




# Memorandum

Subject: INFORMATION: In-service Performance Evaluation and Continuous  
Monitoring of Roadside Safety Features

Date: NOV 17 2005

From: *for*   
John R. Baxter, P.E.  
Director, Office of Safety Design

Reply to  
Attn. of: HSA-10

To: Safety Field

Ideally, all highway agencies should know precisely what has been incorporated into its roadway/roadside infrastructure and be able to monitor the performance of individual components of its highway system. Asset management has become a primary means of accomplishing this goal in many states. However, there remains one area where in-service evaluation or performance monitoring seems to be minimal at best, and that is the area of roadside safety features.

As some of you may recall, when the FHWA began formal acknowledgement of successfully crash tested safety appurtenances in the late 1980's, we first accepted a device as an *experimental* feature, and later upgraded it to *operational* status when enough crash data had been gathered to show that it was, in fact, performing as desired under varied field conditions. Several State transportation agencies were reluctant, however, to install a safety device that was labeled experimental and many believed the evaluation process itself to be both time-consuming and expensive, so our two-phase acceptance procedure was dropped. Unfortunately, formal in-service evaluations of safety devices were dropped as well by most States.

Because the crash tests by which safety features are deemed acceptable for use on the NHS are conducted under ideal conditions, are limited in number, and use only two vehicle types, this testing may not reveal longer term operational, maintenance, or repair problems that do not become apparent under short-term certification testing. Actual field experience must be monitored to assure that a safety device is working as intended. In fact, Chapter 7 of the NCHRP Report 350 outlines a simplified procedure for conducting in-service performance evaluations on devices deemed crashworthy through standard testing procedures. The NCHRP Report 490, "In-Service Performance of Traffic Barriers", published in 2003, summarized the results of field evaluations of barrier terminals conducted in three states and provided a model methodology that can be used by hardware manufacturers and transportation agencies to monitor the performance of their hardware.



Several States routinely conduct in-depth evaluations at locations where fatal or otherwise severe crashes have occurred in order to assess potential liability firsthand, but also to determine if roadway or roadside design contributed in any way to the severity of the crash. This specific activity should be conducted by those in the highway agency who are responsible for the design and maintenance of the roadside safety hardware and may be reported as part of each State's HSIP as it will provide valuable input into the report required under 23 U.S.C. 148 (g).

I am enclosing an evaluation study recently completed by a manufacturer on a unique crash cushion that had been developed, tested, and accepted for use on the NHS. In this case, our formal acceptance letter (CC-85) requested that an evaluation be conducted since the product was different from others on the market. One can readily see that the report is very straightforward, primarily requiring notification when a crash occurs and follow-up on site to obtain as much information on the consequences of the crash – to the vehicle involved, its occupants, and the device itself.

Both types of assessments should be an ongoing effort at all levels and for all roadside safety features to verify expected impact performance and, as suggested above, can be used as input to assess the effectiveness of the roadway departure elements of each State's overall HSIP.

Attachment

# SCI Products Inc.

A DIVISION OF STABLER COMPANIES INC.



635 Lucknow Road  
Harrisburg, PA 17110

PHONE 717-234-3106 FAX 717-234-8518

October 28, 2005

Mr. John R. Baxter, P.E.  
Federal Highway Administration  
400 Seventh St., S.W.  
Washington, D.C. 20590

Dear Mr. Baxter:

Per your request in CC-85B, we would like to submit a narrative for our in-service evaluation as discussed in NCHRP Report 350, chapter 7 and FHWA Approval Letter CC-85. We have accumulated documentation on every impact that has been reported to us. When an impact occurs, we request both an incident report and a police report along with pictures. These documents substantiate our safety and cost histories that are summarized in our narrative. We did not receive pictures of each incident as it is hard to engage the cooperation of contractors to provide them.

SCI Products Inc. will continue to document and build our impact histories. We will be looking for safety improvements, safety issues, accident causation and repair costs for the safety and benefit of the motoring public. We hope that this represents a high standard for future in-service evaluations.

Sincerely,

A handwritten signature in black ink that reads "Jeffery D. Smith".

Jeffery D. Smith  
VP  
SCI Products Inc.

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A DIVISION OF STABLER COMPANIES INC.

