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Step-by-Step

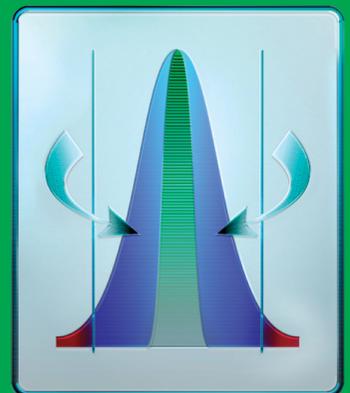
Multi-Vari Chart & Analysis

A Pre-Experimentation Technique

Mario Perez-Wilson

**Follow this step-by-step approach
at your own pace, and teach yourself
how to eliminate the major sources
of process variability.**

**You will be improving processes
right away!**



Multi-Vari Chart and Analysis

Mario Perez-Wilson

Multi-Vari Chart and Analysis
- A Pre-Experimentation Technique -

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MULTI-VARI CHART AND ANALYSIS

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Preface

In the past two days I have been able to witness -one of my passions- the development of one of the most ancient products -wine- being produced by the masters in the art -the Burgundian French- in probably the best-in-class vineyards of the world -Côte d'Or-. Côte d'Or, in most likelihood, is the region in Burgundy, where the most expensive and finest red and white wines come from^[1]. *Qualité* or quality to the Burgundian French is a matter of pride, an expectation that have been demanded from generation to generation.

From the many important variables such as, latitude, vineyard's location, slope, nearness to water, grape varietal, composition of the soil, direction of exposure, and the working of the hand and brain of men influencing the *qualité* and the characteristic of the wine; the human variable is one of the three major interacting variables^[2].

It is fascinating to see these people paying so much attention to detail to each particular vine and to understand the knowledge they have about their processes and how certain variables affect their *qualité*. High technology has not been very influential in the process of producing these wines, as most operations are done manually following centuries-old traditions.

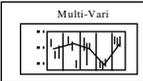
Observing the best-in-class in their art has always been a learning lesson to me and if there is something to be remember from this experience is that in order to achieve a high level of *qualité*, a high attention to detail must be paid and the human variable must achieve a thorough knowledge about their processes.

This publication intends to express the extreme importance in paying high attention to detail in analyzing manufacturing processes, in identifying the sources of variation and in determining cause and effect relationships.

The book is divided into two main section, one which details the construction of multi-vari charts and the other which explains how to statistically analyze multi-vari chart data. The section of analysis of multi-vari data also presents a methodology for partitioning the variation into the different families of variation and this can be expanded by the user as each particular application calls for.

Finally, the book presents various case studies from the computer, automotive and medical manufacturing processes and how multi-vari can be applied to determine the major families of variability.

