Non-Structural Supplement

Textbook

I-CAR®

EDS01-STMAN1-E

IMPORTANT NOTICE

This material provides general directions for collision damage repair using tested, effective procedures. Following them will help assure the reliability of the repair.

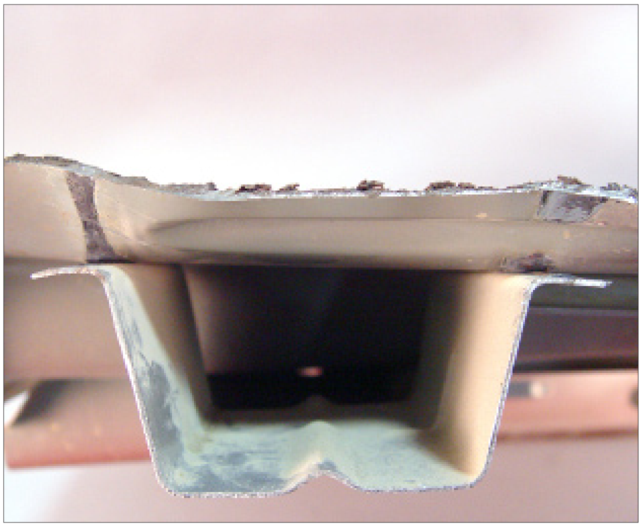
I-CAR cannot accept responsibility for any individual repair, nor can it warrant to the quality of such repair. Anyone who departs from the instructions in this program must first establish that neither personal safety nor the integrity of the repair of the vehicle is compromised by the choice of methods, tools, or supplies.

I-CAR does not endorse or recommend any brands or makes of vehicles, repair equipment and supplies or other products. The appearance of various makes and brand names in any I-CAR material is purely coincidental and is based on the availability of those products at the time of production.

All recommendations presented in this program are based upon research programs or upon tests conducted by laboratories, manufacturers, or selected collision repair facilities. If performed as outlined, these recommendations will provide the basis for a thorough, professional repair.

CONTENTS

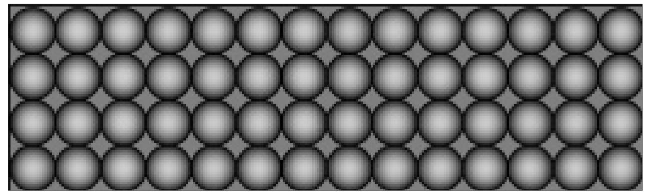
Topic A. Steel Characteristics



A-2 Steel is shaped to make the parts of a vehicle.

Steel is:

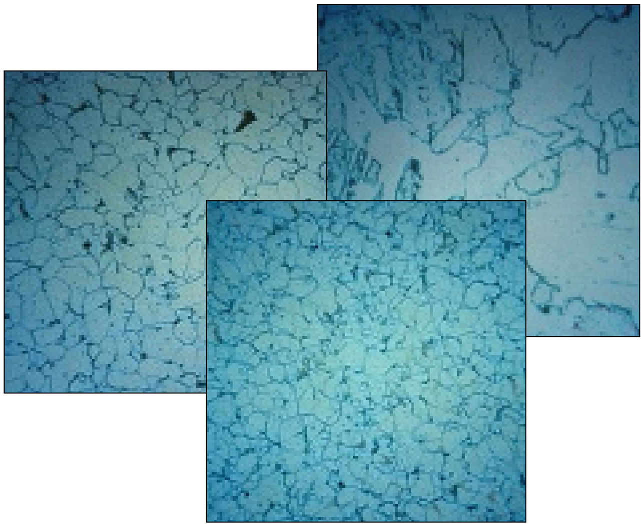
- a commercial form of iron.
- iron that is alloyed with other elements to give the steel specific properties and characteristics. This, however, is not the only contributor to the characteristics of different types of steel. An element is a material that cannot be broken down, such as those found on the periodic table. An alloy is a combination of two or more elements and at least one of the elements is a metal. The combination of elements results in a metallic material that has properties that are different from the individual elements.
- typically iron alloyed with carbon. Other elements that are also alloyed with iron to make certain types of steel include; aluminum (Al), titanium (Ti), manganese (Mn), phosphorus (P), sulfur (S), and silicon (Si).



A-3 The microscopic grain pattern of a piece of steel shows how the atoms are arranged.

The grain pattern, or granular structure, of a material:

- is how the atoms are arranged and linked together. This cannot be seen with the unaided eye.
- determines how the material reacts to force.
- is in a relaxed state when the material has not been damaged or formed.

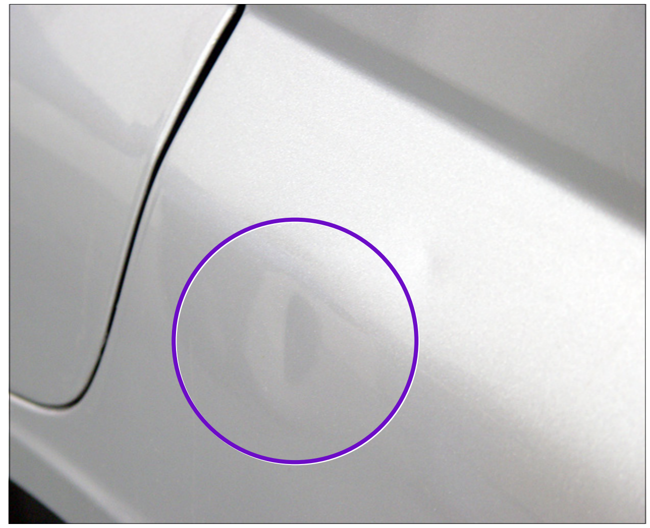


A-4 The grain pattern looks different according to the type of steel.

The grain pattern of steel:

- varies according to the way that it has been heat-treated and worked, but at the same time follows a definite pattern. Certain properties of steel, such as strength, hardness, and ductility, are altered during the heat-treating process. Heat-treating is a controlled process where the metal is heated and cooled to predetermined temperatures for specific time periods.
- determines the extent that the steel can be bent or formed.

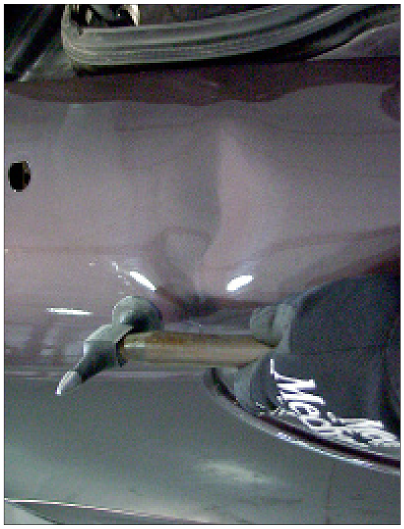
GRAIN PATTERN
Have your Instructor lead you through the Grain Pattern activity.



A-5 A dent in a panel is a type of deformation.

Deformation:

- is caused by a collision or impact.
- is an area where the metal is kinked or bent out of its original shape.
- hardens the metal, making it more resistant to straightening.



A-6 Striking a panel with a hammer will straighten areas adjacent to a buckle because of spring-back.

Spring-back:

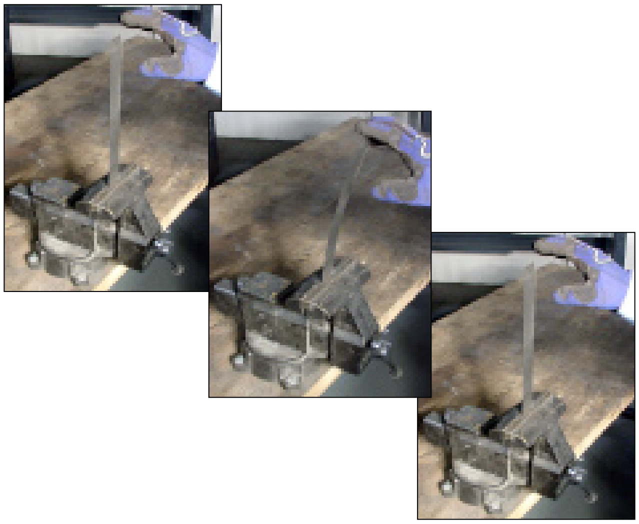
- is the tendency of a metal to return to its original shape after is has been deformed. This property should be taken into consideration when planning the repair.
- occurs in areas that are relatively smooth.
- is a property of the metal that is used to straighten displaced metal adjacent to a buckle. This method of repair is similar to how a dented soda can be straightened by unrolling the buckles that hold the dent.

A-7 There is elasticity in a spring.

Elasticity is the:

- ability of a material to regain its original shape after a deflecting force has been removed. It may also be defined as the tendency of a metal to spring back after a deflecting force has been released.
- opposite of plasticity.

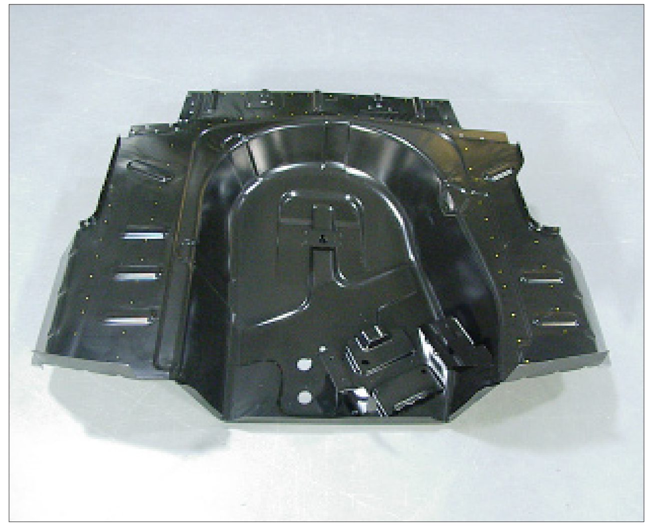
Mild steel has very little elasticity compared to high-strength steel. If a deflecting force is applied to a piece of high-strength steel and a piece of mild steel, the high-strength steel is more likely to return to its original shape when the deflecting force is released.



A-8 A piece of metal will return to its original shape after elastic deformation.

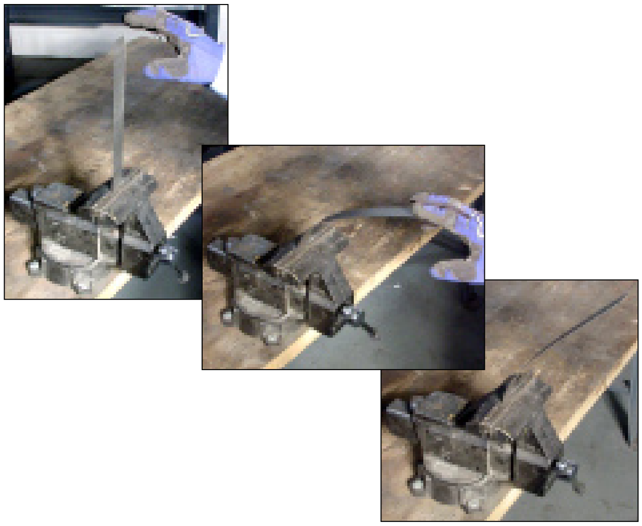
Elastic deformation is:

- the ability of a material to stretch and return to its original shape.
- specific to flat steel. After a flat piece of steel has been formed, it has exceeded its elastic limit and will not return to its original flat state.



A-9 The plasticity of a metal determines if it can be formed.

Plasticity is the ability of a material to be bent or formed when sufficient force is applied. For example, sheet metal would break or split when it is stamped if it did not have enough plasticity. Generally, plasticity is considered the opposite of elasticity, but it is possible for steel to have low elasticity and varying degrees of plasticity. Mild steel typically has a higher degree of plasticity compared to high-strength steel. Cast iron is an example of metal that has no plasticity.



A-10 A piece of metal will not return to its original shape after plastic deformation.

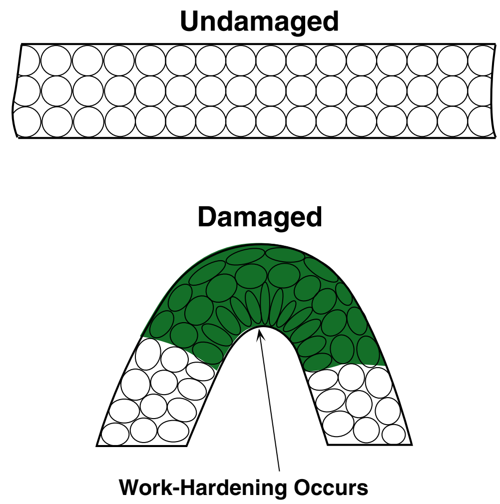
Plastic deformation:

- occurs when metal has permanently changed shape. This property of metal allows it to be formed into vehicle parts.
- occurs when metal has been bent beyond its elastic limit. The metal may spring back, but not to its original shape. The metal will not return to its original shape without the use of tools.
- causes the grain structure to stretch and compress in certain areas. For example, the grains on the outside of a bend may be stretched and the grains on the inside may be compressed.

Mild steel withstands plastic deformation better than high-strength steel.

ELASTIC AND PLASTIC DEFORMATION

Select the Demonstration icon found on screen A-10 of your CD-ROM for examples of the difference between elastic and plastic deformation.



A-11 Work hardening affects the grain structure of the metal.

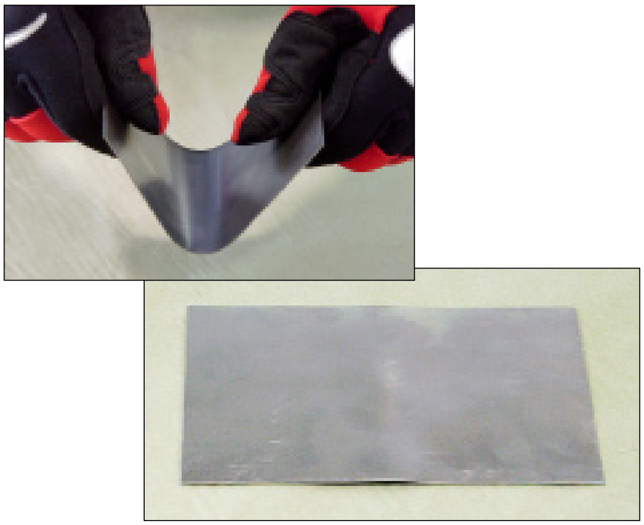
Work hardening:

- is the upper limit of plastic deformation.
- causes the metal to become harder and stronger, but also more brittle. Severe work hardening results in cracking. Depending on the size and location of the crack, the part may require replacement.
- occurs when the vehicle maker forms the panel, during a collision, and when straightening deformed metal.

WORK HARDENING

Select the Demonstration icon found on screen A-11 of your CD-ROM for an example of how bending a piece of welding wire or paper clip back and forth will increase the hardness at the point of the bend.

Strength is defined in units of pressure such as kilopascals (kPa) and megapascals (MPa) in the metric system, and pounds per square inch (psi) in the International System of Units (SI). When comparing metric to SI, 1 kPa equals about 0.145 psi and 1 MPa equals about 145 psi. Strength is closely related to the hardness characteristic of the steel.



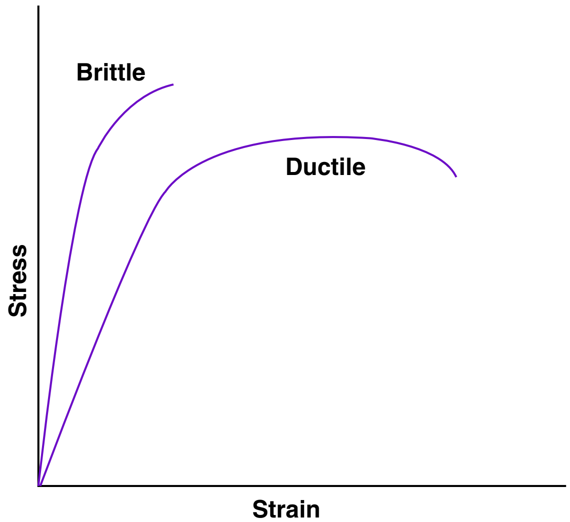
A-13 This piece of metal has reached its elastic limit and is deformed.

The elastic limit has been reached when enough force has been applied to overcome the tendency to spring back. The elastic limit may also be called the yield point. In reference to a tensile test stress-strain curve, it is the point where the material permanently deforms after the load is removed.

A-14 A tensile-strength machine can be used to determine the yield strength of a material.

Yield strength:

- is measured as the minimum force per unit of area that will exceed the elastic limit and cause plastic deformation of a material.
- is determined by evaluating the stress-strain curve from a tensile test.
- may also be called yield stress.

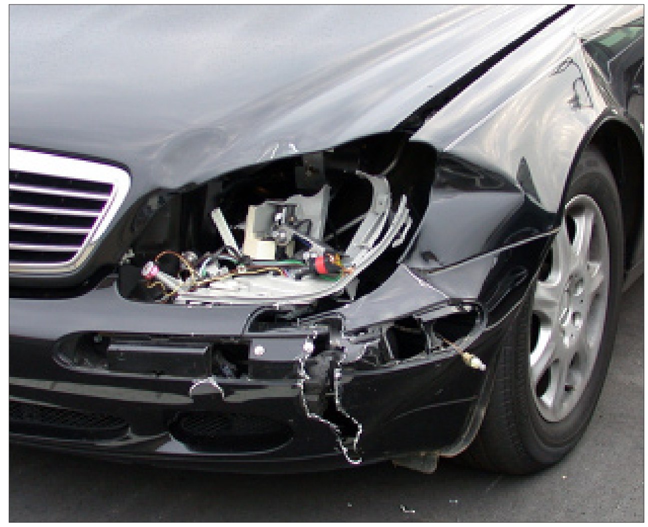


A-15 A stress-stain curve can be used to show the difference between a ductile and malleable metal.

Ductility is the property used to describe the ability to deform under tension. Malleability is the property used to describe the ability to deform under compression.

A-16 Tension is used to try to pull this weld until it peels apart.

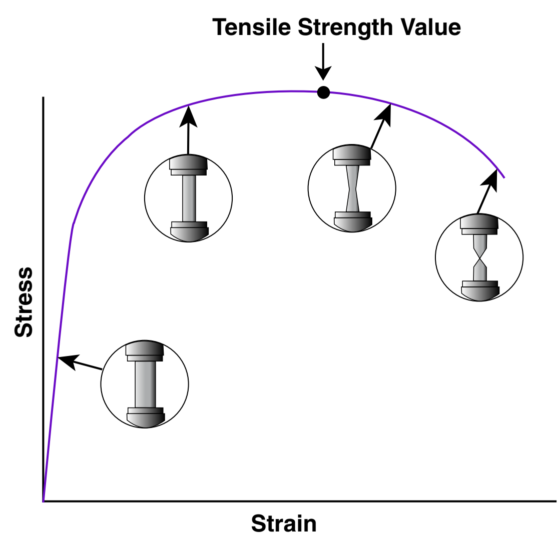
Tension is the load that tries to pull a material, such as steel, apart. Peel is when that load actually pulls the material apart.



A-17 Compression may cause parts to crush.

Compression:

- is a load that forces parts into each other.
- may also be called a pressure area.
- is the opposite of a tension area.



A-18 After the tensile strength value is reached, the stress decreases as more strain is applied.

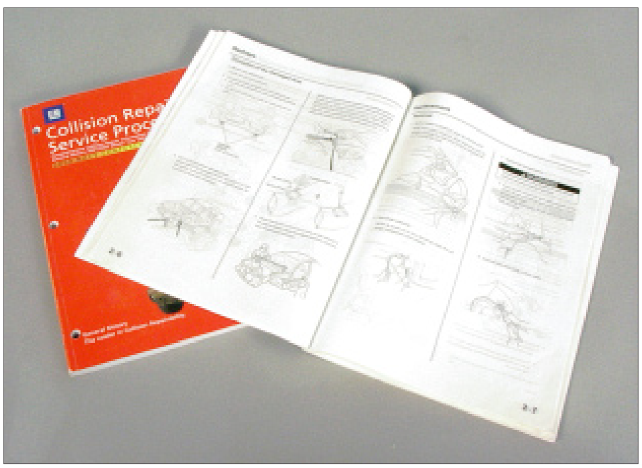
Tensile strength:

- is measured as the maximum force per unit of area that causes a complete fracture or break in a material. It may also cause the metal to elongate, or lengthen.
- may also be called tensile stress.

A-19 A scissors may be used to shear objects.

Shear is a load that pulls parts sideways. Shear strength is a measure of how well a material can withstand forces trying to cut or slice it apart.

Topic B. Types Of Steel

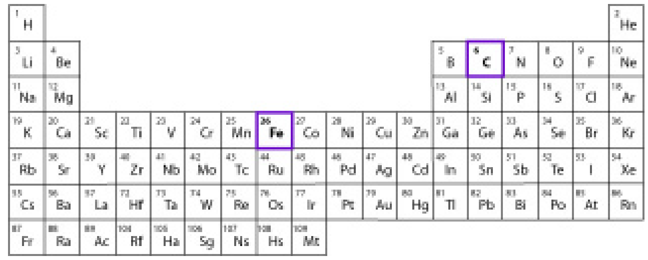


B-1 The vehicle maker may indicate the types of steel that are used in construction.

The type of steel used to make specific parts of a vehicle may be identified in a body repair or service manual.

BODY REPAIR MANUAL

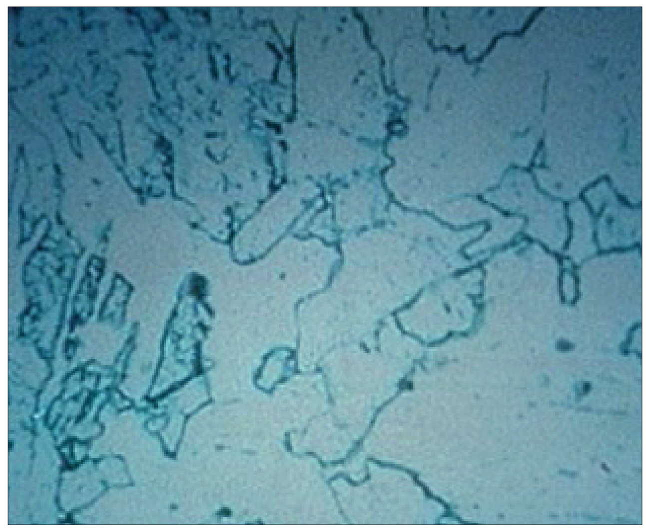
Select the Demonstration icon found on screen B-1 of your CD-ROM for examples of how body repair manuals may indicate the different types of steel found on a vehicle.



B-2 Carbon and steel are elements on the periodic table.

The carbon in steel:

- varies in amount, but is typically less than 2.1%. More carbon typically results in a harder, stronger, more brittle steel.
- acts as a binding agent to lock the easily-moved iron atoms into a rigid matrix or grain pattern.

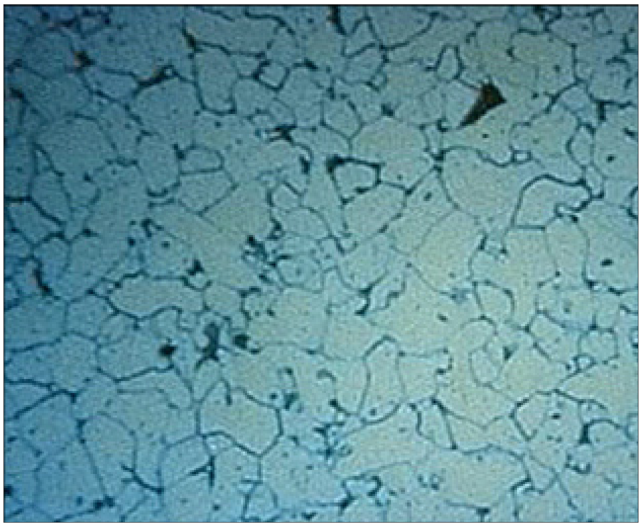


B-3 This is the grain structure of one type of low-strength steel.

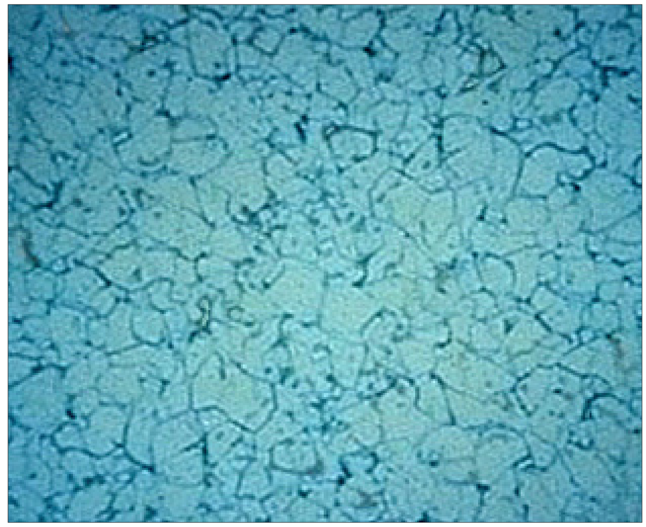
Low-strength steel:

- has a tensile strength that is typically less than 210 MPa (30,458 psi).
- has the least amount of carbon when compared to other types of steel.
- can be heated, welded, and cold worked without seriously affecting the strength. It is easily formed and easy to work with because it is more malleable than other types. Both structural and non-structural parts may be made of low-strength steel.

Low-strength steel may also be called low-carbon or soft steel. Mild steel is an example of a low-strength steel.



B-4 This is the grain structure of one type of high-strength steel.



B-5 This is the grain structure of one type of ultra-high-strength steel.

High-strength steel (HSS):

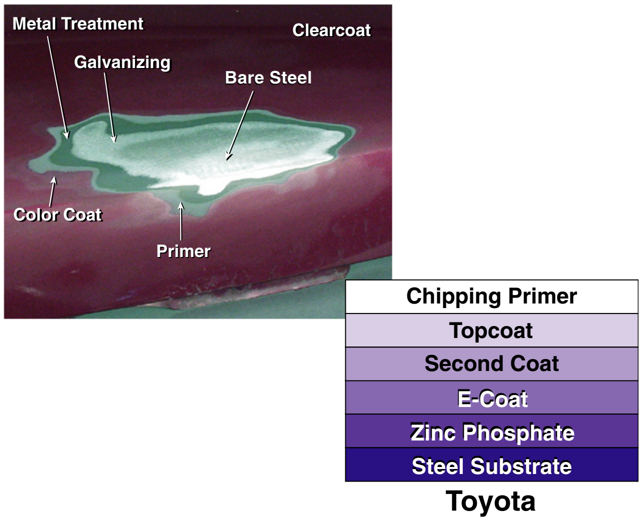
- has a tensile strength that is typically 210–550 MPa (30,458–79,771 psi).
- should be cold straightened. It is more sensitive to heat than low-strength steel. Some vehicle makers have heating recommendations available or cold-straightening recommendations. Both non-structural and load-carrying structural parts may be made of HSS on some vehicles.
- is usually used in thinner gauges. This reduces vehicle weight and can improve fuel economy.

High-strength low alloy (HSLA) is an example of a high-strength steel.

Ultra-high-strength steel (UHSS):

- has a tensile strength that is typically over 550 MPa (79,771 psi).
- should not be straightened, unless specified by the vehicle maker. Therefore, damaged UHSS parts are typically replaced. Use vehicle maker's recommendations. This type of metal that is typically used to make intrusion beams and bumper reinforcements.
- looses its strength if it is heated.

Martensitic steel is typically classified as an ultra-high-strength steel.



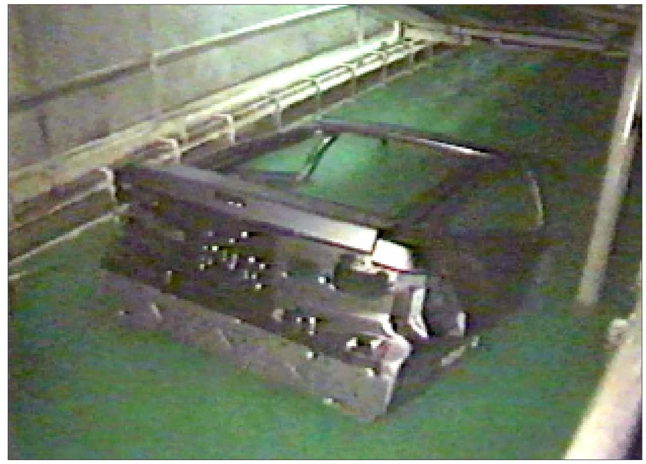
B-6 A thin layer of galvanizing is applied to make corrosion-resistant sheet metal.

Corrosion-resistant sheet metal:

- may have a surface that is plated or coated with zinc, tin, or aluminum. The process of plating or coating sheet metal with zinc is called galvanizing. This process makes the metal corrosion resistant.
- ranges from less than 0.4 to 4 mils of plating or coating. A mil is a metric unit of measure for thickness. One mil is equal to one-thousandth of an inch.
- is used for the exterior panels of some vehicles.

Sheet steel is typically cold-rolled prior to the galvanizing process.

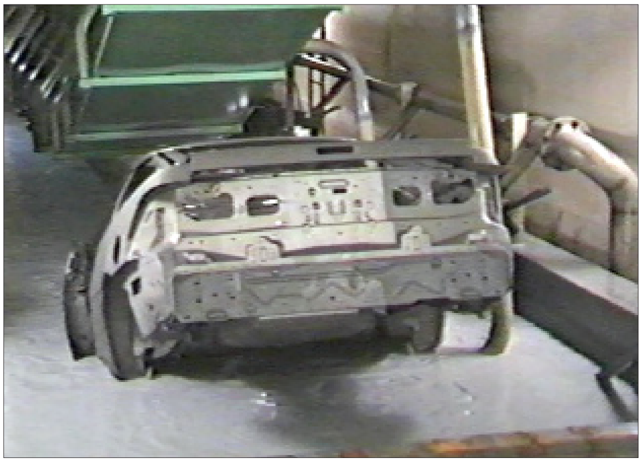
FILM THICKNESS
Have your instructor lead you through the Film Thickness activity.