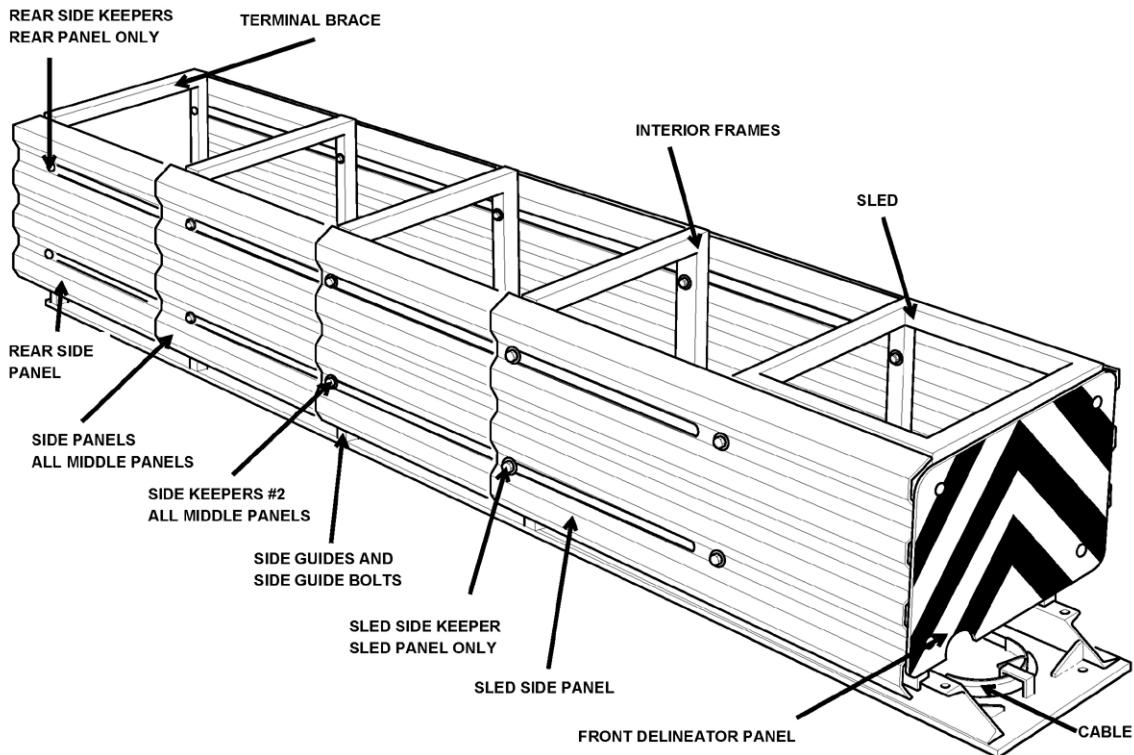


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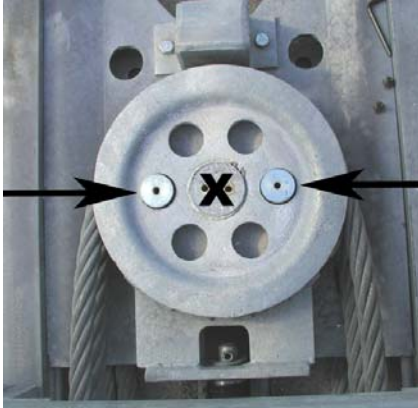
## SCI GM ATTENUATOR IN-SERVICE EVALUATION REPORT

The SCI\_GM attenuators have now completed the two-year in-service evaluation. We documented all impacts to create a history on the performance of our unit which would include safety and cost issues. There are approximately 200 installations to date. Construction zone installations represent the largest number of installations. Permanent locations are difficult to initiate during attenuator introductions due to the hesitancy of states to start installing a critical application product without substantial history behind it. Now that we have over 40 impacts, the permanent locations are becoming a large portion of our installations. We have asked for every incident to be reported along with pictures, police reports and our incident report form. This document includes all of our incidents to date.

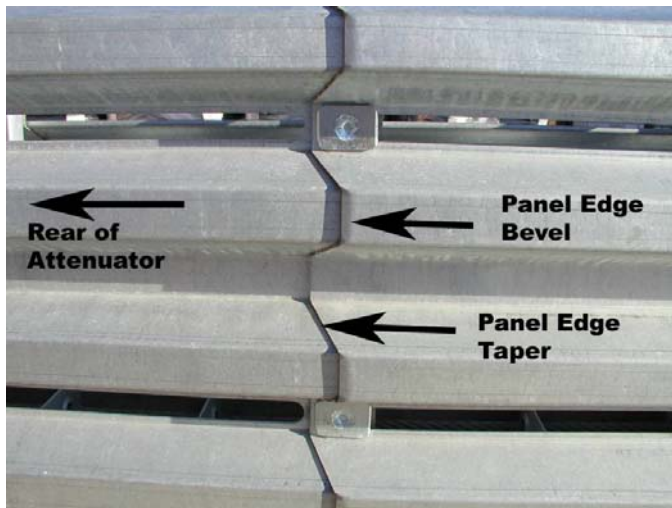
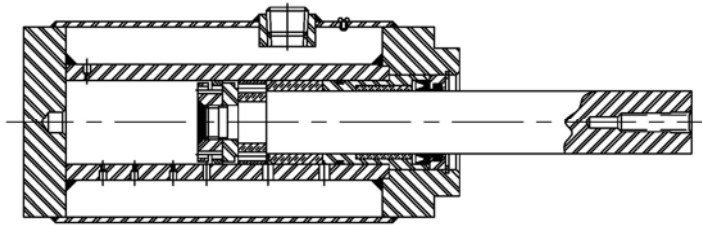