**Mario Perez-Wilson
Tournus, France
June 20th, 1992**

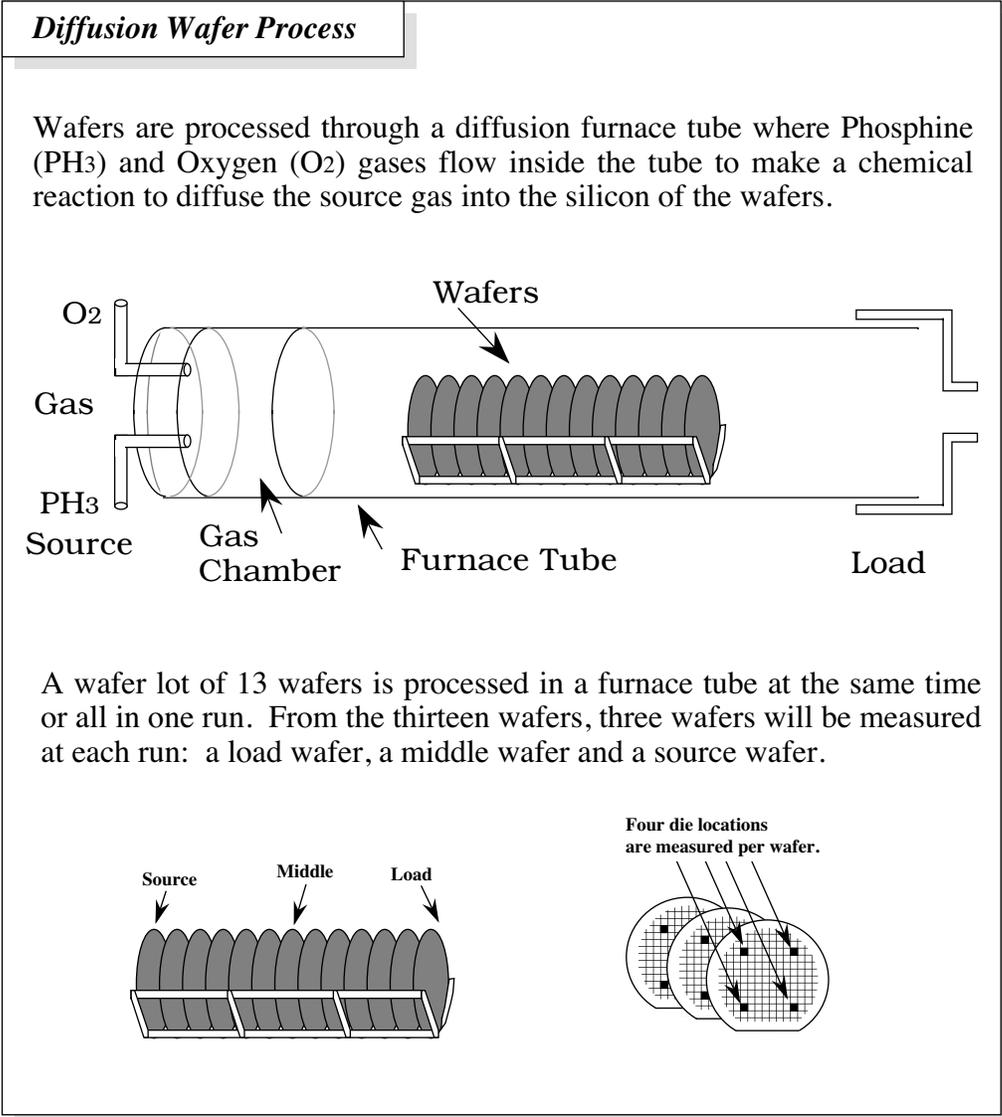


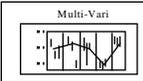
Construction of a Multi-vari Chart

The steps for constructing a multi-vari chart are very simple and straight forward. There are a few rules that should be maintained when constructing a multi-vari chart. These rules are the following:

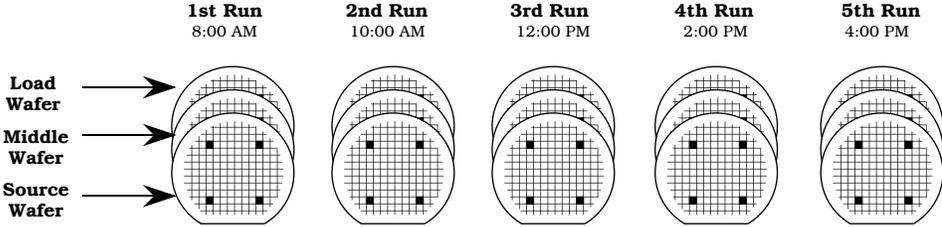
- a. Do not make process changes while collecting data
- b. The sequence should not be randomized

Given the following process data:





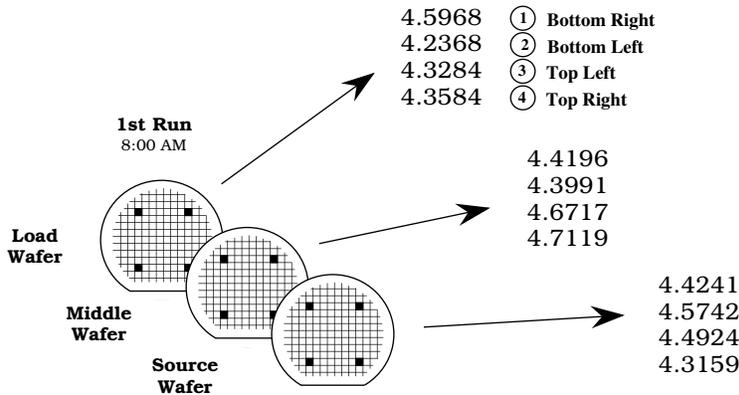
The time scale could also be different shifts, days or even weeks. In some instances, this scale could represent other things rather than time. For example, different runs of product, batches, lots.

