Process Reliability

Unreliable production processes waste money. Unreliable processes are corporate failures. Few companies know or measure the reliability of their processes.

Without measure of process losses companies do not have a careful measure of how much money they're missing each month from unreliable production processes. The reason for worrying about process reliability is to reduce variability in plant output so the business has a consistent paycheck! Resolving process reliability issues is in concert with six sigma concepts for reducing variability and the methodology works for both batch processes and continuous processes.

How do you know for sure your process or production center is running at its maximum output and how much daily variability is acceptable? What if your daily production output showed your could have averaged 30% greater output than you achieved—but you didn't know you had the capacity for improvement? Many processes have extra capacity that is consumed by the hidden factory. You'll never find the hidden losses unless you look for it with new tools and new approaches described below with the Barringer process reliability tool.

Here is an example of a plant that has had two record months of production during the year and they're busy bragging "We're #1"! They didn't know they could have had 30% greater annual output than they achieved. While they may claim they are #1 this plant hasn't recognized **they're only #1 in their lane, but they're racing against 25 other lanes (their competitors).** Each production plant may think they're #1 (in their own lane) but the race is won by the best performer. The laurels reside for the true #1 producer who effectively utilizes the capital of their factories to provide a consistent large paycheck for the corporation.

Figure 1 shows daily production data from a production plant in the traditional time scale—notice the wide scatter.

