

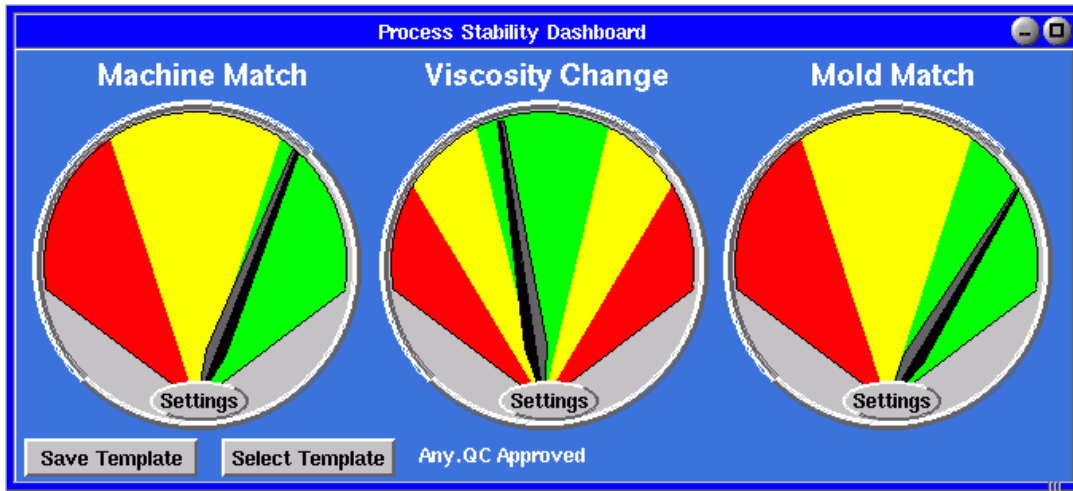
# RJG eDART Process Stability Dashboard

## How To

### Overview

All manufacturing requires at least repeating a process to make the “same” parts. The “*Process Stability Dashboard*” (PSD for short) computes a match to a known process (template) and shows the degree of difference. A set of three needles show this match on the eDART™ and on the Advanced System Overview (if an eDART Data Manager (“EDM”) is installed).

Figure 1: Process Stability Dashboard (“PSD”) on the eDART



The PSD is NOT, by itself, a quality meter. Quality monitoring happens when you have determined the key specifications for the final part, correlated specific eDART summary data values to those specifications and set alarms around them. The PSD only shows a process difference. It cannot know whether that difference is significant to quality or not.

Nevertheless, knowing that a process has changed is a good first step to preventing change in the finished parts.

### Installation and Startup

All eDARTs Release 9.0 and above include the PSD. You will find it on the Architect under the “Controls” tab. We consider that watching for process change and restoring a process is, in fact control. It is process control by a person instead of a machine.

First, choose whether you want to run the PSD on one mold (current) or on all molds. Then drag it on to the appropriate spot.

Figure 2: Attaching the PSD to the Current Mold (drag to blue area)

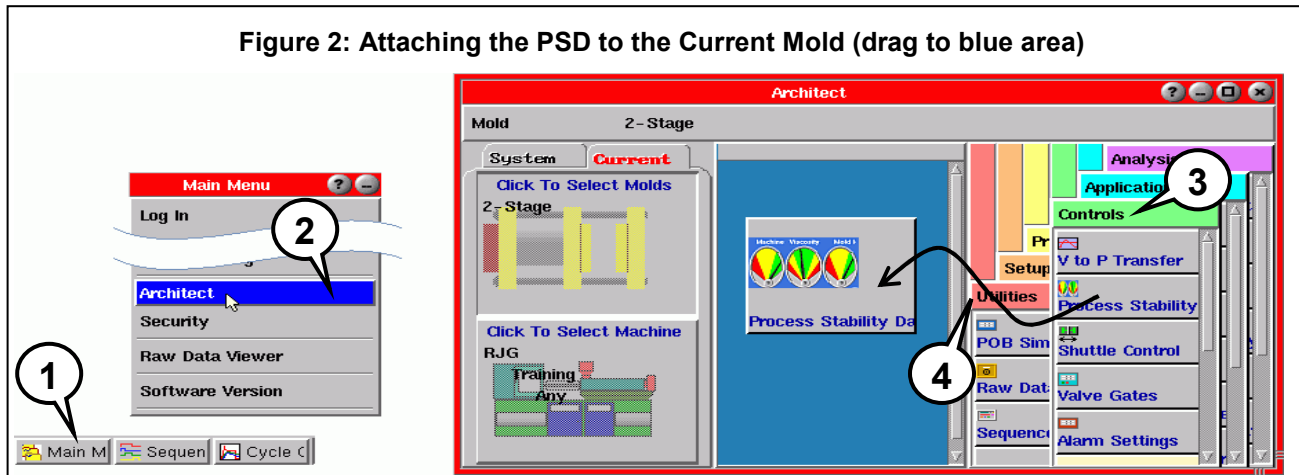
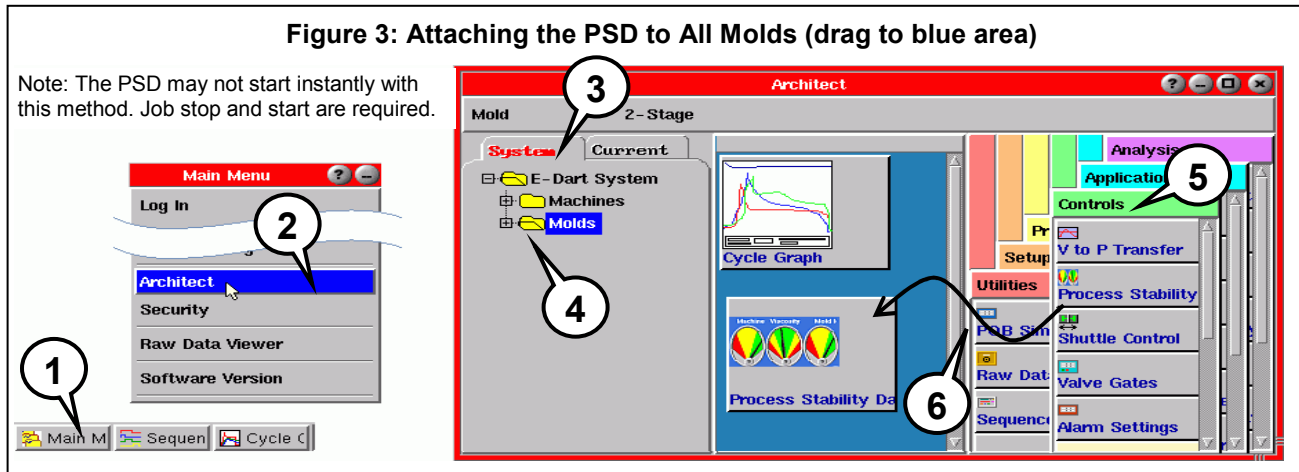


Figure 3: Attaching the PSD to All Molds (drag to blue area)



### How to Save the Standard Process (“Template”)

A “Template” on the eDART is a stored set of curves for a single cycle. It also includes all the numbers computed for that cycle. You can save a template from either the PSD or from the Cycle Graph. Here we’ll use the PSD. The “PSD” compares the current process to the template, regardless of how it is saved.

