

Bigger is not always better

When purchasing fire apparatus, some of the unwary persons responsible for the acquisition are under the assumption that “Bigger is Better”. This myth often will provide an apparatus or piece of equipment that is prone to problems and reduced performance. One such problem encountered is in the foundation brakes of a truck chassis.

It is not uncommon for the fire apparatus committee to discuss with a manufacturer or group of manufacturers the selection of components for an apparatus. From these discussions a set of purchase specifications are drafted for the apparatus.

There is a possibility that because of prior problems with a piece of equipment the specifications are “beefed up” to the point of overkill without regard to or knowledge of the consequences. Since the apparatus will likely be in service for some 10 to 20 years a specification committee sometimes asks that the design allow for the possibility of extra capacity for future expansion. We may want to carry this or that in the future so let’s have “growing room”.

Let’s create an example:

A fire department works with manufacturer ABC to develop a bid specification. Manufacturer ABC’s specification was selected for publication since in preliminary findings this manufacturer could provide an apparatus within the price range or with the features that the department liked.

The published specification was left open for the bidder to make the material selection for the apparatus body and water tank. Why was the material selection left open? Manufacturer ABC proposed a galvaneal body with a galvanized water tank, but the department realized that an aluminum body and/or poly tank would be more desirable. With the equipment required on the apparatus by NFPA and the department’s idea of “growing room” the apparatus designed with manufacturer ABC required an 18,000 front GAWR and 27,000 rear GAWR. Several responses to the call for bid were received. During evaluation of the bids the department accepts and awards the contract to a bidder that provides an aluminum body with a poly water tank.

During the pre-construction process of ordering the apparatus the department is adamant that it needs the 18,000 front GAWR and 27,000 rear GAWR.

The apparatus is built. The department accepts the

piece of equipment and is proud of the purchase they made. Some time later the apparatus starts to develop brake noise.

Sound familiar? Let’s examine the potential cause for the brake noise. The apparatus as delivered met the department’s specification that included an 18,000 front GAWR and 27,000 rear GAWR.

The apparatus is purchased, and at the time of delivery, includes all of the specified features and equipment except there is an aluminum body and poly tank reducing the in-service weight of the apparatus. Oh yea, don’t forget the department wanted “growing room”. With the lighter apparatus design and “growing room” the apparatus in-service only weighs 15,800 pounds on the front axle and 21,000 pounds on the rear axle. This is a problem!

Author’s note - Several rebuttals, I am sure, are coming to mind as to why the department should have purchased the truck from manufacturer ABC, but, we will leave that for another day. In fact, send your rebuttals into Mail Call!

According to a leading axle manufacturer for the fire service, if the in-service laden weight of an axle is greater than 10% less than the certified GVWR there is a likelihood of brake noise due to glazing of the brake shoe and brake drum. Why? Emergency vehicles are designed with a different brake lining compound than a highway truck. Due to the performance requirements established by axle manufacturers for the fire service the lining is more aggressive with a higher coefficient of friction to reduce brake fade. In dynamometer testing, a requirement of FMVSS-121, brakes are tested at their rated load. When the brakes are not worked to the design criteria by having a reduced weight the friction surfaces of the lining, and sometimes the drum, will not properly heat causing surface glaze rather than burn or wear. The effect of surface glazing can be equated to having ice on your windshield and trying to use the wipers to eliminate it. As in the case of the windshield the surface needs to be scraped off (cut off) of the lining and drum removing the crystallized layer.

How do we solve the problem? Properly size the brake actuating system for the in-service weight of the apparatus. To get there we need to have a basic understanding of brake forces and brake operation.