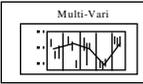


Program:		MULTI-VARI CHART					Study:	
Operation:							Date:	
Characteristic:								
LSL:							USL:	
Time:	1	2	3	4	5			
Chart Scale:	1st Run 8:00 AM	2nd Run 10:00 AM	3rd Run 12:00 PM	4th Run 2:00 PM	5th Run 4:00 PM			
6.0000								
5.7500								
5.5000								

Step 4 : Determine the sampling scheme. Collect three consecutive units from the process at each time interval and take various measurements from each unit.

The number of units to collect in each time interval is usually three, although more or less units could be collected depending on the specific application. Again for each unit various measurements should be taken, it could be two, three or more. The forms handle up to five observations within piece.





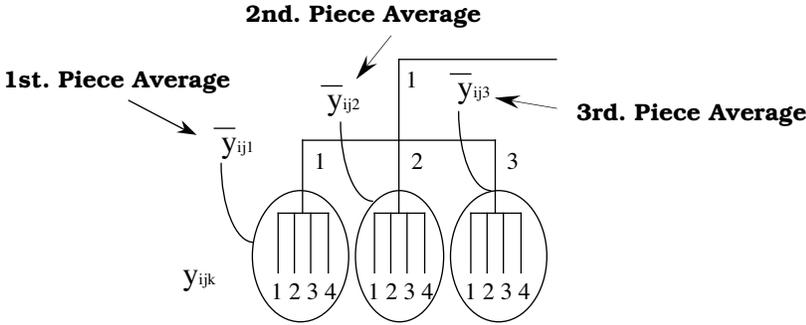
The **variance** is computed by taking the deviation of each piece observation (n) from the piece average, \bar{y}_{ij} , squaring it and dividing it by the degrees of freedom (n-1),

$$\frac{\sum_{k=1}^n (y_{ijk} - \bar{y}_{ij})^2}{n-1}$$

Piece Average

where this **variance** becomes an estimate of σ_w^2 with n-1 degrees of freedom.

The above **variance** is for one piece only. For all pieces of a single time frame the summation should be done for all b pieces, so the estimate of the variance V_W becomes:

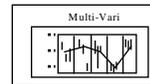


$$\frac{\sum_{j=1}^b \sum_{k=1}^n (y_{ijk} - \bar{y}_{ij})^2}{b(n-1)}$$

To compute the **variance** for all time frames or for all the ab pieces, we proceed by pooling all the variances to obtain the within piece variance (V_W):

$$V_W = \frac{\sum_{i=1}^a \sum_{j=1}^b \sum_{k=1}^n (y_{ijk} - \bar{y}_{ij})^2}{ab(n-1)}$$

