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## Collision Reconstruction Concepts A Series: Change in Velocity (delta-V)

**James R. Schmidt Jr., BSME / Collision Reconstruction Engineer**

**Change** in velocity, also known as delta-V, is a simple concept. It's just the way it sounds ... how much did the velocity (of a vehicle) change during a given event? Let's take a vehicle travelling at 35 mph. If that vehicle slows to a stop at a red light, it's change in velocity/delta-V is 35 mph. How long did it take to slow down though? Under normal braking, it would take about 8.0 seconds, which equates to a 0.20 g rate of deceleration (i.e. rate of slowing down). What if that vehicle skids to a stop instead? In that case, it would take about 2.3 seconds, and the rate of deceleration would be 3 ½ times higher at about 0.70 g.

**We're** talking about collision reconstruction though, so let's have this vehicle crash into a fixed object at 35 mph. First, let's evaluate the scenario in which the vehicle crashes head-on into a utility pole, such that the impact is to the right of center on the front of the vehicle. The 35 mph-worth of forward velocity of this vehicle goes to zero in about 0.11 seconds (give or take). Quite fast, and reflected in the much higher (average) rate of deceleration experienced by the vehicle over such a small increment of time. The g's are now at 14 ½, which is nearly 21 times faster than skidding to a

stop. Next, let's go one step further. Let's have the vehicle crash head-on into a brick wall. The forward velocity of the vehicle stops in about 0.08 seconds (plus or minus), which is even quicker than the utility pole impact scenario. Again, as would then be expected, the g-forces are even higher ... just about 20 g's on average, nearly 29 times faster than skidding to a stop, and 100 times faster than normal braking to a stop at a red light. It's no wonder that severe injuries can result during a collision. (Note: A vehicle has some degree of rebound during a collision which, in the case of crashing into a brick wall for example, results in a delta-V higher than the impact speed alone.)


**So**, what does all this mean? delta-V is a measure of impact severity, BUT ... what type of "impact" are we talking about? You could have the same delta-V for different scenarios. The associated g-forces could be very different, depending on the impact duration. It's this impact duration, and hence these g-forces calculated by the collision reconstruction engineer, that can then be used by a bio-mechanical expert in the evaluation of injuries sustained by an occupant of a vehicle during a crash. This is delta-V made simple.

## Spiral Staircase Installation Daniel M. Honig, PE / Structural Engineer

**Case Synopsis:** Homeowner tripped and fell while descending a spiral staircase in his residence. The building contractor installed the spiral staircase from a pre-engineered kit which was designed, fabricated, and packaged by one of the defendants. During the course of the spiral staircase installation, the improper adjustment and connection of the overall stair and its components, including alignment, created a hazardous and dangerous condition.

**Expert Analysis:** Although properly designed and fabricated to be code conforming, as erected, significant variations far exceeded the code allowed tolerances and dimensioning for this type of stair

which allowed for a significant installation deficiency. In order to be code conforming, neither dimensional riser variations nor out-of-level/out-of-plumb installation are acceptable.

**Result:** Based on measurements and observations, the expert was able to confirm that this staircase was not installed per the recommended instructions and installation procedures supplied with the stair kit. Clearly, the as-built conditions were a consequence of improper assembly, installation, and adjustment of the spiral staircase by the general contractor. Stair manufacturer successfully defended. 

## Jeep Grand Cherokee Class Action Suit

**R. Scott King, BSME**

**Automotive/Mechanical Engineer**

**Case Synopsis:** A New Jersey resident brought a class action lawsuit against DaimlerChrysler alleging brake defects on certain 1999 through 2004 Jeep Grand Cherokee vehicles. According to the complaint, these vehicles suffered from defects that resulted in severe vibration and pulsation during braking. Preliminary data from the manufacturer suggested the problem stemmed from a variation in thickness of the front brake disc rotors, also known as disc thickness variation or DTV, resulting in harsh pedal vibrations called brake judder.

**Expert Analysis:** The phenomena of brake judder typically occurs slowly over time with vehicle use; oddly, however, it is often not associated with brake usage. The condition is typically the result of very small amounts of brake rotor material being removed and/or redistributed across the rotor surface each time it rotates and brushes past the released brake pads. Over time, this redistribution results in alternating high and low spots on the rotor surface. Upon braking, the brake pads follow this varying contour causing the characteristic vibration. Normally, effective manufacturing tolerances limit or prevent this condition; however, relaxed tolerances can result in excess looseness between the front brake components and can thus accelerate the condition. Many Jeep Grand Cherokee owners reported the very-noticeable condition within about 15,000 miles.

