistance horsepower demands for 73,280 and 80,000 pounds GCW at 30 mph; compare the requirements at 50 and 60 mph:

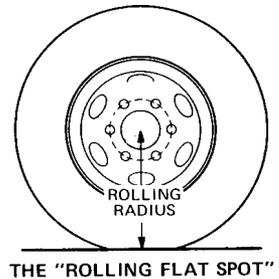


Figure 6-9

LESSON 7

Lesson Objectives

Your studies in Lesson 6 were aimed at an understanding of truck power requirements as related to the upper speed ranges. But when all factors are thoroughly considered, truck performance becomes a broad subject, and at this point you are at the one-third mark. Lessons 7 and 8 have a series of worthy topics in store. Here's what you'll be covering in Lesson 7:

Rear axles are due for attention again, this time with regard to gearing designs and choosing gear ratios according to engine speed and desired geared speed.

Diesel engines offer a considerable latitude for differences in power and torque characteristics. Through changes in fuel injection, camshaft design and the “tailoring” of turbochargers, diesels come in low, high or medium torque outputs, and flat or climbing power outputs. You will have a look at the different diesel mutations, and will learn also why the choice of transmission is vital in bringing out the best from any given type of diesel engine.

Also, you will be studying transmission ratio types and generally taking stock of contemporary transmissions and their best applications—automatics as well as manual transmissions.

Would you recognize a shift pattern chart if you saw one? Good, if you can, but if not, you should be able to analyze and prepare these graphs of engine speeds by the end of this lesson.

We'll draw Lesson 7 to a close with a short discussion about clutches and propeller shafts, mainly so that you will be familiar with the territory. It helps to have a knowing look when someone speaks about ceramic clutches or Series 1710 U-joints. Like the weather, you may not have much choice about clutches and prop shafts, but it's a comfort at least to have some degree of understanding of these driveline components.

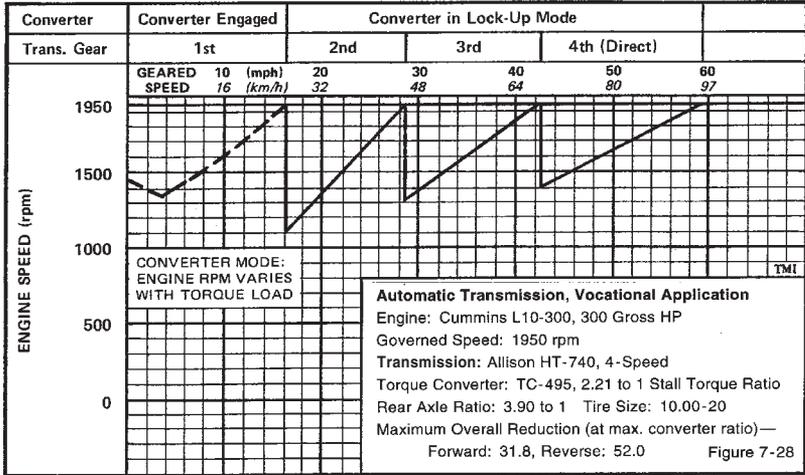
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Illustration Acknowledgments

Figure: Courtesy of:

- 7-3, 7-5, 7-7, 7-8** Spicer Heavy Axle & Brake Division, Dana Corp.
- 7-4, 7-6, 7-9, 7-35** Meritor Heavy Vehicle Systems L.L.C.
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- 7-27** Detroit Diesel Corporation
- 7-30, 7-31** Navistar International Transportation Corp.
- 7-32, 7-33** Pontiac-GMC Division, GM Corp.
- 7-34** Spicer Universal Joint Div., Dana Corp.



In Figure 7-28 we show the shift pattern chart for a 4-speed automatic teamed with a constant power diesel engine. Intended for on-road use, this combination can provide a high percentage of rated power output throughout the entire speed range, from start-up to cruising speed. This powertrain offers extraordinary benefits for the urban tractor operation—say, in petroleum tankers, just to mention one such example.

How to Make Shift Pattern Charts

You have followed the use of shift pattern charts for demonstrating the operating characteristics of powertrains, but how are such charts prepared? And would you be able to draw a shift chart from scratch if the occasion required? Actually, the procedure is quick and easy. Most of the work lies in finding the geared speed for each transmission gear. These speeds should be calculated at governed engine speed. Always begin by determining the geared speed in direct-drive; then you can divide that speed by each ratio to get the geared speeds for all transmission gears. A person can best learn by doing, so try your hand at calculating the geared speeds for this transmission:

LESSON 8

Lesson Objectives

In Lesson 8 we conclude the broad subject of performance with a thorough study of the truck at low speeds: Gradeability, startability and drive wheel traction. Here again, as in Lesson 7, you will come to appreciate the teaming of the drivetrain components — engine, transmission, axle—for the desired performance results.

