

One-Minute Spotlight

Crystal Ball: Capability Metrics

Crystal Ball® version 7.2 introduces a new set of process capability features that support quality improvement methodologies such as Six Sigma, DFSS (Design for Six Sigma), and Lean principles. You can now quickly interpret the capability of a process or product without ever having to leave Crystal Ball and Microsoft® Excel.

This spotlight uses the DFSS Fluid Pump example available with Crystal Ball version 7.2. In the model, a manufacturer is designing a fluid pump for a liquid packaging system that draws processed fluids from a vat into jars at a consistent rate.

You, the design engineer, can use Crystal Ball to simulate various design options for the pump, including motor speed, piston radius, stroke length, and backflow valve. The capability metrics help you to measure the effects of design changes on flow rate.

DFSS LIQUID PUMP STOCHASTIC OPTIMIZATION

Flow Rate Response Equation
 $F = (K \times R^2 L - B) S$

F = Flow Rate (ml / sec)
 K = Constant
 R = Piston Radius (mm)
 L = Stroke Length (mm)
 S = Motor Speed (rpm)
 B = Backflow (ml)

Component Option #	Nominal			StDev			Component Cost Function	Sampled Value
	Lower Limit	Initial Value	Upper Limit	Lower Limit	Initial Value	Upper Limit		
Piston Radius (mm)	25.0000	30.0000	50.0000	0.10000	0.33333	0.33333	\$8.35	30.0000
Stroke Length (mm)	25.0000	35.0000	100.0000	0.10000	0.33333	0.33333	\$14.85	36.0000
Motor Speed (rpm)	30.0	30.00000	40.0	0.10000	0.24000	0.24000	\$3.25	30.0000
Backflow (ml)	3	0.10	0.50000	0.50	0.00250	0.01000	\$0.30	0.5000

Target Flow Rate	50.5950	FLCW RATE FORECAST (ml / sec)	50.6461
Target Flow Rate LSL	47.2617	TOTAL COST FORECAST (\$)	\$26.03
Target Flow Rate USL	53.9283		

COST COEFFICIENTS FOR RADIUS AND LENGTH OPTIONS

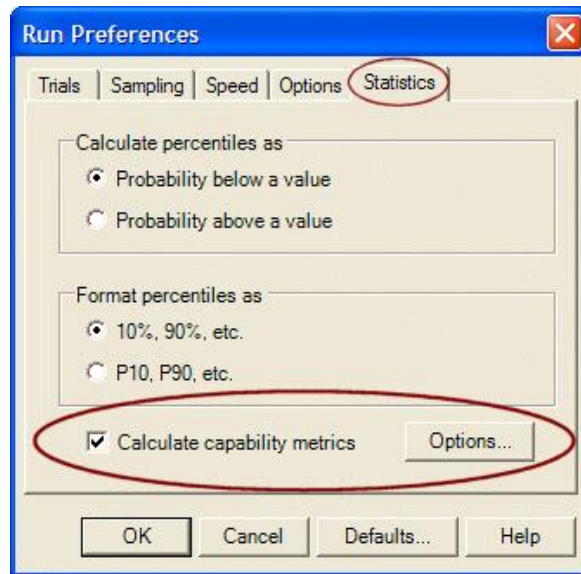
Base Cost Coefficient of Piston (radius)	0.008
Base Cost Coefficient of Piston (stroke length)	0.008

Step 1: Activating the Capability Metrics

You can activate Crystal Ball's process capability features by checking the Calculate Capability Metrics on the Statistics tab of the Run Preferences dialog (shown below).



One-Minute Spotlight

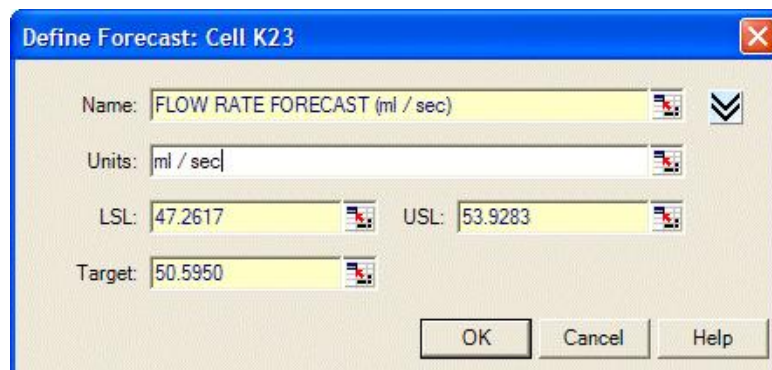


With the Options button, you can adjust several options that control how metrics are calculated, such as whether the data is long or short term and how the metrics are calculated.

You can also activate the process capability features by selecting Quality as the primary application type on the new Welcome screen.

Step 2: Defining the Forecast Parameters

Next, you need to define the forecast, in this case the Flow Rate, and enter the specification limit(s) in the Define Forecast dialog (shown below). Enter one or more values into the three new fields (LSL, USL, Target) for Crystal Ball to calculate the capability metrics.