A detailed inspection of the plaintiffs' vehicles and front brake rotors revealed excessive DTV and road tests confirmed the resulting judder problem. Plaintiff experts theorized that, consistent with previous studies and testing, relaxed manufacturing tolerances of the front brake system components led to the judder condition. With a viable theory, as well as data indicating the scope of the problem, attorneys for the plaintiffs were able to negotiate a \$14.5 million nationwide, consolidated settlement that reimbursed owners for brake repairs, and/or offered free brake inspections, within the warranty period.

## Elevated Boom Lift Tip-Over

**Richard G. Pearson, Ph.D., CPE**

**Human Factors**

**Case Synopsis:** Two contract employees were seriously injured when an elevated boom lift they were using tipped over. Both had been engaged in installing electrical conduit adjacent to an outdoor, roof-top "dust collector" at a manufacturing plant. The operator was in the process of lowering and rotating the lift platform when it tipped over. The boom lift was equipped with a tilt warning light that would activate when the chassis was positioned on a 5 degree or greater slope. Both this light and a tilt alarm horn were mounted on a display panel on the lift platform. The warning horn was designed to sound whenever the lift was out of level 5 degrees in any direction with the boom raised above the horizontal.

**Expert Analysis:** Plaintiff's counsel retained an expert in human factors and occupational safety to address issues of auditory and visual warning devices. Incident workers testified that prior to, and during the tip-over, they did not see the tilt warning light illuminate or hear the tilt alarm horn. The light bulb for the visual warning was found to be missing. The warning horn was deemed to be lacking in terms of its frequency, amplitude, and signature characteristics so as to be perceived relative to ambient noise at the incident site.

Expert analysis revealed the boom lift was defective in design from the perspective of established and recognized human factors engineering design principles. Specifically, both visual and

auditory warning devices were inadequate to gain operator attention and warn of an unsafe condition, i.e. of the imminent risk of a tip-over. Additionally the visual warning was not designed with a "fail-safe" mechanism (to account for the absence or failure of the warning light). Finally, the expert countered defendant's argument that warning labels on the platform and the presence of an operator's manual on the unit would have played a role in prevention of the incident.

**Result:** Settlement reached prior to trial.

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to exceed our clients' needs."***

**- Steven M. Schorr, PE**

## Belt Conveyor Accident

**Thomas J. Cocchiola, PE, CSP**  
Mechanical Engineer

**Case Synopsis:** Postal service owns and operates a number of portable belt conveyors that are used in mail sorting operations. Workers maneuver a portable conveyor into position before loading bundles of mail, wrapped in plastic, onto its inlet end. Other workers typically stand on the sides of the conveyor while sorting bundles, removing their plastic wrappers. Plastic material often accumulates at the discharge end of the conveyor.

On the day of the accident, a worker sorting mail saw plastic material near the conveyor discharge end and reached to remove it. The worker had removed plastic from portable conveyors in this manner many times in the past. Unfortunately, her hand became entangled in the plastic material, which was unexpectedly pulled under the conveyor. Her hand was pulled through an opening under the conveyor and into an inrunning nip point formed between the moving conveyor belt and a rotating roller. Her hand and arm remained trapped until co-workers activated an emergency stop switch and cut the conveyor belt.

**Expert Analysis:** Drawings and specifications showed that the manufacturer mounted guards at the sides and discharge end of

the conveyor. Guards formed barriers that prevented access to rotating rollers and inrunning nip points from both sides. However, it was argued that the guard on the discharge end was inadequate because of a gap between the top of the guard and the underside of the conveyor belt. The size of the gap allowed plastic as well as worker's hands to contact an inrunning nip point underneath the conveyor. Engineering analysis demonstrated the gap was excessive and did not conform to fundamental engineering recommendations for acceptable guard openings.

The postal service recognized the discharge end guard was deficient after conveyors were purchased. A retrofit guard was developed and installed on most of the existing conveyors. For some reason, a retrofit guard was never installed on the incident conveyor. As a result, the conveyor remained in service with a deficient guard until the accident. The accident would not have occurred if the manufacturer equipped the conveyor with an end guard that prevented workers' hands from contacting inrunning nip points in accordance with safety standards and recommendations.

**Result:** Case resolved prior to trial.

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## Catastrophic Diving Accident in an Above-Ground Pool

**Tom Griffiths, Ed.D.**  
Aquatics Consultant

**Head-first** entries of any type should never be attempted in above-ground swimming pools. These pools, typically four feet deep, cause many cases of quadriplegia and paraplegia. What is particularly tragic is that the injured party becomes permanently paralyzed in less than two seconds between the time their feet leave the pool deck or lawn and their head hits the bottom of the pool. As a result, aggressive warnings against dangerous head-first entries are required. When diving cases result in favor of the plaintiff, multi-millions are typically awarded.