Here are the steps in saving a template

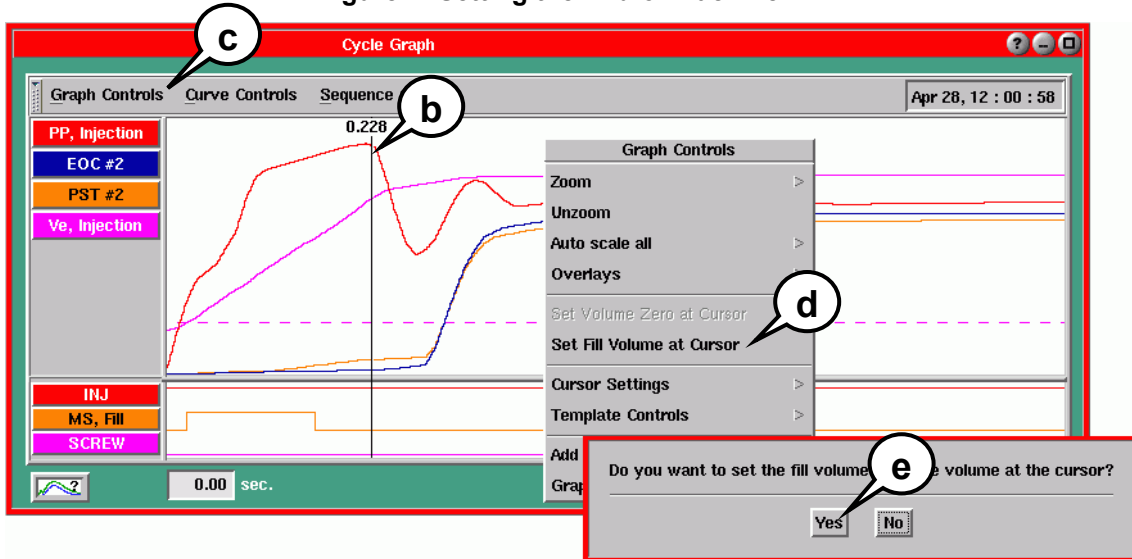
1. Stabilize the Process

If the process is changing (e.g. warming up) the template will not match very long. Also, do not save a template until you have completed any process adjustments and are satisfied that your process is the “reference” process against which you want to compare future processes.

2. Determine and Set the End of Machine Fill

In order to get a good process match calculation the eDART needs to know the point where the machine ends its filling phase and begins packing. It can sometimes find this point automatically. But for best results on the PSD we recommend that you set it by hand thus:

Figure 4: Setting the End of Machine Fill



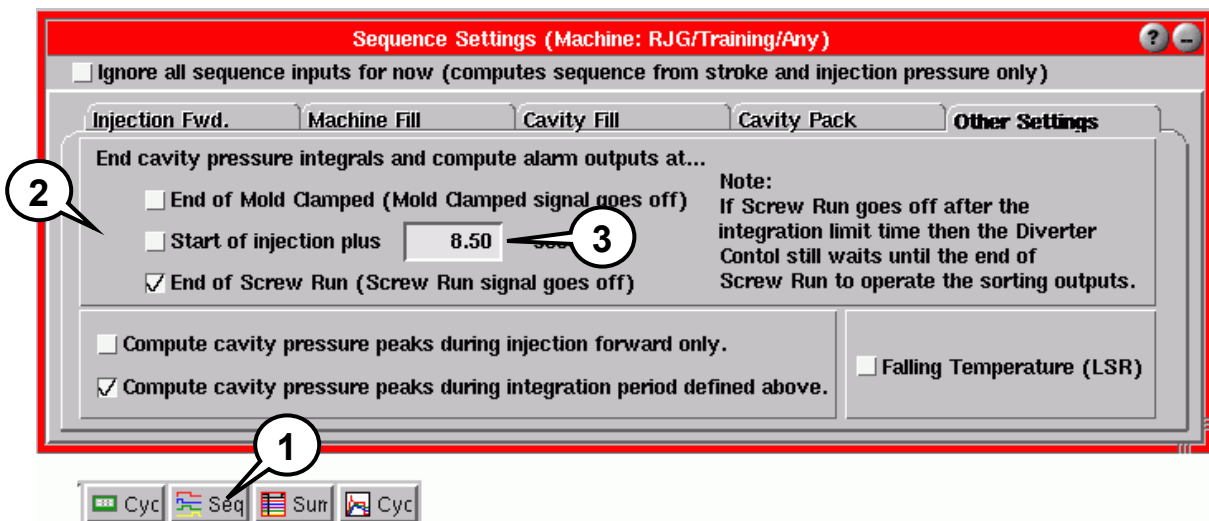
- a. On the Cycle Graph, zoom in close in order to see the fill portion of the curve.
- b. Place the cursor at the point where the machine slows down to pack. In Decoupled 2 molding this will be at transfer. In Decoupled 3 it will be at the transition between fill speed (V1) and pack speed (V2).
- c. Select the “Graph Controls” (or use the right mouse button over the graph)
- d. Select “Set Fill Volume at Cursor”
- e. Confirm your selection by clicking “Yes”

Now the eDART has recorded the volume injected into the cavity as the end of fill. This value gets saved with the template and restored for each template you select.

### 3. Set the Integration Limit

The eDART needs to know how much of the pressure curve is of interest in computing the match. Set this on the “Sequence Settings”, “Other” tab.

Figure 5: Selecting the Integration Limit



In most cases where cavity pressure is zero at the end of screw run you can select “End of Screw Run”. This will allow the sorting signal (if used) to get out to the automation equipment (e.g. flipper chute) before the mold opens.

Some cavity pressure curves rise after the end of hold because the part is solid and the mold is springing back on the sensor. If that portion of the curve does not matter in the process match then you can set the integration limit to a fixed time before the pressure rise.

