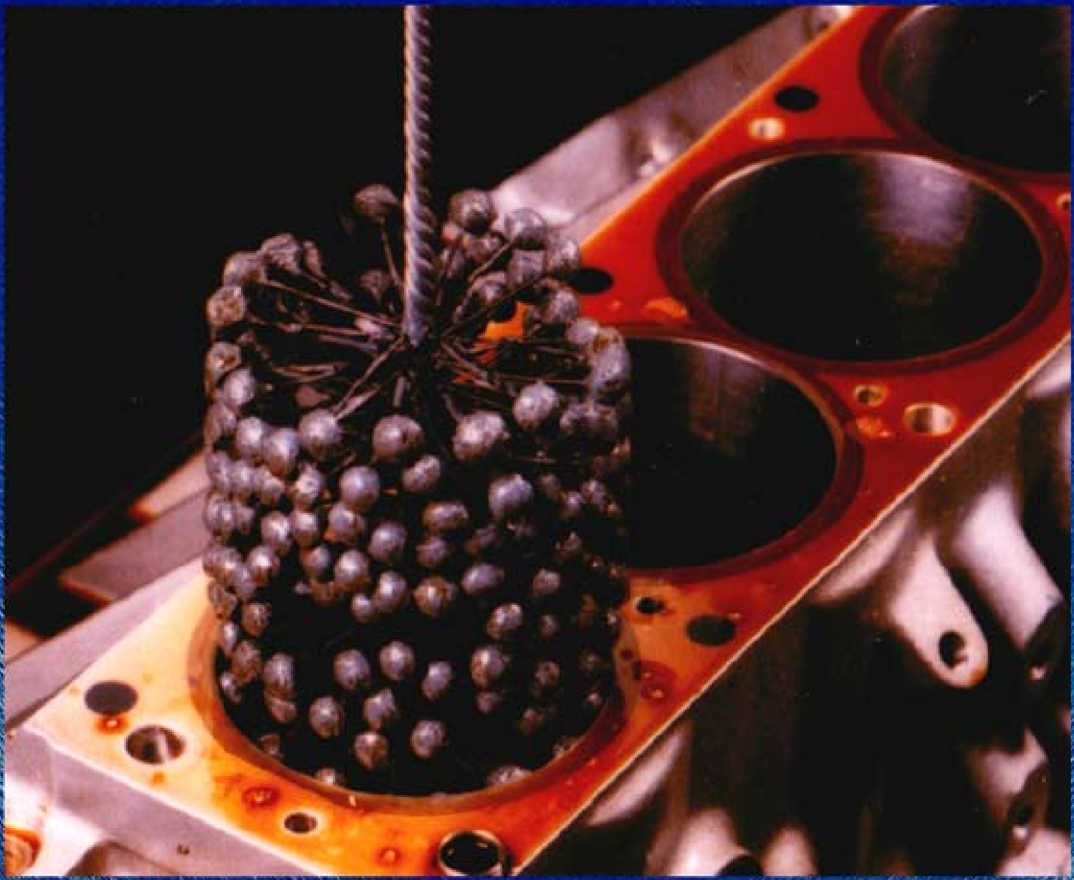


THE NECESSITY OF A PLATEAUED CYLINDER WALL FINISH

BRM

BRUSH RESEARCH MANUFACTURING CO., INC

A “BRM-STATE-OF-THE-ART” ON CYLINDER-WALL FINISHING

A treatise beginning on page 4 of this booklet. A “Should-read”

DIRECTED TO

The Decision Makers of
National Standards Environmental Agencies, Energy Conservation Gps., Original Equipment Manufacturers of Reciprocating Engines, Hydraulics, Pneumatics and Rebuilders of the above equipment.

STRESSING

The Importance of a Plateaued-Finish on any metal-rubbing-surface.

PLATEAUED-FINISH

Mass production methods in the past normally consisted of boring, then finishing to size using a rigid hone. The peaky finish left by the rigid hone then had to be abraided down by piston rings which also had to have a peaky finish in what is known as seating-in or breaking-in process. By the time the peaks had been worn down off the cylinder wall and also from the rings we then had an engine or a hydraulic cylinder that was much less efficient than if the cylinder and rings had this plateaued finish to begin with.

HOW MAY A PLATEAUED FINISH BE DEVELOPED BEFOREHAND?

This desirable plateau may be developed on a cylinder wall by the use of a resilient-based hone with a gentle pressure on the walls that removes very little metal, but does remove the peaks from the surface instead of leaving it to be worn off by the piston rings.

FLEX-HONE PROCESS

This is the name given to plateauing of the cylinder wall surface by the use of patented Flex-Hone. It is a resilient based hone that is self centering, self aligning to the bore, and self compensating for wear. Available in different abrasive grain sizes, it can produce almost any desired finish.

WHAT ARE THE ADVANTAGES?

Besides speeding up or in some cases eliminating the “breaking-in” process, the normal cut-torn and folded metal finish left by the rigid hone is eliminated resulting in higher efficiencies. Two engine tests are included in this report which show the types of advantages that might be expected – SAVINGS OF OIL, LOWERING OF BLOW-BY into the atmosphere, eliminating some of the wear factor of piston rings and cylinder walls, and to some extent, eliminating the “green-engine” that requires for example heavier-than-needed starters. And very important, the elimination of some of the major causes leading to scuffing and probable engine failure.

WHAT ARE OTHER ADVANTAGES?

The same advantages of a plateaued finish are of equal importance in hydraulics and pneumatics to prolong the life of the piston seals and give better sealing characteristics. Cross hole ports are also deburred and radiused. Longer life, better performance and greater safety in operation.

ON THE NEXT PAGE – SEE THE ADVANTAGES IN SUMMARIZED FORM

Details on the following pages. See KC Report and VW test runs.

AN EXPERIMENT TO EVALUATE THE EFFECTS OF A PLATEAUED FINISH

Using a standard VW engine as a test base for 4 controlled test runs using different types of cylinder wall finishes for results comparison. Tests were conducted for Brush Research by and under the supervision of Larry Dawson, President of German Engine Exchange Inc., 15247 Nubia Street, Baldwin Park, California, Larry Dawson Certifies the results as listed.

SUMMARIZED, THE TEST RESULTS ARE:

ENGINE TEST:

(DETAILS FOLLOW FOR CLOSER STUDY)

	BLOW-BY AT END OF TEST WATER PRESSEURE	FINAL COMPRESSION READING (4 CYLINDER AVERAGE)
"A" OEM FINISH	38"	150 PSI
"B" SUNNEN FINISH	31" —18% LESS	155 PSI____3% HIGHER
"C" FLEX-HONED	12" —68% LESS	161 PSI____7% HIGHER
"D" FLEX-HONED	15" —60% LESS	161 PSI____7% HIGHER

	OIL CONSUMPTION ADDED DURING TEST	RING GAP INCREASE (AVERAGE OF 8 RINGS)
"A"	24 FL. OZ.	.0042"
"B"	20 FL. OZ. —17% LESS	.0043"____2% MORE
"C"	16 FL. OZ. —33% LESS	.0029"____31% LESS
"D"	8 FL. OZ. —67% LESS	.0016"____62% LESS

	FUEL DILUTION	METAL TRACE ppm				
		TIN	IRON	COPPER	CHROMIUM	ALUMINUM
"A"	2.8%	5	200	74	1	31
"B"	1.6%	5	180	67	1	30
"C"	1.3%	< 5	130	54	< 1	27
"D"	1.2%	5	160	55	< 1	35
NEW OIL	0%	< 5	< 1	< 1	< 1	< 1

CASE OF A DETROIT DIESEL ENGINE CONSUMING EXCESSIVE OIL WITH NEW IMPORTED LINERS

Imported replacement diesel liners, as received by and international US company, with a CLA finish ranging from 73 to 116 AA were stated to have consumed 14 quarts of oil during a standardized test run. At the end of the test a "slobbering" effect was also observed.

It was reported that domestic made liners would normally consume 3 quarts of oil during similar tests.

Flex-Honing four of the imported liners reduced the finish to 39-42 CLA with plateaued areas. Test running with the opposing band of four liners, which were standard domestic liners with a finish of 55-56 CLA, the oil consumption was reduced to 2 quarts. If all liners had been Flex-Honed the oil usage would undoubtedly have been even lower.

Details and profiles of the test run on pages 15 thru 19.

THE VERY CRITICAL ASPECT OF CYLINDER WALL FINISH:

PREAMBLE

Since the Flex-Hone was first conceived and introduced in 1968 our company has been almost totally involved with the problem of cylinder wall finishing and not only have we read and studied most articles and papers written on the subject but have worked with engine manufacturing engineers throughout the world, not only on a direct basis but also through our exclusive distributors in all major countries of the world. A listing of the major engine manufacturers who have approved the Flex Hone process for their service organizations appears on the inside cover of our Catalog and attests to the experimentation work that has been done. About three years ago we produced a gold covered booklet on cylinder boring, honing and wall finishing which was an observation on some of the common practices in this field and in which we endeavored to explain the Flex-Hone and how it operated. This gold book has since been translated into 15 languages and has been widely circulated by many companies to all of their service dealers, and is used in many schools and technical colleges as a text and a reference on the subject. It is written in simple and easy to understand language and in this booklet we wish to go one step further and try to present in brief form not only some of our opinions but highlights of what has already been written on the subject by engineers in the United States and Western Europe. In the early beginnings our campaigns on cylinder wall finishing were primarily to introduce and sell the Flex-Hone. Now it has become a crusade to raise engineering standards, to improve an engineered mechanism, to produce a better product for the consumer and also in a small way to save energy and to reduce pollution.

A BRIEF HISTORY ON INTERNAL HONING

After World War II there was a tremendous demand for all sorts of consumer and durable goods and in particular engines—automobile, earth moving equipment and farm equipment. Excessive demand and competition for price, for less weight and more horse power demanded high performance production method.

Since Ramsbottom invented the piston ring in 1854 major developments didn't really begin until 1937 instituted by Castlemen. In 1957 and 1959 additional developments were made on the piston rings but it was not until 1969 through 1973 that investigations were begun to any great extent in cylinder wall finishing and the mating surfaces of the rings to the walls. Many large research projects have been going on since that time often with greatly conflicting opinions depending upon the direction which each company took in their research. The controversy still continues and the piston ring manufacturers not having any control over the honing processes attempt to design rings that will accommodate surface finishes produced by their major customers. One type of recommended wall finish is evolving and becoming accepted and that is the recommendation for a plateaued finish. However, some of the major manufacturers of liners, although they concede that they should have a plateaued finish in their products, maintain that developing a plateaued finish is difficult and very expensive.

One of the major developments in the mass production of engines 15 or 20 years ago was the development of the diamond hone. This enabled manufacturing to bore their blocks or liners within .001 to .002 of an inch and then to use the diamond hone to remove the rest of the material to a controlled size. The diamond hone is too hard, it is too sharp, and the great pressure required against the cylinder wall it leaves an extremely peaky finish with cut, torn, and folded metal. Valuable graphite flakes are often either removed from the surface of the cylinder or is smeared over with metal. The cross hatch grooves are inconsistent with some too deep or too fine, leaving a very undesirable surface-finish on which the rings must ride.

ENGINE FAILURE

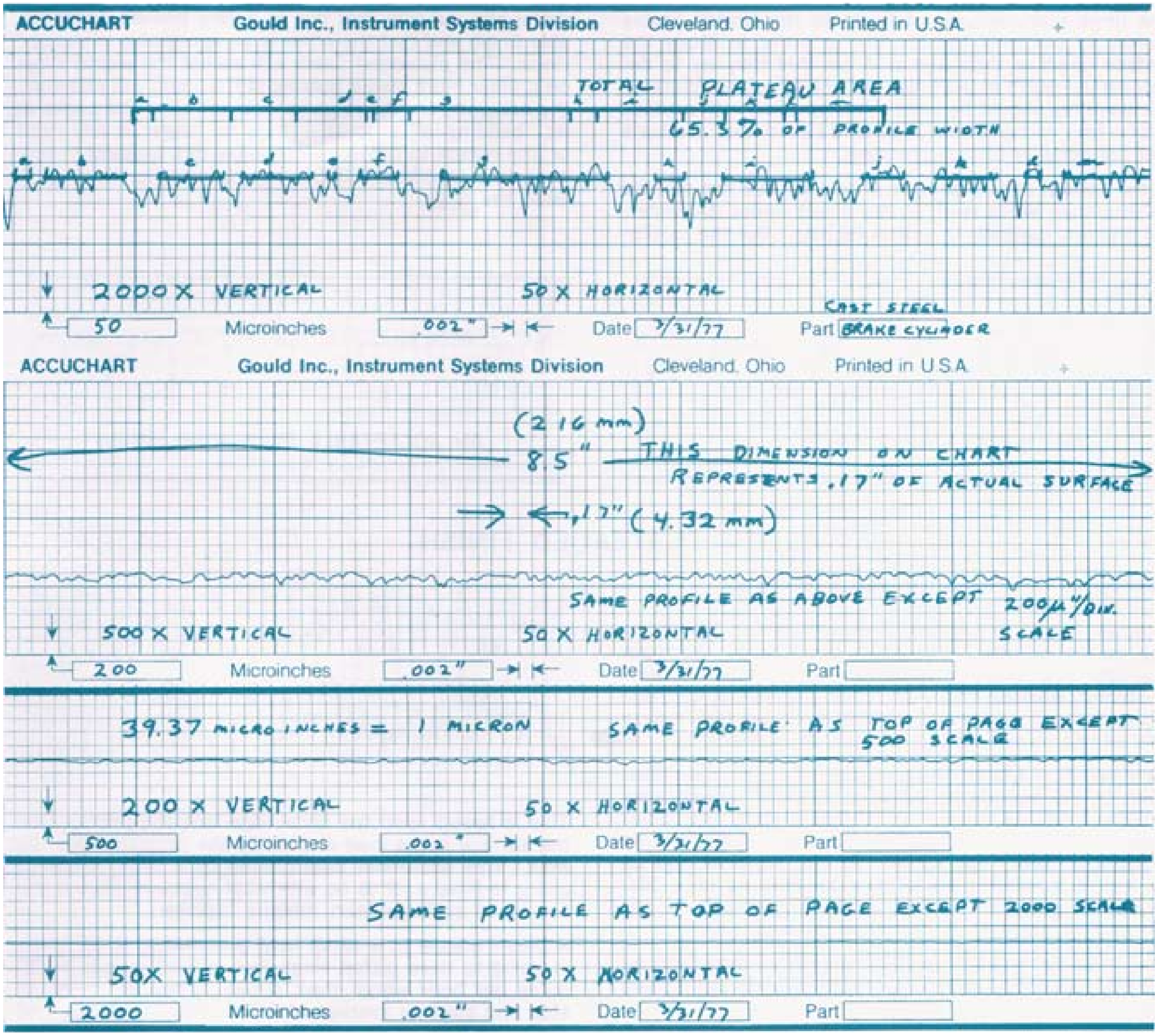
Engine failure can be classified as any engine that suddenly starts to consume large quantities of oil and has a large amount of blow-by. It usually requires immediate attention or there is a possibility of piston seizure that might even tear the liner apart. Many people drive nearly new automobiles that will consume up to 1 quart of oil every 500 miles and they may take it in for a claim on warranty or may continue to drive it and condemn the manufacturer for a bad engine.

MAJOR CAUSES OF ENGINE FAILURE

One of the leading factors in scuffing or what may be described in Europe as scalds, burn-traces or burn marks. Scuffing is an English term that means dragging your heels. When a piston ring drags on a cylinder wall surface with an absence of oil film until the heat builds up to such a point that there is a welding process that develops between the rings and the cylinder wall then we will have a condition of metal transfer which is also called scuffing. There are many underlying causes for scuffing and although we are going to enumerate many of them, the one that we wish to consider at this point is scuffing that may be caused by an unacceptable cylinder wall finish.