**This case**, taking place in the mid-west, was especially compelling because the young adult injured made a running dive from the lawn over the soft sides of the latest version of above ground pools. The traditional above-ground pools have rigid side walls that are difficult to dive over, and if the dive is miscal-

culated, the diver might collide with the pool walls. Plaintiff's expert concluded that the soft-sided pool actually invited young adults to dive over the sides because their construction was so soft and forgiving. Additionally, plaintiff's expert stated because the soft pool walls were so user-friendly, the pool manufacturer had a greater duty to provide more and larger warning signs with warning shapes and colors as the foreseeability of diving over the sides was greater as compared to the older, hard-sided, above-ground pools.

**In the end**, the defense prevailed. The jury sent a loud and clear message that Diving and Drinking DO NOT MIX. The high blood alcohol content of the injured party clearly swayed the jury in their decision; the real cause of this injury was misbehavior induced by overindulgence.

## "Explosion in Plant Doesn't Mean Implosion of Profits"

**Jeffrey Willoughby, CPA, CFF, CFE**  
Forensic Accountant

**Case Synopsis:** Manufacturing company was forced to shut down part of its operations as a result of an explosion that occurred at their plant. Plaintiff argued a faulty piece of equipment exploded causing them to shut down part of their facility for 30 days. Plaintiff claimed more than \$60,000 in lost profits and operating expenses and over \$90,000 in additional costs for repairs and cleanup.

**Expert Analysis:** Analysis of Plaintiff's calculation of lost profits showed it was based upon the profits earned over the previous eleven months for the entire company and all of its operations. Only a portion of the facility was affected and Plaintiff had failed to include a provision for a partial loss. Comparing the lost income claimed with the income earned during the same period the previous year indicated the company incurred a loss instead of a profit, indicating there may have been no lost profits.

Testimony offered could not definitively state whether any revenue was lost due to this explosion. Plaintiff was unsure as to whether any sales had been lost or simply postponed. The claimed lost revenue during this period could not be confirmed as permanently lost. Plaintiff also did not consider the facility was only partially affected and was still generating revenues during this period. Any lost profits calculation would also have to include the actual revenue earned during this same period as an offset.

Analysis of Plaintiff's calculation of lost operating expenses during the loss period showed several items classified as costs

of goods sold. These costs are directly associated with the production of finished goods and would not be incurred during a period in which this portion of the facility was not operating. Additionally, Plaintiff had ample inventory on hand to service sales requests during the period of loss. While manufacturing was disrupted, sales continued unabated.

The additional expenses claimed included payroll costs incurred to clean up debris and repair the damage from the explosion, but Plaintiff could not produce any payroll reports or other documents showing any additional payroll costs were in fact recognized. Testimony offered by the accountant involved in calculating the loss indicated he was unaware of who performed the clean up and could not confirm whether there were any additional costs. Due to the lack of documentation of these and other expenses claimed, it was determined Plaintiff had not supported any such expenses.

**Result:** Expert analysis and report resulted in a significant reduction of Plaintiff's claim for lost profits, operating expenses, and additional costs. Failure to consider all the facts and circumstances of a particular case as well as failing to apply the appropriate methodologies can result in a flawed analysis and incorrect calculation of damages. Neglecting to corroborate information supplied by interested parties can lead to errors as well. Calculating damages in a lost profits case can be a very tricky proposition and due professional care should be exercised in all cases.

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## Bus - Pedestrian Collision: Did the Parking Lot Design Contribute to the Collision?

**Steven M. Schorr, PE**  
Collision Reconstruction Engineer

**Case Synopsis:** A northbound transit bus was traveling along an access roadway within a shopping center parking lot when a collision occurred between the front of the bus and a pedestrian. The pedestrian was crossing from the sidewalk in front of the stores located to the right [east] side of the bus to head to the parking spaces located in the parking lot to the left [west] side of the bus. The pedestrian had crossed the northbound lane, as well as the centerline of the access roadway, and was in the southbound lane when the collision occurred. The bus operator testified that the design of the roadway was such that as the bus negotiated a left turn immediately prior to the area of the collision, he could not keep the bus within the marked, travel lane. As such, he was forced to move into the southbound lane and the collision occurred.

**Expert Analysis:** An engineering analysis of the turning capabilities of the transit bus was completed. Utilizing the specifications of the transit bus and field measurements of the roadway in question, computer-modeling of the possible turning paths of this particular bus were evaluated. The engineering analysis confirmed that, regardless of the actions of the bus operator, a northbound transit bus could not, at any speed, safely negotiate the left curve and remain properly within the northbound lane. The independent engineering analysis was supplemented by actual field video depicting real-world examples of similar model, transit buses failing to remain in the marked travel lane while attempting to negotiate the left curve. The engineering analysis of the transit bus movement was utilized by the parking lot design expert to render opinions critical of the parking lot design.

**Result:** Case settled prior to trial.

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