



## **CARBIDE GAGES – FOR YOUR PRECISION MEASUREMENT NEEDS**

Steel plug and ring gages are expensive when used for dimensional inspection of machined parts produced in volume. Steel gages wear too fast and must be replaced too often. It was for this same reason that most metalworking shops replaced cutting tools of high speed steel with edges made of carbide many years ago. A carbide tool machines more parts with less wear than the best tool available in steel. A carbide gage possesses the same abrasion-resistant characteristics - it can gage more parts with less wear than the best steel or chrome plated steel gage available. Carbide gages resist abrasive wear more than 50 times longer than gages made of steel. Gages do not have to withstand the concentrated use required of cutting tools, so the savings possible are not as highly visible. Nevertheless, in a high volume environment, substantial savings in the annual costs of gages are possible if gages are made of carbide instead of steel. First cost savings are easily established with simple record keeping. But the costs which are incurred to correct out-of-tolerance parts, caused by unexpected wear or the development of a burr on the gage, can be substantial and are much more difficult to evaluate.

### **CARBIDE IS A RUGGED, STRONG MATERIAL**

Carbide is not a fragile material. Most production people are familiar with carbide's capability when used for metalworking cutting tools, including the ability to handle shock involved with interrupted cuts. Many are familiar with carbide punches and dies for cold heading operations - capable of absorbing heavy shock over extended periods while maintaining a sharp cutting edge. These are not applications for a fragile material. Carbide is superior to steel in rigidity and resistance to deflection - by a factor of 2 to 3 times. With a

Young's Modulus of Elasticity which ranges from 60 x 10<sup>6</sup> to 90 x 10<sup>6</sup> psi, and a modulus of rigidity of 22 x 10<sup>6</sup> to 38 x 10<sup>6</sup> psi, carbide is used in many applications requiring exceptional rigidity. It is used in the design of spindles for highly precise applications to minimize deflections resulting from ID or OD grinding forces; quills with large length-to-diameter ratios for grinding small, deep bores; extended-length housings to support long spindles; boring bars for deep-hole machining; and components for other applications where the characteristics of steel, with a Young's Modulus of 30 x 10<sup>6</sup> and a modulus of rigidity of 11.5 x 10<sup>6</sup> psi, are not as suitable for the job.

### **USING THE PROPER CARBIDE GRADE**

The characteristics of carbide can be tailored to suit a wide range of applications by varying its composition or grade. Various grades of carbide are used in the applications mentioned above to obtain the characteristics desired in each case. These applications are successful only if the proper grades of carbide are used. If the grade for cutting tools is employed for the punches and dies, the cold heading application will not be as successful. And if the carbide used for the cold heading tools is applied to gages, the life of the gages will suffer. Thus, the designers must have experience with carbide to assure best results in any application.

### **GLE - KNOWS CARBIDE FROM EXPERIENCE**

support and guide ways GLE manufactures hundreds of different types of carbide products ranging from gages; carbide blanks for cutting tools; drill bushings; rotary bushings and shafts; dies and punches for low, medium, and high impact; tooling for compacting applications such as pharmaceutical supplies, grinding wheels,



uranium pellets for the nuclear power industry, etc.; small precision for gages; to special wear parts of all sizes and shapes for a myriad of different industries. Cutting tools for turning, milling, drilling, etc. are not produced; however, precision ground blanks are supplied to fluted tool manufacturers, and some highly special form tools for turning, broaching, etc. are produced to customers' specifications.

To produce products to satisfy this range of applications requires a comprehensive knowledge of the full scope of carbide materials and their characteristics. This diversity of engineering experience and processing capability has contributed to GLE's success in the development of its line of carbide gages. By the same token, the discipline and the methods developed for the manufacture of precision gages have had a profound influence on the success of the other products.

### **THE SAME GAGE MATERIAL DOES NOT SUIT ALL GAGING APPLICATIONS**

The materials used in standard plug and ring gages reflect over 32 years of gage-Manufacturing experience and satisfies most requirements. Some special applications require gages of carbide with unique characteristics.

