# THE REPAIR OF VEHICLE BODIES

## SEVENTH EDITION

Andrew Livesey • Alan Robinson

# The Repair of Vehicle Bodies

This revised and updated seventh edition of the best-selling reference manual on vehicle body repair brings the book up to date for the current body repair trade. It serves as a comprehensive guide covering the vocationally related qualification (VRQ) required by the modern student and apprentice, as well as providing the CPD essential for all working professionals.

The entire book is overhauled to reflect current industry trends with regards to materials, processes and procedures. New additions include:

- An entirely new section on the work of the MET technician (mechanical, electrical and trim)
- New developments in body repair methodology such as repair pods and the greater use of alignment equipment
- Greater emphasis on the environment with new sections on hybrid vehicles and the hazards of starting current vehicles with high levels of technology
- Details on both the historic and the current joining methods for the vintage and modern markets
- Full coverage on the legalities surrounding insurance work for bodyshop staff
- Updated tables and illustrations

This book not only provides the knowledge and skills for body repair, it helps to develop a real understanding of the how and why behind this information. It will be essential for anyone studying Levels 1–3 Vehicle Body Repair, Vehicle Refinishing and MET courses, including the new apprenticeships and technical certificates from the IMI, Pearson-BTEC and C&G. HNC and degree Automotive Engineering students will find the text valuable to develop skills and knowledge for practical project work. Industry professionals, vehicle restorers and car DIY enthusiasts will continue to find it an essential and comprehensive source of information.

**Andrew Livesey** served a full apprenticeship in the motor industry before going to the University of Manchester as a mature student: he is a Fellow of the Institute of the Motor Industry and Member of the Institution of Mechanical Engineers. He also runs an independent Engineering Consultancy in Kent and teaches part time. He is former Head of Motorsport at Oxford Brookes University, has worked for McLaren and has run a company building race and rally cars.

The late **Alan Robinson** was formerly Section Leader for Vehicle Bodywork and Vehicle Body Repair, as well as Course Coordinator for CGLI 398 Vehicle Body Competencies and CGLI 385 Vehicle Bodywork at Gateshead College.

# The Repair of Vehicle Bodies

Seventh Edition

ANDREW LIVESEY

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To my three favourite teachers at Barden Boys School in Burnley. Stuart Burrows – he introduced me to the work of Robert Thompson; Alan Towers – he showed me how to modify my bike; Alfred Lawson – he helped me write my first book. These great teachers started my quest to learn practical skills and write about them.

# Contents

# Preface

This book has been revised to reflect the on-going changes in the vehicle body repair industry and the developments in technical qualifications and apprenticeships including the new T Level qualification of the Department for Education and Trailblazer apprenticeships being developed by the Institute for Apprenticeships. The author has responded to changes suggested by readers including more information related to MET and detailing. The author remains conscious that this text is also used by mature readers and learners in countries other than the UK and has ensured that the classical craft skills sections remain thorough and detailed.

I hope that you get pleasure reading it and that it helps you develop both the skills and knowledge needed by both industry professionals and vehicle restorers alike. I am always open to new suggestions for the next edition.

Andrew Livesey
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1

# Car body construction

## Starting out

It's worth starting out by asking the question why do we have car bodies in the first place? Then moving on to why are they made like they are? This will help you to understand more about your job. So, let's have a detailed look at vehicle bodies in a general sense.

We now have more variations in designs of car bodywork than we have ever had; we'll come back to that later in this chapter. When the early car designers, probably better known as inventers and engineers back in the day, wanted to get their cars on the road they needed to do it quickly and cheaply so that they could sell their products and thereby make a living – like us in the body repair industry now. So, about 120 years ago, with no online auction sites, in fact not even a telephone, they sourced their materials locally. All towns and villages had blacksmiths, and bigger towns had horse-drawn cart and carriage makers; these were the source of parts. The early cars were made by little more than attaching a petrol engine to what would have been a horse-drawn carriage.

The early cars had the engine underneath the carriage, meaning that the body and its passengers were high off the road, giving a high centre of gravity (CG). This meant that the cars were unstable and liable to roll over if the driver tried to take a corner too quickly.

As the number of cars started to grow, other engineers started to research and design separate parts of the car. These engineers made money by patenting their designs and selling the right to use their designs to car manufacturers or making the parts for manufactures to use. You probably have heard of some of them, such as Ackermann, Lucas, Borg Warner, Bosch, Girling and Dunlop.

Obviously, a petrol-engined carriage would not suit everybody. What's more, the cost of them was horrendous. An early car cost about £2,000 when the wage of a skilled worker was about £1 per week. Yes, 40 years to work to pay for it. So lots of variations started to appear: engines and gearboxes and transmissions in different locations and, more important to us, lots of different body types.

Vehicle construction techniques tend to follow a number of similar patterns from the variety of manufacturers. In this chapter we will discuss some of the general principles involved in how cars and light commercial vehicles are made. You will realize that many vehicles are sold with different names, as though made by different firms, which are almost identical apart from their badges and levels of trim or options. This is referred to as badge engineering; it has been used since the dawn of motoring. The reason for this is that it offers economy of scale in manufacturing and greater customer choice – it is win–win for us all. For the body repairer

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or vehicle restorer, it means that some parts, for example a sill panel, may fit many different makes and models of vehicles. These parts are also frequently available from independent parts dealers at lower prices than through dealerships

## Vehicle safety testing

**EuroNCAP** – one of the main reasons why cars are designed and made as they are is to make them as safe as possible. With smaller cars, this must be done within a tight budget, as cars must be priced to fit within what are referred to as price points. That is, if you look at the motoring magazines and websites, you will see that each of the vehicle manufacturers makes cars which are very similar in performance and specification at very similar prices. They tend to be fairly equal when it comes to safety of the driver, the passengers and other road users. EuroNCAP is an abbreviation for **European New Car Assessment Programme** and assesses the vehicle safety using a number of standard tests.

- *Frontal impact test* – the test for frontal impact is carried out at 64 kph (40 mph). The car strikes a deformable barrier which is offset from the centre. This is similar to many road accidents in which one car strikes another during an over taking accident or strikes another object like a road bollard.
- *Side impact test* – this is similar to many accidents in which one car is hit in the side by another – often referred to as 'T-boning' after the shape of a piece of steak. The deformable trolley is towed

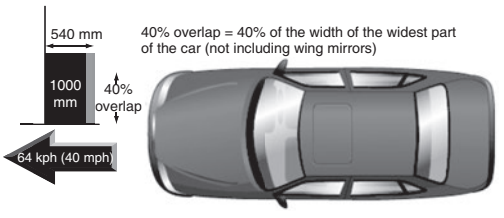


**Figure 1.1a** Frontal impact test

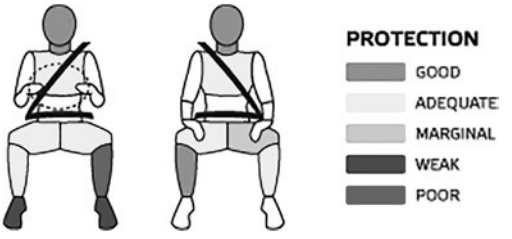


**Figure 1.1b** Protection rating colour coding

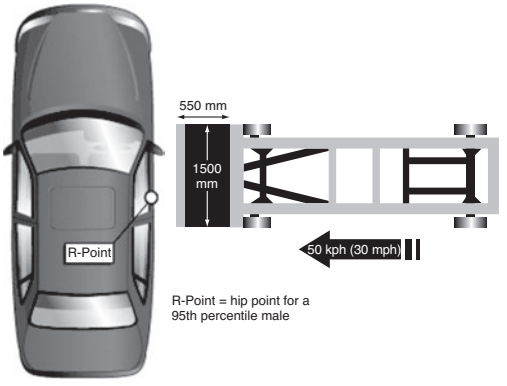


**Figure 1.1c** Side impact test

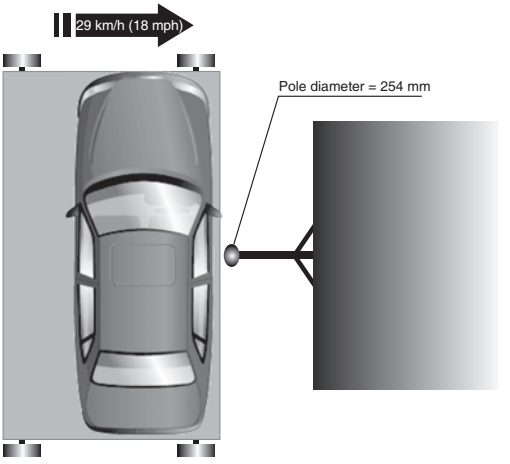


**Figure 1.1d** Pole test


**Figure 1.1e** Pedestrian impact tests

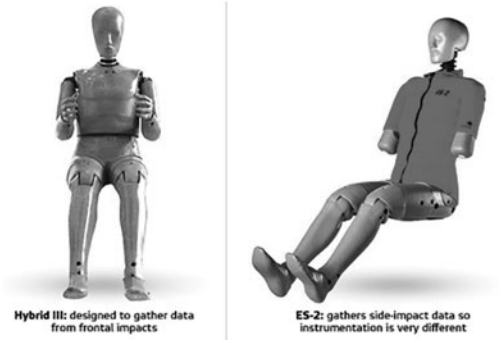


**Figure 1.1f** Typical drivers

on rails into the driver's side of the car at 50 kph (30 mph), typical of accidents at road junctions.

- *Pole test* – about a quarter of all serious or fatal accidents happen because of side impacts. The car being tested is propelled sideways on a trolley at 29 kph (18 mph) into a rigid pole. The pole is similar in size to a telegraph pole or lamppost. The main reason for this test is to assess head injury to the driver. The roof strength and operation of side airbags are important to prevent head injury.
- *Pedestrian impact tests* – a series of tests are carried out to replicate accidents involving both child and adult pedestrian impact at 40 kph (25 mph). This speed is now being adopted as a maximum in high-density build-up areas to reduce pedestrian deaths. This series of tests has led to vehicles having smooth rounded fronts with the absence of bonnet badges or other protruding features.
- *Star ratings* – each vehicle which is tested is given a star rating for its protection of adult occupant, child occupant and pedestrians. The star ratings are made up from points scoring against each test. The ratings of current vehicles can be found on the EuroNCAP website www.euroncap.com.

## Elements of vehicle construction

**Front end construction** – the main purpose of the front end is to locate the engine, the gearbox and the front suspension. The type of construction depends on the drive layout of the vehicle. If the vehicle is of conventional layout – that is, front-mounted engine driving the rear wheels – then it is usually of **integral (or mono) construction** with the passenger compartment. With this type of construction, the chassis rails will be similar at the rear of the vehicle to locate the rear axle and final drive. When being constructed in the factory, the engine and the gearbox are usually lowered into the body assembly. With the sub-frame type of construction, the engine and the gearbox are mounted onto the sub-frame and offered up to the body during manufacture. It is important that the front end of the vehicle is correctly **aligned** to ensure that the vehicle runs straight and true.

**Floor pan** – this is the main strength of the passenger compartment. The ribs and pressed-out shapes are there to make the floor pan stiff and strong. This type of

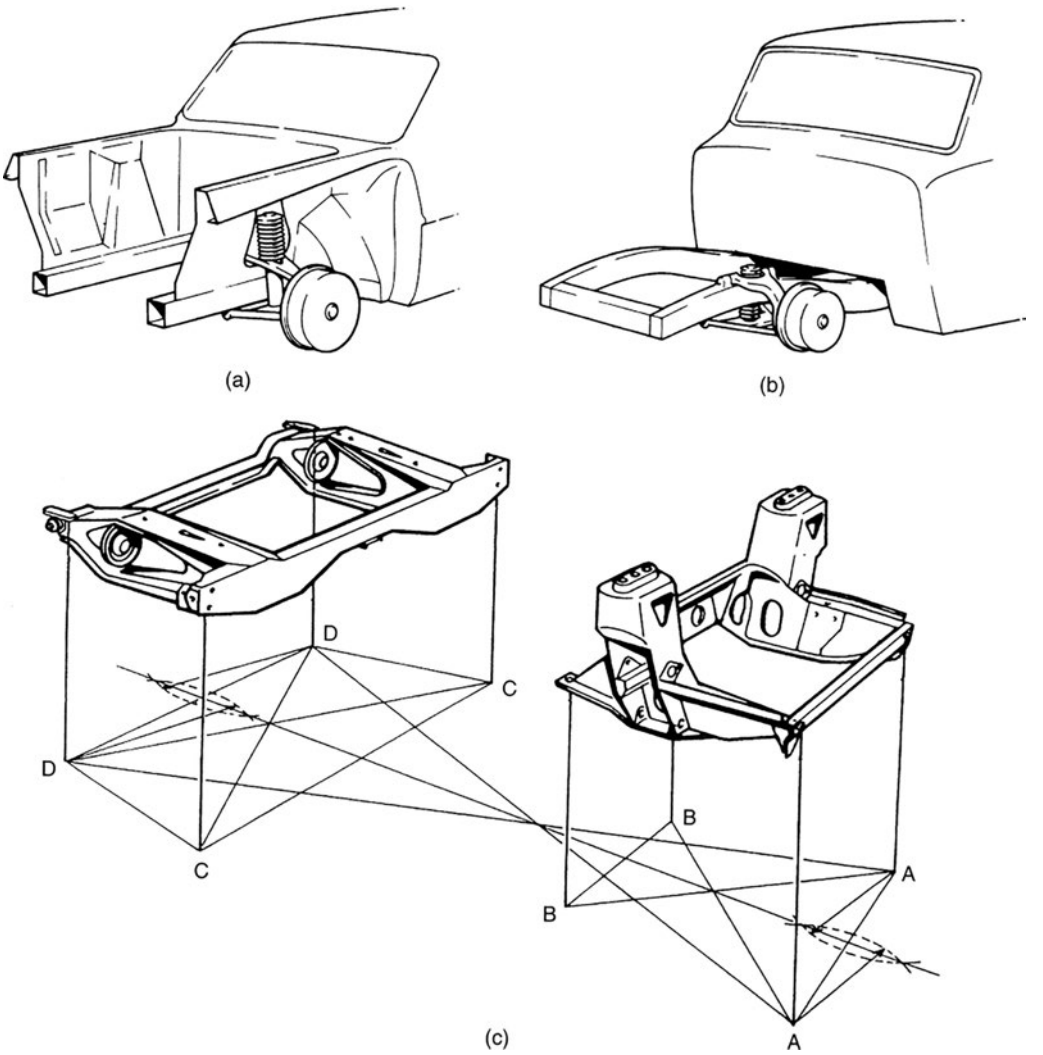


**Figure 1.2** Front end construction (a) integral or mono (b) composite and (c) front and rear subframes, these are bolted separately to the body assembly

construction was invented by Porsche for the first VW in the 1930s to make it light and simple to construct. The floor pan must be strong enough to locate the seats and seat belts as well as connect the front of the car to the rear. The floor pan is usually made of thicker metal than other body panels. Various cross members and the sills are attached to the floor pan to give the passenger compartment extra strength. The floor pan must be resistant to twisting.