The energy required to stop a 45,000 pound apparatus from a speed of 30 MPH within 75 feet with all tires having a 20 loaded

radius is calculated from the following formula:

First we'll calculate the deceleration rate necessary to stop within the distance:

$$SD = \frac{v^2}{(2)(32.2 \times K_r)} + (t)(v)$$

$$75 = \frac{[(30)(1.467)]^2}{(2)(32.2 \times K_r)} + (.2)(30)(1.467)$$

$$75 = \frac{1,936.88}{64.4 \times 2 K_r} + 8.802$$

$$2K_r = \frac{1,936.88}{64.4} + 8.802$$

$$2K_r = \frac{30.076 + 8.802}{75} = 0.518$$

$$K_r = .259 \text{ deceleration rate in G's}$$

Next, we'll calculate the Brake System Deceleration Rate Required:

$$K_b = K_r - RR - A_r + G$$

$$K_b = .259 - .015 - .003 + 0$$

$$K_b = .241$$

The final calculation provides the brake torque necessary to stop the load at the 30 MPH speed within 75 feet:

$$B_{Tr} = CW \times LR \times K_b$$

$$B_{Tr} = 45,000 \times 20 \times .241$$

$$B_{Tr} = 216,900 \text{ in-lbs total braking capacity}$$

This is brake torque required for our sample vehicle for brake certification and compliance to 49 CFR 571.121 at a 45,000 pound GVWR. If we calculate the same torque necessary for the identical conditions except change the weight to the vehicle in-service weight we find:

$$B_{Tr} = 36,800 \times 20 \times .241$$

- B_{Tr} = 177,376 in-lbs total braking capacity
- SD – Stopping Distance
- V – Velocity (ft./sec.)
- T – Brake System Response
- K_r – Deceleration rate Necessary to meet stop ping distance (in G's)
- K_b – Brake System Deceleration Rate
- RR – Rolling Resistance of the vehicle (expressed in # / 1000)
- A_r - Air Resistance of the vehicle (expressed in # / 1000)
- LR – Loaded Tire Radius
- G - Effective Deceleration (Acceleration) Rate of Grade = $(\sin^{-1} \tan \% \text{ Grade})$
- B_{Tr} – Brake Torque Required to Meet Stopping Distance
- CW – Weight of the loaded apparatus
- GVWR – Gross vehicle weight rating
- 1.467 = ft / sec / MPH

Energy / Heat Dissipation Duty Cycle

Energy required to bring the vehicle to a complete stop at GVWR:

$$E_v = \frac{1}{2} MV^2$$

$$E_v = \frac{1}{2} \times \frac{45,000}{32.2} \times 30^2 = 628,882 \text{ ft-lbs}$$

$$E_v = 628,882 / 778 = 808 \text{ BTU per stop}$$

- E_v – Energy vehicle in ft-lbs
- M – Mass of vehicle in slugs (1 slug = 1 pound / (ft/sec²))
- V – initial velocity in ft / sec
- 1 BTU = 778 ft-lbs

Energy required to bring the vehicle to a complete stop at in-service weight:

$$E_v = \frac{1}{2} \times \frac{36,800}{32.2} \times 30^2 = 514,286 \text{ ft-lbs}$$

$$E_v = 514,286 / 778 = 661 \text{ BTU per stop}$$

Continued on next page

Energy Dissipated by the Brake Drum

The most common S-Cam brake found in a fire apparatus is a 16-1/2" x 6" front and 16-1/2" x 7" rear. This is where the commonality stops! The brake size is only a single part in the foundation brake system.

The input power to the brake shoes is developed by the mechanical actuating system. The mechanical actuating components of the brake system include the brake chamber size (area) and the slack adjuster (S-Cam lever) length. Let's look at a basic comparison of these components.

