University of
Waterloo

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The INSTITUTE *for*
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Waterloo, Ontario, Canada N2L 3G1
(519) 888-4593

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**Bovas Abraham, Jock MacKay,
and James Whitney**

**The Institute for Improvement in Quality and Productivity
University of Waterloo, Waterloo, Ontario, N2L 3G1, Canada**

ABSTRACT

Charting is one of the simplest and most useful ways of summarizing and interpreting data collected on a process. However, "There are surprisingly few useful charts". In this paper we discuss why this failure has occurred and how addressing some planning issues can add value to the charting activity. It is our view that a major reason why charting has failed is that the process of charting has not been well defined in most applications. Also, little attention has been given to the planning and management of charting or how charting fits into the overall system. The design of the charting process is highly dependent on its purpose. We discuss the purposes of charting as well as the associated planning. A template is given as an aid to guiding the planning process.

1. INTRODUCTION

The following statement appeared in Ishikawa (1982).

"Control charts are easy to construct, so they are widely used. But there are surprisingly few really useful charts."

In our view this statement, especially the second sentence, is still true today, although it appears that the wave of enthusiasm for charting in the Eighties has diminished so that it is more difficult to find an organization "wall-papered" with charts. Users have abandoned the charts, frustrated with the lack of value added from the charting activity. Why has this failure occurred?

There has been strong interest in the improvement of processes in both manufacturing and non-manufacturing organizations. This interest has arisen both from the internal motivation to reduce costs and the external motivation of customers demanding higher quality. Control charts were expected to be a vital tool to help achieve these improvements. Failure cannot be attributed to lack of trying.

As Ishikawa says, it is easy to learn to construct and interpret simple Shewhart charts. Large numbers of managers, engineers, technicians and employees have been trained, at enormous cost, to use these charts. Students in Colleges and Universities take courses on SPC (Statistical Process Control). There are accessible reference materials available; for example the AIAG manual, *Fundamental Statistical Process Control* (1991). We believe that the lack of success in getting value from control charts cannot be attributed to peoples' lack of understanding of how to construct or interpret the charts.

Statisticians have developed a bewildering array of charts that can be applied in many different situations. Charts have been compared for efficiency and cost. The theoretical

background has been thoroughly explored. We do not think that charts have failed because of the lack of research activity.

To examine the failure more closely, it is helpful to consider the **process of charting** as opposed to the charts alone. The charting process, which we will call **charting** for the sake of brevity, is defined by the establishment and on-going use of the chart. As with any other process, charting has inputs and outputs, suppliers, customers and participants. Charting is usually embedded in a system, a complex network of processes that interact. It is our view that a major reason for the failure of charting is that the process has not been well designed in most applications. The needs of the customers of the charting process have not been clarified. Little attention has been given to the planning and management of the charting or to the understanding of how charting fits into the larger system. There is little mention of these ideas in well known references such as the AIAG manual, the texts by Wheeler and Chambers (1992), and Montgomery (1991), etc. One exception is the work of Nolan (1990). His paper is an excellent discussion of the planning required for charting. We strongly support the ideas it contains.

The present paper explores the planning and management issues from a slightly different perspective. In the next section, we discuss in detail some possible purposes for charting, that is customer needs, since the design of the charting is highly dependent on its purpose. Some general planning issues are discussed in the third section. We also look at some special issues associated with certain purposes of charting and introduce a planning template to guide the implementation of the charting process.

2. PURPOSES FOR CHARTING

The first step in the design of any process is a clear understanding of its purpose. This requires the identification of the customers of the process and an assessment of their needs. Charting can be used for many different purposes; here we list what we believe are the most common. Note that the process referred to in the following discussion is the process whose output is being charted.

1. Process Monitoring or Process Record

In this case, charting gives a history of process outputs over time. The use of a control chart provides a visual display of the process performance. There are many reasons for monitoring. In the short term, an external customer of the process can use the chart to replace inspection activities and to assess stability and capability. Comparison of charts over a long time period can reveal if continuous improvement activities are effective. A chart can provide baseline data to help an internal customer, charged with process improvement, to plan studies on the process and to demonstrate the effects of changes to the process. Note that charting for the purpose of monitoring does not include any direct action on the process as a result of the chart's behaviour.

2. Process Adjustment to Reduce Variation

Process control provides a set of rules to determine when and how process adjustments should be made. It is a tool to assist an operator to make a machine adjustment and to help maintenance make process adjustments. Charting can show when the process output has

undergone a significant change (or not) so that adjustment does not become tampering. The chart provides a record of both the short term effect of the adjustment and the long term effectiveness of the adjustment procedures. The charting continues as long as the adjustment procedure is required.

With this purpose, the charting leads to direct action on the process. The action to be taken must be specified as part of the charting procedure. Note that the adjustment factor and the effect of changing that factor are known outside of the charting.

3. Establishment and Maintenance of Stability

Establishing stable (predictable) process outputs by the detection and removal of special causes of variation is Shewhart's original purpose for charting. The process managers are the customers of the chart in this case. To ensure that stability is maintained, the charting must be continued forever. The charting must include methods for identifying special causes when they occur. These causes are unknown at the start of the charting. Note that removing the effect of an identified special causes usually involves a change in the inputs to the process. Action is taken as a result of changes visible on the chart.