B-7 The entire shell of a vehicle may be galvanized at the same time.

Methods of galvanizing sheet metal include:

- electrodepostition. An electrical current is used to deposit a thin layer of highly purified zinc on the surface of the metal. The zinc is negatively changed and the metal is positively charged. The thickness is controlled by the electrical charge and the speed that the steel goes through the plating area.
- hot dipping. The piece of metal is immersed in a molten bath of zinc. Once removed, a stream of air is used to control the thickness of the zinc coating.

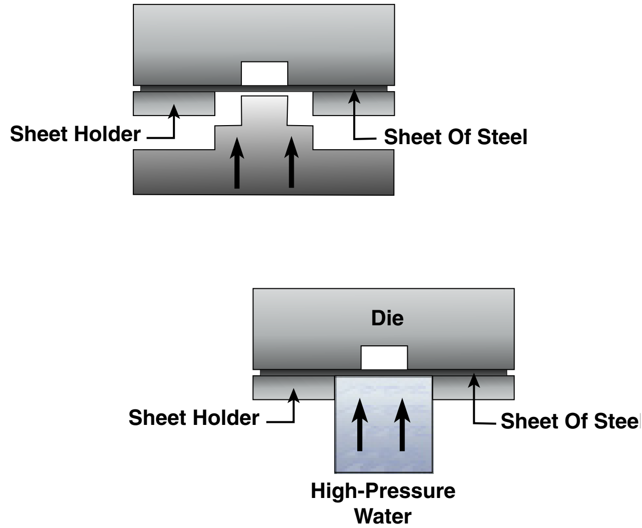


B-8 More than one type of galvanizing process may be used by the vehicle maker.

Alloy-galvanized sheet metal:

- was developed to improve the weldability and paintability characteristics of galvanized sheet metal.
- is galvanized with a layer of iron (Fe) and a layer of zinc (Zn).

Topic C. Forming Sheet Metal

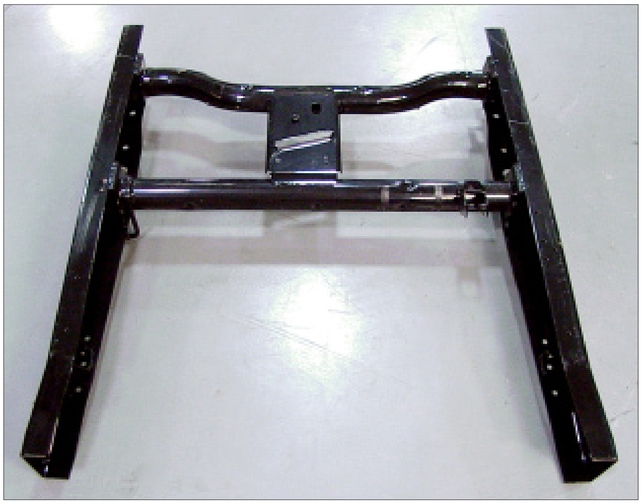


C-1 The forming process gives the part its shape.

The manufacturing process:

- gives the steel different characteristics in addition to the alloying elements.
- includes the bake hardening and annealing process. Bake hardening and annealing is the same as heat-treating. It is a controlled process where that metal is heated and cooled to predetermined temperatures for specific time periods.
- includes the forming process.

There are grades and types within a classification of steel. For example, HSLA steel includes 300X and 300Y. SAE documents, such as J2340, contain additional information on types, yield strength, and tensile strength.



C-2 Structural parts may be made using hot-rolled sheet metal.

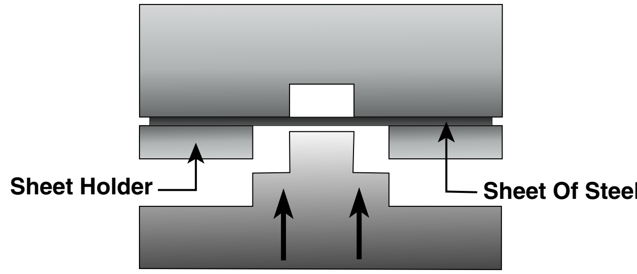
Hot-rolled sheet metal:

- is rolled at temperatures exceeding 800° C (1472° F).
- has a standard thickness ranging from 2–8 mm (1⁄16–5⁄16").
- is used to make vehicle frames and crossmembers.

C-3 This quarter panel was made using cold-rolled sheet metal.

Cold-rolled sheet metal is:

- acid rinsed, hot-rolled sheet metal that is cold rolled thin, then annealed.
- used to make outer body panels.



C-4 Two dies may be used to stamp a part from a flat piece of steel.

Stamping:

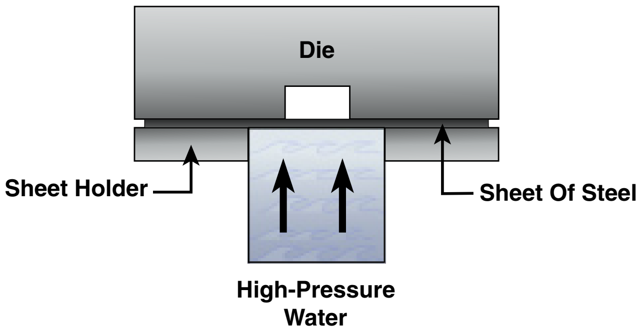
- is a vehicle maker process that is used to form parts for vehicle construction.
- uses two dies. A piece of sheet metal is placed between the two dies and a press forces the metal into the shape of the dies.
- is generally a process that is used to form cold-rolled sheet metal.

C-5 The stamping process may result in stretcher strains that are visible on the part.

Stretcher strains:

- are the result of the metal yielding under the tension that is applied when the panel is being stamped.
- are a pattern of wavy lines on the surface of an inner panel. The pattern varies from part to part and may not appear at all, even on parts from the same press. The pattern may look like a fern, grass, a tree branch, or worms pressed into the surface.
- do not effect the strength or repairability of the metal or the part.

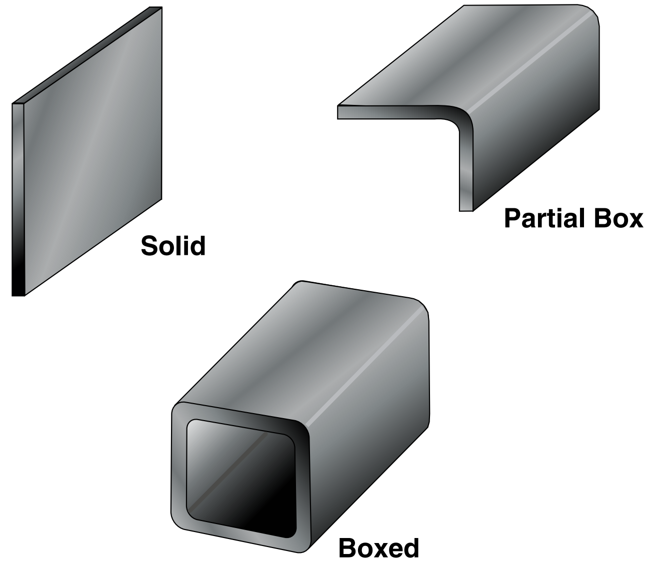
STRETCHER STRAINS
Select the Demonstration icon found on screen C-5 of your CD-ROM for an example of a stretcher strain in a formed metal part.



C-6 High-pressure water and a single die may be used to form a flat piece of sheet metal into a desired shape.

Sheet hydroforming is:

- a vehicle maker process that is used to form parts for vehicle construction.
- similar to stamping except that a pressurized liquid is used instead of the second die.
- used to form some HSS parts.



C-7 The terms solid, partial box, and boxed may be used to define the shape of a specific area of a part.

Different terms are used to describe the shape of a part as a whole or a particular area of a part. Terms that may be used to describe sheet metal include:

- solid. This is an area that does not have any angles. The area may be flat or crowned.
- boxed. This is an area where one or more pieces of sheet metal are angled to form a box that is not necessarily square. Examples of this include some unibody rocker panels and front lower rails.
- partially boxed. This is an area similar to a boxed section except that the angles do not form a complete box. Examples of this include most flanged areas and ridges and feature lines.

SOLID VS. BOXED AND PARTIALLY BOXED
Select the Demonstration icon found on screen C-7 of your CD-ROM for an example of part that contains solid, boxed, and partially boxed areas.

Topic D. Formed Parts

D-1 Different types of crowned areas are found on a vehicle and within a single panel.

A crowned area of a panel is:

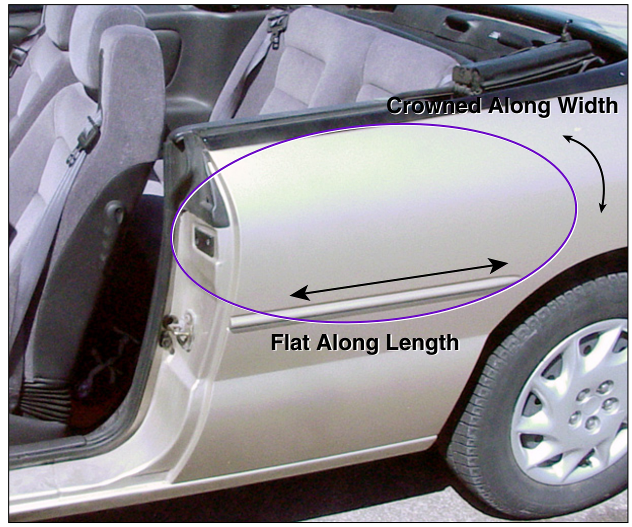
- the combined effect of the shape of the length and the width.
- low, high, combined high and low, or reverse crowned.

D-2 The 2004 Hummer H2 has flat areas on the doors and quarter panels.

A flat area of a panel is:

- an area that is not crowned along the length or the width.
- not common.

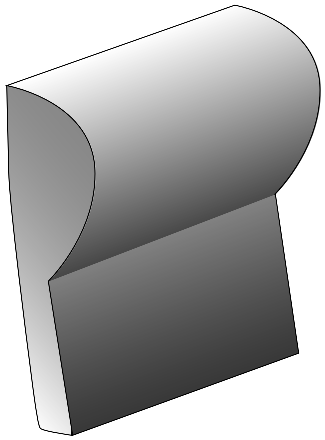
An example of vehicle with relatively flat areas includes many of the panels on the 2004 Hummer H2.



D-3 This is an example of a single crown because it is only crowned along the width and not the length.

A single crown is an area that is:

- crowned in one direction only.
- flat in the opposite direction that it is crowned.



D-4 This high crown panel is also a single crown.

A high crown area:

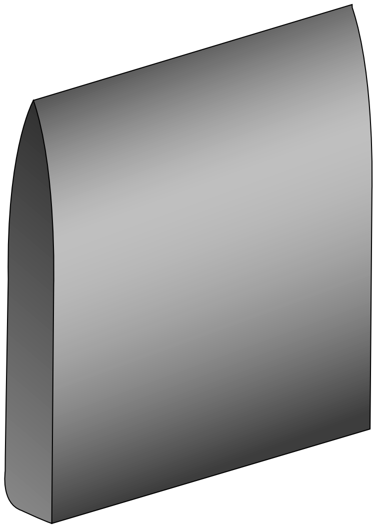
- has a noticeable convex curve over the length or width of the panel and flat in the opposite direction.
- cannot be flexed out of shape using hand pressure.
- will not spring back after being pushed out of shape.

The exact amount of curvature for a panel to be considered high or low crown is subjective and not clearly defined.

D-5 The high crown area on this hood curves with the headlamp, but not the grille.

A high crown area:

- is stronger than a low crown area because of the work hardening that occurred during the forming process.
- when damaged, will generally push outward against adjoining metal.
- can typically be found at the corner of a roof panel, at the rear of the quarter panel, or along the leading edge of a hood.



D-6 This low crown panel is also a single crown.

A low crown area:

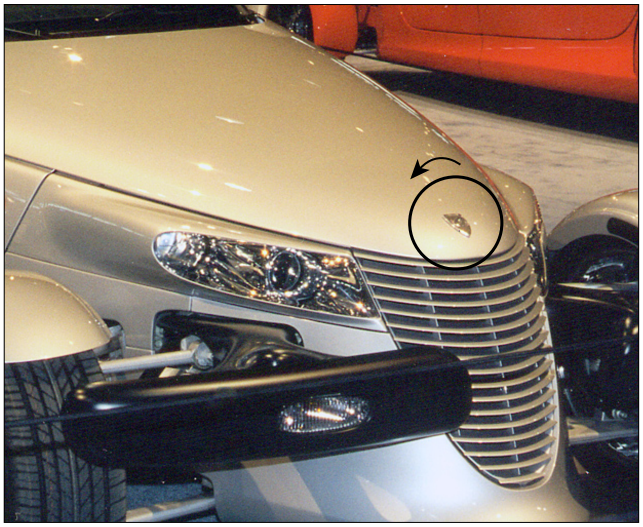
- has a convex curve over the length or width of the panel and flat in the opposite direction.
- has minimal curvature and almost looks flat.
- can be flexed out of shape by hand pressure, but will spring back when pressure is released.

The exact amount of curvature for a panel to be considered high or low crown is subjective and not clearly defined.

D-7 The low crown area of this door almost looks flat.

A low crown area:

- should be treated like a flat panel when it is repaired.
- when damaged, will generally pull inward on adjoining metal.
- can typically be found at the center of a roof, lower door panel, or lower quarter panel.



D-8 This area is an example of a combined crown because it is crowned along the length and width, similar to a computer mouse.

A combined crown area:

- is crowned in both directions, length and width.
- is high-high (high crowned over the length and width), low-low (low crowned over the length and width), or high-low (high crowed over the length and low crowned over the width or high crowned over the width and low crowned over the length). A high-low crown area has the strength characteristics of a high crown.
- can be found on most exterior body panels.
- may also be called a double crown.

D-9 The reverse crowned area is concave instead of convex.

A reverse crowned area has a concave curve over the length or the width, or in both directions. Damage to a reverse crown:

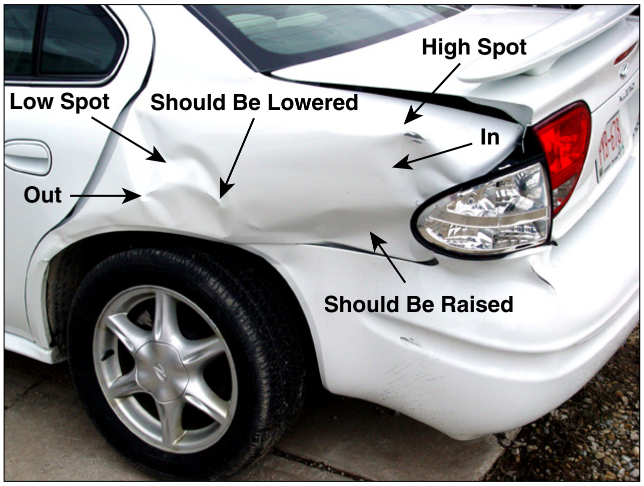
- is typically more severe than other crowns.
- tends to spread less than other crowns because the panel is stronger.

CROWNED PANELS
Have your instructor lead you through the Crowned Panels activity.

Topic E. Review

REVIEW
Refer to screens E-1 through E-2 of your CD-ROM for review questions on steel used in vehicle construction.

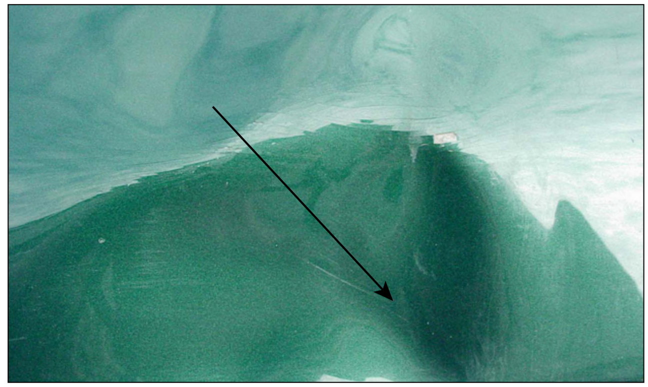
Topic A. Types Of Damage



A-3 In this program, these are the terms that will be used to describe damage and how to remove it.

From this point forward in this program, unless specifically addressed:

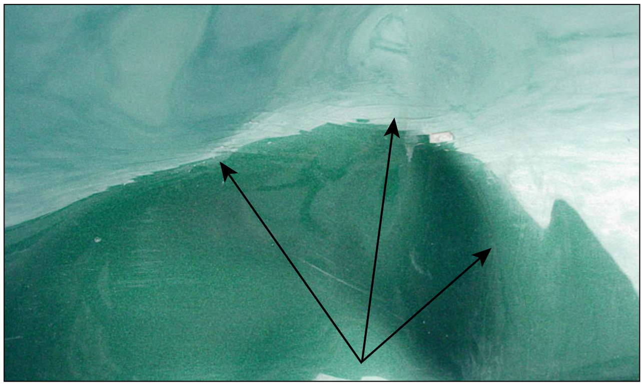
- terms that are used to describe the metal are describing the damage, not the condition of the metal before it was damaged. The pressure, tension, compressed, and stressed areas in a panel that were created during the forming process may affect the damage but they are not the conditions that require removal.
- the front side is the side that is viewed from the outside when the panels are closed. The backside is the opposite side of that panel.
- a high spot is damage that is protruding from the panel. The proper contour of the panel determines what is high and what is low.
- when raising and lowering is used with reference to high and low spots, high spots are lowered and low spots are raised to the proper contour of the panel.
- in and out are also relative to the proper contour of the panel. A low spot is in and should be pulled out or raised.



A-4 The size of the direct damage will depend on the size of the object that impacted the panel.

There are generally two types of damage that result from a collision – direct damage and indirect damage. Direct damage:

- is the point of impact (POI). This is the immediate area where an object collides with another object.
- is usually the lowest spot of a damaged area. Direct damage typically does not cover as large of an area as indirect damage.
- may also be called primary damage.



A-5 The size of the indirect damage will depend on the amount of force used to strike the panel.

Indirect damage is typically more difficult to completely identify and analyze compared to direct damage. Indirect damage:

- is caused by the metal moving away from the direct damage.
- is often identified by a high spot.
- may be used to determine the direction that the damage traveled through a part and vehicle.
- is typically the majority of the damage in a panel.
- may also be called secondary or collateral damage.

A-6 A corroded piece of metal is weaker than a piece that is not corroded.

Corrosion is a chemical reaction called oxidation that forms when bare metal is exposed to oxygen and an electrolyte such as water.

Hot spots will corrode faster than areas that have not been exposed to a collision impact or repair process. Collision damage that creates hot spots includes broken paint film, separated weld joints, damaged coatings, distorted or stressed metal, and exposure to the elements. Collision repair procedures that create hot spots including cutting, heating, drilling, welding, stress relieving, straightening, and touching bare metal with bare hands.

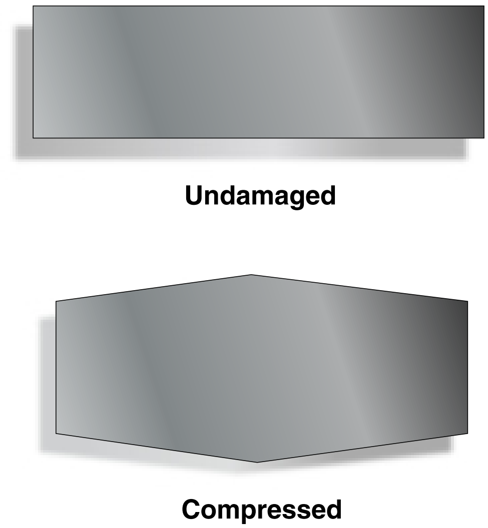
If damaged, the coating should be repaired or replaced. Coatings are designed to seal out moisture and air to protect the metal from exposure to the elements that accelerate corrosion such as ultraviolet rays, road salt, acid rain, and pollutants.

A-7 Damage to an area of a panel can be defined using some basic terms.

Basic damage conditions include:

- compressed metal.
- stretched metal.
- bends.
- buckles.
- displaced areas.
- dings.

The combination of these conditions may be called the fold pattern.

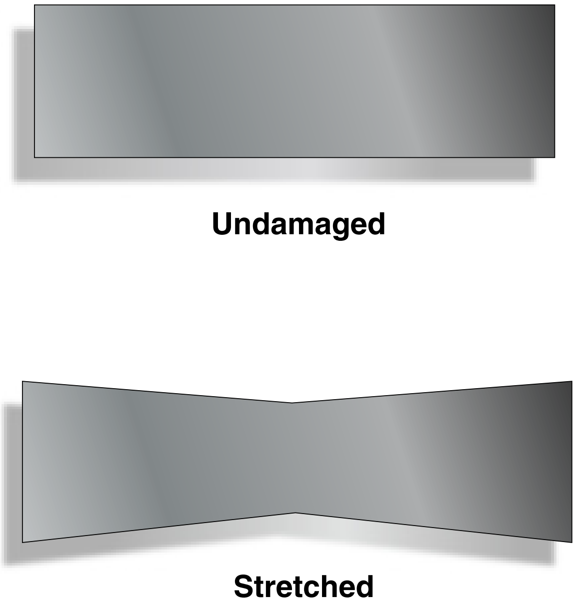


A-8 This compressed piece of metal has decreased in length.

Compressed metal:

- is the result of deformation under compression or pressure. This occurs when forces from different directions push against a central point.
- has a decreased length, width, or both. The area is shortened.
- is usually restricted to a small area.

This type of damage may also be called an upset.



A-9 This stretched piece of metal has increased in length.

Stretched metal:

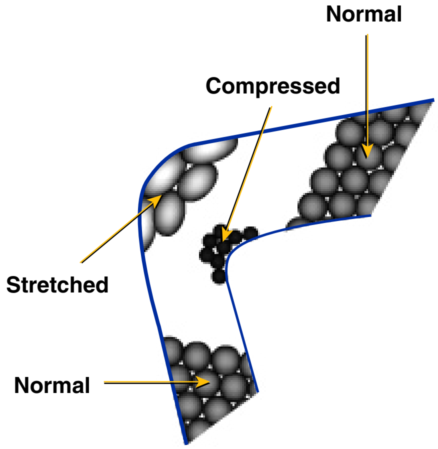
- occurs in areas different from compressed metal. Stretched metal is the opposite of compressed metal.
- is the result of deformation under tension.
- has an increased length, width, or both.
- can be caused by improper use of tools such as excessively hammering-on-dolly.

A crease is an example of stretched metal resulting from collision damage.

A-10 A panel may contain multiple buckles.

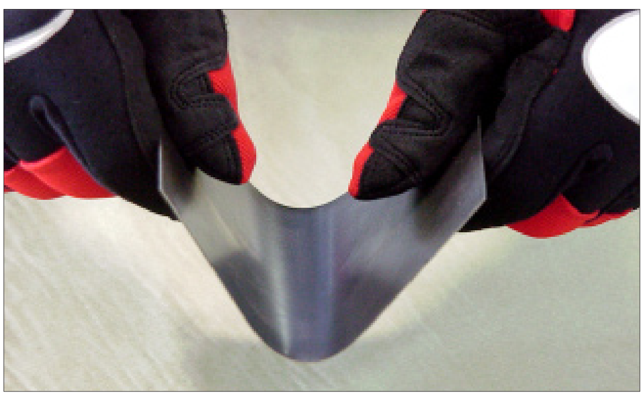
A buckle:

- is the result of the metal bending past its elastic limit.
- is an area that has been work hardened by the collision.
- may be categorized as a hinge buckle or a roll buckle.
- may be further categorized as a simple or collapsed buckle.



A-11 The grain structure is affected by a piece of metal being buckled.

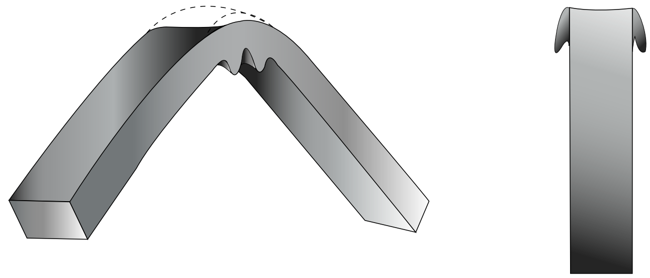
The outer surface of the bent metal in a buckle is typically stretched and the inner is compressed. When inspecting a sharp bend, cracks or breaking may be visible on the outside of the bend. After the sharp bend has been straightened, cracks or breaking may be visible on the inside.



A-12 Folding a flat piece of metal in half is an example of a simple hinge buckle.

A simple hinge buckle:

- occurs in solid sheet metal areas.
- is bent equally along the entire length with one pivot point, like a hinge.
- when severe, should be pulled from the edges out, not from the center. Typically, shrinking is not required.



A-13 Folding a boxed piece of sheet metal in half may result in a collapsed hinge buckle.

A collapsed hinge buckle:

- occurs in boxed and partially boxed sheet metal areas.
- has the center of the outer area that is collapsed inward.
- has an inner area that is crinkled or compressed and the sides are buckles out.

A collapsed hinge buckle may also be called a collapsed box section.

A-14 The concaved center of this damage is the collapsed roll buckle area.

During a collision, a collapsed roll buckle:

- tries to turn the panel inside out and roll over itself.
- increases in length as it rolls.
- creates a concave area in a convex, or crowned, panel.

A-15 The higher ridges of this damage are the simple roll buckle areas.

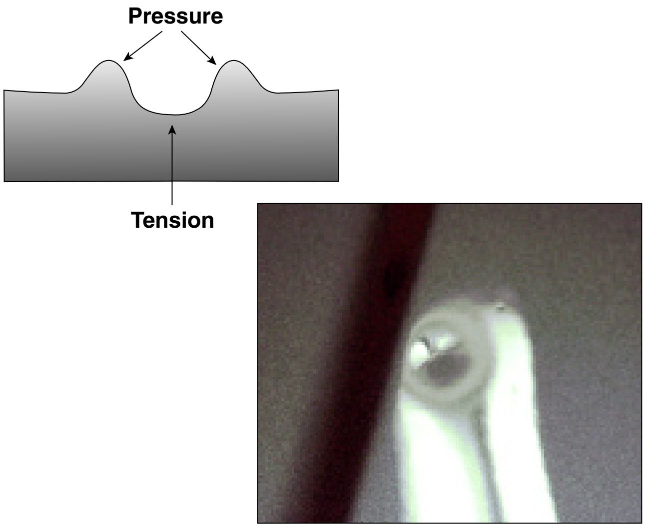
A simple roll buckle:

- occurs crossways in a crowned area.
- is perpendicular to a collapsed roll buckle.
- is the ridges that form at the ends of a collapsed roll buckle. These ridges may also be called eyebrows, smiles, or arrows.

A-16 The direct damage below the rear tail lamp has caused this area of the quarter panel to be displaced.

A displaced area in the metal:

- is not an area of direct damage.
- is part of the damage because it has been pushed out of position by the direct damage.
- should not be directly repaired even though it is typically the last damage that was put into the panel. The damage that pushed the metal out of position should be repaired first to relieve the stress. This is an exception to the first in, last out recommendation. Unless severe, displaced metal typically fixes itself when the adjacent damage is repaired properly.
- may be the result of a buckle. The buckle should be repaired first.

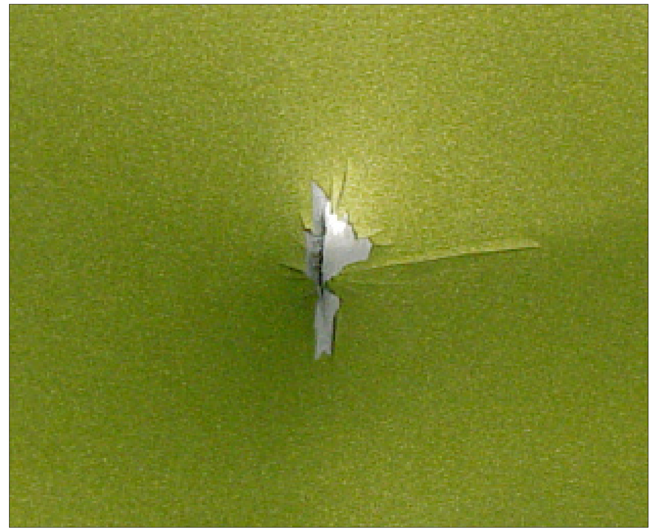


A-17 Dings are a common type of damage.

A ding:

- is a shallow depression in the metal. The force may come from the outside or the inside of the vehicle. For example, an object inside the trunk can damage a panel from the inside out.
- may have a high spot, or ridge, around the edge of the low spot. The impact may have pushed the metal inward, causing a tension area, and spread the force out, creating a pressure area.
- may be caused by a car door, hail, shopping cart, etc.

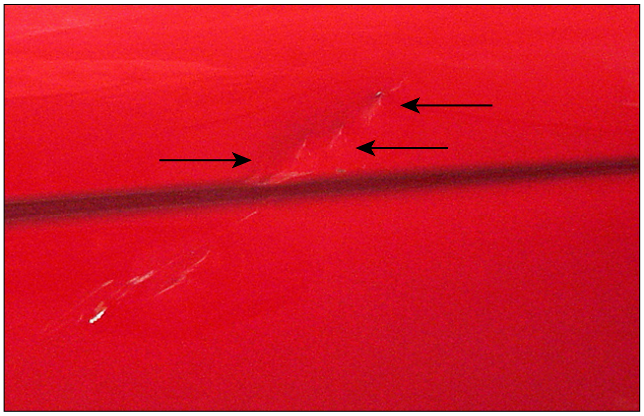
Topic B. High Spots And Low Spots



B-1 Something from inside the vehicle caused the high spot on this panel.

