

# BORON STEEL IN VEHICLES

## Implications of HSLA/UHSS and Boron Steels for Rescuers

by Len Watson



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## CONTENTS

- Vehicle extrication rescue and Boron steel + Applications
- Cutting Boron Steel – Vehicle extrication rescue
- The problems that are mainly experienced
- The different performance of blade configurations sported by cutters
- Boron steel reclining seat-brackets
- The dash cross-member
- Final comment
- Further reading and send comment

# **BORON STEEL IN VEHICLES**



*Document for discussion – Last revised August 2008*

## **Vehicle Extrication Rescue and Boron Steel**

The type of boron steel used on vehicles today has extremely high strength. Boron steel can have a yield point of about 1,350–1,400 N/mm<sup>2</sup> (196,000–203,000 psi). That's about four times stronger than average high-strength steel. But the process used to make it that strong takes away some of the steel's workability properties, such as being able to cut it.

### **Boron Steel Applications**

With new vehicle safety legislation and increased fuel prices, automotive manufacturers have responded with greater car body stiffness and lower body weight for both safety and fuel efficiency. The fields of materials development, engineering, and manufacturing have been working together to achieve these goals. Advanced steels, new forming processes, and new press concepts have been adopted to achieve weight reduction with improved crash worthiness.

The introduction of Boron steel was found primarily on European vehicles (dash cross-member on the 2002 Porsche Cayenne SUV, the safety bar around the rear seats on the 2003 Porsche Boxster, door strengthening beams on the 2003 Porsche 911 Carrera, and the inner centre pillars on the 2003 Mercedes-Benz E Class). Volvo probably uses boron steel the most (On bumper reinforcements, door strengthening beams and seat recliner brackets on the 2004 Volvo S40 sedan and 2005 V50 station wagon). The 2003 Volvo XC90 SUV has additional applications of boron steel, in the windscreen pillars and gussets in the centre pillars where they meet with the roof side channel and sill and as rear body panels. Globally most vehicle manufactures feature boron steel in their 2004 model range in some form or another.



*Strengthening bars, gussets and plates*

The application of Boron steel to strengthen the weaker areas of the motor vehicle is obviously, for the motor industry that is, the correct path for them to take. However, in an ever-growing safety conscious environment, where we now see the inclusion of many new safety features, we must study the available statistics to analyse the end results. Recent outcomes should bear out the assumption that the car-user fatality rate has been reduced significantly in recent years and where it has, it is essential that what really lies behind the reduction is identified. Where 'new innovation' cannot realistically be accredited with the reduction we must ask ourselves, why not?. Many of the statistics available have been massaged to show degrees of success, where a wider range of issues could be introduced to question these outcomes. To gain a wider concept of what this actually means – See '*SRS another perspective*' [www.resqmed.com/SRSperspective.pdf](http://www.resqmed.com/SRSperspective.pdf) - which will introduce the reader to a wider analytic area of airbag technology that has been purposefully overlooked.

Not only are there many other new steels all with differing strengths, there are also many new coatings which the steel has been treated with. Coatings such as Zinc, Bonazinc, Granocoating,

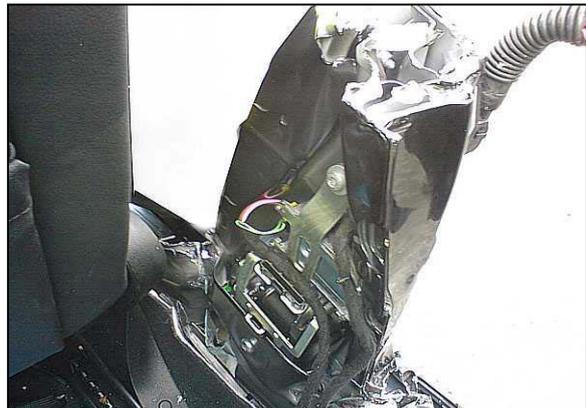
aluminated sheet metals etc. This all adds to the confusion over the steels. USIBOR-BTR-Boron are all the same grade of steel, just with a different name, depending which country it comes from. It is very strong but light in weight. In general it is used to provide extra strength in the sill area, roof and centre posts, chassis areas, door strengthening bars, dash cross-members and roll over bars.