Figure 1 - Time Sequence Plot

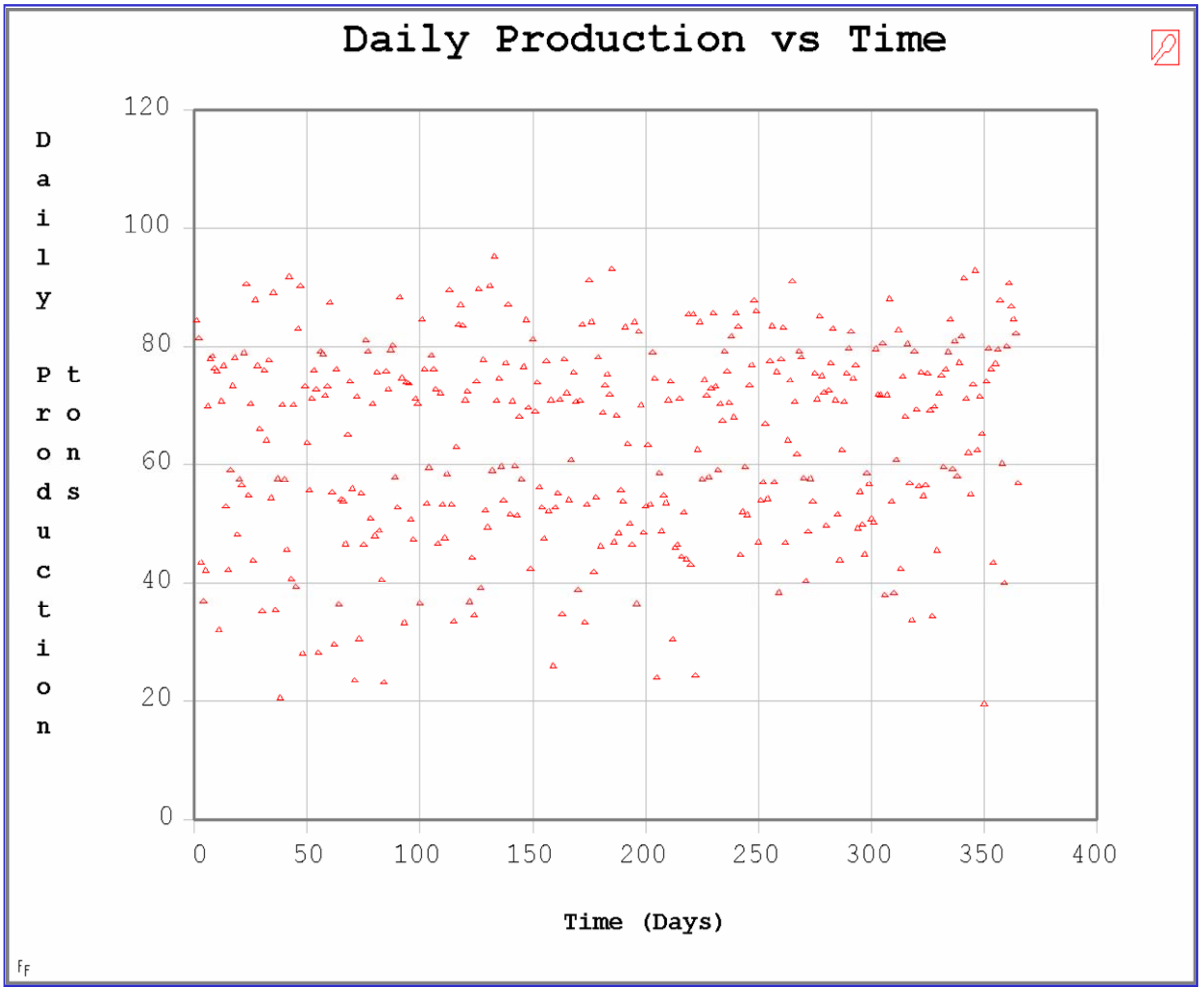
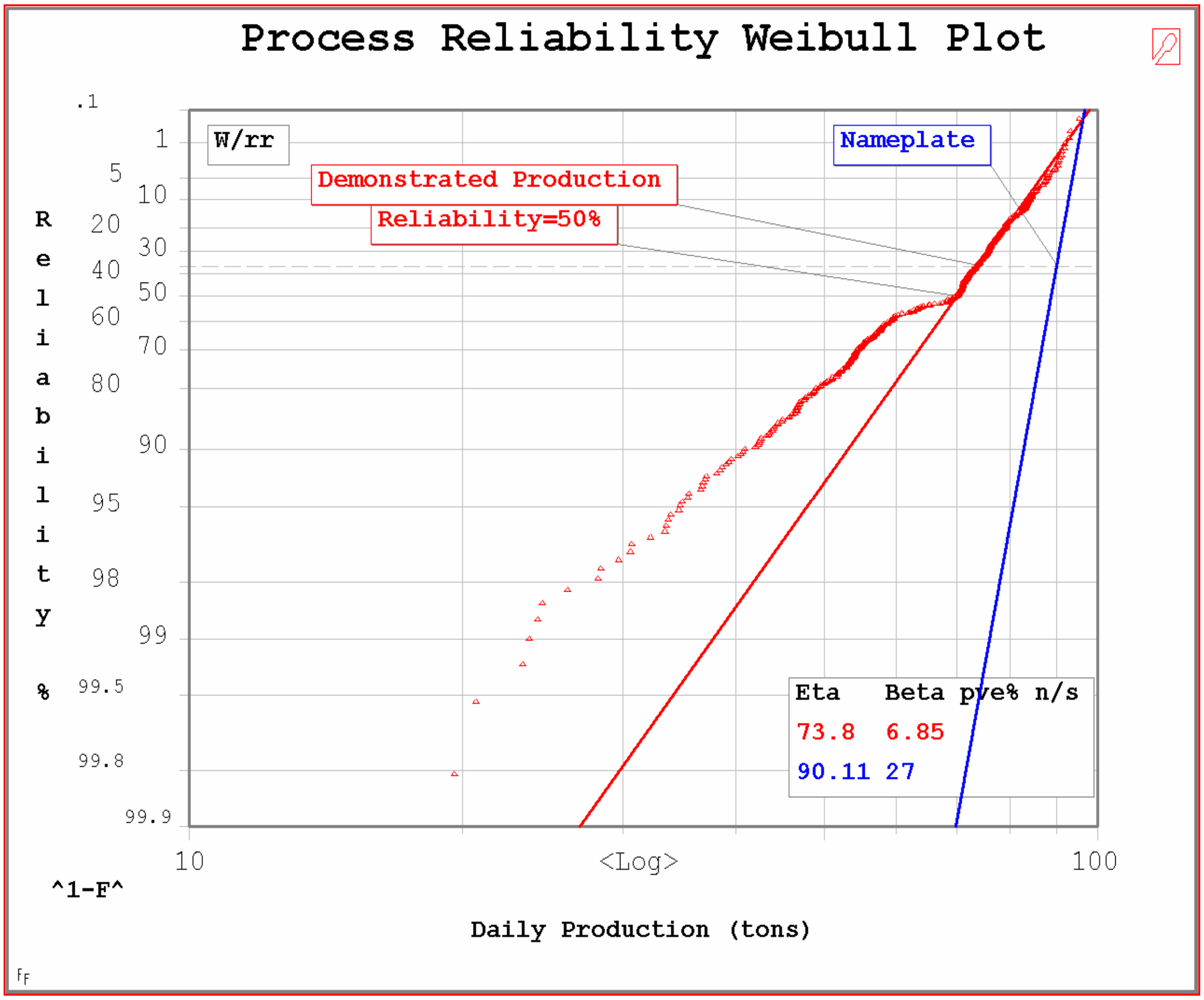