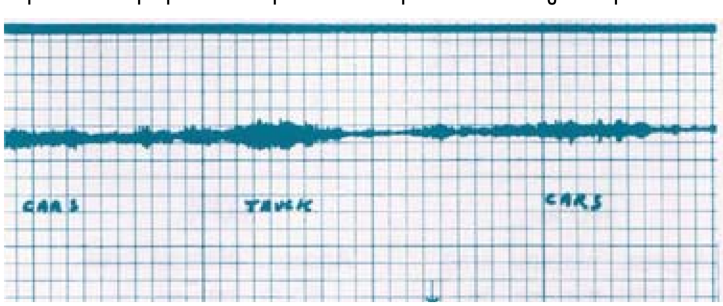
FINISH

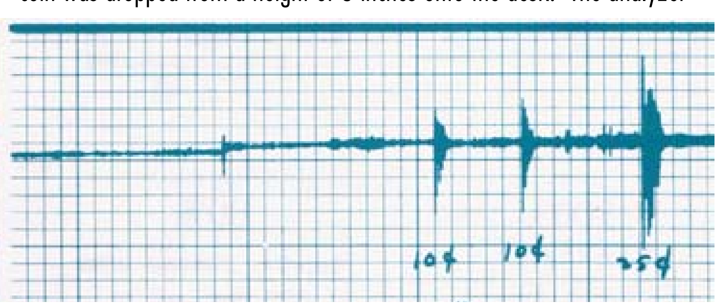
No surface is completely smooth and all surfaces have certain amounts of roughness. Upon being magnified these surfaces will appear as peaks and valleys along the axis on which they are measured. Also there are possibly repeating surface configurations which are known as lay. As on the ocean, not only do we have a wind wave pattern but we also have the regularity if the ocean's swells which is a conformation or a pattern that is repeated or may be intermittently repeated. In the profiles that are shown later in this report I would like you to be aware if the fact that the surface height as shown on the profile is magnified 2,000 times but that the length of the profile is magnified only 50 times. At the bottom of this paragraph we will show you the standard profile with the magnification and in the second frame how this would appear if it was extended only 500 times the vertical instead of 2,000. In the third frame how it would appear at 200 times the vertical and in the fourth or bottom frame how it would appear at 50 times the vertical and, therefore, equalized with the extension of 40 times the horizontal. While you are studying these comparisons we would also



like to indicate a simple method of arriving at the percentage of plateau. In the top frame is a cast iron brake cylinder which was honed with a 180 grit silicon carbide Flex-Hone which represents a plateaued area of approximately 65.3%. There are other more accurate and complicated ways of determining this plateau but the method that we have used is something that you can determine yourself from your own profiles and obtain a relatively accurate figure. Plateau is the tabletop or the flat areas on which the rings are required to ride or the bearing surface for the ring against the cylinder wall. In the second frame you will see that the profile that is shown there does represent approximately .17 inches (4.232 mm) of actual surface. What I find absolutely amazing is the lack of consciousness and concern of the importance of proper surface profile on the part of some large companies.

One of our large major railroads who use the Flex-Hone® uses only a surface-analyzer which employs a skid and a meter. The shop superintendent says that as long as their meter reads 35 AA, this was good enough for him. He has no idea how that profile does appear and whether or not he has any plateaued surface. Also amazing is the lack of care in many large companies in taking the profile of their engine liners or their cylinders. Their meters might be subjected to all the vibrations of the machine shop. We would like to show you below how our particular machine was affected by auto traffic when situated in the back of our shop with the machine mounted on a table saw with three rubber mats cushioning the table from the concrete floor. We also show the same machine situated on a desk in the office where a small coin was dropped from a height of 3 inches onto the desk. The analyzer

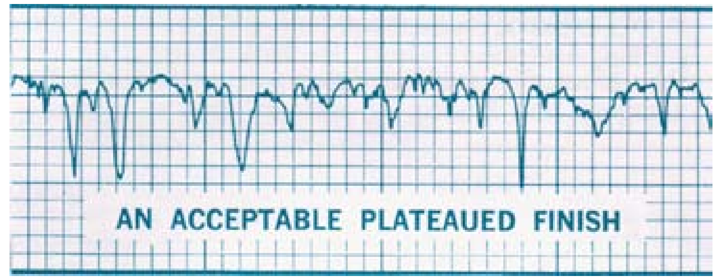




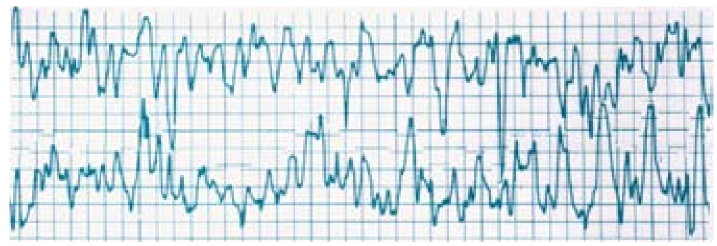
should be placed on a large slab of granite in a vibration proof area and the stylus reader completely separated from the chart recorder in order to avoid picking up resonance.

One large manufacturer of liners in the United States prefers to use only the fax-film in order to study the surface finish of their liners. From this they try to determine the depth of the finish and the amount of plateau. The fax-films should be used in conjunction with profiles and no firm opinions should be held based upon methods that are peculiar to that company.

At the bottom of this paragraph you will see two surface finishes that, when read on the direct re-out AA meter, will give you basically the same reading. But the profilometer will indicate that one is a very peaked unacceptable finish and that the other is an acceptable plateaued finish. The plateaued finish will accept the piston rings on a wider more stable bearing surface and will eliminate the necessity for the rings to wear off all of the peaks in its "bedding-in" process. There no longer is any need or any reason to provide or to allow this bedding-in process as a standard 2,000 miles running-in, which punishes the rings.



THE PLATEAUED FINISH



VARIANCES OF PRESSURE ON A BEARING SURFACE DUE TO FINISH

Whether we are considering surface finish on the piston ring or the cylinder wall or for that matter the main bearings of an engine, we do have two pieces of metal in contact, working under pressure. As neither of these two surfaces is completely smooth we must first realize that we will have a certain amount of interlocking.

We would first like to bring to your attention the differences in the bearing pressure on a different percentages of plateau on one square inch or one square centimeter of two contacting surfaces. In the first illustration we do have in theory two completely flat surfaces and on the top of number 1 let us assume that we have 500 pounds of pressure so that we have 500 pounds per square inch pressure on the lower surface.

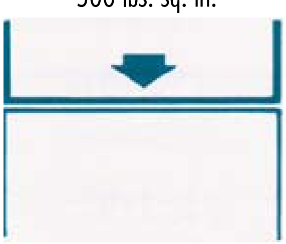
If we have for example an 80% plateaued area then we will have a surface pressure of 625 pounds per square inch. With a 40% plateau the 500 pounds pressure will now increase to 1.250 pounds per square inch.

With a 10% plateaued area, such as we would find in an extremely peaked surface, then the bearing area is 1/10 which increases the pressure of the contacting surfaces up to 5,000 pounds per square inch.

This is based upon the knowledge that the pressure on the surface is the load divided by the projected bearing area. This additional load caused by a peaky finish is going to have a lot to do with what happens when these two metal surfaces start rubbing together.

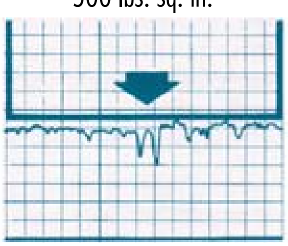
A diesel engine in a small boat proceeding at 15 knots is going to have piston rings that exceed speeds of 30 miles per hour within their stroke. They are going to stop and start an average of 4,000 times a minute, and during an hour of running time are going to be dragged across the cylinder surface a distance of about 19 miles. A mental realization of this will emphasize the importance of the surface finish that is needed on a cylinder wall when you think of the punishment that the piston ring is going to be subjected to in the first hour of running on a cylinder that may have a peaked finish.

500 lbs. sq. in.



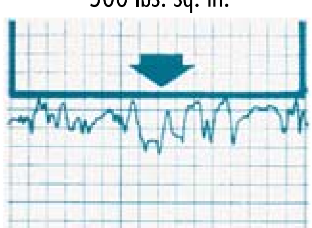
100%
CONTACT
500 lbs. sq. in.

500 lbs. sq. in.



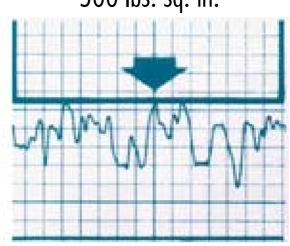
80%
Approx. plateau area
625 lbs. sq. in.

500 lbs. sq. in.



40%
Approx. plateau area
1250 lbs. sq. in.

500 lbs. sq. in.



10%
Approx. plateau area
5000 lbs. sq. in. pressure

THE EFFECT OF THIS BEARING AREA PRESSURE ON LUBRICATING OIL

The secret of course is lubricating oil and a condition that is going to permit a film between the two metals so that there is no metal to metal contact. In theory 1/10 of a micron of oil lubrication or film between two rubbing surfaces will prevent them from touching. One major oil company expert has stated that all you need is oil one molecule thick. Oil on a standard ½" ball bearing one molecule think and enlarged to the size of the earth would only mean oil up to the depth of your waist. However, the viscosity of the oil has been found to be very important and we now realize that we have a lot of other factors that have to be considered. Some of these factors are the blow-by that removes the oil from between the top ring and the piston wall, the pressure of the ring against the wall which squeezes the oil from the surface and heat that destroys it. There must be a film of oil between these two rubbing surfaces if we are going to prevent metal to metal contact because the moment we do have this contact then we are going to have a condition which will lead to excessive heat and possible temporary welding of one surface to another.

There is solid friction and fluid friction and there are three major features to determine the amount of each. Solid friction is the load or the amount of pressure that is placed upon the metal whether it be a ring or a bearing. Three factors in order of importance are first, the contact area which supports the load; second, the speed at which it travels; and third, the viscosity of the oil itself. Contact area, speed and lubrication. Consider the fact that oil is going to be squeezed out either by the pressure of the ring against the cylinder wall or the pressure of the connecting rod against the bearing. In order to have full film lubrication the oil must be replaced faster than what it is squeezed out. If the speed is too great or the area is too small for the load, then solid friction with accelerated wear is going to be the result. When an engine is started up from a standing stop we are going to pass through three phases of lubrication. This period of time is going to last from the time you start the engine until you see the oil pressure gauge reach its proper operating pressure. We will probably start off by having almost metal to metal contact with very little or no lubrication. Then we will have a thin film – a boundary or border-like lubrication. Then a thick film or a full film lubrication. It is very important, therefore, to have a surface that is capable of being wetted out of a surface that is going to maintain and hold a thin film of oil either when the engine is in operation or after it has stopped and is standing still. With a porous surface as you might find in some chrome cylinders or in some chrome rings, the oil will drain from the porosity whereas if you have a proper cross hatch finish with the proper valleys for oil retention the oil may remain wetted out on that surface. Viscosities of oils are an extremely important consideration at this point depending upon compression ratios, clearances, types of rings and cylinder wall surfaces, engine types, lubrications, heat of the engines, etc.

BLOW-BY

A piston on its upstroke really acts like an air compressor. It takes all of the air that has been sucked into the cylinder on its down-stroke and compresses it to a ratio of either 8 to 1 or 22 to 1 or any range in between. This pressure gradually builds up not only on the top of the piston but also on the top of the piston ring and the pressure gets down in behind the ring and forces it outward to the cylinder. On a diesel the compression of these gases builds up heat until it reaches an ignition point and we have a resulting heat flame that in the combustion era is probably as hot, if not hotter than an oxyacetylene torch. This instant heat, of course, expands the top of the cylinder head and piston, and the top ring and also the top part of the liner. At this point we have some distortion prior to the downward movement of the piston. If the ring is not mated or seated to the cylinder wall the greatest blow-by is going to be at this initial point of contact or lack of contact. Any blow-by is going to escape past the top ring, past the junction of the split in the ring (or at the horns) and the pressure is going to continue down to the second compression ring. The action there is going to be the same as with the first, where the pressure is going to get in behind the ring and force it out to the surface. There is a second danger at this point that we might suffer ring-collapse of the first ring and oil carbonization might build up between the ring and its groove which will prevent its future function and ring breakage will result. Sometimes there is so much blow-by on the first ring, that the major part of the pressure is on the second ring as we quite often see scuffing starting to develop at the second ring before we see scuffing on the first one. If these hot blow-by gases escape between the ring and the cylinder wall, then at this point any oil film that might be there is going to be burned off. When we talk about the use of the Flex-Hone we always say to be sure bring the Flex-Hone out of the cylinder while it is still rotating, because we want to produce a uniform cross-hatch finish completely throughout the entire length of the cylinder and particularly at the top of the ring travel. This advice then becomes more apparent to you because of the utmost necessity of trying to have a plateaued finish at the top of the ring travel to eliminate as much as possible the initial blow-by with the destroying of whatever oil film might be there. The pressure of the ring to the cylinder wall is going to have a squeeze action on whatever lubrication might have been placed there by the upward travel of the piston before its power stroke and by the connecting rod splashing or otherwise depositing oil on the cylinder wall itself. On its downward stroke the oil rings are going to scrape the oil back into the oil reservoir in the pan. The cylinder wall is cooled by the oil as the oil becomes a heat-sink. It is also going to be cooled in a wet sleeve by the water circulating around portions of the liner. The block itself is also going to be cooled by the oil going down through the oil galleries. The piston and the ring which are much hotter than the cylinder wall, are going to be cooled by the cylinder wall itself on its downward stroke and by the taking in of new air. We see that we have rapid expansion and contraction of the piston and the rings and actually the liner itself. One of the major causes of scuffing, particularly in the early running-in stages, is his initial lack of seating on a peaked finish which might be alleviated greatly by having a plateaued finish. All of this is extremely important on a new engine where a plateau might help eliminate or alleviate the start of the troubles. A peaky finish will give us less contact area for the rings themselves, thus greatly increasing the load or the pressure. Because of the lessening of this contact area we have the possibility of great blow-by thus destroying the oil film with greatly increased temperatures. This results in the rings themselves heating to a point whereby thy might melt the peaked metal off the cylinder wall and weld it to the ring. At this point we have scuffing. Be sure to study the engine tests on the effects of finish.

The rings themselves often have to do the final honing job and remove by abrasion all the peaks from the surface of the cylinder wall. In doing this the metal is worn away, imbedding away, imbedding particles of this metal into the cylinder wall and sometimes into the ring. If you have chrome rings, the chrome laminate is sometimes removed from the ring face itself. The heat reaches such a temperature that instead of the metal being worn down in a normal abraded fashion by the rings, it is smeared in a plastic formation against the cylinder wall. This is evident in some of the cylinder wall surfaces that you see after a failure during a running-in process. This plastic deformation or smearing of the metal down a cylinder wall removes all of the necessary cross hatch that is needed to hold a film of oil. The rigid hone often covers up in its smearing and plowing action the very important graphite particles that are part of the cylinder wall surface. These graphite particles besides being a lubricant themselves will also hold large amounts of lubrication and the Flex- Hone will cut the surface finish clear and expose the graphite particles. We used to say during our very early advertising, ''will allow the walls to breathe." This breathing or opening up of the surface permits oil retention and lubrication. Otherwise this plastic deformation of the cylinder wall metal and the changing of the micro sub-structure to an inferior status is compounded and additional scuffing is an inevitable result.

OTHER CONTRIBUTING FACTORS TO SCUFFING

In the early days of selling to the small engine rebuilder we used to get the comment that the Flex-Hone was great for the ''Hard Spots" or the ''Hot Spots" What did they mean? On an originally finished cylinder wall there might be a spot where dirt or imbedded metal (such as the torn and folded metal from heavy rigid honing) which would cause a greater spot resistance to the rings. This area would have greater heat build-up from the increased friction and the metal would expand at this point forming a ''bump." Sometimes these bumps got abraded off and sometimes they just continued to get bigger, thus being just another cause of scuffing. Excessive heating caused this Hard Spot which originally was a Hot Spot, which was originally debris imbedded into the wall or a fault in the finish. Some of these spots may be eliminated by proper original honing methods as they are difficult to analyze after they have developed.

When a surface is not too rough and there is a large contact area which will hold the necessary film of oil there is always some wear that takes place between the rings and the cylinder wall. In developing a mating surface, there is a mild abrasion which at some point may cause heat build-up to a point where there may be some initial minor scuffing. If the rings bed down or seat during this initial period, then this initial scuffing may not be too serious, and may completely disappear, and providing no great damage is done, the scuffing may even heal itself.

PISTON RING TYPES

Rings of all types have been experimented with and tested in order to give the optimum contact area to the cylinder wall, to prevent the rings from sticking, and allowing them to operate freely within the ring grooves and to have the proper outward pressure caused by the expanding gasses in the power stroke. Many different shapes and surface finishes and surface treatments have been developed mainly in order to accommodate a particular engine manufacturer to overcome blow-by, excessive heat, elimination of oil film, smearing of the metal and the resulting scuffing. One car manufacturer is now working with a piston ring manufacturer to develop a ring design that would reduce the outward ring pressure to 50% or less in order to reduce the problems that we have been discussing. Along with ring design different component expansions must be taken into consideration. As for an example when using aluminum pistons in a cast iron block, it is important to determine the proper cold clearance between pistons and bore. Perhaps, as an ex- ample, the cold clearance should be .005 inches in order to insure a reliable hot clearance of .0007 for minimum blow-by. Rings in their upwards and downwards travel tend to become worn off and have a barrel-shaped surface so a popular ring today is one that is made in that configuration in an attempt to prevent this initial wear on the ring, and its subsequent damage to the cylinder walls. Rings are chromed, they are treated with molybdenum, the cylinder walls themselves are chemically treated by Nitriding and other hardness treatments and cylinder walls are chromed. So far all of these are still in the great stage of experimentation and development and many new innovations will continue to be introduced as the years go by. In the midst of all this activity and research work that is going on with ring development and cylinder wall preparation, I believe that the Flex-Hone has arrived at just the right time. As a plateau developing tool, the Flex-Hone is something that there is an immediate great need of.