**Body side and roof** – this is assembled onto the floor pan to complete the passenger compartment. Each of these panels is pressed out and welded together to form a tough cell-like structure for the driver and passengers.

**Vehicle type approval** – Many industrial sectors are subject to some form of approval or certification system, but road vehicles are a special case because of their importance to and impact upon society and have

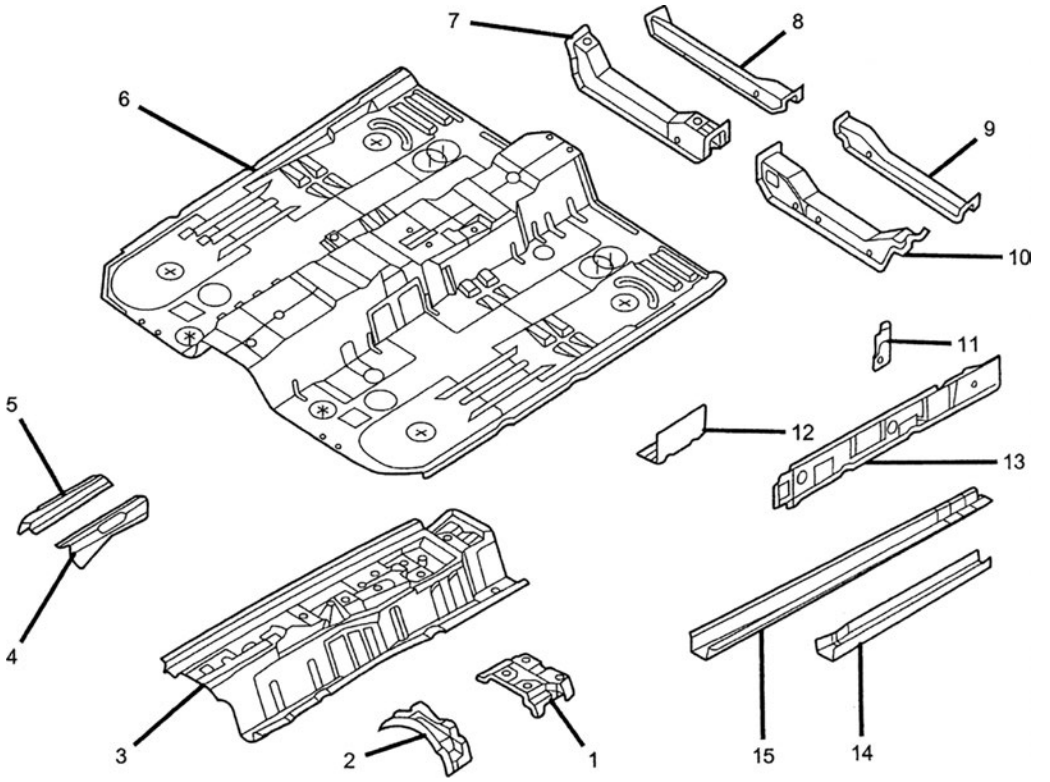


**Figure 1.3** Main floor assemblies and boot floor assemblies *(Proton)*

1 Reinforced parking brake lever
2 Cross member assembly backbone
3 Reinforced assembly backbone
4 Bracket A-Frame LH
5 Bracket A-Frame RH
6 Pan front floor
7 Cross member assembly front floor front RH
8 Cross member assembly front floor rear RH
9 Cross member assembly front floor rear LH
10 Cross member assembly front floor front LH
11 Reinforced seat belt side LH/RH
12 Bracket anti zipper
13 Sill front floor side inner LH/RH
14 Reinforced side member front floor LH/RH
15 Side member front floor LH/RH

NOTE:
A large **reinforcement** has been added to the front floor backbone (reinforcement assembly backbone), and this is coupled with the side sill, side member and cross member to provide increased rigidity to the total floor.

been subject to specific technical standards almost from their first invention. Within Europe, two systems of type approval have been in existence for many years. One is based around EC Directives and provides for the approval of whole vehicles, vehicle systems and separate components. The other is based around UNECE (United Nations Economic Commission) Regulations and provides for approval of vehicle systems and separate components but not whole vehicles.

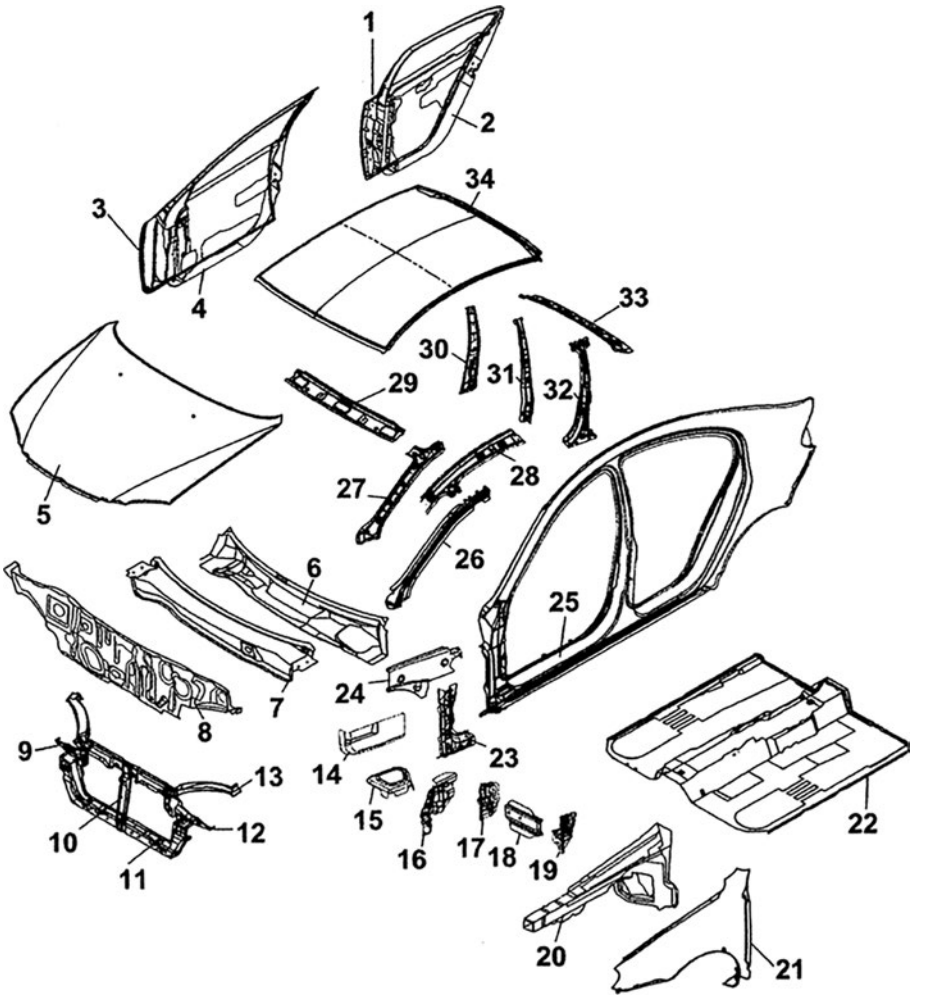


**Figure 1.4** Body side assemblies, roof, BC-post, front and rear door of a hatchback *(Proton)*

1 Panel outer rear door
2 Panel inner rear door
3 Panel outer front door
4 Panel inner rear door
5 Panel hood
6 Panel cowl top inner
7 Panel cowl top outer
8 Panel assembly dash
9 Reinforced radiator side RH
10 Stay hood lock
11 Cross member front end
12 Reinforced radiator side LH
13 Bar front end upper
14 Bulkhead front pillar lower
15 Bulkhead front pillar side sill
16 Bracket cross member front
17 Bracket cross member
18 Reinforced pillar front inner lower
19 Pillar front inner lower
20 Side member front
21 Panel front fender
22 Pan front floor
23 Reinforced front pillar lower
24 Extension upper frame outer
25 Side structure
26 Reinforced front pillar centre
27 Pillar front inner upper
28 Rail roof side inner
29 Rail roof front
30 Pillar centre inner
31 Pillar centre outer
32 Pillar rear inner
33 Rail roof rear
34 Panel roof

Type approval is the confirmation that production samples of a design will meet specified performance standards. The specification of the product is recorded, and only that specification is approved.

Automotive EC Directives and UNECE Regulations require third-party approval – testing, certification and production conformity assessment by an independent body. Each member state is required to appoint an Approval Authority to issue the approvals and a Technical Service to carry out the testing to the Directives and Regulations. An approval issued by one Authority will be accepted in all the member states. Vehicle Certification Agency (VCA) is the designated UK Approval Authority and Technical Service for all type of approvals to automotive EC Directives and ECE Regulations. The VCA also has offices in Europe, North America and the Far East.

Approved parts carry the E-mark. That is a letter 'e' or 'CE' followed by a number that indicates the country of approval.

## Vehicle information code plate

**Location** – the vehicle information code plate is usually riveted on the scuttle inside the engine compartment. It has important information about the vehicle which is often needed for repair processes.

The plate shows model code, engine model, transmission model and colour code.

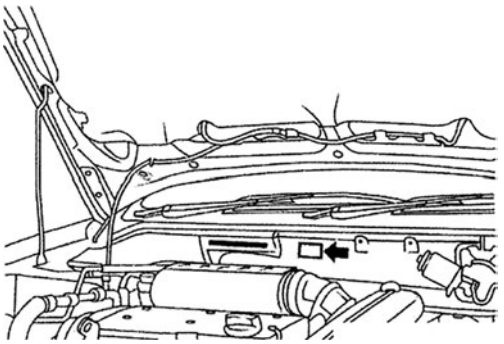

**Figure 1.5** Location of vehicle information code plate

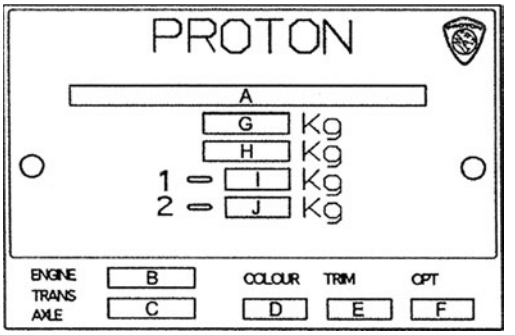


**Figure 1.6** Code plate descriptions

| Position | Description |
|---|---|
| A | VEHICLE IDENTIFICATION NUMBER (VIN) |
| B | ENGINE |
| C | TRANS AXLE |
| D | EXTERIOR CODE |
| E | INTERIOR CODE |
| F | OPTION CODE |
| G | GROSS VEHICLE WEIGHT |
| H | GROSS COMBINATION WEIGHT |
| I | FRONT AXLE WEIGHT |
| J | REAR AXLE WEIGHT |

## Brief history of the motor vehicle

The development of the motor vehicle fits into a timeline stretching over 300 years. The vehicle developed alongside other products and technology. Just as you might go to a trade show and buy a new tool, then discover that it'll work for another purpose, car designers do the same. A recent example is LED lighting used in many cars; a few years ago, it came to our notice by being used for decorative lights in the house. Somebody had the idea to make them more powerful – we now have lots of use for LED lights – and they have the advantage of being very efficient compared to tungsten bulbs. This timeline lists some of the important events which have brought us to have the current range of vehicles.

**1688** Ferdinand Verbiest, a missionary in China, makes a model steam vehicle using the steam turbine principle.

**1740** Jacques de Vaucansen makes a clockwork carriage in Paris.
**1765** Scottish scientist and engineer James Watt develops the steam engine.
**1769** Louis XV of France funds Nicholas Cugnot to build a steam-powered tractor for military use. It carries four people at just over 2 mph for ten minutes.
**1771** Cugnot crashes the steam tractor into a wall – the first motoring accident. Cugnot was put into prison for this.
**1784** James Watt patents a steam carriage but does not build it. William Murdock builds a model steam vehicle in Redruth, Cornwall – it works.
**1801** Lots of steam engines are being installed in tin mines in Cornwall – some of these are featured in the TV film *Poldark*. Another Cornish man, Dick Trevithick, builds a steam carriage and drives it up Cambourne Beacon. Two years later this is in use in London for transporting passengers.
**1817** The bicycle is invented – but it hasn't pedals, it is like a full-size version of current children's toy the balance bike.
**1824** Lots of steam carriages are built and used in London and other parts of England.
**1845** Pneumatic tyre is invented.
**1859** Oil is discovered in the United States.
**1860** Gas engine invented which is used in many factories for power instead of steam – it is quicker to start up.
**1861** Michaux fits pedalling mechanism to the bicycle – a name still associated with cycle parts.
**1876** Otto makes 4-stroke petrol engine.
**1885** Karl Benz produces his first car – this is the first car as we know it.

As you can see it took 200 years from concept to production of the first useable car. As the year 1900 approached, truck and van bodies started to appear. Prior to this, the of cost manufacture was so high that only very rich people could afford them – and they were very much curiosities or toys, like hyper-sports-cars are now. A rolling chassis was made to which a car, a van or a truck body could be fitted. The bodies were made by body-building companies using a mixture of wood, metal and fabric as had been horse-drawn carriage bodies – these were in fact the same companies responding to the new market. Customers could order bodies built to order to fit onto a rolling chassis. Larger cars had their chassis extended to accept limousine bodies – rather like the extended limos used by rock stars and others for fun evenings out.

The First World War led to car chassis being adapted to carry big machine guns and the design of battle tanks and other armoured vehicles. After WWI there was a great increase in car manufacturers – more than 2,000 individual car manufacturers were in business in the UK in 1922. This was responding to the increased desire to own a car – manufacturers looked at ways to make them cheaper – which usually also meant lighter. Cars like Ford, Austin and Morris became available for £100 brand new – but as now, you could spend the same amount of money on accessories – accessories in 1930 included lights and bumpers.

This led to two very significant advances in body design and manufacture. Standard was the first make of car to have 'standardized' parts – parts could be interchanged between models – so vehicle parts departments – then called stores – could stock easy-to-fit parts. The other change was the building of cars with unitary construction – where the body formed the load-bearing member, so no need for a separate chassis – the Morris Minor produced from the 1940s to the 1960s is a classic example of this technique.

At the end of the 1950s was the introduction of what we now call the classic Mini by Austin and Morris – the same car with different badges. It had a mixed

reception until a member of the British Royal Family used one for fun. The body innovation significance of the Mini was in two parts. One significance was that it used two sub-frames – the front sub-frame located the engine and steering, the rear sub-frame just the rear wheels and suspension. This construction allowed the use of cheaper mass-production components and the interchangeability of different engines and gearboxes. The other significance was to have the minimum of interior trim, giving the maximum interior space for such a small exterior size. In other words, this is an example of excellent design, giving minimum weight and maximum carrying capacity. The Mini was also the cheapest car available – its target market was the motorcyclist commuter, a market that it took by storm.

