KEIT | INDUSTRIAL ANALYTICS

IRmadillo™

Setting up Dashboards for Ethanol Fermentation

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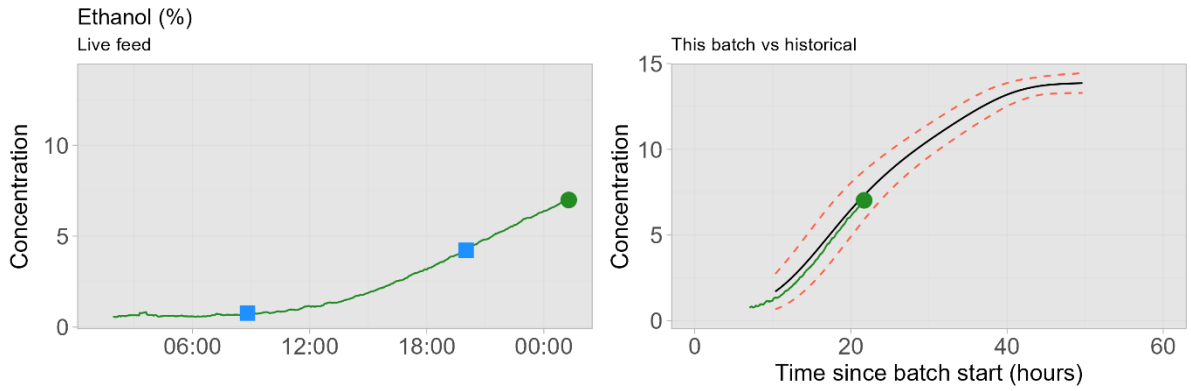
1. INTRODUCTION

The predictions provided by your IRmadillo can be used to set up dashboards to display the trends in your chemical concentrations, to compare your current batch to previous batches, and to send alerts to your operators as soon as there are any deviations from your normal batch trend – so you can act to rescue your batch as soon as something goes wrong, rather than waiting several hours for your next HPLC measurement.

For example, you can set up displays like this for all your species:



Left: A plot of the ethanol concentration over time for the current batch, showing the HPLC results (blue squares) and the IRmadillo's predictions (green line).

Right: A comparison of the current batch (green) with the average of a number of historical batches (black). The red dashed lines are the upper and lower warning limits, which are chosen by you.

The IRmadillo's great strength is that you can use it to look at trends – if you look at individual values, the short-term noise on the IRmadillo's measurements will make it difficult to see whether any individual chemical concentration is increasing or decreasing. Trends allow you to see how your fermentation is progressing at a glance.

2. HOW TO SET UP YOUR DASHBOARD

You will need your IRmadillo to be installed in your process, calibrated, and giving measurements that you are happy with. If you aren't sure, please contact Keit for advice.

2.1. Read your IRmadillo values over your DCS

Read the concentration measurements from your IRmadillo into your plant's DCS network. You may need to arrange this with your DCS contractor. Keit provides support, commissioning guidelines, and register/tag maps for your DCS.

Keit recommends applying filtering (or averaging) to your IRmadillo outputs to reduce short-term noise on your measurements. The KeitSpec software can apply an exponential filter, which Keit can configure for you, or you can apply filtering in your DCS.