Figure 2 shows the same daily production data but the data is plotted in rank order without connection to time—notice the straight line segments. The reliability of the process is 50% which is the point the process looses its consistency. Figure 2 has some horizontal gaps between the data points to the left of the demonstrated production line which usually are associated with things causing deficiencies. Figure 2 also has some gaps to the right between the demonstrated line and the nameplate line.

Figure 2 - Probability Plot



All **<u>un</u>**measured processes are verbalized as reliable. This fantasy continues until the process is measured as shown in Figure 2. Few measured processes are reliable. Most processes are unreliable and thus need improvements. When the trend line of largest production values break away to the left, you can read the reliability of the process directly from the chart in Figure 2.

If you haven't measured the reliability of your process you'll not identify the problems. If you can't identify the problems, you will never correct the money loosing issues. The problems represent **red ink** for production potential. To get the **red** out, you've got to **get the lead out** of the seat of your pants by making a change to get a change!

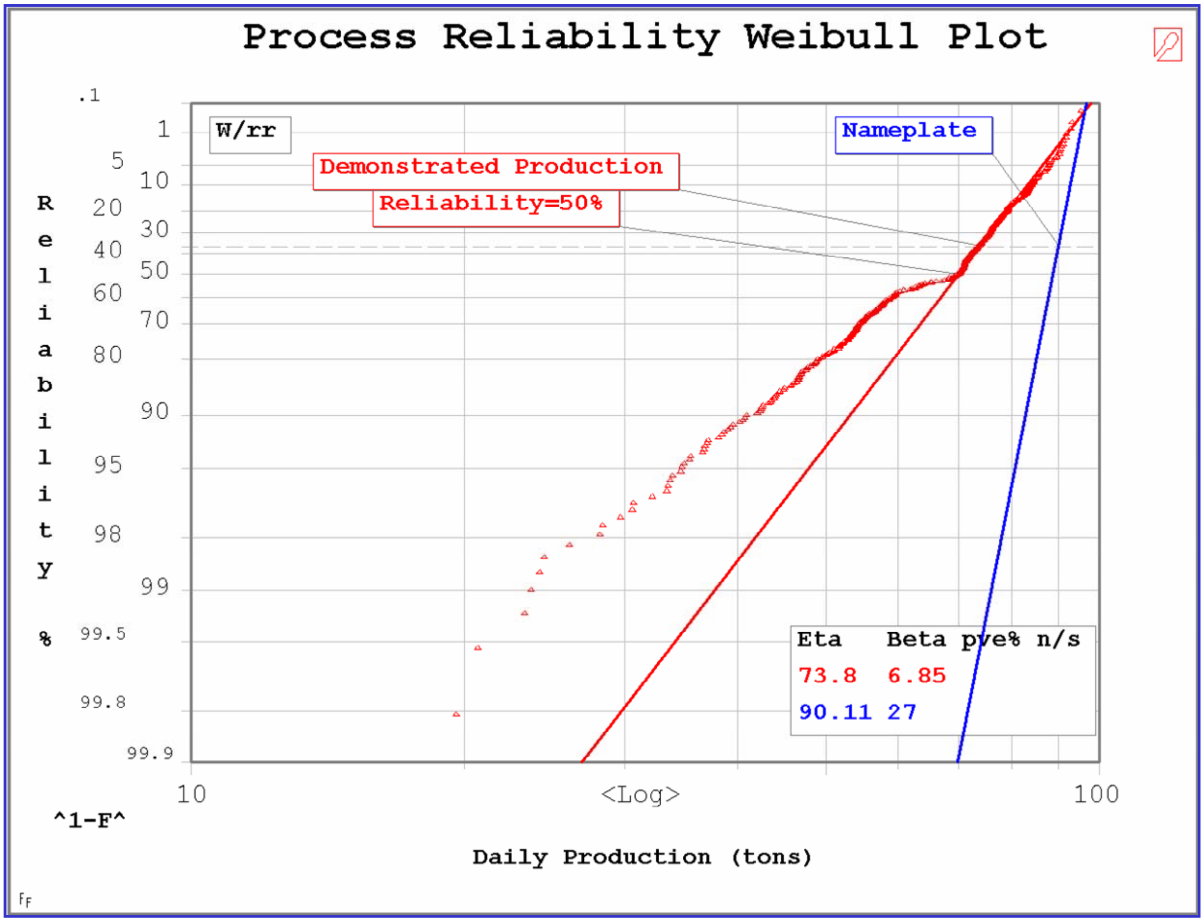
Poor process reliability disrupts the paycheck for the corporation every month. Consistent output from the process generates saleable goods, which drives income for the company. Income from the process is the **paycheck for the corporation**. Process output deficiencies are always promised to be "made up" next month, but next month never comes.

