Body building

LeRoy Hagenbuch P.E., Philippi-Hagenbuch Inc., US, looks at factors important to producing truck bodies.

Almost any good heavy steel fabrication shop can make a 'basic truck body' - floor, sides, front slope and canopy. What really differentiates one truck body manufacturer from another, and what defines a High-Performance Body, is design!

High-Performance Bodies are defined by a design that balances body weight with truck productivity. Actual body fabrication is important, but body payback (body productivity) really hinges on body design. The desired end result is a body design that balances the highest body productivity and lowest body weight.

Understanding the elements of High-Performance Bodies

High body productivity is centred on body design which balances body weight with body productivity. To compare body productivity by weight alone is inaccurate, as body weight can be reduced to the point where it cuts into truck productivity. For reference, the weight of a typical body broken down into components is seen in Table 1.

A body floor makes up the bulk of a body's weight. To cut body weight, we need to consider floor weight, which to some means cutting down floor size. This typically yields a narrower (possibly deeper sided) body. Taken to the extreme, narrow bodies are high-sided bodies. As body height goes up, truck loading times and loading impacts go up dramatically. High-sided bodies also present a challenge to front end loaders. A balance must be maintained between body weight, body floor area and productivity. The approach taken by Philippi-Hagenbuch, Inc. is to first

Figure 1. Mass impact.

Figure 2. Shovel/body mismatch, refer to Figure 4.

design to body/truck productivity and then the desired body weight.

Consider the factors which can destroy any truck body and how proper body design mitigates these destructive factors.

Table 1. Typical body	
Component	% weight
Floor	51 - 59
Sides	14 - 21
Slope	10 - 12
Canopy/bullnose	6 - 10
Other	6 - 9

The factors that can destroy any truck body

There are eight basic destructive factors that must be considered when specifying a High-Performance Body for your haulage application:

- Abrasive wear.
- Mass impact.
- Projectile impact.
- Haul cycle frequency.
- Type and size of loading equipment.
- Body inside width relative to load centering and loading impact.
- Dump site/tail chute damage.
- Loading equipment damage.

Abrasive wear

High-performance lighter weight bodies typically utilise thinner steel sections and higher hardness, higher strength, high abrasion-resistant steels. The body components that come into contact with the hauled material need to be as abrasion-resistant as possible. Also in a High-Performance Body, all load containment plates, including the floor plate, are thinner, so they must be strong and abrasion resistant to withstand any measurable thinning over the body life. Minimising sidewall abrasion, High-Performance Bodies are designed with outwardly tapering body sides allowing better load release.

Mass impact

Body mass impact occurs when a truck is loaded in two to three passes, such as loading a 240 t truck, with 80 - 120 t/pass dropped into the truck body. The key to a truck body floor resisting mass impact is the body floor support structure. In High-Performance Bodies, the body floor support structure is more extensive, with floor supporting members more evenly distributed, (see Figure 1).

Projectile impact

Sharp material projectile impact occurs when hauled material is fairly sharp, large and chunky and not easily broken up on impact. This creates an 'armour-piercing' situation. A proper steel to use in the construction of a High-Performance Body should be a derivative of steel armour plate.

Haul cycle frequency

The more loads dropped, hauled and dumped by a truck body, the more stress the body incurs. In some deep pit applications, maybe only one load per hour is being hauled; in other operations, as many as five loads per hour may be hauled. Over a 20,000 hour body life, a truck could be hauling anywhere from 20,000 to 100,000 loads. A body must be built to withstand the number of loading/dumping cycles it will be subjected to, not just the number of hours it is operated.

Type and size of loading equipment

The three main types of loading equipment are the cable shovel, hydraulic shovel and front end loader. Each interacts with a truck body in a different way.

Cable shovel

With really large cable shovels, (80 to 120 t bucket capacities) High-Performance Bodies incur higher loading impacts and less favourable load placement.

In a mismatched truck body/cable shovel situation, a truck body will typically be loaded off-centre, causing the body to twist slightly. With larger shovels, further body stress occurs due to the height that material is dropped from. These issues can be greatly diminished with a properly designed body, (see Figures 2 and 3).

Hydraulic shovel

Hydraulic shovels have a tendency to minimise off-centre loading, though material drop and truck body impact remains similar between cable and hydraulic shovels.

Figure 3. A further consequence of off-centre loading, causing body twisting every time the truck dumps, stressing the body, truck frame and the body/hinge pivots. Each hydraulic jack pushes up with equal force against unequal load resistance.