A high spot is:

- an area that is higher than the surrounding surface.
- a bump in the sheet metal.
- a pressure area.



B-2 Something from outside of the vehicle caused the low spots on this panel and feature line.

A low spot is:

- an area that is recessed below the surrounding surface.
- a dent in the sheet metal.
- a tension area.

B-3 The high and low spots are identified before the damage removal begins.

To properly repair damage in a panel, it is important to identify the high and low spots. This may be done using:

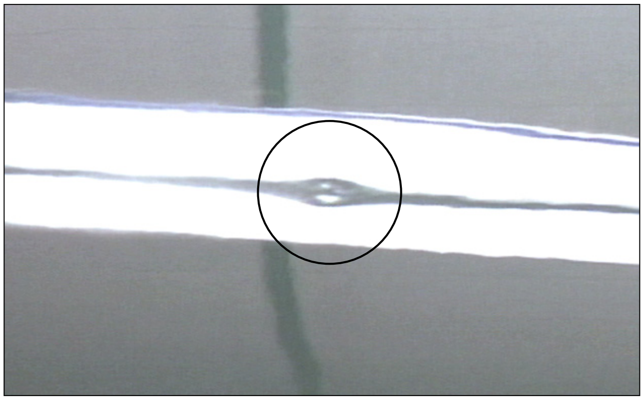
- a straightedge to help see the damage.
- light and the reflection off the panel to help see the damage.
- a hand to feel the damage.
- a body file or sandpaper on a rigid block to help see the damage.

B-4 A metal ruler is an example of a straightedge that can be used to identify a low spot.

When using a straight edge to identify high and low spots:

- place the edge, not the face, of the straightedge against the panel over the damaged area. Use a true straightedge.
- look for gaps between the straightedge and the panel. This method is not as affective on combined crowned areas.
- a ruler or metal paint stick may be used as straight-edge tools.

USING A STRAIGHTEDGE
Have your instructor lead you through the Using A Straightedge activity.



B-5 The beams of light break in the area where there is a low spot.

When using light to identify high and low spots, the movement of the reflection will:

- be smooth when viewed on a smooth, undamaged surface.
- dance around or break up on a rough, damaged surface.

IDENTIFYING HIGH AND LOW SPOTS USING LIGHT

Have your instructor lead you through the Identifying High And Low Spots Using Light activity.

B-6 Feeling for high and low spots is an acquired technique that can be used throughout the repair process.

When using a hand to feel the high and low spots:

- either hand can be used. One opinion is that the least dominate hand is more sensitive and can feel the contour better. The beginner should try both hands and decide what works best for them. Using a glove or a clean cloth may help identify small highs and lows better than a bare hand.
- the hand should be kept as flat as possible. Maintain contact with the surface from the heel of the palm to the fingertips.
- use light pressure against the panel.
- the contour of the panel is felt by pulling backward or pushing forward. One opinion is that pulling backwards increases sensitivity. The beginner should try both directions and decide what works best for them. At a minimum, move along the length and width of the damage. Continuing to feel the contour from different directions may be required.
- move from an undamaged area to the damaged area.

This method is most common and can be used in damage analysis and throughout the repair process.

IDENTIFYING HIGH AND LOW SPOTS BY FEEL

Have your instructor lead you through the Identifying High And Low Spots By Feel activity.

B-7 The bare metal areas are the highest spots and the areas with paint are the lowest spots.

A body file or sandpaper on a rigid block can be used to identify high and low spots after initial straightening. Other methods are typically used prior to this point. A body file or sandpaper on a rigid block is used to scratch the high spots and make the low spots visible because the paint has not been removed.

Use caution to avoid thinning the metal when using a body file.

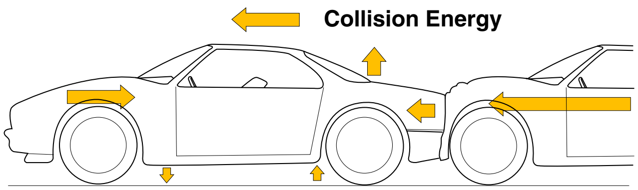
USING A BODY FILE
Have your instructor lead you through the Using A Body File activity.

Topic C. Damage Analysis

C-1 Many factors determine whether a part should be repaired or replaced.

When deciding whether to repair or replace a panel, consider:

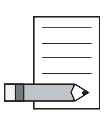
- the severity of the damage.
- the location of the damage.
- the condition of the original finish.
- accessibility to the damage. Determine if the backside can be properly corrosion protected.
- the durability of the repair.



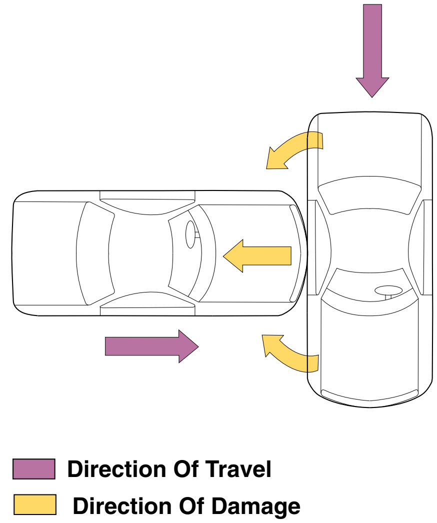
C-2 Newton's laws of motion can be used to help explain how energy affects vehicles in a collision.

Newton's laws of motion include:

- the first law of motion which is that a stationary object has a tendency to resist being put in motion. This is also described as an object at rest will remain at rest unless an outside force is encountered. The first law of motion also includes that a moving object has a tendency to continue moving. This is also described as an object in motion will continue in motion unless an outside force is encountered. The first law predicts behavior when the forces are balanced. The tendency to resist change, as described in the first law, is called inertia. Inertia depends on mass. An increase in mass increases inertia and the tendency to resist a change in state of motion.
- the second law of motion which is that an unbalanced force will cause an object to accelerate by changing its speed, direction, or both. The net force (F) is the mass (m) of an object multiplied by the acceleration (a) of the object $F=ma$.
- the third law of motion which is that for every action there is an equal and opposite reaction. For example, the wheels on a vehicle spin backwards on the ground and the ground makes the vehicle move forward. The forces between the vehicle and the ground equal each other.

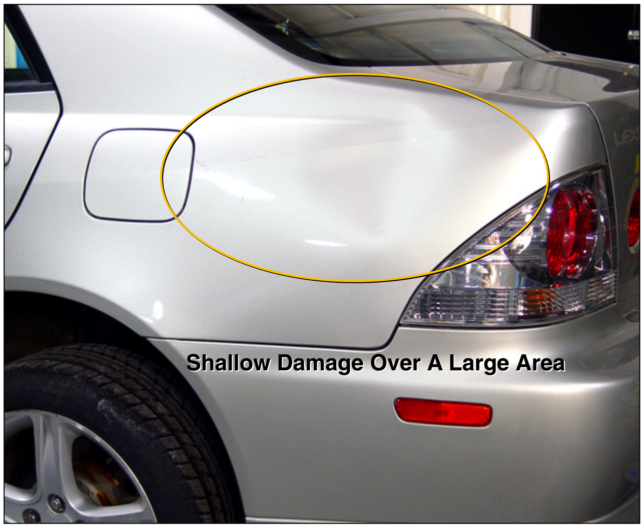


NEWTON'S LAWS OF MOTION
Have your instructor lead you through the Newton's Laws Of Motion activity.



C-3 The speed and weight of the objects involved in a collision will directly affect the type and severity of the damage.

A high-speed impact may cause more severe damage at the point of impact than a low-speed object. A heavier object traveling at lower speed may transfer more damage past the point of impact than a lighter object.



C-4 An object with a large surface area collided with this quarter panel.

The surface area of the object that is making contact with a vehicle affects the degree of damage because:

- a smaller surface area concentrates the force.
- a larger surface area distributes the force over more of the vehicle and may damage reinforcements more than the outer body panels.

The severity of the damage should not be judged on the size of the exterior damage alone.

C-5 A truck towing a camper is an example of a pulling force on the truck.

Sheet metal that is damaged by a pushing force will react differently than from a pulling force.

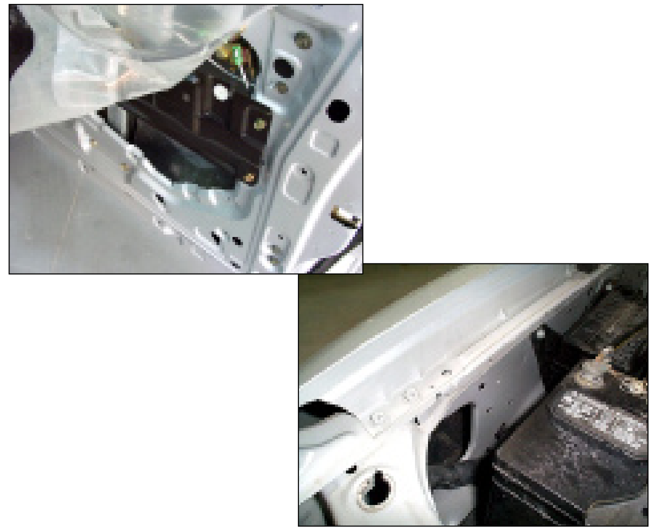
C-6 The damage to this quarter panel is not easily accessed from the backside.

If the panel damage is not too severe and replacement will disrupt the original welds and corrosion protection, repair may be a better option than replacing the panel. The degree of damage is used to determine the repair options for damage to a specific location. This, however, is not the only criteria.

C-7 A film thickness gauge should not damage the finish.

The condition of the finish will have an affect on the repair method. If the finish:

- is damaged, several straightening methods may be used.
- is undamaged, paintless dent repair (PDR) may be an option.
- has excessive film thickness, the paint thickness will have to be reduced to allow for refinishing. This may affect the repair versus replace decision.
- is in good condition and the location allows for blending color within a panel, repair may be more practical than replacement, provided the damage is not too severe.



C-8 Access to the damage affect the methods that can be used to remove the damage.

Depending on the location of the damage, it may be accessible from:

- both sides.
- both sides, but with limited access to the backside.
- one side only.

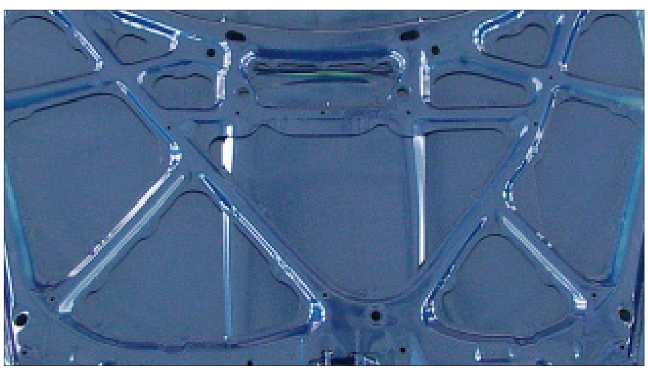
The accessibility may have an affect on the repair method. Regardless of the repair method used, corrosion protection materials must be applied to bare metal areas on the backside of the panel following repairs. Refinishing the backside of panels may also be required to create a repair that is as close to being undetectable as possible.

C-9 The part design of this fender restricts access to the damage from the backside.

Some restrictions to accessing the damage include:

- part design.
- vehicle design.
- location of reinforcements.

Do not alter or modify the design of the part or the reinforcements to gain access.



C-10 The reinforcements on the underside of this hood restrict access to the damage on front side.

Reinforcements may be:

- formed into the panel.
- welded to the panel.
- the inner and outer panels bonded together.

C-11 The body lines on this vehicle's doors act as reinforcements that may affect the ability to remove damage.

Reinforcements formed into the metal:

- prevent vibration and flexing of the panel.
- include flanges, ridges, and feature lines used for stiffness.

The ridges in inner door panels and floor pans are examples of reinforcements formed into the metal.

C-12 The durability of a repair near a door handle may be compromised by stress and wear to this area of the panel.

Consider the durability of a repair to:

- a high-wear area.
- areas that are subject to stress, such as a hood crush zone or areas next to spring-type hood hinges.

Topic D. Hammers

D-1 All hammers are not the same.

Hammers can be broken down into two basic groups: initial straightening hammers and body hammers. Types of body hammers include bumping and finishing hammers. Be aware that there are many different names and categories of hammers that are not universal throughout the industry. This is a broad overview of the basic types.

D-2 Minor details of a hammer are used to determine when it should be used in the repair process.

An initial straightening hammer:

- is used to initially straighten the damage.
- is heavier and may have a larger face than a body hammer.
- may have a flat, square, rounded, or pointed head.

Use caution when straightening with an initial straightening hammer to avoid creating more damage than repair.

D-3 There are many different styles of body hammers.

A body hammer is:

- a basic tool used to straighten sheet metal.
- used by striking the part squarely and allowing the hammer to rebound. The part should not be struck like a nail.

D-4 This is an example of one type of bumping hammer.

A bumping hammer:

- is lighter than an initial straightening hammer, but heavier than a finishing hammer.
- is used after initial straightening and before finish straightening.
- may be used with a dolly.

D-5 This is an example of a finishing hammer.

A finishing hammer:

- may have a crowned face to concentrate the force. The face may be smaller than a bumping or rough-out hammer.
- is used for finish straightening to match the contour of the panel.
- is lighter than a bumping or rough-out hammer.
- is used by lightly and rapidly tapping the damage.
- may be used with a dolly.

D-6 The head of the hammer is used to strike the panel.

A body hammer usually has two heads. A combination of styles and shapes may be found including:

- pick.
- cross peen.
- shrinking, which is serrated.
- a flat or crowned face.
- a square or round head.

BODY HAMMER HEAD TYPES
Select the Demonstration icon found on screen D-6 of your CD-ROM for examples of different body hammer head types.

D-7 The marks on the face of this hammer may imprint the sheet metal causing additional damage.

When using a body hammer, consider that:

- it should only be used to strike sheet metal. Do not strike a body hammer and dolly or a body hammer and spoon against one another and never strike two body hammers together. It is also important to note that a body hammer should not be used to strike nails or a chisel.
- marks on the face will imprint on the sheet metal when it is struck with the hammer, especially when using the hammer-on-dolly technique.

D-8 Technician preference may also play a role when selecting a body hammer.

When selecting a hammer, consider:

- the size and type of damage.
- the panel contour. The face of the hammer should match the contour of the panel.
- the step in the repair process. A rough-out hammer should not be used for finish straightening.
- personal preference. In many instances, there is no definite right or wrong hammer.

D-9 This is an example of how to properly hold a body hammer.

The proper way to hold a body hammer is to hold:

- it tightly with the middle, third, and little fingers to prevent it from slipping.
- the sides lightly with the thumb and index finger to prevent sideways movement. Sideways movement may interfere with accuracy during repairs.

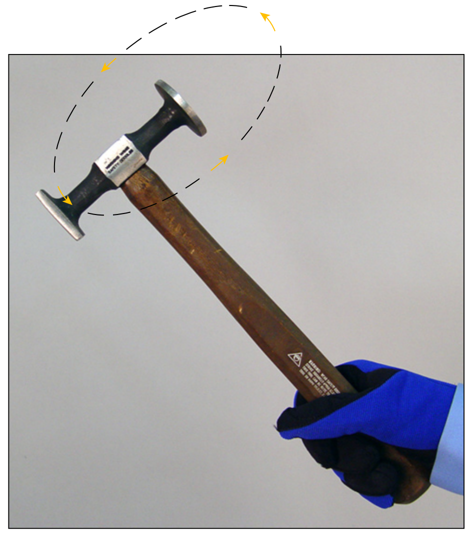
HOLDING A HAMMER
Have your instructor lead you through the Holding A Hammer activity.

D-10 The amount of hammering force required may vary from dent to dent.

Some general guidelines to follow when using a body hammer include:

- swing with the wrist.
- use light and consistent strokes.
- begin by striking softly, using increasingly stronger blows. This helps reduce the risk of further damaging the panel.
- keeping the face of the hammer flush with the surface of the panel to avoid unwanted damage.

Impact-resistant gloves may be worn to cushion the vibration and help prevent stress-related injuries.



D-11 This is the type of circular motion that should be followed when using a body hammer.

When using a body hammer:

- swing it in a circular motion at the wrist. The whole arm and shoulder should not be used to swing a body hammer.
- space the blows about 10–13 mm (3⁄8–1⁄2") apart.

D-12 Notice the high spots in and around the circle.

D-13 This technician is using a fine tooth file to remove the surface imperfections from the face of this body hammer.

One of the most difficult skills to learn when first using body hammers is striking a desired location on the backside of a panel. The only way to learn this skill is through practice and experience. One method of learning this skill is to:

- draw a circle on the front of a panel and mark an "X" in the middle of the circle. Strike the backside of the panel and attempt to raise the center of the circle on the "X."
- repeat this practice until the center of the "X" is struck on a consistent basis.

LOCATING THE HAMMER ON THE PANEL BACKSIDE

Have your instructor lead you through the Locating The Hammer On The Panel Backside activity.

To properly maintain the face of a hammer:

1. Clamp the hammer in a vise face-up.
2. File the hammer face in all directions using a flat fine-tooth metal file. Do not file in only one direction. This will cause an uneven face.
3. File the hammer face so that it is slightly crowned, not flat.
4. After smoothing with the file, polish the face with fine sandpaper. An oil stone can also be used.
5. Apply paint, or a grease marker, to the hammer face and strike a flat piece of sheet metal while the paint is still wet. The paint should come off of the center of the face. If the paint comes off of a section other than the center of the face, file and polish the surface again. Repeat this process until the paint comes off of the center of the hammer face.

When maintaining the pick portion of a pick hammer, make sure to file the length of the pick and not around the pick. Filing around the pick could weaken the pick and cause it to break when it is used for straightening.

HAMMER MAINTENANCE

Select the Demonstration icon found on screen D-13 of your CD-ROM for a demonstration of hammer maintenance.

Topic E. Dollies

E-1 Different types and shapes of dollies are used to repair damage.

The different types of dollies include:

- general purpose, or rail dollies. This type of dolly has both wide and narrow crowned faces.
- utility dollies that have various degrees of crowned surfaces and can be handled easily in narrow spaces.
- toe dollies that have two flat surfaces and a connecting crowned surface. These can also be used in narrow spaces.
- heel dollies. Heel dollies have one flat side and one crowned side.
- comma or comma wedge dollies. These have a crowned surface that changes gradually from sharp to gentle. The sharp end can be inserted into narrow spaces.
- spoon dollies. These are long dollies that can be used to access damage.
- shot dollies. Shot dollies can be altered to fit different contours.

DOLLY TYPES

Select the Demonstration icon found on screen E-1 of your CD-ROM for examples of different dolly types.

E-2 The technician has a variety of dollies to choose from for each application.

When selecting which dolly to use, consider:

- the weight of the dolly. Typically, the dolly should be heavier than the body hammer. The weight of the dolly provides the inertia to resist the force of the hammer blow.
- the ability to balance the dolly to distribute the weight properly.
- the contour of the panel. The dolly should be held so that the face matches the contour of the panel as closely as possible.
- personal preference. In many instances, there is no definite right or wrong dolly.

E-3 This is an example of how to properly hold a dolly.

The technique used for holding a dolly is similar for each type. The dolly should be placed in the technician's palm and held lightly. A dolly can be used as a backup tool or as a hammer. Depending on the damage, access to the damage, and the technician's comfort level, the dolly can be placed on the front side or the backside of the panel. For example, when a dolly is used as a backup tool on the backside, the dolly raises the low spot and the hammer lowers the high spot. When used on the front side, the dolly lowers the high spot and the hammer raises the low spot.

Impact resistant gloves may be worn to cushion the vibration and help prevent stress-related injuries.

E-4 If this side of the dolly was used like a hammer, it would cover a larger surface area than the face of a hammer.

When a dolly is used like a handleless hammer to strike the panel, it is typically:

- used for initial straightening.
- better to use several moderate blows than a few hard blows.
- used in areas where access is limited with a hammer.
- used when the face of the dolly matches the panel contour better than a hammer. A dolly is able to lift a larger surface area than a hammer.

USING A DOLLY AS A HAMMER
Have your instructor lead you through the Using A Dolly As A Hammer activity.

Topic F. Using A Dolly As A Backup Tool

F-1 The dolly is being used as a backup tool for a hammer blow to the opposite side of the panel.

When using a dolly as a backup tool:

- access to both sides is required. This may require parts or trim to be removed to gain access.
- a hammer is used. This procedure may also be called hammer and dolly, which includes hammer-on-dolly and hammer-off-dolly techniques.

Personal safety equipment required when using hammers and dollies includes:

- safety glasses.
- gloves.
- hearing protection.

F-2 The dolly may be held on the front side of the panel while a hammer is used to strike the backside.

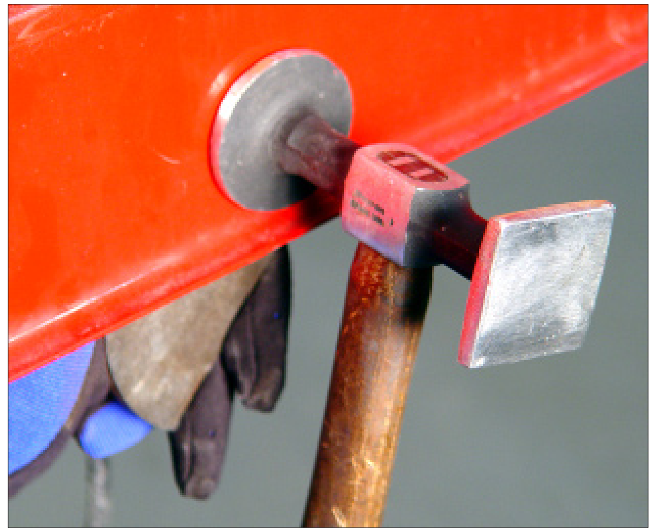
One procedure for using a hammer and dolly to repair a dent is:

1. Verify that the hammers and dollies are clean and free of damage.
2. Identify high and low spots. This will help determine the removal sequence.
3. Use a combination of hammer-on-dolly and hammer-off-dolly techniques to return the panel as closely as possible to its original contour.
4. Continually monitor the panel to identify high and low spots.
5. Use a finishing hammer to complete the repairs. Prepare the repair area for body filler, if necessary.

F-3 When using the hammer-on-dolly technique, the tools are directly on top of each other.

When using the hammer-on-dolly technique:

- the dolly is placed on one side of the panel and the hammer is used to strike the opposite side of the panel directly over the dolly.
- the metal struck by the dolly and hammer becomes smoother.
- the metal stretches and gradually returns it to its original contour.
- shallow dents may be removed using this technique.

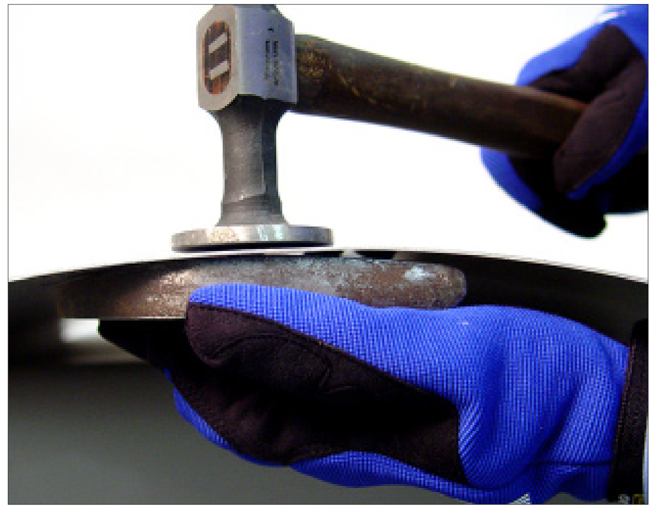


F-4 Hammer force affects how the hammer-on-dolly technique removes the damage.

When using the hammer-on-dolly technique:

- each blow should overlap the previous.
- use light hammer blows for smoothing and finishing.
- use hard hammer blows for stretching. Hammer and dolly positioning must be accurate to avoid damaging the panel. Enough force must be applied to exceed the elastic limit of the metal.
- the dolly should be held firmly. Adequate hand pressure is required to counteract the force of the hammer blow.

F-5 When the hammer strikes the panel, the location of the dolly is critical.



F-6 Use caution to avoid over-stretching the metal when using the hammer-on-dolly technique.

Proper hand-eye coordination is required when using a hammer and dolly together. Sound can also be used, for example, when the hammer:

- strikes the dolly, it makes a high pitched "ping" sound.
- misses the dolly, it makes a dull or dead sound. An unwanted dent may also be seen.

Sound and the rate of hammer deflection can be used to determine if enough force was applied to stretch the metal. If hammer deflection is:

- slightly delayed and the sound is slightly deadened, enough force was applied.
- instantaneous and the sound is sharp and clear, not enough force was applied.

HAMMER-ON-DOLLY

Have your instructor lead you through the Hammer-On-Dolly activity.

F-7 When using the hammer-off-dolly technique, the tools should not touch each other through the panel.

When using the hammer-off-dolly technique:

- the dolly is placed on one side of the panel and the hammer is used to strike the opposite side of the panel in an area adjacent to the dolly.
- high spots are lowered and low spots are raised at the same time. When the dolly is placed on the backside, the dolly raises the low spots and the hammer lowers the high spots from the front side. When the dolly is place on the front side, the dolly lowers the high spots and the hammer raises the low spots from the backside.
- the pressure that is use to hold the dolly against the panel affects the amount that the metal will move. The dolly rebounds after the hammer strikes the opposite side to help move the metal. The amount of pressure on the dolly is more important when using the hammer-off-dolly technique than hammer-on-dolly.

F-8 Changing the distance between the edge of the dolly and the face of the hammer makes the metal react differently.

When determining where to place the hammer and the dolly on the panel:

- a general rule is to keep them within 25 mm (1") of each other.
- if the dolly is too far way, it cannot rebound properly to remove the damage. This distance is affected by the shape, strength, and thickness of the metal.

HAMMER-OFF-DOLLY
Have your instructor lead you through the Hammer-Off-Dolly activity.

HAMMER AND DOLLY DENT REMOVAL
Refer to screen F-9v of your CD-ROM for a video on removing a dent using hammer-on-dolly and hammer-off-dolly techniques.

The material in this program will usually focus on one way to repair a particular type of damage, that it is not necessarily the only repair option available.

Topic G. Spoons

G-1 A spoon looks like a cross between a hammer and a dolly.

Spoons:

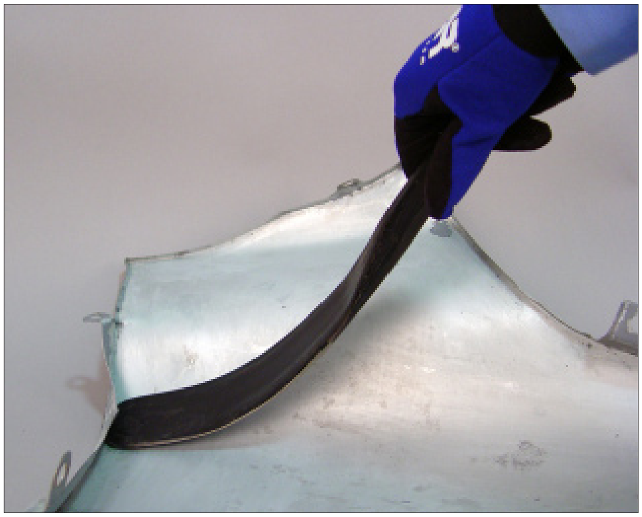
- are used in areas with limited access.
- may be used to straighten creases and ridges.

G-2 Like hammers and dollies, spoons are also available in different styles.

Spoons:

- may be flat or crowned to various degrees.
- vary in weight.
- vary in length and thickness.
- may be designed for a specific purpose such as shrinking.

SPOON DESIGNS
Select the Demonstration icon found on screen G-2 of your CD-ROM for examples of different spoon designs.



G-3 This spoon is being used to pry and access an area that would be difficult to reach with a hammer or dolly.

G-4 A spoon should not be used as a dolly if there is a dolly that will work.

Depending on the design, a spoon can be used:

- like a dolly in areas that are inaccessible with a dolly. The handle of a spoon allows it to access hard-to-reach areas. A dolly is the preferred method for hammer and dolly operations.
- to pry out damage by leveraging off of an adjacent area, or raise low spots along damaged edges.
- like a hammer to strike the damage.
- by being struck with a hammer. This may also be called spring hammering.

The hand-eye coordination that is used with a dolly is different from what is required for a spoon. Some disadvantages of using a spoon as a dolly include that:

- the handle is positioned away from the striking surface.
- the spoon may wander when the metal is stuck.
- a spoon is more difficult to balance.
- the rebound is limited, therefore, it is less effective at raising low spots.

G-5 The pick end of the ball peen hammer has a larger surface area than a body hammer.

A ball peen hammer:

- is heavier than a body hammer.
- may be used to strike a spoon. A body hammer should not be used to strike a spoon.

G-6 A dead blow hammer may have an interchangeable head according to the repair.

A dead blow hammer:

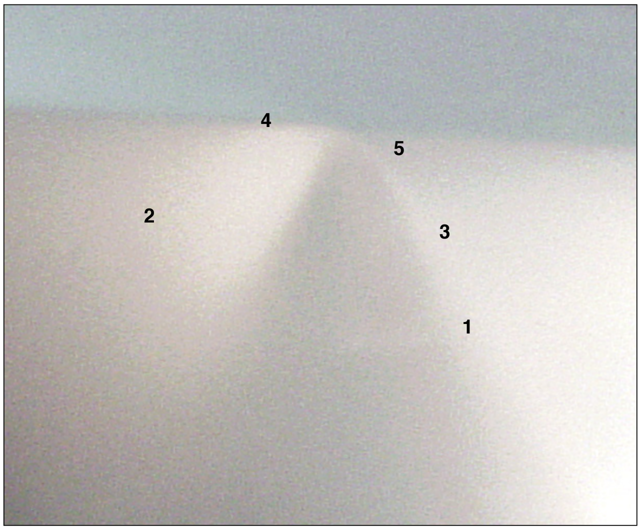
- has a head that is filled with lead shot to prevent it from rebounding when struck against a surface.
- will not bounce back after it strikes a surface.
- may be used to strike a spoon.