If your personal paycheck were as variable as the monthly paycheck from most processes you would be the heel in your family—not the hero! Want to see how this works with **your** paycheck?—download the paycheck simulation (see http://www.barringer1.com/MC.htm as shown in simulation 8) using the same beta as found from your process studies. Then ask the question, how much free advice would you get from your mate if your paycheck varied by that amount?

It's also interesting to compare the same production process at two locations, and study why one is more successful than the other. Likewise the process reliability methodology gives M&A (mergers and acquisition) teams a quick look at the "quality" of processes. The process reliability techniques allows comparing production processes from different operations and deciding the capabilities of the management team's ability to make the rough gemstone into polished jewelry. This quick study of production processes for Process A and Process B is similar to the quick screen your health provider does for you during a visit when results of your blood pressure, pulse, temperature, visual observations of your throat, ears, and nose, along with sounds from your lungs/heart give a quick assessment of your health—after all it is not helpful to physically disassemble you to find the real details of your health!

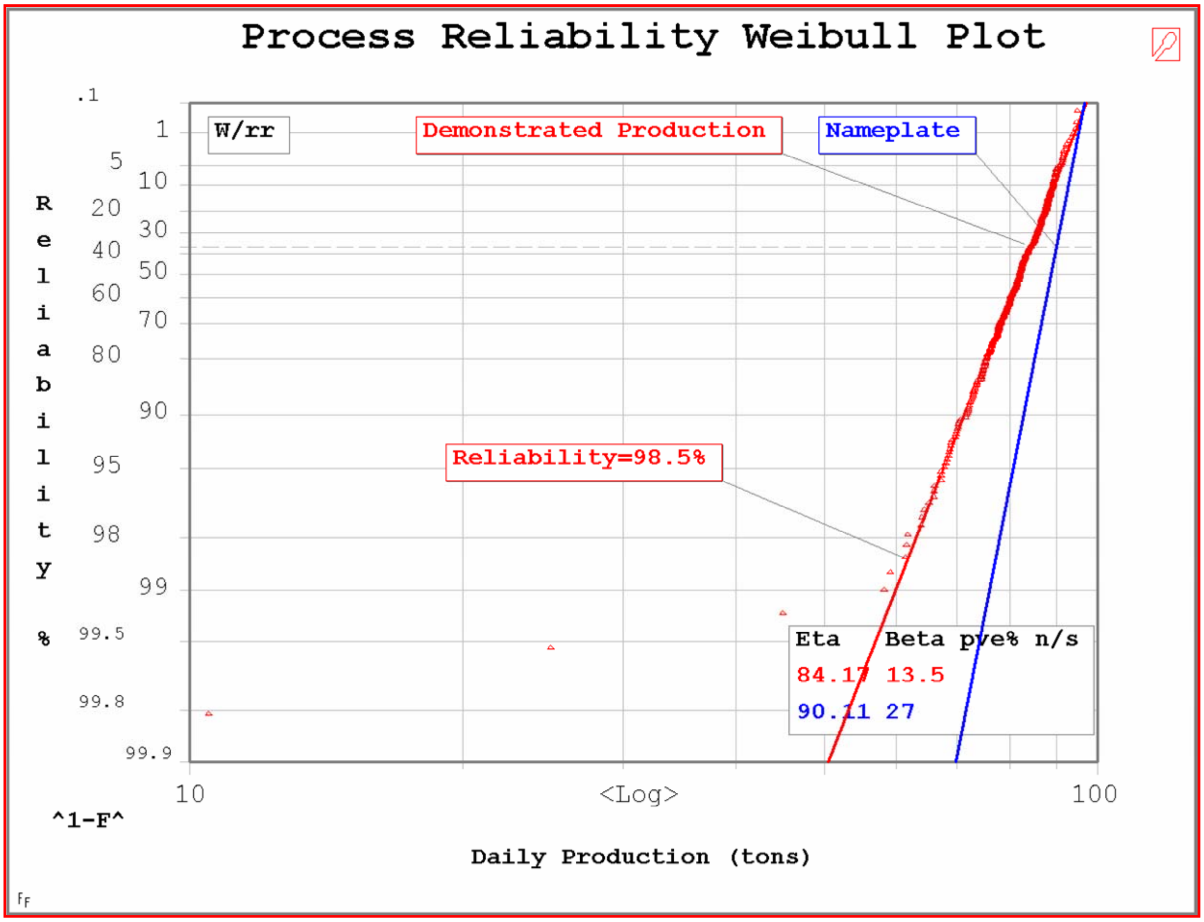
Clearly Figure 3 for Process A has less consistent output than Figure 4 for Process B. The horizontal gaps between the datapoints and the demonstrated production line are much smaller for Process B for reliability issues and efficiency and utilization.