The next big change in body design was the introduction of the hatchback, now almost universal in current small cars. The secret of the design was to use the car roof as a structural load-bearing member so that the equivalent of a door could be cut at the rear. So we use the terms "three-door' and 'five-door cars'. The first car to do this was the 1958 Austin A40 Mk2, but the rear door was split horizontally into two parts. The 1974 VW Golf, quickly followed by the Ford Fiesta, had a one-piece top-hinged door – as is almost universal on current hatchbacks.

The classic Mini morphed into the current BMW Mini in 2000. The change with this model was the level of specification of trim and electronics in such a small outer shell. Where the classic Mini was a showcase for minimalism and utility, the new Mini is a showcase for comfort and functionality. Since its introduction, it has grown in size and model range. In this time period many vehicle models have also grown but kept the same badge and model name range.

In 1970, the Range Rover was introduced. This combined 4 × 4 off-road capability with a luxury interior. This was a bodywork concept to be followed by many other manufacturers leading to the term 'sport utility vehicle' – SUV. The Range Rover was followed by others of different sizes, such as intermediate sports utility vehicles – ISUV – and smaller ones designated SSUV. Now the concept is applied to two-wheel-drive versions with the same bodywork.

To some extent the design of vehicles has gone full circle. The rolling chassis has become a floor pan – that is, a series of structural members with engine, transmission and suspension may be fitted with a full range of bodies. The current BMW 3 Series is a good example. It is available in convertible, coupe, saloon, estate and SUV forms. All use the same platform, the name used for the rolling chassis or floor pan assembly. In addition, different platforms are available for different sizes of engines within the same range. This concept is not new; it was first used by Ferdinand Porsche in the design of the 1930s VW beetle, then applied to make the first Porsche sports-cars and a whole series of one-off vehicles. The use of this concept is largely due to the developments in design and manufacturing. The introduction of computer-aided (CAD) and associated computer-aided manufacturing (CAM) means that new designs can be made in minutes, and production lines are not linear but are based on cells that can be reconfigured quickly to move model production to suit design requirements.

Customers may now order their new car online choosing platform, body, colour and trim. This translates into a manufacturing specification and can all be carried out without speaking to a person.

## Skills and questions

As well as knowledge about vehicle construction, you need to develop a range of skills, which will depend on the type of vehicle that you are working on and your previous skill level. The following tasks and questions will help you

to develop your skills and understanding of vehicle construction:

1 Identify the construction of two different vehicles, making notes and sketches of the vehicle layout and how the major components are attached to the passenger compartment.
2 Obtain a body parts manual for one of the vehicles you work on and make sketches to show how the panels are attached to each other.
3 Look at two different variants of the same vehicle, for example saloon and convertible or saloon and light commercial, and find how many panels are interchangeable.
4 Remove and refit any major components you get the opportunity to do.
5 Describe how the body code and the trim code are identified from the code plate on a vehicle which you work on – write down the details.

2

# Health and safety and the environment

Health and safety and the environment are controlled by a number of Acts of Parliament and subsequent regulations and statutory instruments. These may have regional variations or specifics relating to the various parts of the vehicle repair trade. These topics are also impacted by other laws, for instance those relating to the country side. Perhaps the most important aspect of the health and safety laws is that they are vicarious. That is, if you are a manager or supervisor of a bodyshop, you may be prosecuted for any injury or death caused by one of the technicians or other staff actions, as well as the staff involved being prosecuted. Breaking health and safety or environmental laws may result in custodial sentences as well as fines and damages to the injured parties. Meeting the requirements of the health and safety and environmental laws and regulations is the responsibility of everybody. Ignorance of the law is not an excuse, so you need to take care

## Personal health and safety procedures

**Skin care (personal hygiene) systems** All employees should be aware of the importance of personal hygiene and should follow correct procedures to clean and protect their skin in order to avoid irritants causing skin infections and dermatitis. All personnel should use a suitable barrier cream before starting work and again when recommencing work after a break. There are waterless hand cleaners available which will remove heavy dirt on skin prior to thorough washing. When the skin has been washed, after-work creams will help to restore its natural moisture.

Many paints, refinishing chemicals and bodyshop materials will cause irritation on contact with the skin and must be removed promptly with a suitable cleansing material. Paint solvents may cause dermatitis, particularly where skin has been in contact with peroxide hardeners or acid catalysts: these have a drying effect which removes the natural oils in the skin. There are specialist products available for the bodyshop which will remove these types of materials from the skin quickly, safely and effectively.

**Hand protection** Body technicians and painters are constantly handling substances which are harmful to health. The harmful effect of liquids, chemicals and materials on the hands can be prevented, in many cases, by wearing the correct type of gloves. To comply with COSHH Regulations, vinyl disposable gloves must be used by painters to give skin protection against toxic substances. Other specialist gloves available are: rubber and PVC gloves for protection against solvents, oil and acids; leather gloves for hard wearing and general repair work in the bodyshop; and welding gauntlets, which are made from specially treated leather and are longer than normal gloves to give adequate protection to the welder's forearms.

*The Repair of Vehicle Bodies*, Andrew Livesey, 9780815378709, 2019, Taylor & Francis

**Protective clothing** is worn to protect the worker and his clothes from coming into contact with dirt, extremes of temperature, falling objects and chemical substances. The most common form of protective clothing for the body repairer is the overall, a one-piece boiler suit made from good quality cotton, preferably flame-proof. Worn and torn materials should be avoided, as they can catch in moving machinery. Where it is necessary to protect the skin, closely fitted sleeves should be worn down to the wrist with the cuffs fastened. All overall buttons must be kept fastened, and any loose items such as ties and scarves should not be worn. Protective clothing worn in the paint shop by the spray painters should be either good-quality washable nylon garments, anti-static, and complete with hood, elasticated wrists and ankles; or low-lint disposable coveralls, which offer a liquid barrier protection from splashes, airborne dusts and paint overspray. The coveralls must withstand continuous exposure to a variety of chemicals and must be suitable for protection when using isocyanate based two-pack paints; they also prevent the environment being contaminated by particles from the operator's clothing and hair. They can be of the one-piece variety or can have separate disposable hoods.

**Head protection** is very important to the bodyworker when working underneath a vehicle or under its bonnet while it is being repaired. A light safety helmet, normally made from aluminium, fibreglass or plastic, should be worn if there is any danger from falling objects and will protect the head from damage when working below vehicles. Hats and other forms of fabric headwear keep out dust, dirt and overspray and also prevent long hair (tied back) becoming entangled in moving equipment.

**Eye protection** is required when there is a possibility of eye injury from flying particles when using a grinder, disc sander, power drill or pneumatic chisel, or when removing glass windscreens or working underneath vehicles. Many employers are now requiring all employees to wear some form of safety glasses when they are in either the repair or the paint areas of the bodyshop, because in any bodyshop location, there is always the possibility of flying objects, dust particles, or splashing liquids entering the eyes. Not only is this painful, but it can, in extreme cases, cause loss of sight. Eyes are irreplaceable: therefore, it is advisable to wear safety goggles, glasses or face shields in all working areas. The following types of eye protection are available:

- *Lightweight safety spectacles* with adjustable arms and with side shields for extra protection. There is a choice of impact grades for the lenses.
- *General-purpose safety goggles* with a moulded PVC frame which is resistant to oils, chemicals and water. These have either a clear acetate or a polycarbonate lens with BS impact grades 1 and 2.
- *Face shields* with an adjustable head harness and deep polycarbonate brow guard with replaceable swivel-up clear or anti-glare polycarbonate visor BS grade 1, which gives protection against sparks, molten metal and chemicals.
- *Welding helmet or welding goggles* with appropriate shaded lens to BS regulations. These must be worn at all times when welding. They will protect the eyes and face from flying molten particles of steel when gas welding and brazing and from the harmful light rays generated by the arc when MIG/MAG, TIG or MMA welding.

**Figure 2.1** Lightweight safety glasses

**Figure 2.2** Face protection mask

**Figure 2.3** Automatic welding mask

**Foot protection** – Safety footwear is essential in the bodyshop environment. Boots or shoes with steel toecaps will protect the toes from falling objects. Rubber boots will give protection from acids or in wet conditions. Never wear defective footwear, as this becomes a hazard in any workshop environment.

**Respiratory protection – lungs** – one of the most important hazards faced by the bodyshop worker is that of potential damage to the lungs. Respirators are usually needed in body repair shops even though adequate ventilation is provided for the working areas. During welding, metal or paint preparation or spraying, some form of protection is necessary. Under the COSHH Regulations, respiratory protection is essential and therefore must be used. Respirators give protection against abrasive dusts, gases, vapours from caustic solutions and solvents, and spray mist from undercoats and finishing paint by filtering the contaminated atmosphere before it is inhaled by the wearer. They may be either simple filtering devices, where the operator's lungs are used to draw air through the filter, or powered devices incorporating a battery-driven fan to draw contaminated air through the filters and deliver a flow of clean air to the wearer's face. There are four primary types of respirator available to protect the bodyshop technicians: dust respirators, cartridge filter respirators, powered respirators and constant-flow air line breathing apparatus.

**Dust respirators:** (masks), the most basic form of respiratory protection is the disposable filtering half-mask, typically used when preparing or finishing bodywork such as by rubbing down or buffing, and where dust, mist and fumes are a problem. This face mask provides an excellent face seal while at the same time allowing the wearer to speak freely without breaking the seal. Breathing resistance is minimal, offering cool and comfortable use. Various types of mask are available for use in a variety of environments where contaminants vary from nuisance dust particles to fine dusts and toxic mists. These masks can only be used in atmospheres containing less than the occupational exposure limit of the contaminant.

**Cartridge filter mask:** The cartridge filter or organic vapour type of respirator, which covers the nose and mouth, is equipped with a replacement cartridge that removes the organic vapours by chemical absorption. Some of these are also designed with a pre-filter to remove solid particles

from the air before the air passes through the chemical cartridge. They are used in finishing operations with non-toxic paints but not with isocyanate paints. For the vapour/particle respirator to function correctly, it is essential that it fits properly against the face. Follow the manufacturer's instructions for changing the cartridges when spraying over a continuous period.

**Powered respirators** using canister filters offer protection against toxic dusts and gases. The respirator draws contaminated air through filters with a motor fan powered by a rechargeable battery and supplies clean air to the wearer's face. This avoids discomfort and fatigue caused by the effort of having to inhale the air through filters, permitting longer working periods. These devices find great use both in the spray shop and in the repair shop when carrying out welding.

**Constant-flow compressed air line breathing apparatus** is designed to operate from an industrial compressed air system in conjunction with the spray gun. Using a waist-belt-mounted miniature fixed-pressure regulator and a pre-filter, the equipment supplies breathing-quality air through a small-bore hose to a variety of face masks and visors to provide respiratory protection for paint spraying (such as with isocyanates), cleaning and grinding. The COSHH Regulations have made it mandatory for all respiratory protection equipment to be both approved and suitable for the purpose, for the operatives to be correctly trained in the equipment's use and maintenance, and for proper records to be kept.

**Ear protection** – the **Noise at Work Regulations** define three action levels for exposure to noise at work:

- A daily personal exposure of up to 80 dB. Where exposure exceeds this level, suitable hearing protection must be provided on request
- A daily personal exposure of up to 85 dB. Above this second level of provision, hearing protection is mandatory.
- A peak sound pressure of 87 dB.

**Tech note**

Noise is measured in decibels (dB) – this is measured on a scale based on logarithms. That is to say that increases do not follow the normal arithmetic scale in terms of increase in noise. An increase of 3 dB, from say 84 dB to 87 dB, will give a doubling of the noise heard. So cutting the reading by 3 dB will reduce the noise heard by half.

Where the second or third levels are reached, employers must designate ear-protection zones and require all who enter these zones to wear ear protection. Where the third level is exceeded, steps must be taken to reduce noise levels as far as is reasonably practicable. In every case where there is a risk of significant exposure to noise, assessment must be carried out and action taken to minimize hearing damage.

The first two noise action levels relate to exposure over a period (one day) and are intended to cater for the risks of prolonged work in noisy surroundings. The third level is related to sudden-impact noises like those occurring in metalworking procedures.

## Fire precautions

The Fire Precautions (workplace) Regulations 1992/1993/1997 replaced and extended the old Fire Precautions Act 1971. These regulations are aligned with standard practice in EC Directives in placing the responsibility for compliance on the employers. They require employers not only to assess risks from fire but to include the preparation of an evacuation plan, to train staff in fire precautions and to keep records. Workplaces with fewer than 20 employees may require emergency lighting points and fire warning systems. The self-employed who do not employ anyone but whose premises are regularly open to the public may only require fire extinguishers and warning signs; they

will, however, need to be able to demonstrate that there is a means of escape in case of fire. Where five or more persons work on the premises as employees, all assessments need to be recorded in writing.

Most of these requirements were already covered by existing legislation. There is a detailed requirement for the recording of assessments, the provision of training and the requirement that means of fighting fire, detecting fire and giving warning in case of fire be maintained in good working order.

**What is fire?** Fire is a chemical reaction called combustion (usually oxidation resulting in the release of heat and light). To initiate and maintain this chemical reaction, or in other words for an outbreak of fire to occur and continue, the following elements are essential:

- *Fuel*: A combination substance, solid, liquid or gas.
- *Oxygen*: Usually air, which contains 21 per cent oxygen.
- *Heat*: The attainment of a certain temperature – once a fire has started it normally maintains its own heat supply.

**Methods of extinction of fire.** Because three ingredients are necessary for fire to occur, it follows logically that if one or more of these ingredients are removed, fire will be extinguished. Basically three methods are employed to extinguish a fire: removal of heat (cooling); removal of fuel (starving); and removal or limitation of oxygen (blanketing or smothering).

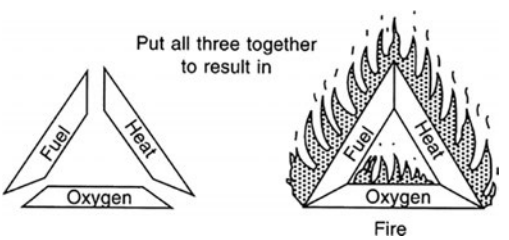


**Figure 2.4** The fire triangle

**Removal of heat** – If the rate of heat generation is less than the rate of dissipation, combustion cannot continue. For example, if cooling water can absorb heat to a point where more heat is being absorbed than generated, the fire will go out.

**Removal of fuel** – This is not a method that can be applied to fire extinguishers. The subdividing of risks can starve a fire, prevent large losses and enable portable extinguishers to retain control; for example, part of a building may be demolished to provide a fire stop. The following advice can contribute to a company's fire-protection programme:

- What can cause fire in this location, and how can it be prevented?
- If fire starts, regardless of cause, can it spread?
- If so, where to?
- Can anything be divided or moved to prevent such spread?