To describe our unit, we would like to start by explaining how the SCI\_GM functions. We have included an isometric layout above. Our stopping forces are a combination of three different mechanical forces. The first force is the transferal of the energy needed to accelerate our parts. The sled, side panels, etc. have to be brought up to speed with the vehicle and this causes a reduction in speed of the vehicle. This represents around

20% of the stopping force. The next two forces work together. Our cable wraps completely around the ends of our hydraulic cylinder three times; so, there are six pulleys. This creates a six to one reduction of travel distance of the cylinder as compared to the attenuator collapse distance. The pulleys do not turn during an impact, as you can see the anti-rotation locking pins in the picture to the left. The cable is dragged over the pulley surfaces creating friction. The cylinder applies a resistance force and as this force increases the friction increases. The cylinder has metering ports that are based on speed. Higher masses will force fluid through the ports faster but this reaches a limit, as does any shock-absorbing hydraulic



application. If the vehicle is not slowing down fast enough the forces keep increasing to stop the vehicle before it reaches the end of the attenuator. As the piston is pushed into the cylinder, holes are covered up and there are fewer orifices from which the oil will escape. The car is slowing down so the desired effect is achieved. This gives us the ability to adjust the number of orifices to give a smooth ridedown. Cold temperature does not affect the performance, as we use Sharp Orifice Technology, which shears the oil instead of trying to compress it through the orifices.



Our side panel profile is designed to withstand impacts in a straight line toward our support frames to reduce crush potential. During NCHRP Report 350 side impact tests, this design resulted in no crush. When panels crush on reverse side impacts, the panel overlaps open up and cause snagging, much like a cheese grater effect. To further reduce snag potential, we beveled the edges to close up any gaps. We then tapered the edges and put a gusset behind the panels to redirect the vehicle before it reaches the overlap.

**Equipment costs** of our Test Level III units are in the range of \$13,000 - \$18,000 depending on the options and transition requirements. Our first installation in Nebraska took 57 minutes, from taking the unit off of the truck to completion, including torque down. This installation required no transitions which could add additional time. The SCI\_GM attenuators are delivered fully assembled, ready for a pick and set installation. They have no obstructions inside which makes all of the base plate holes easily accessible for drilling anchor holes. We have transitions to most hazards but we only

have a 24" width at the rear. If you have a 30", 36" or Gore area width, we have transitions to cover those applications. We have chosen not to make a wider unit because our resilience is based on a small taper from front to rear. This allows the side panels to collapse over each other with no stress. This attenuator is designed to fold up like stacking boxes inside of each other with each box designed to fit perfectly. Any time you force panels in an outward fashion during collapse, there is a significant amount of stress. We may design a true tapered unit for Gore areas in the future, but currently, we have chosen not to make this product unless it can take multiple impacts and still be fully reusable like our current unit.

**Our impact history report** can be seen on the next page. We included all of the information that we typically receive. Impact speed is an important piece of information but is never available. We have received many police reports. Chapter 7 of the NCHRP Report 350 discussed an in-service evaluation. This is referenced in new approvals issued by the FHWA. If you have difficulty receiving police reports, you can reference this requirement and that will enable you to receive these reports. Some states only required that we send in a fee to get a copy. From these reports you will get posted speed, vehicle information, a descriptive drawing and an explanation of the incident. By analyzing this information, conclusions can be made that may make the roads safer.

<b>Trailing Unit</b>		<b>Type Unit</b>		1=Towing Pass. Veh		4=Mobile/Modular Home		7=Semi-Trailer		Tag No		Tag Year		Tag St	
No. of Trailing Units: 1		7		2=Towing Truck		5=Camper		8=Other		27TLR 11036		P		ME	
3=Towing Utility Trailer		6=Full Trailer		9=Unknown											
<b>Direction of Travel</b>		<b>*Vehicle Position</b>		<b>*Movement</b>		<b>*See</b>		<b>Special Usage</b>							
E		03		08		D		21							
<b>Vehicle Color</b>		<b>Vehicle Type</b>		05=Large Truck		20=Unicycle, Bicycle, Tricycle		12=Commercial Passenger Carrier							
04		05		06=SLV		21=Other Pedalcycle		17=Trailer							
01=Blue		01=Automobile		07=Van		22=Horse & Buggy		21=Tractor Trailer							
02=Red		02=Motorcycle		10=Snowmobile		23=Horse & Rider		22=Triple Trailer							
03=White		03=Bus		11=Farm Equip		24=Train		23=Triple Trailer							
04=Green		04=Small Truck		12=Construction Equip		25=Trolley		23=Triple Trailer							
05=Black		(If "02", Complete Form M, Section 26)		13=ATV		98=Other		23=Triple Trailer							
		(If "20" or "21", Complete Form M, Section 27)		18=Other Type Spec Veh		99=Unknown		11=Pupil Transport							
				19=Unk. Type Spec Veh											
<b>Initial Impact Point</b>		<b>Damage Indicator</b>		<b>Gradient</b>		3=Downhill		<b>Road Alignment</b>							
01		3		1		4=Bottom of Hill		1							
00=Non-Collision		0=None 2=Functional		1=Level 2=Uphill		5=Top of Hill		1=Straight							
01-12=Clock Points		1=Minor 3=Disabling				9=Unknown		2=Curved							
13=Top		9=Unknown						9=Unknown							