Figure 3 – Process A



Thus process B in Figure 4 is preferred over process A in Figure 3 as it is more reliable and has less variability in output. Notice that Process A and Process B have the same nameplate line but the gaps between the lines/points are significantly different.

Figure 4-Process B



Process reliability technique uses currently available daily production information. Production data is usually accurately maintained for long periods as daily production output. If your production data of prime product is not accurate, then you have more problems than this process can solve! Using daily production numbers means no new data is required and no new culture must be installed at the floor level to acquire information. It's a simple plug and play effort to make your daily data "talk" to quantify problems. Problems must be identified for corrective action. If the problem exists, you must fix it to improve consistency of production output (i.e., remove variability in your process output). If you don't want to improve your process, then the rest of this article will be of no value to you.

Daily output from both continuous and discrete production processes, when plotted on a Weibull probability plot, produce straight lines. Where consistent output is lost, a cusp is formed on the trend line signifying the loss of process reliability. Unreliable processes strangle the paycheck for the corporation. Few companies identify and correct their problems—thus they struggle along with highly variable monthly paychecks while the losses continue. Most companies **only talk about** changes to the process—few have the industrial courage to make process reliability improvements.

A Weibull trend line can be fit through the straight line portion of the reliable production numbers. Gaps to the left between the Weibull production trend line and the deficient daily production numbers are summed to give the annual losses assigned to the unreliability (these reliability losses are usually "things" issues).

The slope of the demonstrated production line on the Weibull plot gives clues as to the grade of the process. Low grade processes have flat line slopes with high variability in output. High grade processes have steep line slopes indicative of small variability in output. World class processes have steep vertical lines with high reliability. Fourth quartile processes have flat slopes with only a small percentage of the daily production on the steepest portion of the trend line.

A nameplate line for the process is drawn on the same Weibull production plot which falls to the right of the demonstrated production trend line. Horizontal gaps between the nameplate line and the demonstrated production line are summed to give the annual losses assigned to efficiency and utilization problems (these are management issues). In six sigma parlance, the nameplate line is the entitlement line.

Two types of losses represent the hidden factory:

1) Reliability gap losses (usually associated with things).
2) Efficiency/utilization losses (usually associated with management issues).