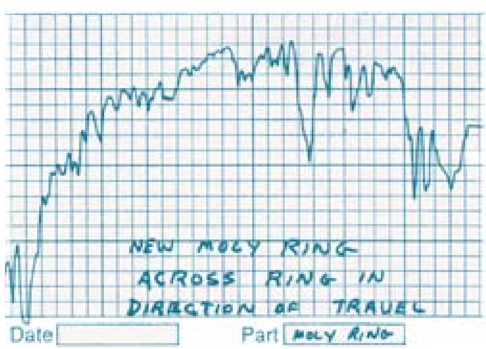
ADDITIONAL PROBLEMS CAUSED BY SCUFFING

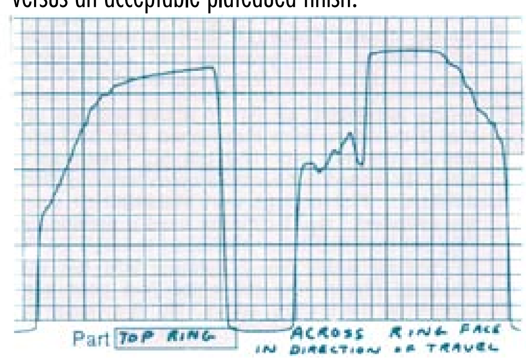
There is general agreement that scuffing is a running-in problem. The damaged surfaces have quite often been associated with the appearance of a white layer. This white layer is noticeable in both steels and cast irons and this white layer usually forms not only during the running-in but generally increases in coverage over the surface prior to the formation of an oxide which seems to take place towards the end of the running-in process. This white layer has been studied and although the researchers do not know exactly how it forms, it seems to be a Carbide structure. Almost always this white layer didn't form immediately, but was proceeded by a plastic flow of the surface, which deforms the subsurface structure, and causes hardening and other transformations of the metal structure itself. This hardened surface layer usually oxidizes, and after wear would eventually disappear off the surface. This white layer also appeared on piston rings, and the heat affected microstructure would extend in depth up to about 10 microns with about 10 microns on the cylinder wall. The white layer, as we stated, seemed to be a carbide in a very small crystal size which seemed to be a product of the deformation of the metal together with high friction temperatures. It is usually produced under unlubricated conditions with very high temperatures. It is very hard and brittle and eventually will fall from the surface to form an abrasive-wear debris, and to be the result of and not the cause of scuffing. Graphite which is present in cast iron in different forms reduces the cuff science of friction and actually to quite an even, resists scuffing in and after the oxide film is formed these graphite particles also form areas which will retain and hold oil.

SOLUTION

There are many, many reasons for engine failure, break- down, scuffing, or for the local breakdown of oil film, and almost any engineer can give you up to 50 reasons that may be Contributing factors. This is mentioned because we don't want you to get the idea that we feel that everything is going to depend upon cylinder wall finish because it does not. One of the prime causes, of course, is poor surface finish of the bore. Then we have many other causes such as the wrong design of rings, over- heating, distortion of the rings, the pistons, the top of the cylinder; incorrect use of oil, or the wrong viscosity of the oil; improper fuel mixtures, carbonizing or sticking of the rings themselves; ring collapse or breakage; improper cooling or water distribution In the cylinder block; incorrect oil galleries which also should aid in the cooling; improper oiling from the connecting rod itself into the cylinder wall: incorrect fuel, valve clearances, fuel mixtures. Any or all of these may be at fault. The one thing that the Flex-Hone can do and that is possibly to assist in one of these areas, which is to improve a poor surface finish that might be the major initial contributing fault.

Let's go back to diamond honing which we agreed is an excellent means of bringing a bore to its proper size, but it is an operation that must be very carefully controlled. It must be a suitable honing procedure, stones must be straight and dressed or it's going to produce totally unsuitable surfaces. Follow this, however, with a secondary honing method that is going to remove the peaks and establish a plateaued finish, the Flex-Hone may correct a lot of the problems that we have just discussed and which contribute to piston ring scuffing and engine failure. Many piston rings have been made with hardened rough surfaces in order to do the final honing, and perhaps if a plateaued finish yare developed these very hard and abrasive surfaces might not be necessary, as they might also contribute to the harm. We will show at the bottom of this paragraph a profile of a molybdenum ring in its new state. We have included in this booklet the Korody-Colyer test report and our own four stage engine test-runs. The profile of the ring that was used after 10 hours of running, (below) shows what happens to a ring when it is subjected to this severe running-in process of bedding down on a peaked surface. So it is altogether possible that a different type of ring may be more suitable on a Flex-Hone plateaued finish than the ring best suited for the ''unacceptable finish" which is all too common today. Standard cast iron rings have been found to be excellent with a scuff resistance somewhere between the chromium and the molybdenum and it might be interesting for you to measure the before-and-after ring gap difference between operations over an equivalent number of mites when running on an unacceptable finish versus an acceptable plateaued finish.





PROFILES ABOVE: On the left is the surface of a new Moly coated ring. On the right is the profile of a new AM top ring after 10 hours of running-in on a very peaky rigid hone finish as reported in the K-C Report (pg 15). Build-up in the center is probably carbon deposit. Wear-factor did plateau the ring as it originally had a thread patterned surface.

NEW BORING IMPROVEMENTS

Kwik-Way of 500 57th St., Marion, Iowa USA for several years have endorsed the Flex-Hone as a finishing tool to their boring bar without the necessity of using a rigid hone to bring the bore to a required size. The KW boring bar can bore to .0005" or less with a low CLA surface enabling the use of the Flex-Hone to produce the desired plateaued finish. In Germany the KW boring bar and the FH are presented as a team. Van Norman Machine Co. of 3640 Main St., of Springfield Mass. have recently conducted some experiments with us and intend presenting to the owners of Van Norman Machines, tools and recommendations to also bore to size and Flex-Hone finish. We feel sure that soon all manufacturers of boring equipment will follow suit.

SUMMARY

What we believe the engine manufacturers really want is to have the lowest possible temperature between the interface of the ring and the bore, lowered blow-by and a defect-free bore surface which is going to retain a lubricant. Lowering the ring-bore interface temperature is going to be helped by reducing the amount of friction, or the metal that the ring has to remove in its bedding-in process, and by a plateaued finish to also help to eliminate that wear and to give a larger bearing surface which In itself will reduce temperature by reducing the load on the piston ring and those sections of the bore at the point of contact. Greater area contact between the ring and the plateaued finish is going to lower the blow-by. Valley type finish is going to help retain the lubricant which is needed for rapid ring seating and resistance or elimination of scuffing. A cross hatch finish is also going to help spread the oil sideways on the up and down strike of the piston instead if forcing it up into the combustion chamber. Scuffing is gross surface damage caused by local welds between the sliding surfaces, and we feel that our Flex-Hone plateaued finish is going to help prevent this initial form of seizure.

AN EXPERIMENT TO EVALUATE THE EFFECTS OF A PLATEAUED FINISH

Using a standard VW engine as a test base for 4 controlled test runs using different types of cylinder wall finishes for results comparison. Tests were conducted for Brush Research by and under the supervision of Larry Dawson, President of German Engine Exchange Inc.,
15247 Nubia Street, Baldwin Park, California. Larry Dawson Certifies the results as listed.

The VW engine was the same for all test runs changing only matched sets of cylinders, pistons, piston rings, piston pins, new bearings, intake and exhaust valves and engine oil. The same crankcase, crankshaft, connecting rods, cylinder heads, camshaft and running accessories (carburetor, manifolds, cooling fan, etc.) were rerun in each test run to duplicate test base for a fair comparison of the various cylinder wall finishes.

"A" engine was assembled using new O.E.M. Kolbenschmidt cylinder assembly set exactly as received from the factory in Germany.

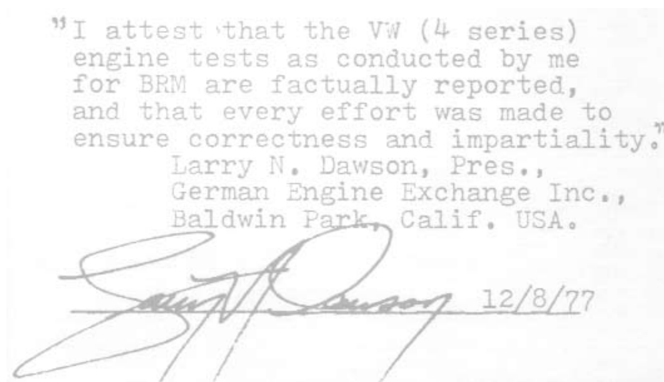
''B" engine was assembled using another matched set of Kolbschmidt assemblies except that the cylinder wall surface had been refinished with a Sunnen hone Model LBB-1710 using AN-200 (150 grit size) honing stones. Stock O.E.M. rings were assembled after honing. New bearings and valves were replaced and the valve seats resurfaced.

"C" engine assembled similar to above engines except that 2 cylinders were Flex-Honed with 120 grit SC and 2 cylinders with 180 grit SC. Bearings were also Flex-Honed to develop a cross-hatched plateaued finish. Piston rings were modified on some of the cylinders. No. 1 cylinder used a previously-run ring set that had been plateaued through 24 hours of running wear. No. 2 cylinder was run with a Hastings piston ring set which had been slightly lapped on the leading edges. No. 3 cylinder had a standard O.E.M. ring set. No. 4 cylinder used an O.E.M. ring set that had been lapped by Brush Research to remove the peaks and plateau the ring surface.

"D" engine was run with a Kolbschmidt cylinder set except that the cylinders had been Flex-Honed for 30 seconds with a GBD 3-1/2'/ 180 grit SC FLEX-HONE. Stock O.E.M. piston rings and pistons were run as received from the factory. New bearing and valves were replaced and valve seats resurfaced as were all above engines.

Cylinder wall finish profiles were taken before and after each test using a Gould Surfanalyzer. The Surfanalyzer uses a .0001/' radius diamond tip stylus with a system accuracy of +- 1 % full scale readings and records flatness of +-1 micro-inch per 14 inch of travel. The tests were run on a Stuska Dynometer for a 24 hour period under a scheduled sequence of various RPM and BHP load conditions. Measurements were taken for comparison at the end of 7 time intervals during each test run. The measurements consisted of blow-by, compression, oil addition, oil pressure and cylinder head temperature.

The basic test engine had a sealed crankcase system from which the pressure build up from blow-by was measured using a water manometer. The 7 readings were averaged for each test run to give an overall comparison of each run plus the final blow-by measurement gives a ring seating comparison at the end of 24 hours of running in.


"I attest that the VW (4 series) engine tests as conducted by me for BRM are factually reported, and that every effort was made to ensure correctness and impartiality."
Larry N. Dawson, Pres.,
German Engine Exchange Inc.,
Baldwin Park, Calif. USA.
12/8/77

BLOW-BY: measured in inches-of-water pressure build-up in crankcase.

ENGINE TEST	AVERAGE OF 7 READINGS TAKEN DURING TEST RUN	READINGS AT END OF TEST RUN
"A" OEM FINISH	35" H20	38" H20
"B" SUNNEN FINISH	39" —11% more	31" —18% more
"C" FLEX-HONED	28" —20% less	12" —68% more
"D" FLEX-HONED	23" —34% less	15" —60% more

COMPRESSION

After the completion of the four 24 hour test runs all cylinder sets were again reassembled on the test engine and run for a 3 minute warm up period. Using a full charged battery, a new starter and the same cylinder heads without rework, the compression was taken immediately after shut down and after 10 minutes cooling. By creating identical conditions, a fair judgment of compression figures can be used.

AVERAGE OF 4 CYLINDERS	
"A" OEM FINISH	150 P.S.I.
"B" SUNNEN FINISH	155 P.S.I. ——3% higher
"C" FLEX-HONED	161 P.S.I. ——7% higher
"D" FLEX-HONED	161 P.S.I. ——7% hgiher

OIL CONSUMPTION

There are many variables for oil consumption and cylinder wall finish is one of the main items to consider. The results of this particular test are not conclusive but give an indication of the effect cylinder wall finish can have under the same set of conditions.

Oil consumption for these tests was calculated by using the amount of oil needed to maintain the oil level at the full mark throughout each test. After each test the engine oil was collected and sent to an oil analysis laboratory for complete physical, chemical and spectrographic tests.

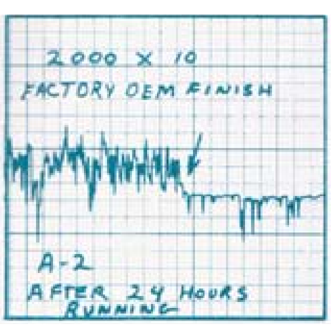
"A" OEM FINISH	24 fluid ounces	(710 CC)
"B" SUNNEN FINISH	20 fluid ounces	(591 CC) ——17%
"C" FLEX-HONE FINISH	16 fluid ounces	(473CC) —— 33%
"D" FLEX-HONE FINISH	8 fluid ounces	(237 CC) —— 67%

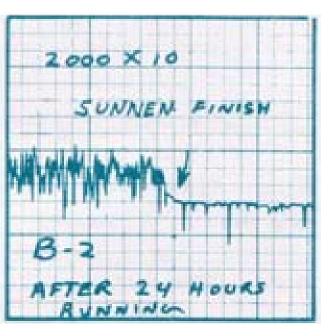
	RING GAP INCREASE Average of all compression rings in each test	CYLINDER HEAD TEMPERATURE Cylinder head temp. was measured at spark plug no.1 position Temperature is the average of 7 readings taken during a 24 hr test
"A" OEM FINISH	.0042"	257° F (125° C)
"B" SUNNEN FINISH	.0043"____2% MORE	249° F (121° C)
"C" FLEX-HONE FINISH	.0029"____31% LESS	232° F (111° C)
"D" FLEX-HONE FINISH	.0016"____62% LESS	244° F (118° C)

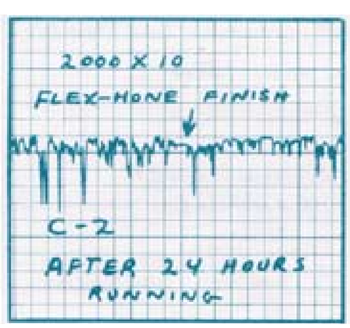
ENGINE OIL ANALYSIS TEST RESULTS

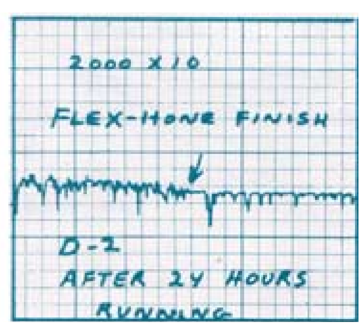
	FUEL DILUTION	METAL TRACE ppm				
		IRON	COPPER	CHROMIUM	TIN	ALUMINUM
"A"	2.8%	200	74	1	5	31
"B"	1.6%	180	67	1	5	30
"C"	1.3%	130	54	1	< 5	27
"D"	1.2%	160	55	1	5	35
NEW OIL	0%	1	< 1	< 1	< 5	< 1

While one particular test by itself does not give an absolute answer it does reinforce by giving a strong indication of some typical results to expect when using the Flex-Hone in any particular application. The unique finish produced by the Flex-Hone is uniform and consistent from cylinder to cylinder. The plateaued finish which the Flex-Hone process produces on any cylinder can be varied to fit any particular requirement from combustion engine cylinders to pneumatic or hydraulic cylinders with excellent results. The Flex-Hone process gives quicker ring seating with better oil control and reduction in blow-by from superior ring sealing. Pneumatic and hydraulic applications report better sealing characteristics and longer seal life using appropriate Flex-Hones for cylinder wall finishing. Elimination of problems of seal wear and shearing across cylinder cross holes and ports have been reported by users of the Flex- Hone.