4. Variation Reduction

This is an activity with the goal of reducing variability of the process output by identifying and removing sources of variability. This activity is more general than Purpose 3 because it does not concentrate only on special causes of variation. All process inputs that change over time are considered. Again the chief customers of the charting are the process managers who will benefit from the reduced cost and improved quality of the outputs. The charting may cease

once the process has been redefined so that further reduction of variability is not feasible or economical at that time.

Direct action must be taken on the process inputs identified by the charting as important sources of variation. Changes to the process that will ensure that the charting has added value are unknown at the start of the undertaking.

5. Special Studies

Sometimes charts can be used as an analysis tool. For example, measurment system studies and analysis of means can be performed using control charts.

In many cases, the charting may have multiple purposes. The broader the stated purpose, the more complex and expensive will be the charting process.

The first step in any charting activity is a clear statement of the objective of the study. This objective should be written in terms of satisfying customer needs, not in terms of the charting method. For example if a process is to be studied to reduce scrap due to a specified defect (Purpose 4), the objective should be stated as "reduce the scrap rate due to the defect from 6% to 1% within the next three months" as opposed to " establish a p-chart on the defect". In many instances, charting will not be the appropriate tool to achieve the objective.

The conflict between proponents of SPC and APC (automatic (?) process control) can be resolved by a clear statement of the objective. In many processes where the outputs show structural variation [Joiner and Gaudard (1990)], the simple adjustment schemes that are possible, based on pre-control or Shewhart charts, are ineffective compared to the more complicated methods proscribed in APC. Of course, the process managers must assess whether the increased

costs due to the complexity of the APC methods are worthwhile.

3. PLANNING AND MANAGEMENT ISSUES

In the previous section, we listed several purposes for charting. Depending on the purpose the requirements for charting and the planning details may vary. However, the following list of tasks applies to all charting. Resources must be provided to carry out these tasks in order to implement charting.

1. Process definition and boundaries

The process to be charted must be well defined. Customers of the process and their needs should be identified. A process flow diagram and a cause and effect diagram are often useful tools to aid in the definition. The boundaries of the process must be clearly defined.

2. Characteristics to be charted

There should be a clear understanding of the process outputs to be measured. These outputs should be relevant to the purpose of the charting.

3. Measurement system check/improvement

Measurement system variation should be small compared with the overall process variation. An assessment of the measurement system for stability and relatively small variability is often required.

4. Base knowledge

How much do we currently know about the process being charted? The more that we know about the past behaviour of the process, the better will be the plan for charting.

5. Sampling plan

The purpose of charting dictates what type of sampling plan is to be adopted, and this determines what type of chart is to be used. Two aspects of the plan are:

- Frequency of sampling: How often to sample? When to sample?
- Subgrouping: This determines the "within" and "between" sample variation.

6. Protocol and provision of human resources.

- Who will take measurements, record data, perform calculations, construct and analyze charts, etc?
- Are these people trained? Do they understand the purpose of charting? Do they have the time to do the assigned duties? Will they carry out these duties?

7. Plan for reaction to charts.

There should be a plan to act upon chart signals if this is part of the purpose.

- Who will take action on the process based on the chart behaviour?
- What is the appropriate action to take?
- Are the people involved trained to carry out these actions?

8. Plan for review

Periodic review for improvement of charting should also be part of the plan. Is the charting meeting the customer requirements continuously?

The above steps may appear unnecessarily complex. However,if any one of them is ignored, the charting is likely to fail.

To make the planning easier a template is presented below. The purpose of following the template is to ensure that planning is done and resources are made available so that a control chart application will provide good value. All of the questions need to be answered!

The template is self explanatory. However in item (6) "capability" check refers to the provision of human resources. Is this person trained to do this job? Does this person have the time? Does this person understand the purpose of charting?

Items numbered 7 and 8 depend on the purpose of the charting. For instance if the purpose is process monitoring, then the following questions are relevant and need to be answered:

- Who is the customer?
- How is the customer involved in planning the charting?
- How do you ensure that the customer is happy with the charting procedure?
- Who will review the charting (and when) to ensure that customer needs continue to be met?

CHARTING TEMPLATE

1. Purpose: _____

2. Who is accountable for the establishment of chart:
_____

3.(a) Characteristic to be measured: _____

(b) Measurement System:☐ Checked previously ☐ Checking now

4. Base knowledge:
_____
_____

5. Sampling plan:
_____

6. Protocol and provision of human resources

Task	Name	"Capability" Check
Collection of data	_____	
Construction of chart	_____	
Analysis	_____	
Review of charting	_____	
:		

7. Plan for reactions to chart:
_____

8. Plan for review:
_____

If the purpose is adjustment, the following questions should be answered:

- How does the charting signal the need for adjustment?
- Who will make the adjustment?
- How much adjustment is required?
- How will the adjustment be verified?
- Who will review the charting (and when) to ensure that the adjustment procedure is efficient?

If the purpose is to establish and maintain stability, then it is pertinent to ask:

- Who will establish control limits?
- What constitutes a signal on the chart that a special cause is acting?
- How will the search and its results be documented?
- Who will review the charting and action on the identified causes to see that progress is being made (and when)?

Thus, depending on the purpose, several question need to be answered regarding plans for reaction and review.

4. SUMMARY

This paper looks at two reasons for the failure of charting

- Charting is rarely viewed as a process.
- Lack of planning and management of charting.

We discussed the various purposes of charting and the associated planning issues. We also introduced a template to guide the implementation of charting.

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