

Flaw and Surface Defect Evaluation with Small Spherical Tipped Styli

• Scope and Theory of Operation

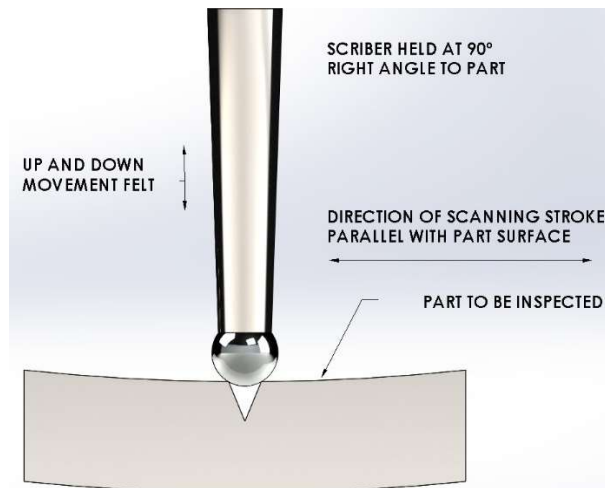
Small spherical tipped scribes have been used for many decades to aid the process of flaw detection. Surface Defect Ball Scribes are tools of flaw evaluation that may be used to test for cracks, scratches, gouges, nicks, dents, dings, scars, scrapes, and chatter. This economical non-destructive test method provides a viable manner in which one can detect surface defects and fatigue cracks that would otherwise be invisible to the human eye. Early detection of fatigue can prevent costly teardowns in complex assemblies. Flaw or surface defect evaluation is less expensive and better suited to field work than the expensive advanced non-destructive evaluation systems. The primary use for flaw or surface defect evaluation is found in the field inspection of aircraft engine bearings. The technique of applying the end of a spherical tipped probe across a flaw in a machined or ground surface provides trained technicians the ability to identify individual imperfections that can be accurately evaluated. Evaluation is performed using a hand-held surface defect ball scribe with the spherical tip end being scanned across the flaw. The relative size of the imperfection can be determined in direct relation to the spherical diameter tip of the scribe.

• Scribe Stylus Usage and Procedures

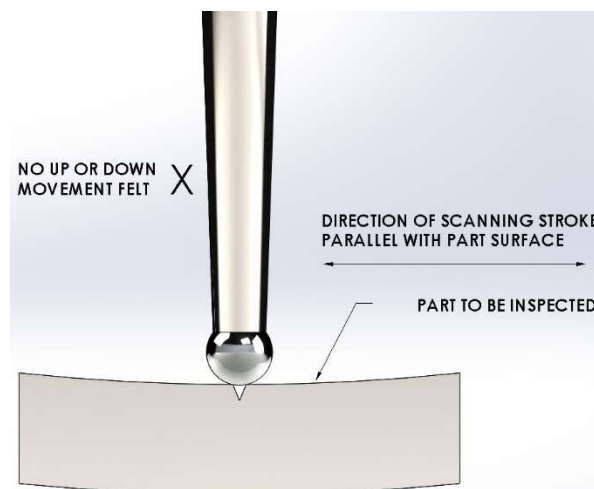
The scribe is held as close to perpendicular as possible to the surface being checked; grasped lightly between the thumb and forefinger (similar to the position when using a pen or pencil to write) with only the weight of the scribe resting on the surface to be checked; and guided across the widest part of the imperfection. In order to fail the scribe test, the imperfection must definitely be felt with the scribe. In other words, the scribe must hesitate ("catch" or "click") as it is drawn across the imperfection. If the spherical tip drops into the flaw by any appreciable amount, a very evident hesitation will be felt. If the radius of a given spherical tip does not penetrate the flaw but instead spans it, there will be no noticeable hesitation and the part is considered acceptable. If the scribe does not hesitate, the imperfection should be treated as being non-existent. As the surface is being scanned with the ball scribe, the operator should divert their eyes away from the area; the purpose being to eliminate vision from the feeling process. In most cases this means, "If you can't feel it, you can't see it – it's not there." This philosophy is often times difficult for novice inspectors to accept. After a defect has been detected, it must be identified. This must be done to ensure that the proper inspection limitations are used in determining the conformity of the defect according to shop manual specifications. The majority of these defects cannot be identified with the naked eye, and therefore, the use of magnification is recommended in making these determinations.