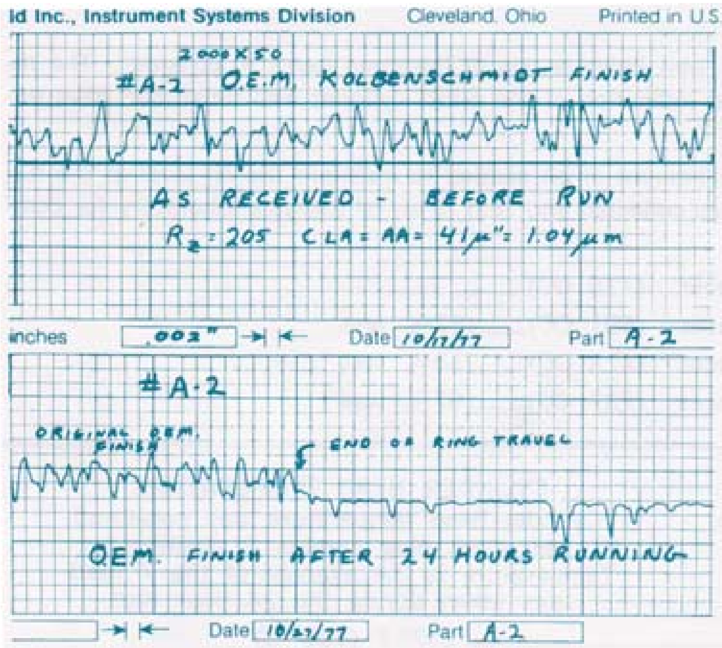


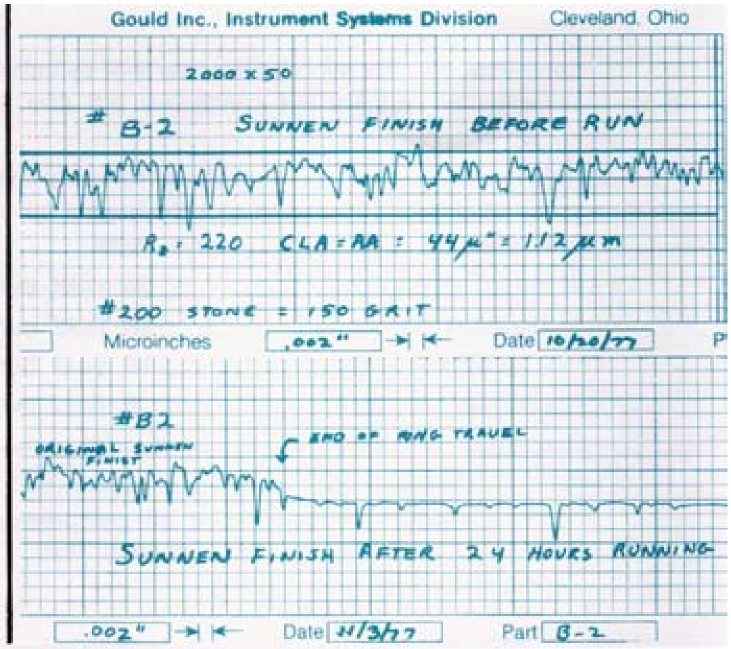






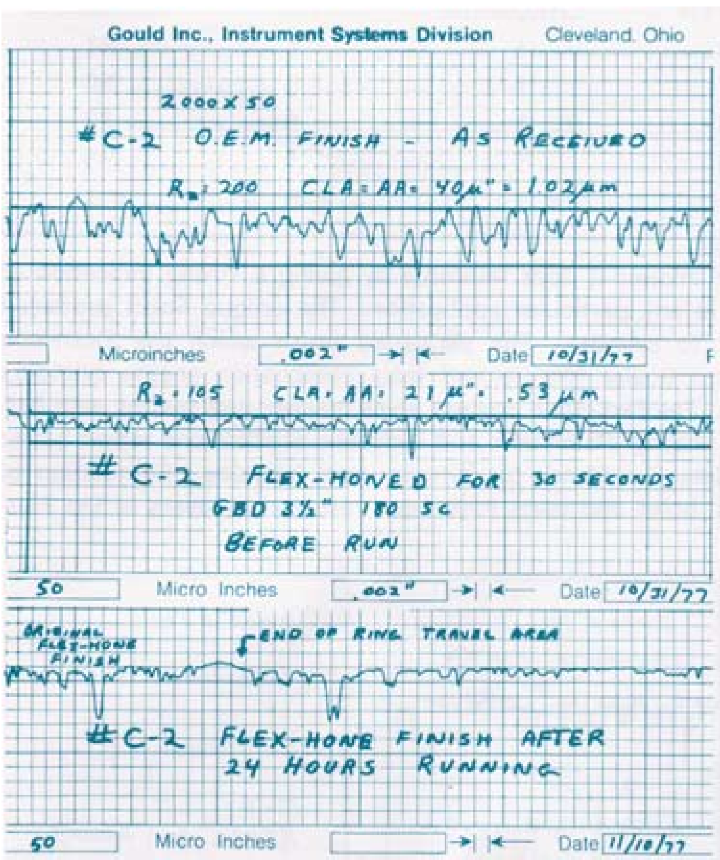
Condensed profiles of cylinder wall finishes for comparison of cylinder wear. Profiles were all taken from the same areas of the #2 cylinder on each test engine. Area of ring travel is the right hand portion of above profiles. Magnification is 2000 times vertical (.00005'/ or .00127mm division) and 10 times horizontal (.010'/ or .254 mm per division).

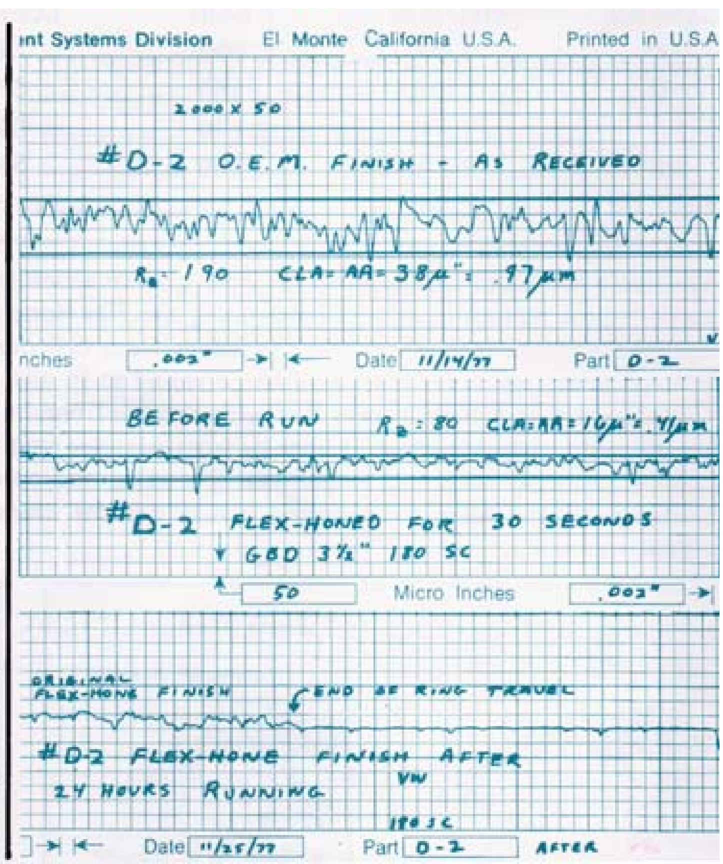




Engine "A" Cylinder #2 showing typical profiles of # O.E.M. finish before and after test run.

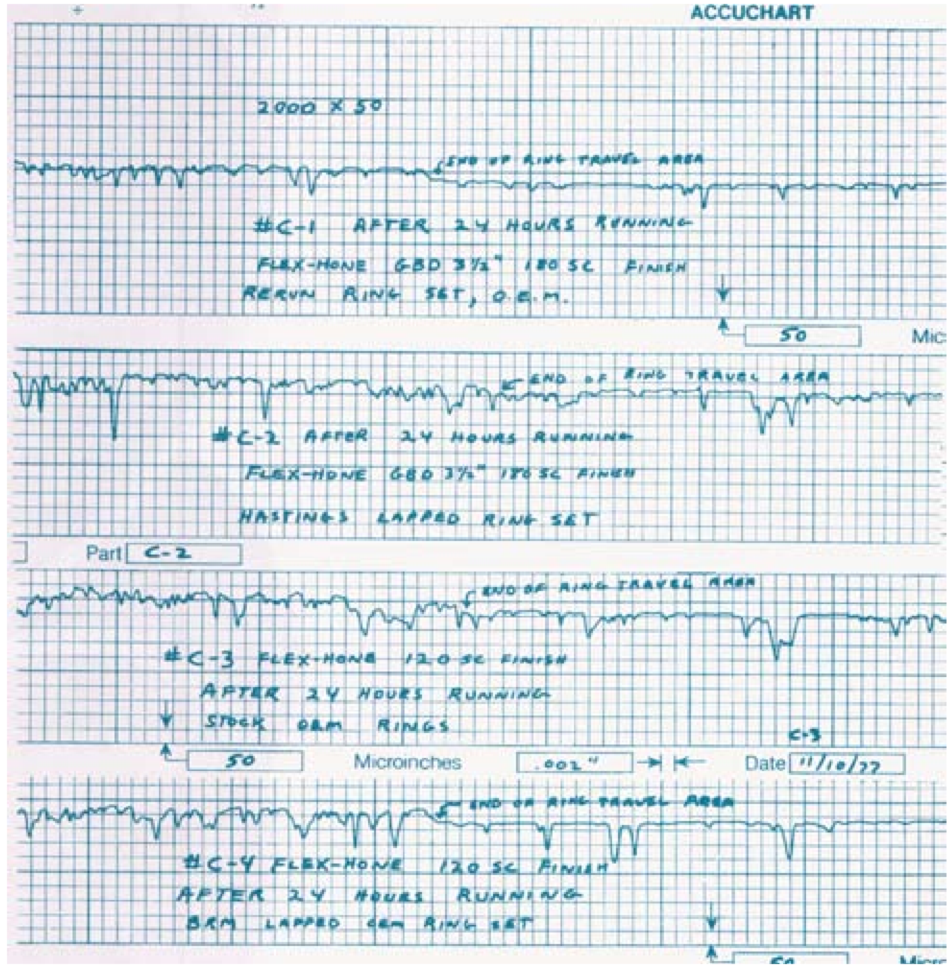
Engine ''B" Cylinder #2 profiles of Sunnen honed finish before and after test run.





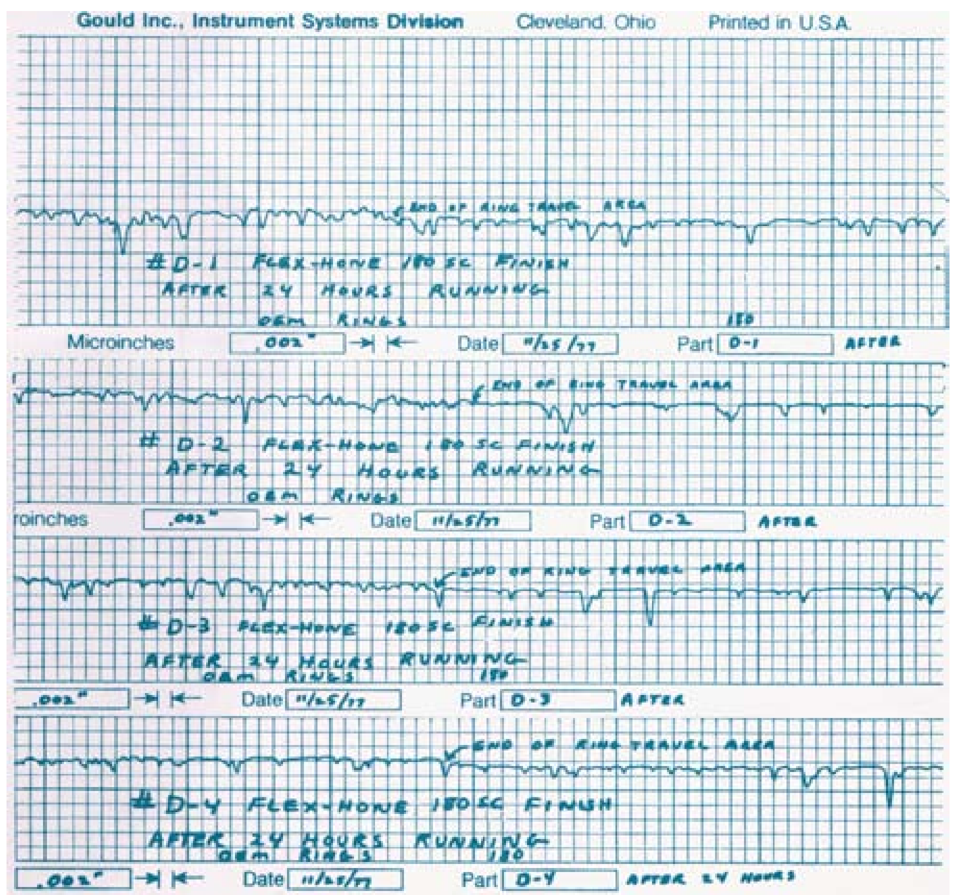
Flex-Honed engines ''C" and ''D" cylinders from # 2 position, profiles of O.E.M. finish as received, profiles of surface finish after using Flex-Hone GBD away 180 grit for 30 seconds and profiles of Flex-Hone surface finish after 24 hours of running in test engines. Compare ''run-in" surface finish in ring travel area of ''A" to Flex-Hone finish on C and D final profiles.

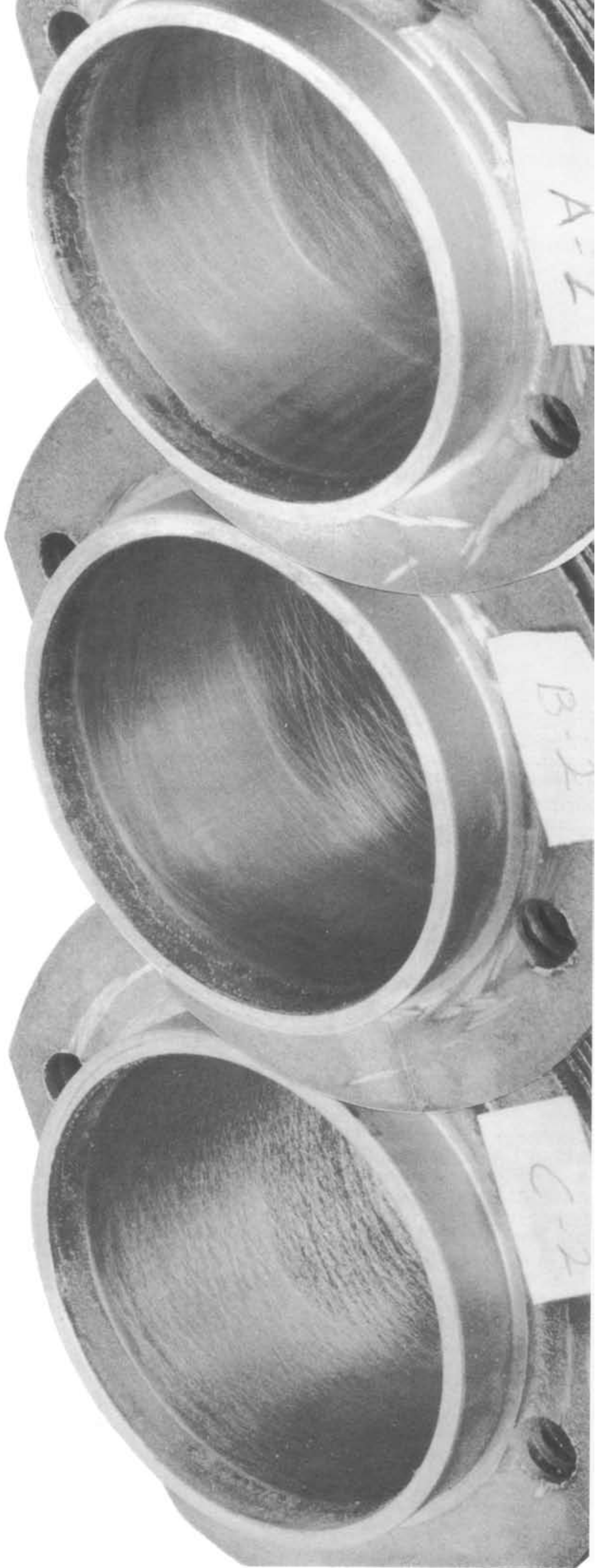
Flex-Honed VW engine ''C'' profiles of all cylinders after 24 hours of running. Profiles were taken at end of piston ring travel area. Cylinders C-1 and C-2 were 180 grit Flex-Honed before test run. Cylinder C-3 and C-4 were 120 grit Flex-Honed. Specially prepared ring sets were used in test run.



See ''after'' photos of No. 2 cylinder next page.

Flex-Honed VW engine ''D'' profiles of cylinders after 24 hours of running. All cylinders were 180 grit Flex-Honed for 30 seconds before test run.





O.E.M. finish after 24 hours of running in engine “A.” Cylinder wall had a glazed appearance and many fine vertical scratches.

Sunnen finish after 24 hours of running in engine “B.” Finish was similar to above with a glazed appearance in ring travel area and many fine vertical scratches.

FLEX-HONE finish after 24 hours of running in engine “C.” Cylinder wall still shows the unique appearance of Flex-Hone finish with cross-hatch clearly visible in entire ring travel area. Surface has a slight matt appearance and “open” look, without any sign of glaze or burnishing.

DETAILS ON THE CORRECTIONS OF A DIESEL OIL CONSUMPTION PROBLEM– KORODY-COLYER REPORT

On March 3, 1977 Korody-Colyer Corporation in Wilmington, California phoned Brush Research regarding a problem of excessive engine oil consumption with their replacement cylinder liners for series 71 Detroit Diesel engines. They were using a new imported source for their cylinder liners, a company call Nippon Piston Ring Co.,Ltd.

The new cylinders as received from NPR reported to consume 14 quarts of engine oil when run in a test engine for 10 hours and had excessive ''Slobbering" at the end of the test run. Typical oil consumption stated for cylinders from General Motors or Sealed Power would be approximately 3 quarts of oil in the same 10 hour test. After analyzing the cylinders as received from NPR we found the profile to be very peaky and not consistent from cylinder to cylinder with the C.L.A. finish ranging from 73 to 116 p" AA (1.85 to 2.95 um). We decided to use a GBD 4-14'/ FLEX-HONE 120 grit silicon carbide in the NPR cylinders for 2 minutes using Flex-Hone Oil as a lubricant.

The 4 NPR Flex-Honed cylinders were assembled on one side of a 8V-71 Detroit Diesel engine in Kor|y-Colyer's test lab. The Flex-Honed finish was very consistent with a C.L.A. of 30 to 42 p" AA (.99 to 1.07 um). The other side of the V-8 engine had 4 Sealed Power already in- stalled, C.L.A. finish of 55 to 56 p" AA (1.40 to 1.42um), waiting for the Flex-Honed cylinders as results were urgently required.