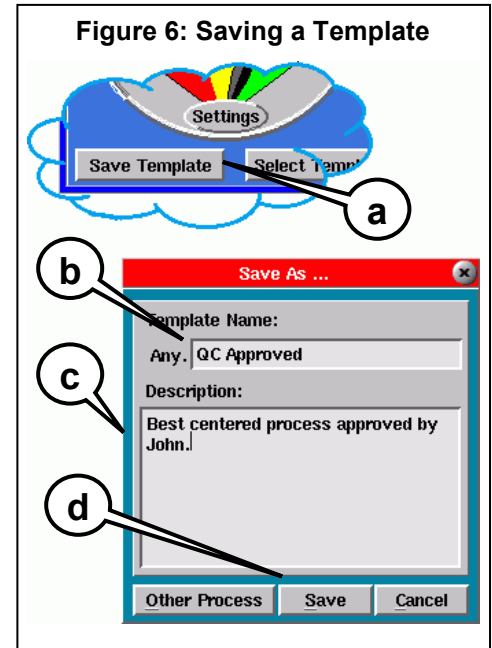
4. Save the Template

- a. Click the “Save Template” button at the lower left corner of the PSD.
- b. Enter name for the template. The eDART records the template under the mold / material and cavity combination. It also records the date. Therefore you don’t need to put those in the name.

We recommend using names that describe what the purpose of the template is like “First Trial” or “After Gate Change” or “QC Approved”.

- c. The description is optional but may be useful for later reference.
- d. Click “Save” to save the template.

The eDART records the current cycle as a template when the cycle ends. Then the meter needles will center themselves at first. Any deviation will shift the needles.



How to Make Machine Match more Precise

The Machine Match checks for position variation until transfer and pressure variation after that. However some parts of the process can be more important than others. For example, a process with a long hold time and significant hold pressure will have most of the curve area there. If the backpressure is low, a minor change there (or even a doubling or quadrupling) will not move the needle very much.

Therefore, to get a better match, use the process ranges you have already defined for certain machine settings and put these into the Alarm Settings tool. These would commonly be the “validated” machine process settings. The summary values that the PSD computation will use are these:

**Table 1: Alarms Used for Machine Match**  
(these override the curve match)

Summary Type	Summary "Location"
Average Value	Back Pressure
Average Value	Fill Speed
Average Value	Fill Flow Rate
Average Value	Pack Speed
Average Value	Pack Flow Rate
Average Value	Stable Hold Pressure
Average Value	Hold Pressure

Decompression	Shot Stroke
Decompression	Shot Volume
Sequence Time	Cycle Time
Sequence Time	Fill Time
Sequence Time	Hold Time
Sequence Time	Plastic Cooling
Sequence Time	Mold Clamped
Sequence Time	Screw Run

If you set alarms on any of these summary values then the PSD calculation no longer matches the curves for the “*Machine Match*” value. Instead, as the value approaches the alarm value the needle moves closer to the red. Similarly if the value approaches the warning value the needle moves down in the green and closer to the yellow. If none of the alarms above are in the Alarm Settings then the PSD calculation uses the curve match as before.

When multiple alarms are set, the match computation reports the *Machine Match* (needle or number) as the worst of the lot; the closest to or over the alarm value (into the red).

This computation “override” takes place when one or more of the above alarms are on the Alarm Settings screen. It uses them for process matching regardless of whether they are used for sorting or for a light tree (“Indicator” column).

Note: Both an upper and lower alarm (or warning) must be set (“*Above*” and “*Below*”). If you set a machine value alarm and then remove an upper or lower alarm then the alarms match will not function for that value.

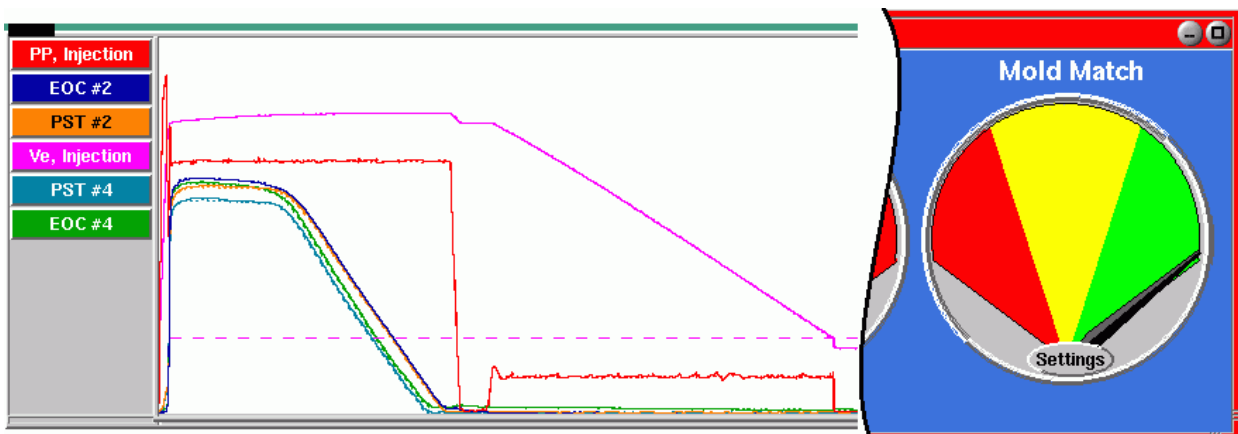
## How to Interpret Needle Variation

### Mold Match

The “Mold Match” meter only appears if the mold has cavity pressure sensors. If it does not you can slide the right edge of the PSD over to show just the Machine and Viscosity match meters.