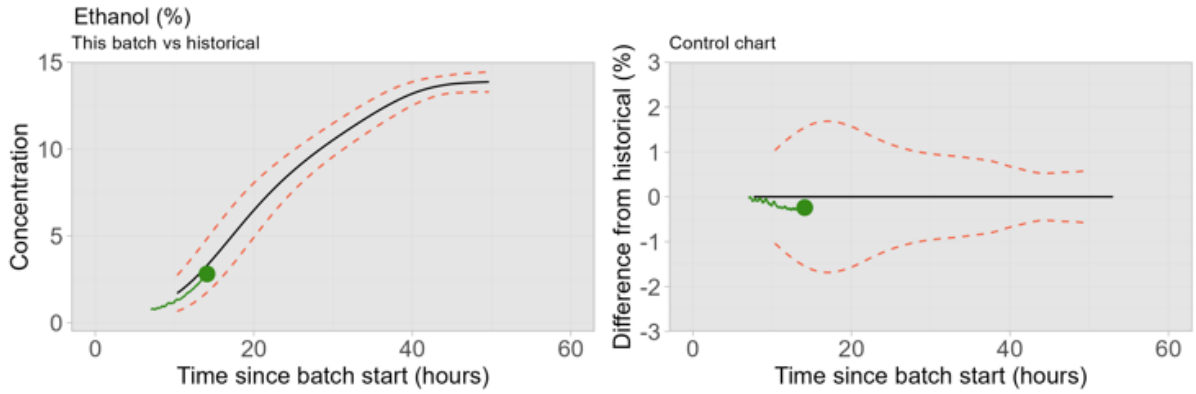
2.2. Calculate the historical batches

Calculate your historical batches for each species, based on a certain number of recent successful batches that you have measured on your IRmadillo. For each time point throughout the fermentation (measured in hours since the start of the batch), calculate the average concentration for each species that you want to measure.

If you need help to calculate your historical batches, Keit can provide them for you – all we'll need are your IRmadillo's outputs and a list of the batch start times.

2.3. Decide what you want to see

You will need to decide whether you want to see the data as trends or as control charts:



Left: Ethanol concentration plotted over time for the current batch (green) and historical batch (black). The red dashed lines are the upper and lower warning limits. This shows the trend, i.e., how much ethanol is actually present at this time. You can see how the ethanol concentration has changed over the batch.

Right: The difference between the ethanol concentration and the historical average ethanol concentration (green) plotted over time for the current batch. The historical average is plotted as a black line. Again, the red dashed lines are the upper and lower warning limits. This shows a control chart, i.e. how far away from 'normal' the concentration of ethanol is for this batch. This does not show the exact ethanol concentration, but does show at a glance whether or not your batch is going wrong.

2.4. Choose your warning levels

You'll need to decide where to set your warning levels. These will vary depending on the time through the batch – for example, you'll want to warn your operators that something is wrong if your ethanol concentration is 5% at the 40-hour mark, but at the 20-hour mark, 5% ethanol concentration may be normal.

Keit recommends setting the warning limits based on the standard deviation of your previous batches. This means that they will be based on how much variation you have seen – so if you've got a much wider range of concentration of DP4+ at the start of your batch than you do at the end, your warning limits will be wider at the start of the batch.

You can choose whether to set an upper limit, a lower limit or both for each species.

If you need help to calculate your warning limits, Keit can help to provide these – we'll need to agree with you how you want them to be calculated, and then we can run the calculations.

2.5. Understand the IRmadillo's diagnostics

The IRmadillo has some on-board diagnostics that indicate when there is something wrong with the instrument. You'll need to make sure you're acting on these. For example, high humidity inside the IRmadillo (which can be caused by an interruption in the purge air supply) will cause the IRmadillo's concentration measurements to be wrong. You don't want your operators to act based on incorrect measurements – and you want to be able to resolve the problem with the IRmadillo as soon as possible – so you will need to be able to flag when the IRmadillo is showing errors or warnings. The errors or warnings can be read over your plant's DCS along with the concentration measurements.