• Usage Illustration

Field evaluation of flaws, defects, scratches, or cracks is most often carried out by passing the spherical tip of a known diameter ball in a parallel fashion over the part surface. With the ball-probe held perpendicular to the test surface, the stroke of the spherical probe is made at right angles to the anomaly of interest. The scribes are typically held in the writing position which allows the operator to easily feel the hesitation, catch, or click due to the fingertips being very sensitive to the movement of the scribe when discovering a flaw as the tip of the stylus traces over the area of interest.



If the spherical tip drops into a flaw, the scribe will move up and down, and a distinct hesitation, catch, or click will be felt



If the spherical tip spans the flaw, the scribe will not have up or down movement, no hesitation, catch, or click will be felt

• Scriber Stylus Material and Specifications

The spherical radius of the scriber tip must be highly polished, smooth, and free of flats, nicks, or raised material, so as not to interfere with the measurement of the surface being evaluated. The material of the scribe tip should be as hard or harder than the material being inspected. Carbide Probes, Inc. manufactures scriber styli with Tungsten Carbide balls. Tungsten Carbide has a Rockwell Hardness of 90-92 on the Rockwell "A" Scale which is nearly thirty times harder than typical hardened tool steel. The tungsten carbide ball is silver brazed to a stainless-steel stem to prevent separation due to shear loading. The stainless-steel stem with the silver brazed carbide ball tip is epoxied into an aluminum handle with a knurled surface to provide positive grip, especially in environments with high humidity. The combination of the materials used makes the entire stylus virtually corrosion free. The useful wear life of the scriber is greatly enhanced due to this design. However, the exact life of the stylus will vary according to usage and also the abrasive characteristics of the material being inspected.

Tungsten Carbide is an extremely hard and durable material. It has high resistance to deformation and deflection; and for such a hard material with very high rigidity the impact resistance is high because it is in the range of hardened tool steels of lower hardness and compressive strength. Tungsten carbide has exceptional resistance to galling and material adhesion at the surface due to a highly polished finish on the ball, having a Surface Finish of 0.025 μ m Ra or better. Tungsten carbide can provide wear life up to one-hundred times longer than the best hardened tool steel in conditions which include abrasion, erosion, and galling. Synthetic Ruby or Sapphire is also a very hard material, which slightly exceeds Tungsten Carbide for wear life and surface finish. However, we do not recommend Ruby or Sapphire balls for surface defect scribes due to the fragile nature of the material. The Ruby or Sapphire ball material has low impact strength, and tends to easily fracture, crack, or chip under use, mainly due to the fact that Surface Defect Ball Scribes are hand-held operated tools. Also, the ball must have an epoxy joint to attach it to the steel stem (whereas the Tungsten Carbide ball is silver brazed), and in time, under normal usage, the Ruby or Sapphire ball will separate from the steel stem. Therefore, for the reasons outlined above, Tungsten Carbide is considered one of the best materials for use in surface defect evaluation applications using ball tipped scriber styli. For further detailed information about the material properties of Tungsten Carbide or Synthetic Ruby/Sapphire we offer documentation available for download on our website.