Each Piece Average

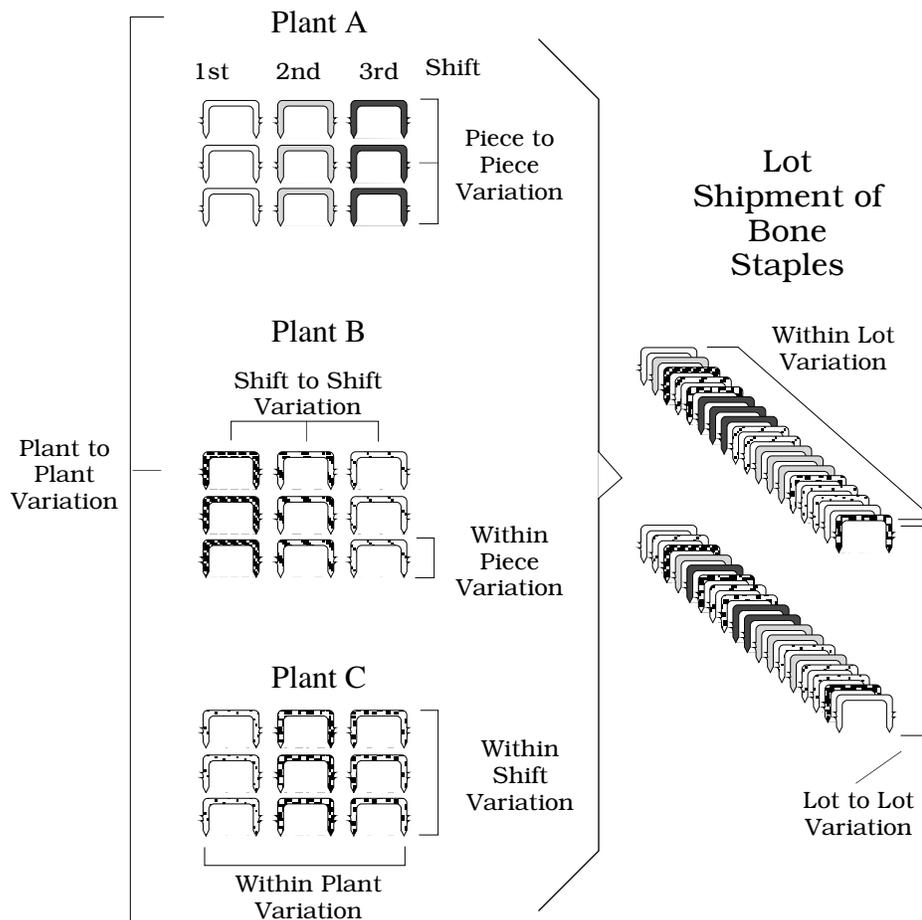


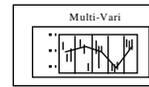
Medical Bone Staples

The bone staple manufacturer does not know if the defective units come from a specific plant, from a specific production shift or if it is just variability inhered in all production machines.

In view of the complexity (of different sources of staples) of the lot formation shipped to the distributor, the process engineer along with the supplier quality engineer decided to run a Multi-vari analysis.

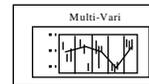
Formation of a Bone Staple Lot ^[10]





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- [10] J. M. Juran & Frank M. Gryna, Quality Planning and Analysis, 2nd. ed. (New York: McGraw-Hill Book Company, 1980), P. 115. The idea for the formation of a bone staple lot was taken from a modification of The anatomy of lot formation.



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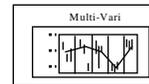
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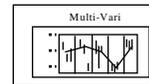
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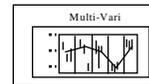
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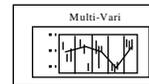
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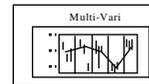
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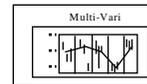


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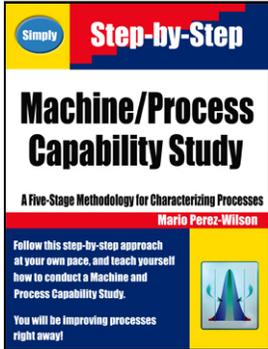
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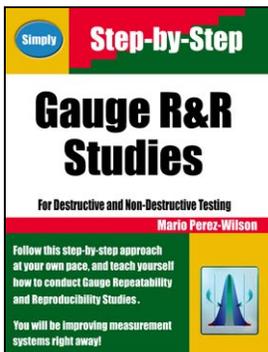
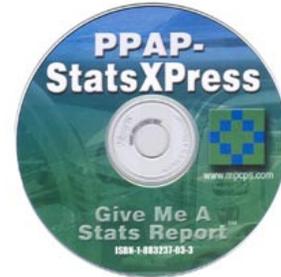


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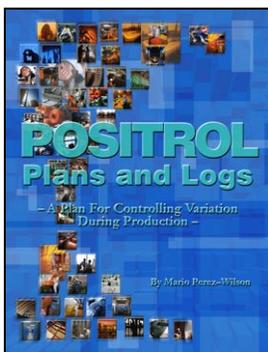
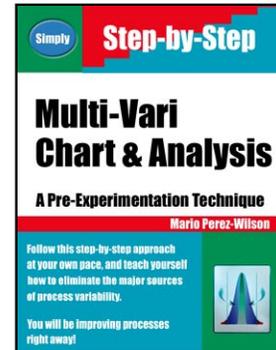
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