The engine was run for a specified 10 hour sequence of RPM and horsepower loading on the test dynometer at Korody-Colyer. After the 10 hour test period the engine was run for 30 minutes at a very light load as a final test of ring seating and oil control. Engines in which the rings have not seated allow so much oil past the rings and out the exhaust ports that the oil will leak out of the exhaust manifold gasket and run down the side of the engine, this effect is what the engineless at Korody-Colyer describe as ''Slobbering". If the final test was not run at light load the ''Slobbering" effect would not be found as the excessive oil would be burned up by the high exhaust temperatures at maximum horsepower loads.

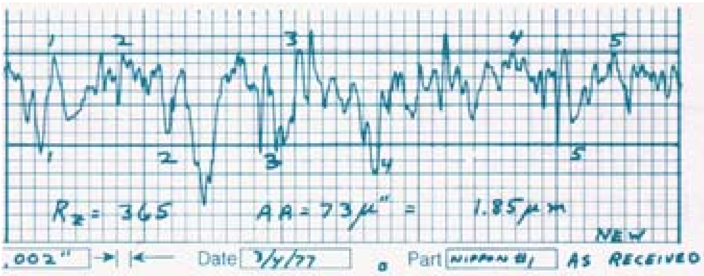
The engine in which the Flex-Honed cylinder liners were run consumed only 2 quarts of oil during the 10 hours of the test run. As typical oil consumption stated for this engine with all S.P. or GMC liners would be 3 quads of oil, then it could be assumed that 4 sap- or GMC cylinders would use 114 quarts of oil. The conclusion is that an engine with all 8 cylinders Flex-Honed to a Plateaued Finish would then probably consume only 1 quart.

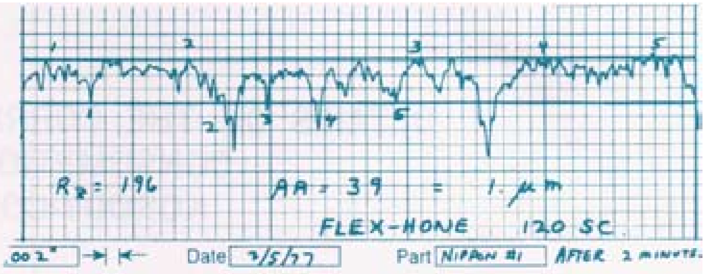
We visited the site during the test period and the engine was stopped after the first 1 ½ hours of the test had been completed. The exhaust manifolds were removed and the ports examined. A wet look inside the pods is an indication of excessive oil being used and indicates which bores are responsible. Three of the Sealed Power cylinders showed a faint sheen inside the exhaust arts indicating only slight oil passage. Only one of the Flex- Honed cylinders showed a faint sheen inside the pod. At the completion of the 10 hour test the exhaust ports were examined on both sides of the engine and none of the ports showed any signs of oil passage.

We also received additional cylinders from Korody-Colyer for examination and Flex-Hone experimentation. The results are attached with comments. The Detroit Diesel Engine is a two-cycle engine which has different requirements for ring seating and oil control than a four-cycle engine. The DD engine has two sets of rings, one set near the top of the piston are for combustion citron and act as an intake valve as they go past the intake ports on the cylinder wall. The bottom set of rings are mainly for oil control and do not pass the ports and are not subject to combustion pressures. Seating-in of the bottom set of rings is very similar to the problems involved in ring seating of an air compressor.

As is clearly visible on the Sealed Power cylinders, the profile created by the Flex-Hone is virtually identical to the finish produced by running the same type of cylinder in an engine under load for 10 hours. The Flex-Hone accomplished in 2 minutes the same finish that 10 hours of running produce in a new Sealed Power cylinder.

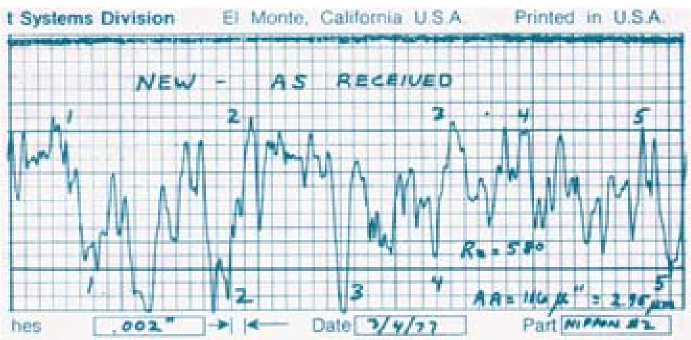
All surface profiles were taken on a Gould Surfanalyzer 15 system using a .0001"radius diamond tip stylus, stylus force of 800 mg. System accuracy ±1 % full scale. Sensitivity of 50 microinches per chart division was used on following profiles, system has the capability of sensitivity of 5 microinches per chart division. Flatness from a horizontal plane is ±1 microinch for 1/2 inch of travel. Profile magnification is 2000 times on the vertical axis and 50 times on the horizontal axis.

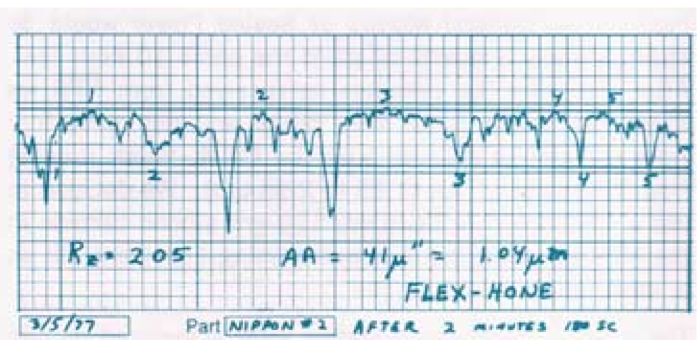




NIPPON #1 CYLINDER:

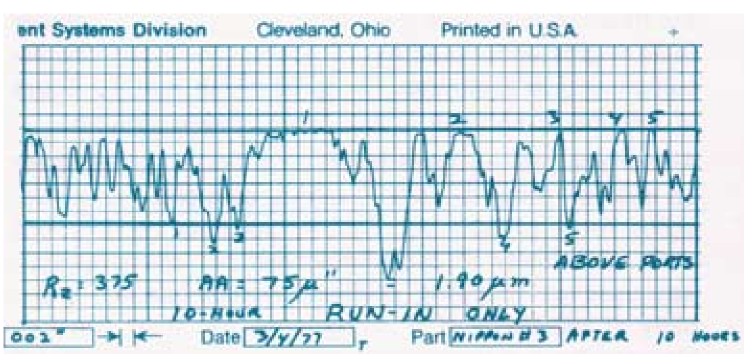
A new cylinder as received from manufacturer. This was one of six new Nippon liners that were brought to Brush Research by Korody-Colyer because of ring seating problems. This cylinder shows the typical peaky profile of these cylinders as received. This cylinder had an AA finish of 73 μ" (1.85 um). After using a Flex- Hone GBD 4 ½" 120 grit Silicon Carbide for two minutes in the above bore the finish was improved to a semi- plateaued AA finish of 39 μ" (1 um). Material removed after two minutes of honing .00025" (.006 mm). The cylinder material had a high boron content and difficult to hone as compared to a cast iron engine block.

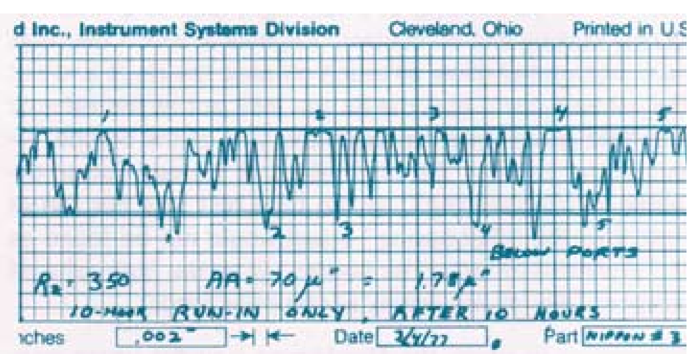




NIPPON #2 CYLINDER:

A new cylinder as received showing the very peaky finish typical of the new Nippon cylinders. This bore had an AA finish of 116 μ (2.95 um). After using a 180 grit Silicon Carbide Flex-Hone for two minutes the finish was improved to a plateaued AA of 41 μ" (1.04 um). After an additional two minutes of Flex-Honing the surface finish was not changed much at an M of 42 μ" due to the original rough surface and the hardness of the material being honed.



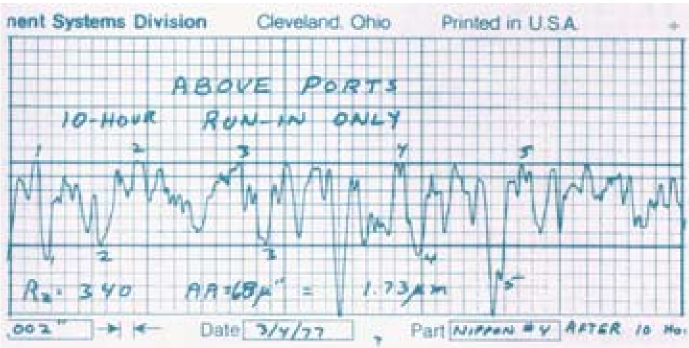


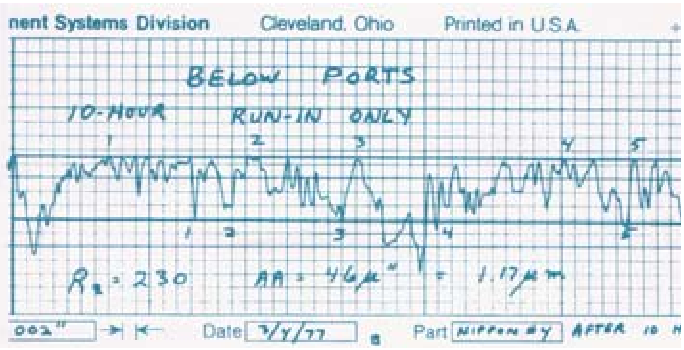
NIPPON #3 CYLINDER:

As received after being run for 10 hours in a V-8 test engine at Korody-Colyer. During the test the engine was reported to have consumed 14 quarts of lubrication oil (typical usage for General Motors or Sealed Power cylinders was stated to be 3 quarts). The area above the ports is subject to combustion pressure and showed considerable ring blow-by as discoloration on the wall surface. The profile of the surface shows very little plateau from the rings and the AA of 75 μ" (1.90 um) is still very peaky. The area below the ported area was typical of the finish above the pods with an AA finish of 70 μ, (1.78 um).

NIPPON #4 CYLINDER:

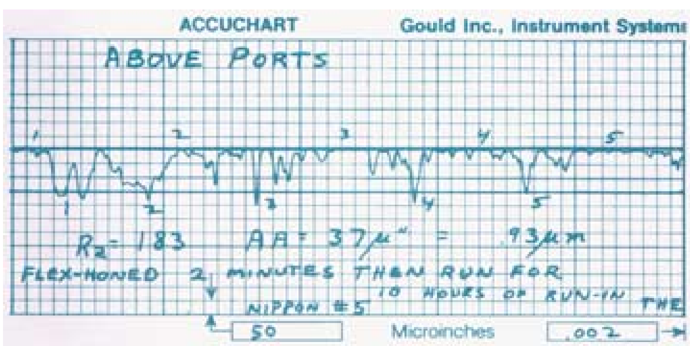
As received after being run for 10 hours. Profile of cylinder above ports shows no signs of plateau from ring seating. As received AA was 68 μ" (1.73 um). The profile of the cylinder area below the ports shows minimal signs of ring seating and an AA of 46 μ" (1.17 um).

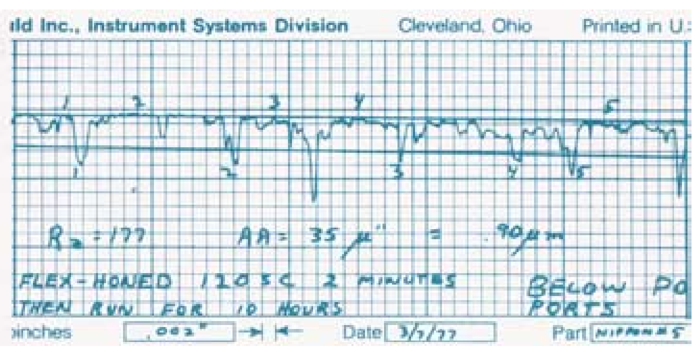




NIPPON #5 CYLINDER:

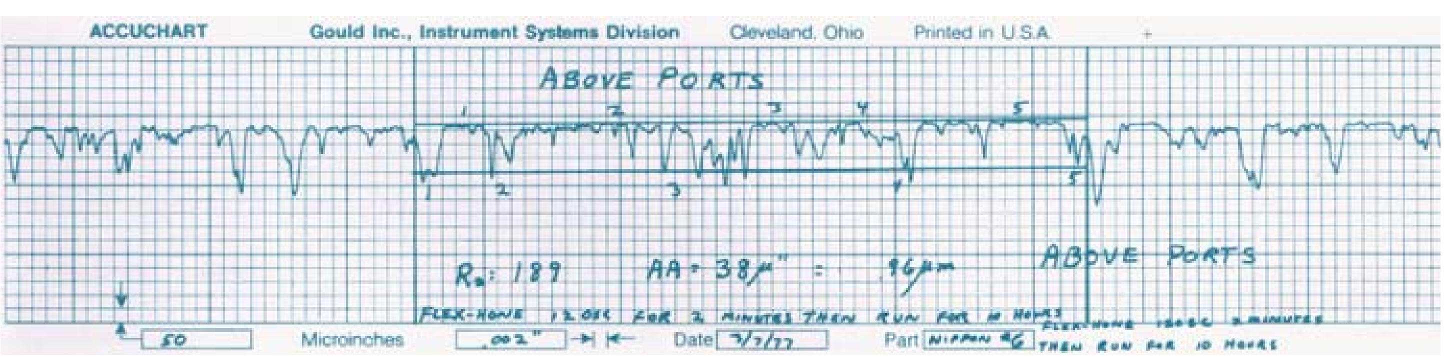
This cylinder was Flex-Honed for two minutes with the GBD 4 ½" Flex-Hone 120 grit Silicon Carbide using Flex-Hone oil for a lubricant before the 10 hour run-in test at Korody-Colyer. The profiles were taken of the cylinder bore above and below the ported area. Piston ring seating was excellent as the engine consumed only 2 quarts of lubrication oil during the 10 hour test. The plateau profile is evident in both ring travel areas. Deep scratches from the original manufacturing are still evident as valleys much deeper than the regular profile pattern.

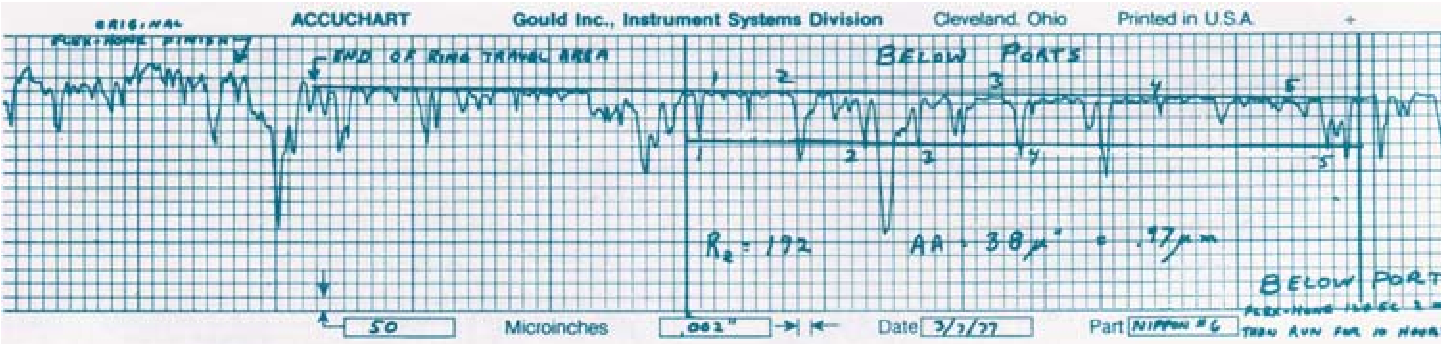




NIPPON #6 CYLINDER:

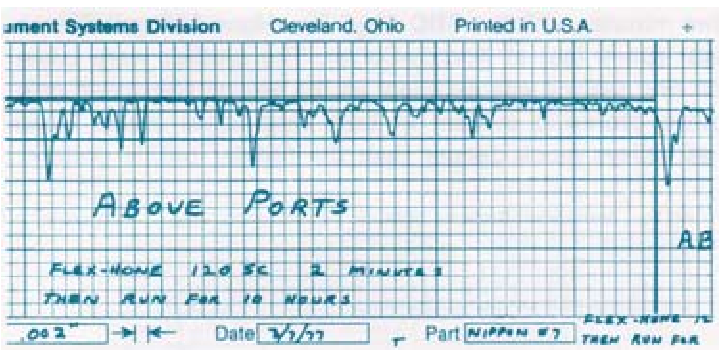
This cylinder is one of the four cylinders run in for 10 hours at Korody-Colyer in their engine test. The excellent plateau profile finish is quite evident in both areas of the cylinder. This cylinder had been Flex-Honed for two minutes with 120 grit Silicon Carbide using Flex-Hone oil as a lubricant. The original Flex-Hone finish is still visible on the left hand portion of the profile beyond the ring travel area. Approximately 75 millionths of an inch (.000075" or .001905 mm) of stock was removed by the piston during the 10 hours of run in.