It could be called the “most ultra” of the ultra-high-strength steels. Boron steel may be a dream material for vehicle makers, but to the collision industry it can be challenging. To some collision repair technicians who have called the I-CAR Tech Centre, “working with” and “boron steel” does not seem to go hand-in-hand. Boron steel can be worked with, short of straightening, it can be welded just like any other steel, and it can be cut if the right tools are used. However the motor industry has once again totally overlooked the Rescue profession

The type of boron steel used on vehicles today has extremely high strength. The boron steel used on Volvo cars has a yield point of about 1,350–1,400 N/mm<sup>2</sup> (196,000–203,000 psi). That’s about four times stronger than average high-strength steel. But the process used to make it that strong takes away some of the steel’s workability properties, such as being able to straighten it.

### Cutting Boron Steel – vehicle extrication rescue:

Volvo recommend that the garage repair trade cut Boron steel with a disc cutter or a plasma-arc torch, both of which are not suitable for Rescue. The reciprocating saw is next to useless on Boron steel and would take far too long. It will remove the teeth on the saw’s blade very quickly when sawing and requires many blade changes. The older hydraulic cutter will also prove fruitless. Newer up-rated cutters with a cutting force in excess of 40 ton/es (40>kN force), have sufficient power to cut HSLA (high strength low alloy) steels but will struggle with UHSLA (Ultra high strength low alloy) steels, especially where the channel contain multi layers.



**The problems that are mainly experienced:** when trying to cut the base of the centre post on cars equipped with Boron it will be found that 40 ton (350 kN approx) cutters are simply not up to the job. Manufacturers’ claims for some of their cutters are somewhat misleading as they intimate that all their cutters are capable of cutting all UHSLA and Boron steels (AHSS- Advanced high strength steel). Many cutters have nowhere near the capacity, especially those that only generate a maximum of 30,000 lbs (130 kN approx) at the centre of the blades. As you know the stock cutting notch measurement of force has little bearing when making these cuts as the stock will not butt up against the Boron within the metal channel that needs to be cut. This is the main area of confusion. Cutter are often demonstrated cutting sections of Boron steel and Boron bar where the cutter blades totally encircle the cut and the full force of the tool comes into play. Of course this does not represent the real world; where the tips of the blades (where the cutting force is least) fail to puncture the larger cross-sectional area at the base of the centre post, the cut cannot be completed.



Many rescue tool manufacturers’ display their cutters shearing through strengthening bars and HSLA channel with Boron steel bar inserts. Be aware of the cross sectional area in respect of the cut. Where the channel is small it will butt up against the stock where the tool has the most cutting force. This display of the cutters ability is not a true indication of what is actually required.

*Subaru WRX 2004 – top of centre post*

The large cross-sectional area at the base of the centre post is quite a different matter. Many cutters available on the market just do not have the power to complete the cuts to the base of the centre post on many vehicles incorporating Boron steel inserts. This problem can only increase with greater strength Boron inclusions in new vehicle design. With the introduction of the Volvo X90 in 2002, tool manufacturers were invited to test their equipment. At that time most manufacturers' cutters professed in the region of 40 ton (350 kN approx) cutting forces at the stock but, without exception, all cutters tested failed to cut the base of the centre post. It was for this reason that most manufacturers upgraded their tools, up to and above 90 ton (800 kN approx) cutting capacity.

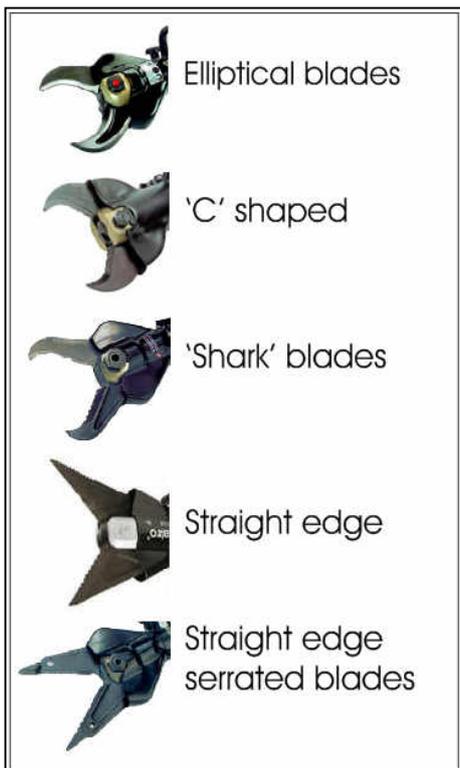
That was then and of course we must now appreciate that the motor industry has moved on and that tool manufacturers are committed to staying abreast of the situation. Even so, tool companies can only ever hope to measure their tools against a small proportion of new vehicles and then, only when invited to do so or where vehicles are donated by a motor manufacturer. Tool manufacturers do not develop Boron capable cutters unless they have to, and fire services do not buy these tools if they are not necessary.