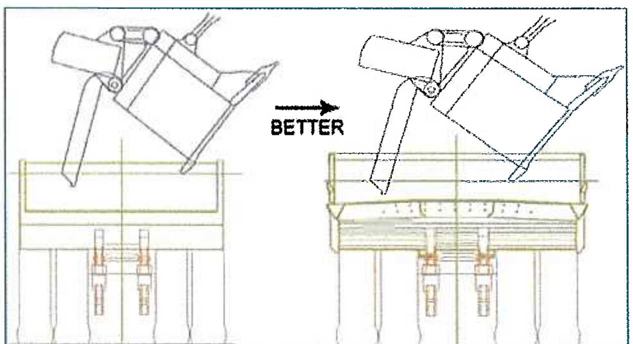

Figure 4. A wider body allows for better centre loading with reduced loading impacts.

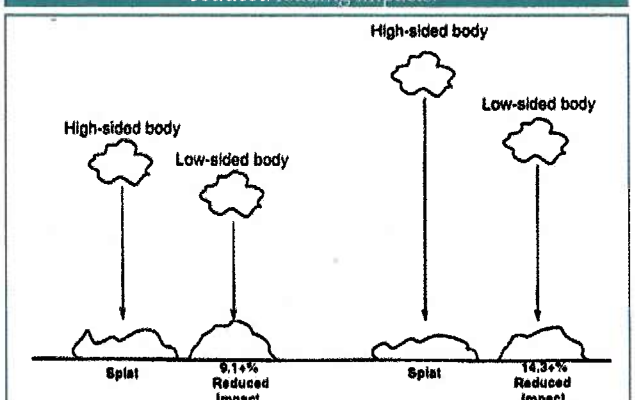

Figure 5. In High-Performance Bodies, a wider, lower-sided body by its very nature minimises loading impacts.

Front end loader

Front end loaders typically drop the material further and cause greater impact to the body oft side, adversely impacting body life.

Body inside width relative to load centering and loading impact

With properly designed bodies and a good body to loading equipment match, loading damage can be minimised, as shown in Figure 4. A little wider body allows for better centre loading and for discharge of the material closer to the floor, with reduced loading impacts, (see Figure 5). Signs of a loading equipment /truck mismatch:

- Loading shovel equipped with large bucket can't comfortably load into a truck bed without the shovel door banging into the near body side.
- Front end loader literally throws material against the oft body side.

Loading equipment damage is minimised where possible with the correct loading equipment/truck match.

Body dump site/tail chute damage

At the dump site, one needs the greatest practical tail chute dump clearance, (see Figure 6). Two ways to improve dump clearance are:

- Body design - floor configuration.
- Angle of body floor dump to release material from the truck body - typically a 45° floor angle at full dump is sufficient. Dump angles in excess of 45° typically provide little, if any, dumping advantage.

Loading equipment damage

When there is a loading equipment/truck mismatch, loading equipment will typically damage the body sides, (see Figure 7).

The six key elements to the manufacture of High-Performance Bodies

Correct body application
Knowing and adjusting body design for the factors that could destroy the body.

Correct sizing
Correct body 'effective' volumetric sizing preferably determined through some type of Load Profiling® process.

Body materials and type
Using the correct steel types and thicknesses.

Finite element analysis of the body
Using the correct load assumptions and loading constraints and how to apply them correctly in the FEA analysis.

Using quality welding consumables (wire/rod) throughout the body construction
Utilising consistent quality steels produced to tight metallurgical and physical parameters and the proper welding techniques.

End user (the purchaser) buy-in, including understanding of the implications and limitations of High-Performance Bodies.
A desire to make the product work.

Figure 6. Dump clearance.

Figure 7. Damage from loading equipment.

Figure 8. PHIL Load Profiled® overburden body.

Correct body application
A solid High-Performance Body design must address the actual body application. If any factor(s) that can destroy a High-Performance Body exist, these factors must be mitigated in the design and manufacture of the body.

Correct sizing
A body must have the right 'effective' volumetric capacity so that the advantages of a High-Performance Body can be fully utilised. A correctly designed body is properly sized through a proven load 'profiling' process. The SAE 2:1 heaped rating of a body typically overrates the 'effective' volumetric capacity of a body by 7 to 14%! Thus the PHIL Load Profiled® body sizing process, (see Figure 8).

Material and type
A correctly engineered body design considers the actual load containment plates and the structure that supports those load containment plates: the floor, the side, front slope structures and the use of the best possible steel in all body components, (see Figure 9).