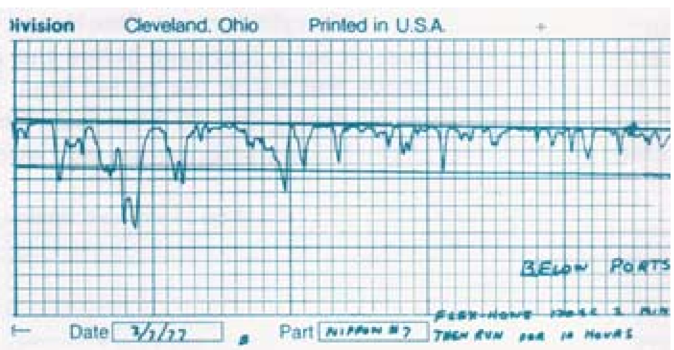


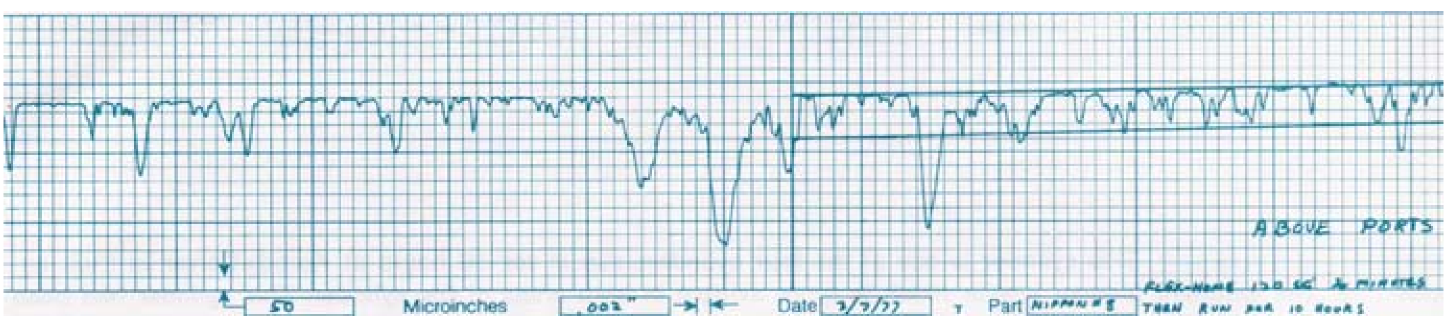


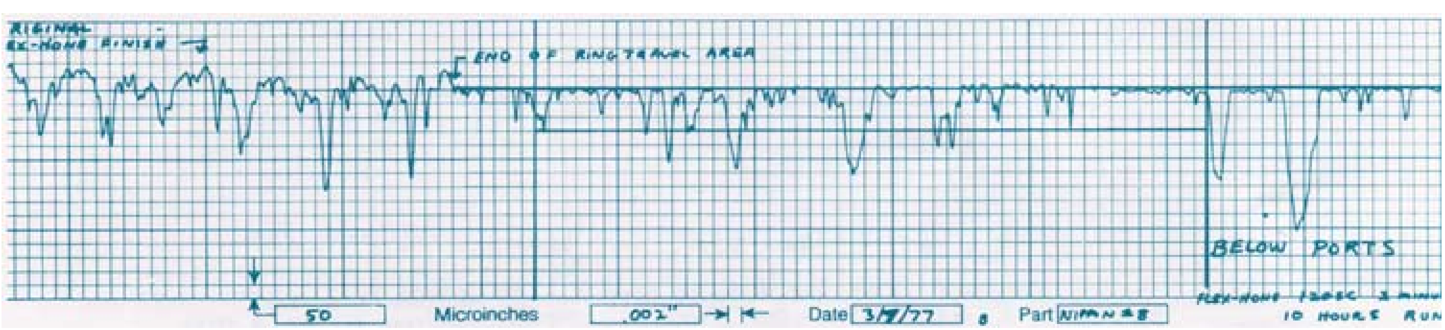
NIPPON #7 & #8 CYLINDERS:

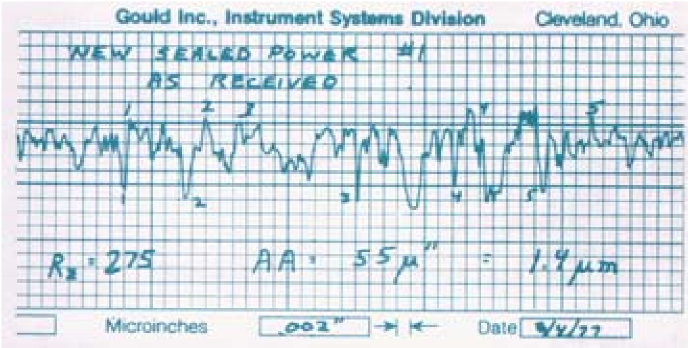
Profiles of the cylinder areas above and below the intake ports shows the excellent plateau created after running for 10 hours on a Flex-Honed surface. The cylinders were Flex-Honed for two minutes before run in a test engine. The original Flex-Hone finish is visible on the left hand portion of the profile of cylinder #8. Approximately 75 millionths of an inch (.001905 mm) of stock was removed during ring seating. During the 10 hour test the engine consumed 2 quarts of lubrication oil (typical usage during a 10 hour test is about 3 quarts when using either General Motors or Sealed Power cylinders in the same engine.)

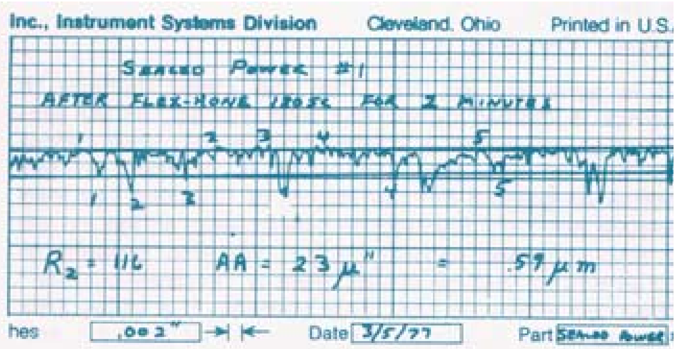






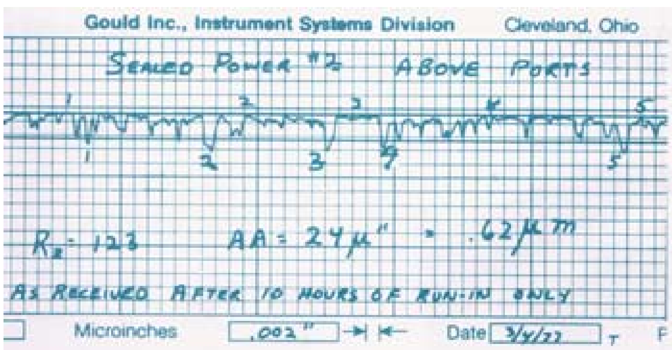


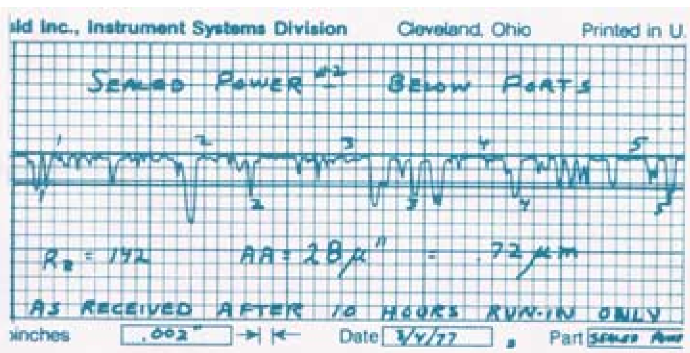




SEALED POWER #1:

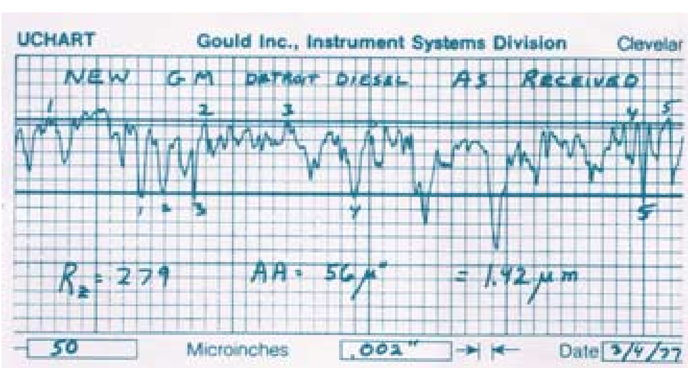
A new cylinder as received from Sealed Power with a consistent and uniform AA finish of 55 μ" (1.4 um) throughout the bore. After Flex-Honing for two minutes with 180 grit Silicon Carbide the surface was improved to a 23 μ" (.59 um) plateau profile typical of the Flex-Hone. Stock removal after two minutes .0001-(.00254 mm).

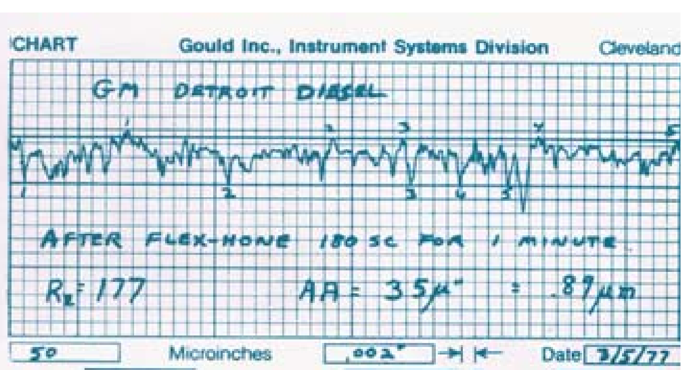




SEALED POWER #2:

A Sealed Poker cylinder received after having been run for 10 hours in a test engine. The finish is an excellent plateau profile in the areas above and below the intake ports. The AA 24 μ" (.62 um) finish above the ports is virtually identical to the Flex-Hone finish created in the new Sealed Power cylinder #1 above. The Flex-Hone accomplished in two minutes the same profile finish that was produced by 10 hours of running in an engine under load. The area below the ports had an AA of 28 μ" (.72 um) with a similar plateau profile finish.





GM #1 CYLINDER:

Profile of a new cylinder as received from General Motors showing a finish of AA 56 μ" (1.42um). Finish is consistent and uniform through out bore. After Flex-Honing for one minute with 180 grit Silicon Carbide the finish was improved to an AA of 35 μ" (.89 um) with an improvement in plateau profile.

BEARING

Mains, Con Rod, Cam

It is generally assumed that the major damage to bearings is caused during the first 10, 15, or 20 seconds after an engine is started from a cold start before thin - film or full - film lubrication is reached. In our Treatise we pointed out the effects of ''bearing" or load pressure not only involved in the squeeze action on oil but also the heat causing factor. We also brought to your attention that oil drains from a ''smooth surface" or from a surface that has only porosity. If a valley area is necessary in a cylinder wall to retain or hold oil, and if a cross hatch is necessary to spread the oil, and if you agree with this concept, then should not the same surface be on the face of a bearing for the same reasons?

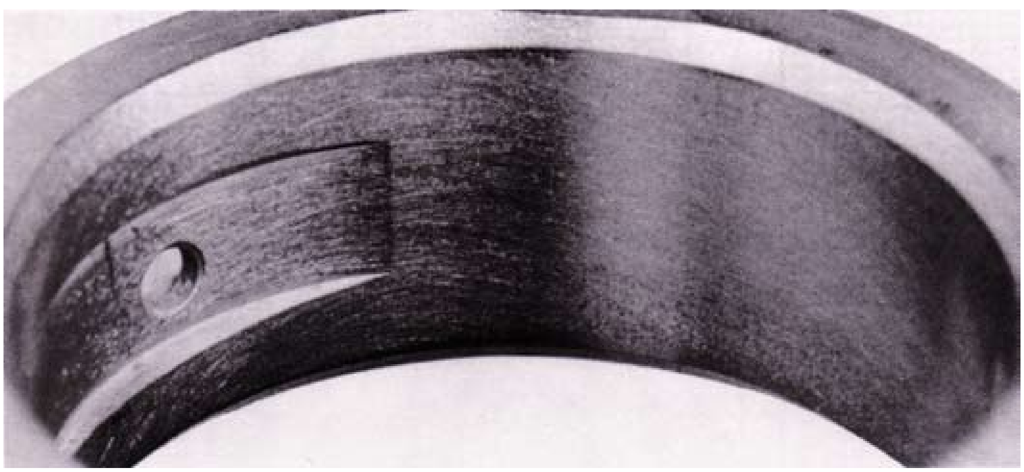
Any time we have suggested trying a Flex-Hone type finish on a bearing face, we got expressions of horror, and amazement that we should even suggest such a thing. So we tried it out on Engine Jest ''C ' One large US Bearing Manufacturer agreed with our thinking and are (we believe) experimenting in their R&D Lab. But most large companies take years, and often the results never reach the Decision Makers. The Chief Engineer of this R&D thought that the Flex-Hone process also DEBURRED the INTERSECTS OF THE CROSS HATCH FINISH, AND STRESS- RELIEVED THE METAL AT THIS POINT OF INTERSECTION. THINK ABOUT IT. We are not bearing manufacturers, but we have learned a little about surface finish.

If the concept of a plateaued finish is desirable for a cylinder wall,

THEN SHOULD IT NOT APPLY TO:
PISTON RING SURFACES,
BEARING SURFACES,
VALVE GUIDES,
AND ANY TWO METAL RUBBING SURFACES?

Usually the main concern is COST. Most engineers tell us that Quality Control is not their concern, but if they can get the same or equivalent finish, performance, etc. as is NOW accepted or is common practice within their company or field, AT A COST SAVINGS then that is all they are interested in. COST SAVINGS ONLY. They are not in a position to change anything so they express no opinions. If they can save a penny on the operation, or reduce its weight, they are heros. We need more than Government Regulation and Competition to force change, we need the constant desire to improve for the benefit of the consumer, which In short time will be of mutual benefit for all.

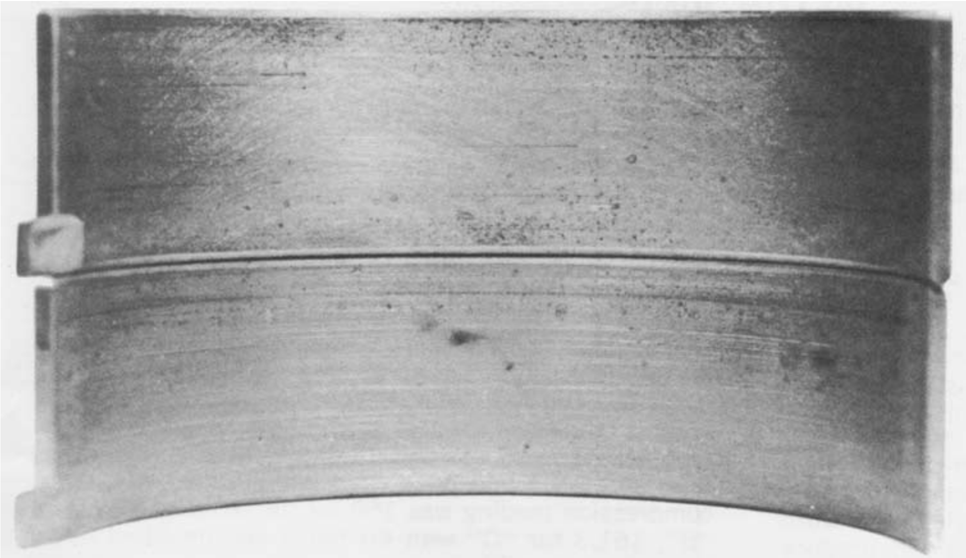
NOTE THE APPEARANCE OF PHOTOS OF BEARINGS
USED IN THE ENGINE TRIALS



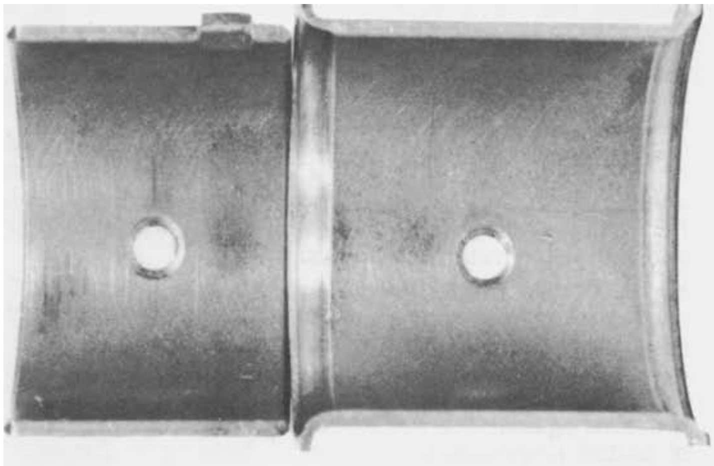
Bearing from "C" engine No. 2 cylinder taken after 24 hour run. All "C" Engine bearings were Flex- Honed first for 12 strokes with 320 AO.

