LOW VOLUME VEHICLE TECHNICAL ASSOCIATION Inc

Material composition of modern vehicle structures

Introduction:

Given the changes in materials and construction methods used in unitary-constructed and space-frame vehicles built since around 1980, it is essential to ensure that, when approving modifications to post 1980 era vehicles, serious consideration is given to the vehicle's many different material types, construction methods, and details associated with any manufacturer-designed frontal-impact protection systems or side-impact systems incorporated within the vehicle design.

To follow is a basic guideline that, if followed, will help to ensure that any modifications carried out do not have the potential to adversely affect or compromise a vehicle's design characteristics, from either a structural point of view, or an occupant protection point of view.

Note that this guideline is aimed only at unitary-construction and space-frame ('space-frame' in the high-volume late model vehicle construction sense) vehicles, and does not apply to separate body/chassis vehicles.

Also, this guideline is very generalised in terms of application dates. Australian and American vehicles have generally been a little slower to incorporate the technology built into European and Japanese-manufactured vehicles.

Application dates of material types:

Modern vehicle construction methods have progressively changed throughout the past 30 years, and one of the areas where the most advances have been made are in the types of materials used within the vehicle structure. The materials used within a vehicle determine how, or even whether, a modification can take place, particularly in relation to welding.

The following information provides a basic evolution of material types and composition used in motor vehicles, manufacture date-dependent:

- <u>Pre-1983 vehicles:</u>

  Up until 1980, no high-strength steels (HSS) or other specialised materials were used in vehicle body construction. Therefore, there are no particular restraints in place as to the welding processes that are used in a modification, as the vehicle body structure is made entirely from basic mild steel.

  Similarly, occupant protection systems did not incorporate any progressive deformation characteristics, so the only emphasis required for modifications is ensuring that no strength is lost as a result of the modification.

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- 1983 – 1989 vehicles:

  High-strength steels (HSS) began being incorporated into vehicle body structures from around 1983, although up until about 1989 the content of HSS was still very minimal. No more than 20% of a vehicle structure manufactured during this era will be made from HSS. The types of high-strength steel used are the common-garden variety of HSS, and can be capably welded by conventional methods, as specified in the 'welding basic high-strength' steel section of this Information Sheet.

  A pointer here is, that because 1983-1989 vehicles do incorporate some – although minimal – HSS, any welding to the vehicle structure should be carried out as if it is in fact HSS. This is because the visual difference between mild steel and HSS generally cannot be distinguished.

- 1989 – 1998 vehicles:

  Vehicles built between 1989 and 1998 start to incorporate quite complex materials. Much of a vehicle's structure will be made of the common-garden variety of HSS, however the vehicles will also incorporate some high-strength low-alloy (HSLA) steel, and some ultra-high-strength steel (UHSS).

  The body material ratio in this era is around 10-40% HSS and 60-90% mild steel. The welding processes required however, becomes very difficult because there is no visual clues to differentiate between the common-garden HSS (which can be welded by conventional means) and the HSLA and UHSS steels (which cannot be welded by conventional means).

  When dealing with vehicles of this era – and onward – it is very necessary to find out exactly what the component or section you are considering welding is actually made from.

- 1998 – 2006 vehicles:

  During this period, the mild steel content of a vehicle is reduced to 30-50%, with the remainder of a vehicle's structure made up of common-garden and more clever types of HSS, including advanced high strength steels (AHSS).

  Examples are:

  - 2002 Audi A4; – 38% mild steel; 29% HSLA; 22% AHSS; 11% UHSS
  - 2002 Mercedes C class; – 42% mild steel; 47% HSS & UHSS; 10% aluminium

  After about 2000, key parts of vehicle structures are really not weldable by our conventional repair or modification welding processes.

  During this period, within a vehicle's HSS content, 'trip-steel', and 'boron' steel materials - which are extremely hard steels start to be introduced. These types of steel are so strong that conventional drill-bits are not capable of penetrating the material.

- 2006 – 2008 vehicles:

  Vehicles manufactured in this era now have much less mild steel content, with the balance of the structure made from common-garden HSS, exotic HSS, and now commonly introduced (particularly on European and Japanese vehicles) is composite plastics, and aluminium pressings, extrusions, and castings.

The high-strength steel content of vehicle structures has increased by 45% in the last decade and the proportion of clever HSS over common-garden HSS is increasing.

Examples are:

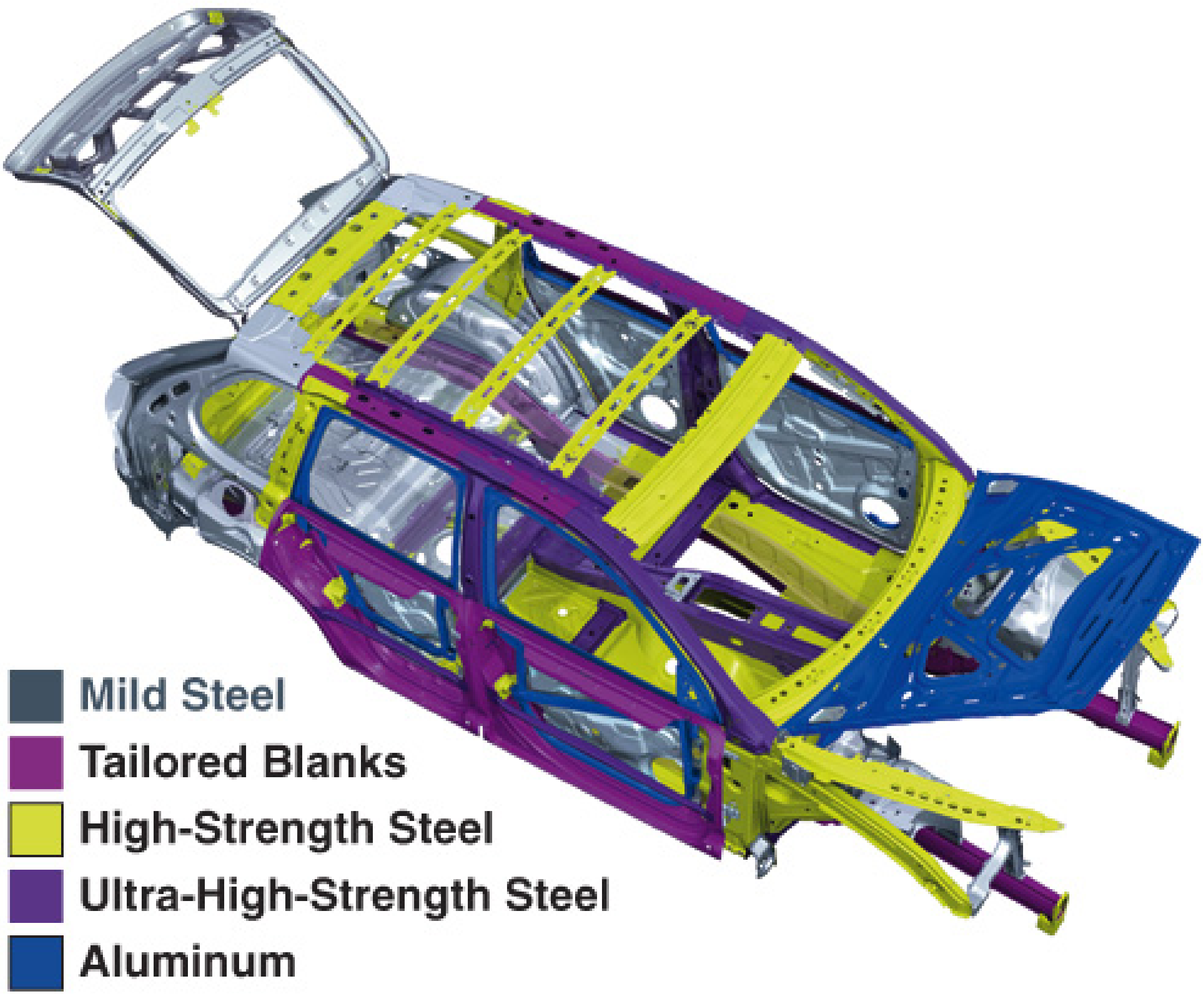
- o 2007 Saturn; – 74% HSS and UHSS
- o 2008 Mercedes C-class; – 70% HSS UHSS and AHSS
- o 2009 Audi Q5 – most of the body-shell is HSS and UHSS

Components commonly manufactured from high-strength steels:

High strength steels (including the various high-tech derivatives including HSLA, UHSS, AHHS, and high strength aluminium pressings, extrusions, and castings) are most commonly found in areas that are subject to high loadings, or are in key areas relative to occupant protection in a crash.

These critical areas include bumper beams, A-pillars, B-pillars, roof rails, cant rails, tunnel reinforcement, sills, and suspension towers.

The illustration below (of a Porsche Cayenne, courtesy of Porsche New Zealand) gives an idea of where the different materials are located. Not all vehicles will be the same, but the spread and location of materials shown in the illustration will be quite typical.



Another good example of the rapid increase of use in clever materials on very late model vehicles shows up in the differences in materials used between the Holden's previous VZ Commodore and their current VE Commodore.

In the VZ, 23% of the vehicle structure is medium strength steel, and the remaining 73% is made up of low carbon steel. Compare that with the VE Commodore; - 32% medium strength steel, 19% low carbon steel, 36% HSS, 10% AHSS, and 3% UHSS.

Welding high-strength steels:

It is essential for anyone who is considering welding any component or section in a late-model vehicle – and this relates to both modifications and repairs - to understand what sort of HSS is in question. UHSS types such as 'Complex-phase', 'Trip', 'Martensitic', and 'Boron' cannot be welded using a high-temperature process under any circumstances.

Normal HSS such as HSLA and Dual-phase, may be welded, provided that care is applied. It should be understood that the heat applied to a HSS reduces its strength, effectively turning the make-up of HSS back to more like a mild steel material. The less heat that is applied therefore, the less damage that is done to the material's molecular structure.

In order to achieve this, any welding should be carried out only by MIG or TIG. Under no circumstances should gas welding be used when carrying out a modification or repair to a part of a vehicle made from any type of high-strength steels, due to the increased heat build-up created by gas welding.

Regardless of the welding process used, short stitches should always be used to minimise heat build-up. Never carry out continuous welds on high-strength steel.

Given the explanation above regarding reducing the amount of heat applied during any welding process, it becomes fairly obvious that any component or section manufactured from high strength steel should never be heated in an effort to straighten or reform its original shape.

Finally:

An entirely different mind-set must be applied to vehicle modification (or repair for that matter) to that which we might have applied to an HQ Holden or XA Falcon. The composition of vehicles of today is entirely different because manufacturing processes have changed dramatically, and that which was appropriate thirty years, is no longer. The mind-set of anyone involved in the vehicle modification industry – most of all the LVV Certifiers – must change with it.

LVV Certifiers may also consider contacting a Repair Certifier for advice, as this is their field of expertise, and they may have knowledge of the vehicle, or system or component, you're dealing with.

If you require any additional clarification or information, please contact a member of the LVVTA technical team in the Wellington office.

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