GOODSON

Tools and Supplies for Engine Builders

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Crack Repair Manual

CRK-150/350

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PRODUCTS CO., INC.®

CR-MANUAL

INTRODUCTION

The Goodson crack repair process is a cold repair process for repairing cracks in castings by adding metal and by moving the metal in the casting to close the crack.

Just as castings vary in dimensions, in points of stress, and in the development of cracks, likewise, the application of the crack repair process must be both flexible and adaptable.

It is necessary initially to understand the basics of the cold crack repair process. In applying the process during the repair of casting, techniques for repairing specific cracks will evolve naturally within the skill and experience of the particular operator.

This manual will discuss the repair of cracks generally, the principles involved, and the tools and materials used. A few examples will be given of the crack repair process applied to engine castings and the injector seat area of diesel engine heads.

It is our hope in preparing and presenting this crack repair manual to be of further service to the engine repair and rebuilding industry.

PRELIMINARY DISCUSSION

The crack repair process for cracks in metal castings involves four basic steps:

1. Detection of the crack - determining the exact location and extent of the crack.
2. Relieving the stress in the casting in the area of the crack
3. Adding and moving metal in such a way as to close the crack
4. Refinishing the surface of the repaired casting.

A fundamental advantage of the crack repair process is that metal is added and moved to close the crack without subjecting the casting to high temperature changes that take place in the welding process. This avoids altering the physical characteristics of the metal in the casting.

For example, the heat treating characteristics of the original casting are not altered when a crack in the casting is repaired through the crack repair process. The hardness of the casting remains exactly as it was before the repair of the crack.

This can be of importance in many instances. For example, in some diesel engine heads where the injector hold is threaded, welding that area of the casting may reduce the hardness of the casting and increase the likelihood of subsequent stripping of the threads in the injector hole when the injector chamber is torqued into place. A repair of the injector area through the crack repair process will avoid the effects of such temperature changes.

The crack repair process is not new. It has been in use successfully for many years. In addition to the normal repair of cracks on flat surfaces of engine heads and block, one of the more common uses of the process has been the repair and replacement of cracked and worn injector seat area in Cummins and GMC Detroit Diesel engine heads. The cracked or worn area is reamed out and tapped, then a tapered threaded plug is torqued into place. The area is resurfaced and drilled, then a new seat is cut to match the original configuration of the injector head. This application will be discussed in detail later in the manual.

As Goodson continues to offer new tools and techniques, the use of the crack repair process continues to expand.

Cracks in metal castings are the result of stress or strain in a section of the casting. This stress or strain finds a weak point in that section of the casting and causes the casting to distort or separate at the weak point.

Such stresses or strains in castings may develop because:

• The casting was subjected to pressure or temperature changes before the casting was properly aged.

• The casting was subjected to excessive heat or excessive cold.

• The casting was sujected to a change in temperature that was too rapid.

Whatever may have caused the crack, the important job is to relieve the stress at the point of distortion or cracking. Then, add more metal and move the metal in such a way as to close the crack.

DETECTION OF THE CRACK

Detecting a crack in a metal casting means not only finding that a crack exists, but also determining the exact location and the extent of the crack. It should be chalked or otherwise marked so that it can be subsequently repaired.

With the Goodson crack repair process, cracks may be detected by three processes:

1. Magnet and Magnetic Powder
2. Penetrant Dye (developed especially for non-magnetic cast ings such as aluminum heads and blocks)
3. Leak Detection Plates

MAGNETIC CRACK DETECTION

With castings that react to magnetic charges, such as cast iron engine heads or blocks, cracks often can be located by using a magnet and magnetic powder.

First, clean the surface of the casting which is to be checked. Remove oil and grease from the surface and leave the surface dry and free of moisture.

Position the magnet on the surface of the casting and then gently dust or drift magnetic powder onto the surface of the casting in the area of the magnet. Where there is a crack in the casting, at or near the surface of the casting, the magnetic powder between the poles of the magnet will accumulate and show the existence and location of the crack.