G-7 Both ball peen and dead blow hammers may be used to strike a spoon.

When a hammer is used to strike a spoon:

- the repair area is typically too large for the head of a body hammer. A spoon more evenly distributes force over the surface than several blows with a body hammer.
- it spreads the force of the hammer over a larger area then the head of a hammer alone and flexes the surrounding metal.
- do not resist the downward movement of the handle. The panel could be damaged if too much pressure is applied to the end of the spoon.

USING A SPOON WITH A HAMMER
Have your instructor lead you through the Using A Spoon With A Hammer activity.



G-8 This is one recommended order for removing the buckle in this panel using a spoon.

When using a spoon to remove buckles:

- start at the point of least distortion.
- use a series of blows.
- zigzag along the buckle.
- do not use if the buckle is too sharp. Metal that is folded over should not be straightened using a spoon because the metal is too rigid.

G-9 Some spoons look like a hammer without a head.

When using a spoon like a body hammer:

- tap down the high spots.
- the spoon may have a smooth face for straightening or a serrated face for shrinking.

USING A SPOON LIKE A BODY HAMMER
Have your instructor lead you through the Using A Spoon Like A Body Hammer activity.

Topic H. Repairing Damage

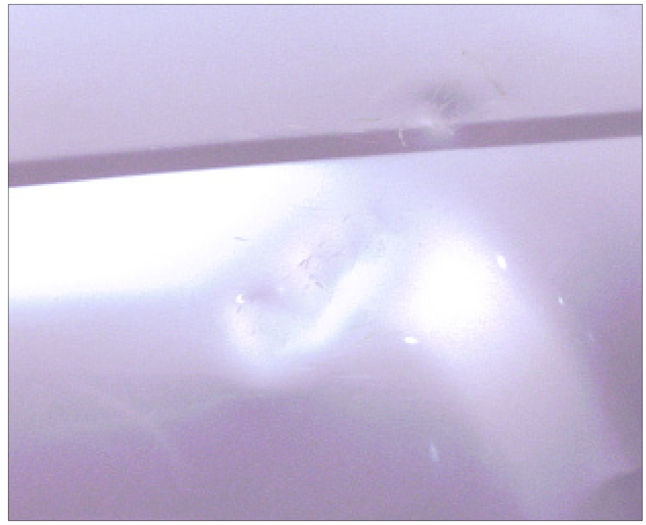
H-1 Some areas of a panel are stronger by vehicle maker design.

When analyzing collision damage, identify where the metal was strongest and weakest before it was damaged to help determine if the damage can be removed or if the part should be replaced. Typically, forces used for repair are applied in reverse order from how the damaged occurred. This process is called first in, last out or last in, first out.

H-2 The ability to straighten damage is a skill.

The basic straightening skills that are required to repair collision damage are:

- knowledge and understanding of how to straighten.
- manual dexterity to properly use the tools required for straightening.



H-3 The damage to this feature line and the high crown area resist straightening more than a flat area.

More advanced types of damage repair include damage:

- to feature lines.
- to contours.
- that is long and narrow.
- that is sharp such as a crease.
- to highly formed areas.

When repairing damage to areas with feature lines or contours, the straightening process may be monitored by referencing the same panel on the opposite side of the vehicle.

H-4 A sharp force was used to create this type of damage to a feature line.

Ridges and feature lines:

- are harder to damage.
- require more effort to straighten.
- have relatively small areas that are distorted from damage, but the damage may be severe.

H-5 A hammer and dolly can be used to remove damage without the use of heat.

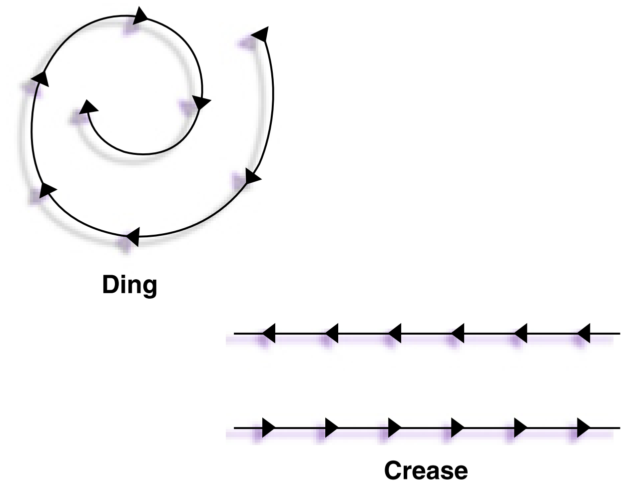
Cold working:

- is repairing the metal without using heat.
- involves using tools such as hammers, dollies, spoons, and picks.

H-6 Experience will help when determining where to begin.

When determining the removal sequence:

- it will vary from dent to dent.
- identify the high and low spots.
- choose a sequence that will do as little additional damage to the panel as possible.
- take into account the length of the damage and determine the best method for removal.
- take into account the shape of the panel and the shape of the damage. A technician may choose to begin straightening panel edges or feature lines first because these areas give the part strength and shape. Damaged feature lines and panel edges will distort and displace metal in adjacent areas.



H-7 These are examples of how to remove a ding or crease using the first in, last out method.

First in, last out is:

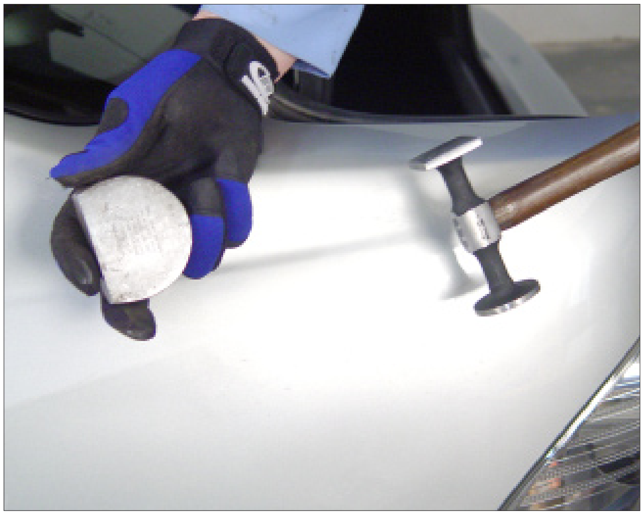
- one method of removing damage.
- reversing the order of damage. The point of impact is typically removed last.
- also called last in, first out.

H-8 It is important that the repair area is clean before beginning repairs to prevent contamination and addition damage.

To prepare a damaged panel for straightening:

- remove any parts necessary to gain access to the backside of the panel when possible.
- clean the panel using soap and water.
- use wax and grease remover to remove any non-water-soluble contaminants.
- remove undercoating from the backside of the panel. If heat is being used for repairs, the coatings will be damaged or burned if they are not removed. If a hammer and dolly are being used for repairs, the coatings could transfer onto the tools if they are not removed.

Adjacent panels, moldings, and trim should be protected or removed to prevent them from being damaged during the straightening process.



H-9 A hammer or dolly may be used to initially straighten damage.

During initial straightening:

- restore the general contour of the panel.
- a hammer or dolly may be used.
- remove as much damage as possible before removing topcoats.

H-10 The technician is using the hammer-off-dolly technique for intermediate straightening.

During intermediate straightening:

- move around the damage. Do not work on only one area or the metal may stretch.
- continue to monitor high and low spots.
- use more of the hammer-off-dolly than hammer-on-dolly technique.

H-11 A finishing body hammer is used to straighten the panel to the proper contour.

During finish straightening:

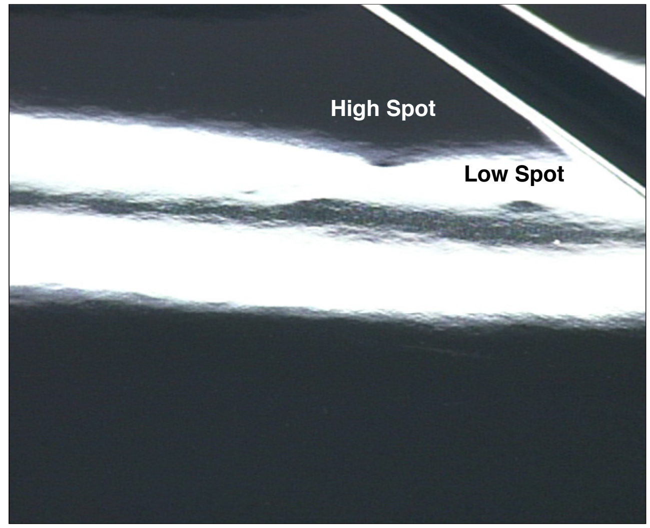
- the hammer-on-dolly technique may be required.
- continue to check for high and low spots to determine if additional straightening is required.
- straighten to within 3–6 mm (1⁄8–1⁄4") of panel contour to prepare for body filler application. The degree of straightening depends on the type of body filler that is being used; 3 mm (1⁄8") is typically recommended for polyester glazing putty and 6 mm (1⁄4") for body filler.

Topic I. Metal Finishing

I-1 The repair to this quarter panel will not require the use of body filler.

Whenever practical and possible, an attempt to metal finish a dent should be made. Metal finishing:

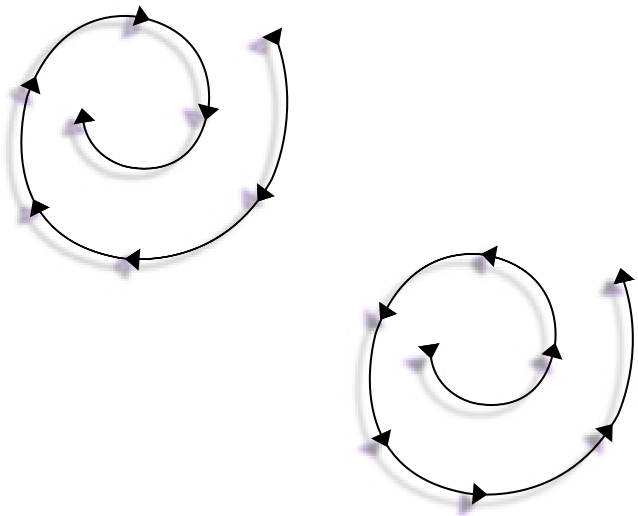
- is returning the metal to its original contour with no body filler. This is a skill that will be learned with time and practice. Not all damage can be completely metal finished.
- requires the proper repair techniques and attention to detail.
- uses a technique called pick and file. The panel is picked, and a body file is used to locate high and low spots. This process continues until the panel is straight. Tools such as picks, hammers, spoons, and dollies are used to straighten the panel.



I-2 Notice the difference between a high and low spot using the reflected light.

Picking:

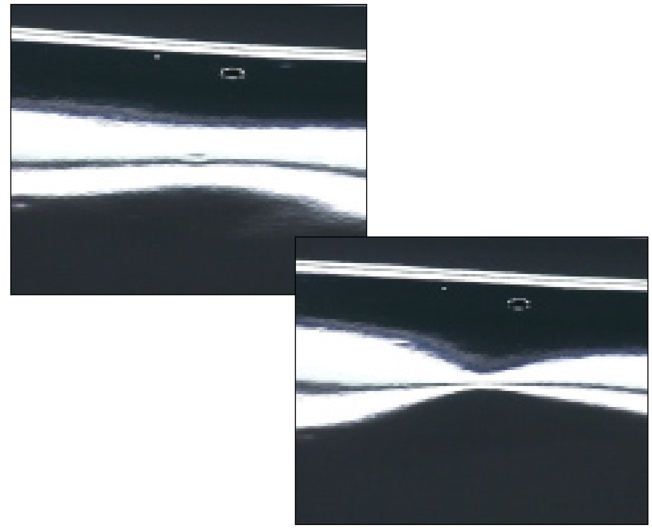
- is lifting low spots to be level with the contour of the panel and no higher. Too much picking may cause a bulge instead of repairing the area.
- may be done using a pick, spoon, or pick hammer.
- slightly stretches the metal. Use caution to prevent overstretching.



I-3 The technician should us a technique that best suits them.

When picking:

- the technique may be to start at the lowest point or to gradually work toward the lowest point.
- the first in, last out technique may be used.
- the surface should get smoother not rougher. Excessive pick marks will make the surface rougher.



I-4 As pressure is applied with the pick, the beam of light changes shape.

Challenges when picking include:

- working blind. To verify the location of the pick, place the tool under the panel, hold it against the panel and look for the change in reflection. Do not press too hard and create a high spot.
- when using a pick hammer, to strike a hammer toward one's self.

I-5 A pick hammer may be used for metal finishing.

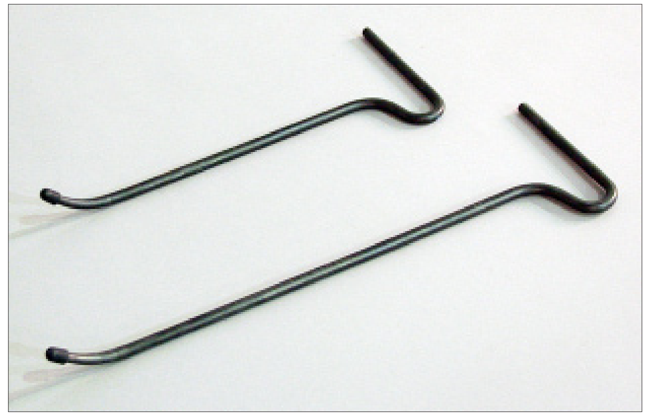
A pick hammer has a pointed tip:

- on one end and typically has a flat head on the other end.
- that is used to raise low spots from the backside of the panel and may be used to lower high spots from the front side of the panel.

I-6 Many different pick tips have been designed to access and remove damage.

There are a variety of different types of picks available including:

- picks of different lengths to reach the damage deep within the panel.
- picks with round or pointed tips that also may be different lengths to reach the damage.
- bullseye picks. Bullseye picks allow the technician to see exactly where the pick will strike. Using a bullseye pick requires access to both sides of the panel.
- paintless dent repair (PDR) picks.



I-7 The length of the pick will usually correlates with how far the damage is into the panel.

Picks:

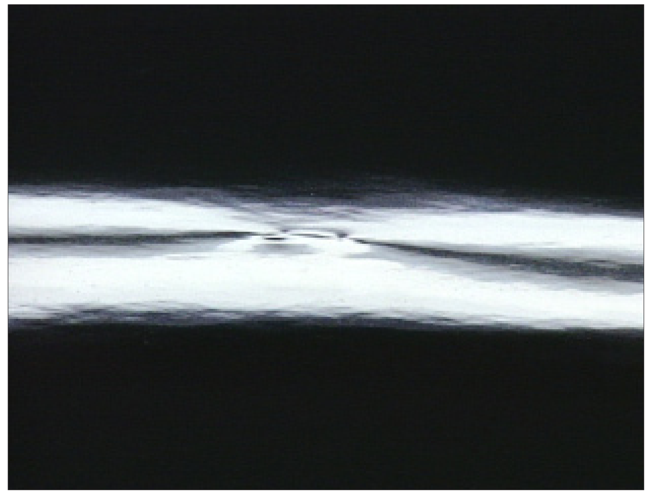
- are used to access hard-to-reach or confined areas.
- are inserted into an existing hole in the panel or used where there is access to the back of the panel. Do not drill holes in undamaged areas to gain access to the damage.
- require a fulcrum point to raise the low spot. To avoid damage, a block of wood can be placed against the panel to act as a fulcrum.

A pick can also be used like a dolly similar to the way that a spoon can be used like a dolly. The handle of a pick allows it to access hard-to-reach areas. A dolly is the preferred method for hammer and dolly operations.

I-8 A fulcrum point is required to raise the low spot.

To remove damage using a pick:

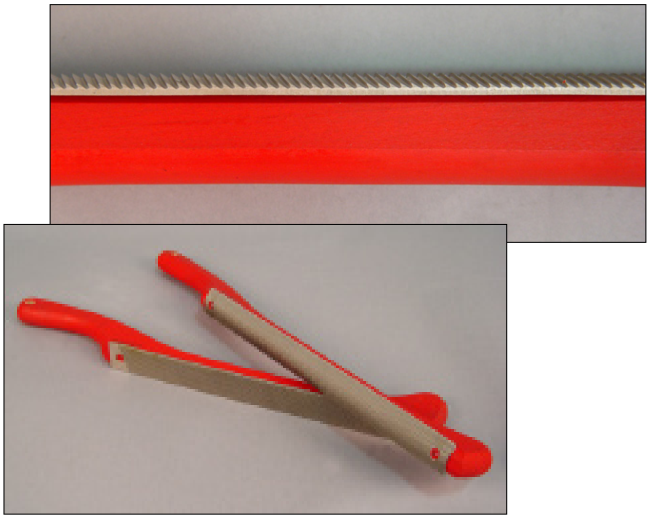
1. Insert the pick through an existing hole. Do not drill holes in undamaged areas.
2. Apply pressure to locate the pick. Watch for the metal to move as an indication of the pick location.
3. Apply additional pressure to raise the low spot.
4. Work around the damage. Do not keep the pick in one area.
5. Check for high and low spots and repeat the procedure until the damage has been removed.



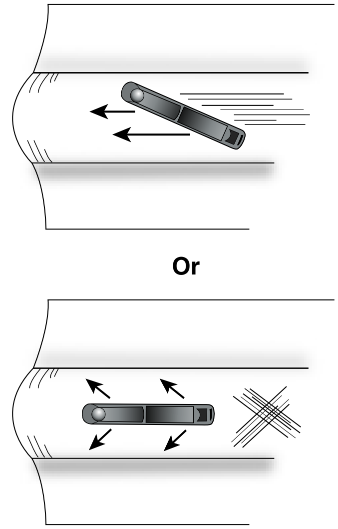
I-9 This unwanted pick mark can be repaired using PDR.

Pick marks that have been raised too far above the contour of the panel and pick marks that strayed away from the repair area require straightening. To lower these high spots in:

- a high crown area, the small end of a combination hammer may be used.
- low crown and flat areas, a flat dolly and light hammer-on-dolly blows may be used.



I-10 The teeth of a body file cut in one direction.



I-11 There are a couple of the ways that a body file may be used.

A body file:

- is used to mark high spots and low spots.
- is available in two different cuts. A body file may have 8 teeth per 25 mm (1") or 6.5 teeth per 25 mm (1").
- may be called a Vixen® file.
- should not be used primarily to remove metal.

Body files are also available in flat and half-round shapes.

When using a body file:

- stroke in the general direction of the flattest crown.
- move forward and shift right or left to widen the cut. Let the front lead the rear of the file because the teeth only cut in one direction.
- crisscross the file marks.

I-12 Even pressure on the body file must be used to accurately identify high and low spots.

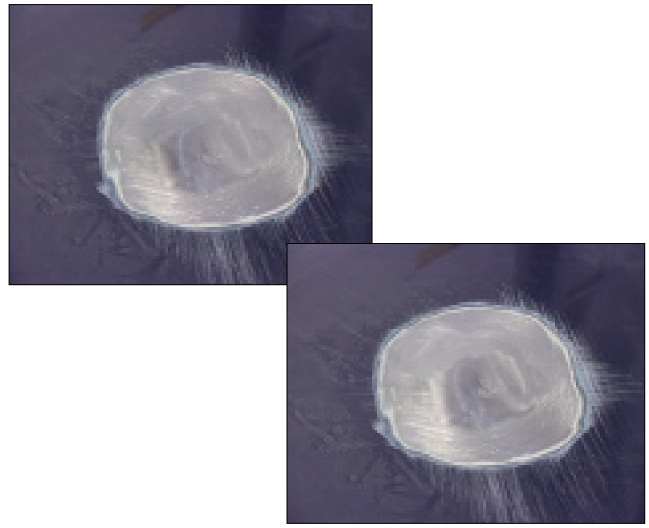
When using a body file:

- the first stroke should contact at least half of the total repair area to have the maximum bridging over low spots.
- use caution to avoid removing excessive metal or making holes in the thin sheet metal. This is important when filing high spots and around panel edges where the metal thickness has already been reduced during panel forming. A sanding board and sandpaper could also be used in place of a file to reduce the amount of material that is removed.

METAL FINISHING A DENT
Refer to screen I-13v of your CD-ROM for a video on metal finishing a dent.

The material in this program will usually focus on one way to repair a particular type of damage, that it is not necessarily the only repair option available.

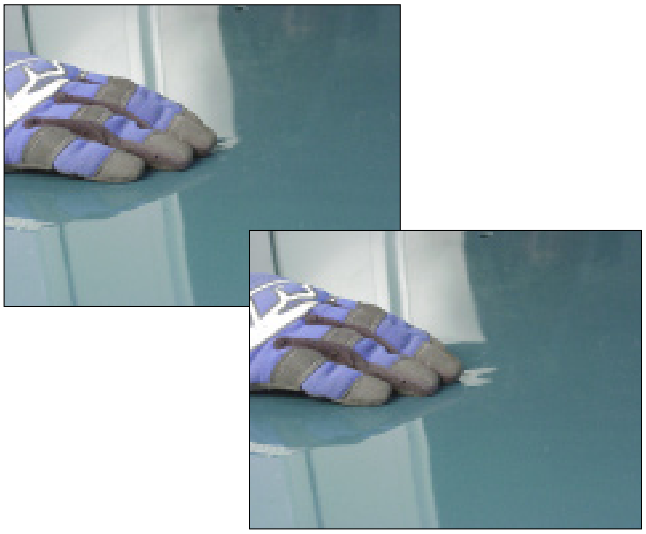
Topic J. Shrinking Theory



J-1 When pushed in, this dent pops back out because the metal has been stretched.

Stretched metal:

- is thinner.
- has a larger surface area.
- is typically found in the direct damage area.
- is typically found along ridges, channels, and buckles.



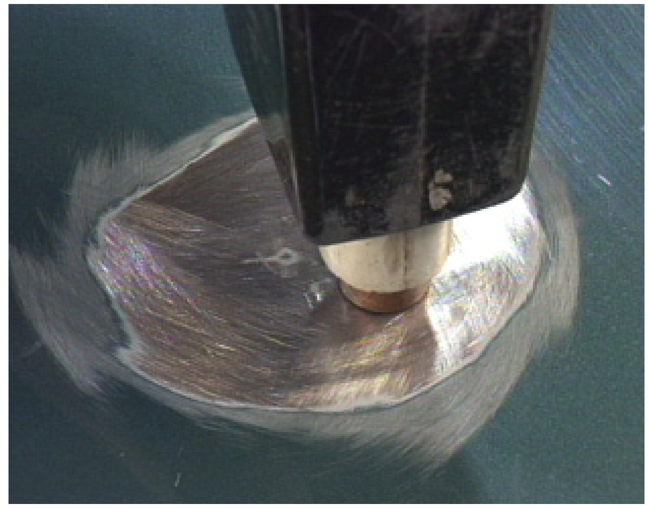
J-2 Light can be used to help identify stretched areas.

Stretched metal is located by:

- pressing on the damaged area in several locations.
- how it reacts. Stretched metal reacts like the bottom of an old oil can. It can be pushed in, but as soon as the pressure is released, the area will pop back out again.

The largest elastic dent is where the metal is stretched the most. The highest area can also be considered the area that is the most stretched.

LOCATING STRETCHED AREAS
Have your instructor lead you through the Locating Stretched Areas activity.



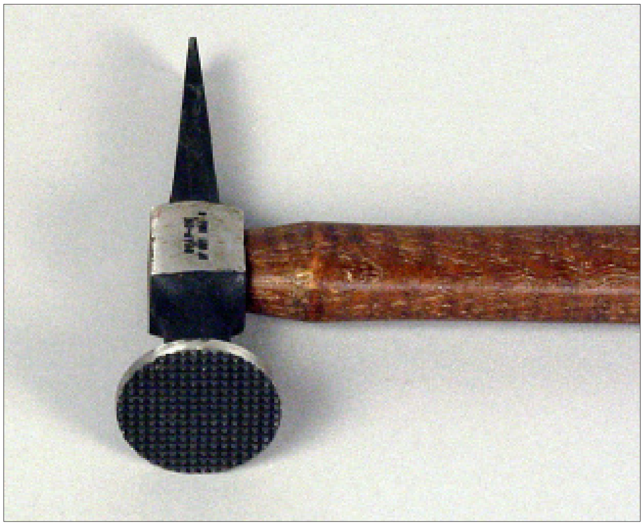
J-3 Stretched metal requires repair before body filler should be applied.

Stretched metal is shrunk to remove the tension. If a tension area is filled with body filler, panel stresses, such as road vibration, may cause the panel to pop or flex and the body filler may crack and fall off.

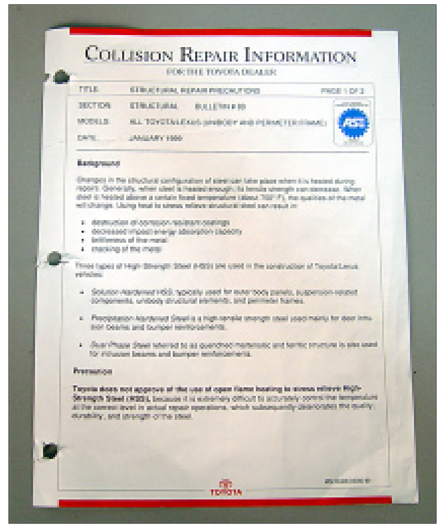
J-4 There are cold and hot methods of repairing stretched metal.

Shrinking can be done:

- cold using a shrinking hammer or shrinking spoon.
- using heat from an oxyacetylene torch, stud gun, dent removal tool, or induction heater.



J-5 The face of a cold shrinking hammer has teeth.



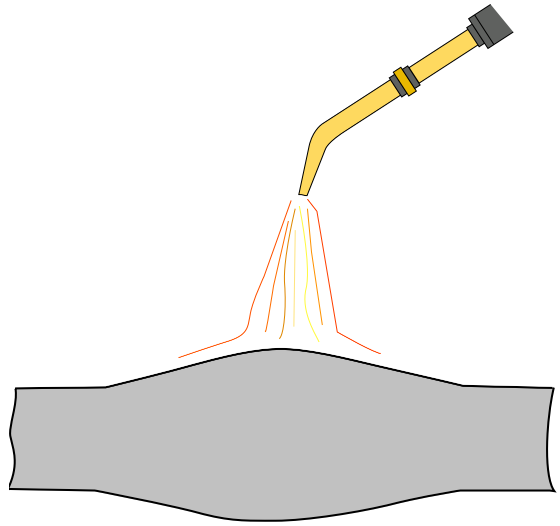
J-6 Check with the vehicle maker for specific heating recommendations.

Cold shrinking:

- is done using a shrinking hammer or shrinking spoon that has serrated teeth.
- is done using the hammer-on-dolly technique with a shrinking hammer or by using a shrinking spoon like a hammer.
- uses the serrated teeth of the tool to form small dents in the metal that draw it tightly together.
- requires continuous monitoring.
- should be repeated until the stretched area regains its strength and there is no longer an oilcan effect.

Before heating a steel part, check the vehicle maker's heating recommendations. The temperature should be monitored using a temperature indicator. HSS is being used to make more body panels than in the past. HSS softens faster and characteristics, such as strength, are affected by excessive heating.

J-7 Temperature indicators are used to monitor the heat affect area.



J-8 Heat causes the metal to expand.

The temperature should be monitored as close to the heat source as possible. Tools that can be used to monitor the amount of heat applied to a part include:

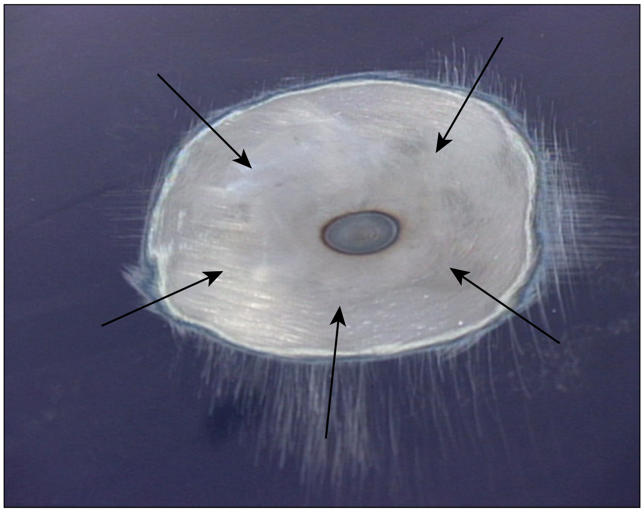
- heat detection crayons. Mark the metal with a heat detection crayon. When the metal reaches the temperature of the melting point of the heat detection crayon, the mark will melt.
- heat detection paint. This works the same way that heat detection crayons work, except the paint is applied with a brush.
- heat monitoring strips. Placed a heat monitoring strip on the area that will be heated and it will change color when the desired temperature is met.
- a noncontact thermometer. A noncontact thermometer reading may be inaccurate when checking bright metallic surfaces.
- a thermocouple with a digital volt ohm meter (DVOM). A thermocouple with a DVOM can be used with a surface temperature probe.

TEMPERATURE INDICATORS

Select the Demonstration icon found on screen J-7 of your CD-ROM for examples of temperature indicators.