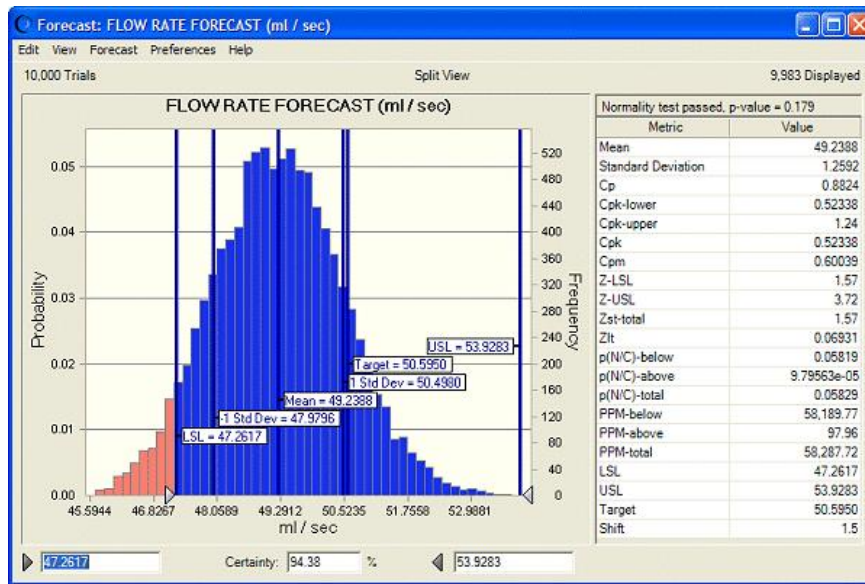


One-Minute Spotlight

You have already listed these three values in the worksheet, and you can link to them from this dialog. If a flow rate forecast occurs outside of the spec limits, you consider it to be a defect.

Viewing the Capability Metrics

After completing a simulation, Crystal Ball quickly runs a normality test on the data and calculates the capability metrics based on the results of the fit. Crystal Ball then displays the frequency chart and metrics table in the Split View forecast (shown below).



Crystal Ball automatically sets marker lines at each parameter and positions the triangular grabbers at the spec limits, which are 47.2617 and 53.9283 ml/sec. The certainty that the flow rate will be within the required limits is 94.38%.

In the metrics table, you can view the capability of the flow rate (Cp, and Cpk) and the Sigma level (Z scores). You can also view the percentage of non-compliant trials (p(N/C)) and can see the same values converted into millions (PPM). In this design, most of the defective results occur below the LSL, which indicates that some aspect of the pump is causing slow flow rates.

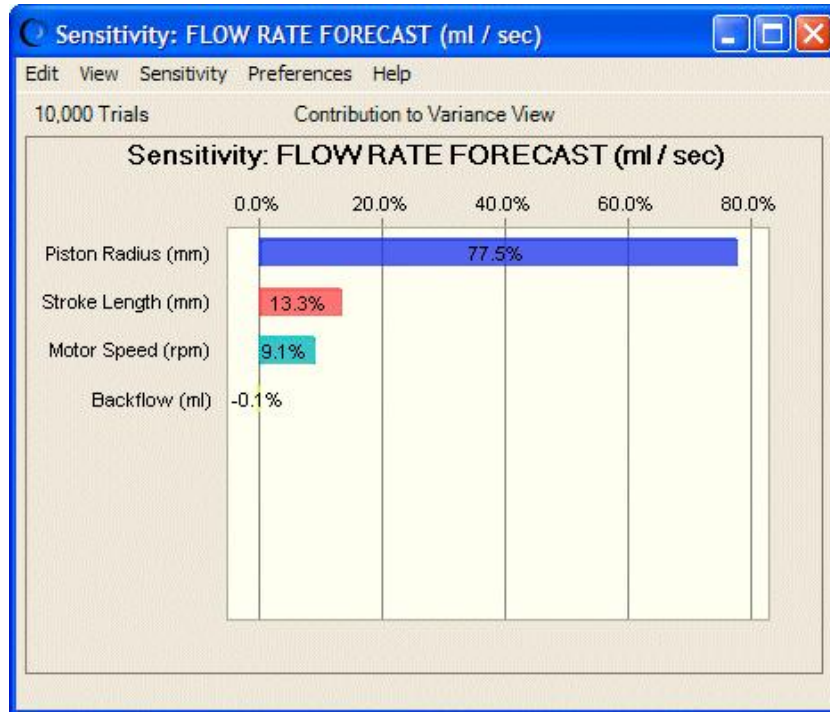
What Are the Next Steps?

The short-term Sigma level (Zst-Total) is only 1.57, and you need to improve your design. The next step is to use the Sensitivity Chart (shown below) to examine which of the



One-Minute Spotlight

assumptions is driving the slow flow rate. You can open the sensitivity chart from the Toolbar, Analyze menu, or Forecast menu on the forecast chart.



The Piston Radius contributes 77.5% of the variance in the Flow Rate forecast, so this is the next logical place to improve the design. Once you have addressed this parameter, you can re-run the simulation and view the new – and hopefully improved – capability metrics.

In addition to viewing the capability metrics in the forecast table, you can extract capability metrics to a worksheet, include capability metrics in reports, and specify a subset of the metrics as optimization objectives or requirements in OptQuest.

Additional Resources

- [The Crystal Ball 7.2 Capability Metrics page](#)
- [The Crystal Ball technical support knowledgebase](#)

For more information or to contact us, browse to <http://www.crystalball.com>