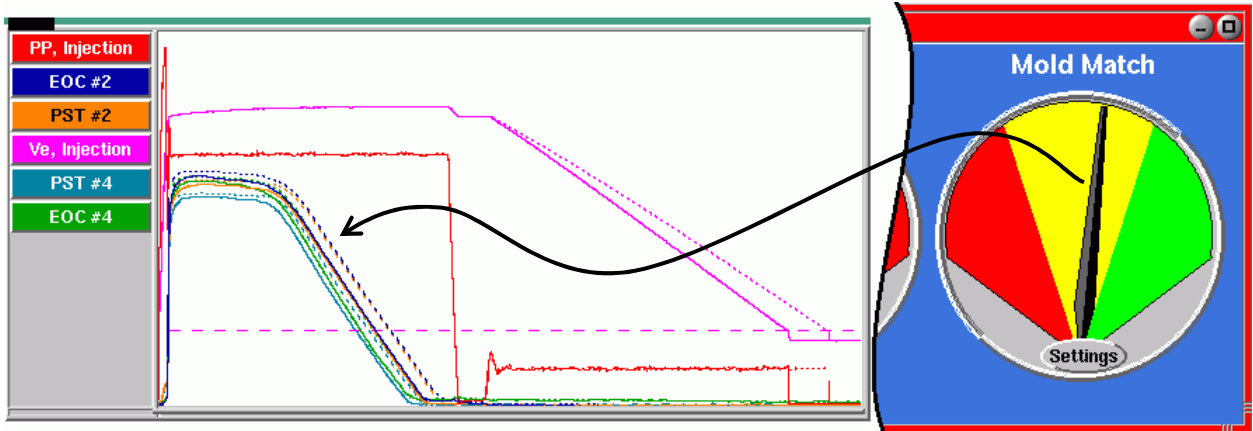
A perfect match would be when the cavity pressure curves exactly match the template. This pushes the needle to the far right of the green. If the needle begins to move left then there is a slight difference between one of the cavity pressure curves and its associated template (to the integration limit time, page 3).

**Figure 7: Near Perfect Template Match (new curves overlay dotted template line)**



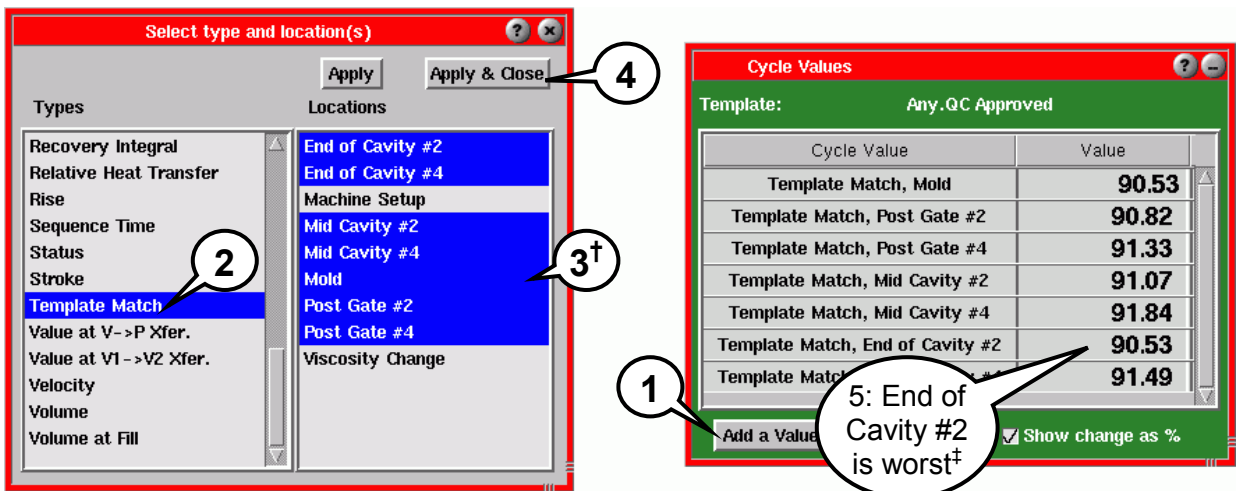
The needle always shows the worst match among all of the cavity pressure curves. If the Mold Match needle begins to fall to the left then look at the cavity pressure curves to find out which cavity and where in the process the deviation is.

**Figure 8: Mold Match Not Good - Cavity Pressure Not Matched to Template**



You can find out which cavity is causing the mis-match by adding the "Template Match" values to the Cycle Values tool. The worst cavity will have the same template match number as "Template Match / Mold". The values are in percent with 100% being a perfect match.

**Figure 9: Finding the Cavity Sensor Causing the Mis-Match**



† Hold down the "Control" (CTL) key to select more than one.

† You may click the "Value" header to sort.

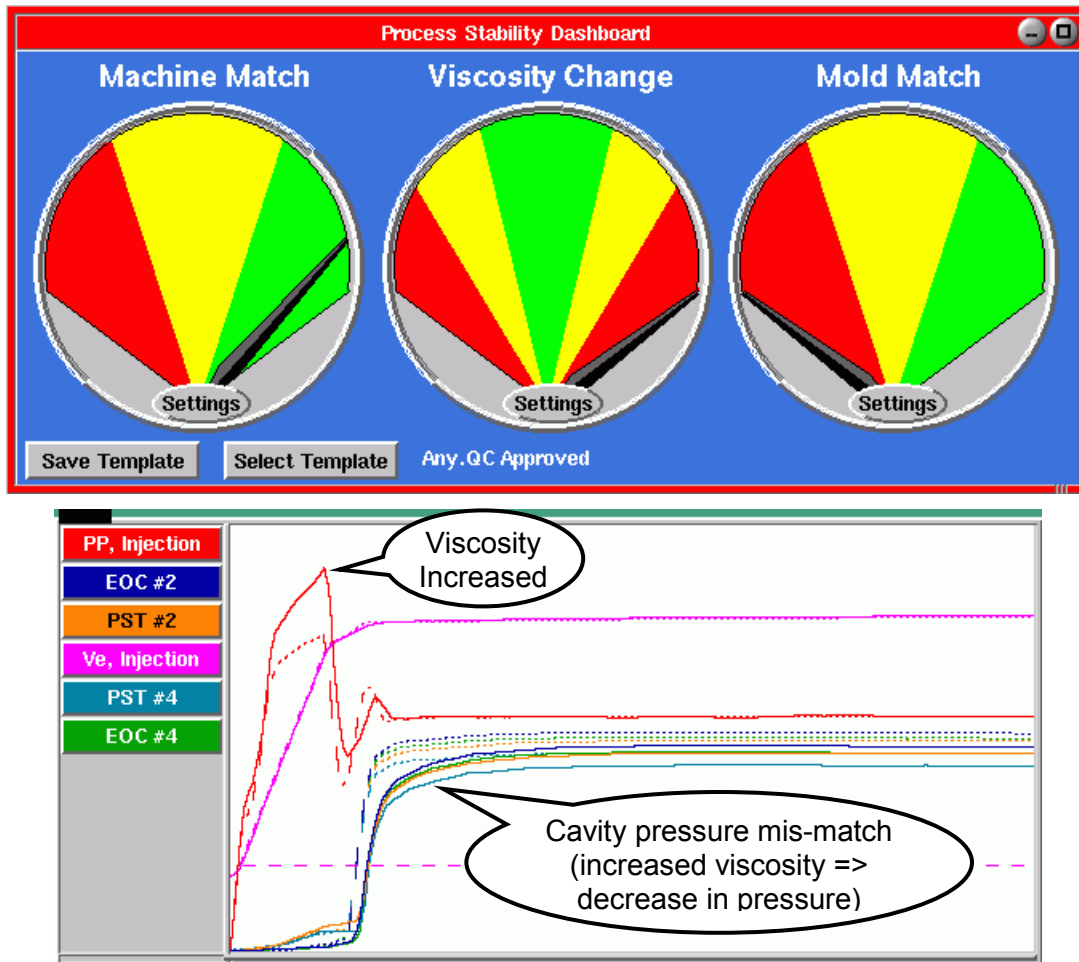
You can also plot the "Template Match" values on the Summary Graph to find any rogue cavities historically.