Fire services are generally slow to react to operational demands. This is mainly due to an entrenched attitude of 'if it isn't broke don't fix it'. It certainly doesn't help when the new Corporate Manslaughter and Homicide Act fails to recognise fire service responsibility for the casualty's medical treatment. However it does not exclude 'duty of care'. However if Rescuers do not point out and submit evidence in writing the problems that arise with obsolete or mis-sold equipment, it is likely to take much longer to be recognised and acted on. It is therefore essential for managers to establish whose responsibility it is to evaluate operational performance of extrication equipment and also, their share of responsibility in underwriting the rescuers obligation to 'duty of care'.

It is worthwhile visiting manufacturers of rescue equipment web sites to measure their cutters performance in relation to 'centre of blade' cutting forces. To contend with the problem of Boron inserts and strengthening, most manufactures have generated cutters that have a max cutting force in excess of 150,000 lbs (660 kN approx) with some as high as 250,000 lbs (1112 kN) at the cutting notch. But again, let me remind you, that it is the cutting force at the centre and points of the blades that really matter in vehicle extrication.

**The different performance of blade configurations sported by cutters:**

Blade design must necessarily deviate from being too round in contour to prevent opposing forces reducing the shearing ability of the blade. It is desirable that the concentric or scissor design of the blade, crushes the material as it cuts.



**Elliptical and 'C' Shaped Blades:** These blades work with a pincer action and are traditionally the design used for hydraulic cutters. They prove very effective for general use, particularly on motor vehicles that pre-date HSLA, UHSS and Boron steels.

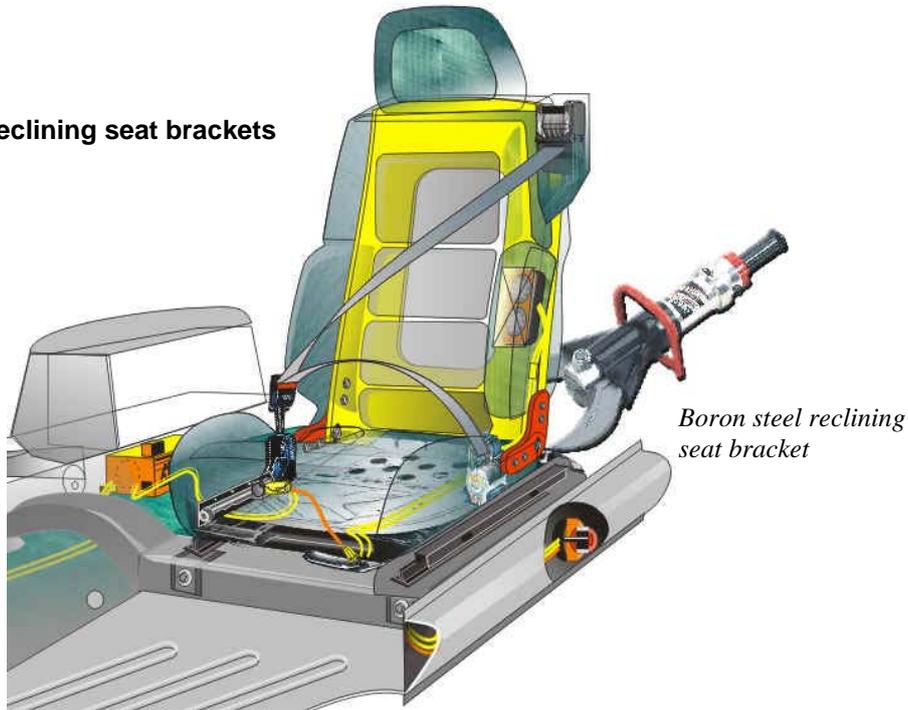
Vehicle design plays a large part in the effectiveness of hydraulic cutters. The relatively small opening of these blades is not conducive to cutting large cross-sectional areas.