Since magnetic powder reacts this way only between the poles of the magnet, it is necessary to move the magnet around on the surface of the casting to check the area for cracks.

When the magnetic powder shows the existence and location of the crack, the crack should then be completely chalked or otherwise marked so that it can be easily located later when the repair is undertaken.

It is very important, after having detected a crack, to carefully outline the crack with chalk so that it can be easily identified after the magnet is removed. As will be discussed later, it is also important

The **Magnetic Crack Detection Kit 110V** has everything you need to find cracks in cast iron heads and blocks. Order No. **MM-300**

Position the magnet on the head surface. The dust will clearly show cracks between the poles of the magnet, even cracks below the surface.

The **Compact Magna-Ray Magnet** is an ideal alternative to the 110V typw. It includes 1 lb. powder and applicator bulb.

Order No. **MM-200**

Magnaflux® Magnetic Powders from Goodson

Color	▼ 1 lb.	▼ 5 lbs.	▼ 25 lbs.
White	**WCD-100-G**	**WCD-500-G**	**WCD-2500-G**
Yellow	**WCD-101-G**	**WCD-501-G**	**WCD-2501-G**
Red	**WCD-103-G**	**WCD-503-G**	**WCD-2503-G**

to move the magnet along the ends of the crack in order to find the limits of the crack. Frequently, the crack that appears initially does not totally relieve the stress in the casting and it is necessary to go beyond the apparent limits of the crack to relieve the stress in the casting.

Position the magnet on the head surface. The dust will clearly show cracks between the poles of the magnet, even cracks below the surface.

DYE PENETRANT CRACK DETECTION

Many non-ferrous castings such as aluminum heads and blocks do not respond to magnetic detection. For such castings, a dye is used to show the cracks that are on the surface of the casting.

Goodson offers a reliable way to find cracks in aluminum castings with its simple Alumni-Chek 3-step process:

Step 1 **AC-1 Cleaner** – Clean and condition the area for the dye and developer.

Step 2 **AC-2 Penetrant** – Spray penetrant on the cleaned and conditioned casting. Dye penetrates all surface cracks and flaws.

Step 3 **AC-3 Developer** – Spray on surface to turn cracks and flaws bright red in plain room light.

LEAK DETECTION PLATES

Goodson offers this simple, reliable test for leaks. Neoprene-faced metal plates seal the head to find flaws with pressure. Use shop air and bubble fluid or a dip tank. Kit has main plate and all smaller plates needed for that head. Air regulator, bolt set, and bubble fluid are sold separately.

REPAIRING THE CRACK

Repairing the crack with the Goodson crack repair process involves the use of tapered threaded plugs, drills of the correct size, specially tapered reamers and specially made tapered taps. Together with the **PT-GUN** and peening tools for use with the **PT-GUN.**

The first step in making a repair is to stop or capture the crack. This means to make certain that the limit of the crack created by the particular stress in the casting is determined so that the repair will cover the entire crack.

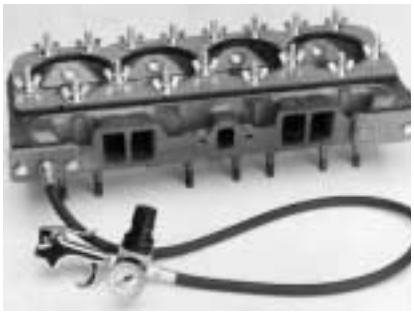
At the end of the crack, as detected, drill a hole using a drill suitable for a Goodson **CRP-235** or **CRP-235A** plug. Then retest the area to see if the crack runs beyond the hole. Continue this process until you have definitely determined that the full extent of the crack is established.

The particular technique or method to be used in repairing the crack depends on the location and accessibility of the crack and the thickness of the metal at the crack. Experience will develop the most suitable techniques for each operator.

This manual will describe some of the most commonly used techniques in repairing cracks in engine and head blocks. These will point the way toward the development by an operator of his own approach to repairing specific cracks.

The **Alumni-Chek Kit** is an easy, reliable way to find cracks in aluminum castings.
Order No. **AC-KIT**

NOTE: These sprays are also sold separately.