If the Mold Match is in error and several (or all) cavity sensors are in error then you need to look at the Viscosity and Machine Match to begin to figure out why.

## Viscosity

The Viscosity match is a percentage change above or below the viscosity recorded when you saved the template. This value only has meaning if you have not changed the machine settings for speed or transfer position. If the machine settings are identical (machine match needle to the right) and you know that no temperatures have changed (melt or mold) then something about the incoming material has changed.

**Figure 10: Viscosity Change Causing Cavity Pressure Change (machine constant)**



Viscosity changes in material lots can be due to molecular chain length (which affects strength) or additives such as nucleating agents or flame retardants.

Temperature changes can also cause changes in viscosity. Melt temperature changes viscosity somewhat in most molds. In thin-wall parts changes in mold temperature can also change the effective viscosity.

Procedures for Viscosity Mismatch:

1. Check machine match
2. If there are no machine changes, check temperatures.
3. If there are no temperature changes determine whether the material is still acceptable.
4. If the material is acceptable adjust the transfer position or hold pressure for the new material. Then save a new template with a name like "High Viscosity".

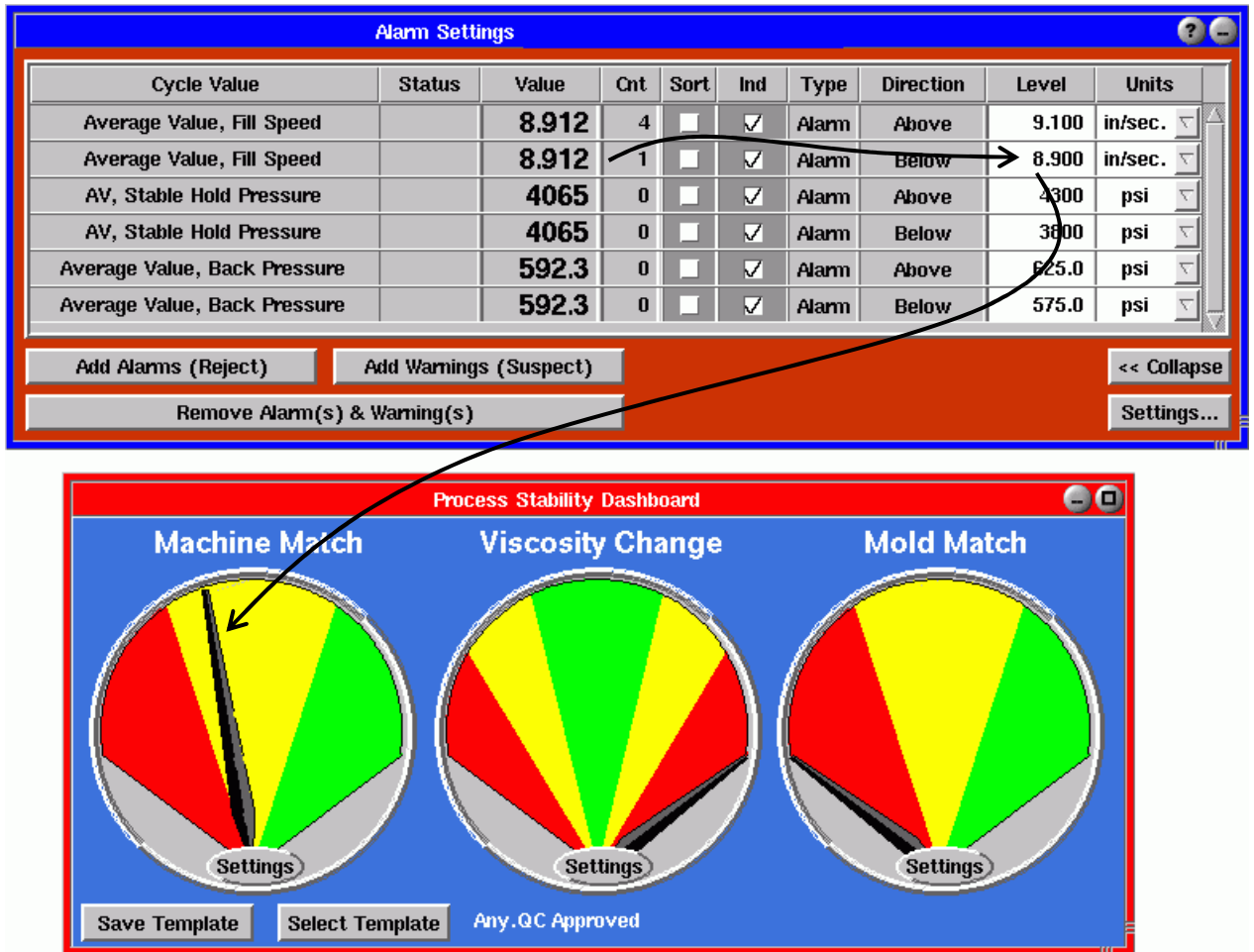


## Machine Match

### With Alarms Set

If you have set any alarms from Table 1 (page 4) then the Machine Match meter uses them to set the needle position. If the needle is approaching the red level then the value is almost at the alarm level. In the example below the *Average Value / Fill Speed* is close to its alarm so it is controlling the needle.

Figure 11: Machine Alarms Controlling the Machine Match Needle



When the machine match needle moves out of the green into the yellow investigate the cause by finding the alarm value that is closest to its limit. This tells you, without looking at the graph, what has changed on the machine. Now rather than a percent change you are looking at closeness to the limit.

If you include warnings as well as alarms then the green-yellow boundary will be crossed when a value goes above or below its warning level.

With multiple alarms set the value closest to its limit controls the needle. The fraction of distance to the limit from the center of the alarm band determines the fraction of needle movement inside its color.