FORM # AA-500 (12/02)

PENNDOT COPY

**The SCI GM has the lowest ridedown accelerations** for the 820kg vehicle reported on the FHWA website. This is due to its speed-dependent stopping force. The SCI\_GM is metered for speed. It will not ramp up force until the cylinder experiences a speed that its metering holes will not allow. In other words, each metering location on the cylinder is set for a certain speed. Unless this speed is present, the cylinder will not provide full stopping force. Smaller vehicles lose speed more quickly than larger vehicles due to the initial impact with the attenuator. Until the vehicle reaches a point in the collapse where the metering holes take over, the cylinder will not ramp up force. This design makes the system a self-compensating system that ramps its forces up or down depending on circumstances of the impact. Mass will play a part in the event but the fluid in the cylinder can only escape at a certain rate. The SCI\_GM will attempt to stop any mass or speed that impacts it.

**No secondary impacts have been reported** from side impacts. The NCHRP Report 350 side impacts tests both reported zero degrees, which is the lowest reported angle of

## SCI\_GM ATTENUATOR IMPACT HISTORY

Date	Location		Serial No.	Test Level	Vehicle	Injuries	Drive Away	Posted Speed	Impact Type	Collapse Distance	Repair Parts	Repair Hours	Notes	Repair Cost	Parts Cost Only	Additional Notes
	Road	City/State														
8/7/04	Hgwy 67/167	Pulaski Co, AR	163	3	Not Known	No	Yes	55	Frontal	8 feet	Shear Bolts	2	No Report - Hit and Run - Pictures	\$201.50	\$1.50	
8/16/04	Interstate 78	Lehigh Co, PA	17	3	Tractor/Trailer	No	No	55	Frontal	Full	Shear Bolts	2	Police Report - Pictures	\$201.50	\$1.50	
8/24/04	Interstate 78	Lehigh Co, PA	14	3	Not Known	No	Yes	55	Frontal	3 feet	Shear Bolts	1.5	No Report - Hit and Run	\$151.50	\$1.50	
9/22/04	Interstate 78	Lehigh Co, PA	17	3	Tractor/Trailer	No	No	55	Frontal	6 feet	Shear Bolts	2	Non-Reportable Police Report	\$201.50	\$1.50	
10/18/04	Interstate 78	Lehigh Co, PA	14	3	Tractor/Trailer	No	No	55	Frontal	Full	Shear Bolts	N/A	Pulled up unit as job was done	N/A	\$1.50	
10/25/04	Hgwy 67/167	Pulaski Co, AR	163	3	Not Known	No	Yes	55	Frontal	Full	Shear Bolts	2	No Report - Hit and Run	\$201.50	\$1.50	
11/2/04	Hgwy 67/167	Pulaski Co, AR	163	3	Tractor/Trailer	No	Yes	55	Frontal	14 feet	Shear Bolts	1.5	No Report - Hit and Run	\$151.50	\$1.50	
11/10/04	Hgwy 67/167	Pulaski Co, AR	163	3	Tractor/Trailer	No	Yes	55	Frontal	Full	Side Keepers and Side Panel	N/A	Pulled up unit as job was done	N/A	N/A	
2/7/05	Interstate 77	Jonesville, NC	9	3	Tractor/Trailer	No	No	70	Frontal	8.5 feet	Shear Bolts	2	Police Report - Pictures	\$201.50	\$1.50	
2/8/05	Interstate 77	Jonesville, NC	9	3	Tractor/Trailer	No	No	70	Frontal	6 feet	Shear bolts, Sled Panel	0.5	Police Report - Pictures	\$426.50	\$251.00	
2/13/05	Interstate 77	Jonesville, NC	9	3	Tractor/Trailer	No	No	70	Frontal	7 feet	Shear Bolts	0.5	Police Report - Pictures	\$51.50	\$1.50	
2/25/05	Interstate 77	Jonesville, NC	9	3	Tow Truck	No	No	70	Frontal	4.5 feet	Shear Bolts	0.5	Police Report - Pictures - 70 mph	\$51.50	\$1.50	
3/19/05	Interstate 78	Lehigh Co, PA	17	3	Tow Truck	No	No	55	Frontal	N/A	2 Side Panels & 4 Side Keepers	3	Police Report	\$787.50	\$487.50	
3/19/05	Interstate 78	Lehigh Co, PA	17	3	Honda Prelude	No	No	55	Frontal	N/A	Shear Bolts	N/A	Police Report	N/A	\$1.50	
3/22/05	Interstate 78	Lehigh Co, PA	17	3	Tractor/Trailer	No	No	55	Frontal	4.5 feet	Shear Bolts	1.5	Police Report - Pictures	\$151.50	\$1.50	