**Shark-Bill and Straight Edge Blades:** A variation on cutter blades has seen a change in design patterns. With the introduction of the Combination tool it was quickly recognised that, when cutting, the tool had a tendency to slip off the cut. The longer the blades the greater the tendency. Serrated patterns on blades were introduced to counteract this tendency but the gradual introduction of high strength steels, except for blades with deeper serrations, seems to have eroded any advantage gained.

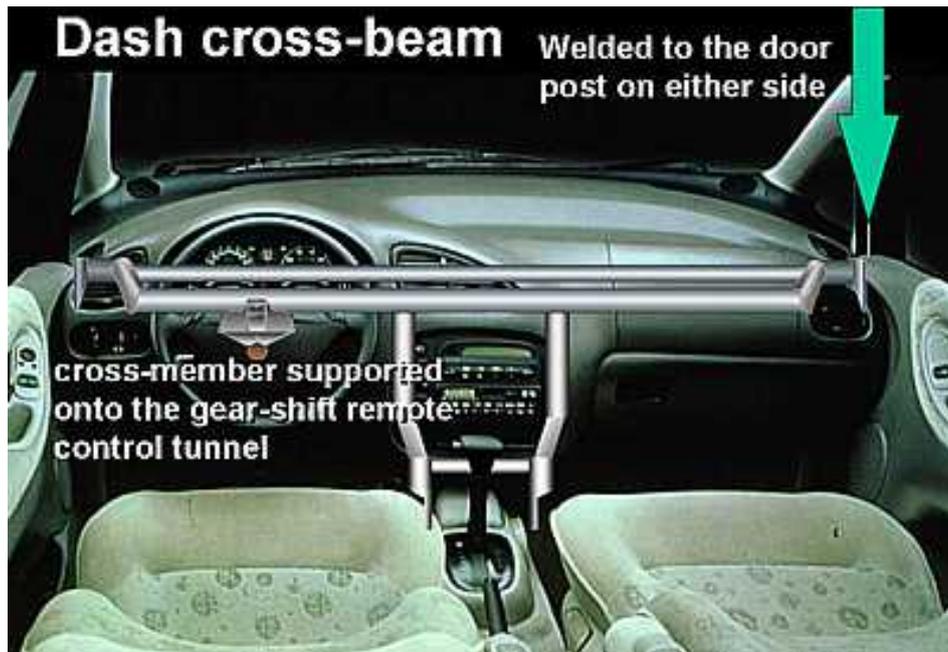
While the 'Shark-Bill' offers the greater scope when cutting large cross-sectional areas e.g. the base of the centre post and the larger 1/4 panel roof post ('C' post), 'Straight' edge blades cater for the thicker gauge of steel and aluminium to be found on trains. Even so, we must respect that the cutting force at the tips and centre of the blades are far more relevant than the cutting force at the stock.

	'D' shaped blades	<p><b>'D' Shaped and Rectangular Blades:</b> Nike hydraulics were the first tool company to offer 'D' configuration blades. When cutting round bar/tube or where the blades encircle the cut, the shape of the blades has a strong tendency to draw the tool onto the cut utilising the greater force at the stock. In terms of cutting HSLA, UHSS and Boron steels cutters equipped with 'D' shaped blades will still need sufficient force at the tips, centre of blade and at the stock to be successful.</p> <p><b>'C' Shaped Serrated Blades:</b> These blades have a 'toothed' serration incorporated into the cutting edge to enhance grip and reduce slippage off the profile as the cut progresses.</p> <p><b>'Elliptical' Low Profile Blades:</b> This type of blade has no pincer action. As there is no pointed tips to the blade, cutting relies solely on the crushing and shearing action of the blades when they close. Although the blades have no serrations to counteract slippage, cutting force is applied as a scissor movement and, similar to the straight edge blades, they have a greater capacity for cutting heavy gauge panning.</p>
	'D' rectangular shaped blades	
	'C' shaped serrated blades	
	'Elliptical' low profile blades	

**Boron steel reclining seat brackets**



Boron steel seat brackets have afforded additional strength to the seat-back, so much so that the seat belt retractor can now be incorporated at the top of the seat back, allowing the seat and safety features to be fitted as a complete module. However, this innovation comes at a premium which has not been taken into account by the motor industry. On occasions Rescuers will need to remove the seatback for casualty release and removal from a wreck. Where access to the side of the seat to unbolt this bracket is not available these brackets will have to be cut. Your hydraulic rescue cutters may not have sufficient power to cut these bracket or, where they have, it will take much longer and, at the conclusion of the cut, a considerable jarring effect will reverberate through the seat and transfer to the casualty. The reverberation may adversely affect blood coagulation and damage nerve endings between sharp fragments of bone and, as on most occasions, it will go unnoticed and un-recorded.