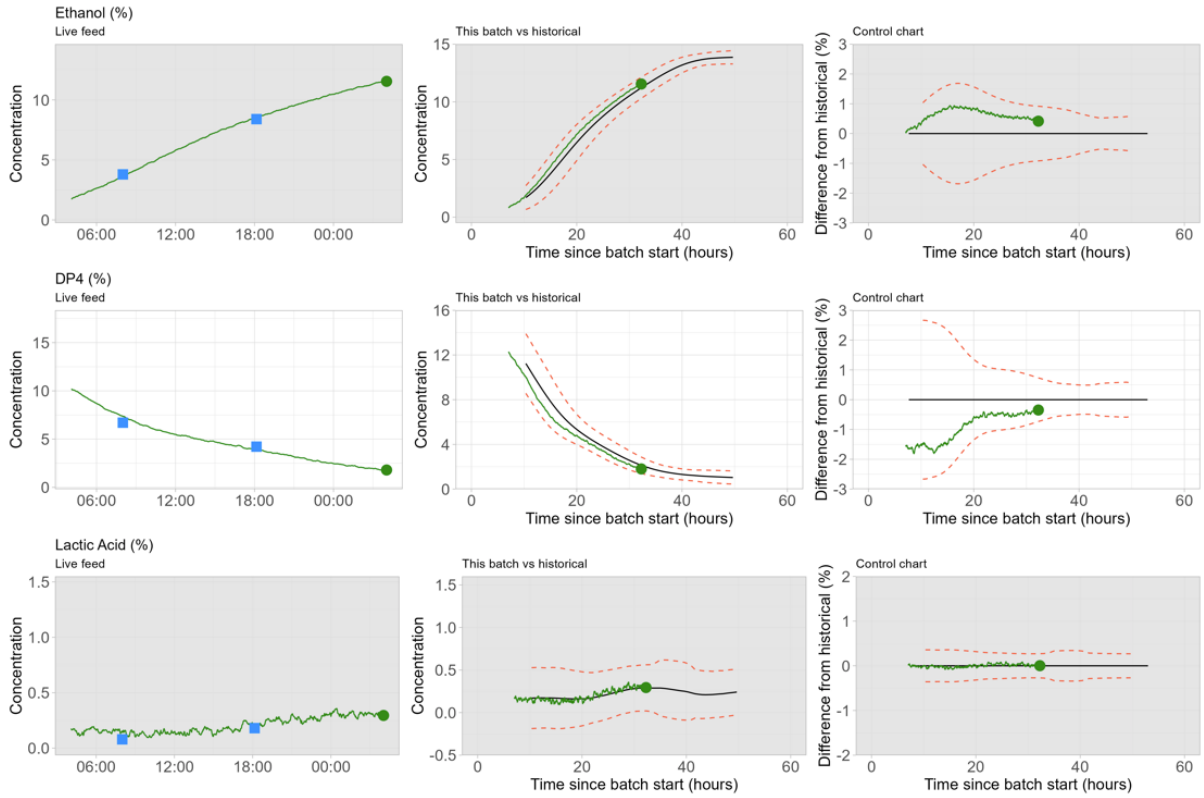
2.6. Create your dashboard

You will need to arrange this with your DCS contractor.

Your DCS contractor will program the dashboard to display the live and historical concentrations and the warning limits to your operators. You will need to decide how this is displayed – do you want all the plots to be visible all the time in your control room?

You will need to decide how you want the warnings from the IRmadillo to be communicated. Do you want them to be displayed prominently on the screen in your control room? Do you want them to be sent to your operators by text message or email? Do you want an alarm bell to ring so that everyone nearby knows something has gone wrong? Your DCS contractor will need to set up these alerts.

If your HPLC samples are entered into your control system, you can even display these on your dashboard.



An example of a dashboard.

Left: A plot of the concentration of three species (from top: ethanol, DP4+ and lactic acid) over time for the current batch. The blue squares are your HPLC samples and the green line shows the IRmadillo's predictions.