Expansion:

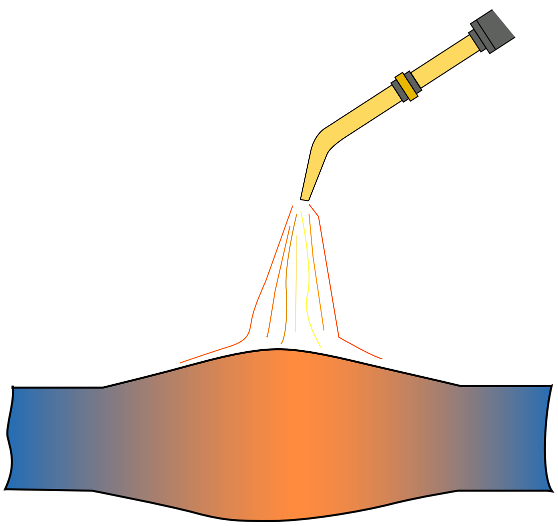
- is an increase in the size of the material.
- occurs when the temperature is raised.
- is variable to the material. Expansion occurs in nearly all materials, but some materials expand and contract more easily and to a greater amount than others.
- causes the metal to push outward in all directions.



J-9 As the metal cools, it contracts.

Contraction:

- is a decrease in size.
- occurs when the temperature decreases.
- is variable to the material.
- causes the metal to gather together.



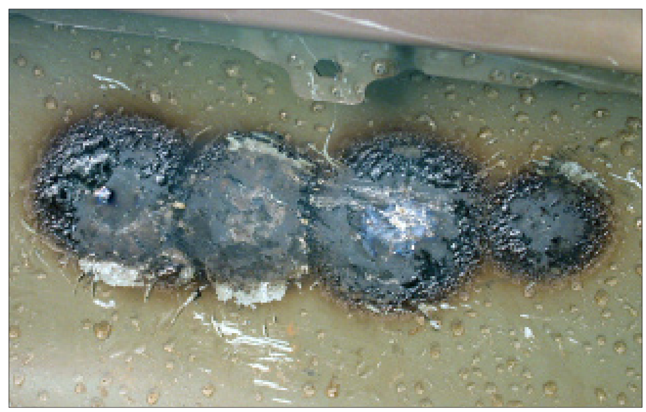
J-10 The colder surrounding metal helps with the heat shrinking process.

The general principle of heat shrinking is that the heat expands the stretched metal while the cooler metal keeps the heat contained. When the hot, expanded metal is cooled, the metal contracts and eliminates the stretched metal. Quickly cooling the metal causes it to contract more than allowing it to cool naturally.

J-11 Applying heat may result in warping the panel.

Heat distortion:

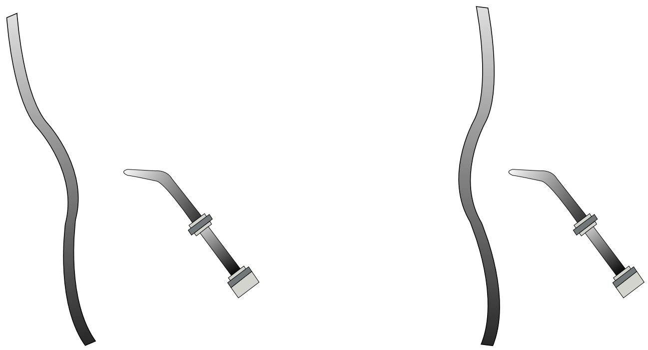
- warps the metal and makes it look wavy.
- is primarily caused by the cooler adjacent metal restricting the metal from expanding when an area is heated.



J-12 Heat transfers from the front side to the backside.

Scale is:

- an iron oxide film that forms on the steel when it is heated.
- heavier on the backside of the heated area.



J-13 For heat shrinking to be effective, the metal should bulge out, not in.

When metal is heated, it expands and pushes outward on the cooler metal. When heated, the metal should bulge out. If it does not, stop heating and straighten more before reheating.

J-14 Minimal temperature is required to shrink thin metal.

The temperature used to heat shrink:

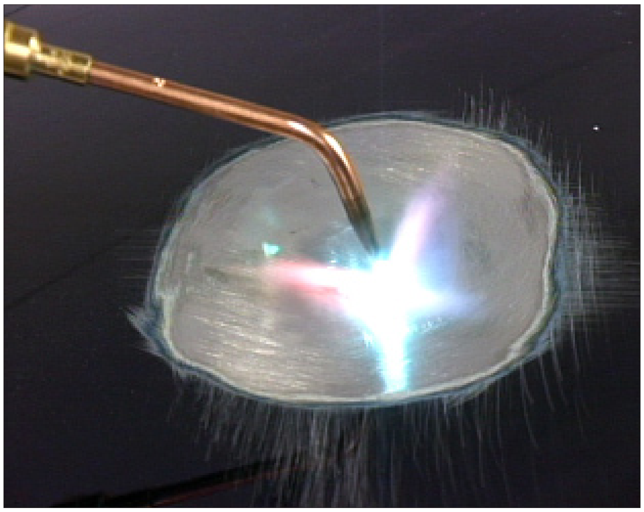
- is not exact and will vary according to the material, location, and the size of the damage.
- should not exceed bright cherry red.
- should be the minimum amount necessary to do the job. Adjacent areas should not be heated if it is not necessary.

General Temperature	Perceived Color
221° C (430° F)	Begins At Pale Yellow
	Straw
	Brown
	Purple
	Light Blue
315° C (600° F)	Dark Blue
	Fades Into Gray Or Greenish
482° C (900° F)	Begins To Turn A Reddish Glow
600° C (1112° F)	Dark Red
700° C (1292° F)	Red
800° C (1562° F)	Red Rose
825° C (1550° F)	Blood Red, Dark Cherry, Medium Cherry, Or Full Red
	Increases In Brightness Through Salmon
900° C (1652° F)	Yellowish Red Or Orange
1000° C (1832° F)	Yellow
1100° C (2012° F)	Lemon Yellow
	Light Yellow Or Pale White
1200° C (2192° F)	White
1300° C (2282° F)	Brilliant White
1427° C (2600° F)	Melting Point

J-15 The color of the steel can indicate the approximate temperature.

The color of steel changes when it is heated. The light that the metal is viewed in also changes the color slightly, for example:

- the red range of color looks different in dim light when compared to sun light.
- colors below the red range are not affect by the light condition.

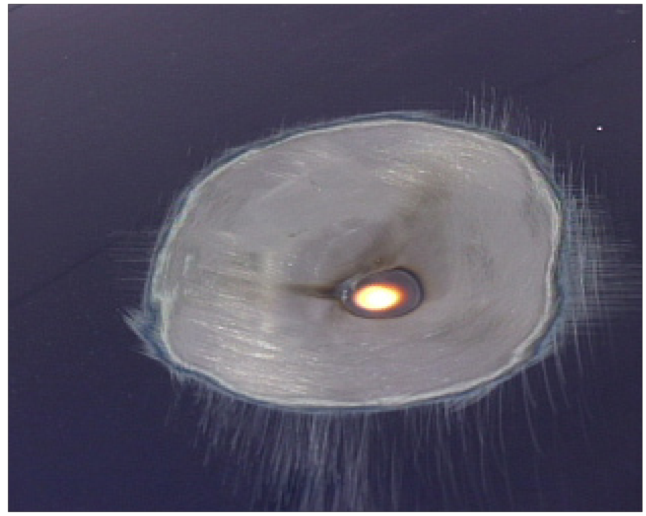


J-16 The heat should be focused directly in one spot, not the entire stretched area.

When shrinking stretched sheet metal:

- start with the highest area and work towards the lowest area.
- the area should be proportionate to the area of distortion, but never larger than the diameter of the body hammer face being used.
- make sure that all of the stretched metal has been removed to avoid body filler failure.

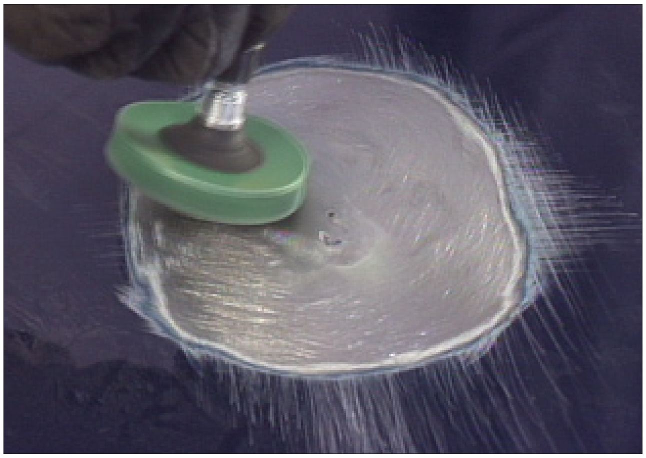
Interior trim removal may be required when heat shrinking because it is important to know what is behind the damaged area. Part removal or relocation may be required to prevent damaging parts such as wiring, control modules, etc. Noise, vibration, and harshness (NVH) materials are also often located behind panels and are combustible.



J-17 The red spot is where the metal is the softest.

When steel is heated, it begins to soften the same time the color begins to change and progressively softens as the temperature rises. The metal must be soft enough to relieve the stress of the stretched metal. Red heat is not always required.

Topic K. Shrinking

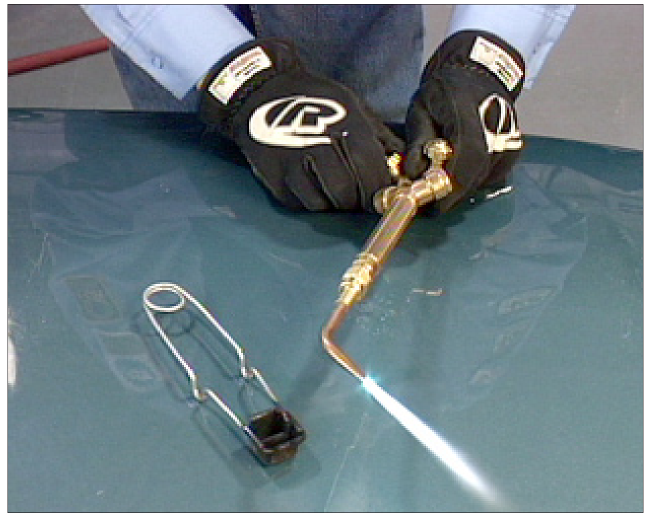


K-1 A plastic abrasive wheel may be used to remove the coatings without removing the metal in the repair area.

Before shrinking:

- straighten as much as possible and as close to the original contour as possible.
- remove coatings from the front side and the backside if using a dolly. Heat will burn the coatings and transfer them to the face of the body hammer or dolly.

Be sure to remove all metal objects such as rings, watches, necklaces, coins in pockets, etc. These objects can heat up when using an induction heater.



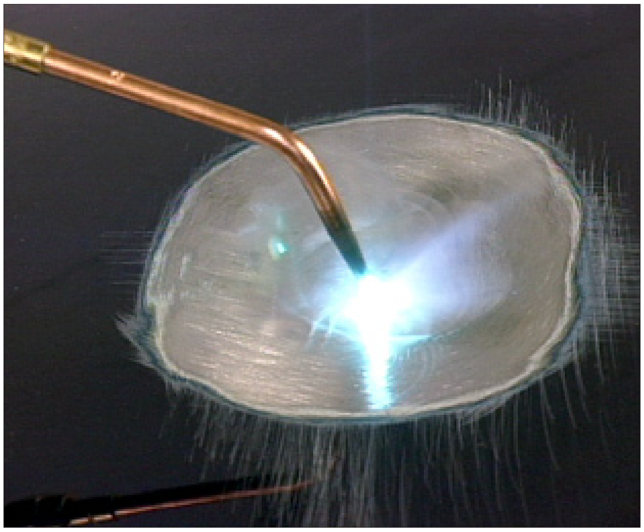
K-2 A neutral flame has the inner and outer cones in alignment with each other.

To heat shrink a stretched area using an oxyacetylene torch:

- heat the area, straighten it, then cool it.
- use a neutral flame and a small tip.
- hold the flame cone at a 90° angle to the panel and about 3 mm (1⁄8") from surface.
- starting from the center of the shrink location, circle to the outer edges, or start from the outer edges and circle to the center. The technique is a personal preference.
- use small shrinks on low crown and flat areas. Use caution because heat distortion is more of a concern.

When using an oxyacetylene torch, make sure that there is a bucket of water and a fire extinguisher in the immediate area.

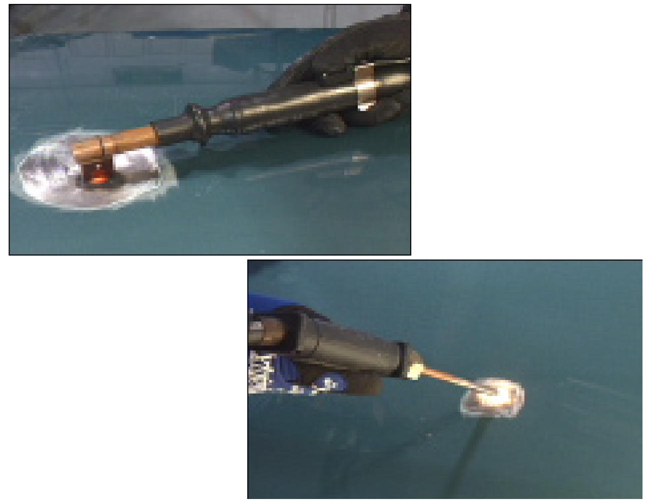
Remove any undercoating, wire harnesses, sound deadening materials, etc. from the backside of the panel to avoid starting a fire. Also, verify that there are no oily rags or flammable materials in the area.



K-3 Black heat is used for a lower temperature heat shrinking process.

Heat shrinking using black heat:

- uses heat below the red range.
- is not practical for work-hardened areas.
- is used for minor shrinking such as large areas that are not severely stretched. A work-hardened area is severely stretched.



K-4 Heat shrinking can be done by inducting heat through electricity.

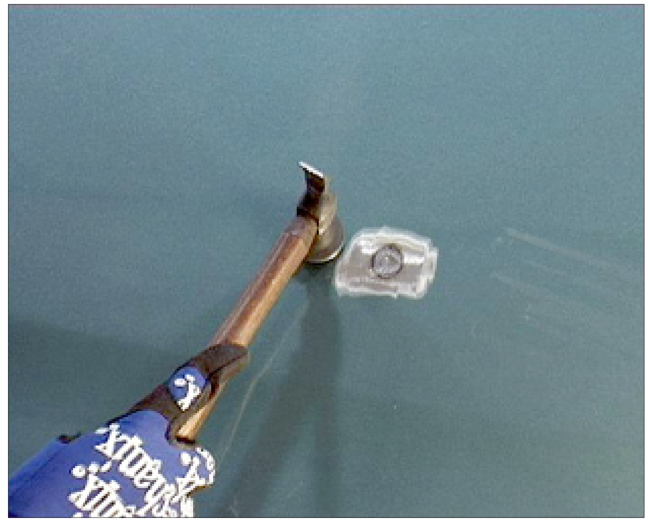
To heat shrink a stretched area using an electrical tool:

- heat the area, straighten it, then cool it.
- a stud gun, dedicated dent removal tool, or induction heater may be used.
- remove any paint coatings around the stretched metal unless using an induction heater.
- press the trigger to initiate current flow. The trigger only needs to be pressed for a couple seconds.

K-5 Tap lightly when hammering during heat shrinking to prevent distorting the softened metal.

When hammering during the shrinking operation:

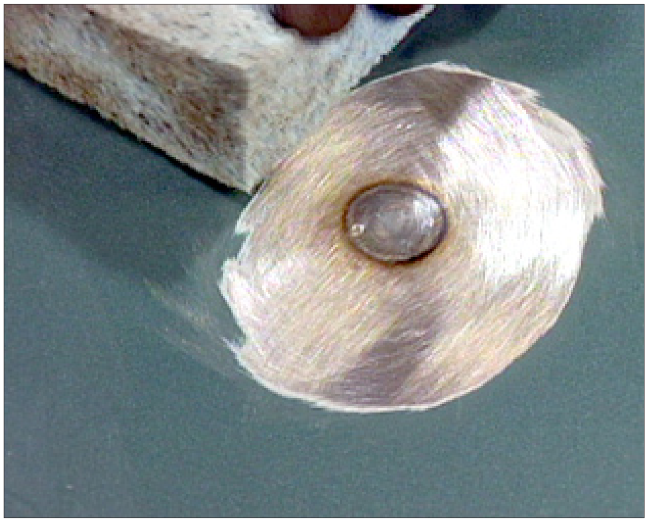
- begin after heating.
- do not make indentations.
- allow for metal contraction and do not hammer the metal completely level with the surface, stop when it is a little high. The metal will continue to contract and lower until it is fully cooled.
- tap lightly and accurately.
- begin in the center then move to the outside edge. There are two techniques for hammering along the outside. Either hammer to work the metal away from the center or toward the center. The technique is a matter of personal preference.



K-6 A dolly is being used on the backside of the panel during this heat shrinking process.

A dolly is not necessary unless the metal collapses when it is first struck with the hammer. When using a dolly:

- hold it lightly to support the panel. Rebounding is not required.
- light hammer-on-dolly and hammer-off-dolly blows are typically required.



K-7 A wet sponge can be used to quench the heated area.

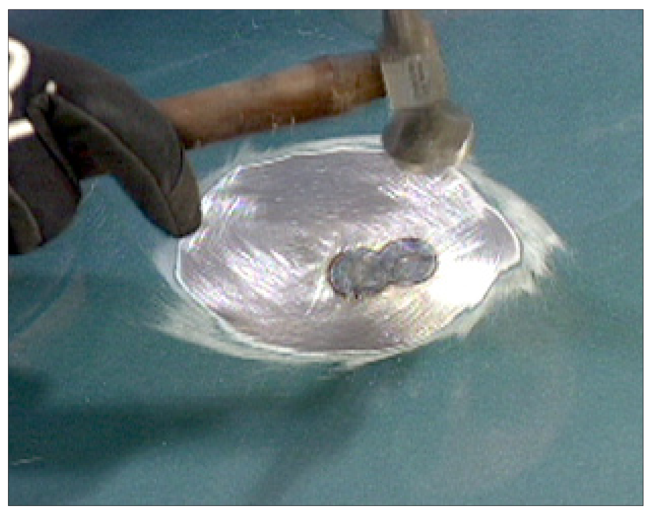
Quenching:

- is done before the metal is cooled, but not while it is still red.
- shrinks the area more than cooling naturally. There are various degrees of contraction. The faster the metal is cooled, the more it will contract and shrink.
- is done by moving a wet sponge, rag, or compressed air back and forth while monitoring the shrinking or contracting. It is difficult to monitor the shrinking if the wetting object is held stationary.
- is not always necessary.

K-8 Notice the gap between the straightedge and the panel indicating overshrinking.

Overshrinking:

- may result from overquenching.
- has a gathering effect after the metal cools completely which forms distorted metal.
- is typically caused by the last area that was shrunk.
- distortion spreads along the panel into areas that may not have been previously damaged.



K-9 The hammer-on-dolly technique is used to repair to an overshrunk area.

To repair an overshrunk area:

- focus on the area that was shrunk last.
- use the hammer-on-dolly technique to stretch the metal back to contour.

HEAT SHRINKING
Refer to screen K-10v of your CD-ROM for a video on different methods that can be used to heat shrink stretched steel.

The material in this program will usually focus on one way to repair a particular type of damage, that it is not necessarily the only repair option available.

Topic L. Shrinking Creases

L-1 The bottom of this door has a long crease in it.

A crease:

- is a sharp dent or gouge in a panel.
- causes stretching.
- must be shrunk. If the crease is not repaired properly, the body filler may crack or pop out.

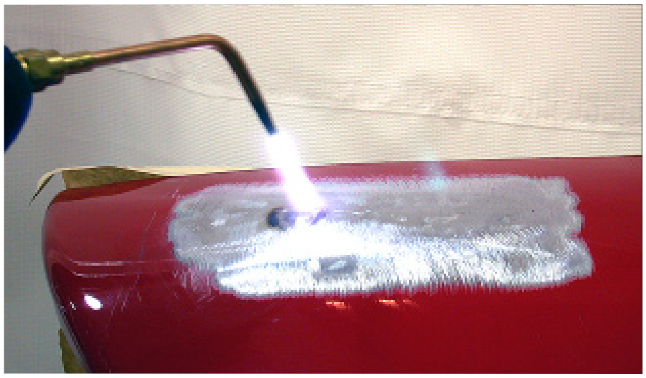
L-2 A sharp crease will stretch the metal.

Shrinking a crease is different from shrinking other stretched areas because a:

- crease is below the surface instead of above.
- crease is typically more severely stretched.
- dolly is required to force the crease out from the backside.

L-3 A dolly can be used on the backside of the panel to raise the crease above the surface.

One method of shrinking a minor crease is to hammer out the crease without using heat, then shrink it like it is raised metal. When using this method, heat to at least dull red, but never bright cherry red. Use caution because the stretched metal in a crease tends to spread over a wider area.



L-4 Typically the sharpest area of a crease is at one end and is gradually worked to the other end.

When applying heat to shrink a crease:

- do not heat more of an area than can be worked with the hammer and dolly.
- heat the entire length of the crease whenever possible.
- start applying heat to the area with the least amount of damage and slow down as the damage increases.

L-5 The hammer-on-dolly technique is used to shrink a crease.

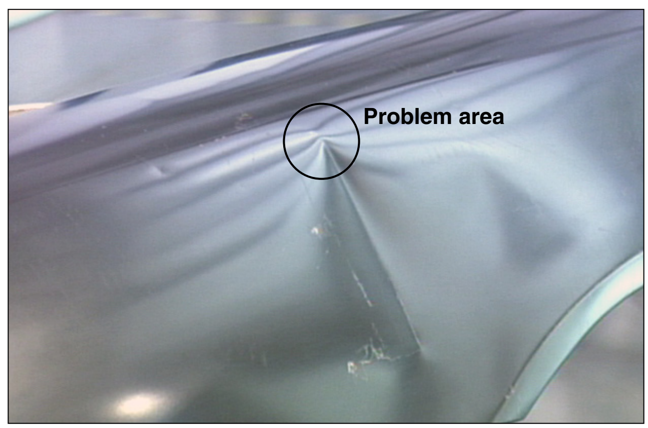
A crease may need to be stretched back:

- because creases tend to shrink more lengthwise than across the width. If allowed to cool without stretching back, the area will be overshrunk and distorted.
- by using the hammer-on-dolly technique as the surface cools.
- as soon as the pressure starts to build and causes distortion.

L-6 This crease was allowed to cool slowly without quenching.

Quenching a crease:

- is typically not required.
- should not be done until the surface is cool enough that steam does not rise.
- may cause overshrinking if not done properly.

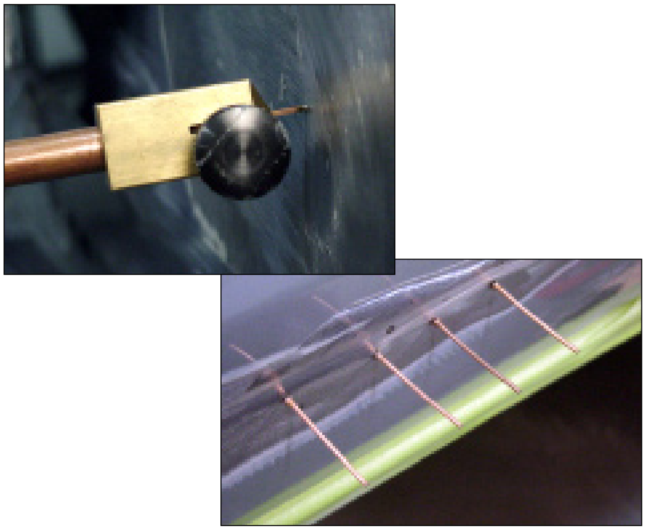


L-7 The metal in this area is compressed, not stretched.

A false stretched area:

- is found in a smooth, unworked area where tools were not directly used.
- looks like stretched metal but may not act like stretched metal.
- is actually compressed metal.
- may be caused by improperly repairing a buckle.

Topic M. Weld-On Dent Removal

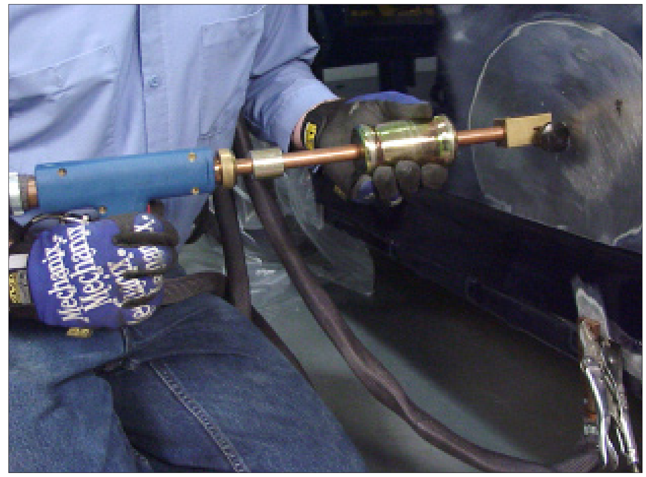


M-1 Weld-on dent removal tools are removed after the damage has been repaired.

Weld-on dent removal tools:

- have attachments that are welded to the panel and used to pull out the damage.
- are used to repair damage in areas with limited or no access to the backside.
- may be used to repair hail damage and damage to feature lines.
- require interior trim removal to identify what is behind the damaged area. If this is not done, a fire could start inside the vehicle.

Interior trim removal may be required when using weld-on dent removal tools because it is important to know what is behind the damaged area. Part removal or relocation may be required to prevent damaging parts such as wiring, control modules, etc. Noise, vibration, and harshness (NVH) materials are also often located behind panels and are combustible.



M-2 All weld-on dent removal tools require a ground to complete the weld cycle.

Types of weld-on dent removal tools include:

- a stud gun.
- spot welder attachments.
- dedicated dent removal tools.

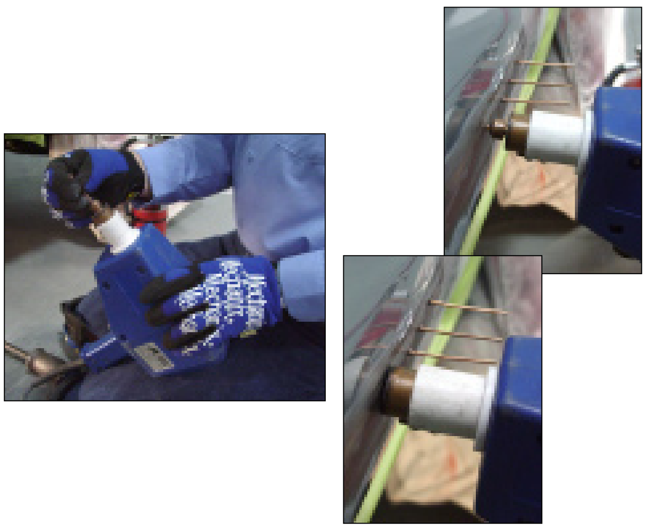
M-3 A kit may be available that includes the stud gun, pins, and slide-hammer.

Stud gun dent removal:

- uses a stud gun to weld attachments to the panel.
- attachments include studs, pins, washers, and wiggle wire.
- uses a slidehammer or a mini-puller to raise low spots.
- may also have a shrinking tip that may be used to heat shrink stretched metal.
- may also have a wiggle wire tip that is used to weld the wiggle wire to the panel.

Avoid drilling or punching holes in panels that are going to be reused. Only make holes when the panel is going to be replaced or under unusual circumstances. This is recommended because:

- drilling or punching weakens the panel and should be avoided.
- holes make the panel more prone to corrosion.
- the holes require welding shut and additional corrosion protection is required.



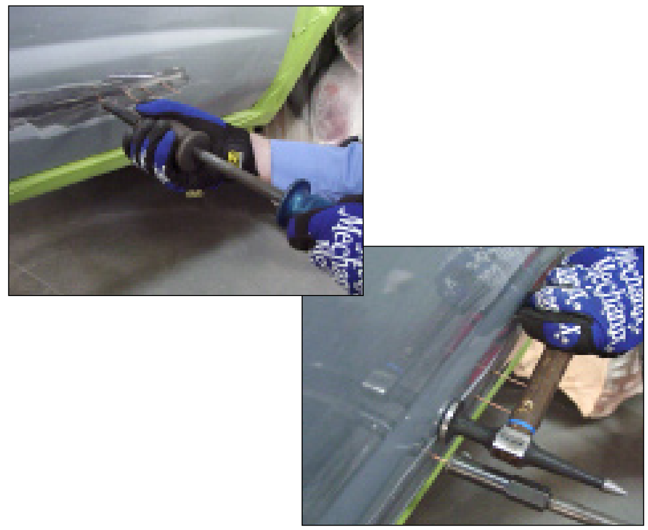
M-4 Pins are one type of attachment that can be used with a stud gun dent removal tool.

To use a stud gun:

- remove the paint. The tip and stud gun ground collar, or ring, must contact bare metal to complete the circuit which welds the attachment to the panel.
- insert the stud, pin, or washer into the tip of the stud gun.
- place the stud gun against the panel until the ground collar is in contact with the bare metal and pull the trigger. The trigger should only be depressed for about one second.

Personal safety equipment that should be worn when using a stud gun includes:

- safety glasses or goggles.
- gloves.
- particulate respirator or combination particulate/vapor respirator.



M-5 While a slidehammer is applying pressure to the pin, a hammer is used to relieve the tension on the panel.

A slidehammer:

- may be threaded. This type is used with pins.
- may have a hooked end. This type is used with washers. Other hook-type ends may be used to attach to finger pullers that are used with wiggle wire.
- has a strike weight which is used to initially raise the low spot.
- should remain attached to the panel with tension applied while the high spots are hammered down.
- may be the mini-puller type which is used for light damage and tight areas.