Leak Detection Plate Kits

Make	Engine	Order No.
Chevy	Small Block	**LDP-GM1**
	Big Block	**LDP-GM2**
GM	151 / 2.5L	**LDP-GM4**
	1.8L / 2.0L / 2.2L	**LDP-GM5**
	3.3L / 4.3L	**LDP-GM11**
	173 / 2.8L	**LDP-GM13**
	6.2L Diesel	**LDP-DS21**
	Quad 4	**LDP-GM27**
Ford	255-351W	**LDP-FO7**
	230 / 3.8L	**LDP-FO12**
	171 / 2.8L (cars)	**LDP-FO20**
	6.9L Diesel	**LDP-DS20**
Honda	EW1500	**LDP-H3**
Chrysler	"K" 2.2L	**LDP-CR2**
	G53/54 (2.0/2.6L)	**LDP-CR3**
	318, 340, 360	**LDP-CR4**
	W8 - HP	**LDP-CR4-HP**
	Chry / Mitsu V6	**LDP-CR10**
Toyota	20R, 22R	**LDP-T4**

Leak Detection Accesories

Air Regulator: Complete set-up fits all Plate Kits. Includes gauge, air hose and pressure regulator.
Order No. **LDP-BK**

50-Bolt Set: 10 each of 5 lengths with washers and nuts. Fast installation of Leak Plates.
Order No. **LDP-BK**

Bubble Fluid: (1/2 pint) Use with Leak Plates or other air test systems. High viscosity fluid.
Order No. **CRB-10**

THE IMPORTANCE OF PEENING THE CRACK

Whatever technique is used in installing the tapered threaded plugs, certainly one of the most important steps in the repair process is the peening of the metal to move it to close the crack. The proper use of the air hammer and peening tools to help close the crack is an art that is learned only by practice.

For this peening process, Goodson offers the PT-GUN and a variety of peening tools. The PT-GUN itself has 2 unique features. The primary advantage of the gun is its total position control over the peening tool. In addition, it has a swivel which permits it to be used either in a pistol grip fashion or in a straight-away fashion.

When peening the metal in the crack area, always peen in toward the center line of the crack. Do not peen down the middle of the crack or away from the line of the crack.

After the tapered plugs have been installed and cut off, as an added measure, peen the stub end of the plug. Again, always peen outwardly toward the outside of the plug. It is there at the thread that you are making certain there will be no leak.

The **Pnuematic Drive Gun** (Order No. **PT-GUN)** is included with the Goodson Crack Repair Kit (Order No. **CRK-350**) and is also sold separately.

Goodson offers a wide selection of Threaded Plugs, HSS Drills, Extension Drills, Tapered Reamers and Tapered Taps. Please call toll-free 1-800-533-8010 (or 507-452-1830) for more information.

TECHNIQUE #1

Installing tapered plugs along the line of the crack in areas of the casting that are subjected to high pressure and temperatures.

One of the best examples of this type of crack is one in the valve seat area of a head. Here the metal is relatively thick and the area is subjected to high pressures and temperatures.

In this situation, the plugs are installed at angles to the casting surface, not perpendicular to the casting surface. In addition, they are installed in an overlapping fashion.

Normally, one plug hole is drilled, reamed and tapped. The plug is fully torqued in place and the excess part of the plug is cut off before the next hole is started. This permits a better location of the next plug so that it will overlap the preceding plug, not only at the surface but below the surface as well.

Where the metal in the casting is relatively thick, after drilling the hole, it should be reamed with a tapered reamer before tapping with the tapered tap. With the tapered tap, the full length of the tap is cutting and the hole must be tapered if the tap is to have a reasonable life.

The next step after installing the plugs and cutting off the excess ends is to peen the crack.

However, before peening the crack area and the ends of the plugs, a rough cut should be made on the valve seat cutter for installing the new valve seat, there will be a minimum of disturbance of the peening.

