Chamber Pressure Measurement

By Terry Hart

Recently I noticed several posts and questions about published chamber pressures in the 60,000 PSI neighborhood for some of the newer cartridges. It is important to note that there are several ways that chamber pressures are measured, and the maximum safe load numbers (maximum average pressure, or MAP) are quite different for these different methods.

After much testing and discussion, standards organizations like SAAMI, ANSI, CIP and others determine and publish maximum chamber pressure specifications for all common cartridges. In recent years both CUP and PSI values are listed in these standards and they are quite different. Firearms and Ammunition Manufactures then use these standards for the design and loading of their Guns and Ammunition.

Until the mid 1960's the only method commonly used for measuring chamber pressures was the copper crusher. Basically, a hole is drilled in the chamber of a firearm and a crusher chamber is attached to that hole. In this crusher chamber is placed a very precisely manufactured piece of copper.

When the gun is fired the copper pellet is crushed (deformed) by the pressure to some degree. The amount of this deformation is then precisely measured and a very standardized indication of pressure is determined.

To this day, most published chamber pressure (MAP) data for metallic cartridges is taken by the copper crusher method of measurement. The proper name for this type of measurement is CUP, or Copper Units of Pressure.

Another, similar, method uses lead crusher pellets and the resulting pressure values are called "Lead Units of Pressure," or LUP. Lead is more easily deformed than copper, and the LUP method is normally used for measuring relatively low chamber pressures, such as those generated by shotgun shells, while copper crushers (CUP) are used for

measuring the pressure of handgun and rifle cartridges. LUP and CUP numbers are not interchangeable, and neither is interchangeable with the newer PSI numbers.

Before the 1960's it was common to leave off the CUP and most publications simply labeled these readings as PSI, or pounds per square inch. If the pressure figure dates to the 1950's or earlier, it was determined by the crusher method, even if it is expressed in terms of PSI. Today when you see a modern chamber pressure number it should always be clearly indicated as CUP or PSI. If it isn't, ignore it.

The crusher method of determining chamber pressures has been around for a very long time and the methods used have become very rigid and standardized. Measuring pressure this way is expensive and tedious, but works well if done correctly.

No method of measuring chamber pressure is 100% accurate. If you measure 100 rounds of exactly the same load, in exactly the same gun, with exactly the same test equipment using the crusher method the measurements will typically vary plus or minus 5% from round to round. Some rounds may be off from the average for that group by 10% or more. A small portion of those variations is caused by actual differences from one round to the next, but most of it results from errors, or variations, inherent in the crusher measuring method itself. This is not a perfect science.

During the 1960's another method of measuring pressure was developed. This second method is called the Conformal Transducer or Piezo method. It is similar to the crusher method except that a quartz crystal transducer replaces the standardized copper pellet.

When pressure is applied to a crystal its electrical properties change. Using very sensitive equipment these changes can be measured and recorded, thus giving an indication of the pressure exerted. The pressure readings obtained this way are stated in terms of PSI, or pounds per square inch.

The conformal transducer method is somewhat less expensive as the transducer is used over and over. It is also significantly more accurate. Readings obtained this way may typically vary about plus or minus 3%

from identical round to round. Exactly how precise either the crusher or conformal transducer methods are is impossible to determine, as there is no way to know exactly what the pressure *actually* is.

The piezo method has become the most common method used today to measure pressures. But the crusher method is still also widely used for verification and other reasons. The bottom line here is to know what you are looking at when reading pressure numbers, CUP or PSI.

To make things even more interesting, or confusing, a third method has been developed and is also widely used today. This third method is called the Strain Gauge method. A small piece of specialized wire, or metal, called a strain gauge, is attached to the outside of the gun barrel near the front of the chamber. When the gun is fired the barrel expands slightly. The strain gauge is stretched, or strained. A relative pressure indication can then be determined by measurement of the resulting change in the electrical properties of the strain gauge using sensitive measuring equipment.

The readings obtained using a Strain Gauge are also stated in PSI. Strain gauge readings are not absolute and must be interpreted based on the variation from a known reference load. Strain gauge results are reasonably accurate but are generally not published, as they are not as reliable as the first two methods.

This Strain Gauge method is the simplest and least expensive. There are strain gauge units that the serious reloader or gun smith can purchase for as little as $300.

Now suppose you see a pressure given in PSI for some hot new cartridge and want to relate that to the more familiar CUP in order to compare it to another cartridge or load measured by that method. As I mentioned earlier, these pressure measuring methods are not 100% accurate and, primarily for that reason, there does not exist an accepted formula for making this conversion.

I suppose that it would be reasonable to guess that, in general, if a cartridge has a published maximum average pressure in the 50,000 CUP range that the PSI equivalent will be considerably higher, generally in the 60,000 range. If the CUP specification is in the 40 to

45,000 range, there is a reasonable chance that the PSI specification may be nearly the same. And if the CUP number is lower than about 40,000 the PSI equivalent will probably be considerably less. Unfortunately, none of these generalizations are accurate or consistent enough to be meaningful to shooters, reloaders, or anyone else.

For reasons not yet understood there are numerous exceptions for individual cartridges. The measured CUP and PSI readings vary considerably from one cartridge to the next and are not consistently different. Remember that the earlier mentioned standards organizations now publish both CUP and PSI specifications, as determined from actual measurements, for all cartridges.

I also understand that at least some recent reloading manuals are giving both specifications. The A-Square Reloading Manual, "Any Shot You Want," is a good source for this information. In fact, that reloading manual is an interesting read even if you are not a reloader.

The subject of chamber pressure is infinitely complex and there are literally thousands of documents covering various aspects of this subject. One could spend a lifetime studying pressure measurement and still be surprised on a regular basis by unexplained exceptions to the generally accepted rules.

The bottom line is don't push your reloads and always start with the recommended starting loads for your particular cartridge and firearm. Work up gradually and never exceed published maximums. Believe me, you do not want to experience the excitement of a separated case!