3/31/05	Interstate 78	Lehigh Co, PA	17	3	Chevy S10 Pkup	No	No	55	Frontal	N/A	Shear Bolts	N/A	Police Report	N/A	\$1.50	
3/31/05	Hgwy 230	Jefferson Co, WV	24	3	Tractor/Trailer	No	Yes	25	Frontal	3 feet	Shear Bolts	1	No Police Report Filed	\$101.50	\$1.50	
4/1/05	Interstate 78	Lehigh Co, PA	17	3	Kia Rio (car)	No	No	55	Frontal	N/A	Shear Bolts	N/A	Police Report	N/A	\$1.50	
4/1/05	Interstate 95	Philadelphia, PA	10	3	Not Known	No	Yes	55	Frontal	3 feet	Shear Bolts	1	No Report- Hit and Run- Pictures	\$101.50	\$1.50	
4/8/05	Interstate 64	Allegheny Co, VA	3	3	Tractor/Trailer	No	No	65	Frontal	4 feet	1 Sled Panel & Shear Bolts	N/A	Awaiting Police Report - Pictures	\$376.50	\$1.50	
4/11/05	SR 114	Cumberland Co, PA	44	3	Truck-26K GWR	No	No	45	Side	6 feet	Shear Bolts	1	No Report - Information taken	\$101.50	\$1.50	Truck snagged panel and pulled sled back
4/12/05	SR 114	Cumberland Co, PA	44	3	Not Known	No	Yes	45	Frontal	6 feet	Shear Bolts	1	No Report - Hit and Run	\$101.50	\$1.50	
4/13/05	SR 114	Cumberland Co, PA	44	3	Not Known	No	Yes	45	Frontal	6 feet	Shear Bolts	1	No Report - Hit and Run	\$101.50	\$1.50	
4/13/05	Interstate 78	Lehigh Co, PA	17	3	Tractor/Trailer	No	No	55	Frontal	N/A	Shear Bolts	N/A	Awaiting Police Report (APR)	N/A	\$1.50	
4/15/05	SR 114	Cumberland Co, PA	44	3	Tractor/Trailer	No	No	45	Frontal	10 feet	Shear Bolts	1	No Report	\$101.50	\$1.50	
4/16/05	Interstate 95	Philadelphia, PA	7	3	Not Known	No	Yes	55	Frontal	Full	Shear Bolts	1.5	No Report - Hit and Run	\$151.50	\$1.50	
4/16/05	Interstate 78	Lehigh Co, PA	17	3	Tractor/Trailer	No	No	55	Frontal	N/A	Shear Bolts	N/A	APR*	N/A	\$1.50	
4/18/05	SR 114	Cumberland Co, PA	44	3	Not Known	No	No	45	Frontal	10 feet	Shear Bolts	1	APR*	\$101.50	\$1.50	
4/20/05	SR 114	Cumberland Co, PA	44	3	Tractor/Trailer	No	No	45	Frontal	7 feet	Shear Bolts	1	APR*	\$101.50	\$1.50	
4/20/05	SR 114	Cumberland Co, PA	44	3	Chevy S10 Blazer	No	No	45	Frontal	7 feet	Shear Bolts	1	APR*	\$101.50	\$1.50	
5/3/05	Interstate 76	Philadelphia, PA	96	3	Not Known	No	Yes	55	Frontal	4 feet	Shear Bolts	1.5	APR*	\$151.00	\$1.50	
5/11/05	SR 114	Cumberland Co, PA	124	3	Not Known	No	No	45	Side	N/A	2 Side and 1 Rear Panel	2	No Report - Hit and Run	\$770.00	\$570.00	
5/16/05	Hgwy 202	Phoenix, AZ	158	3	Chevy 1500	Yes	No	55	Frontal	Full	New Unit and Transition Assembly	3.5	High Speed Impact (APR)	\$21,333.72	\$19,353.72	Catastrophic Impact includes air freight for parts - Estimated speed 90+mph - Driver check and release injuries
5/17/05	SR114	Cumberland Co, PA	83	3	F350/ W/ Trailer	No	No	45	Frontal	5 feet	Shear Bolts	2	APR*	\$201.50	\$1.50	
5/25/05	SR22	Cambria Co, PA	104	3	Tractor/Trailer	No	No	40	Frontal	Full	Shear Bolts / Delineator Panel	1.5	Police Report - Pictures	\$191.50	\$41.50	
5/25/05	SR22	Cambria Co, PA	104	3	Tractor/ Wide Load	No	Yes	40	Frontal	Full	New Unit and Transition Assembly	2	Witnesses to Incident No Report	\$13,500.00	\$12,900.00	Wide load hauling track excavator destroyed unit.
5/31/05	SR114	Cumberland Co, PA	152	3	Not Known	No	Yes	45	Frontal	2 Feet	Shear Bolts	1	No Report	\$101.50	\$1.50	
7/7/05	Interstate 76	Philadelphia, PA	96	3	Not Known	No	Yes	55	Frontal	4.5 feet	Shear Bolts	1.5	APR*	\$151.50	\$1.50	
7/8/05	Interstate 95	Philadelphia, PA	7	3	Not Known	No	Yes	55	Frontal	3 feet	Shear Bolts	1	No Report	\$101.50	\$1.50	
7/11/05	Loop 202	Phoenix, AZ	166	3	Not Known	No	Yes	55	Frontal	11.5 feet	Shear Bolts / Delineator Panel	1.5	No Report	\$151.50	\$41.50	
8/1/05	Loop 202	Phoenix, AZ	166	3	Not Known	No	Yes	55	Frontal	4 feet	Shear Bolts / Delineator Panel	1	No Report	\$115.00	\$41.50	

