The process reliability technique uses saleable production output data from a manufacturing process for analysis. The scatter in daily production data quickly tells the “health” of your process. The production reliability technique will tell you:

a) How reliable is the process?
   (Reliability issues are associated with special causes which are solved by reliability engineers.)

b) How predictable is the process?
   (Predictability issues are associated with common causes which are solved by six sigma black belts.)

c) What are the hidden factory losses from reliability problems?
   (One class of hidden factory problems is associated with tangible “things”.)

d) What are the hidden factory losses from efficiency and utilization problems?
   (A second class of hidden factory problems concern systemic problems under management controlled “things”.)

These four problems result in smaller factory output and higher operating costs. These hidden factory issues reduce the factory paycheck. These waste driven problems lower stockholder equity. With the process reliability technique, all of these issues are quantified on one side of one sheet of paper with a graphic that makes explanations easy to understand for teams assigned to attack the problems. In short, the process reliability method is fact-based using production data (prime product produced) that is a precursor for money that can be recovered by sale of the prime product (this drives the gross margin potential for a manufacturing facility).

The process reliability technique helps set key performance indicators (KPI’s). KPI’s cannot be set too high because they are unobtainable, unrewardable, and demotivating to the workforce. KPI’s cannot be set too low because the KPI’s are wasteful of assets, rewards are out of proportion to the effort, and KPI’s set too low lack competition drives for greater production which reduces costs.

KPI’s, when correctly established, result in competitive efforts toward success by establish worthwhile challenges. Each KPI must be realistic. Each KPI must be attainable. Each KPI must be in the best interest of both the customer and the stockholder. The process reliability technique can produce realistic KPI’s in less than 30 minutes. Two very important KPI’s are:

1) demonstrated production capacity—the single point value for the center of the production bulls-eye, and

2) nameplate capacity (or in six sigma parlance, entitlement)—the single point value for best achievable conditions.
WinSMITH Weibull is the tool of choice for making probability plots to define items a-d noted above. Most production data makes straight lines (or in many cases, straight line segments with cusps) on a Weibull plot. The Weibull distribution is usually not symmetrical, and for many well run production processes the tail of the data is very short on the high capacity end and very long on the low capacity end which best defines production processes.

Recent enhancements in WinSMITH Weibull make the data highly visible and easy to describe for people unskilled in the art of producing and interpreting the Weibull plots using production data. The new feature allows the Weibull data sets to be converted into Weibull Probit plots which maintain their Y-axis plotting positions. The trend lines produced are helpful for building Monte Carlo simulations for seeing how the randomness of the data changes the output of the process and thus when multiple plants are modeled; the VP of Manufacturing can better understand how complex production systems affect the company wide output system and this is helpful for setting rewards for the combined plants and meeting promises to customers.

You can follow along on this problem using authentic downloadable zip files. Use the files with the demonstration version of WinSMITH Weibull. If you enter your own data into the demo programs, it will randomize the input. However, the authentic files will not be randomized. You can download a brief tutorial on how to input data to WinSMITH Weibull.

Figure 1 shows 365 days of production imported from Excel and pasted into WinSMITH Weibull.
The important information for the demonstrated production line and finding the cusp for reliability is hidden in the upper right hand portion of the Weibull plot. Figure 2 zooms in on the important data in the steep portion of the curve (in WinSMITH Weibull, click on the magnifying glass icon and using option G to click/drag the approximate size of the graph, then use option F to fine tune the graph for presentation). Always zoom to see information hidden by the steepness of the Weibull trend lines in the upper right hand corner.
Under the mixture icon, choose Process Reliability option, then choose production line, next choose plot point fit and draw a box around the data on \( \sim 45^\circ \) angle to have the computer fit the trend line for the demonstrated production line as shown in Figure 3. The demonstrated line identifies predictability of the factory output. Also in the Process Reliability menu choose option G/Plot Point Fit and click on the cusp where the data begins to break away to the left to set the reliability at 67%. 
The nameplate line needs to be added at a beta slope = 75 (world class betas are 100°) and it needs to cross the demonstrated line at the Y-axis altitude of the 365th data point as shown in Figure 4. Thus the nameplate line will be set by beta=75 and a point on the line (6319.134,99.80843%).
Figure 5 shows the nameplate line (entitlement) installed on the Weibull probability plot from the Process Reliability menu, item F which is set At A Value using the Weibull slope beta=75 and a point on the line at 99.80843% occurrence with an X-datum of 6319.134.
WinSMITH Weibull will sum the gaps between the demonstrated production line and the data points to the LEFT of the line and BELOW the reliability point to find the reliability losses. WinSMITH Weibull will sum all the gaps between the demonstrated production line and the nameplate line to calculate the nameplate losses. The following results occur from clicking the green check mark icon on the process reliability page to find:

Barringer Process Reliability
Data Set = (#1) Reliability = 67%
Production Line = Eta 6124.502, Beta 58.61673
Nameplate Line = Eta 6166.5, Beta 75

Total Reliability (67-100%):
Loss = 188,315 (tons/year) ←This is the #1 problem to correct
Process Reliability (%) = 67

Efficiency + Utilization (Production - Nameplate):
Loss = 19,757 (tons/year)

The hidden factory is 188,315 + 19,757 = 208,072 tons/year which is equal to 208,072/6167 = 34 days of nameplate production. Cost for this hidden factory are usually covered but the production is not available to pay the bills and provide the paycheck for the factory. You must destroy the hidden factory losses and recover the production so it is saleable!
WinSMITH Weibull, version 4.0 WH and above, can transform the data into Weibull Probit format. Probit format allows each line segment of Figure 1 to appear with a different symbol to illustrate the different regimes of problems. Click on the Methods icon choose the Grouped/Probit icon with selection of Probit #2 and tell the program to automatically convert the data into Probit format. Each data point will be numbers so to reduce the confusion, go to the Magnifying glass icon and select option Q by toggling to Quantity-Hide so you’re back to symbols.

Next you must copy/paste the single column of data into individual columns representing the line segments. The advantage of the Probit method is each point will maintain it’s X-position and it’s Y-position as shown in Figure 6.

Please note three data points in Figure 6 were altered slightly to avoid impossibly steep Weibull slopes.

For the “outage” line, the point 1x1x365 was changed slightly to $0.99x1x365$. The point $1x5x365$ was changed slightly to $1.01x5x365$. For the “Cutback 1” line, the point $1x6x365$ was changed slightly to $1.01x6x365$. This prevents the calculation from blowing up with a vertical line for the “outage” which produce infinite beta values. The line slopes for each line have been muted along with the table of data for the line slopes by use of the Zoom icon and submenu for hiding lines and under the labels icon for hiding the statistics. Each line segment will have some common characteristics that need to be identified and eliminated to reduce losses.
Line segment details are helpful for Monte Carlo modeling of the process Weibull’s—particularly for multiple plant sites.

How are companies around the world using this technique? They update their plots about every quarter as the results don't change very fast. They look for three main indicators:

1) Quantify the hidden factory due to reliability issues (and work to reduce reliability losses).
2) Quantify the hidden factory due to efficiency/utilization issues (and work to reduce efficiency and utilization losses).
3) Steepen the demonstrated output line (make the monthly paycheck for the company more predictable).

Their improvement targets are reduction in losses (usually they do not set a target on % reliability). They’re particular about assignments of people to work on the problem. They emphasize knowing who is doing what for reducing losses. They push to make the process more predictable for financial business performance. They cherish steeper line slopes (betas) for the demonstrated production line to make the business more predictable. Must you use this tool?—No, using these techniques your competitor will take care of putting you out of business while you smugly avoid destruction of your wasteful hidden factories because you don’t now how to put your battle plans together on one side of one sheet of paper.

What’s the most common problem associated with the process reliability technique? **Many managers and engineers just don’t get the idea about reliability and hidden factories!** They fail to implement an improvement plan. How can you motivate them to make improvements?—it’s easy, make their monthly paychecks vary as much as the process output varies every month….spouses will quickly explain the corrective action required and how fast the plans should be implemented. Download the attached Excel paycheck simulator to see an example using Monte Carlo simulation.

Other items concerning process reliability are available at:

- 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
- Papers On Process Reliability As PDF Files For No-charge Downloads

Return to the list of problems by clicking here.

Refer to the caveats on the Problem Of The Month Page about the limitations of the following solution. Maybe you have a better idea on how to solve the problem. Maybe you find where I've screwed-up the solution and you can point out my errors as you
check my calculations. E-mail your comments, criticism, and corrections to: Paul Barringer by clicking here. Return to the top of this problem.

Technical tools are only interesting toys for engineers until results are converted into a business solution involving money and time. Complete your analysis with a bottom line which converts $'s and time so you have answers that will interest your management team!

You can download a PDF copy of this Problem Of The Month by clicking here.