Procedure for Needle Out of Green

1. Check the Alarm Settings window to see which alarms are in the red or yellow.



2. If none are, check which value is closest to its limit.
3. Correct the error on the machine settings.

### **Without Alarms Set**

If you do not have alarms set then the Machine Match needle is a match of the speed portion of the curve until end of machine fill and the pressure portion afterwards.

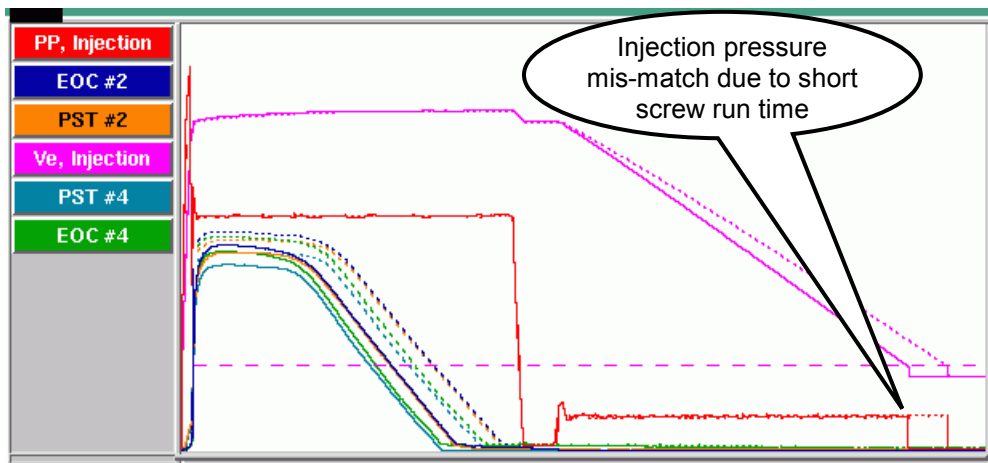
#### Using the Cycle Graph

Look at the cycle graph for the various phases of the process. Check the following:

1. Fill speed or speeds and positions
2. Transfer position.
3. Hold pressure
4. Hold time
5. Backpressure
6. Screw speed
7. Mold clamped time or cooling timer.
8. Decompression (before and after recovery)

In some cases the machine controls can be unchanged but the material may change the machine match. In Figure 10 (page 7 above) you see a slight change in the machine match needle. In this case the match error occurs at the end of the curve because the screw runs for a shorter time with the higher viscosity material.

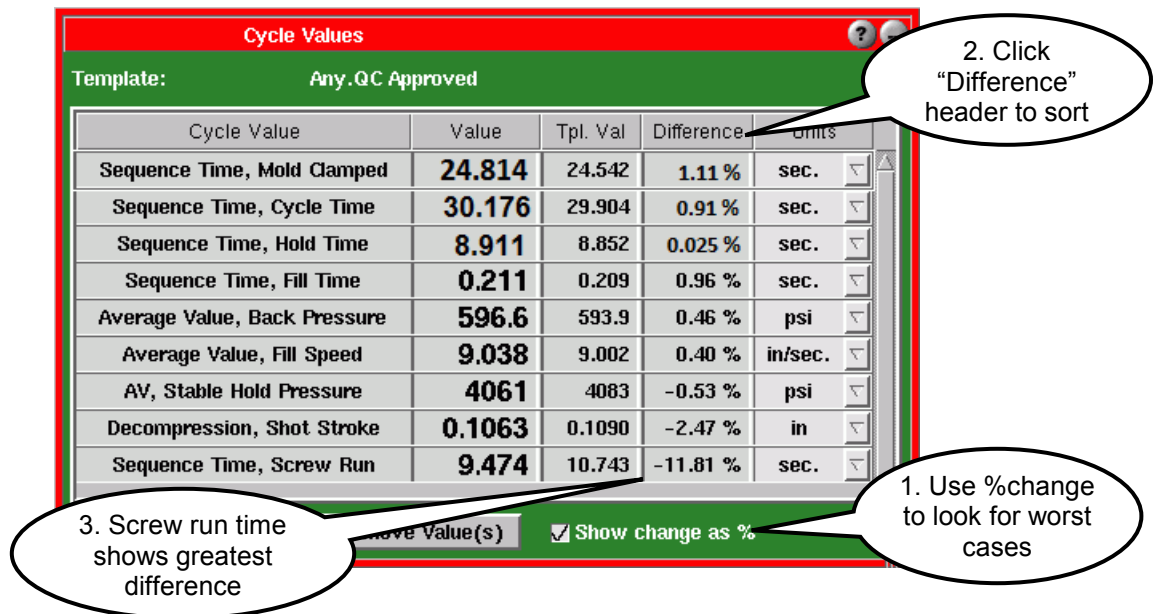
**Figure 12: Change in Machine Match due to Material (not control settings)**



## Using the Cycle Values

Look at the Cycle Values with the standard machine control monitoring values shown.

Figure 13: Changes in Cycle Values for Machine Settings



Note that this is the same change as shown in Figure 12 (page 9). In this particular case it was caused by the material change. It could also be a change because of a change in screw speed on the machine.

## How to Set the Match Level Limits

The "Settings" button on each PSD meter lets you set the percent levels for the green-yellow, yellow-red and maximum meter ranges. At this time we have proposed three different methods for setting these levels.

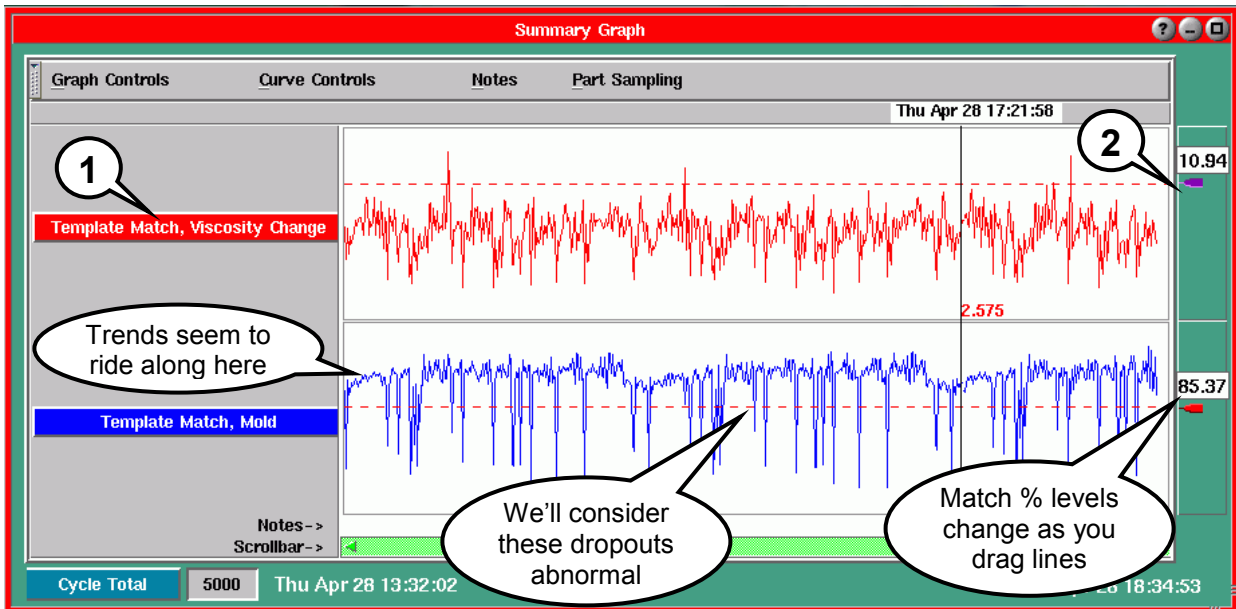
### Caution when using machine alarms for Machine Match:

As of release 9.0 and until further development the levels for the Machine Match must be set at 85% (full range), 90% (red -> yellow) and 95% (yellow->green).

## Plot the Template Match Summary Values

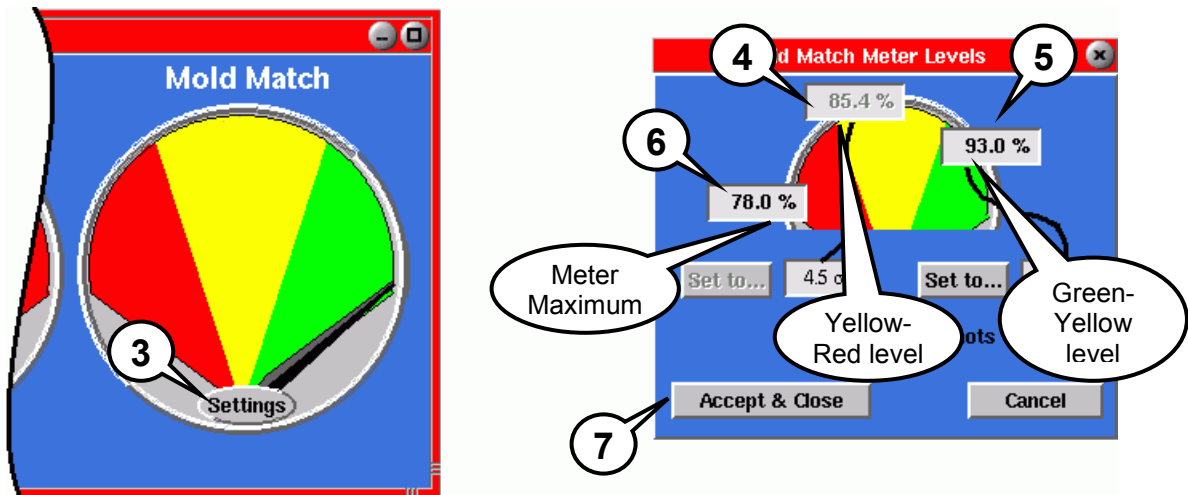
1. On the eDART Summary Graph, add the curves for *Template Match for Mold, Machine Setup and Viscosity Change*.
2. Over an appropriate period of stable processing observe what is considered standard and what is not. You might set alarms to make it easier to line up the values.

Figure 14: Finding Levels by Observation and Estimation



3. Open the levels with the Settings button.

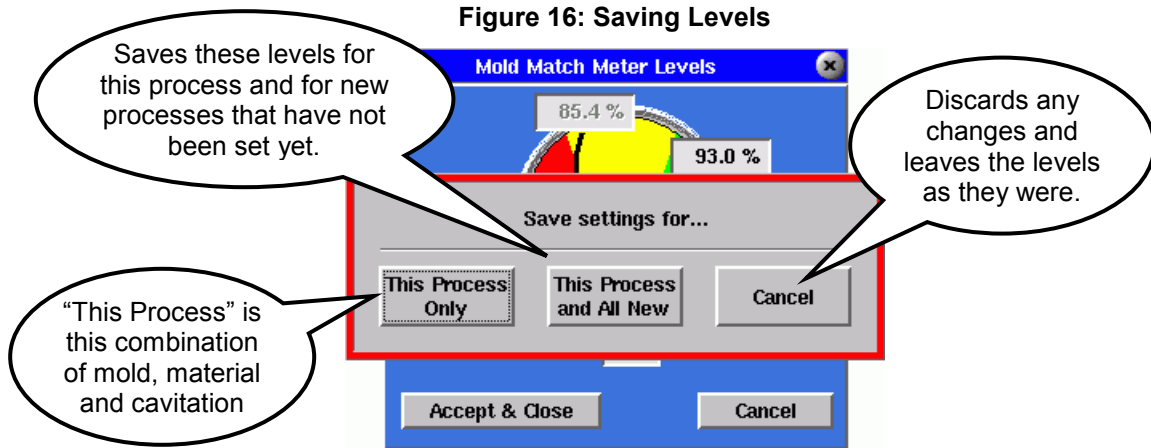
Figure 15: Entering Other Levels



4. Set the yellow-red level to the worst case tolerance that you think is acceptable. In this case having set the alarm already the number has been transferred to the yellow-red box. It is grey because the Alarm Settings tool has control of it. You can adjust it on the Alarm Settings tool.
5. Set the green-yellow to half way between that and 100 % (mold and machine) or half of that for viscosity. In this case it is about 15% between yellow-red and 100%. So we added ~7.5% for to the yellow-red to come up with the 93% shown here
6. Set the meter maximum to an equal amount beyond the maximum thus dividing the meter into thirds. Here since we had 7.5% between levels we subtract 7.5% from 85.4% to make the maximum 78%

Note that these divisions are rather arbitrary. You are welcome to set levels tighter or looser in any range to accomplish a particular strategy.