After roughing in the valve seat area, thoroughly peen the crack area and the installed plugs. It is in situations like this that the total position control feature of the PT-GUN is so important. For example, with the peening tool with the curved tip, the PT-GUN allows you total control of the position of the peening tip.

Again, when peening the casting, always peen toward the center line of the crack. When peening the ends of the plugs, always peen toward the outer edge of the plug.

This photo shows the first stage of a valve seat area repair. For illustrative purposes only, all of the plugs have been left in position (the excess parts of the plugs have not been cut off) to show the angles at which they have been installed so that they overlap both on the surface and below the surface of the casting.

The repaired area is now ready for resurfacing and finish cutting and installation of new valve seat.

In this kind of a repair, the crack is closed primarily by the adding of more metal in the form of the plugs and by the peening of the castings and the plugs. Accordingly, the positioning of the plugs and the peening are very important parts of the repair.

TECHNIQUE #2

Installing tapered plugs along the line of the crack in readily accessible areas of the casting that are not subjected to high pressure and high temperature.

Metal castings, like most materials, have a degree of elasticity. The technique discussed here is one that installs the plugs along the line of the crack in a manner that takes advantage of this elasticity in the metal.

After capturing the crack at both ends and installing plugs at each end (as previously discussed), follow along the line of the crack. Drill, ream, and tap holes along the line of the crack. Space the plugs 1/4" to 1/2" apart. Here, the most widely used plug is the Goodson **CRP-235** plug which calls for the **CRD-235** Drill, **CRR-235** Reamer and **CRT-235** Tap.

If the metal at the point of repair is thin, normally it is not necessary to use the tapered reamer before tapping. However, if the metal is more than 1/4" thick at the location of the drilled holes, the tapered reamer should be used. With the tapered tap, the full length of the tap is cutting, unlike a straight tap where the lead threads do all of the cutting. Accordingly, where the metal is very thick, it is necessary to ream the hole with a tapered reamer if the tapered tap is to have a reasonable life.

Now, along the line of the crack, torque in the tapered plugs. The plugs should be torqued in concurrently so that none of them will be loosened as other plugs are torqued in. As the plugs are torqued in, the crack will be forced open further. This will build up in the metal a counter elastic pressure to push the crack closed.

After the plugs are all torqued into place, cut them off about 1/16" above the surface of the casting. Do this by putting a nick in one side of the plug with a small saw and breaking off the upper part of the plug by tapping it lightly with a hammer.

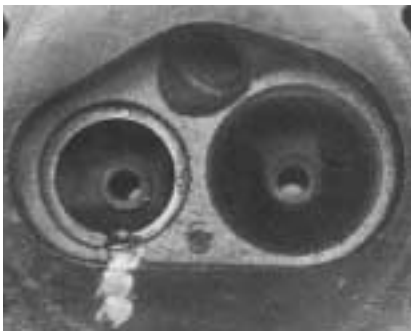
Now peen the crack thoroughly. Peen from both sides of the crack, always toward the center line of the crack. Then peen the stub ends of each plug, always peening outwardly toward the thread of the plug.

Here, the adding of the metal in the form of the tapered threaded plugs, the moving
of the metal from the peening, and the built up elastic pressure of the metal in the casting to spring back - all combine to close the crack.

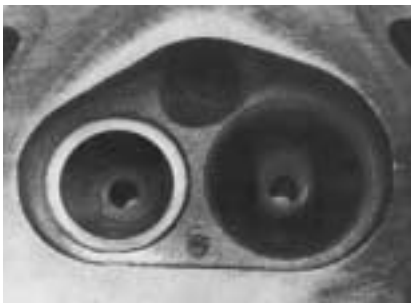
TECHNIQUE #3

Lacing the crack with plugs on both sides of the crack which are not subjected to high pressure and high temperatures.

Another repair technique which is frequently used in areas where the metal is not very thick, readily accessible and not subjected to high pressure or temperatures is to lace the crack on both sides



This photo shows the same valve seat area crack repair after the plugs have been cut off and the area has been peened.



This photo shows the repair after resurfacing and refinishing ready for installation of the new valve seat.

and move the metal by torquing in of the plugs as well as by peening.