Calculating the Brake Power developed into the camshaft we use the following formula:

$$P_b = C \times S_L \times B_{PSI}$$

$$P_b = 30 \times 6 \times 30$$

$$P_b = 5,400 \text{ in-lbs}$$

Brake chamber size – 30 square inch

Slack Adjuster length – 6"

Brake air pressure with brakes applied – 30 psi

Where:

C – Brake Chamber Area in Square Inches

S_L – Slack Adjuster length

B_{PSI} – Brake Application Pressure

Chamber Size	Slack Adjuster Length	Camshaft Power (in.-lb.)
Type 24	5.5	3,960
Type 30	5.5	4,950
Type 30	6.0	5,400
Type 30	6.5	5,850

The chamber type is the nominal area of the piston or diaphragm in square inches. One thing to note is that all chambers are not alike. There are variances in the output forces of chambers of the same size due to internal design differences. Investigation into chamber forces should be examined on an individual part number basis by comparing manufacturers published output charts.

Some of the aspects we did not discuss in the process of over spec'ing an apparatus are the facets of increased weight, increasing the initial purchase price and a probable increase in maintenance cost. For another time!

Reader Service Index

Use this index along with our Reader Service page on our website at www.onthestreet.net to request information from our advertisers. Log on to our website using the access code provided above your name on the mailing label.

Spencer Manufacturing

RS# 103

4-Guys Incorporated

RS# 104

HME Parts

RS# 102

Ferrara Fire Apparatus

RS# 106

Boise Mobile Equipment

RS# 107

Alexis Fire Equipment Co., Inc.

RS # 108

Rosenbauer America (Central States Fire Apparatus, L.L.C/General Safety Equipment)

RS# 109

HME, Incorporated

RS# 110

FireFighting.com

RS# 112

Williams-Detroit Diesel-Allison

RS# 120

OnTheStreet.net

Visit Our website for these convenient services

Reader Service

Request information from the advertisers in this issue. See the Reader Service index on this page for instructions.

Tech Corner On-line

Look up Tech Corner articles from past issues

Subscriptions

Request a free subscription to On The Street Magazine

Change of Address

Let us know if you've moved or need your magazine sent to a different address

Guestbook

Sign our guestbook and leave your comments

Calendar of Events

Review up-coming Fire Service Industry events

FIRETRUCKS.COM



COPYRIGHT

All content included on this site, including text, graphics, logos, button icons, images, audio clips and software, is the property of On The Street and is protected by U.S. and international copyright laws. The compilation (meaning the collection, arrangement and assembly) of all content on this site is the exclusive property of On The Street and protected by U.S. and international copyright laws. All software used on this site is the property On The Street. or its software suppliers and is protected by U.S. and international copyright laws. The content and software on this site may be used as a source of general information. Any other use, including the reproduction, modification, distribution, transmission, republication, display or performance, of the content on this site is prohibited.

All e-mail, questions, answers, and other electronic submissions sent to On The Street, posted on OnTheStreet.net, or sent to someone identified as a representative of On The Street is at all times the exclusive property of On The Street.

TRADEMARKS

On The Street is a trademark of On The Street in the United States and other countries. On The Street's trademarks may not be used in connection with any product or service that is not On The Street's, in any manner that is likely to cause confusion among customers, or in any manner that disparages or discredits On The Street.

DISCLAIMER

THIS SITE IS PROVIDED BY ON THE STREET ON AN "AS IS" BASIS. ON THE STREET. MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, AS TO THE OPERATION OF THE SITE, THE INFORMATION, CONTENT, MATERIALS OR PRODUCTS, INCLUDED ON THIS SITE. TO THE FULL EXTENT PERMISSIBLE BY APPLICABLE LAW, ON THE STREET. DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. ON THE STREET. WILL NOT BE LIABLE FOR ANY DAMAGES OF ANY KIND ARISING FROM THE USE OF THIS SITE, INCLUDING BUT NOT LIMITED TO DIRECT, INDIRECT, INCIDENTAL PUNITIVE AND CONSEQUENTIAL DAMAGES.

OnTheStreet (<http://www.OnTheStreet.net>) is a production of
HME, Incorporated
<http://www.hmetruck.com>
1950 Byron Center Avenue Grand Rapids, Michigan 49509

© 1999 On The Street. All rights reserved.