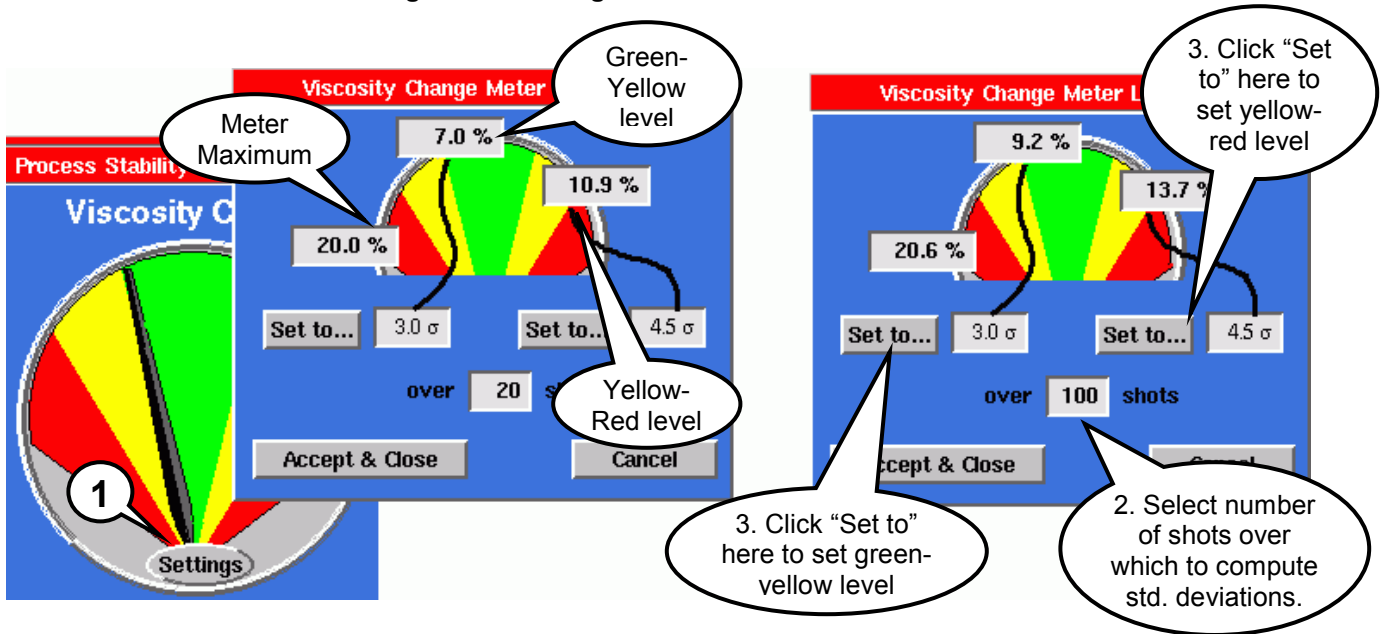
7. Click “Accept and Close”. You will be prompted with this message:



Run a Stable Process and use the Sigma Buttons on Levels

Begin as before running a process for a number of shots you consider stable. Then open the levels button and set the levels as follows. Here we are doing the viscosity change meter levels.

**Figure 17: Setting Levels with Standard Deviations**



When you click “Set to...” the software calculates the standard deviation for the match numbers. It then multiplies it by the “3.0  $\sigma$ ” over the number of shot selected (“ $\sigma$ ”, “sigma” is “standard deviation”) and puts the value in as the new level. You can change the sigma multiplier for each as you wish.

When you set the yellow-red level the calculation adjusts the meter maximum to fit.

When finished click “Accept and Close” to save the new values.

## Drive the Process to Limits and Watch Template Match Values

In this case you need only observe the template match values as you make methodical changes in the process. For example, suppose you have a range of hold pressures that you wish to use to drive the mold match.

1. Place "*Template Match / Mold*" on the Cycle Values window.
2. Stabilize the center process.
3. Save the template match (these are really the same three steps stabilizing on page 2).
4. Adjust the process to the high pressure limit.
5. After a couple of cycles record the template match percentage.
6. Adjust the process to the low pressure limit.
7. Again, make a note of the template match percentage.
8. Select the highest of the two values (we're doing the mold match here). You may want to increase it slightly just to be conservative.
9. Enter this value for the yellow-red percentage on the mold match level settings.
10. Split the difference to 100 and set that as the green-yellow percentage (step 5, page 11).
11. Set the meter maximum level to the split difference below yellow-red (step 6, page 11).
12. Accept and save the changes.

## **How to Move the Process to a New Machine**

1. Select template from the original machine
2. Match normalized machine values (cycle values or cycle graph)
3. If there are cavity pressure sensors, match those templates
4. Cross check the process (e.g. fill only parts, part quality etc).
5. Adjust process settings as necessary for acceptable parts or a centered process.
6. Save a new template with the same root name (like "QC Approved").

Now when a job runs on either machine with that template name it will pick the template for that machine. The technician who starts the job will always get the correct template.

## **Additional Methods**

### Set Security

On template saving, levels, sequence setup and Alarm Settings for those responsible for processes

On template selecting for those responsible for choosing appropriate template for viscosity changes.

### Plot Summary Values for Match Numbers to look for Trends

Steps in data are usually caused by people making changes to control settings.

Spikes are random events like cold slugs or machine stop and re-start to warm up.

Slopes are caused by things that change gradually like temperatures or material properties.

Cycles in the data are caused by rogue control loops: hot runner controllers, barrel temperatures or mold temperature controllers (“thermolators”).

### High, Low and Medium Viscosity Templates

Save different templates and process settings for each significantly different material lot and then select the one that fits.

### Using Match Values to Sort Parts

This is not to be used for quality directly. But it will prevent parts from being shipped that were not made with validated process settings. You need to turn on the “sort” switches on the Alarm Settings if you use these.

Add “Template Match” to Alarm Settings if desired. For example, set alarms around “*Template Match / Machine Setup*” after you have set individually validated machine alarms. Then you cause parts to be thrown out that are not within the validated machine limits.

You could also set part sorting around “*Template Match / Viscosity Change*”. If you know that your material viscosity should only change  $\pm 10\%$  you could set the level there. If someone tries to use the wrong material the parts will be discarded before they can reach the customer.

### Using Template Match Values for Indicators

Set warnings (or alarms or both) but don’t sort (indicator only) to take preemptive action on process changes.

## **Background Details**

- The match numbers are summary values like any other. They can be plotted, set alarms, discard parts etc. They also appear in the Analyzer data.
- Match numbers for machine and mold are 100% for a perfect match (curves match template or values in the center between two alarm limits for machine). Viscosity is a “Change” number with 0% being exactly the same (no change),  $\pm\%$  being a shift relative to the original.
- The match numbers are calculated regardless of whether you use the PSD on the eDART or not. Even without the PSD they are available to the ASO.
- A Cycle Integral and curve match are similar but not identical. The match looks for any error, over or under the curve. A cycle integral just looks at total area for comparison. Some curves can rise above the template and fall below again causing the same cycle integral value. But the template match calculation will not be fooled.