**Removal or limitation of oxygen** – It is not necessary to prevent the contact of oxygen with the heated fuel to achieve extinguishment. It will be found that where most flammable liquids are concerned, reducing the oxygen in the air from 21 to 15 per cent or less will extinguish the fire. Combustion becomes impossible even though a considerable proportion of oxygen remains in the atmosphere. This rule applies to most solid fuels, although the degree to which oxygen content must be reduced may vary. Where solid materials are involved, they may continue to burn or smoulder until the oxygen in the air is reduced to 6 per cent. There are also substances which carry within their own structures sufficient oxygen to sustain combustion.

## Fire risks in the workshop

Fire risks in the vehicle body repair shop cover all classes of fire: class A is paper, wood and cloth; class B is flammable liquids such as oils, spirits, alcohols, solvents and grease; class C is flammable gases such

as acetylene, propane, butane; and also electrical risks. It is essential that fire is detected and extinguished in the early stages. Workshop staff must know the risks involved and should be aware of the procedures necessary to combat fire. Bodyshop personnel should be aware of the various classes of fire and how they relate to common workshop practice.

## Class A fires: wood, paper and cloth

Today wood is not used in cars, although there are exceptions. Cloth materials are used for some main trim items and are therefore a potential fire hazard. The paper used for masking purposes is a prime area of concern. Once it has done its job and is covered in overspray, it is important that it is correctly disposed of, ideally in a metal container with a lid, and not scrunched up and thrown on the floor to form the potential start of a deep-seated fire.

## Class B fires: flammable liquids

Flammable liquids are the stock materials used in the trade for all body refinishing processes: gun cleaner to clear finish coats and cellulose for the more modern finishes can all burn and produce acrid smoke.

## Class C fires: gases

An increasing percentage of cars run on liquid gas (LPG/LNG), also welding gases or propane space heaters not only burn but can be the source of ignition for A or B fires.

## Electrical hazards

Electricity is not of itself a class of fire. It is, however, a potential source of ignition for all of the fire classes mentioned above. The Electricity at Work Regulations cover the care of cables, plugs and wiring. In addition, in the bodyshop, the use of welding and cutting equipment produces sparks, which can, in the absence of good housekeeping, start a big fire. Training in how to use firefighting equipment can stop a fire in its early stages. Another hazard is the electrical energy present in all car batteries. A short-circuit across the terminals of a battery can produce sufficient energy to form a weld and in turn heating, a prime source of ignition. When tackling a car fire, a fireman will always try to disconnect the battery, as otherwise any attempt to extinguish a fire can result in the re-ignition of flammable vapours.

Body filler is a further possible source of ignition to be aware of as the result of mixing two materials to use as a body filler material. The result of mixing in the wrong proportions can give rise to an exothermic (heat-releasing) reaction; in extreme cases the mix can ignite.

## General precautions to reduce fire risk

- Good housekeeping means putting rubbish away rather than letting it accumulate.
- Read the manufacturer's material safety data sheets so that the dangers of flammable liquids are known.
- Only take from the stores sufficient flammable material for the job in hand.
- Materials left over from a specific job should be put back into a labelled container so that not only you but anyone (and this may be a fireman) can tell what the potential risk may be.
- Take care when welding that sparks or burning underbody coating does not cause a problem, especially when working in confined areas of vehicles.
- Be extremely careful when working close to plastic fuel lines.
- Petrol tanks are a potential hazard: supposedly empty tanks may be full of vapour. To give some idea of the potential problem, consider 5 litres (1 gallon) of petrol: it will evaporate into 1 $m^3$ (35 $feet^3$) of neat vapour, which will mix with air to form 14 $m^3$ (500 $feet^3$)

of flammable vapour. Thus the average petrol tank needs only a small amount of petrol to give a tank full of vapour.

The keys to fire safety are:

- Take care.
- Think.
- Train staff in the correct procedures before things go wrong.
- Ensure that these procedures are written down, understood and followed by all personnel within the workshop.

**Tech note**
Any carbon-based material will burn in air if at the temperature needed for combustion – be aware of this with dust in the body or paint shop.

## Types of portable fire extinguishers

**Water** is the most widely used extinguisher agent. With portable extinguishers, a limited quantity of water can be expelled under pressure and its direction controlled by a nozzle.

There are basically two types of water extinguishers. The gas ($CO_2$) cartridge operated extinguisher, when pierced by a plunger, pressurizes the body of the extinguisher, thus expelling the water and producing a powerful jet capable of rapidly extinguishing class A fires. In stored-pressure extinguishers the main body is constantly under pressure from dry air or nitrogen, and the extinguisher is operated by opening the squeeze grip discharge valve. These extinguishers are available with 6-litre or 9-litre-capacity bodies and thus provide alternatives of weight and accessibility.

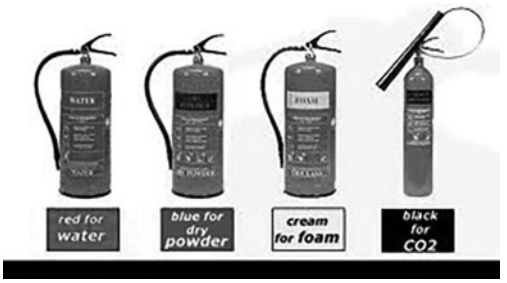


**Figure 2.5** Types of portable fire extinguishers

**Foam** is an agent most suitable for dealing with flammable-liquid fires. Foam is produced when a solution of foam liquid and water is expelled under pressure through a foam-making branch pipe, at which point air is entrained, converting the solution into foam. Foam extinguishers can be pressurized either by a $CO_2$ gas cartridge or by stored pressure. The standard capacities are 6 and 9 litres.

## Spray foam

Unlike conventional foams, aqueous film forming foam (AFFF) does not have to be fully aspirated in order to extinguish fires. Spray foam extinguishers expel an AFFF solution in an atomized form which is suitable for use on class A and class B fires. AFFF is a fast and powerful means of tackling a fire and seals the surfaces of the material, preventing re-ignition. The capacity can be 6 or 9 litres, and operation can be by $CO_2$ cartridge or stored pressure.

## Carbon dioxide

Designed specifically to deal with class B, class C and electrical fire risks, these extinguishers deliver a powerful concentration of carbon dioxide gas under great pressure. This not only smothers the fire very rapidly but is also non-toxic and is harmless to most delicate mechanisms and materials.

## Dry powder

This type of extinguisher is highly effective against flammable gases, open or running fires involving flammable liquids such as oils, spirits, alcohols, solvents and waxes, and electrical risks. The powder is contained

in the metal body of the extinguisher, from which it is supplied either by a sealed gas cartridge or by dry air or nitrogen stored under pressure in the body of the extinguisher in contact with the powder.

Dry powder extinguishers are usually made in sizes containing 1 to 9 kg of either standard powder or (preferably and more generally) all-purpose powder, which is suitable for mixed-risk areas.

### Choosing and siting portable extinguishers

Because there is such a variety of fire risks in bodyshops, it is important to analyse these risks separately and (with the help of experts such as fire officers) to choose the correct firefighting medium to deal with each possible fire situation. It should be noted that portable fire extinguishers are classified as first-aid firefighting and are designed for ease of operation in an emergency. It is important to realize that because they are portable they have only a limited discharge. Therefore their siting, together with an appreciation of their individual characteristics, is fundamental to their success in fighting fire.

| Class of fire | Water | Foam (AFFF) | $CO_2$ gas | Powder |
|---|---|---|---|---|
| A Paper Wood Textile Fabric | ✓ | ✓ | | ✓ |
| B Flammable liquids | | ✓ | ✓ | ✓ |
| C Flammable gases | | | ✓ | ✓ |
| Electrical hazards | | | ✓ | ✓ |
| Vehicle protection | | ✓ | | ✓ |

**Figure 2.6** Choice of fire extinguishers

## Safety signs in the workshop

It is a legal requirement that all safety signs used in a bodyshop comply with BS 5378: Part 1. Each of these signs is a combination of colour and design, within which the symbol is inserted. If additional information is required, supplementary text may be used in conjunction with the relevant symbol, provided that it does not interfere with the symbol. The text can be in an oblong or square box of the same colour as the sign, with the text in the relevant contrasting colour, or the box can be white and the text black. BS 5378 divides signs into four categories:

- *Prohibition* signs have a red circular outline and crossbar running from top left to bottom right on a white background. The symbol displayed on the sign must be black and placed centrally on the background, without obliterating the crossbar. The colour red is associated with 'stop' or 'do not'.
- *Warning* signs have a yellow triangle with a black outline. The symbol or text used on the sign must be black and placed centrally on the background. This combination of black and yellow identifies caution.
- *Mandatory* signs have a blue circular back ground. The symbol or text used must be white and placed centrally on the background. Mandatory signs indicate that a specific course of action is to be taken.
- *Safe condition* signs provide information for a particular facility and have a green square or rectangular background to

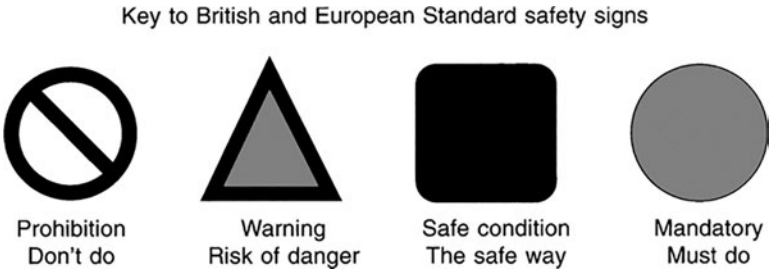


**Figure 2.7** Standard safety signs

accommodate the symbol or text, which must be in white. The safety colour green indicates 'access' or 'permission'.

Fire safety signs are specified by BS 5499, which gives the characteristics of signs for fire equipment, precautions and means of escape in case of fire. It uses the basic framework concerning safety colours and design adopted by BS 5378.

## General safety precautions in the workshop

The Health and Safety Act is designed to ensure that:

- Employers provide a safe working environment with safety equipment and appropriate training
- Employees work in a safe manner using the equipment provided and follow the guidance and training which is provided
- Customers and others entering any business premises are safe and protected

The following section looks at some of the details related to health and safety. In all cases you should ask yourself the following questions:

- Are there any regulations relating to this, what are they, and what do I need to do to follow them?
- What is the risk involved, and how can I remove or reduce the risk?
- Is any documentation needed?

**Remember**
It is all about keeping yourself, your colleagues and your customers safe, as you would want them to keep you safe too.

Particular hazards may be encountered in the bodyshop, and safety precautions associated with them are as follows:

1 Do wash before eating, drinking or using toilet facilities to avoid transferring the residues of sealers, pigments, solvents, filings of steel, lead and other metals from the hands to the inner parts and other sensitive areas of the body.
2 Do not use kerosene, thinners or solvents to wash the skin. They remove the skin's natural protective oils and can cause dryness and irritation or have serious toxic effects.
3 Do not overuse waterless hand cleaners, soaps or detergents, as they can remove the skin's protective barrier oils.
4 Always use barrier cream to protect the hands, especially against fuels, oils, greases, hydrocarbon solvents and solvent-based sealers.
5 Do follow work practices that minimize the contact of exposed skin and the length of time liquids or substances stay on the skin.
6 Do thoroughly wash contaminants such as used engine oil from the skin as soon as possible with soap and water. A

waterless hand cleaner can be used when soap and water are not available. Always apply skin cream after using waterless hand cleaner.

7 Do not put contaminated or oily rags in pockets or tuck them under a belt, as this can cause continuous skin contact.
8 Do not dispose of dangerous fluids by pouring them on the ground or down drains or sewers.
9 Do not continue to wear overalls which have become badly soiled or which have acid, oil, grease, fuel or toxic solvents spilt over them. The effect of prolonged contact from heavily soiled overalls with the skin can be cumulative and life threatening. If the soilants are or become flammable from the effect of body temperature, a spark from welding or grinding could envelop the wearer in flames, with disastrous consequences.
10 Do not clean dusty overalls with an air line: it is more likely to blow the dust into the skin, with possible serious or even fatal results.
11 Do wash contaminated or oily clothing before wearing it again.
12 Do discard contaminated shoes.
13 Wear only shoes which afford adequate protection to the feet from the effect of dropping tools and sharp and/or heavy objects on them, and also from red-hot and burning materials. Sharp or hot objects could easily penetrate unsuitable footwear such as canvas plimsolls or trainers. The soles of the shoes should also be maintained in good condition to guard against upward penetration by sharp or hot pieces of metal.
14 Ensure gloves are free from holes and are clean on the inside. Always wear them when handling materials of a hazardous or toxic nature.
15 Keep goggles clean and in good condition. The front of the glasses or eyepieces can become obscured by welding spatter adhering to them. Renew the glass or goggles as necessary. Never use goggles with cracked glasses.
16 Always wear goggles when using a bench grindstone or portable grinders, disc sanders, power saws and chisels.
17 When welding, always wear adequate eye protection for the process being used. MIG/MAG welding is particularly high in ultraviolet radiation, which can seriously affect the eyes.
18 Glasses, when worn, should have 'safety' or 'splinter-proof ' glass or plastic lenses.
19 Always keep a suitable mask for use when dry flatting or working in dusty environments and when spraying adhesive, sealers, solvent-carried waxes and paints.
20 In particularly hostile environments such as when using volatile solvents or isocyanate materials, respirators or fresh air–fed masks must be worn.
21 Electric shock can result from the use of faulty and poorly maintained electrical equipment or misuse of equipment. All electrical equipment must be frequently checked and maintained in good condition. Flexes, cables and plugs must not be frayed, cracked, cut or damaged in any way. Equipment must be protected by the correctly rated fuse.
22 Use low-voltage equipment wherever possible (110 volts).
23 In case of electric shock:
   (a) Avoid physical contact with the victim.
   (b) Switch off the electricity.
   (c) If this is not possible, drag or push the victim away from the source of the electricity using non-conductive material.
   (d) Commence resuscitation if trained to do so.
   (e) Summon medical assistance as soon as possible.

## Electrical hazards

The Electricity at Work Act 1989 fully covers the responsibilities of both the employee and the employer. As a body repairer, you are obliged to follow these regulations for

the protection of yourself and your colleagues. Some of the important points to be aware of are given below.

Voltages – the normal mains electricity voltage via a three-pin socket outlet is 240 volts; heavy-duty equipment such as vehicle hoists uses 415 volts in the form of a three-phase supply. Both 240-volt and 415-volt supplies are likely to kill anybody who touches them. Supplies of 415 volts must be used through a professionally installed system. If 240 volts is used for power tools, then a safety circuit breaker should be used. A safer supply for power tools is 110 volts; this may be wired into the workshop as a separate circuit or provided through a safety transformer. Inspection hand-lamps are safest with a 12-volt supply; but for reduced current flow, 50-volt hand-lamp systems are frequently used.