While top gear performance usually is determined through a power analysis, you will learn in this lesson why low gear performance is torque oriented. You will see the case of finding maximum gradeability by a torque analysis—and the ultimate ease of simply looking at a chart to predict gradeability, or tractive effort available or required.

Gradeability and startability —how well a truck can get moving—go largely hand in hand. There is always the question of how much of each is needed for the particular truck and operating conditions. You will be examining the how and why of these factors—and gaining insight into the “how much” as well.

When we talk about traction as related to truck performance, it’s drive wheel traction, the ability of the tires to transmit tractive effort or “rim pull” up to the point of tire slippage. A subject that often escapes attention, drive wheel traction can be mighty important in some operations. You will have a chance to learn the factors that affect traction ability, and moreover, how to determine and fit traction ability into a balanced performance package. Best of all, these are simple and straightforward concepts—no engineering degrees needed here.

After all the fundamentals have been covered, you’ll be looking at the practical aspects of gearing trucks for satisfactory low speed performance. By categories, there are on-highway uses to consider, on/off highway trucks and tractors and gearing with automatic transmissions.

In all, Lesson 8 will serve as the grand finale to a three-lesson series on just about all the essential aspects of performance for the heavy-duty truck. Time permitting (or make time, if you can) a quick refresher look at Lessons 6 and 7 would be helpful in getting your performance knowhow together.

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Illustration Acknowledgments

8-3	Spicer Heavy Axle & Brake Division, Dana Corp.
8-4	Meritor Heavy Vehicle Systems LLC

Now, getting back to manual transmissions, it would be well to point out that the 10% start-up allowance is a generalization. It should not be implied that a tractor having a calculated gradeability of only 15% could not get started on a 6% grade. Indeed, a good driver may have no difficulty at all, and would cause no undue driveline strain. But, of course, some drivers are less expert and less considerate of the truck. To that extent, some of the 10% start-up cushion is insurance against careless or inept drivers, so don't infringe on the safety margin. Target low-gear (and reverse) gradeability for at least 10% above the steepest anticipated grade on the poorest expected road surface.

How Much Gradeability is Needed?

To answer the question of gradeability requirement authoritatively, you must determine the possible exposures calling for gradeability: maximum grade wherever the truck may travel, along with adverse road surfaces (or off-road conditions). Then the gradeability needs are totalled, including the start-up factor:

Gradeability — How Much is Needed:

- | | |
|---|-------|
| 1. Start-up (manual transmissions) | 10 % |
| 2. Steepest Expected Grade | ___ % |
| 3. Adverse Road Surface Correction (Table 20) | ___ % |
| 4. Gradeability Needed (lines 1 + 2 + 3) | ___ % |

For any specific case, all you need do would be to insert the grade requirements in a summary such as the above, and add to arrive at the gradeability requirement. But in a general sense, what are the likely grades to be encountered for on-highway operations? On major routes in the United States, very few grades exceed 7% for any significant distance. Grade design standards were set for the U.S. Interstate Highway System in accordance with intended maximum passenger car speeds. Here are the grade standards:

Grade Standards for the U.S. Interstate System

Design Speed	Maximum Grade
70 mph	3%
60 mph	4%
50 mph	5%
Severe Terrain	7%

LESSON 9

Lesson Objectives

Three lessons ago you began an intensive study of what it takes to make a heavy-duty rig move as intended. Since performance is vital to the successful application of a truck, that topic certainly merited extensive coverage. But every bit as important will be the matter of bringing the moving vehicle to a safe, sure stop under whatever conditions prevail — on level road or heading downhill, emergency situations or a normal slowdown for traffic controls. Hence, Lesson 9 will be devoted entirely to vehicle speed control.

While power-assisted hydraulic brakes offer increasing promise for heavy-duty trucks, operators tend to prefer air brakes. Therefore, these studies will center primarily on air operated service brakes. Included will be the forces and functions of braking, the brake system, its component parts, and principles that will help you in evaluating brake systems.

But service brakes are just one facet of the many-sided subject of vehicle retardation. Interestingly, your studies about vehicle performance forces and resistances will enter the braking picture, but in reverse, for all the forces that work against truck performance will now help the brakes to bring movement to a halt. Also, you will have a thorough exposure to auxiliary retarders — driveline and transmission retarders, exhaust brake and engine brake designs.

Perhaps more than any lesson so far, at times Lesson 9 will expand upon the narrow perspective of pure truck specifications planning to occupy a vantage point where you can experience the needs and views of drivers and equipment supervisors. As your professional stature grows, so must your ability to think the thoughts and communicate on the “wavelengths” of all the people you deal with. It becomes easier, then, to understand and fulfill their needs. In turn you will profit from their respect for your unique abilities. But so much for philosophical reasonings. No doubt you’re eager to dig in, so scan the contents to see what’s ahead, and then be on the way once more.