\* N/A Not available

\* APR = Awaiting Police Report

Many vehicles are reported not known due to lack of confirmation

exit that we have seen reported. The SCI\_GM is quite rigid. The front of the vehicle crushes and then redirects away from the unit. The rear of the vehicle does the same and the resulting redirection is an exit parallel to the attenuator. This greatly reduces the chance of a secondary accident.



**There was only one reported injury** in all of the impacts. The resulting injury was a check and release from the hospital with facial lacerations. This impact was at a very high speed. We have impacted a single attenuator multiple times at our test location at 74 mph+ and have never experienced fatigue with our ½” stop plate. This picture of the forces sustained by the SCI\_GM shows how the cylinder bent our stop plate back ½”. All of the components held with no failure. This was one of two units that we opted to replace as we have never been able to tow a vehicle at this speed to analyze results. We have not yet received the cylinder back from the

Arizona Department of Transportation to perform an analysis on it.

**Repair times on frontal impacts** are below ½ hour once a crew has performed one or two repairs. The first time a frontal repair is performed, it is taking between 1-2 hours but after the crew becomes accustomed to the unit, that time is dramatically reduced. The repair time for a crew in North Carolina started at 90 minutes. The next repair times were 45 and 26 minutes, respectively. This is quite representative of the learning curve of this product. It is helpful to watch our videos before performing the first repair but often this does not happen.

**Repairs on side impacts** are rare as we are not getting reports of side impacts unless they are very extreme, even though we know they occur often. The SCI\_GM panel's



profile pushes on our support frames in a straight line and the steel is rated at 60,000 psi. Our panel and transition fabrication costs are a little higher due to the difficulty in working with this hard material, but the results are worth it. Service crews are seeing tire marks on the side of the attenuators but our side panel's profile and our support structures are so strong that side impacts go unreported. We have had a couple of units' side panels ripped open by Tractor/trailers but they had wide loads and actually were raking

across our unit. One of two such incidents had a very large track excavator impact it. This was one of two units that were catastrophic replacements.

**Repair parts costs** are averaging \$39 per impact for 39 impacts excluding two catastrophic impacts, even though the majority of our impacts were considerably above NCHRP Report 350 design criteria. Most of our impacts were heavy trucks. The SCI\_GM usually required only two shear bolts to repair the majority of the units after a frontal impact. Many units sustained multiple impacts, such as serial #'s 17 and 44



which have sustained 9 and 7 impacts respectively, and only one impact out of these 16 incidents needed more than shear bolts. Nine of these impacts were documented heavy truck impacts and three impacts were 'not known' vehicles as they were drive-away incidents. Due to this fact, states are categorizing our product as Severe-Duty, Low-Maintenance, etc. The statistics on repair parts, vehicles, injuries, etc. were:

1. 83% needed shear bolts only
2. 7% needed a new front panel (We think some people supplied their own)
3. 51% were heavy truck impacts
4. 41% were documented Tractor/trailers
5. 36% were unknown vehicles
6. 41% were drive-away incidents
7. 98% reported no injuries
8. 2% reported minor injuries
9. 20% were full-collapse impacts
10. Average repair time was 1.45 hours – range was .5 hours to 3.5 hours
11. Average Repair parts (39 impacts) - \$ 39.00 excluding two catastrophic impacts

**Some interesting facts** have come to the surface in construction zone impacts. The majority of our installations and impacts were in construction zones. An alarmingly high percentage of these impacts were Tractor/trailers. One unit was impacted nine times and had a barrel taper in front of it. We believe the Tractor/trailers were hitting the barrels for amusement and found an attenuator at the rear of the taper. To correct this, we may suggest channelizing devices such as 42" cones, that do not totally restrict the view of the SCI\_GM's front reflective panel. We will continue to study this anomaly to see if we can come to any further conclusions as to why this is occurring.

Permanent locations are not getting impacted as often as predicted. We have installed evaluation units in locations that experienced frequent hits and the frequency of hits has been dramatically reduced. There was a location in Dallas that experienced two impacts per month. Our unit was installed as a replacement for a competitive product in March '05 and it has yet to be impacted. We performed an August '04 install in Nebraska that was a new attenuator location, and was expected to be impacted within a month, but it has yet to be impacted. We feel that this is due to our front panel having six square feet of flat surface pointing at traffic. We utilized high intensity or diamond grade reflective sheeting on our front panels and they present a highly visible reflective surface as compared to narrow or rounded surfaces. Some states do not require reflectivity on the front of attenuators. We feel that the cost is minimal for this added protection.