When the material of the part to be gaged is unusually soft, for example, gages made from carbide having a high lubricity can be required. The lubricity lowers the threshold of static friction and minimizes pickup or galling in the part. Many gages have been furnished to resolve this problem.

Some applications require that the gage be totally non-magnetic; these are satisfied with special nonmagnetic carbide, engineered with the best characteristics possible for the specific gaging application.

GLE'S knowledge of carbide and its characteristics coupled with a user's knowledge of his parts and gaging problems have solved many difficult situations satisfactorily.

Many customers specify a special carbide grade for gages. This is no problem, and in many cases the carbide material is available from stock. In some cases, customers specify a grade as manufactured by a specific carbide manufacturer; this is no problem either. GLE furnishes certification, as a common procedure, that the material furnished and its manufacturer are as specified.

### **CHARACTERISTICS OF THE CARBIDE USED IN STANDARD GAGES**

The carbide used in the manufacture of gages has been selected for the best combination of strength, rigidity, hardness, stability, corrosion resistance, and impact resistance which, over the years, has proven best for most gaging applications. It has a compressive strength and rigidity which is about 3 times that of tool steel, heat treated to 62-64 Rc. It has a relatively high impact resistance. It must accommodate the shop inspection environment and accept the handling necessary to accomplish inspection tasks.

### **HARDNES AND RESISTANCE TO WEAR**

Carbide gages are used primarily in applications involving the production of parts in high volume because of carbide's unusual hardness and wear resistant properties. The life of carbide gages is 50 to 100 times that of steel gages. This is a far greater ratio than that for carbide when used for metal cutting, but it is not clear to many people why the wear ratio is so much greater for carbide used for gaging than it is for carbide used for cutting edges.



Tungsten carbide metal, or cemented carbide as it is also known, is a mixture of pure tungsten carbide (WC) powder and a small amount of binder material (generally cobalt) which is processed and sintered (heat is applied under various atmospheric conditions). The sintering procedure binds the carbide particles with the cobalt to form the metal; this binding action is the source of the term, "cemented carbide".

The accepted standard for carbide hardness measurements is the Rockwell A scale hardness test. All of the tests for hardness involve the application of a known load for a specified period of time to the surface of the specimen, and the depth or diameter of the resulting indentation establishes the relative hardness. The procedure reflects the hardness of a homogeneous mass accurately; but in the case of carbide, the depth of penetration merely establishes the strength with which the binder suspends the carbide particles.

This is of interest in evaluating carbide for a cutting application, but it is of limited significance when evaluating it for gages.

Pure tungsten carbide, at a Vickers hardness number of 2800 kg/mm<sup>2</sup>, is the hardest man-made material next to diamond. It is harder than Zirconia, whisker reinforced alumina, silicon carbide, etc. It is the hardness of these pure tungsten carbide particles which resist abrasive wear in gaging applications.

The action which a gage sees during use is primarily one of sliding or rubbing friction. The hardness of the individual grains of carbide, themselves, resist the wear; the binder (cobalt) merely holds the carbide grains in place. In contrast, the sharpness of an edge is important for cutting – and this involves both the hardness of the carbide grains and the strength of the binder to resist the shearing

action of cutting forces and hold the grains fixed in position. The less-demanding work which a gage performs extends its wear-life ratio compared to that of the cutting tool.

Gages made from carbide maintain their precision in use far longer than steel gages - more than 50 times longer - if they are handled with the care which is necessary with any precision instrument.

### **DIMENSIONAL STABILITY**

Carbide materials, after 'final sintering by the carbide manufacturer, are characteristically stable. They do not undergo phase changes which would affect size or shape during subsequent exposure to high and/or low temperatures. This is not necessarily true for steels. If the steel for gages is heat treated in the ordinary manner and is not completely stabilized, dimensional changes and warping can become evident as the material is machined or otherwise processed.