Using a center punch, spot along both sides of the crack where it is intended to drill. Tap and install the tapered plugs. The holes should be spotted very close to the crack about 1/8" apart in a lacing fashion alternately on the two sides of the crack.

After spotting the locations for the plugs along the line of the crack, and before beginning to drill holes for the plugs, the entire crack should be peened, always peening toward the center of the crack.

After the crack has been peened, then drill and tap the holes for the plugs.

The plugs should now be torqued into place. Torque the plugs in a concurrent pattern. Do not torque in one plug all the way and then move on to the next one.

After the plugs are torqued into place, cut off the part of the plugs extending above the surface. Notch them with a small saw about 1/16" above the surface and break them off by tapping lightly with a small hammer.

Now, the crack should be peened again. In addition, the stub ends of the plugs should be peened.

In this type of repair, the crack is closed only by the moving of the metal in the casting caused by torquing in plugs alongside of the crack and by the peening. This is why the location of the plugs and the peening of the casting are very important.

This photo shows a repair with the holes drilled and tapped. Here, where the metal in the casing is relatively thin, it is not usually necessary to use a tapered reamer before tapping the holes.

This photo shows a repair with plugs installed and peened ready for resurfacing the casting.

CERAMIC SEAL

Ceramic seal, when properly applied, leaves a fine ceramic coating on the inside of the casting, which serves to close porosity and the inside of minor cracks. It is applied to the casting after the crack repair process is completed to give it a finishing touch and added assurance that the crack is closed.

The head or block is remounted on a pressure tester and the water ports are sealed so that the casting can be pressurized. After pressurizing the head or block and confirming the quality of your crack repair, secure the outlet and inlet hoses on the circulator and circulate the ceramic seal through the casting at the temperature supplied by the circulator.

After circulating the casting for a period of 15 to 30 minutes, close off the return valve and then depress the air pressure button, holding it down for a few seconds and then releasing it. This pressure forces the ceramic seal in the casting out into the interior of any cracks and into any porosity in the interior of the casting.

Now, turn the head over, open the circulator return valve and press the air pressure button for only a few seconds. This will force the remaining liquid ceramic seal in the casting back into the circulator tank.

Remove casting and set it to the side to allow the ceramic seal in the interior of the casting to set or "fix."

After a period of time, the ceramic seal will fix on the inside of the casting and will serve as an additional seal to the crack. Time required for the seal to set will vary depending upon the temperature and the humidity of the atmosphere.

Ceramic Seal (Order No. **CRS-16**) is pictured above with the Goodson Crack Repair Kit (Order No. **CRK-350**)

SEAL-ALL™

After years of research and development, here is a way to impregnate and seal porosity, pin holes and fine cracks in cast iron and cast aluminum cylinder heads and motor blocks.

This product makes all ceramic seals obsolete. No circulators, no heaters, or special equipment required. Just pour Seal-All™ into the water jacket. Wait one hour, or apply 10 PSI for 1 minute to penetrate the leak. Pour excess out and store in the original bottle to reuse. Cure for 1 hour at 200°F or 8 hours at 72°F.

Seal-All™ outperforms ceramic sealants. It cross-links with oxides (rust) inside the water jackets to form a tough, flexible lining that seals leaks and contains cooling systme pressures. Not effected by water or coolant (anti-freeze). It prevents rust and corrosion; insulates and distributes heat evenly through the casting. Seals porosity it welds and withstands engine operating temperatures. Seal-All™ is safe, easy, permanent and economical.

RESURFACING THE CASTING

Having completed adding and moving metal in the casting to close the crack, the surface of the casting should then be restored to its original condition.

For this purpose, Goodson supplies drills, rotary files, abrasive grinding stones, and grinding mandrels and sleeves. See our most current catalog for complete listings, or call for more information. Toll-free 1-800-533-8010 or direct at 507-452-1830.

Order No. **CPS-32** (32 oz. bottle) Also available in a 1 gallon bottle, Order No. **CPS-128**.

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