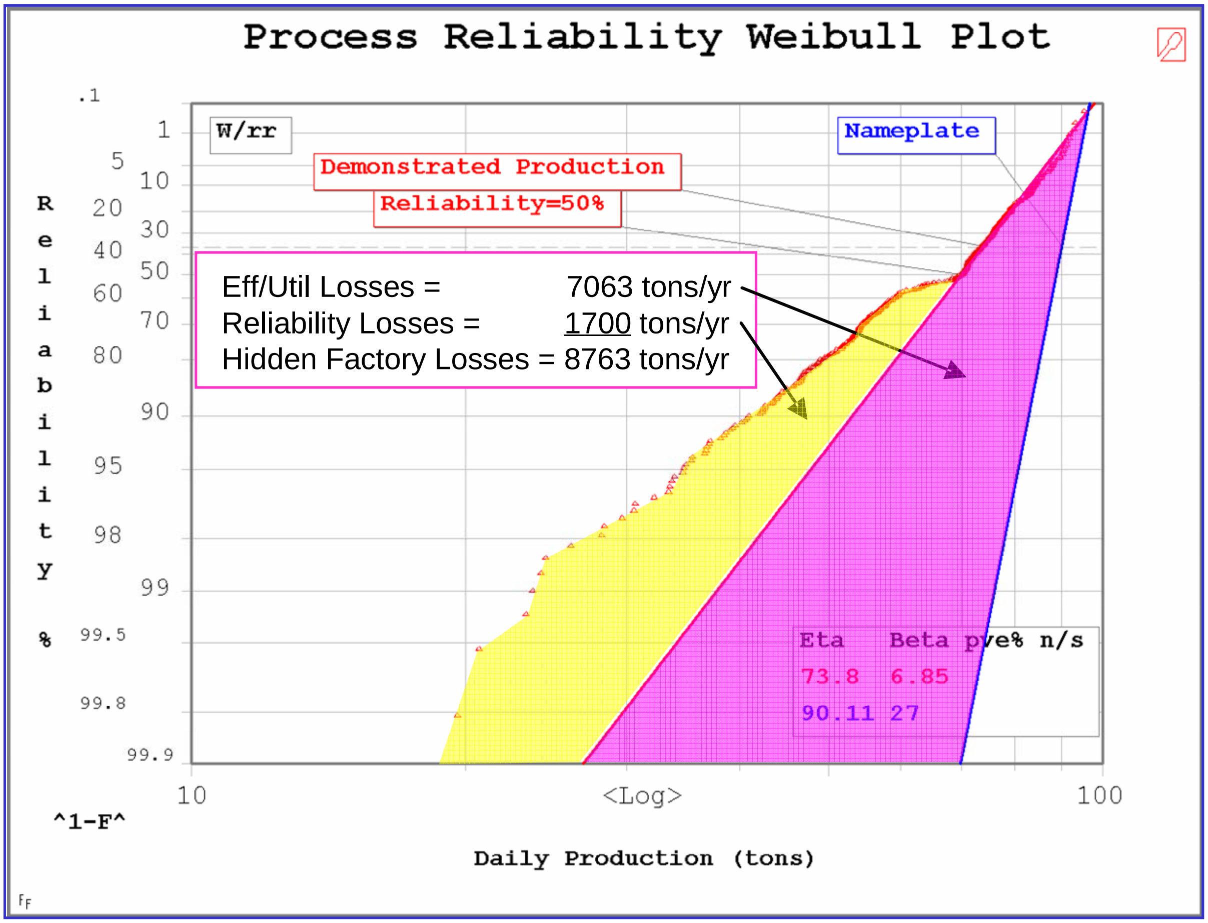
For process reliability studies, all of this information goes into a single sheet of paper for a one-page assessment of the process.

The process reliability plot on Weibull probability paper is a comprehensive tool for managers and for mergers and acquisitions teams. This one page assessment summarizes battle damage within the process. The assessment clearly describes the size and location of the hidden factory. The method uses daily production output (saleable product without inclusion of scrap or off grade product). WinSMITH Weibull software will calculate the gaps and sum the losses for both reliability issues and efficiency/utilization issues as shown below. Table 1 and Table 2 summarize data from WinSMITH Weibull's calculation of gaps. The losses for Process A are ~4 times larger than for Process B. Furthermore reduction in losses occurs in Process B by improving consistency in output for Process B which reduces the management losses in the category of efficiency and utilization. Knowing the magnitude and type of losses is important for M&A assessments and for continued improvement programs within the usual six sigma improvement programs.

Table 1-Process A	Table 2-Process B
Production Line = Eta 73.8, Beta 6.85 Nameplate Line = Eta 90.11, Beta 27	Production Line = Eta 84.17, Beta 13.5 Nameplate Line = Eta 90.11, Beta 27
Process Reliability (%) = 50	Process Reliability (%) = 98.5
Reliability Losses = 1700 (tons/yr) (Sum of all gaps between the demo line and data points from 50% to 100% reliability)	Reliability Losses = 91 (tons/yr) (Sum of all gaps between the demo line and data points from 98.5% to 100% reliability)
Eff./Utilization Losses = 7063 (tons/yr) (Sum of all gaps between the demo line and name plate line)	Eff./Utilization Losses = 2665 (tons/yr) (Sum of all gaps between the demo line and name plate line)
Hidden Factory Losses = 8763 (tons/yr) (Sum of reliability and efficiency/utilization losses)	Hidden Factory Losses = 2756 (tons/yr) (Sum of reliability and efficiency/utilization losses)