### Checklist

Before using electrical equipment, the body repairer is advised to check the following:

1 Cable condition – check for fraying, cuts or bare wires.
2 Fuse rating – the fuse rating should be correct for the purpose as recommended by the equipment manufacturer.
3 Earth connection – all power tools must have sound earth connections.
4 Plugs and sockets – do not overload plugs and sockets; ensure that only one plug is used in one socket.
5 Water – do not use any electrical equipment in any wet conditions.
6 PAT testing – it is a requirement of the Electricity at Work Regulations that all portable electrical appliances are tested regularly. They should be marked with approved stickers and the inspection recorded in a log.

## COSHH

The **Control of Substances Hazardous to Health** regulations require that assessments are made of all substances used in the body repair shop, for instance paint and body filler. This assessment must state the hazards of using the materials and how to deal with accidents arising from misuse. Your wholesale supplier will provide you with this information as set out by the manufacturer in the form of either single sheets on individual substances or a small booklet covering all the products in a range.

## RIDDOR

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 require that certain information is reported to the Health and Safety Executive (HSE). This includes the following:

1 Death or major injury – if an employee or member of the public is killed or suffers major injury the HSE must be notified immediately by telephone.
2 Over-three-day injury – if as the result of an accident connected with work an employee is absent for more than three days an accident form must be sent to the HSE.
3 Disease – if a doctor notifies an employer that an employee suffers from a reportable work-related disease then this must be reported to the HSE.
4 Dangerous occurrence – if an explosion or other dangerous occurrence happens, this must be reported to the HSE. It does not need to involve a personal injury.

## Maintain the health, safety and security of the work environment

It is the duty of every employee and employer in the motor industry to comply with the statutory regulations relating to health and safety and the associated guidelines which are issued by the various government offices. That means you must work in a safe and sensible manner. A body repairer is expected to follow the health and safety recommendations of his/her employer; employers are expected to provide a safe working

environment and advise on suitable safe working methods.

*Health and safety law states that organizations must*

- *provide a written health and safety policy (if they employ five or more people);*
- *assess risks to employees, customers, partners and any other people who could be affected by their activities;*
- *arrange for the effective planning, organization, control, monitoring and review of preventive and protective measures;*
- *ensure they have access to competent health and safety advice;*
- *consult employees about their risks at work and current preventive and protective measures*.

**Tech note**

Everybody in an organization has a duty of care related to health and safety. The HSE may bring about prosecutions or lesser prohibitions subject to timed actions – for instance, being given a short period of time to rectify a machine fault. However, the final consequences can be devastating for a firm and its employees. Possible outcomes are:

- unlimited fine
- imprisonment
- closing down of the business
- disqualification from working in that job or type of business

You must work in a safe manner or you are breaking the HSWA and are liable to a fine and possible imprisonment and maybe disqualification from working in that job. This means following the safe working practices which are normally used within the industry. The guidelines published by the Health and Safety Executive (HSE) and motor vehicle textbooks usually identify industry-accepted safe working practices. Examples of important procedures are:

1 Always use axle stands when a vehicle is jacked up.
2 Always use an exhaust extractor when running an engine in the garage.
3 Always wear overalls, safety boots and any other personal protective equipment (PPE) when it is needed, for example safety goggles when grinding or drilling and a breathing mask when working in dusty conditions.
4 Always use the correct tools for the job.

Even if you are working in a safe and careful manner, you are still likely to spill the odd small amount of fluid or snag the air line, which will then create a hazard. The procedure here is always to remove the hazard, no matter how it was created, immediately. If you spill petrol or oil when you disconnect a pipe from the engine, you should clean it up immediately, or else you or a colleague may slip and fall. Absorbent granules should be used for this job, as they will soak up the liquid without causing a fire hazard or making the floor more slippery. Brake fluid is a special hazard because if it is spilled on the vehicle's paint work it will soften the paint and may cause it to peel off, just like paint stripper. Therefore any spilled brake fluid should be wiped off immediately and the paint surface washed and polished if needed. Antifreeze spilled on paintwork will soften the paint surface and cause discoloration, so it too must be wiped off immediately with absorbent paper roll or towel and washed down if needed.

When working on any system which contains fluids, it is good practice to use a drip-tray to catch any possible spillages. This saves having to clean the floor as well as ensuring that all the used oils and fluids are disposed of safely, that is, you can pour them from your drip-tray into your disposal container. The Environment Protection Act requires that you dispose of used oils and other fluids in a way which will not cause

pollution. In practice, many vehicle manufacturers now collect used oil and brake fluid for recycling or safe disposal. Smaller garages without franchises will dispose of these liquids either through a private waste-collection company or through a scheme in conjunction with the local authority. No waste oil, petrol, brake fluid or similar chemicals must be allowed to enter the drainage system.

Exhaust fumes are very dangerous. They can kill you. Small intakes of exhaust fumes will give you bad headaches and over time can cause lung and/or brain diseases, so ensure that you do not run a vehicle in a workshop without an exhaust extractor. Also ensure that the extractor pipe is correctly connected and is not leaking.

The air line used in most garages operates at between 100 and 150 psi (7 and 10 bar). This is a very high pressure, so it must be handled with great care. When you are using an air line, always wear safety goggles to prevent dust entering your eyes. You must not use an air line for dusting off components, especially brake and clutch parts, as the very fine dust can cause damage to the throat and lungs. Before you use an air line, ensure that the coupling is fitted firmly into the socket and that the pipe is not leaking anywhere along its length. Any damage or leaks should be immediately reported to your supervisor or manager so that they can be repaired. The high pressure of the air can quickly turn a small leak in an air line into a large gash, which in turn may make the air line whip around and cause damage to colleagues or customers' vehicles. Another area of potential danger is when using electrical equipment such as an electric drill, hand-lamp or grinder. Most mains-operated equipment runs at 240 volts; an electric shock from such a voltage is most likely to kill you straight away. Some companies use 110-volt equipment which is operated through a transformer. This is much safer, especially if the transformer is fitted with an overload cut-out. Hand-lamps should operate at 50 volts, or preferably 12 volts to give the highest level of safety. Plugs should only be fitted to electrical equipment by skilled persons. At the same time, a fuse of the correct amperage rating should be fitted and the equipment tested and logged in accordance with the Portable Appliance Testing Regulations (PAT testing). PAT tested equipment should be numbered and carry a test date label. Before you use any electrical equipment, visually check it for signs of damage and check that the cable is not frayed or split. Then ensure that you plug it into the correct voltage outlet. Do not attempt to use any electrical equipment which you suspect may be faulty; report the fault immediately to your supervisor.

## Where identified hazards cannot be removed, appropriate action is taken immediately to minimize risk to own and others' health and safety

This section is about those situations in which the hazards cannot be readily removed – that is, how do you behave in accident situations or when equipment malfunctions and you can see an accident about to happen? Most mechanics are only likely to encounter such problems every few years, but the professional is the person who can save the day. The following is an example of when a service manager colleague came to the rescue. The central locking and the car alarm on a vehicle malfunctioned. A small child was trapped in the vehicle; it was a very hot day at a local car boot sale. The mother and child were hysterical, and the father had gone for the fire brigade; other members of the public just watched. The mother shouted for help. My quick-witted friend grabbed a screwdriver off one of the stalls, inserted it behind the rear quarter-light rubber and levered out the glass, put his hand inside the car, opened the door and released the child. The panic was over.

There were other ways in which this situation could have been dealt with, but this one was acceptable because it provided a

very quick solution and caused the minimum amount of damage to the vehicle. The important point is that people come first and property second, although the amount of damage to the property should be kept to the minimum.

Working by the roadside is always hazardous, but you can minimize the risks by following a few simple rules:

1 Always wear a high-visibility safety vest.
2 Use the warning triangle and hazard lights.
3 Use the flashing lamp on your recovery vehicle.
4 Only work on hard and level ground.
5 If you are on the hard shoulder, get as far over to the left as possible.
6 Always use props when vehicle cabs or other panels are raised.
7 Think through the possible hazards; never take risks.
8 Have the vehicle towed to the workshop if necessary.

Often it is better to do nothing than to cause damage; this is referred to as preserving the situation. Many times things look different after a cup of tea or you have had time to check it out with a colleague.

## Dangerous situations are reported immediately and accurately to authorized persons

As a trainee in the motor industry your company will require you to report any dangerous situations to your supervisor; this will be a person that you know as the charge-hand, foreperson or service manager. Any internal matter should in the first instance be reported to one of these people – you will know who this is from your induction training. However, if you are working alone or the matter is not a company one, then you must inform the relevant authority. The four emergency services in the UK are Police, Fire, Ambulance and Coast Guard. To call them, use any telephone and dial 999.

## Suppliers' and manufacturers' instructions relating to safety and safe use of all equipment are followed

Many pieces of garage equipment are marked 'only to be used by authorized personnel'. This is mainly because incorrect use can cause damage to the equipment, the workpiece or the operator. Do not operate equipment which you have not been properly trained to use and have not been given specific permission to use.

The suppliers of garage equipment issue operating instructions, and as part of your training, you must read these instruction booklets so that you will understand the job better. You will also find that certain safety instructions are marked on the equipment. The vehicle hoist (ramp), hydraulic jack and other lifting equipment are marked with the Safe Working Load (SWL) in either tonnes or kilogrammes. You must ensure that you do not exceed these maximum load figures. Some items of equipment have two-handed controls or dead-man grips – do not attempt to operate these items incorrectly.

## Approved/safe methods and techniques are used when lifting and handling

Do not attempt to manually carry a load which you cannot easily lift and which you cannot see above and around. The maximum weight of load that you should lift is 20 kilogrammes, but as a trainee this may still be too heavy for you.

When you are lifting items from the floor, always keep your back straight and bend your knees. Bending your back whilst lifting can cause back injury. If you keep your feet slightly apart, this will improve your

balance. It is always a good idea to wear safety gloves when manually lifting.

Hoists and jacks are available for lifting vehicles; hydraulic or chain-operated equipment is available for lifting engines; hydraulic devices are available to lift gearboxes. For moving equipment and heavy components you should have either a trolley or a sack-truck.

You are advised to seek the assistance of a colleague when moving a heavy load even when you are using lifting equipment.

## Required personal protective clothing and equipment are worn for designated activities and in designated areas

The following table lists typical items of personal protective equipment (PPE) and states when they must be worn.

You will often see safety notices requiring you to wear certain PPE in some areas at all times. This is because other people are working in the area, and you may be at risk. Hard hats are sometimes required when working underneath vehicles on a hoist.

**Table 2.1** PPE Usage

| *No.* | *PPE* | *Usage* |
|---|---|---|
| 1 | Cotton overalls (boiler suit) | All the time |
| 2 | Safety footwear | All the time |
| 3 | Disposable gloves | Dealing with dirty or oily items |
| 4 | 'Rubber gloves' | Operating the parts cleaning bath |
| 5 | Reinforced safety gloves | Handling heavy, sharp-edged items |
| 6 | Dust mask | Rubbing down |
| 7 | Breathing apparatus and paper coveralls | Spray painting |
| 8 | Goggles | Using grinder or drill |
| 9 | Waterproof overalls and boots | Steam or pressure washing |

## Injuries involving individuals are reported immediately to competent first aiders and/or appropriate authorized persons, and appropriate interim support is organized to minimize further injury

Should there be an accident, the first thing to do is call for help. Either contact your supervisor or a known first-aid person. Should any of these not be available, and it is felt appropriate, call for your local doctor or an ambulance.

You are not expected to be a first-aid expert, nor are you advised to attempt to give first aid unless you are properly qualified. However, as a professional in the motor industry, you should be able to preserve the scene, that is, prevent further injury and make the injured person comfortable. The following points are suggested as ones worth remembering:

1 Switch off any vehicle or power source.
2 Do not move the person if injury to the back or neck is suspected.
3 In the case of electric shock, turn off the electricity supply.
4 In the case of a gas leak, turn off the gas supply.
5 Do not give the person any drink or food, especially alcohol, in case surgery is needed.
6 Keep the person warm with a blanket or coat.
7 If a wound is bleeding heavily, apply pressure to the wound with a clean bandage to reduce the loss of blood.
8 If a limb has been trapped, use a safe jack to free the limb.

## Visitors are alerted to potential hazards

The best policy is not to let customers into the workshop – many garages have a notice to this effect on the workshop door. For MOT

purposes, garages must have a customer viewing area. However, it is not always possible to keep people out of the workshop. Insurance company assessors and RAC/AA engineers will probably also require entry to the workshop, as will some customers who are concerned about their vehicles. So, before allowing them into the workshop you should warn them of potential hazards, for instance the dangers of oil and grease and the requirement to wear a hard hat.

It is always a good idea to accompany customers when they are in the workshop. This way you can advise them in the event that they may do something potentially dangerous or if there is a hazard of which they may not be readily aware.

## Injuries resulting from accidents or emergencies are reported immediately to a competent first aider or appropriate authority

If a person is injured, the first action must be to ensure that first aid is given by a competent first aider or other suitable person. Most companies have a designated first aider who is trained to deal with accidents and emergencies. If your company has no such person on the staff, then you will have a designated person who you must contact in the event of a colleague being injured. That person may be your supervisor or another senior member of the staff. If no manager or other senior person is available, you should either dial 999 for an ambulance or telephone your company doctor, then inform the garage manager.

## Incidents and accidents are reported in an accident book

By law all companies are required to maintain records of accidents which take place at work. These records are usually kept in an accident book. Accident books may be inspected by HSE inspectors. They must be kept for a period of at least three years from the date of the last entry.

The information which is required to be recorded in the accident book is:

- Name and address of injured person
- Date, time and place of accident/dangerous occurrence
- Name of person making the report and date of entry
- Brief account of accident and details of any equipment/substances which were involved.

It is always a good idea to keep a notepad to help remind you which way round things go when working on unfamiliar vehicles, this would also be useful for making any other notes, such as those about an accident.

## Where there is a conflict over limitation of damage, priority is always given to the person's safety

You can always buy a new wing for a car, but you cannot buy a new arm for a mechanic. In the event of an accident, people come first. For instance, if a building is on fire, do not re-enter to retrieve your belongings; wait until the fire is out and there is no risk before going back into the building. If a car is about to fall off a jack, get out of the way. Do not try to catch the car with your hands or some such other dangerous action.

## Professional emergency services are summoned immediately by authorized persons in the event of a fire/disaster

An authorized person is somebody who has the task of carrying out a specific job. Anybody may call the emergency services if they are needed.

**The four emergency services are:**

1 **Police**
2 **Fire**
3 **Ambulance**
4 **Coastguard**

All are called by dialling 999 on an outside-line telephone. The emergency services operator will ask you which service you require. In certain cases, the police will automatically be called, for instance in the case of a severe fire.

All emergency telephone calls are recorded on tape at the telephone exchange. You will be asked for your name, the place where the emergency is and where you are calling from. With the introduction of electronic telephone exchanges, the number which you are calling from is automatically recorded, and you will be asked for the number to help confirm that your call is not a hoax.