**The dash cross-member:** was introduced into new vehicle designs as early as 1996. The design has matured and can incorporate HSLA/UHSS, Boron steels and Aluminum with aluminum foam-filling for extra strength. The design subtracts and resists considerably extrication techniques such as 'steering wheel relocation' and, where the cross-member is tied to the transmission tunnel, it adversely affects 'dash lift'. This becomes particularly relevant in the more severe head-on and front ¼ oblique impacts where the entrapped casualty's feet are hidden from view because of bodywork deformity and restricts access for close proximity spreading and cutting.

Exposing and cutting this cross-member is at best difficult and, as such, not a very realistic option. However exposing and cutting the tie strengtheners will help considerably and can be performed by most modern cutters.

**Final comment:**

When evaluating hydraulic cutters, trials should reflect the actual workload to ensure that the performance meets the demand that's going to be placed upon it. This is virtually impossible for the average fire department to underwrite these tests as the availability of new vehicles for this purpose is non-existent. This is where the problem lies and where the sales person and demonstrator is also mislead and misinformed and is therefore able to convince the customer into believing that the cutter is fit for purpose.

It is pointless purchasing equipment that is incapable of performing the tasks that are required of it. The notion that it will suffice for the majority of extrications is totally misplaced and is one whereby obligations to the victim are being dismissed out of hand.

When purchasing new cutters it is essential that their performance meets a yield point when cutting of about 1,350–1,400 N/mm<sup>2</sup> (196,000–203,000 psi). And don't forget it's the cutting force at the tips and centre of the blades that are the most important measurements.

We can expect more applications of ultra high-strength and Boron steels in future model years to reduce weight, strengthen the chassis and improve crash worthiness. Perhaps alongside new steel innovations better rescue equipment and tool options for working with these steels will also materialise, along with a clearer indication of actual cutter performance.

**Obligation to the community:** There is no reason to discard older cutters as they are a valuable asset. Make the best use of resources. Two cutters are better than one and will add efficiency to the extrication. Efficiency and increased performance is a real life saver. No room on the truck, stowage is a problem, well use them for training or sell them on; the Third-World are very much in need and HSLA and Boron are a long way in the future for some countries.

## Further reading -

### **The Garage Trade – working with Boron steel:**

<http://www.i-car.com.au/pdf/advantage/online/2004/051004.pdf>

### **The Centre for Auto Safety:**

**European vehicles exceed the standard for US vehicles**

### **Can you believe this !!!**

Scott McClellan, executive vice president of 'Independent Witness', a Salt Lake City safety research firm that has been equipping NASCAR vehicles with safety instrumentation for the past 2 ½ years.

*"I can't recall a rollover or flip that resulted in a serious injury," McClellan said. "If the occupant compartment integrity is maintained, the potential for injury is pretty low."*

How divorced is that from the Real World where roll-overs carry one of the highest percentages of road kill.

However the article is worth a read '**Test margins in question' at the end of the report**

<http://www.autosafety.org/article.php?did=896&scid=8>

### **Anatomy of Vehicle Extrication: By Gordon Sweetman –**

*Gordan Sweetnam is a training officer for the City of Calgary Fire Department in Calgary, Alberta, Canada.*

<http://www.advancedrt.com/articles/rtarticles/extric.html>

### **Press Hardening Process of Boron Sheet Steels; Auto Focus Asia**

[http://www.autofocusasia.com/automotive\\_materials/press\\_hardening\\_boron\\_steel.htm](http://www.autofocusasia.com/automotive_materials/press_hardening_boron_steel.htm)

### **Niobium-Boron Steel – Composition:**

<http://www.journalarchive.jst.go.jp/jnlpdf.php?cdjournal=isijinternational1966&cdvol=27&noissue=2&startpage=130&lang=en&from=jnlabstract>

### **New Forms of Auto Body Stamping**

<http://www.crash1-4me.com/Techpage.htm>

NFPA – National Fire Protection Association USA; 1936 Standard on Power Rescue Tools

<http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=1936&cookie%5Ftest=1>

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