Notice absence of scoring and wear and appearance of original Flex-Hone finish.

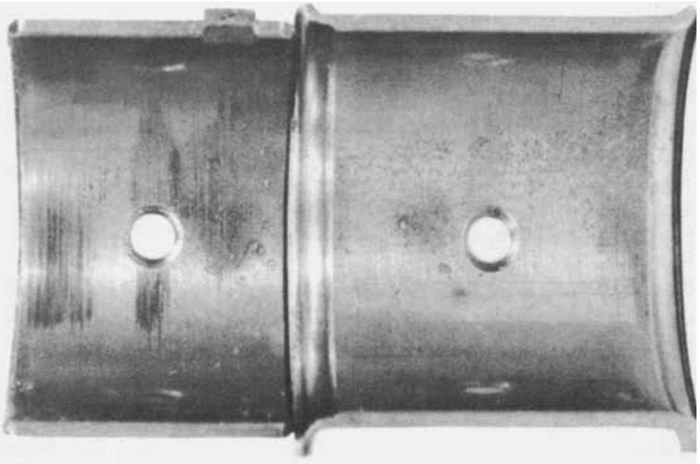
Bearing from No. 2 cylinder "A" engine after 24 hour run. An OEM new bearing such as were used in all the trials. Similar effects will be noted on all bearings as shown on the next page.



Flex-Honed Finish is easy to distinguish. Both from No. 2 cylinder assembly after the 24 hour run. "C" test on top and "A" below.



Original Flex-Honed Finish looks the same as before the 24 hour run. "C" No. 2.



O.E.M. set from "A" No. 2. The appearance does not leave much choice, does it?

NOW, LET US RECONSIDER THE OIL ANALYSIS

Wear elements of metal indicate engine condition. Iron from cylinder wails shows up in high levels during ''break-in' 'and then falls back as wear is stabilized. Nickel is found in valve stems and crankshafts. (of which all above tests showed a minus-trace), and when combined with copper, tin and lead can be an indicator of serious bearing and crankshaft wear. Nickel, without the other three, indicates the need of a valve job. Chromium may indicate rings and cylinder wall. Lead, copper and tin are common bearing metals known as ''babbit". High readings can mean loss of an engine. Aluminum is used in some blocks and pistons. Oil analysis is readily available, is inexpensive and is a clue to many problems.

The relationship of the metal traces indicated in the Oil Analysis shown on page 3 and the appearance of the wear factors on the bearings above now becomes evident. Here is a WHOLE NEW FIELD for the S.A.E. to study and perhaps the President should appoint a committee.

PISTON RINGS
THE CRITICAL ASPECT OF COMPATIBILITY WITH BORE SURFACES

Piston Ring Manufacturers normally have no control over cylinder wall finishes, but try and develop a ring to meet an engine manufacturer's specifications. Many different shapes barrel faced, positive twist, reverse twist, head land, etc., designs have been produced from grey iron to ductile iron from thicknesses of 1/8 inch down to 1/16th inch, with some chrome faced, chrome sided, treated with molybdenum and other hard facing materials, and experiments with exotic materials. Some of these changes were undoubtedly made for economy and speed in the manufacture of the rings and the pistons to house them. Positive and Reverse twists were intended to provide seals against blow-by and oil, but few took into consideration the damaging abrasive punishment given to them in the ring-seating process while the peaky finish normally found in a rigid honed cylinder is worn down to develop the plateaued finish that will produce firing heading's. Usually the rings also have this peaky finish, and in the case of the "moly" not only is it peaky but also hard, so that the attrition of the peaked finish on both cylinder and ring will equalize to end up with a plateau on both metal faces.

It is our contention that with a plateaued finish on a cylinder wall surface such as that produced with a Flex- Hone, the peaky finish on a ring was not only unnecessary but undesirable and the ring face should also be plateaued.

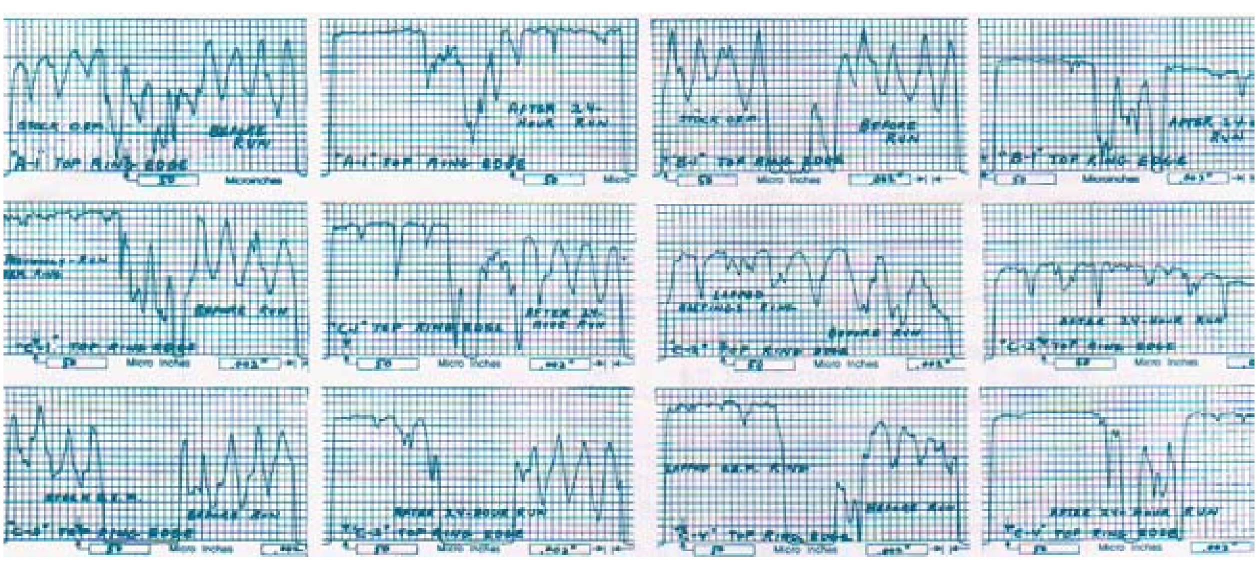
To try out our theory, on the ''C" Test run on the VW engine, we had various modifications of rings. First the cylinders were plateau finished with the Flex- Hone.

Cylinder No. 1 was fitted with pre-run rings that had been used in ''A" test. This ring was plateaued from the first test and we really expected great things from it, providing the ring gap had not been increased too much from its first run. Cylinder No. 2 had a Hastings Piston Ring Set in which we had asked Hastings to lightly lap the peaked finish to a plateau. This ring set was lapped but not down to the plateau wanted. Cylinder No. 3 was an original equipment ring with its peaky finish. Cylinder No. 4 was an OEM ring set which we lapped in by hand, and feel that we did not do the job properly because of lack of proper equipment. It was lapped in on a used cylinder by hand using an abrasive slurry. We could have lapped it unevenly and also out of round. I think the results will support these suppositions.

The average compression reading taken at the end of the test run were higher on this ''C" test than on A, B, or D. The C- 1 cylinder (pre-run ring) gave us the highest reading of the test (169.5 psi). The C-2 cylinder (Hastings lapped) was second with C-3 (OEM ring) being third and C-4 (our lapped ring) being 4th. The average compression reading was 150 for ''A" engine; 154.6 "B," 161.3 for "C" with FH finish and modified rings; and 161.2 for "D" engine with FH cylinders and oem rings.

One test is not conclusive by any means but might point out a direction we should explore further. We noticed for example the No. 1 cylinder on each engine test had a better compression test than the others. Perhaps the combustion area was different, or perhaps other factors unknown. That is why we averaged the combustions of each cylinder in comparing test results. Actually the "D" engine with Flex-Honed cylinders and the peaky OEM rings did as well as the ''C" with its modified rings on an average basis. And this is contrary to our firm belief. Perhaps this may be a challenge to an engine builder and his piston ring manufacturer.

Barrel shaped rings and the positive and reverse twist rings are tapered on their upper edges for various good reasons in today's way-of-doing-things. However, it occurs to us that the gas pressures on these tapered edges would force the ring inwards and if so would lessen ring pressure against the walls and even might be the cause of partial ring-collapse: Instead of bedding in the rings through attrition does it now seem possible that we can have this ''finished" condition to start with?

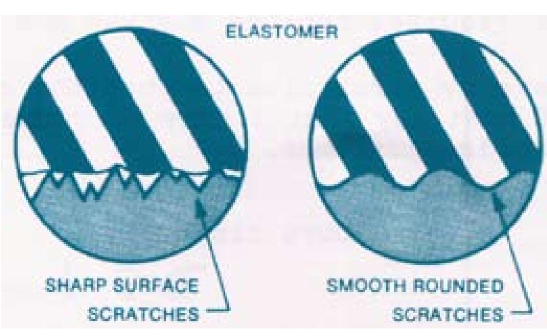


SURFACE FINISHING OF HYDRAULIC/PNEUMATIC CYLINDER WALLS

The problems surrounding obtaining the wall finish which is required on any pneumatic or hydraulic cylinder is extremely complex and certainly cannot be answered with any one particular formula. The cylinders themselves may be made of regular gray cast iron or instead they may be alloy steel, brass, stainless, chromed or they may be one of hundreds of different types of aluminum alloy each one with its different characteristics which need special consideration in the treatment. We must also take into account the types of piston seals that are used. We may have leather, we may have some form of natural rubber, neoprene, butyl, nitrile, ethylene-proplene, silicone etc. cups or pistons with "0" rings or pistons without any rings whatsoever which depend upon a lap fit with possible oil grooves in the piston themselves. Instead of the "0" rings they may even have piston rings similar to the combustion engine.

In the overall determination as to exactly the finish you may require on your cylinder wall, we must also take into account the type of power that is going to be used whether it is powered by air or by a hydraulic fluid and the quality of this power. Is the air going to be completely dry or is it going to contain a lot of moisture and if it is going to contain a lot of moisture then perhaps the cylinder wall should be bronzed In order to eliminate the rust factor. If hydraulic fluids are going to be used, how good and how pure and what specifications is the fluid going to be? Is it going to contain contaminants which may affect the seals that are used or may cause rust or corrosion of the cylinder wall and also what must be taken into account is the amount of pressure that is going to be applied to operate this cylinder. All of these factors are extremely significant and all of them must be taken into account in determining what is going to be the optimum for your unit. The things that we are really looking for, of course, is primarily the sealing characteristics and also in being able to obtain the maximum number of cycles before failure of your seal, and tests should be conducted very definitely to determine the number of cycles that different finishes will give you to determine the most life that can be obtained from your hydraulic unit before rebuilding Is necessary.

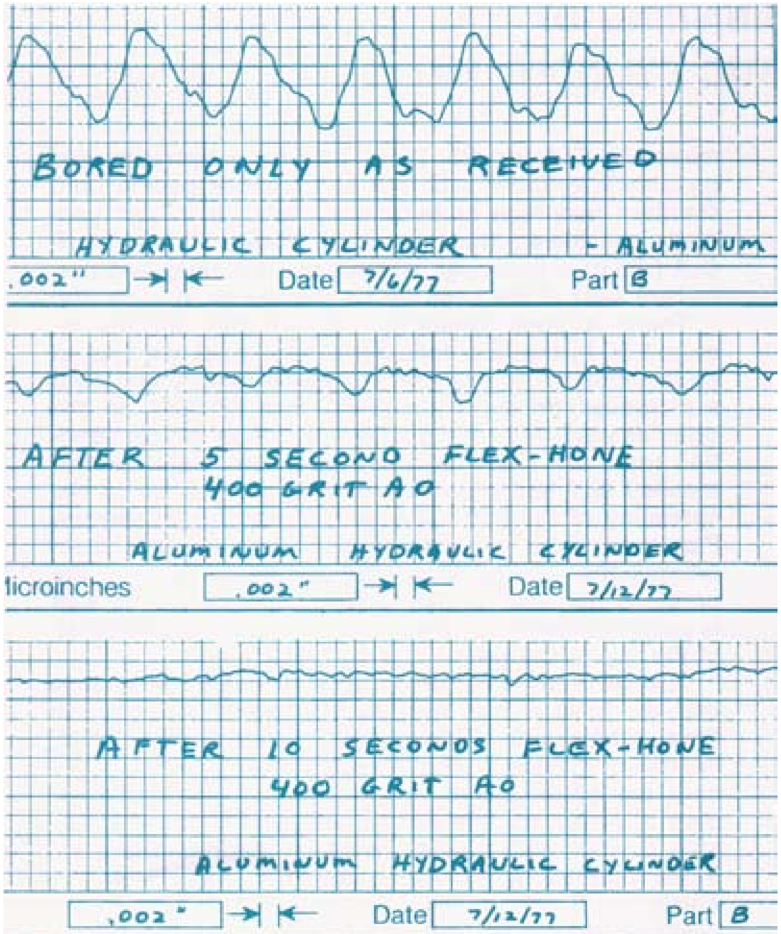
The general consensus of opinion that we have received from the industrial trade is that the finish of less than 5 microinch CLA (or| .13 μ) is not satisfactory because the wall is too smooth and there will be insufficient lubrication underneath the seal which may cause seizure or weeping and failure. The generally accepted and recommended finish runs anywhere from 10 to 15 microinch CLA (or .25-.28 μ) both for a hydraulic and pneumatic cylinder with one of the more popular and standard neoprene or butyl cup seals. It Is also generally considered that any finish above 30 microinch CLA (.76 μ) is too rough and will cause leaking and premature wear of the curls with a shortening of cycle life.

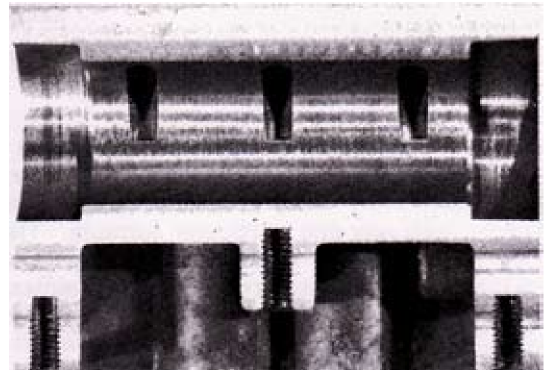


There is great similarity between the finishes required in hydraulics/pneumatics and what we find in the combustion engine whereby we do require and need a plateaued finish of anywhere from 60-80% of the cylinder wall area. We do require valleys for oil retention and a fine cross hatch has also been highly recommended and has been found to be a great aid in the spreading of the lubrication and prevention of seizure.
Plateaued finish is extremely important because it in- creases the bearing area. We are all aware that the pressure per square inch on the cup against the wall is going to vary directly with the amount of bearing area of the cup to the wall.

Another Item of extreme importance is to make sure that we have a burr-free surface particularly in the through-hole ports. As a matter of economy many small hydraulic cylinders are roller-burnished which does have the advantage of very quickly and inexpensively developing a very tiny finish In the cylinder and being able to roll that cylinder out to a desired diameter. Roller burnishing, however, has its drawbacks In the finish that it imparts on the wall, because It takes the peaks of the finish that is left there after the boring operation, and folds them down into the valleys and this metal may break loose during the roller burnishing and forced into other parts of the surface. These peaks that are distorted may also break Boone and get into the hydraulic system after the cylinder Is fully assembled. As there are always voids in the metal, the roller burnishing operation will produce very sharp burrs on the edge of these voids which causes an excessive wear on the cups and shortens the cycle life considerably. Some of the major manufacturers that are roller- burnishing are Flex-Honing their cylinders before the roller-burnishing operation in order to remove these high peaks and some of them are even lightly honing their Cylinders before and after roller-burnishing operation first to remove the high peaks and develop a plateaued finish then roller-burnishing and a final Flex-Honing to give the desired microinch finish to the cylinder itself. A flexible type cylinder hone will, In one operation, deburr the ports and deburr the finish by removing the high peaks off the wall itself and create the necessary plateaued area and develop the required microinch finish.

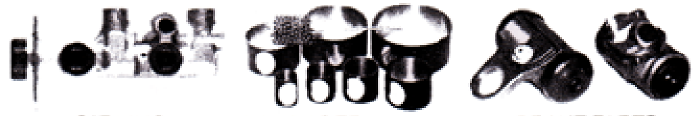
If surface scratches (peaks and valleys) are sharp, elastomer may not be able to conform to the irregularities, permitting leakage. Sharp scratches also cause accelerated abrasion wear. Elastomer easily conforms to surface with smooth, rounded peaks and valleys.





A FREE EXPERIMENTAL OFFER

More and more Original Equipment Manufacturers of Hydraulics and Pneumatics are turning to the FLEX-HONE™ for their final finishing operations such as:



OFFER:

Send us two of your cylinders or two tubing sections in your finished condition. We will Flex-Hone one and return both parts to you together with before and after profiles and also the FlexHone used in the test.

TESTIMONIALS:

As an adjunct to the following UK Situation Report, we want to add one of the many success stories reported to us. Such reports and new-application information are documented in our Monthly Sales Bulletins which now reaches its 114th issue.