Many companies have a direct telephone line to the fire station, and these automatically call the fire service if a fire is detected by sensors or if someone breaks the glass of a fire alarm. In such cases, if the fire service is called out and there is not a fire, they may charge the company a large fee. So do not tamper with such a device unless you are authorized to do so or there is a dangerous fire.

### Alarm/alert/evacuation systems are activated immediately by authorized persons

Generally only senior staff (managers) are allowed to operate alarms and other forms of alert/evacuation systems. This is because of the costs which may be involved if the fire service is called out wrongly and the damage which may occur if staff and/or customers panic.

In the case of a fire, the normal alarm is a form of siren or bell. For other emergencies, say a serious injury, an audible warning from a speaker announcement system may be used. In a garage, these are usually operated from the service department office.

### In the event of warnings, procedures for isolating machines and evacuating premises are followed

If you hear a fire/emergency warning, you must follow the company's evacuation procedure – this is usually stated on the workshop wall. If you hear a fire alarm, a typical evacuation procedure is:

1 Shut off the electricity by pressing the emergency stop button.
2 Leave the premises by the nearest route and go to the assembly point or muster point, which is in the customers' car park.
3 Do NOT re-enter the building until your supervisor tells you that it is safe to do so.

In the event of discovering a fire, raise the alarm by breaking the glass of the alarm button.

### Reports/records are available to authorized persons and are complete and accurate

The Social Security (Claims and Payments) Regulations 1979 require employers to maintain an accident book as well as regulation 7 of the HSWA. This book requires brief details of any accident or dangerous occurrence to be recorded. An approved book BI 510 is available from the HSE direct or through most good bookstores. For more detailed information, HSE Form 2508 should be completed. HSE staff have a statutory right to see a completed accident book or Form 2508, and they may also ask for further information. If you are personally involved in an accident, you are advised to keep a copy of the book entry and any completed forms as well as your own notes on the event. These may be useful in the event of legal proceedings.

### Machines and equipment are isolated, where appropriate, from the mains prior to cleaning and routine maintenance operations

You must always isolate an electrical machine from the mains supply before either cleaning it or carrying out any maintenance or repairs. There are two reasons for this: first, if you touch an electrically live part,

you may get an electric shock; second, the machine may be accidentally started, which could cause injury or damage.

With portable electrical appliances this simply means switching off and taking the plug out of the socket.

With fixed machinery, for instance a pillar drill, you will need to switch off the power supply at the isolator switch. This is usually found on the wall near the machine. Isolating this way is fine while cleaning the machine, but for carrying out maintenance or repair work it is advisable to remove the supply fuse from the isolator box. With the fuse removed, the machine cannot be restarted if the isolator is accidentally turned on by a colleague who confuses the isolator for the one on an adjacent machine.

## Safe and approved methods for cleaning machines/equipment are used

There are three main items of cleaning equipment used in the garage: the cleaning bath (or tank), the pressure washer and the steam cleaner.

The cleaning bath uses a chemical solvent. This is usually used for cleaning dirty/oily components. The components are submerged in the solvent and dirt is loosened with a stiff-bristled brush.

The pressure washer is used for cleaning the mud off the underside of vehicles; water at very high pressure will clean off mud. For hard-to-remove dirt, detergent can be added to the pressure washer. The steam cleaner, often referred to as a steam jenny (jenny = generator), produces hot pressurized water with the option of detergent. This is used for removing very stubborn grease and dirt, like that found on the underside of high-mileage goods vehicles.

If you are cleaning an engine or electrical equipment, it is important not to get water inside. Before cleaning inside an engine bay with a pressure cleaner the electrical components and engine inlets should be covered over with polythene.

When cleaning portable electrical appliances be careful not to get water on the plug. This could cause a short circuit.

The mechanical parts of fixed machines may be cleaned with solvents, then dried with absorbent paper towel.

## Appropriate cleaning and sanitizing agents are used according to manufacturer's instructions

Before using any solvent, detergent or sanitizing agent such as bleach you must read both the label on the container and the COSHH sheet which the manufacturer or your company has prepared.

Solvent should only be used in the cleaning bath for which it is designed.

The pressure washer or steam jenny should only be used with the recommended detergent.

Electrical items can be cleaned with one of the many aerosol sprays which are available for this purpose, but the volatile fumes which are given off must not be breathed in.

You should remember that all cleaning agents should be kept away from your mouth and eyes, and contact with your skin may cause irritation or a more serious skin disease. Always wash your hands and any other exposed areas of skin with toilet soap after carrying out a cleaning task.

## Used agents are safely disposed of according to local and statutory regulations

The Environmental Protection Act (EPA) and local by-laws in most areas require that used cleaning solvents must be disposed of safely. This means that they must be put into drums and either collected by a refuse disposal firm or taken to a local authority amenity site, where they are put into a large tank for bulk incineration. Several local authorities, for instance Surrey and Hampshire, are now looking at ways of using the energy produced by burning waste material

to produce electricity. Emptying used solvents into the drain can lead to a heavy fine or even imprisonment.

Detergents are by their nature biodegradable, that is, they break down, do not build up sludge and will not explode, unlike solvents. However, if you use large quantities of detergents, wash bays which are fitted with the correct type of drainage system should be used.

## Machinery, equipment and work areas are cleaned according to locally agreed schedules

In your company's Health and Safety Policy document, there will be reference to the cleaning of the floors and equipment in the garage and general amenities such as toilets and rest areas. Also there will be maintenance and repair records for the workshop equipment, which will include a regular schedule of cleaning and inspection.

Most companies work on the basis of sweeping down fixed machinery and floors at the end of each day, unless the generation of dirt requires more frequent attention.

On a weekly basis there will be a more thorough cleaning programme which may include window cleaning and wet cleaning certain areas.

Workshop equipment is usually cleaned and inspected on a monthly basis unless there is reason, such as a fault, for a more regular treatment.

## Appropriate safety clothing and equipment is used when working with hazardous cleansing agents and equipment

To protect yourself from the cleaning agents which you are using, you must, where appropriate, wear personal protective equipment (PPE). Most cleaning agents are poisonous and cause irritation or more serious complaints if allowed to come into contact with your eyes or skin.

Whenever you are working on a motor vehicle, it is expected that you wear cotton overalls and safety footwear. In addition, the HSWA requires that employers provide and employees wear the appropriate PPE for hazardous jobs such as using cleaning equipment. The general requirements are as follows:

1 Cleaning bath – rubber protective gloves which extend over the user's wrists, plus goggles and plastic apron. Avoid getting solvent on your overalls as this can lead to skin irritation, be especially careful not to put solvent-soaked or oily rags in your overall pockets.
2 Pressure washer – rubber protective gloves and goggles, waterproof (plastic) over-trousers and jacket and finally rubber boots (wellingtons). The idea is to be able to take the waterproof gear off and be dry underneath.
3 Steam cleaning plant – The hazard here is that as well as being wet, the water is scolding hot. So the waterproof clothes must be of such a manufacture that they will protect the wearer from the high-temperature, high-pressure steam. This means thick and strong over-trousers, coat, boots, gloves and a hat. A full-face mask is used to give complete protection.

**Notes**

1 Health and safety issues are further discussed in the appropriate chapters.
2 Examples of a Risk Assessment and a COSHH Data Sheet can be found in Appendix 1.

## Skills and questions

Care for health and safety and the environment is something which MUST be part of EVERY job that you do EVERY day. However, these skills need developing and do not always come easily. Keep practising until health and safety

are second nature for you. Meanwhile, try these questions:

1 State five basic rules concerning dress and behaviour which demonstrate personal safety in the workshop environment.
2 List five necessary precautions for safety in the workshop and describe each one briefly.
3 What is meant by a skin-care system as used in the workshop?
4 Explain the importance of eye and face protection in the workshop environment.
5 Explain the importance of protective clothing for a body repairer and a paint sprayer.
6 Explain the significance of headwear and footwear while working in the workshop.
7 State the minimum noise level at which ear protection must be used.
8 With the aid of a diagram, explain the fire triangle.
9 Identify the correct colour code for the following fire extinguishers: water, foam, $CO_2$, and dry powder,
10 Explain the precautions which must be taken when handling toxic substances in a workshop environment.

3

# Hand and power tools

## Hand tools used in body repair work

Vehicles are designed for **volume production**, not for ease of repair. Most of the large manufacturers produce cars at the rate of about one per minute, taking about a day to produce each car. Every second of production counts in the vehicle's price, so production methods are very finely tuned. They are not designed to be undone. That means that to replace panels and carry out repairs requires special techniques, skills, and tools. Specialist tools have been designed to suit the varying contours and shapes of the present all-steel bodies and panels. These tools are made of high-carbon tool steel, which is forged and then heat treated to give long service in the hands of a skilled body repair worker. In a body repair toolkit the basic tools are the **hammer** and **dolly**. All other tools have been developed around these, giving us the body repair specialist tools which are now currently available. A repair job cannot be successfully carried out before one has completely mastered the skill of using the **planishing hammer and dolly** in coordination with each other, as this skill is the basis of all body repair work involving the use of hand tools.

## Hammers

The **planishing hammer**, or panel hammer, is used more than any other tool in the body repair trade, and for this reason the best hammer available should be obtained. The principal purpose of the panel hammer is for smoothing and finalizing of a panel surface after it has been roughed out to the required shape. The planishing hammer should have a true and unmarked face, and it must be kept polished and free from road tar, underseal and paint, which readily adhere to its working faces during use. This tool is designed solely to be used in conjunction with a dolly block; it must never be used for chiselling or any other work which might mark or impair the faces of the hammer, for if the face of the hammer became marked, the marks would be transferred to the surface of the panel.

These particular hammers are generally made with one face square. This face is usually flat, while the other, round end is slightly domed or crowned. However, hammers are available with the square end domed and the round end flat, or alternatively with both faces flat or both faces crowned. In practice the square end, which is usually flat, is used for planishing on a curved surface of a panel, in corners or against swaged recessed sections and the crowned end for reasonably flat panels. The difference in the faces stops the panel surface being marked with the edge of the hammer when used in conjunction with the dolly block. The weight of the planishing hammer for general and new work ranges from 12 oz. (340 g) to 16 oz. (450 g), and the handles, which are usually very thin at the neck of the shaft for balance purposes,

*The Repair of Vehicle Bodies*, Andrew Livesey, 9780815378709, 2019, Taylor & Francis

**Figure 3.1** Body repair hammer and dolly set

are made of hickory or ash to give the hammer a good rebound action when used with a dolly block.

**Standard bumping hammer.** This hammer is used for initial roughing out of work on damaged panels. It is also used for finalizing and finishing. The round face is 1 3/8 inch (35 mm) in diameter and the square face is 1½ inch (38 mm) square, and the total weight is 14 oz. (395 g). The hammer is made with either flat or crowned faces.

Light bumping hammer. This tool is ideal for work on light-gauge materials. It is used in the same manner as the standard bumping hammer. The squared face is 1 in. (25 mm) square and the round face is 1¼ in (32 mm) in diameter, and it has a weight of 12 oz. balanced and gives a very good finish when used correctly. Hammers can be obtained for light or heavy work with weights from 12 oz. (340 g) to 18 oz. (510 g).

**Shrinking hammers** are similar in design to a normal planishing hammer but have faces which, instead of being smooth, are serrated, giving a cross-milled effect like a file. The purpose of these serrations is to achieve a shrinking effect when the hammer is used in conjunction with a dolly block. This is caused by the fact that the contact area between hammer and metal is greatly reduced by the serrations on the face. This tool is used largely when beating the surface on over-stretched panel areas which have to be hot-shrunk in order to return them to their normal contours. Hammers are available for light or heavy shrinking, according to the depth of the serrations.

**Dinging hammer.** This hammer is a long-reach planishing hammer and is designed for careful, controlled finishing work. It is extremely well balanced and gives a very good finish when used correctly. Hammers can be obtained for light or heavy work with weights from 12 oz. (340 g) to 18 oz. (510 g).

**Pick and finishing hammer.** This tool is used in place of or in conjunction with the planishing hammer. Its main use is to pick up small, low areas on the surface of a panel which is in the process of being repaired by planishing. On panels that are reasonably flat, such as door panels, parts of roof panels and bonnets, this method of raising low areas is quick and, if carried out correctly, does not unduly stretch the metal. To lift a low area with a pick hammer, one or two taps with the pick end of the hammer are directed from underneath the panel under repair to the centre of the low area. The blows stretch the metal sufficiently to raise the surface surrounding the point of the low spots where the blows were struck. This slightly raised area is next tapped down lightly with a planishing hammer or the finishing end of the pick hammer onto a suitably shaped dolly block, and the panel is finished off by filing with a panel file. When one becomes proficient in using this tool, it is possible to raise the surface with light blows and finish off by filing only. However, without sufficient experience there is a danger of over-stretching the metal owing to the inability to direct the blow accurately onto the low area under repair. The pick and finishing hammer has a pointed end which is suitable for removing low spots and is also a useful finishing hammer, having a crowned surface on a round face of 1½ inch (38 mm) diameter; it is well balanced and weighs 14 oz. (395 g).

**Straight pein and finishing hammers.** These hammers are used in a similar manner to the pick and finishing hammer but are designed with either a straight or a curved peined end, which acts like a chisel, and a domed round end which is used for planishing. They are suitable for roughing out prior to planishing, or in the finishing stages of planishing for stretching small low areas. These hammers can be used to dress out sections which are difficult to work on owing to their awkward shape or position, such as around lamp openings and in recessed and moulded sections on panels.

**Curved pein and finishing hammer.** This tool is identical in use to the straight pein and finishing hammer except that its curved pein end allows for greater flexibility in dressing out sections which are difficult to work on owing to their awkward shape or position.

**Fender bumping hammer.** This tool has a long curved head with one face which is circular to reduce the effect of stretching the metal when in use. This hammer is used for roughing out and dressing out damaged sections on panels to restore them to their correct shape and curvature before planishing begins. The heavy weight of this hammer, together with the curve, makes it very effective for hammering out difficult and inaccessible sections.

**File hammer or beating file.** This tool is designed to be used like a hammer in conjunction with a dolly block, although it is actually a file with a serrated face and is suitably shaped for holding in the hand. The milling on the file blade tends to shrink the panel as well as leaving a regular rough patterned surface ideal for locating low spots on the panel under repair and for finishing with a body file. The tool is used in conjunction with a hand dolly and with a glancing blow. It is most effective on large, flat sections, where it will be found ideal for smoothing and levelling out wavy panels. Two types of beating files are available; one is flat for use on low- and high-crowned surfaces, while the other is half-round in shape and is used on convex or reverse-curved panel sections.