Finite element analysis (FEA)
A solid finite element analysis of the body design (one must know the extreme loadings, the load constraints to apply and the fatigue strength of the steel) to identify all potentially high-stress areas, and then these areas must be mitigated in the body design. (See Figure 10). (Many steel suppliers never test/do not know the fatigue strength of their high strength steels.)

Quality steels and welding consumables
Steel quality and steel fatigue strength play a key role as to whether a High-Performance Body will perform successfully or not. Typically with high strength, abrasion-resistant steels, a key enumerator is the hardness of the steel; the range of hardness is set by the steel manufacturer. Steel that is produced with + or - 20 points variance in Brinell hardness is of a higher, more consistent quality than a steel that is + or - 40 points in hardness. Consistent steel plate quality is a must in a High-Performance Body.

High quality welding consumables are the other half of the material

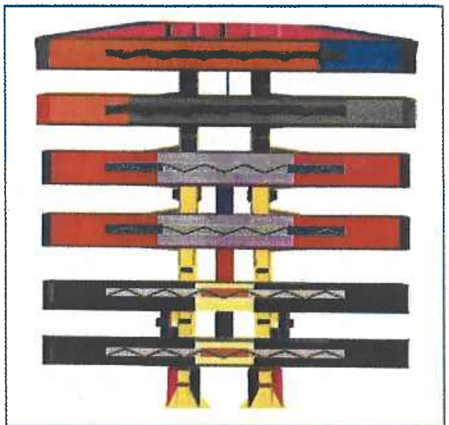

Figure 9. Floor support.

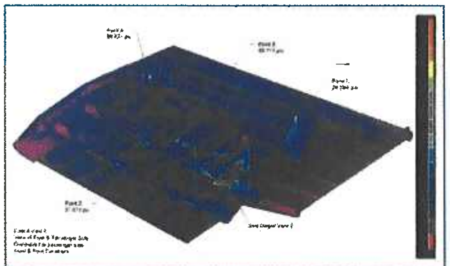

Figure 10. FEA Analysis.

equation in producing High-Performance Bodies. Quenched and tempered steel plate is of a higher strength than can be achieved in the welding process. Therefore, a welding process that calls for a slightly larger weld size as well as ductility in the weld is essential. Weld ductility is even more important if the body will be used in low temperature winter climates. High-Performance Bodies are typically produced using a nickel class of welding wire to provide weld ductility.

User buy-in

The final element in the success of a High-Performance Body is you, the user and is therefore user-driven. A mine needs to buy into the High-Performance Body concept and understand the implications and limitations of a body. High-Performance Bodies can work well, but there has to be a mine-wide operational buy-in.

Emerging technologies

As High-Performance Bodies find greater roles in the marketplace, future technology improvements that will ensure success are:

- Better and higher strength steels.
- Selective use of highly abrasive wear materials.

Years ago, the standard high-strength, high-abrasion steel was 360 Brinell material. Today it is 450 Brinell plus material, meaning a more durable body.

The second emerging technology is a bi-metallic highly abrasion-resistant wear plate (50 to 60% chromium carbide) installed in specifically targeted body wear areas.

Projected body life

What is the projected life of a High-Performance Body? Its life is principally controlled by two factors: wear and the floor support structure. As long as floor support structure integrity is maintained and (any) body wear is addressed, a High-Performance Body will live. In other words, produce the floor support structure correctly, (one gets no second chances - the body floor structure either is good or bad, with no in-between) and address body wear, if and as it occurs, and you have a winner.

And, remember the actual number of haul cycles a body will carry over its life must be considered versus body operating hours. Consider this example: one load per hour with an expected body life of 20,000 hours means 20,000 loads. Four to five loads per hour and a 20,000 projected body life means 80,000 to 100,000 loads.

Conclusion

Reducing body weight 25,000 - 30,000 lbs with High-Performance Bodies requires creating exactly the right mix of key body design/application elements. Design elements consist of:

Engineering activity factors

Product design, finite element analysis and production.

Component factors

The steel and welding consumables used to construct the body.

Application or usage factors

Controlled by the product user.

With an understanding of the application, the components that bring a High-Performance Body to fruition are:

- 'Effective' volumetric sizing.
- Design.
- Finite element analysis.
- Steel.
- Welding consumables.
- Workmanship.

When these six items are properly brought together, along with a true understanding of the factors that must be mitigated in the body design process, a High-Performance Body will more than justify its purchase.