Dear Mr. Nichols,

16 January 1978.
Your Ref.
Our Ref. DJA/aa.

125cc YAMAHA SPRINT MOTORCYCLE

About a year ago I purchased a Flexhone to assist in the preparation of the above engine for a record attempt at the Elvington meeting, held in July 1977. I Was fortunate enough to be able to secure the 125cc class flying quarter-mile British record with a two-way average speed of 119.5mph (with a fastest one-way speed of 128.9mph and using 14,600rpm maximum on all runs). I believe that the use of the Flexhone was a material factor in this, since I found that the pistons and rings bedded down almost immediately and that the engine temperature was lower (for a given ignition and carburetted settings). I also found that even in this case, where the bore was hard chrome, piston scuffing was eliminated under these most arduous conditions, ie. no grunting Inc was required for the pistons and rings - none! London were OHW.

If it is of any use, you have my permission to show the contents of this letter to your inquirers, to whom I must say that I have no connection with your organization other than as a satisfied customer.

Yours Sincerely,

D.J. Armstrong

D J Armstrong
C Eng,MIMechE.

SITUATION REPORT:
FLEX-HONE IN THE UNITED KINGDOM AND IRELAND

The Flex-Hone was introduced to the U.K. and Ireland in November 1970. By November it had been tested and made approval by Perkins. In 1971 further service approvals were issued by Massey Ferguson, Chrysler Europe and Ford Europe. Subsequently, service approvals have been issued by British Rail, Ruston Diesels, David Brown Tractors, J . 1. Case, A.E.C. and J.C.B. Excavators. In 1972 Cosworth Engineering Limited, builders of the famous Ford DFV of Grand Prix racing engine which has won 102 Grand Prix since it was introduced in 1967, adopted the Flex-Hone for their engine cylinders and many other bores in the block (tappet blocks, oil ways etc.). Lotus, Brabham, Maclaren, March, Elf Tyrell, Swindon Racing Engines, Broadspeed, Hesketh, Team Suttees, Frank Williams Racing, David Purley LEC Racing Team and many others in the racing world all use Flex-Honed engines or use the Flex-Hone in their own workshops.

British Rail issued an instruction to all British Rail workshops to use the Flex-Hone on their English Electric and Sulzer engines after exhaustive tests over four years. They proved that the period between substantially increased since adopting that the rings bed in faster and last longer. There has been a parallel benefit in improved oil consumption. Most operating companies within the National Bus Company use the Flex-Hone for engines and air brake compressors. It is used by British Leyland, Rover, Triumph, Vauxhall Bedford (G.M.C.), Rolls Royce Motors Limited, National Carriers, British Road Services, London Transport and many large U.K. haulage fleet operators.

In 1972 the Flex-Hone was introduced into the industrial market, i.e. to manufacturing organizations who use the Flex-Hone as part of a manufacturing process. The Flex- Hone has been particularly successful in the hydraulics and pneumatics market because air compressors and hydraulic cylinders all require plateau finishes because any form of debris on the cylinder wall surface is just as damaging in these applications as in internal combustion engines. Typical applications are:

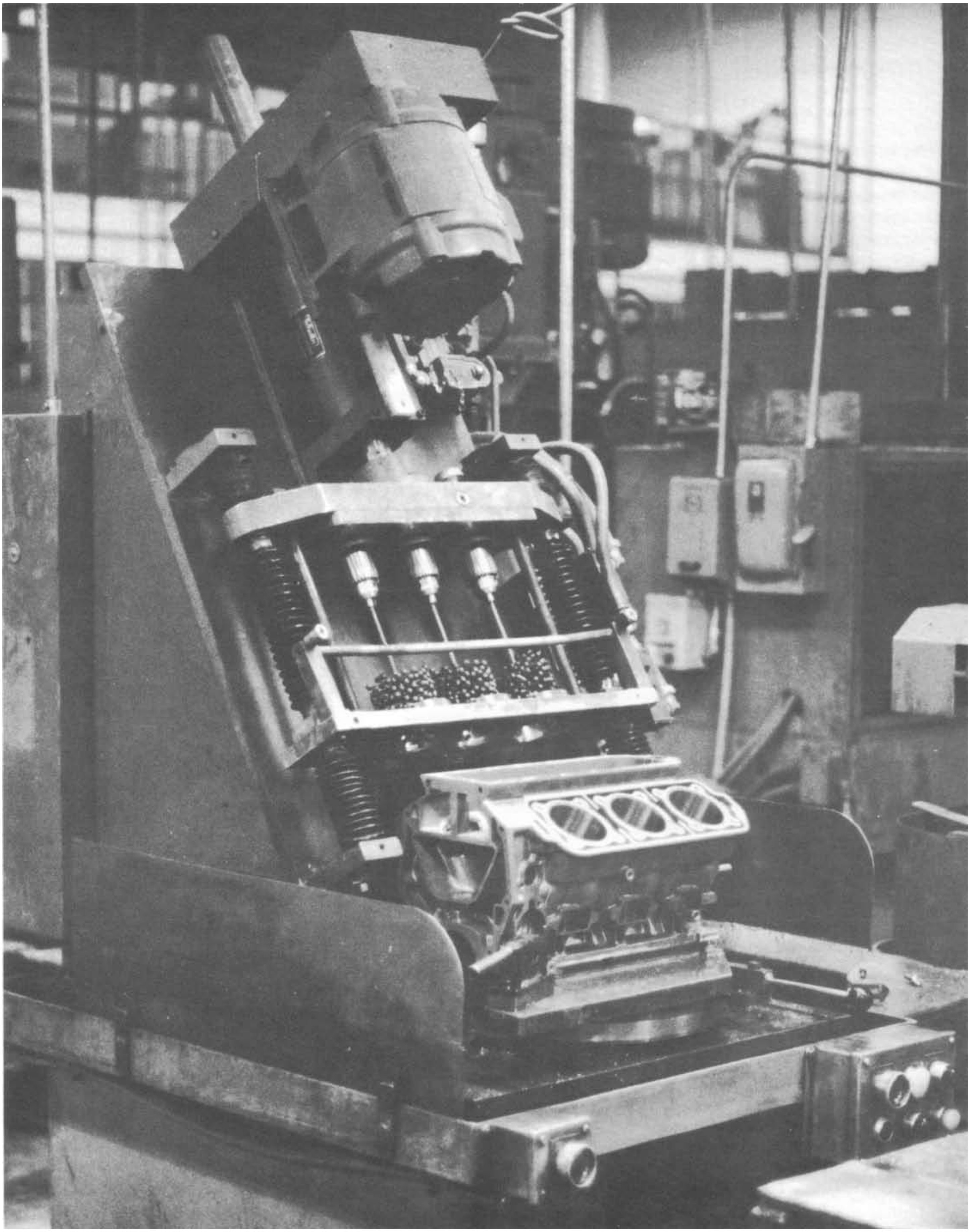
Air Compressors
Hydraulic Ram Cylinders
Hydraulic Spool Valve Bodies
Hydraulic Motor Bodies
Pneumatic Cylinders
Compressed Air Tool Bodies
Brake Cylinders (wheel)
Clutch and brake master cylinders
Our customers in this field include Girlings, Automotive Products, Dotty Group, National Coal Board, Sperm Vickers, Vickers Hydraulics, Teiehoist, Rubery Owen, Burman & Sons, Cam Gears, Desoutter, Hamworthy, Gullick & Dobson, Dobson Park Industries, Kango, Rutter Templair, Westinghouse Brake & Signal, Atlas, Copco, Compair, British Aluminum, Schrader, Kismet Dynaflex, Lucas Group, G.K.N. Birfield, Renold Group, Chloride, each, etc.

The Flex-Hone has now been adopted by the Nuclear Industry for fine surface finishing of stainless steep tubing and other materials. Vickers Nuclear, Rolls Royce Nuclear and G.E.C. are all customers in this field, as consistent debris free finishes are a prime requirement in this market. Babcock & Wilcox, one of the biggest makers of electricity generating station boilers have been users of the Flex-Hone for some years for improving the surface finish of boiler components prior to welding.

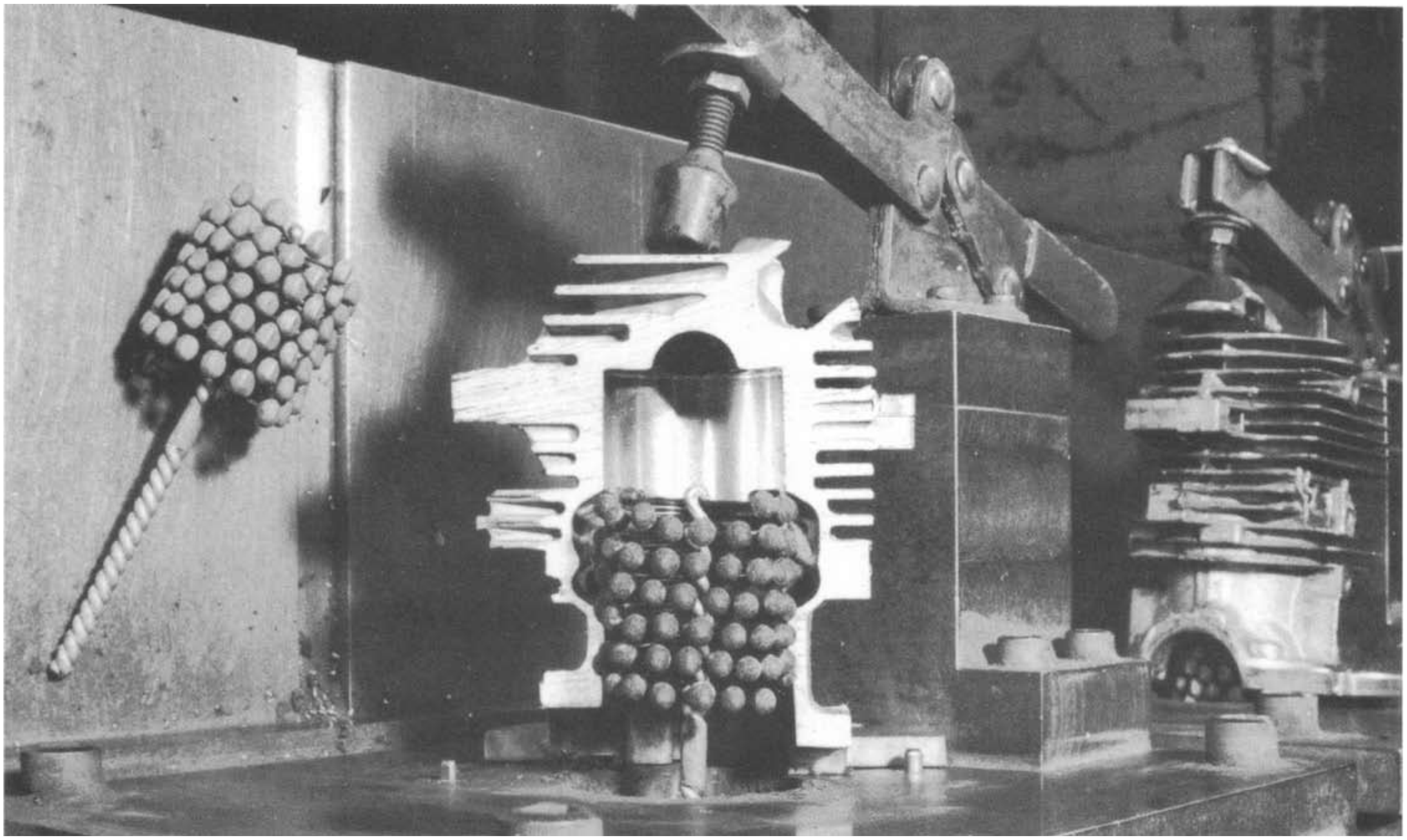
Most British based lubricating oil research centers such as Lubrizol, B.P., Shell Research, Amoco and Duckhams use the Flex-Hone for finishing cylinders in their research engines. Air-force, Army, and Naval Establishments throughout the U.K. use the Flex-Hone but details of usage are classic fed. The oil industry and petro-chemical industries find the Flex-Hone a superb maintenance tool which achieves the desired result but also because the tool is portable, i.e. the tool can be easily taken to the work whereas the work cannot always be taken to the tool. We list Imperial Chemical Industries (I.C.I.) among our many customers.

In the marine engine field the Flex-Hone market has been opened up as a result of service approvals from Pilestick and Ruston Diesels. Again the portability of the Flex- Hone is so important as the tool can be carried on board ship and cylinder maintenance done in situ. We list P & 0, Esso, Texaco, Jebsons, Denholm & Maclay, Scottish Ship Management, Humber Tugs and Boston Deep Sea Fisheries among our customers in this growing market.

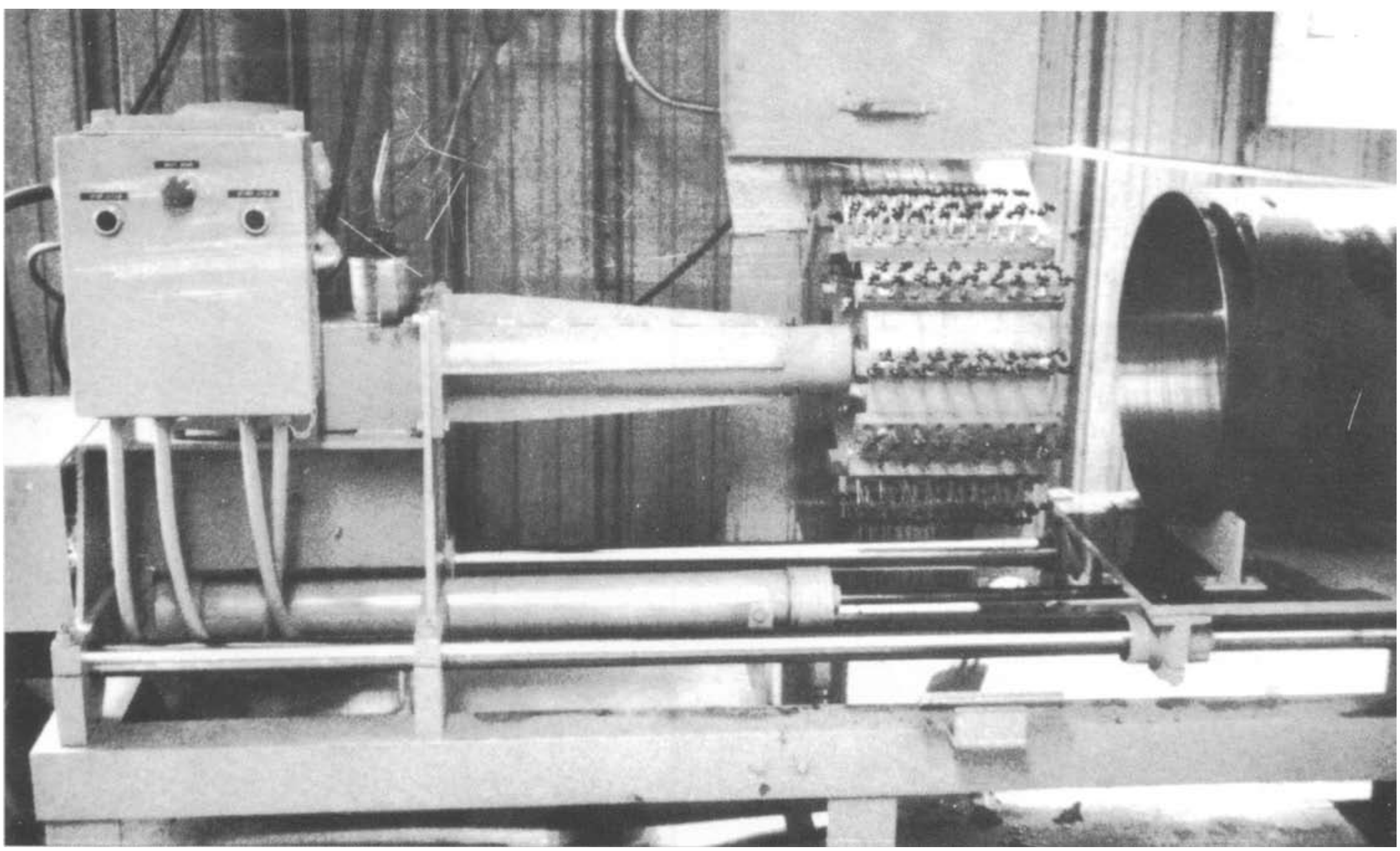
(as reported by Peter Nichols, mgn. dir. NICRO (L) Ltd Fromehall Mi!I, Lodgemore Lane, Stroud. Glob., England GL5 3GH), exclusive distributor for the UK)



FLEX-HONE MACHINE DEVELOPED FOR PRODUCTION HONING ON NEW ENGINES



MACHINE DEVELOPED FOR FLEX-HONE USE ON NEW 2-CYCLE ENGINES. HOLDING FIXTURE LOCATES CYLINDER ON DOWEL PINS AT BASE FOR ALIGNMENT WITH FLEX-HONE. POWER STROKING AND ROTATION ARE AUTOMATICALLY CONTROLLED THROUGH FIXTURE BASE.



MACHINE DEVELOPED FOR PRODUCTION HONING OF 12" TO 20" (305 TO 508 MM) HYDRAULIC CYLINDER BORES USING GBDX FLEX-HONE

BRUSH RESEARCH MANUFACTURING CO., INC

BRUSH RESEARCH MANUFACTURING CO., INC.

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