To stabilize the steel for gages, the heat-treated material is subjected to several alternating cycles of heating and sub-zero cooling. This procedure changes the state of the steel by transforming austenite into martensite. Each heating/cooling cycle performs a partial transformation. After the proper number of cycles (established historically by trial and error), the total transformation to martensite is completed and the steel is totally hardened. At this point the material is stable.

If stabilization is not completed for any reason and some austenite remains, size changes and deformation can occur in the gage maker's facility as subsequent manufacturing operations cause the transformation. On the other hand, it is quite possible for the size changes and deformation to occur later in a



user's facility as the transformation is completed due to natural aging over some period of time. The physical changes in the gage result from the fact that the transformation of austenite to martensite is accompanied by an increase in volume of up to 4%.

These problems will seldom, if ever, arise if the steel gages are manufactured by a skilled, reputable firm. It pays to know your gage maker.

If you have experienced unexplained changes in the dimensions and/or configuration of steel gages, it is possible that they stemmed from incomplete stabilization procedures. Natural aging in your facility may have finalized transformation, causing the physical changes. Carbide is inherently a more stable, dependably precise medium. It does not require comparable stabilization procedures and you should not experience unexplained changes such as these.

#### **GLE CARBIDE GAGES**

GLE manufactures carbide plug and ring gages from .010" (.254mm) to 4.010" (101.85mm) in diameter and up. Carbide master setting disks are manufactured from .010" to 6.000" (152.4mm) and master rings from .020" to 4.010" and up. The gages are manufactured to ANSI standard dimensions in tolerance classes XXX, XX, X, Y, and Z. Specials are produced to customer specifications. (See Options for plug gages and rings.)

The coefficient of thermal expansion for standard carbide gages is  $2.9 \times 10^{-6}$  in/in/°F; for tool steel it is  $6.6 \times 10^{-6}$  in/in/°F. Scratch-free finishes to one micro inch are supplied. The gages are corrosion resistant and are practically non-

magnetic; they are extremely hard, resist scratches in use and do not burr.

#### **PLUG GAGES - Diameters .010" (.254mm) to 2.510" (63.75mm) and Larger**

Reversible, Taper Lock, and Tri-Lock gages are furnished as carbide gage elements only, or complete with single or double-end handles. The handles of Reversible gages are equipped with a collet (two collets if double-ended) which grips the reversible carbide gage element on the OD in conventional fashion. Bushings are furnished to bridge the smaller diameter of the elements to fit the capacity of the collets.

The handles of Tri-Lock gages are equipped with a tapped hole and three locators on each end (both ends if double-ended). Each Tri-Lock element locates to the end of the handle and a bolt, screwed into the tapped hole, secures it in place. The Tri Lock elements are reversible.

#### **GAGE MARKING**

GLE, as standard procedure, identifies a gage by customer part number, "GO" or "NO GO" labels, "GO" or "NO GO" dimensions, and gage tolerance class - XXX, XX, X, Y or Z. The customer part identification is engraved on the body of the handle for all three types of gages. For reversible gages, the "GO" label, diameter and tolerance class is engraved on the "GO" (green) collet nut the "NOGO" label, diameter and tolerance class is engraved on the "NO GO" (red) collet nut. Comparable information for Taper Lock and Tri-Lock gages is supplied on the ends of the handle, located nearest their associated carbide element.

#### **GAGING BLIND HOLES**

For 5/16" diameters (3125", 7.94mm) and larger, GLE manufactures all carbide gage



elements with a through hole. The through hole is incorporated to decrease the weight and to facilitate inspection of blind holes. The through hole provides a path for the escape of entrapped air, preventing a pressure buildup due to close fits between the gage and the part, and eliminates the need to grind air grooves along the length of blind-hole gage elements. The through hole has no effect on accuracy, stability, or the life of the gage.

#### **Options (Plug Gages)**

**SIZE** - We regularly manufacture gages for sizes both smaller and larger than the limits shown as standard sizes in our Carbide Gauges brochure. If you do not see the size you need, contact us.

**TOLERANCE CLASS** - We manufacture to XXX tolerance class, as indicated in our Carbide Gages brochure. If you need better accuracies than those presented, contact us.