Sand barrel arrays are also used in locations where vehicles should not be allowed to penetrate through the attenuator, as there are significant dangers on the other side of the array. Those dangers include oncoming traffic, steep slopes or other hazards.

**State and Federal savings** for attenuators can be substantial. The state of Iowa uses severe duty units for some construction zone applications. They are cognizant that these locations are potentially high impact areas and severe-duty attenuators will

reduce their repair costs. They specified a number of these units on a Polk County project that required permanent installations to complete the project. They allowed the contractors to use the severe duty units from the construction zone to be moved to the permanent locations at the end of the project. The end result of this approach was that the state was upgraded to severe duty units in the permanent locations, the overall initial cost of the project was reduced and their future maintenance costs were minimized.

Sand barrels are used in many construction zones. They are damaged by construction equipment, vehicular impacts and in transit, which adds cost or makes them unable to perform per specifications. These sand barrel arrays cost between 30% – 45% of what the SCI\_GM costs. These arrays are destroyed upon impact and the cleanup after an impact is a substantial issue. These arrays stand a good chance of experiencing several impacts during a project. After three impacts, the state has nothing to show for its investment, yet it could have paid for a low-maintenance attenuator and would still have the attenuator for use on its next project. The state could also require redirective attenuators in every location where they are applicable to minimize repair costs. Maintenance of sand barrels is another issue. Greg Gentsch of the Arizona Department of Transportation made this statement on sand barrels: “They are clearly not a ‘leave alone’ product. The maintenance effort required to stir up the sand in each and every barrel about twice a year is a significant use of manpower alone. This is necessary to prevent that granular mass from solidifying. Also, the plastic is susceptible to aging and cracking in the desert sun and heat so we also have to replace any of them when inspection shows that they are cracked and won't hold sand in or keep water out.” If the state were to invest in a number of low-maintenance attenuators for construction zones and also maximize their use in permanent locations, the payback would be quick and future expenses would be minimized.

**In summary**, the SCI\_GM attenuators have many proven beneficial safety and economic aspects in the field based on the injury and cost reports. Our costs are modestly more than units that have many sacrificial parts. Other units that are considered low maintenance or severe duty also need repair parts and their initial costs are substantially higher. The SCI\_GM attenuators have motivated many states to look at life cycle costs. There is resistance to performing this work as people believe it may be an exercise in futility. It takes a significant difference in a product for government officials to initiate this study. Because of life cycle costing issues, we have also seen a reduction in the purchase price of units with high repair costs. These cost reductions attempt to ensure that the units with high repair costs win bids and are installed so that profits can be made on parts. These parts prices may rise very quickly. Construction contractors make considerable profits on selling parts in states that allow force accounts to pay for impacts in construction zones. Some states have changed this policy already to force contractors to control construction zone impact costs. Contractors will argue that they have no way of knowing how many impacts to include in the bids. Now there are attenuators that are relatively inexpensive to repair and are priced marginally more than those with high repair costs. Catastrophic impacts are not usually drive-away incidents and the contractor will collect insurance. In state purchases, the use of initial costs as the only competitive bid criteria may cause an exorbitant cost to the public after just a couple of impacts. We have also witnessed attenuators that were required to be reset quickly and were missing required parts. These units were put back into service

out of specification while waiting for these parts. Either the number of parts needs to be reduced or they should be stocked at all times. With a moderately priced low-maintenance attenuator, government agencies should take a hard look at the life cycle costs of all attenuators to assure that they have the safest and most economical attenuators being installed.

The creation of systems that are not fixed force will enable smaller vehicles to have longer ridedown distances with lower ridedown decelerations. With the depletion of fossil fuels and the development of hybrids, smaller vehicles are a public responsibility and we expect the large SUV trend will taper off. We need to protect these motorists although the new NCHRP350 rewrite is raising the small car vehicle weight by 617 lbs. New vehicle models should be watched to see if this new weight is appropriate.

SCI Products Inc. will continue to build our impact history. We will be looking for safety improvements, safety issues, accident causation and repair costs for the safety and benefit of the motoring public.

Jeffery D. Smith  
VP  
SCI Products Inc.

## Pictures



8-7-04 - 1st incident - Serial# 163  
Frontal Impact - Collapse 8 feet  
No Injuries  
Part Required – shear bolts  
Repair cost part and labor - \$201.50  
Vehicle – not known  
Posted speed – 55



11-2-04 - 3rd Incident – Serial# 163  
Frontal Impact - Collapse 14 feet  
No Injuries  
Part Required – shear bolts  
Repair cost part and labor - \$151.50  
Vehicle – Tractor/trailer  
Posted speed – 55



8-16-04 - 1st Incident Serial# 17  
Frontal Impact – Collapse - Full  
No Injuries  
Part Required – shear bolts  
Repair cost part and labor - \$201.50  
Vehicle – Tractor/trailer  
Posted speed – 55



Close up of above incident  
When attenuator collapsed, the front wheel of the Tractor/trailer was taken off and the fuel tank was severely damaged. The Tractor/trailer followed down the barrier before coming to a stop. With significant side pressure on the sled, there was no damage to the attenuator except for small dent in top corner which doesn't affect function.



