MEASURMENT THROUGH the AGES

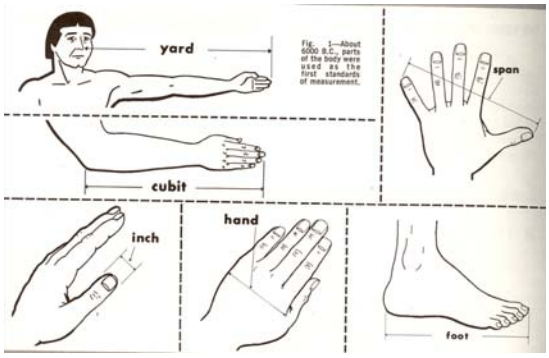
(Measuring while Manufacturing is the Key to Good Products)

Steve Krar

In this age of space exploration, manufacturing requires precision measurement in order to make spacecraft dependable and reliable. All parts in the spacecraft must be manufactured to exact measurements in order to be interchangeable and function properly in the conditions faced in space. To accomplish this, the craftsperson must use the best machinery, along with accurate tools to measure the work, and the skills to produce accurate work.

Early Measuring Tools

As early as 6000 B.C. humans used parts of a body as guide to estimate the dimensions for things. From this came the first standards of measurement such as the inch, hand, span, foot, yard, and fathom. These early tools were not very accurate since all products were made by hand and a fraction of an inch one way or another made little difference.



Measurement has to do with distance that involves a standard and a means of applying that standard between two separated points. The first-recorded linear standards were used by the ancient Egyptians and Sumerians and their measurement standard was parts of the human body:

- A cubit was the length of a forearm from point of elbow to end of the middle finger, or about 20 inches.
- The digit was the width of a finger, or from .72 to .75 inches.
- The palm was the width across an open hand at the base of the fingers, or about three inches.
- At a later date, the Olympic cubit became a foot and was divided by the Greeks into 12 thumbnail breadths.

Measurement Systems

There are two systems of measurement used in the world: the inch (Imperial) system and the metric (decimal) system. Over 90% of the world uses some form of the metric system while the one most commonly used in United States and Canada is the inch system.

- ✓ The **Inch System** has for many years been the standard system for North America with the base unit of length being the inch. Other linear units are related to the base unit by odd and unusual factors.
- ✓ The **Metric (Decimal) System** is used by over 90% of the countries in the world. Its base unit is the metre and all linear units are directly related to it by a factor of ten. It is less confusing than the inch system.

Basic Measuring Tools

The most common tool initially used for linear (length) measurements was the rule. Its accuracy depended on the skill of the user and the accuracy of the measurements was generally within one sixty-fourth of an inch.

The diameter of internal or external round objects could be measured with a rule or for more accuracy a caliper, whose two legs contacted the diameter of the object. A rule was used to measure the distance between the two caliper legs.

Precision Measuring Tools

The development of the micrometer by Jean Palmer in 1848, the forerunner of the modern day micrometer, made it possible to measure objects to an accuracy of one thousandth of an inch.

In 1862, Joseph Brown invented a vernier caliper with a graduated bar and a sliding leg that made measurements to within an accuracy of one thousandth of an inch. These were later equipped with a direct-reading dial for easy reading.

Electronic Measuring Tools

Manufacturing processes have become so precise that parts can be made in several different places and shipped to one location for assembly. To make this interchangeable manufacturing process possible, there must be some assurance all parts will fit on assembly. The inspection of parts is done rapidly and economically by comparison measurement. The most common tools used for this process are various dial indicators, comparators, and air gages whose accuracy can be as small as one ten-thousandth of an inch.

In-Process Gaging

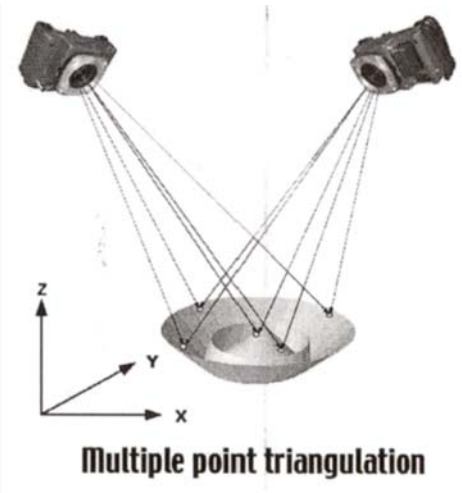
In the past ten years a quiet revolution of in-process gaging has resulted in manufactured products to unheard of degrees of accuracy. Measuring gages that take finer measurements, report the results instantaneously and work inside production machinery have been developed.

These gages contribute to high level of repeatability and have moved inspection from the lab onto the machine to measure the part while it is being produced. Years ago, manufacturers used to talk about tolerances in thousandths of an inch, then they went to ten-thousandths of an inch, and now tolerances are in the millionths of an inch.

The general trend in industry is to do as much measurement on the machine tool as possible before removing it and taking it to a separate monitoring station, such as a Coordinate Measuring Machine.

Photogrammetry

The fundamental principle of photogrammetry is triangulation, a 3-dimensional coordinating technique that uses photographs for measurement. Photographs are taken from at least two different locations called lines of sight. These lines of sight intersect and produce 3-dimensional coordinates (measurements) of an object. To obtain the highest degree of accuracy, reliability, and automation the system is capable of, photographs must be of the highest quality. Depending on the cameras used, accuracies of one to four thousandths accuracy measurements are possible.



Multiple point triangulation