**GAGE LENGTH** - The lengths of GO and NOGO gage elements shown in the brochure are standard. Optionally, we manufacture to any length required.

**PROGRESSIVE GAGES** - We manufacture progressive gages with 2, 3, 4, or more steps; for true position and concentricity.

**EASY ENTRY PILOTS** - Special Entry Radii, Depth Notches, etc. We supply any modification or special configuration which is required for the application.

**TAPER GAGES** - For Morse, Brown & Sharpe, Jamo, American Standard Machine, British Standard, machine tool spindle tapers, etc.

**SPECIAL GAGES** - Slot, Cross, Depth, Paddle, etc. If made of carbide or some combination, we manufacture it to customer print.

#### **RING GAGES - .010" (.254mm) To 4.010" (101.85mm) and Larger**

##### **Diameters .010" to 2.00" (.254mm--50.8mm)**

Ring gages from .010" to 2.00" in diameter are manufactured as a heavy-walled carbide ring protected by an outer jacket of knurled steel. They are engineered so that the carbide insert is the controlling master of the carbide/steel-jacket assembly. GLE standards require the wall thickness of the carbide ring for all gages above 1/4" (6.35mm) to be greater than the thickness of the steel jacket. As gage diameters increase, the thickness of the carbide rings must be further increased with respect to that of the jackets.

This design concept for ring gages and masters is the reason that the wall thickness of GLEs carbide insert is greater than that of most other gage manufactures. The gage design has evolved from over 32 years of experience with precision carbide gages in the field. This is your assurance that the gage can be subjected to wider swings in temperature, during shipment and in operation, without damage or loss of accuracy.

##### **Diameters 2.00" and Larger**

Ring gages greater than 2.00" in diameter are manufactured as a carbide insert protected by a knurled jacket composed of a new special nylon material. Previously the protective jacket was made of steel. The ring gages are now lighter in weight (the new jacket material is about 1/7 the weight of a comparable volume of steel) and these larger sizes are more dimensionally stable because the new outer jacket, acting as an insulator, resists the transfer of external heat to the carbide gaging element.



### **GAGE MARKING (Rings)**

Unless otherwise specified by the customer, ring gages smaller than 2.00 inches in diameter are identified by engraving on the face of the steel jacket. The information includes the customer part identification, GO or NOGO label, GO or NOGO dimension, and gage tolerance class (XXX, XX, X, Y, Z). For gages 2.00" and larger, the identification is etched on the face of the carbide near the outer diameter. NOGO gages are easily identified by a groove which circles the OD of the jacket, centered on the gage length.

### **Options (Ring Gages)**

**TOLERANCE CLASS** - We manufacture to XXX tolerance class, as indicated in our Carbide Gages brochure. If you need better accuracies than those presented, contact us.

**GAGE LENGTH** - The gage lengths of GO gages shown in the brochure are standard. We show a NOGO gage length which is shorter than that of ANSI's standard, but it has been found satisfactory by many users. We manufacture to any length required.

**PROGRESSIVE RING GAGES** - For parts with 2, 3, 4, or more steps will check for true position and concentricity. To check size of stepped parts individual ring gages, Twin-Ring gages (each assembly with a GO, NOGO ring gage for individual diameters), or Multiple-Ring gages for special applications can be supplied.

### **DIMENSIONAL CONSIDERATIONS FOR PLUG AND RING GAGES**

Plug and ring gages are used both as gages (GO, NOGO applications) or as masters (to set limits or to calibrate gages). Unless otherwise specified, when ordered for use as a master the gage tolerance class will be split. When ordered for gaging, the tolerance will be applied unilaterally. For information on Master Setting Disks and Rings, ask for publication GLEI010.

### **PLUGE GAGE**

For a specified diameter of .2830" diameter XX tolerance class plug gage, the tolerance is .000020". The master will be supplied within the limits of .283011 .28299. If for a gaging application and the dimensions are specified as .2820 (GO) and .2822 (NO GO) and the plug gage is to tolerance class XX, the limits for the GO gage will be .282001/.28202 and for the NOGO, .282201/.28218.