SLIDEHAMMER
Select the Demonstration icon found on screen M-5 of your CD-ROM for examples of slidehammers and tip attachments.

M-6 The design of the spot welder attachment may differ from equipment maker to equipment maker.

M-7 Leverage bars and dent removal tools may be dedicated just for dent removal.

Spot welder attachments:

- work similar to a stud gun.
- are much larger than stud gun attachments.
- may include a gun attachment.
- may include a slidehammer attachment. A pin at the end of the slidehammer is welded to the panel and the slidehammer is used to raise a low spot. Once the low spot has been raised, a twist of the gun and slidehammer attachment breaks the pin free. There is also a washer installation tip available that can be used with a hooked-end slidehammer.
- may include a mechanical handle. This attachment has a pin that can be welded to the panel and a plate that acts as a base that rests against the panel. By squeezing the handle, the pin that is welded to the panel raises the low spot. The pin height is adjustable.
- allow for more precise controls compared to a stud gun.

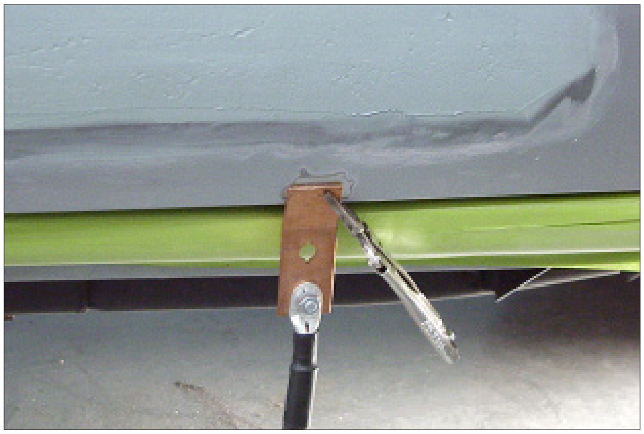
These attachments can be used when metal finishing because a stud is not left welded to the panel surface.

SPOT WELDER ATTACHMENTS
Select the Demonstration icon found on screen M-6 of your CD-ROM for examples of spot welder attachments.

Dedicated dent removal tools:

- weld handles, studs, washers, wiggle wires, or a slidehammer to the damaged panel.
- may use a leverage bar. A handle is welded to the panel. The leverage bar slides over the handle and has a base that acts as a fulcrum against the panel to raise low spots.
- may use finger puller for wiggle wire. After attaching the wiggle wire, the finger puller is used to raise the low spots. Creases may be repaired using wiggle wire.

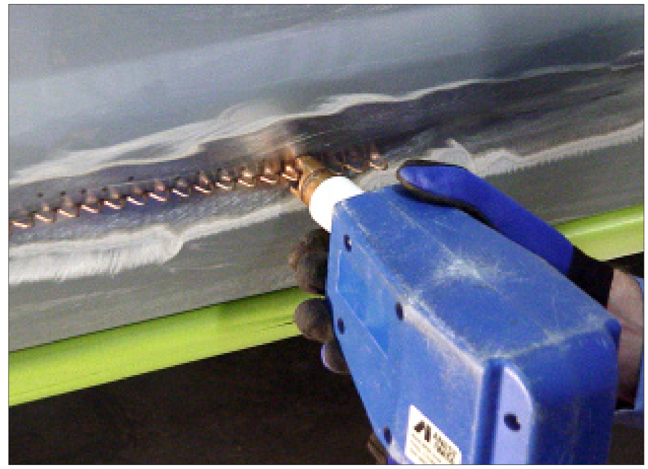
DEDICATED DENT REMOVAL TOOLS
Select the Demonstration icon found on screen M-7 of your CD-ROM for examples of dedicated dent removal tools.



M-8 Paint coatings must be removed from an area of the panel so that a ground plate can be attached.

To use a dedicated dent removal tool:

- a ground plate must be attached to a bare metal area on the panel. The ground plate may be attached magnetically, to a stud, or clamped.
- set the current and time on the machine following the machine maker's recommendation. The recommendation will be based on the type and thickness of the panel.



M-9 Wiggle wire can be attached to the lowest point of a crease to help repair the area.

Although slightly different, the procedure for using a stud gun, spot welder, and dedicated dent removal tool is similar. A general procedure would be:

1. Remove the paint coatings from the damaged area following the machine maker's recommendation.
2. Weld studs, washers, pins, handle, or wiggle wires to low spots.
3. Use the slidehammer, leverage bar, or finger pullers to raise the low spots.

M-10 A hand puller may be used with wiggle wire to apply pressure similar to a slidehammer.

A general procedure for using a weld-on dent remove tool would be:

4. Use a body hammer to lower adjacent high spots while applying tension to the slidehammer, leverage bar, or finger pullers.
5. Remove the studs, washers, pins, handle, or wiggle wires after restoring the panel to the proper contour. They may also require removal to allow access to additional attachment areas. Studs, washers, pins, and wiggle wires can be cut or twisted off with side-angle pliers and ground flush. A welded handle can be removed by twisting the handle.
6. Grind the surface flush and prepare the repair area for body filler.

Following weld-on dent removal, corrosion protection materials must be applied to the backside of the panel. Interior and exterior trim may require removal to access the backside.

After using a weld-on dent removal tool, a GMA (MIG) welder should be used to weld any holes that were accidentally formed during straightening.

WELD-ON DENT REMOVAL

Refer to screen M-11v of your CD-ROM for a video on removing damage using weld-on dent removal tools.

The material in this program will usually focus on one way to repair a particular type of damage, that it is not necessarily the only repair option available.

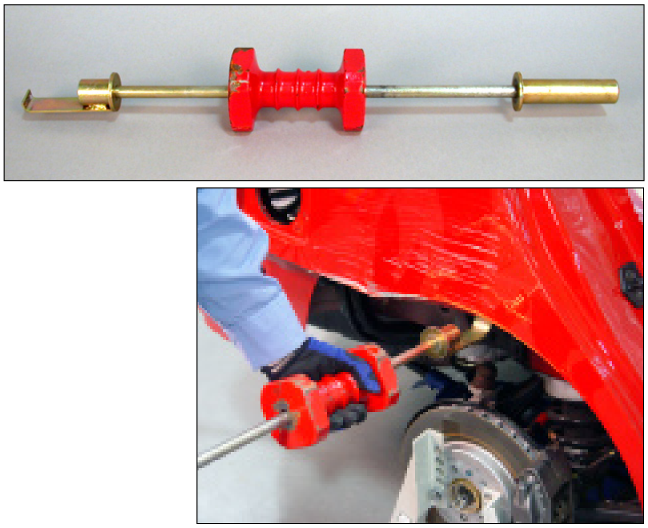
Topic N. Other Repair Methods

N-1 After using suction to repair damage, refinishing may not be required.

Suction tools for repairing damage:

- include the handheld type. These are similar to suction cups used for glass installation.
- include the pneumatic type that attaches to an air hose.
- include a combination machine that uses suction and welding. This machine has a pin that is welded to the panel and air is used to raise the dent to a predetermined height.
- are generally used for large, shallow dents.
- will not easily pull out dents that are locked in by a crease.

SUCTION TOOLS
Select the Demonstration icon found on screen N-1 of your CD-ROM for examples of suction tools.



N-2 A flat hook tip used with a slidehammer can be used to gain access at the edge of a panel.

A flat hook tip on a dent puller or slide hammer may be used to straighten the edges of panels.

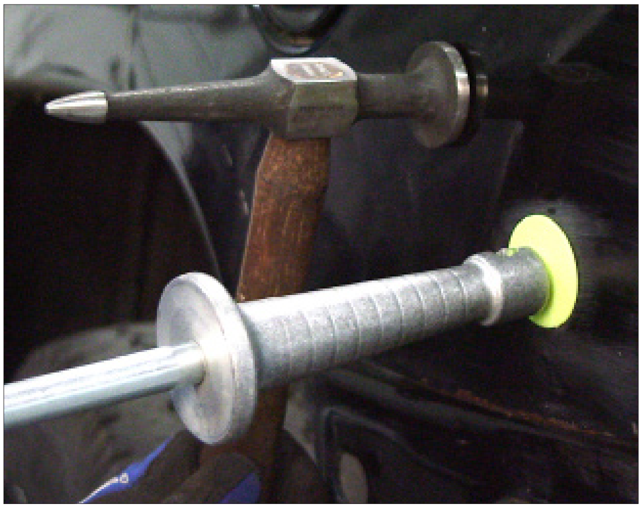
N-3 Adhesive dent removal kits are available that include equipment required for repair.

Adhesive tools used to repair damage use:

- glue sticks.
- a variety of discs of different shapes, sizes, and strengths.
- a hot glue gun to melt the glue sticks.
- a slidehammer or bridge that attaches to the discs.

Adhesive dent removal tools may be used to remove damage with no access to the backside of the panel.

ADHESIVE TOOLS
Select the Demonstration icon found on screen N-3 of your CD-ROM for examples of adhesive tools.



N-4 This slidehammer slips over the collar of the adhesive disc.

One procedure for using adhesive discs to remove damage is:

1. Clean the damaged area using the recommended cleaner.
2. Choose the appropriate disc for the dent and apply glue to the middle of the disc. New discs should be scuffed before using.
3. Glue the disc to the lowest point of the damage and allow it to cool. Pressurized air may be used to cool the glue.
4. Attach the slidehammer to the disc or use the bridge to raise the dent.
5. Use a heat gun to soften the glue and remove the disc from the panel.
6. Remove the excess glue residue using the recommended cleaner.

Additional personal protection required when applying or removing an adhesive disc includes:

- gloves.
- a vapor respirator.

Do not store or use cleaning solvent near open flames or welding sparks.

Topic O. Review

REVIEW

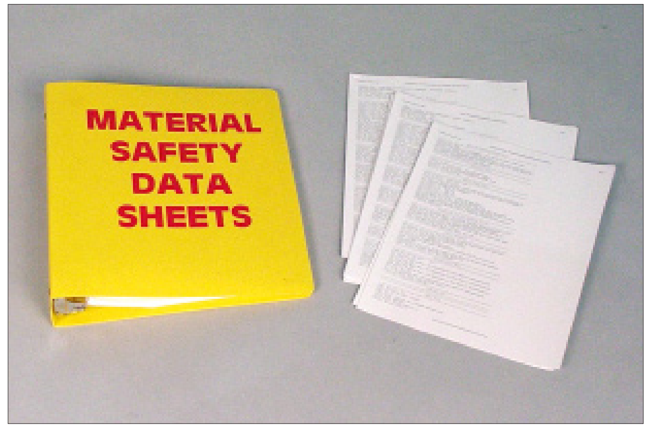
Refer to screens O-1 through O-2 of your CD-ROM for review questions on repairing damage.

MODULE 3–BODY FILLERS AND SANDING

Topic A. Background Information On Body Fillers

Body fillers have come a long way, for example:

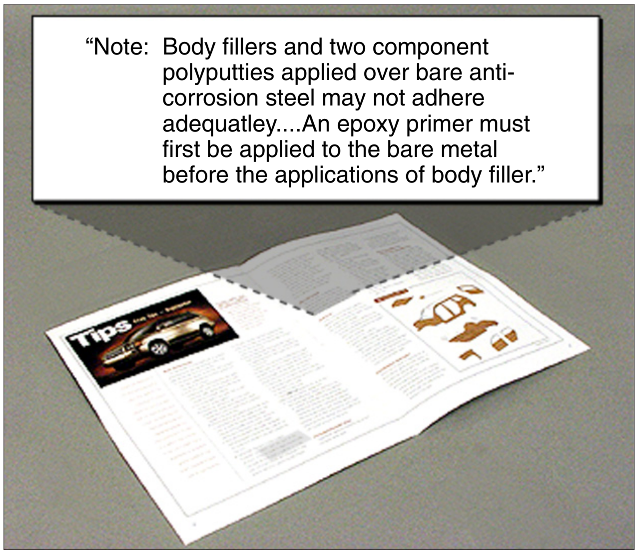
- in the early 1950s, epoxy-based body fillers were developed. They were usually mixed with aluminum powder. Epoxy body fillers cured very slowly and did not cure at all if applied too thick.
- in the mid 1950s, the first polyester resin-based body fillers were developed. They were made from the same resin used to make fiberglass boats. They required mixing with liquid hardener and accelerator. The early polyester body fillers were also very brittle and hard because fiberglass resin was very brittle when cured and depended on the cloth or matte for flexibility.
- the first successful body filler was named "Bondo." Many collision repair technicians still refer to body fillers as Bondo. Early body fillers were composed of approximately 40% resin and 60% talc by weight. The Bondo Corporation is still in existence.
- when early body fillers and hardeners were mixed together, the body fillers cured very hard. Early body fillers were difficult to file and had to be leveled with a grinder.
- as technology developed, body fillers became softer, easier to apply, and easier to shape.
- body fillers soon appeared in black, red, gray, white, and yellow. Cream hardeners were developed in contrasting colors red, white, green, and blue.
- a cheese grater could be use to sand the soft body filler. This reduced the amount of sanding that was required.
- today's body fillers use very fine grain talc to provide superior workability, sandability, and featheredging.
- high-quality resins ensure excellent adhesion, flexibility, and quick curing properties.
- thinner metals made the old lead repair method almost obsolete. The heat that is required for lead filler warped thin panels, and hammer-and-dolly techniques stretched metals too thin for filing.



A-5 The material safety data sheet contains information for personal safety.

Personal safety when working with body filler includes:

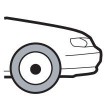
- reading the material safety data sheet (MSDS).
- keeping heat and open flames away from body filler.
- avoiding skin contact with body filler and sanding dust. Wear neoprene gloves, a long sleeve shirt, and pants. Ingredients in body filler can be absorbed through the skin and may cause liver damage.
- avoid inhaling vapors and sanding dust. Use a dustless sanding system when possible. Wear a particulate or combination particulate/vapor respirator when sanding. Sanding dust may cause lung and liver damage.
- wearing safety glasses.



A-6 This vehicle maker recommends applying an epoxy primer before body filler application.

Body filler is:

- used to fill minor imperfections. Body filler should not be used to fill areas that were repaired using poor or improper straightening techniques.
- applied to bare metal or over epoxy primer. Follow the body filler maker's recommendation for surface preparation. If using an epoxy primer, make sure that it is from the same product line that will be used for the refinishing process. Do not intermix paint products, stay with one system.
- not applied over metal cleaner or conversion coatings. The chemicals used in these products can adversely affect the body filler.



Body filler should not be applied to the windshield pinchweld area.

Topic B. Body Fillers

B-1 Body filler is made of a solid material and a binder.

Body filler is made of a solid material and a binder. Types of solids that are used include talc, microspheres, fiberglass strands, and aluminum.

B-2 Polyester resin is the most common binder in body filler for collision repair.

The binder in body filler:

- holds the body filler pigments together after the solvent evaporates.
- is polyester resin in most body fillers.

Body fillers have many names such as conventional, premium, lightweight, heavyweight, polyester, metal, and fiberglass. Most types of body fillers use polyester as the resin. The term "polyester filler" may be used to describe body fillers that use talc or microspheres as the solid and polyester as the binders.

B-3 A cheese grater may be used to remove the shiny paraffin produced by some body fillers

B-4 Corrosion will typically bubble under the paint before it breaks through and creates a hole.

Body filler paraffin:

- is produced by some body fillers.
- is a waxy film that forms and prevents oxygen absorption.
- must be removed before sanding. Wax and grease remover or a cheese grater may be used to remove body filler paraffin.

Some body fillers are hygroscopic which means that they absorb moisture. Holes, cracks, and joint gaps should be welded before body filler is applied to prevent moisture from coming in contact with the body filler. It is also important that these areas are corrosion protected.

B-5 Talc is the basic pigment in many of today's body fillers, but it is not the only pigment.

Talc-type body filler:

- must be sanded shortly after it has cured because of the high degree of hardness.
- will absorb moisture.

Talc-type body fillers are not widely available. Talc is a mined mineral that is pulverized and screened into different grades according to size.

B-6 Lightweight body fillers offer easier sanding compared to other types of body fillers.

Microsphere-type body filler:

- has a certain percentage of the talc that had been replaced with microspheres.
- has microspheres that are suspended in the resin, technically called homogenous. Microspheres do not settle to the bottom of the can like talc.
- may be considered a finishing filler.
- has better filling and is more easily sanded compared to fiberglass, aluminum, and talc body fillers. It is more water resistant than talc body filler because of the microspheres.

B-7 Fiberglass body filler may be packaged similar to talc and microsphere body fillers.

Fiberglass body filler:

- is reinforced with fiberglass.
- may use the same type of hardener that is used for talc and microsphere body fillers.
- is not a finishing filler. Fiberglass body filler is not used for filling minor surface imperfections because it does not allow the technician to create a finished surface that is smooth enough for priming and refinishing.

B-8 A long-hair fiberglass filler may be more difficult to smoothly apply compared to a short-hair type.

Fiberglass body filler:

- can be used on metal and fiberglass.
- is stronger than talc or microsphere body fillers. This also makes it harder to sand.
- is water resistant. This makes it a popular choice for repairing damage caused by corrosion.
- may be the short-hair or long-hair type. The long-hair type is stronger than the short-hair, but it is also harder to mix.

B-9 The hardener for aluminum body filler is thinner than the hardener for the other types of body filler.

Aluminum body filler:

- is made of an aluminum powder and resin.
- uses a liquid hardener that is different from the talc, microsphere, and fiberglass body fillers.
- is water resistant. This makes it a good choice for repairing damage caused by corrosion and for vehicle restoration.
- is stronger than talc, microsphere, or fiberglass body fillers. This also makes it more difficult to sand.

B-10 Compared to the other types of body filler, it is not as easy to tell when aluminum body filler and hardener are mixed thoroughly.

Aluminum body filler:

- was introduced in 1965. The solid part of aluminum body filler is 100% aluminum.
- is difficult to mix properly. There is no color change when the harder and body filler are mixed together.

B-11 A spot putty may be a one-part or two-part product.

Spot putty:

- is used to fill minor surface imperfections such as scratches and pinholes.
- typically has a maximum recommended fill thickness of 3 mm ($^{1}/_{8}$"). Check product maker's recommendations, 0.8 mm ($^{1}/_{32}$") may be recommended for one-part products.
- is available as a one-part or two-part product.

Spot putty is also called glazing putty.

B-12 One-part spot putty is typically packaged in a tube.

One-part spot putty:

- cures slowly. It could take hours to days to cure. The spot putty must be fully cured before it is sanded or refinished.
- has good featheredging characteristics which makes it desirable.
- may absorb solvents and swell. Solvent penetration is where the pigments in the body filler bleed through and are visible under light colored topcoats.
- is typically lacquer-based. Polyester is not used as the binder.
- is typically not recommended.

B-13 Two-part spot putty is typically packaged similar to a polyester-based body filler.

Polyester glazing putty:

- is a two-part spot putty.
- may be used over bare metal, scuffed paint, or body filler. It should not be applied over metal cleaner or conversion coatings. Check the paint maker's and product maker's recommendations. Polyester glazing putty is not required on all repairs.
- should be sanded to contour using P180 grit or finer. Follow the paint maker's recommendation for finish sanding grit.

B-14 Thin coats of polyester glazing putty should be used.

Polyester glazing putty:

- is more fluid and easier to sand than other types of body filler.
- has limited shrinkage.
- resists solvent penetration.

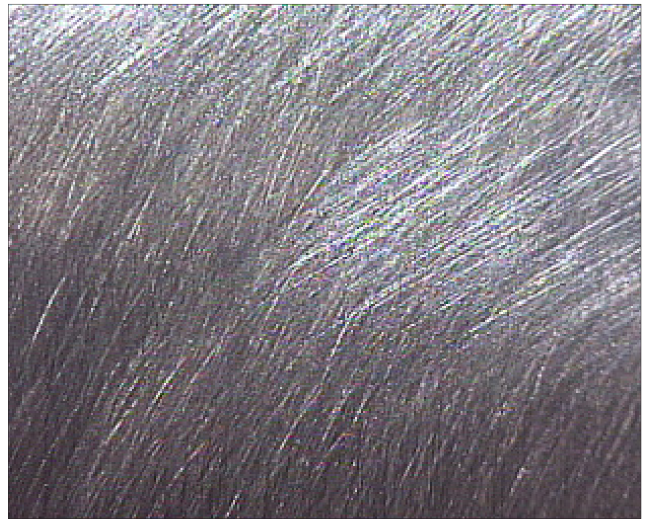
STEPPED-OUT BODY FILLER PANEL
Select the Demonstration icon found on screen B-14 of your CD-ROM for an example of a panel in various stages of repair.

Topic C. Preparation For Body Filler

C-1 A primer may be recommended before body filler is applied.

Although it is usually recommended to apply body filler over bare metal, some product and vehicle makers may recommend applying body filler over an epoxy primer. Follow the paint maker's recommendations for primer application. Body fillers are usually not applied over self-etching primers. The acid used in self-etching primers can cause the body filler to blister, bubble, crack, or lift.

C-2 Body filler should not be applied to a smooth painted surface.



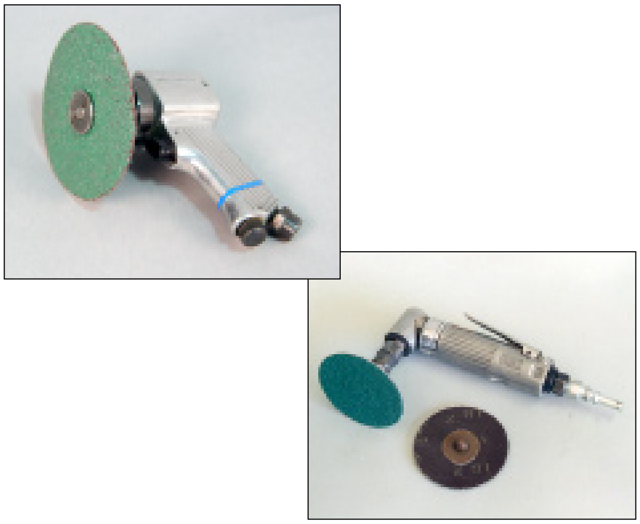
C-3 Sanding creates a ruff surface for the body filler to adhere.

When abrading, or sanding, the surface before applying body filler:

- remove at least 80–100 mm (3–4") of paint around the area where the body filler will be applied.
- use a sander or a grinder. A media blaster may also be used with a mildly aggressive material.
- generally 36–80 grit is used.

When determining if the surface should be abraded to bare metal, consider the:

- body filler maker's recommendations.
- vehicle maker's recommendations.
- size of the damage.
- method that will be used to remove the damage.
- affect on adhesion between the body filler and the surface.



C-4 Determining the proper size grinding disc is dependent on access to the damage.

A grinder:

- may be used to abrade the surface before applying body filler.
- is available in a variety of sizes. Use the size that matches the size of the repair area and is able to access the damage.
- uses grinding discs and paper. Grinding discs and paper are stiffer than sanding discs and sanding paper.

Personal safety when using a grinder includes:

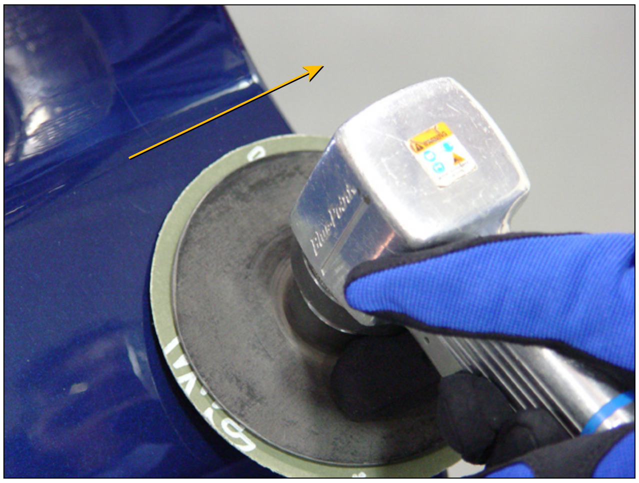
- protect eyes, face, and body from sparks and the grinding disc. Do not wear loose clothing or jewelry when grinding. Wear long sleeves.
- do not free-rev the grinder. Pieces of the grinding disc could break off and become projectiles.
- check the condition of the backing plate and grinding disc for cracks and chips. Replace if cracked or chipped.

Vehicle protection when using a grinder includes protecting the surrounding surface from sparks and accidental grinding. Areas that require attention include panel edges, painted areas, trim, glass, and the interior. Remove parts, mask them off, or cover them for protection.

C-5 The face of the grinding disc should not be held flat to the surface of the panel.

When using a grinder to remove coatings:

- hold it at a 5–20° angle to the surface.
- apply just enough pressure to make contact with the surface. Excessive pressure may remove too much material including metal, cause discoloration, or cause panel distortion due to heat.



C-6 The rotation of the grinding disc should move off the edge of the panel, not into it.

When using a grinder to remove coatings:

- sweep from side-to-side, not in circles.
- use overlapping strokes. Side-to-side, overlapping strokes is called cross-cutting and is used to identify high and low spots. The paint will be removed from the high spots and will remain in the low spots.
- do not hold the grinder in one place.
- grind so that the disc spins off of an edge, not into it. If a disc is spun into an edge or a sharp area, it may cut too deeply or it may tear apart the disc and create projectiles.

C-7 If large grinding particles are not removed before additional sanding, they could cause deep sand scratches.

After grinding the surface in preparation for body filler:

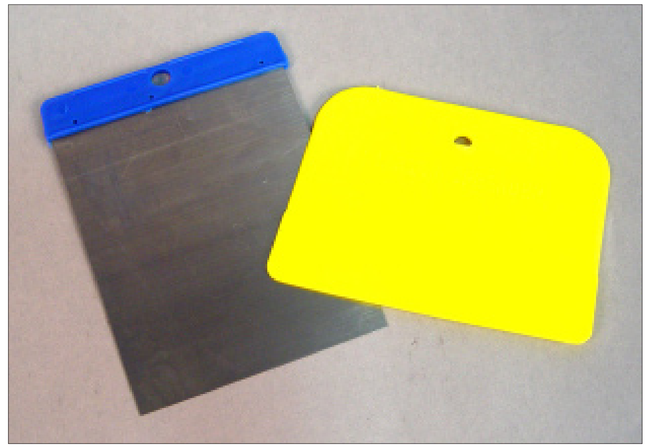
- use compressed air or a vacuum to remove the grinding particles.
- make sure the area is dry and clean.

C-8 The paint is sanded so that the edge of each coat is visible.

Featheredging the paint:

- is sanding to level out the harsh lines around the repair area and other minor damage to the finish. Minor damage may include scratches and nicks.
- is done before or after body filler application. If the paint is featheredged before body filler is applied, featheredging may also be required after the body filler is sanded to contour. When to featheredge during the repair process is a matter of personal preference.
- requires about 6–10 mm (1⁄4–3⁄8") of coating be removed per layer. The featheredge should look like a bird's feather with soft edges.

Topic D. Mixing Body Fillers



D-1 Plastic or metal spreaders may be used to mix body filler.

Spreaders are:

- made of semi-flexible plastic or metal.
- used to mix and apply body filler and polyester glazing putty.
- available in various sizes. Use the size that matches the repair area and fits the contour of the panel. The spreader may need to be cut to the proper size for the job.

D-2 The solid and liquid have separated in this can of body filler.

When preparing the body filler in the can:

- mix it thoroughly. If body filler has been left in the can for a long period of time, it may begin to separate and it should be stirred in the can or shook on a paint shaker before use. If the body filler is not mixed properly before it is removed from the can, the body filler near the top of the can will be too thin and the body filler on the bottom of the can will be thick, coarse, and grainy.
- stir it using a separate spreader from the one that will be used to mix or apply it. This prevents unmixed body filler that is on the spreader from being applied to the repair area.
- do not bend the lid of the can. The body filler will eventually harden if it is exposed to air.
- replace the lid promptly after use.

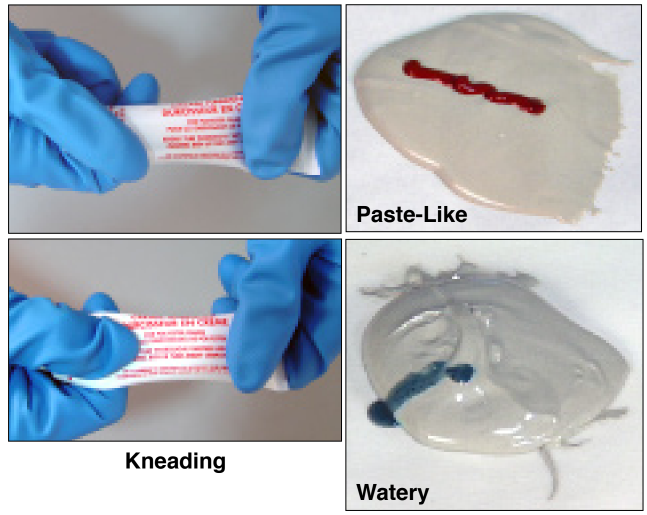
D-3 This mixing board is designed for mixing body filler.

A mixing board used for body filler and polyester glazing putty should be a flat surface such as glass, plastic, metal, or nonporous paper. Cardboard should not be used because a number of problems may occur. If cardboard is used, the waxes in the cardboard may dissolve during the mixing process and cause body filler problems. The cardboard could absorb some of the chemicals in the body filler or hardener and slightly change the curing quality. The cardboard fibers may stick in the body filler and damage the finish.

D-4 The color of the hardener is different than the body filler that it will be mixed with.

Body filler and polyester glazing putty hardeners:

- are a catalyst or activator.
- are a liquid or cream.
- require kneading before use.
- may be specific to the type of body filler or polyester glazing putty.
- are available in contrasting colors to the body filler. This helps ensure that the body filler and the hardener are adequately mixed. If there are streaks in the mixture, the body filler and hardener are not properly mixed.