11-10-04 - 4th Incident - Serial#163  
Frontal Impact – Collapse - Full  
No Injuries  
Part Required – shear bolts, side keepers, and side panel  
Repair cost part and labor - \$332  
Vehicle – Tractor/trailer  
Posted speed – 55



Side panels from above picture  
This incident was this attenuators 4<sup>th</sup> impact all by very large vehicles and required extra parts. The Tractor/trailer was full and running around 80,000 lbs.



2-7-05 - 1st Incident – Serial #9  
Frontal Impact – Collapse – 8.5 feet  
No Injuries  
Part Required – shear bolts  
Repair cost part and labor - \$201.50  
Vehicle – Tractor/trailer  
Posted speed – 70



Side view of above incident  
You can see a piece of the tool box left on the attenuator on the top picture and the tire marks down the side on this picture. The corner was caught and the collapse started. We are coming to the conclusion that truck drivers are able to steer off of our unit. The unit was still structurally sound and ready for further collapse.



2-8-05 - 2nd Incident – Serial #9  
Frontal Impact – Collapse – 6 feet  
No Injuries  
Part Required – shear bolts and sled panel  
Repair cost part and labor - \$426.50  
Vehicle – Tractor/trailer  
Posted speed – 70



Close up of incident above  
This happened one day after the previous incident. It was a glancing blow with something very sharp catching the panels. Even with significant side pressure the sled was not racked and it only required minimal parts.



4-20-05 - 6th Incident – Serial #44  
Frontal Impact – Collapse – 7 feet  
No Injuries  
Part Required – shear bolts  
Repair cost part and labor - \$101.50  
Vehicle – Chevy S10 Blazer  
Posted speed – 45



5-3-05 - 1st Incident - Serial #96  
Frontal Impact – Collapse – 4 feet  
No Injuries  
Part Required – shear bolts  
Repair cost part and labor - \$151.50  
Vehicle – not known  
Posted speed – 55



5-16-05 - 1st incident – Serial #158  
Frontal Impact – Collapse – full  
Injuries – facial lacerations  
Part Required – replace unit and transitions  
Repair cost part and labor - \$21,333.72 included air freight and expedited fabrication  
Vehicle – Chevy 1500 + added weight from 5<sup>th</sup> wheel attachment  
Posted speed – 55



Incident above was impacted at very high speed. The  $\frac{3}{4}$  ton pickup was making a quick change from an HOV lane into regular traffic. The vehicle hit the attenuator just left of center in front of the steering wheel.



The SCI\_GM has machined rollers on its' front sled. These rollers dug into the channel  $\frac{3}{16}$ " deep from the side force caused by the lane change.



The cylinder rod pushed the  $\frac{1}{2}$ " plate back  $\frac{1}{2}$ " but did not fail. Our units have been impacted numerous times at 75 mph and this plate has never fatigued but with an impact that was 2.3 times above NCHRP350 criteria, it still held.

End result: The driver walked away from the incident as a check and release for facial lacerations.



5-25-05 - 1st Incident – Serial #104  
Frontal Impact – Collapse – full  
No Injuries  
Part Required – shear bolts and front panel  
Repair cost part and labor - \$191.5  
Vehicle – Tractor/trailer  
Posted speed – 40



Incident above  
Shows how the panels nest without being stressed.



5-25-05 - 2nd Incident – Serial #104  
Hit 2<sup>nd</sup> time same day after reset  
Frontal Impact – Collapse – full  
No Injuries  
Part Required – replace unit  
Repair cost part and labor - \$13,500.00  
Vehicle – Tractor/trailer  
Posted speed – 40



This was an angled impact. A significant object on the Tractor/trailer caught enough of the attenuator to collapse it fully then break the concrete barrier. The speed was probably not excessive so the cylinder did not provide full stopping force but the energy of the Tractor/trailer bottomed out the unit and cracked the barrier wall.





5-31-05 - 1st Incident – Serial #152  
Frontal Impact – Collapse – two feet  
No Injuries  
Part Required – shear bolts  
Repair cost part and labor - \$101.50  
Vehicle – not known  
Posted speed – 45  
Nuisance impact but attenuator could take another impact



7-7-05 - 2nd Incident – Serial #96  
Frontal Impact – Collapse – 5.5 feet  
No Injuries  
Part Required – shear bolts  
Repair cost part and labor - \$151.50  
Vehicle – not known  
Posted speed – 55



8-1-05 - 2nd Incident – Serial #166  
Frontal Impact – Collapse – 4 feet  
No Injuries  
Part Required – shear bolts and front panel  
Repair cost part and labor - \$115.00  
Vehicle – not known  
Posted speed – 55