Ball Scriber constructed of Tungsten Carbide Ball Tip Silver Brazed to Stainless Steel Stem secured in Knurled Aluminum Handle

Surface Defect Scriber Styli are available from Carbide Probes Inc.
<https://www.carbideprobes.com/product-category/surface-test/surface-defect-ball-scriber/>

• Scriber Stylus Inspection and Calibration

Small flats on the carbide ball will eventually develop after usage, and therefore, each scriber stylus should be inspected prior to every inspection session. The ball tip on the scriber stylus should be inspected for flats, nicks, or raised material on the ball. The inspection should be conducted under 10X minimum magnification. If the ball tip exhibits any defects in the surface under magnification, the scriber stylus should be discarded immediately. Scriber styli should be classified as perishable tooling in this respect. It is not recommended to submit used scriber styli exhibiting any surface defects in the carbide ball under magnification for recalibration through a NIST laboratory or other inspection/calibration facility. New scriber styli can be purchased from Carbide Probes, Inc.; and as an option, NIST Traceable Certification of Calibration for the Tungsten Carbide Ball can be included for an additional cost if this certification is required.

• How Long are Certificate of Calibration Reports Valid?

This is a frequently asked question from end users receiving a NIST Traceable Certificate of Calibration for our Surface Defect Ball Scribes which may have an older Calibration Date printed on the Certificate. Many end users assume that a Certificate has become expired or is no longer valid after a certain time period from the printed calibration date. However, ISO/IEC 17025 is quite clear about such matters. There is no established criteria outlined in the specifications which imply, or express, an issued Certificate has an "Expiration" date; nor is there any criteria which specifies a requirement for the Next Calibration Due Date. Therefore, per ISO/IEC 17025 there is no standard for any Certificate of Calibration to become invalid or expired simply due to lapse in time. This is especially true if the calibrated item is new and has never been used. Carbide Probes Inc., inventories all Certified Ball Scribes in sealed containers from the Calibration Lab in a temperature/humidity-controlled environment. Also, the container is sealed and labeled with a NIST Certificate Serial number which matches the Serial number engraved on the enclosed Ball Scriber.

Although ISO/IEC 17025 does not specify criteria for expiration dates on issued certificates, it is the end user of the equipment being calibrated who must determine the calibration frequency, or recalibration date requirement for every item used at their facility. No one else knows the conditions of use or anticipated future usage of the tool. Therefore, calibration frequency, or a recalibration due date must be determined by the end user, which should also be contained in the guidelines as specified in the quality system implemented by the institution using the tool. Again, Certificates of Calibration never expire according to ISO/IEC 17025, but the recalibration, or Next Calibration Due Date is always determined or established by the end user; and this determination should be made based on the extent of usage after the date the tool was first used.

Surface Defect Scriber Styli **WITH NIST CERTIFICATION** are available from Carbide Probes Inc.
<https://www.carbideprobes.com/product-category/surface-test/surface-defect-ball-scriber-cert/>

• Scriber Stylus Selection Specifications

Surface defect scribes are available with Tungsten Carbide balls in diameters starting from five thousandths of an inch diameter ($\emptyset.005''$ or $\emptyset.0127\text{mm}$), up to $\emptyset.2400''$ [$\emptyset.6.096\text{mm}$] in diameter, which is typically the largest size used in flaw evaluation. The carbide ball diameters mounted on the scriber styli have a maximum diameter tolerance of $\pm 0.0005''$ [$\pm 0.0127\text{mm}$]. Selection of scriber styli should follow the "Ten Percent (10%) Rule;" that is, the largest size ball diameter by which a crack (including any other flaw or defect) can be detected is Ten (10) times the crack width. For example, if a $0.001''$ [0.0254mm] width, or larger, crack needs to be detected, then the largest ball diameter on the scriber stylus would be $\emptyset.010''$ [$\emptyset.254\text{mm}$] in diameter. A $0.002''$ [0.051mm] wide crack would employ a scriber stylus with a maximum ball diameter of $\emptyset.020''$ [$\emptyset.51\text{mm}$] and a $0.004''$ [0.102mm] wide crack would require a $\emptyset.040''$ [$\emptyset.1.02\text{mm}$] ball diameter, etc. This rule allows the correct portion of the chord segment on the spherical radius of the ball to drop into the crack, creating enough movement to be sufficiently detected by the operator. The usage of a scriber stylus with a ball diameter exceeding the "Ten Percent Rule" will allow the chord segment of the ball to span the crack, preventing the operator from sufficiently detecting the flaw.