### **RING GAGE**

For a specified diameter of .3830" diameter XX tolerance class ring gage, the tolerance is .000020". The master will be supplied within the limits of .382991/.38301. If for a gaging application and the dimensions are specified as .3820 (GO) and .3822 (NOGO) and the ring gage is to tolerance class XX, the limits for the GO gage will be .382001 .38198 and for the NOGO, .38220/.38222.

### **GAGING ACCESSORIES**

Carbide accessories for gages and for locating and fixturing parts precisely for gaging are manufactured to customer print. Carbide centers, pins, staking anvils, etc.; carbide micrometer tips, probe points of special shapes – spherical ball, square, or needles with point diameters as small as .0005" (.0127mm); and precision flat wear parts.

### **GAGE CERTIFICATION - NEW GAGES**

Certificate of Class/Conformance - We supply certification of compliance at no charge with all gages. It certifies that the gage has been inspected at 68°F 120°C and is within the required tolerance for its classification, traceable to NIST, and details standards to which the gage was made and inspected.



**Certificate of Calibration** - We supply this certificate (extra charge) if specified at the time of order. It displays the customer's name, P/O no, item no. customer tool no., the masters used (serial number), the type of gage, specified diameter, GO, NOGO, Bilateral (master), tolerance class, the diameter at 0 and 90 degree angular locations at 3 points on the gage (front, center and back), and certifies the gage was inspected at 68°F/21°C. Deviation errors are displayed to the sixth decimal place.

#### **GAGE INSPECTION, CERTIFICATION, AND REWORK**

An inspection and calibration service for existing carbide gages is available. Our recommendations can include calibration (the gage is good and still within tolerance); rework to a new size (the gage is out of tolerance but is in good physical condition); or discard (the gage is no longer useful). A Certificate of Class/Conformance (no charge) or Certificate of Calibration (extra cost) is supplied, if specified at the time of order.

#### **QUALITY CONTROL LABORATORY**

Much of GLE's work is highly precise. We manufacture gages to XXX tolerances and other precision parts requiring accuracies of 0.000010" (0.00025mm); some work is performed to 0.000005" (0.00013mm). To measure parts of this quality with an acceptable level of assurance, the Company maintains a Quality Control Laboratory (Gage Room), temperature and humidity controlled, equipped with modern precision dimensional measuring equipment. All Laboratory personnel are skilled metrologists and all inspection equipment and master blocks have precision traceable to the National Institute of Standards and Technology (NIST), formerly National Bureau of Standards (NBS). A strict certification schedule for all masters is

maintained. If you would like a copy of our QC Laboratory Calibration Standards, ask for GLE1004.

The QC Laboratory is equipped with an automated, state-of-the-art inspection system which can measure and evaluate all circular geometry elements necessary for completely qualifying a part - ID and OD roundness; circular run out; concentricity; circular flatness, perpendicularity, and plane run out; plane run out and circular parallelism of top and bottom faces; and in-depth analyses such as slope analysis, harmonic analysis, DRIDO etc. Data can be printed out in graphic form for verification.

The Laboratory is also equipped with a state-of the art, stylus type profiling system for measurements of surface texture. The surface texture analysis includes arithmetic mean deviation of the roughness profile (Ra), Root-mean-square deviation (Rq), maximum peak-to-valley height (Rt), 10 point height of irregularities (Rz), peak count (Pc), bearing length ratio (tp), etc. A matrix printer provides job identification and a printout of calculations and graphic displays for verification.

#### **SPECIAL GAGE ASSEMBLIES**

We manufacture special gaging assemblies to customers' prints which incorporate indicators and electronic sensors. These are production gages for specialized purposes for which standard instruments are not commercially available - to check diameter, hole depth, ID taper dimension at a specified depth, etc.

The ability to work to close tolerances, SPC throughout the shop, and a gage laboratory for measurements to millionths are additional capabilities which are valuable in satisfying these special instrument needs.