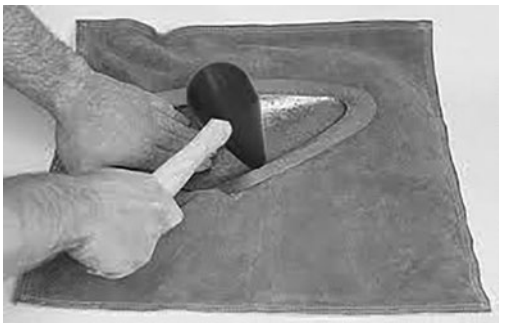

**Figure 3.2** Body mallet in use

**Mallets** can be of the round or pear-shaped type, made from boxwood or lignum vitae, or can be rubber, aluminium or plastic faced. Some mallets have interchangeable heads so that the correct head can be used for the material being worked. A mallet is greatly used in the initial stages of smoothing and roughing out of a panel prior to planishing. When hot shrinking, the mallet is the tool to achieve a most successful shrink because a normal planishing hammer would tend to stretch the metal rather than shrink it. Without a mallet, aluminium work would be most difficult, as this metal is so easily marked and stretched. The working faces of the mallet must be kept in first-class order, or marks on the surface of the metal will result.

## Hand dollies

These are either cast or drop forged steel blocks, heat treated to provide the correct degree of hardness. The shapes of the dolly blocks have been designed to provide a working surface that is highly polished and suitable for use on the many contours found on motor vehicle bodies. They are used in conjunction with the planishing hammer or beating file and act as a support or anvil to smooth out the surface area of panels that have been damaged.

These dollies, together with the planishing hammers, are the most essential tools for the panel beating trade. Obviously one

dolly block will not be suitable for all shapes requiring planishing; therefore it is advisable to have a set of these dollies which would be suitable for a wide range of the shapes and contours encountered on the ever-changing body styles of the modern motor vehicle. When selecting a dolly block for a particular job, it should always be remembered that as flat a dolly block should be used as possible for the job in hand; then the dolly will not only cover the panel area more quickly because of its bigger face area but will smooth out the metal without excessive stretching. When working on panel contours, it must be borne in mind that a dolly block having a high-crowned surface will tend to stretch the metal much quicker than one having a low-crowned surface; hence the choice of block depends on whether the particular section under repair needs to be stretched quickly or just smoothed and planished without stretching.

It is very common for the faces of the dolly blocks to become coated with paint, road tar or anti-drum compounds, which it picks up from the underside of panels under repair. This coating must be removed from the surface of the dolly block so that when it is used with the hammer there is a metallic contact (metal to metal) between dolly block and work and hammer. This contact should be heard as a ringing noise if successful planishing is to be achieved.

Some details are as follows.

**Double-ended hand dolly** is conveniently designed for a good grip with two useful surfaces, one high crowned and one low crowned. It is ideal for general planishing and roughing out. Its weight is 3 lb 4 oz. (1473 g).

**Utility dolly** forms the basis of every body kit. It offers a variety of useful faces, and is found ideal for working in confined spaces.

**General-purpose dolly** is very well shaped and easy to hold and offers wide, low-crowned faces which are essential when working on the new body styles. Its weight is 2 lb 12 oz. (1247 g).

**Heel dolly** has a low flat face with radiused corners. It is suitable for corner and angle work and is easy to handle because of its fairly small weight of 2 lb 14 oz. (1020 g). It is used in places where other dollies cannot be used. Its weight is 2 lb 4 oz. (1020 g).

**Toe dolly** combines a large flat face with a low crown on other faces and is long and thin for easy handling in narrow sections. The bottom face is ground flat which adds to the versatility of this block. Its weight is 3 lb (1360 g).

**Thin toe dolly** has similar surfaces to the toe dolly but is thinner and is ideal for working in awkward places where other dollies cannot be used. Its weight is 2 lb 4 oz. (1020 g).

**Shrinking dolly block** is designed for shrinking welded seams and reducing stretched areas prior to filling. It has a groove down the centre of the block into which the stretched or welded seams can be dressed. Its weight is 3 lb (1360 g).

**Grid dolly** is similar in shape to the toe dolly but has a large crowned grid face on the upper surface. The base has a plain flat face for normal finishing work. It has been designed to act as a shrinking dolly when used in combination with a shrinking hammer and the application of heat. The weight is 2 lb 4 oz. (1130 g).

**Curved dolly or comma block** has a long curved face, combined with the high- and low-crowned and the tapering face; it is extremely well suited to the modern body design and is comfortable to hold in difficult areas and narrow corners. The weight is 3 lb 6 oz. (1530 g).

**Round dolly** is light and small and very easy to hold. It offers high- and low-crowned faces for work on small areas of damage. The weight is 1 lb 10 oz. (736 g).

## Body spoons

These tools are made from a high-grade steel which has been drop forged and heat treated. They are sometimes called prying spoons because the spoon end is used in the same manner as a dolly in conjunction with a hammer. The body spoon really does the same job as a dolly block but is designed

**Figure 3.3** Body spoon set

for use in confined spaces where a normal dolly block cannot be held in the hand, e.g. between door frames and outer door panels. The spoon end, which acts as the dolly, must be kept in good condition and free from anti-drum compound so that it gives a metal-to-metal contact when used in conjunction with a hammer. The spoon can also be used for roughing or easing out by wedging the spoon in between panels.

**Surface spoon** has an extra-large working area which is very slightly crowned, and it is ideal for working in between and round struts and brackets without much dismantling.

**General-purpose spoon** is a double-ended body spoon and is also a basic item in most panel beaters' toolkits. The applications for a spoon offering such different curves are many and varied and meet the needs of modern body shapes.

**High-crowned spoon** has been designed to offer a broad working blade with a high crown to work in positions where other dollies and spoons cannot be used.

**Drip moulding spoon** has a special lip which can be hooked under the drip moulding of the roof section and hence simplifies the repair. The curved surface is fully finished to enable the tool to be used as a short standard spoon.

**Spring hammering spoon** is a light pressed-steel spoon which is designed for spring hammering on panels which have minor blemishes in their finishing stages. The broad blade spreads the blow evenly over a larger contact area, thereby reducing the possibility of sinking the metal. This spoon is not made for prying or levering.

**Heavy-duty pry spoon** is ideal for heavy prying and roughing-out work. It has a long, low, curved blade which can be inserted into very thin sections.

**Pry and surfacing spoon** has a short handle which gives easy access in limited spaces and can be used efficiently for prying behind brackets and panel edges.

**Long-reach dolly spoon** is a special long-handled body spoon designed to be used in restricted spaces between double-skinned panels such as doors and quarter panels.

**Thin spoon** is a very special thin-bladed spoon, the blade having a very slow taper which permits entry into restricted spaces between double-skinned panels which would not be possible by using a normal spoon.

## Body files

**Flexible panel file.** This tool is designed with a two-position handle and has a 14 in. (30 cm) spring steel backing plate to give adequate support over the whole blade. Positioned between the two hand grips is a turnscrew threaded left and right hand for adjusting the blade to concave or convex positions to suit the user's requirements. The main use of this tool is to assist in the final planishing of the work. First and most important, it locates areas which are low on the surface of the panel under repair; second, it files out small marks or defects on the panel surface. It can be adapted to file the surface of almost any shaped panel by setting

**Figure 3.4** Body file

the blade either straight, concave or convex. The file blades are specially designed so that they do not remove too much metal, and the milled serrations are wide apart and curved to prevent clogging when filing metal which has been painted, soldered or plastic filled. It is important to release the tension on the file blade after use in order to reduce the risk of breakage if it is dropped or struck by accident.

**Flat file.** This file has a solid wood holder designed to take a standard 14 in. (30 cm) blade, which must be used in a rigid position.

**Half-round body file.** This tool is similar in design to the flat file, but the blade is half-round. It is very useful for curved surfaces.

**Abrasive file.** This is not a normal file but an abrasive holder with a wood handle having spring clips at either end onto which can be attached an abrasive grit paper. This tool is of greatest use when rubbing down plastic body fillers to their final finish.

**Body file blades.** These flexible, double-sided blades are produced from a special alloy steel and heat treated. The milled teeth allow a smooth filing operation and are specially shaped to reduce clogging. The blades are either flat or radiused according to the surface to be filed.

**Supercut blades** are 8 tpi (teeth per inch) general-purpose standard blades.

**Standard cut blades** are 9 tpi and used for soft metals such as lead and solder fillers.

**Fine cut blades** are 13 tpi and used for aluminium, copper and brass.

**Extra fine cut blades** are 17 tpi and suitable for cast iron, steel or any narrow section of metal.

**Plasticut blades** are 6.5 tpi and used for plastic body fillers only.

## Hand snips

The offset combination of universal snips is preferred by the panel beater when cutting thin-gauge metal. Universal snips are suitable for cutting straight lines, outside and inside curves. A right- and left-hand pair of combination snips will be suitable for most of the sheet metal cutting that will be encountered by the panel beater, and there is no need for any curved-blade snips. When the more popular right-hand snips are used, the waste metal forms a coil to the left of the cutting blades, thus causing little distortion to the surface of the sheet or panel being cut; similarly, with the left-hand pair of snips, the waste metal passes to the right of the cutting blades, leaving the undistorted sheet or panel on the left. Snips can be obtained in varying sizes with either straight or crank handles. A straight pair of snips is often necessary for long straight cuts.

**Figure 3.5** Aircraft snips

## Specialist panel beating tools

**Panel puller.** This tool comprises a long steel rod with a cross T-piece at the top which acts as a hand grip. At the other end a fixed hexagonal nut holds a strong self-tapping screw, while a heavy cylindrical weight can slide up and down the shaft against a stop which is near the handle. This tool has been designed to pull out dents and creases from the face side of the panel without the necessity of removing the trim and lining materials to gain access behind the dents. It can also be used on double-skinned panels where access is impossible with conventional tools.

The panel puller is used by drilling a 1/8th-inch (3 mm) -diameter hole at the deepest part of the dent, then inserting the self-tapping screw in the hole and screwing it until a firm grip is obtained. One hand holds the T-bar while the other pulls the sliding weight towards the stop; there the weight rebounds, forcing the dented panel out under the impact of the blow.

**The Zipcut spot-weld remover** is used with an electric or air drill, and is ideal for

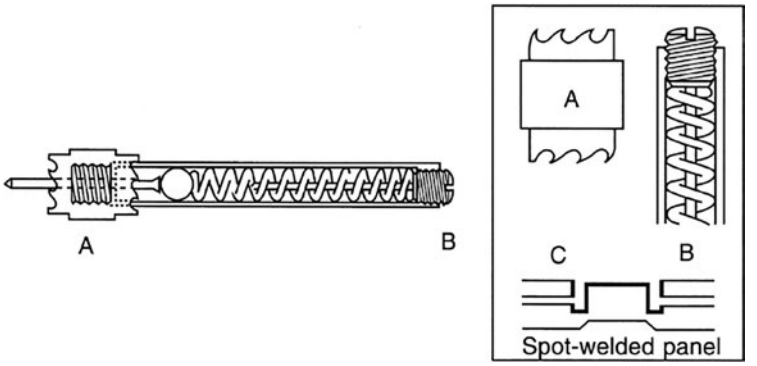


**Figure 3.6** Zipcut spot-weld remover *(Sykes-Pickavant Ltd)*

removing spot welds on all areas of bodywork and subframes. The cutter blade A is reversible with two cutting edges. Adjustment B provides for varying depth of cut so that only the upper panel is released (C), leaving the original spot weld behind on the lower panel.

**Cone drills or variable hole cutters** are special alloy steel drill bits which have been hardened to give a fine cutting edge. They are shaped like a cone and fit in the chuck of a standard power drill. The hole diameter can vary from 6 to 40 mm depending on the hole cutter in use. These cutters are used for fitting wing mirrors, aerials and rubber grommets into body structures.

**Cobalt drills or spot drills** are special alloy steel drills to which cobalt has been added to give a very hard sharp cutting edge. The design of the cutting edge allows spot welds to be drilled out of panel assemblies without creating any panel distortion.

**The impact driver** will loosen or tighten the most stubborn screws, nuts and bolts. The tool is supplied with a complete range of interchangeable bits.

**Body trim tool** is a universal spring steel tool for removing body trims and clips and also weatherstrips, door trims, headlamp fittings, windscreen clips, plastic mouldings, motifs and badges.

**Door handle spring clip removers** are specially designed pliers for fitting or removing the spring clips used on many modern door handles. One jaw sets in the neck of the spring whilst the other grips the other end, and the whole spring is then levered out.

**Trim panel remover.** This tool is designed to remove vehicle trim panels, upholstery and roof liners without damage. It also fits a wide variety of button-type fasteners used on vehicle trim.

**Door hinge pin remover and replacer** is designed for the removal and replacement of hollow hinge pins used on vehicle door hinges.

**Corrosion assessment tool.** This tool has been designed for vehicle inspection. It acts as a combined tapping hammer, blunt scraper and short lever. It has been introduced to standardize the methods of corrosion assessment employed by MOT testers and is ideal for bodyshops conducting pre-MOT checks and assessment for corrosion.

**Bendable file.** This tool is a standard round file, but it can be bent to the desired shape, which allows it to be used in difficult locations where a normal straight file would not have easy access.

## Clamps

**Sheet metal clamp** is a general-purpose clamp which can be locked onto sheet metal with a powerful quick-release grip, making panel assembly and tack welding procedures much easier operations.

**Welding clamp** has a powerful grip which holds parts in alignment while leaving both hands free for the welding operation. The deep-throated jaws and centre opening provide the operator with maximum visibility and full access to the welding area.

**C-clamp** has a wide jaw opening with a relatively small gripping area, which produces pressure without permanent jaw damage to panel surfaces. It allows accurate close-up working in restricted areas and on awkward shapes, for example sill panels.

**Figure 3.7** Door skinner tool

## Punches

**Hole punches** have interchangeable heads to punch holes of either 5 mm (3/16 inch) or 6 mm (1/4 inch) diameter, and enable joining panels to be accurately aligned for welding. The 5 mm diameter hole is for gas welding or brazing, and the 6 mm hole is for MIG welding.

**Wing punch** is a hole punch with a specially designed head which allows it to be used on wing panels and channel sections and also fit over roof gutters and wheel arches.

## Edge setters or jogglers

The **edge setter** is a portable, hand-operated tool designed to provide a 'joggled' joint or stepped edge on a repaired or new panel, thus creating a flush-fitting lap joint. The joggled panel edge provides a stiff joint and helps prevent distortion when welding. It can be used on mild steel up to 1.2 mm (18 gauge) and applied in many situations which require this type of joint. The **Rolastep edge setter** is a portable tool used on the vehicle or a panel assembly. Its rollers produce a smooth, uniform stepped panel edge to create a flush-fitting lap joint, allowing a panel replacement to be inserted.

**Door skinner**. This is a special tool for crimping flanges tightly on replacement door skins. It is used by first bending the flange to an acute angle and then tightening or crimping the flange to the door frame. During this operation, interchangeable tough nylon pads prevent damage to the surface of the door skin.