• Surface Defect Test Specimen "Crack Test" Block

The Surface Defect Test Specimen Block is a NIST Traceable artifact used to validate the effectiveness of the ball scribe test method. The block is used to train personnel in surface defect detection, and it allows the operator to become proficient on what a specific gap size feels like with a given ball diameter on a scriber stylus. The top surfaces of the block are perfectly machined and lapped on the same plane. The block is free of burrs along the edges of each gap, exhibiting sharp edges along the top sides of the gaps. The multi-grooved test block contains parallel, straight-sided gaps with minimum depths of $0.030''$ which allow ample clearance for the ball tip and also future refurbishment and re-calibration of the top surface of the block in the case of excessive wear. The combination of these features is to replicate the condition of a true crack. The body of the block is made of tool steel, which is through hardened to minimum 58 HRC. The block is mounted to a heavy steel base for stability. The Surface Defect Test Specimen block contains Four (4) individual gaps of precise widths separated by precision shims that protrude from the backside. The precision spacer determines the exact width of each gap and is used to simulate the exact width of a defect, flaw, or crack. Two typical standard test blocks are available that contain four gaps per specimen. One block containing gap widths of $0.0005''$ [0.0127mm], $0.001''$ [0.0254mm], $0.002''$ [0.0508mm], and $0.003''$ [0.0762mm]; the other containing gap widths of $0.004''$ [0.1016mm], $0.006''$ [0.1524mm], $0.008''$ [0.2032mm] and $0.012''$ [0.3048mm]. Carbide Probes Inc. Part Numbers for these standard blocks are SDTS-B1 and SDTS-B2, respectively. However, the test block specimen can be provided with custom gap widths as specified by the end user, along with any special engraving requirements. The block utilizes a cover or protector on the backside, covering the exposed spacers from damage, which is removeable for calibration purposes. The

width of each gap and an individual serial number are laser engraved on the front side face of the Surface Defect Test Specimen Block. (Refer to illustration below.)



Surface Defect Test Specimen Block

Surface Defect Test Specimen Blocks are available from Carbide Probes Inc. Part Number SDTS-B1 pictured above

<https://www.carbideprobes.com/product-category/surface-test/sds-calibration-block/>

• Personnel Training and Testing Procedures

The Certified NIST Traceable Surface Defect Test Specimen Block can be used to train individual technicians in the method of surface flaw evaluation. Using a known artifact like this block is an excellent method of testing each individual's ability to actually detect flaws correctly and consistently. The process of tracing a handheld spherical-tipped scribe over a surface to evaluate flaws such as cracks, scratches, and other blemishes is inherently subjective. Depending on each individual, the results of this procedure can vary. Therefore, all technicians require proper training, having their individual sensitivity of feeling measured against a known standard. Using a surface defect ball scribe with a specific ball diameter, which correlates to a particular gap width in a surface defect test specimen block, provides an excellent training tool to educate unqualified personnel in the flaw testing procedure. Using a pre-determined ball size on the scribe in conjunction with at least two different gap sizes in the test block will teach a new inspector the proper and correct technique in flaw evaluation. During the training and testing of each operator, the laser engraving that shows the gap widths on the surface defect test specimen block should be concealed using opaque tape or by any other means as determined best by the end user. Covering the gap identification mark on the block allows the trainee to ascertain the correct feel by detecting THE UP AND DOWN MOVEMENT ONLY (i.e. hesitation, catch, or click) of the scribe between the finger tips when evaluating a particular known flaw specification. This method eliminates any visual element or the operator's knowledge of the exact gap width beforehand so the results won't be skewed.