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Illustration Acknowledgments

- | FIGURE | COURTESY OF |
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| 9-32 | Detroit Diesel Allison Div., GM Corp. |
| 9-33 | Caterpillar, Inc. |
| 9-34 | Jacobs Manufacturing Company |

But what advantages can be seen in using disc instead of drum brakes for heavy-duty trucks? Disc advocates see it this way:

1. Smoother braking effort (not self-energized).
2. Greater heat dissipation, cooler running.
3. Self-cleaning and relatively unaffected by rain.
4. Better stability for balanced braking.
5. Longer lining life.
6. Lower overhaul cost in less time.
7. Lighter weight.

Electronic Braking Systems

We've now spent a good deal of time explaining the types of foundation brakes and the variety of valves, relays and releases that have been created to optimize performance. All of the components operate with a flow of air. What if these various functions could be handled electronically? For example, valves could be released by an electronic signal, not by an air pressure message.

That is the basic premise of electronic braking systems (EBS), sometimes generally referred to as "brake-by-wire". The first EBS was released in Europe in 1997 by Mercedes-Benz using air operated disc brakes on all axles. While the basic brake structure did not change, the mechanical treadle valve and valves at the axles were replaced by electronic versions. Depressing the brake pedal now sends a signal to activate all the brakes.

The development of EBS marks a significant milestone in brake technology. For the first time, the driver of a multi-axle combination vehicle can achieve virtually instantaneous brake application on all axles. EBS can even monitor trailer braking and increase pressure to the trailer brakes if needed.

As EBS is implemented, it will result in more uniform brake wear and elimination of many of the valves used for trailer control, quick release and relays. Although first released in Europe, the United States expects that minor amendments to the FMVSS-121 air brake rules (see following section) will permit EBS on U.S. made vehicles.

LESSON 10

Lesson Objectives

You're now in the home stretch—which goes to prove that perseverance pays off! This being the final lesson, catch-all would seem like an honest description for the lesson objectives. You have covered the major elements of truck selection work, and now comes a myriad of minor details—any one of which can prove to be of major consequence in a particular trucking situation. In store for you are all the fine points about:

1. Electrical Systems.
2. Cooling, Intake and Exhaust Systems.
Diesels and Emissions.
4. Noise Abatement.
5. Power Take-Offs.
6. Final Details: Trim and Accessories.
7. The Safe Truck.
8. The Optimum Vehicle Application.

While the above list indicates the broad subject categories, a scanning of the contents page (over) will reveal a thoroughness of treatment in all areas. In this last lesson, as in times past, some material pertains to basic truck design and factory-level equipment choices. Even so, your deeper understanding of trucks will make your judgment just that much more authoritative than the next guy's. After all, a superficial guide on “how to spec a truck” would take maybe one lesson; professionalism goes appreciably deeper, as you well know, from the inside looking out. At any rate, enjoy this wide-ranging windup lesson and score big on your final test!

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- 342** Instrumentation and Protective Devices
- 344** The Safe Truck—Everyone’s Responsibility
- 345** Ultimate Result: The Optimum Vehicle Application

or trash compactors. Nevertheless, your basic understanding of the truck as a power source will pay valuable dividends—and perhaps avert costly misapplications. With this understanding, you can work in partnership with the equipment specialist to achieve top efficiency at the job site as well as on the move.

The Power Take-Off Spectrum

Spend an hour counting the devices and equipment that a truck can power, then multiply that total by some factor such as five or ten, and you will have arrived at a vague approximation of the types and variations of power takeoff installations. Our purpose will be to acquaint you with the multitude of power takeoffs types, terms, scopes of usage, and expected capabilities. We'll begin with a look at the basic types of power takeoffs, or PTOs as abbreviated.

Side-Mounted Transmission

PTO is by far the most commonly used power source to drive auxiliary devices. Side-mounted PTOs are relatively inexpensive, are easily installed, and are simple to operate. With due care in the choice of the transmission and the power takeoff, the versatility of side PTOs can be extended from light jobs to include all but the most strenuous demands for torque or power. Most transmissions have standard openings on both sides to accommodate power takeoffs.

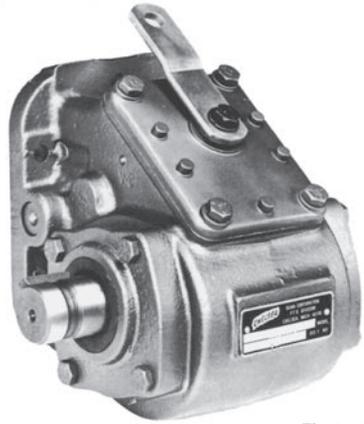


Fig.10-9:
Side Mounted Power Take-off (SAE 6-Hole). For extra-Heavy-Duty Operation. Shown for cable Control, with Lever-Shift or Air-Shift Available. (Chelsea 42 Series—Dana Corp.)

Power Tower is the common name given to top-mounted power takeoffs for auxiliary transmissions. The power tower has the capability of sustaining full torque output of the engine; by contrast, transmission-side-mounted PTOs are limited to a fraction of the engine's rated torque and power capability. The power tower also

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