**Inter-grip welding clamp**. The inter-grip clamp is approximately 25 mm cube shaped and uses a wing nut and toggle bar to firmly clamp pieces of metal together edge to edge and perfectly level, leaving only a small gap which will allow full penetration of the weld and filler rod. Once the two sections are tack welded together the wing nut is slackened, the toggle bar removed and the clamp lifted from the job prior to final welding. The end result is a first-class butt weld requiring very little dressing. The clamps are ideal when welding patch repairs in floors, wings and door skinning or when assembling fabricated or new panels.

**Temporary sheet metal fastener system**. This sheet metal holding system is a set of pins, installed with special pliers, which quickly and easily clamps panels together before final welding, bonding or riveting. The clamps will securely hold together body panels and sections where no other clamp will reach because there is no rear access. The 3 mm blind fasteners have an expanding pin which, when inserted through the panel and released, exerts over 8 kg (18 lb) holding pressure. The edge grips have 12 mm deep jaws to clamp flanges and other edge work. To install or remove either, the pliers are needed to overcome the powerful spring pressure.

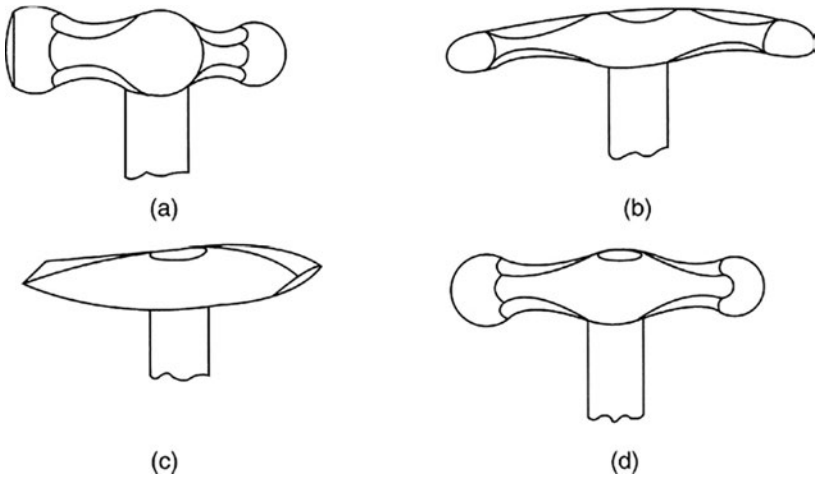


**Figure 3.8** (a) Engineer's ball-pein hammer (b) stretching and flanging hammer (c) wiring hammer (d) hollowing or blocking hammer

## Sheet metal bench stakes

Quite often when making panels and parts of panels in sheet metal, it is necessary to perform some operation such as bending, flanging, seaming, shaping and planishing which cannot be done by machine. In such cases these operations will have to be carried out by hand using bench stakes. There are many different types of stake in use; the smaller types are usually made from cast steel, the heavier are of cast iron and for special work stainless steel stakes may be used.

All these stakes must have highly polished working surfaces and should be kept in a dry atmosphere to reduce the possibility of corrosion on the working surface. Certain stakes are used only occasionally, and to maintain a bright, smooth surface, they must be given a coating of light oil from time to time. The condition of the stakes has much to do with the workmanship of the finished job, for if a stake has been roughened by hammer or chisel marks the completed job will look rough and lack finish. For this reason stakes should not be used to 'back up' a sheet of metal or a panel directly when cutting it with a chisel; hammer blows should be aimed with care; and a mallet should be used whenever possible when forming sheet metal over the stakes.

Special reinforced square holes of various sizes are made at intervals in the bench for insertion of the bases of the stakes, which are usually square in cross-section and taper in shape to facilitate a good grip in the bench. There are many different types of stake available, and those most commonly used are as follows:

- *Pipe stake* consists of one or two cylindrical arms having different diameters. This stake is used for forming pipes and cylindrical work pieces.
- *Grooving stake* has a grooved slot cut along the top face. The slots are used for wiring and swaging.
- *Funnel stake* has a thick tapered head and is used in forming, riveting and seaming tapered articles such as funnels.
- *Anvil stake* has a flat, square-shaped head with a short shank and is used for general working operations.
- *Side stake* consists of one long elliptical shaped head. It is used for bending, seaming and forming curved radii.
- *Beck iron stake* has a square tapering flat head on one side and a round tapered head on the other side. It serves as a general-purpose anvil for riveting and shaping round and flat surfaces, straight bending and corner seams.

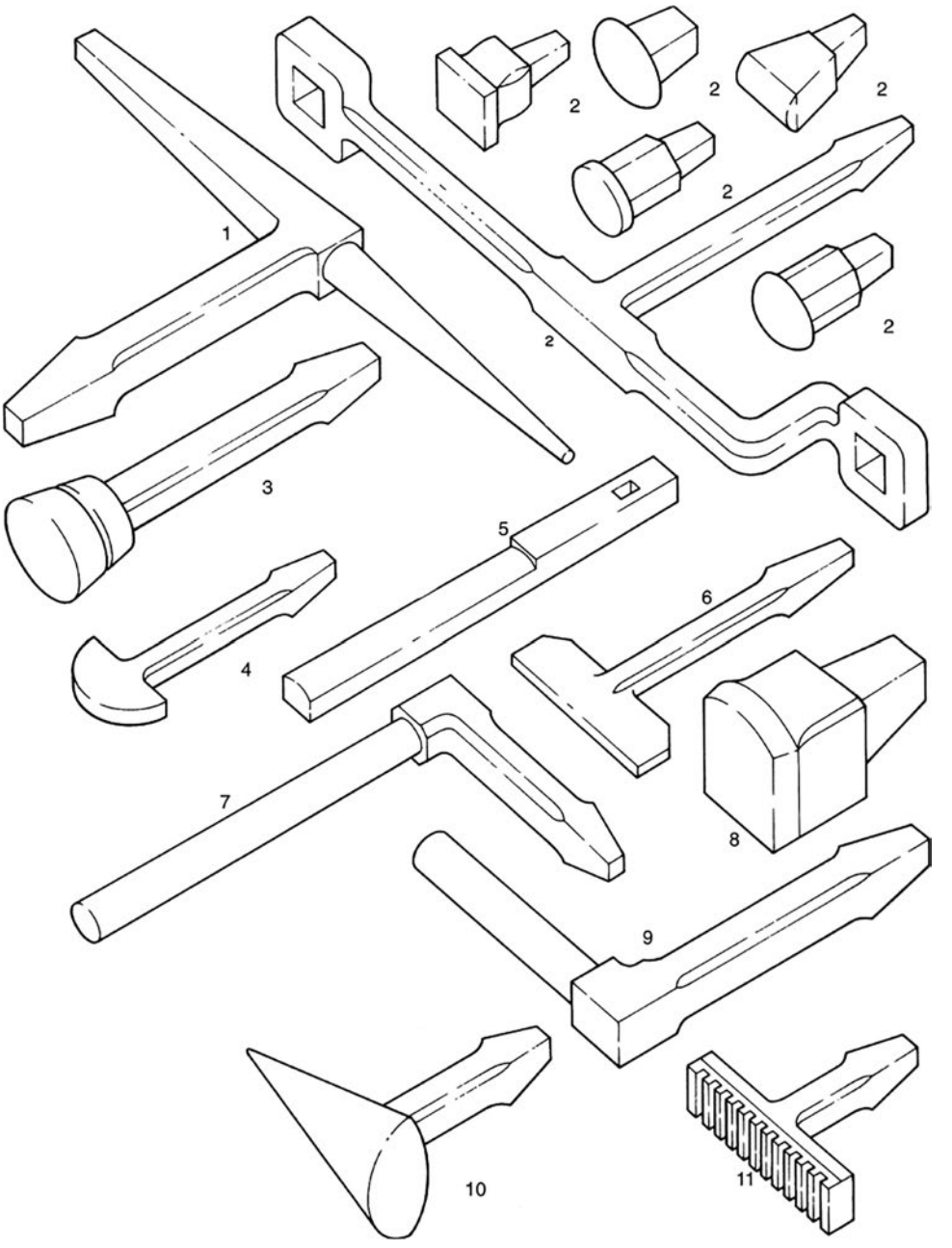


**Figure 3.9** Sheet metal bench stakes

1 Beck iron stake
2 Horse stake with heads
3 Round-bottom stake
4 Half-moon stake
5 Tinman's mandrel
6 Hatchet stake
7 Pipe stake
8 Anvil stake
9 Side stake
10 Funnel stake
11 Grooving stake

- *Horse stake with heads* has holders (the horse part of the stake) which can take various-shaped small heads. This stake is useful in many operations for which other stakes are not suitable.
- *Round-bottom stake* consists of a single vertical piece with a flat round head on top. It is used for flanging circular and curved work.
- *Tinman's mandrel* is a single horizontal metal bar, one section of which has a flat surface and the other section of which is rounded. The flat length has a slot cut in it which permits the stake to be fastened directly to the bench. The stake is used for riveting, seaming and forming.
- *Half-moon stake* consists of a single vertical shank with a half-rounded head on top. The stake is used for forming or shaping curved flanges.
- *Hatchet stake* consists of a horizontal, sharp, straight edge and is used for making straight sharp bends.
- *Panel head stake* is shaped like a mushroom and is made in various sizes. It is used for raising, tucking and planishing.
- *Ball stake* is shaped like a ball and is used for the planishing of hollowed or raised articles. It is also used for raising domes or hemispherical shapes by mallet or raising hammer.

## Hand grooving tools

The **hand groover** is used when making a seam joint by hand between two pieces of sheet metal. The end of the tool is recessed to fit over the joint formed when the edges of the two pieces of metal are pre-bent into a U-shape and interlocked. The grooving tool is then placed over the interlocked edges and hammered. One edge of the tool acts as a guide while the other forces the metal down into a crease, thus forming a groove. This crease or set in the metal should be made gradually, the tool being hammered while tilted very slightly in the direction in which the crease is to be made. This will avoid marking the metal on the opposite side of the joint to the crease. A tool a size larger than that of the grooved joint should be chosen to give clearance in use. The tools are manufactured in various sizes from 1/8th in. to ¾ in (3–19 mm). These grooved joints can be used to advantage when fastening large flat panels together as used on commercial vehicles.

## Rivet sets

A rivet set is made of tool steel. A deep hole in the bottom of the set is used to draw the rivet through the metal sheet before riveting, and a cup-shaped hole is used to form the finished head on the rivet. The drawing-up hole and the cup hole are offset slightly to the direction of the vertical hammer blows, and therefore great care should be taken to hold the set in an upright position when riveting. If the tool is allowed to tilt, it is liable to make indentations on the area of the metal which has been riveted. Hand rivet sets are made in various sizes ranging from 3 mm to 19 mm (1/8 inch to ¾ inch).

## Cutting tools

**Hand snips** These are used to a great extent in the fabrication or repair side of the panel beating trade, for cutting thin-gauge mild steels and aluminium alloys. The limits to which these snips can cut satisfactorily, leaving a good edge, is a thickness of 1 mm (20 SWG) in mild steel and slightly greater thicknesses in aluminium. Snips are available in a variety of types and sizes and are made from the finest tool steel forgings. The blades are ground and set for the accurate cutting of all sheet material.

The most popular hand snips are the **universal combination snips**, which are made in sizes 10 in. to 13 in. (254–280 mm) with narrow or broad blades, with straight or cranked handles, and left or right handed. The handles are offset on the cranked variety so that straight and curved cuts can be made in any direction in one operation with the sheet kept flat and the operator's hand clear of the metal, the cut being followed from above. The word 'universal' means that this single pair of snips can be used for cutting

straight lines and both external and internal curved edges. **Standard pattern straight snips** are also very popular, although limited in their use to straight-line cutting or large external curves. Sizes vary from 6 in. to 12 in. (152–305 mm). **Standard pattern curved or bent snips** are designed for cutting circular outlines and inside circles or curved shapes, as the actual cutting blades themselves are curved.

The cutting tools known as **aviation snips** were originally developed for the aircraft industry. In contrast to the single pivot of ordinary tin snips, aviation snips feature compound leverage for greater shearing power, being able to cut up to 1.2 mm (18 gauge) steel and 1.6 mm (16 gauge) aluminium. The blades are made from heat-treated forged chrome steel and are radiused in order to maintain a constant cutting angle from the back of the jaw to the front, allowing good cutting pressure for the user.

The terms 'left hand' and 'right hand' used for snips in this country have the continental meaning. *Left hand* means that the lower blade, which should be on the underside of the sheet of metal being cut, is on the left-hand side. *Right hand* means that the lower blade is on the right-hand side of the metal being cut. The US reference is exactly opposite to that used in this country.

**Monodex cutters**. This tool is designed for cutting thin sheet metal. Unlike snips, it has a flat face with one central serrated blade which in use cuts a slot equal in width to the thickness of the blade, 3 mm (1/8 inch). As the material is cut, it coils up in front of the cutters. The advantage of this tool is that it can cut sheet metal internally, and work along either a straight or curved line by drilling a small access hole in the metal to allow the blade to penetrate through the metal to commence cutting. Allowance must be made for the wastage of 3 mm strip (1/8 inch) when cutting to a final size.

**Cold chisels**. These are often used by the body repair worker for cutting out components which have been damaged, chipping off rusted bolts which cannot be removed by normal methods and chiselling sections which cannot be cut by snips or hacksaws. Chisels are made from high-quality steel. The cutting edge is specially hardened and tempered, while the remainder of the chisel is left soft to enable it to withstand hammer blows.

The chisel is subdivided into cutting edge, shank and head. The cutting end has a wide, flat taper and is ground on both sides to form the cutting edge. Metalworking chisels should have sufficient length to allow the shank to be gripped properly, as short chisels are difficult to handle and may lead to accidents through hammer blows if the head projects insufficiently beyond the gripping hand. On the other hand, excessively long chisels cannot be guided so well and consequently may vibrate and break easily. Only the cutting edge of the chisel is hardened. When the chisel has been in use for some time, a ridge forms on its head which is called a burr; this needs to be removed because it may lead to accidents during use. Chisel joint angles vary between about 30° and 60°, the sharper angles being used for cutting softer metals. The metalworker's chisel is flat and is used for working on flat or curved surfaces of thin sheet. It is also used for cutting solid bolts and rivets.

**Hacksaws**. The hacksaw is used by the body repair worker to advantage where a clean, neat cut is required, usually where two pieces have to be cut to form a welded joint, and is ideal for cutting irregular-shaped panels which could not be cut with snips or chisel. There are many different types of hacksaws, but in general they consist of a fixed or adjustable frame fitted with a renewable blade of hardened and tempered high-carbon or alloy steel. The hacksaw blades are classified by length and the number of teeth to the inch. Coarse blades have 14 to 16 teeth to 1 in. (25.4 mm) and are used to cut soft metals; finer blades have 18 to 24 teeth to 1 in. (25.4 mm) and are used to cut harder metals. The blades must be fitted with the teeth pointing away from the operator to the front of the frame, and the blade should be slightly tensioned in the frame.