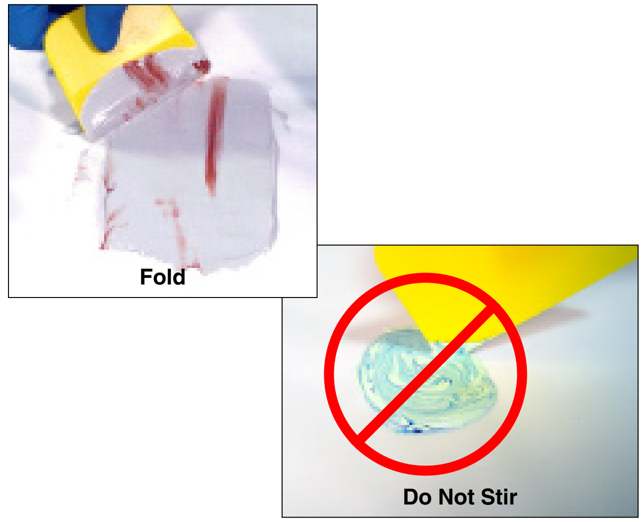
D-5 The hardener will look paste-like after it is kneaded properly, it should not look watery.

Knead the hardener by squeezing the hardener back and forth inside the tube until it is a paste-like consistency. If the hardener is watery when it is squeezed from the tube, do not use it. This chemical break down of the hardener may result from freezing or from being stored for too long. If the hardener is not kneaded properly, the same types of problems that can result from improper mixing may occur.

D-6 The label on this tube of hardener indicates that it contains peroxide.

When the body filler is mixed with the hardener, the curing process that take place:

- is sped up because the hardener contains peroxide. The amount of hardener used correlates to the length of cure time. It will take longer to cure if there is an insufficient amount of hardener added. Cure time decreases as the ratio of hardener to body filler increases. The amount of hardener also has an affect on how well the cured body filler sands.
- is a chemical reaction. Once the product has cured it will not shrink or soften.
- creates heat. Unused body filler should not be discarded unless it has been mixed with the hardener and has fully cured and cooled.



D-7 The spreader that is used to mix this body filler will not be used to apply it to the repair area.

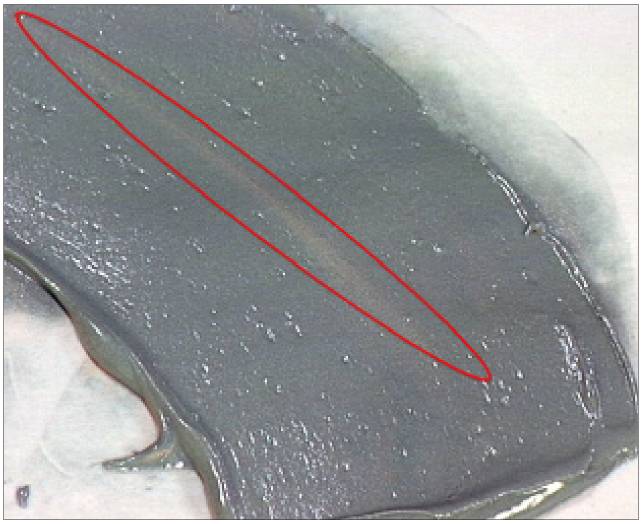
When mixing the body filler and hardener together:

- fold it, do not stir. Stirring may trap air in the body filler and cause pinholes.
- use the product maker's mixing ratio recommendations. Typical mixing ratios include ¼ of a tube of hardener for ¼ can of body filler and a 25 mm (1") line of hardener for a golf ball-sized amount of body filler.
- mix using one spreader and use a different spreader to apply the body filler. This will help prevent unmixed body filler that may be on the spreader from being applied to the repair. Unmixed body filler can cause soft spots or the paint to peel.

The same recommendations apply to polyester glazing putty.

MEASURING BODY FILLER

Have your instructor lead you through the Measuring Body Filler activity.



D-8 The light gray streak in this body filler indicates that it should continue to be mixed until it is a uniform color.

When mixing the body filler and hardener together:

- mix it until it is a uniform color. This is done to prevent soft spots and peeling.
- as a general rule, mix only enough that can be applied within five minutes.
- check the product maker's recommendations for cure and sand times. Typically, body filler can be sanded after 20–30 minutes. Factors such as temperature and humidity will affect cure time.

MIXING THE CORRECT AMOUNT OF BODY FILLER

Have your instructor lead you through the Mixing The Correct Amount Of Body Filler activity.

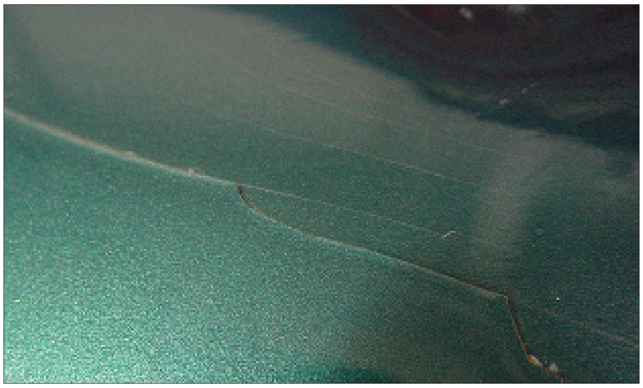
D-9 Body filler shrinks when it has cured.

Body filler shrinks when it has cured. The negative effects of shrinking can be minimized by applying thin coats and allowing adequate cure time between coats.

D-10 This body filler and hardener mixture began to cure before the technician was finished applying it to the repair area.

Overcatalyzation is using too much hardener. Problems that may result from overcatalyzation includes:

- premature cure.
- application difficulties. If the body filler begins to harden during application, it may be difficult to apply uniformly.
- repair failure and body filler defects.
- inadequate adhesion.



D-11 This body filler cracked after the repairs were complete and panel was refinished.

Additional overcatalyzation problems include:

- pinholes.
- cracks.
- bleedthrough or topcoat staining.
- poor sanding and featheredging. The body filler may sand harder and peel along the edges.

Some problems, such as cracks and bleedthrough, will require the body filler to be removed and new body filler applied.

D-12 This sandpaper was used on body filler that was not completely cured.

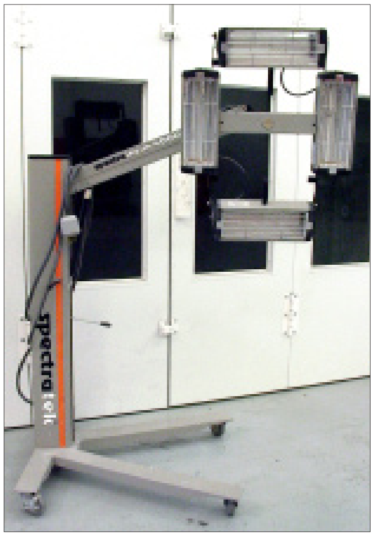
Undercatalyzation is not adding enough hardener. Undercatalyzation problems include:

- soft or gummy body filler.
- inadequate adhesion.
- body filler that will not cure.
- poor sanding and featheredging. The body filler may not sand cleanly and the sandpaper will clog.

MIXING THE BODY FILLER

Refer to screen D-13v of your CD-ROM for a video on the procedure for mixing one type of body filler.

Topic E. Body Filler Application

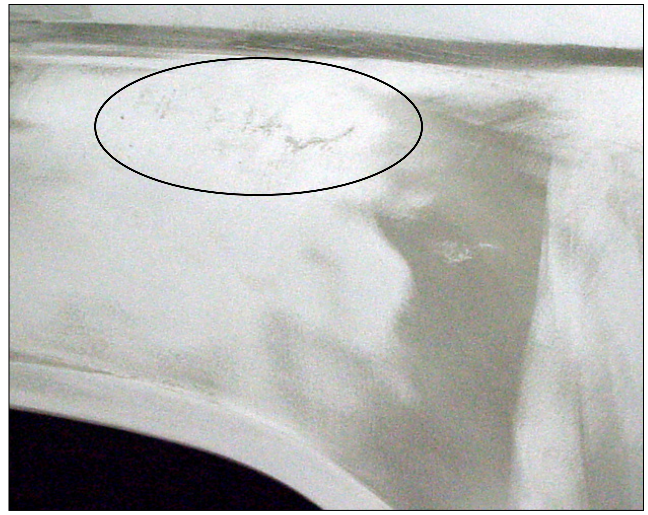


E-1 An infrared lamp may be used to warm cold metal parts.

When body filler is applied to metal that is too cold:

- it may not cure properly, resulting in a tacky surface that will not sand properly.
- it may result in pinholes.
- moisture is created.

Room temperature is usually considered 15–30° C (60–85° F). The surface should be at room temperature. A heat lamp may be used to warm the metal before the body filler is applied.



E-2 Moisture caused pinholes in this body filler.

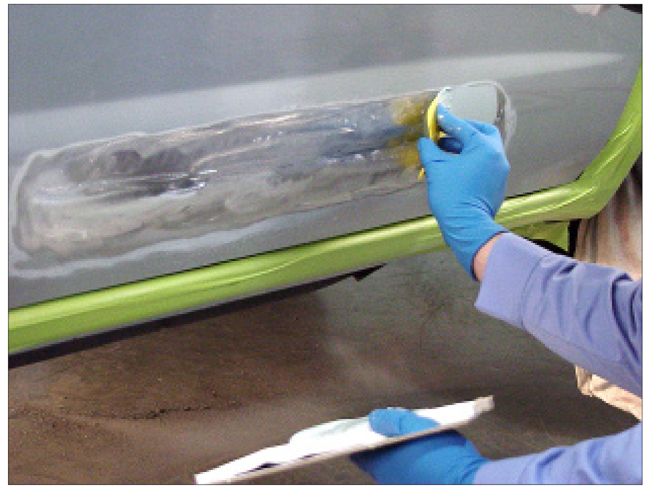
The repair area should be clean and dry before body filler is applied. Body filler problems caused by moisture include:

- inadequate adhesion.
- poor featheredging.
- pinholes.
- lifting when refinished.
- corrosion.

E-3 It will not always be necessary to apply additional coats of body filler.

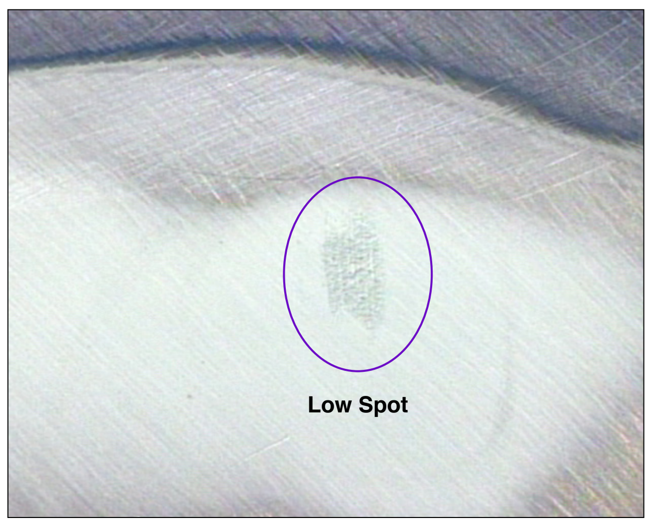
When applying body filler:

- use multiple thin coats. Thick coats may result in cracking, pinholes, or improper adhesion of the body filler to the metal.
- a general rule is to apply a maximum thickness of 6 mm (¼") after sanding. Follow the product maker's recommendation for maximum thickness. Some body filler makers may recommend a maximum thickness of 3 mm (⅛") for body filler application.



E-4 A plastic spreader may be used to apply the first coat of body filler.

Apply the first coat of body filler using firm strokes to ensure that the body filler gets into the sandscratches and forms a bond. On a rough surface, fill the lowest spots first and allow it to cure. After applying body filler, the spreader should be cleaned so it is free of any hardened body filler. It is difficult to apply even coats of body filler using a dirty spreader.



E-5 Continue to monitor the panel throughout the sanding process.

Before applying additional coats of body filler:

- allow the previous coat of body filler to cure.
- sand the previous coat of body filler to ensure adequate adhesion of additional coats.
- use compressed air or a vacuum to remove the sanding dust.

E-6 Do not apply body filler to areas that have not been properly sanded.

E-7 Repairs to a hood near the hinge or on a rocker panel may fail over time.

Apply additional coats of body filler:

- to the entire repair area.
- by working the body filler in at least two directions.
- until the body filler is built up slightly above the surface. The extra body filler will be removed when the body filler is sanded level.

Before applying body filler to a particular area, consider that:

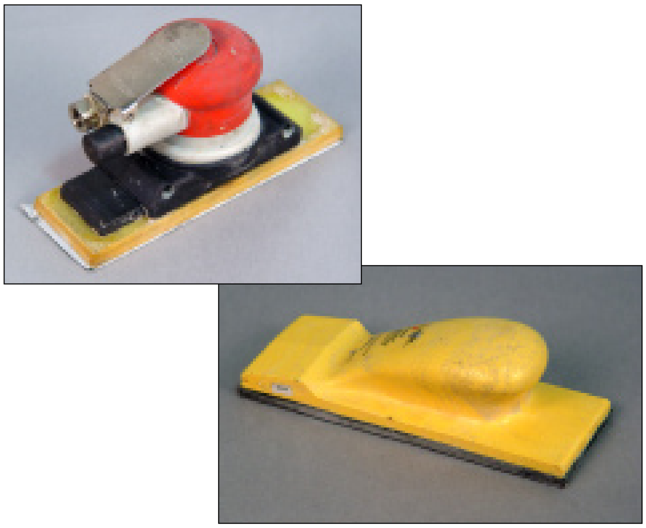
- the body filler should not be applied too thick or over too large an area.
- there is a greater risk of damage to the filler if it is applied to areas that are subject to vibration or expansion, such as hoods.
- there is a greater risk of damage to the filler if it is applied to areas that absorb road shock and torque flex, such as quarter panels.
- there is a greater risk of damage to the filler if it is applied to areas that are subject to stone chips, such as rocker panels and wheelhouse openings.

Adhesion and cracking are the biggest concern when applying body filler to higher risk areas.

BODY FILLER APPLICATION

Refer to screen E-8v of your CD-ROM for a video on applying body filler to a repair area.

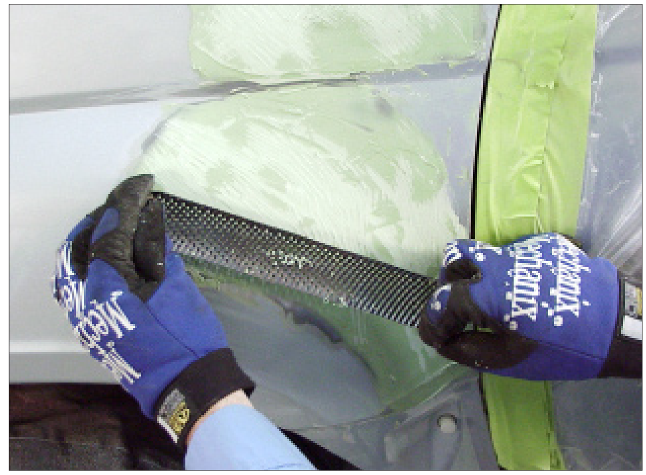
Topic F. Tools For Sanding Body Filler



F-1 Manual and pneumatic sanding tools are used to shape body filler.

There are a number of different ways to shape body filler. The choice will usually be made based upon technician preference, the size of the repair area, and the contour of the panel. Tools used to shape body filler include:

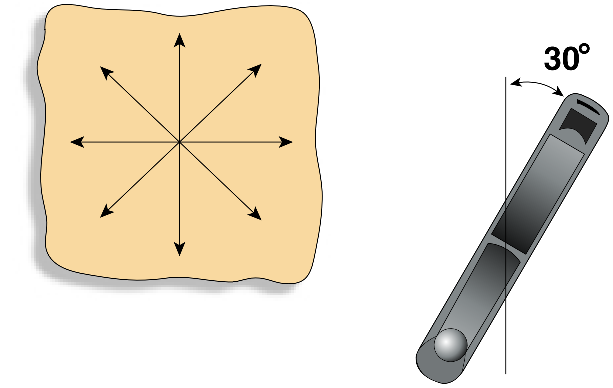
- cheese graters. These tools are also called Surform® files.
- pneumatic or electric sanders.
- hand sanders such as board files, sanding blocks, sanding tubes, and contour-matching guides.



F-2 Cheese graters work well for quickly removing high spots.

A cheese grater is used:

- to initially shape the body filler when it hardens to a consistency of cheese, but are not effective after it has completely hardened.
- about 5-10 minutes after body filler application, while it is still soft. Factors such as temperature and humidity will affect cure time. The body filler is ready if a white mark appears after it has been scratched with a fingernail.



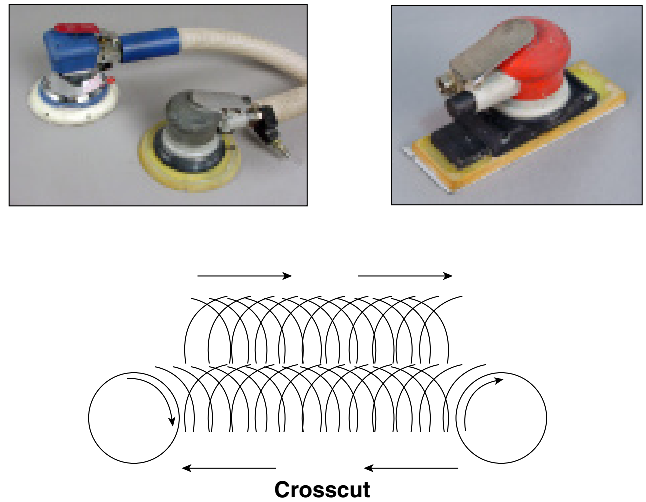
F-3 Even pressure should be applied when using a cheese grater.

When using a cheese grater:

- use long, smooth strokes.
- use it in multiple directions.
- hold it at a 30° angle in the direction of travel.

After using the cheese grater, identify any low spots and apply additional body filler.

CHEESE GRATER
Select the Demonstration icon found on screen F-3 of your CD-ROM to see how to use a cheese grater.



F-4 Sanders can be round or rectangular.

A sander may be:

- round or rectangular. The sandpaper is shaped like the pad on the sander. Be aware that orbital is not a universal term. Orbital could mean that it is a round, single action round, or dual action round sander.
- single action or dual action (DA). A round single action sander spins, and a rectangular single action sander moves back and forth. An example of a round single action sander is a grinder. On a round DA sander, the shaft that spins also moves in a non-linear pattern. A sander may be able to be switched between single and dual action. A single action is more aggressive than a DA. Finishing sanders are typically dual action.
- a weighted or gear driven DA. The dual action on a round sander may be weighted or gear driven. The dual action on a rectangular sander is gear driven. Weighted dual action is random and affected by pressure and speed. Gear-driven dual action has a set pattern and does not change. When a weighted DA is free-revved, it will spin like a single action until pressure is applied. When a gear driven DA is free-revved, it will spin and follow a pattern.
- a short or long stroke sander. A longer stroke is more aggressive than a shorter stroke. Finishing sanders typically have a shorter stroke.

When using a sander, move it continuously and in a crosscut pattern.

TYPES OF DA SANDERS
Select the Demonstration icon found on screen A-3 of your CD-ROM to see different types of DA sanders.

F-5 Pneumatic tools are lubricated using a specific oil.

When using a pneumatic sander:

- do not lay it down on the edge of the pad. This may warp the pad and cause it to vibrate during use.
- clean the ventilating system to prevent overheating.
- follow the equipment maker's recommendations for lubrication. Daily oiling or in-line lubricators may be recommended.

A sander should never be used without proper eye protection because it throws off particles of grit and metal cuttings at tremendous speeds.

When not in use, an air sander should:

- never be laid down while the pad is still turning.
- not be placed on a surface where the air hose could trip someone. Disconnect the air hose or place the sander on the floor. This is a good safety practice when working with any air tool. It also applies to power tools and electrical cords.

The same personal safety applies to grinders and sanders.

When not in use, an air sander should:

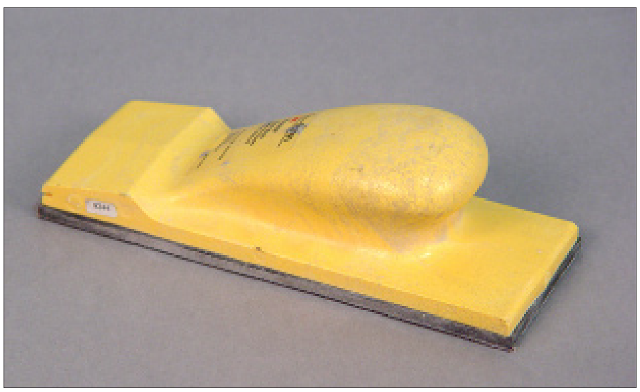
- never be placed on a panel in an area that is not being repaired. The abrasive could damage the finish or coating.
- not be placed on the floor with the abrasive down. This may contaminate the sandpaper.
- be placed on a surface and in an area where it is not easily knocked down and damaged.

The same vehicle protection applies to grinders and sanders.

F-6 Handles are used to grip this type of file.

A hand sanding board file is:

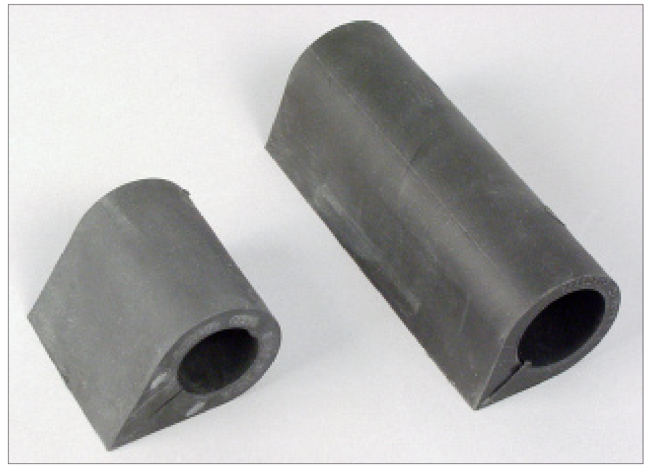
- a rigid sandpaper holder that is about 430 mm (17") long and 80 mm (3") wide.
- used to sand quickly using long, level strokes.



F-7 Determining which sanding method to use will depend on the size of the damage and the personal preference of the technician.

Hand sanding blocks are:

- available in various sizes.
- available in various shapes.
- used with sheets of sandpaper.



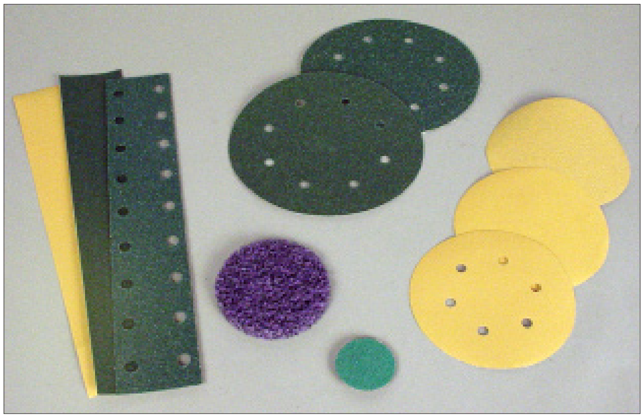
F-8 Sandpaper is wrapped around this type of contour sanding block.

Contour matching sanding guides:

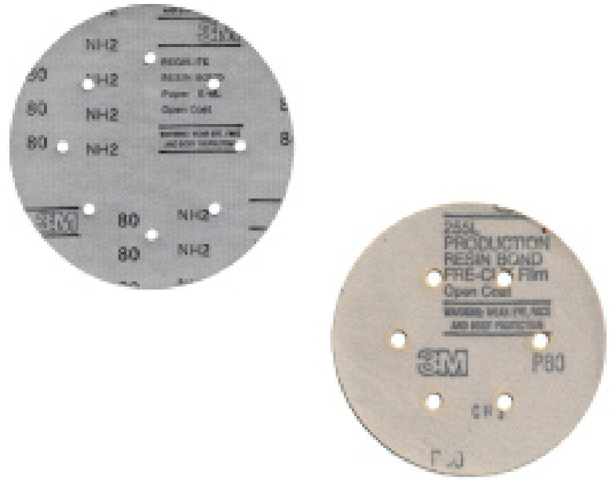
- are specialized tools used for sanding straight contours.
- may use a guide that is mounted on the panel with a sanding block that mounts in the guide.
- include sanding blocks that have been designed for irregular shapes and contours.

CONTOUR MATCHING SANDING GUIDE
Select the Demonstration icon found on screen F-8 of your CD-ROM for examples of a contour matching sanding guides made for a specific vehicle and feature line.

Topic G. Sandpaper



G-1 Sandpaper is available in different shapes and sizes.



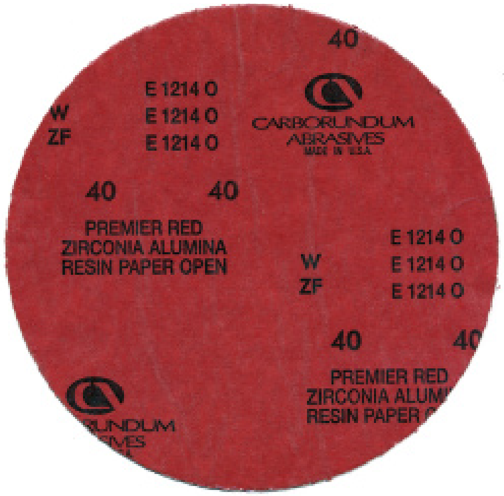
G-2 Different grading systems may be used by the same sandpaper maker.

Sandpaper:

- is paper that has one side that is coated with an abrasive material.
- is used to remove coatings, metal, and body filler.
- uses a numbering system to define how coarse or fine the abrasive. The bigger the number, the finer the abrasive grit.
- may be the dry sanding or wet sanding type.

ABRASIVES
Have your instructor lead you through the Abrasives activity.

There are basically four different grading systems that are used to determine the number that is used on a piece of sandpaper. Each grading system has a different tolerance for the size of the grains that are used to make the sandpaper. A sandpaper maker may use more than one grading system.

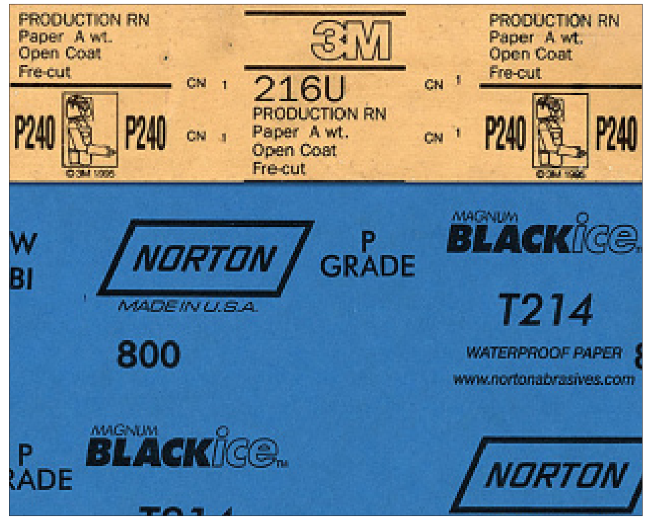


G-3 This is a piece of 40-grit sandpaper that has been defined using the CAMI grading system.

The CAMI grading system:

- ■ is a grading system that was established by the American National Standards Institute (ANSI) for the Coated Abrasives Manufacturer's Institute (CAMI). This system may also be called the U.S. System.
- ■ has a wider tolerance than other grading systems. One piece of sandpaper may have coarser and finer grits that equal out to the number on the paper.
- ■ is often used by sandpaper makers for grits coarser than 80 grit.

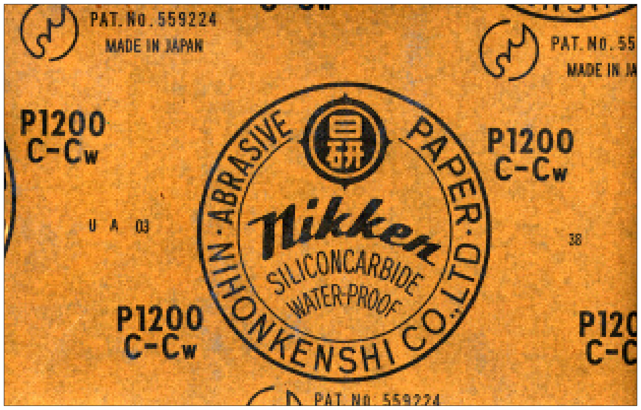
This system does not use a prefix or suffix for identification.



G-4 Notice the "P" grading that is identified on these pieces of sandpaper.

The FEPA grading system:

- ■ is the Federation of European Producers Association (FEPA).
- ■ has a tighter tolerance for particle size than CAMI.
- ■ is identified by the prefix "P."
- ■ is often used by sandpaper makers for 80 grit and finer.



G-5 Notice the JIS symbol and the "made in Japan" designation.

The JIS grading system:

- is the Japanese Industrial Standard (JIS).
- has a tighter tolerance for particle size than FEPA.
- does not use a prefix or a suffix for identification.
- may be used by sandpaper makers for 800 grit and finer.

G-6 Notice the smaller number followed by the "µ" and the word "MICRO" in all caps.

The micron grading system:

- has the tightest tolerance for particle size.
- is identified by the suffix "µ". This is the metric symbol for micro, which is 1 millionth (0.000001).
- may be used by sandpaper makers as an option for a highly polished surface.