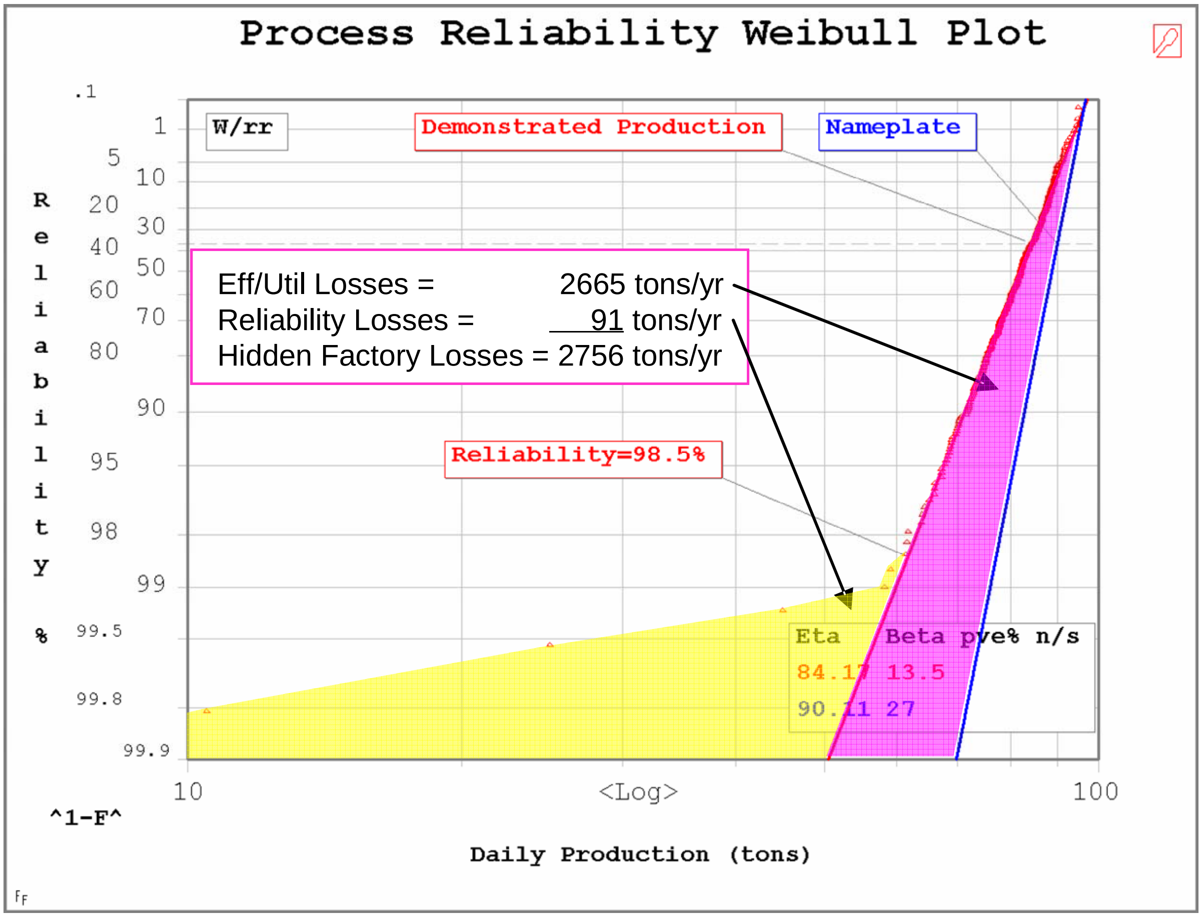
Upper management teams love these one page Weibull process reliability plots shown in Figure 5 and Figure 6—**particularly when the losses are converted to money**. One page gives the facts along with a graphic of the problems.

Figure 5 Process A



The vision of upper management gives them a reason for new game plans on one side of one sheet of paper when they see the performance in Figure 6 which has less scatter and higher reliability. The story is short. It's sweet. It's understandable to those with visions.

Figure 6-Process B



Lower level management and engineers usually dislike the Weibull process reliability plots. Why the dislike?--because they must make changes to correct the problems. Usually a paradigm change is required as they are booted from their comfortable, but unreliable, nests to improve the paycheck for the corporation. For the lower level guys, it's changes they don't want to make because they're happy as hogs in their own pig sty and "they" want me to change my little kingdom—how could they!!