COAT ABRASIVES CONVERSION CHART

CAMI GRADE	FEPA GRADE	JIS GRADE	MICRON SIZE
			5
1200			
	2500	2000	8
1000			
	2000	1500	10
800			
	1500	1200	13
		1000	
	1200		15
600			
	1000		
		800	
500			
			20
	800		
400			
			24
	600	600	
360			
		500	
	500		30
	400	400	
320			
	360		
280		320	

COAT ABRASIVES CONVERSION CHART

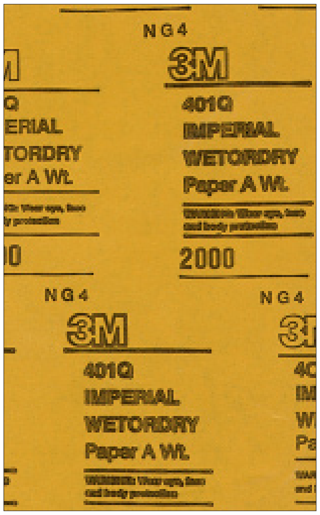
CAMI GRADE	FEPA GRADE	JIS GRADE	MICRON SIZE
	320		
		280	50
	280		
240			
		240	
	240		
		220	60
220			
	220		
		180	
180	180		
		150	
150			
	150		
		120	
120			
	120		
		100	100
100			
	100		
		80	
80	80		
	60		
60			
		60	
		50	
	50		

COAT ABRASIVES CONVERSION CHART

CAMI GRADE	FEPA GRADE	JIS GRADE	MICRON SIZE
50			
		40	
	40		
40			
	36		
36			
		36	
	30		
		30	
30			
24			
	24		
		24	
20			
	20		
16			

G-7 This is how the different grading systems compare to one another.

This chart compares the four different systems of grading sandpaper.



G-8 This paper backing is grade "A" weight.

Sandpaper backing:

- may be made of paper, film, or cloth. Cloth is a fiber-based material that is the most flexible.
- is available in different weights. Paper backing ranges from A to F. A is the lightest and the most flexible. Cloth backings are J, X, and Y with Y being the heaviest.

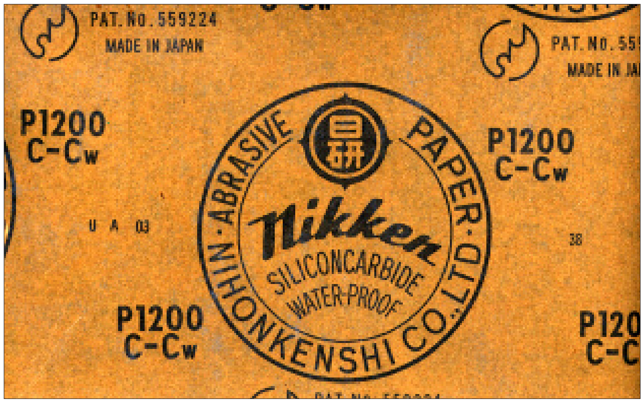
SANDPAPER BACKING
Select the Demonstration icon found on screen G-8 of your CD-ROM for examples of different types of sandpaper backing.

G-9 The sandpaper attachment method matches the sanding tool.

Sandpaper may be attached to the sanding tools using:

- Velcro®.
- Roloc®.
- a bolt.
- adhesive.

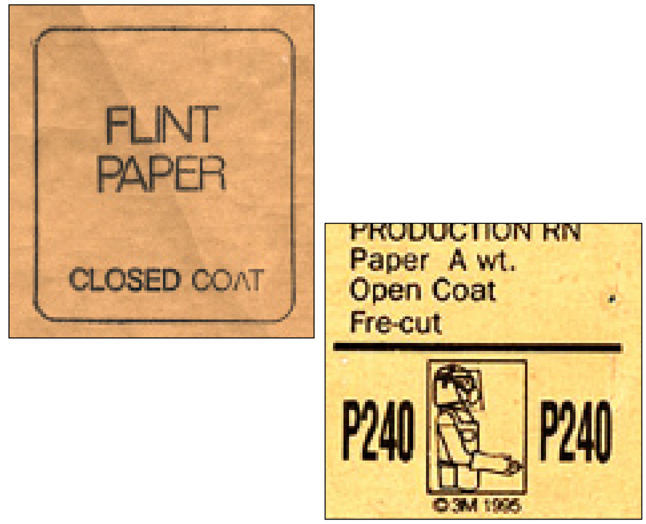
SANDPAPER ATTACHMENT METHODS
Select the Demonstration icon found on screen G-9 of your CD-ROM for examples of different types of sandpaper attachment methods.



G-10 This piece of sandpaper is made using silicon carbide as the abrasive.

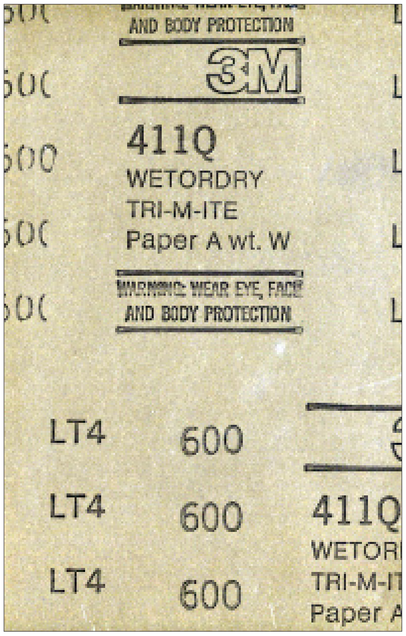
The type of abrasive material that is used may be:

- aluminum oxide.
- silicon carbide.
- a product-specific blend.
- identified on the backside of the sandpaper using a code. The code may be a combination of letters and numbers. This code is not for consumer use.



G-11 Sandpaper used for collision repair is typically open coat.

Open-coat sandpaper has evenly spaced voids between the grain particles, and the resin that bonds it to the paper only contacts the bottom of the grit. The grit on open-coat sandpaper covers 50–70% of the surface. Closed-coat sandpaper does not have voids between the grain particles, and the resin covers that grit. The grit on closed-coat sandpaper covers 90–100% of the surface. Whether it is open or closed coat may be identified on the backside of the sandpaper.

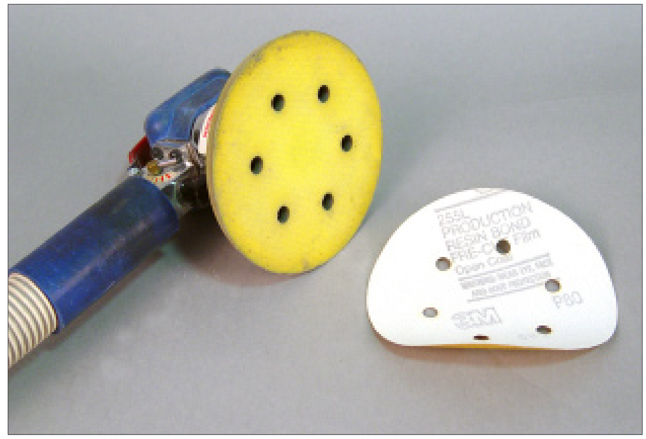


G-12 This sandpaper can be used wet or dry.

There are some differences between wet and dry sandpaper. Wet sandpaper:

- adhesives, backing material, and abrasive may be different.
- may be used with or without water. Dry sandpaper cannot be used like wet because the backing and adhesives typically are not waterproof.
- may have different paint maker's recommendations for surface preparation. Different grits may be recommended depending on the type of sandpaper that is used.
- should not be used to sand body filler because water should not be used around body filler.

WET VS. DRY SANDPAPER
Select the Demonstration icon found on screen G-12 of your CD-ROM for examples of wet vs. dry sandpaper.

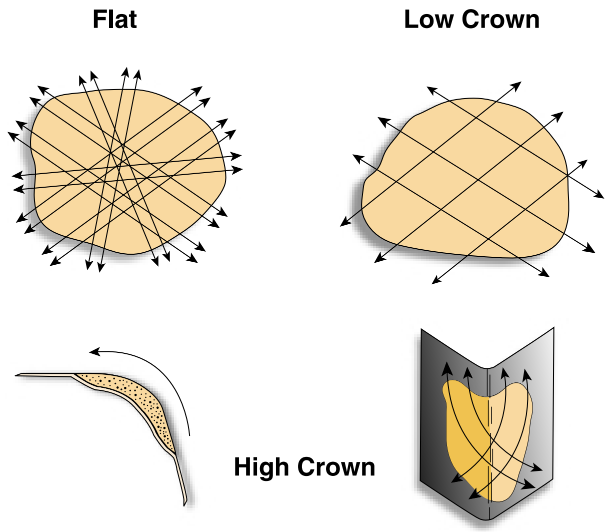


G-13 Notice the corresponding holes in the DA sander and sandpaper.

A vacuum sanding system:

- uses sandpaper and a sanding pad that has holes in them.
- uses a vacuum that pulls sanding dust off of the surface and through the sander into a collection system as the surface is sanded.
- removing the sanding dust reduces the technician's exposure and makes the repair environment and work area cleaner.

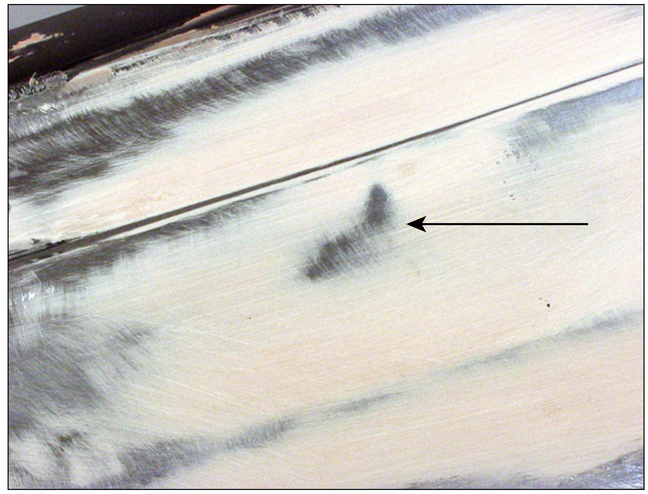
Topic H. Sanding Body Filler



H-1 The direction that the body filler is sanded can affect how well it matches the contour of the panel.

When sanding body filler:

- move from side-to-side, up-and-down, and at angles. A sanding block may be used similar to a body file or cheese grater by holding it parallel to the contour and moving at a 30° angle.
- sand a little and then check the contour of the surface.
- remember that refinishing will highlight imperfections, not hide them.

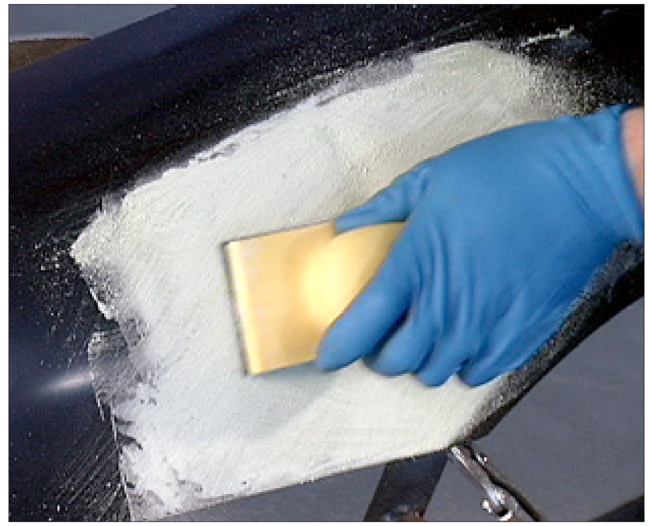


H-2 The bare metal in the middle of this body filler is a high spot.

After sanding, if there is bare metal within the body filler area:

- too aggressive or improper sanding techniques may have been used to remove too much body filler. If this happens, additional body filler should be applied.
- there may be a high spot in the repair area caused by improper straightening techniques. If this happens, tap the high spot down and apply additional body filler.

H-3 The highest areas of the body filler will be sanded first.



H-4 Use even pressure to sand the entire repair area.

One method of shaping the first layer of body filler is:

1. Initially shape the body filler using 36–P80 grit or a cheese grater. Oversanding during this step, for example, would be initially sanding the first layer of body filler until it is level with the contour of the panel. The sanding method that should be used is based on personal preference and the size and contour of the repair area.
2. Check the contour. Apply additional coats if there are low spot or if additional coats are required to fill the damage properly. Small imperfections can be filled with polyester glazing putty.
3. If the body filler is smooth and uniform to the contour of the panel, remove sandscratches using P80–P120 grit sandpaper.

When sanding additional layers of body filler:

- initial sand using 36–P80 grit until the repaired area is the proper contour, yet slightly high.
- only hand sand an area without a block if the area cannot be accessed or contoured with a sanding block, tube, or sander. The sanding method that should be used is based on personal preference and the size and contour of the repair area.

H-5 Guide coat can be used to help identify the high and low spots when sanding body filler.

Guide coat:

- is a thin layer of a spray-on or powder product that is applied to the repair. It may be applied after the body filler is sanded with P80 grit and before it is sanded with P120 grit.
- is a contrasting color to the body filler.
- identifies high and low spots. When sanded, it is removed from the high spots and remains in the low spots and imperfections such as sandscratches and pinholes.

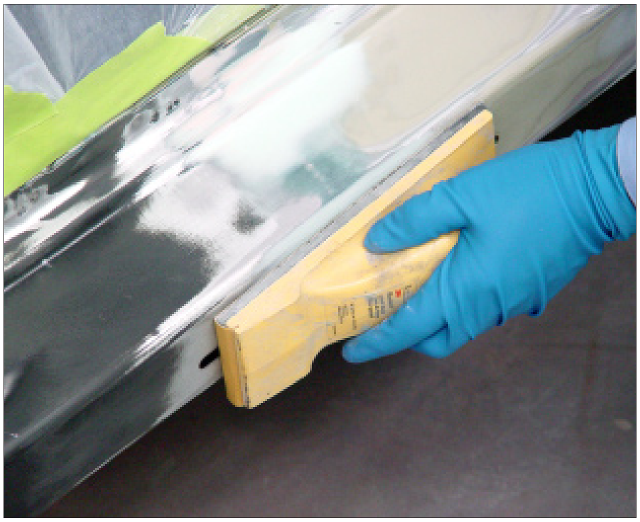
H-6 There are products specifically designed to be used as a guide coat.

Guide coat is:

- sprayed on. A thin mist of this product is used.
- a fine powder. Guide coat that is a powder is typically available in a plastic container and applied using a sponge.

GUIDE COAT

Select the Demonstration icon found on screen H-6 of your CD-ROM for examples of types of guide coat and application.



H-7 Finish sanding makes the repair area smooth.

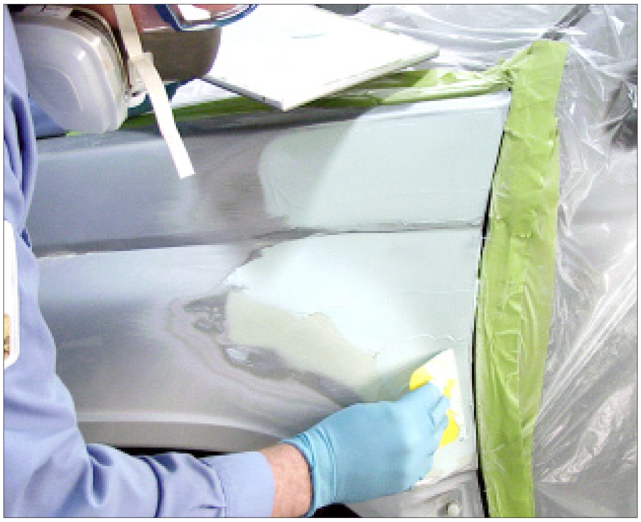
When finish sanding the body filler:

- start with P120–P180 grit sandpaper to remove the 80 grit sandscratches. Continue to sand until the body filler is the proper contour.
- follow paint maker's recommendations for finish sanding grit.

H-8 The contour of the panel has been restored.

When finish sanding the body filler:

- featheredge the paint, if necessary. This step may have been done earlier and may not be required. If it is required, a general recommendation of about 6–10 mm (¼–⅜") of coating should be removed per layer.
- as a general rule, do not step more than P100-grit between 36 and P500 grit, and do not step more than P200-grit between P600 and P1000 grit.



H-9 Polyester glazing putty is applied to the entire repair area to maintain proper contour.

Polyester glazing putty is used over body filler to fill pinholes and sandscratches. It should not be a thick layer of body filler. Polyester glazing putty is applied using minimal strokes because repeated passes may pull the polyester glazing putty away from the body filler. After the polyester glazing putty has cured, the repair area can be finish sanded. Check paint and polyester glazing putty maker's recommendations for sandpaper grit.

SANDING BODY FILLER
Refer to screen H-10v of your CD-ROM for a video on sanding body filler.

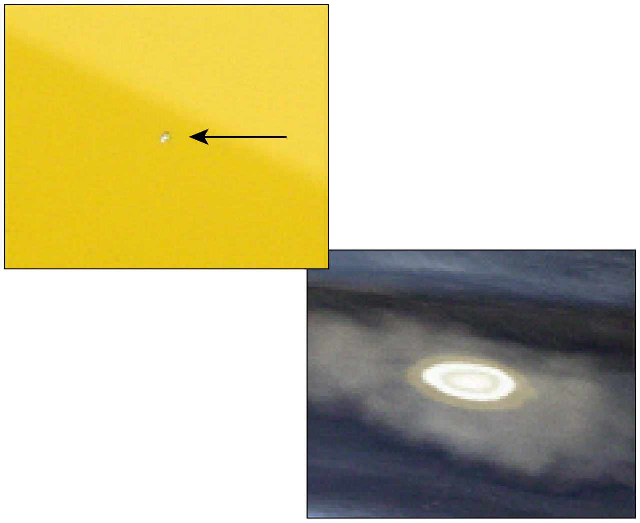
The material in this program will usually focus on one way to repair a particular type of damage, that it is not necessarily the only repair option available.

Topic I. Review

REVIEW
Refer to screens I-1 through I-2 of your CD-ROM for review questions on body fillers and sanding.

MODULE 4–ADDITIONAL REPAIR METHODS

Topic A. Minor Repairs



A-2 Stone chips are a common example of a nick.

To repair a nick in the finish:

- sand to remove any corrosion and featheredge the paint around the nick. Refinishing materials will not adhere properly to a corroded surface.
- body filler or polyester glazing putty may be required if the nick is too deep.
- complete the repair by priming and applying topcoats.

A-3 A sharp object, such as a key, was used to vandalize the finish on this vehicle.

To repair a scratch in the finish:

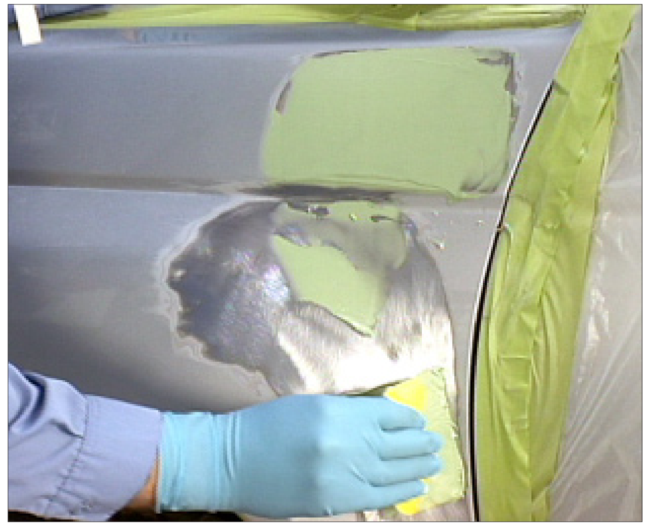
- featheredge the paint around a shallow scratch.
- body filler or polyester glazing putty may be required if the scratch is too deep.
- complete the repair by priming and applying topcoats.

Topic B. Repairing Complex Areas

B-1 Because this damage extends into multiple contours of the panel, a combination of repair methods will be used.

Due to the design of the part and the type of damage, a combination of dent removal techniques may be required to repair a damaged panel. The repair method that is used is based on:

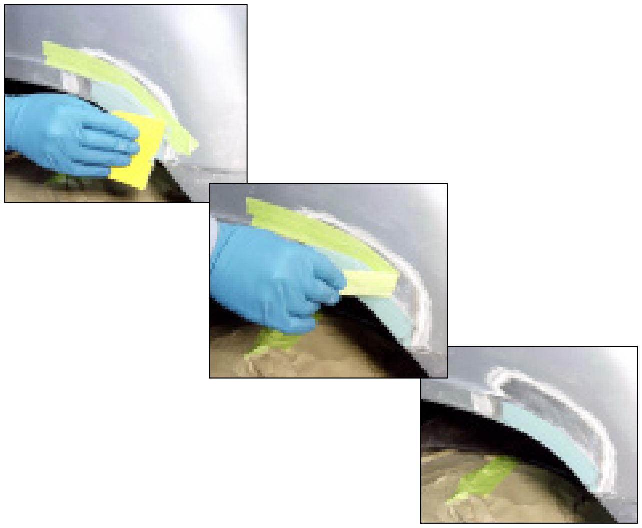
- personal preference.
- access to the backside of the panel. Parts or trim may have to be removed to gain access.
- the shape of the part and the damage. A technician may choose to repair a flat area differently than a feature line or crowned area.
- the tools available to the technician and their familiarity with them.



B-2 Separate contours within a panel may allow the body filler to be applied in separate stages.

When there are multiple designs in a panel, body filler application becomes more complicated. The repair area may cover flat, crowned, and sharply angled areas. One method of applying body filler to a complex area is to apply the body filler:

- in stages. Do not try to cover multiple contours simultaneously.
- to match individual shape and the contour of each area.



B-3 Masking tape may be used to prevent the body filler from being applied to specific areas.

B-4 Separate contours within a panel may allow the body filler to be sanded in separate stages.

One area that may pose difficulty to apply body filler to and shape properly is a sharp feature line. One method of applying body filler to a feature line is:

1. Apply masking tape along one side of the body line.
2. Apply body filler to the other side of the body line.
3. Remove the masking tape and let the body filler cure.
4. Lightly scuff the exposed edge of the body filler for adhesion, and repeat the procedure by applying tape to the body filler and applying body filler to the other side of the body line.

When sanding a combination of complex areas:

- the sanding direction must follow the contour of the panel.
- it is more difficult than sanding a flat surface or a surface that has a single crown. It is necessary to change the sanding technique based on the contour of the area.
- sanding through is more likely due to the different shapes and contours. This is especially true when sanding along sharp edges such as the edge of a wheelhouse opening.

B-5 Along with the contour of the panel, the feature lines must also be sanded to match the rest of the panel.

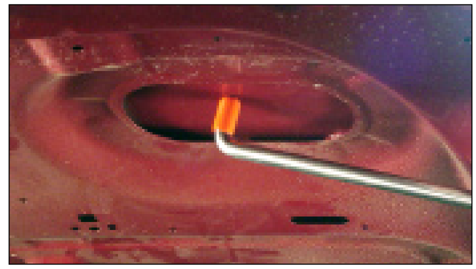
One method of sanding body filler along a feature line is:

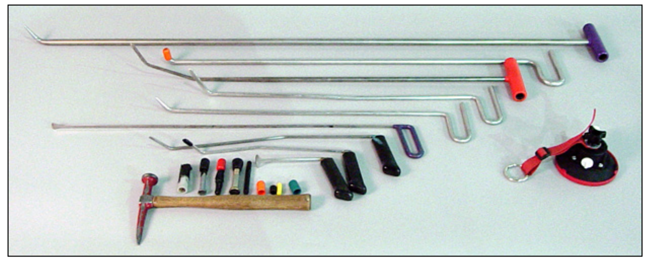
1. Apply masking tape to one side of the feature line and sand the opposite side of the feature line.
2. Apply masking tape to the sanded side of the feature line and sand the other side. Use caution to avoid sanding through the body filler and exposing bare metal along the feature line.
3. Check the feature line using a straightedge to verify that the proper contour has been achieved.

REPAIRING DAMAGE TO A COMPLEX AREA
Refer to screen B-6v of your CD-ROM for a video on repairing damage to a complex area.

The material in this program will usually focus on one way to repair a particular type of damage, that it is not necessarily the only repair option available.

Topic C. Paintless Dent Repair (PDR)





C-1 PDR is a skill that requires specific tools and techniques.

Paintless dent repair (PDR) is a repair process that:

- may be an option for certain types of damage such as hail damage or door dings.
- does not require that the panel be refinished following repairs.
- requires practice.
- requires patience.
- is not recommended by some vehicle makers.

C-2 PDR technicians use lighting to monitor the dent removal process.

A collision repair facility must decide whether they want to:

- have a trained technician in-house. PDR is a specialized repair process that requires training, experience, and continued use to perfect. It must be decided whether or not the volume of vehicles that can be repaired using PDR warrants training and maintaining a person within the collision repair facility.
- sublet the repair to PDR specialist.

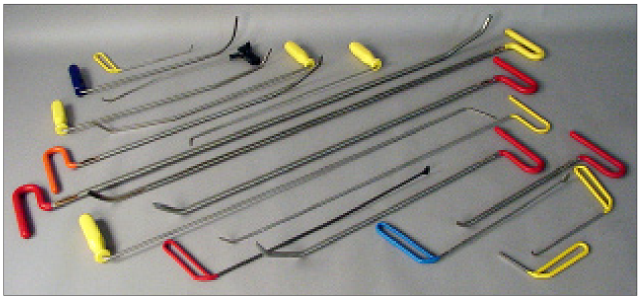
C-3 The number of dents in this hood is excessive.

Characteristics of the damage that determine if PDR can be use for repair include:

- the condition of the finish. There cannot be any damage to the finish.
- the shape of the dent. Sharp angles may be difficult to remove.
- access to the dent. Part or trim removal may be required to gain access to the panel backside. There are areas on a vehicle that cannot be accessed using existing holes and therefore, are not an option for PDR. Do not drill holes in undamaged areas to gain access.
- the diameter of the dent. Dents with a diameter of 50 mm (2") or more may be difficult to repair using PDR. Experienced technicians may be able to repair larger damage.
- the depth of the dent. Deep dents may be difficult to remove.
- the number of dents. Even if the dents can be repaired using PDR, it may not be practical to repair a panel if there is an excessive number of dents.

REPAIRABLE VS. NON-REPAIRABLE

Select the Demonstration icon found on screen C-3 of your CD-ROM for examples of repairable and non-repairable damage using PDR.



C-4 Like most dent removal techniques, choosing the appropriate pick is largely based on personal preference.

PDR picks have:

- rods and tips that are various lengths to access the damage.
- tips that are round, pointed, or flat.
- tips that are typically made of steel or plastic. There are also plastic tip covers available. Plastic is recommended to prevent corrosion on the backside of the panel. Steel and graphite tips can scratch the E-coat on the backside of the panel and create a corrosion hot spot.

PDR TOOLS
Select the Demonstration icon found on screen C-4 of your CD-ROM for examples of different style PDR picks.

C-5 PDR technicians sometimes may make their own accessories to fit their individual needs and preferences.

PDR tool makers have various PDR accessories available including:

- rings and hooks. These hook into existing holes or are pinched between panel gaps and the pick is slid through the hook and used as a fulcrum.
- tapdowns or knockdowns. These are used when damage is accidentally raised above the original contour. These are made of plastic and do not damage the finish when used correctly.
- lighting and reflectors. These are used to monitor the repair process. Lighting can be plugged into a wall outlet or a vehicle auxiliary power outlet. Reflectors are used for outdoor repairs and reflect sunlight to the repair area. Lighting may be used by some technicians to heat the panel which reduces the chance of cracking the finish during straightening.
- wedges. These are used to create an opening between the glass and the exterior door trim to insert a pick through without damaging the glass.
- door jammers. These are used for holding doors securely open.

PDR ACCESSORIES
Select the Demonstration icon found on screen C-5 of your CD-ROM for examples of PDR accessories.

PDR
Refer to screen C-6v of your CD-ROM for a video on how minor dents may be removed using PDR.

The material in this program will usually focus on one way to repair a particular type of damage, that it is not necessarily the only repair option available.

Topic D. Using Lead Filler

Lead filler is typically made of 30% tin and 70% lead. This alloy of lead filler may also be referred to as $^{30}/_{70}$ solder. To use lead filler:

1. Straighten the damage.
2. Grind the repair area down to bare metal.
3. Heat the repair area and brush on tinning flux. There are a variety of different types of tinning flux available. Tinning flux is designed to clean microscopic corrosion from the bare metal and prevents corrosion from forming. Tinning flux also promotes adhesion between the solder and the sheet metal.
4. Tin the repair area by heating the metal with a torch and rub a small amount of lead filler over the hot metal to deposit a thin layer. While the lead filler is still pliable, wipe the area with a clean shop rag or scuff pad to spread it over the metal and remove impurities. It should look like the lead filler has been painted on. (Another option is to replace steps 3–4 with acid core solder.)
5. Heat the adjacent metal and 25 mm (1") of lead filler rod. An oxyacetylene torch or soldering torch may be used. Use low heat with a wide carburizing flame to avoid overstressing low-strength steel such as mild steel. Lead filler becomes soft at about 182° C (360° F) and liquid at about 255° C (490° F).
6. Press the heat-softened lead filler on the sheet metal to fill the repair area.
7. Heat the lead filler by moving the flame back and forth until the filler begins to sag.
8. Wax the paddle so that it does not stick.
9. Spread the solder and smooth using a paddle, slightly above the panel.
10. While the metal is still hot, quench the area with cool water. Quenching relieves the stress in the panel. It also cools the area so that it can be filed and straightened to contour.
11. Use a body file and sandpaper to shape the lead filler.

Controlling the heat is a concern when working with lead filler. It may be easier for the beginner to start practice on high crown areas because flat areas are more easily distorted by heat.

Consider personal safety issues when working with lead.

LEAD FILLERS
Select the Demonstration icon found on screen D-2 of your CD-ROM for examples of difference lead filler materials and equipment.