What's the reliability of your process? Have you measured it? To answer this question, refer to the Problems Of The Month starting in May 1997 and subsequently following the hyperlinks at the bottom of this page. The methodology is explained in The New Weibull Handbook, 5th edition, by Dr. Robert B. Abernethy.

The quest for improving process reliability runs parallel to six sigma efforts—both methodologies work toward reducing variability. Process reliability starts with the premise that most output from production process is **non-bell shaped data** (skewed with long tails to the left) as compared to most six sigma premises that the data is reasonably bell shaped data (normal). Seldom do the six sigma tools identify reliability and rarely the reliability of processes. The process reliability effort commences with a common tool from the field of reliability—Weibull probability plots. The key issue is to find the problems and fix them so the corporation receives a consistent (and consistently high) paycheck every month.

You can download a ZIP file containing the files you need to reproduce these results using the demonstration versions of SuperSMITH. The ZIP file contains:

1. An Excel spreadsheet, **PR-Example Data.XLS**, with the raw data plus some typically computed best 1-day results, best 7-day results, etc and you can compare these usual criteria to the numbers obtained from the process Weibull plots.
2. A WinSMITH Visual file, **PR-Example-A.V** for Figure 1, which you can import into the demonstration version of WinSMITH Visual software and it will handle the original file without randomizing the data.
3. A WinSMITH Weibull file, **PR-Example-A.W** for Figure 3, which you can import into the demonstration version of WinSMITH Weibull software and it will handle the original file without randomizing the data.
4. A WinSMITH Weibull file, **PR-Example-B.W** for Figure 4, which you can import into the demonstration version of WinSMITH Weibull software and it will handle the original file without randomizing the data.

Since some art is involved in making the process reliability plots (look under the Mixture Icon on WinSMITH Weibull for the computer assist) your numbers will not exactly agree with my numbers—close is good enough, don't struggle to make them exact.

Once you've identified the problem you must correct the issues. You must make a change to get a change. The process reliability plot usually induces into the organization the same five (oversimplified) stages of human dying that was enumerated by Dr. Elizabeth Kübler-Ross:

1. **Denial** that the process is deficient and owners of the process are unable to admit to themselves their "golden haired" child needs improvement. This is the shock stage typified by: "It's not true", "You must be mistaken", "Can I get another opinion", and frequently the denial is expressed loudly and profanely. This is simply a way of cushioning the shock of disclosure of bad news that no one wants to hear.
2. **Anger and Rage** which is the "Why me?" reaction that someone is trying to pin the bad news onto me (the blame issue). The anger strikes out at the bearer of the bad news and everyone else associated with disclosing their "golden haired" child is really an "ugly baby". Often the greater the anger/rage the more significant is the issue to be resolved—something about where there's smoke you're likely to find fire.
3. **Bargaining** which is the effort to avoid corrective action by gaining just a little more time before taking the necessary decisive corrective action to make changes and disrupt the dogs nests to make a paradigm change for better results.
4. **Depression** when the full impact of making changes to comfortable, but unreliability processes, is eminent and recognition that indeed the process/people (friends & relatives)/procedures must be corrected to make output from the process more predictable.

5. **Acceptance** when everyone comes to grips that the inevitable change is about to occur to improve the process and unfinished business is never going to be completed because the game plan has changed and preparations are underway for a new way of doing things.

All these six steps sound like the usual arguments given in a production facility. Save the life of your process by eliminating the hidden factory to make the process more consistent in output by eliminating losses.

Other items concerning process reliability are available at:

- Special Cause Variations, Common Cause Variations, and Process Reliability Plots
- Summary Of Process Reliability
- Process Reliability Punch List
- Production Output/Problems
- Six Sigma
- Coefficient of Variation
- Nameplate Capacity
- Production Reliability Example With Nameplate Ratings
- Key Performance Indicators From Weibull Production Plots
- Process Reliability Plots With Flat Line Slopes
- Process Reliability Line Segments
- Papers On Process Reliability As PDF Files For No-charge Downloads
    - Process Reliability: Do You Have It?—What's It Worth To Your Plant To Get It?
    - Process Reliability
    - New Reliability Tool for the Millennium: Weibull Analysis of Production Data
    - Process Reliability and Six-Sigma
    - Process Reliability Concepts

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