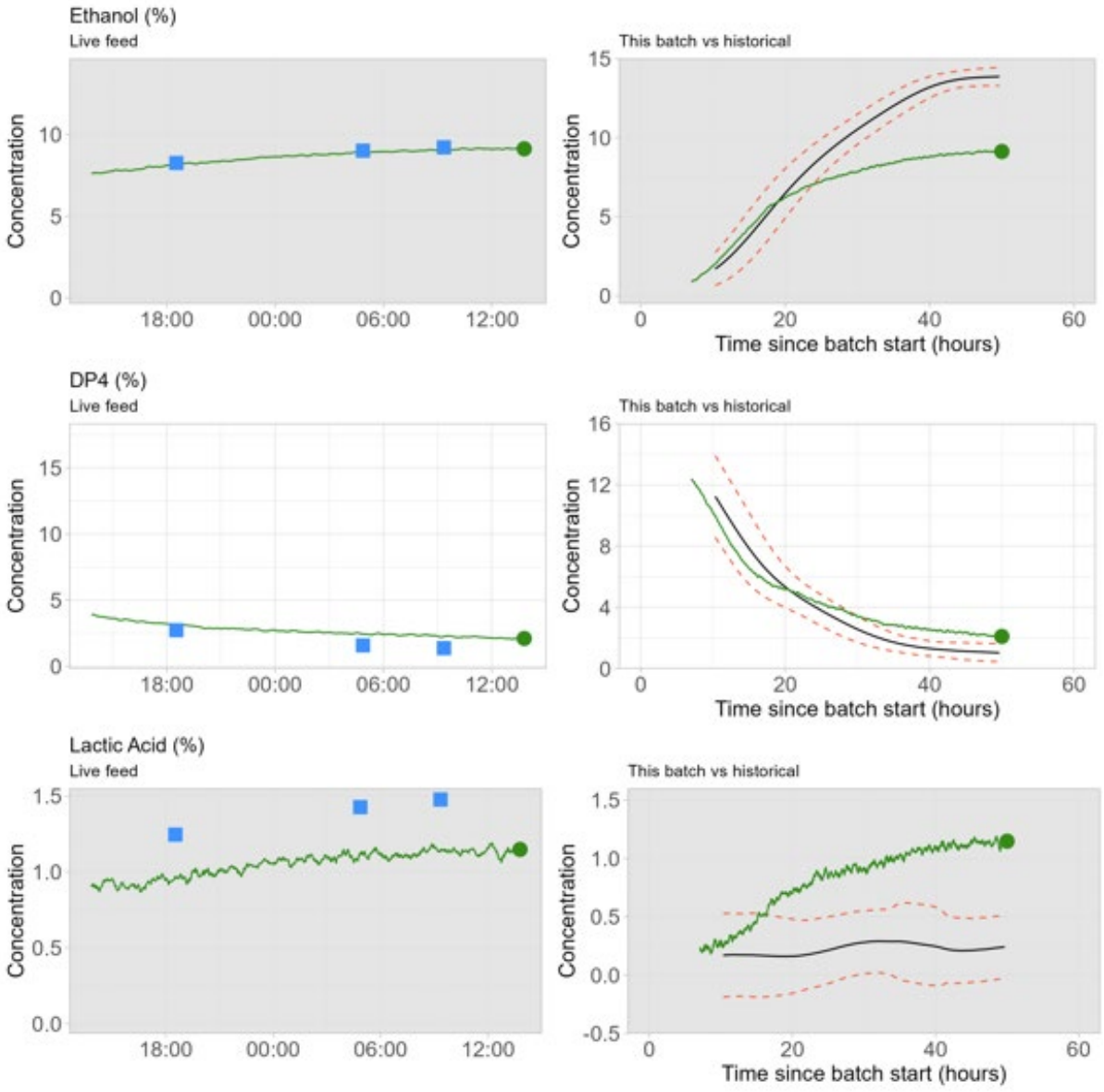
Center: Ethanol concentration plotted over time for the current batch (green) and historical batch (black). The red dashed lines are the upper and lower warning limits.

Right: The difference between the ethanol concentration and the historical average ethanol concentration (green) plotted over time for the current batch. The historical average is plotted as a black line. Again, the red dashed lines are the upper and lower warning limits.

3. USING YOUR DASHBOARD

Now that your dashboard is set up, you can start using it to make process improvements!

Here's an example of a fermentation batch with a lactic acid spike, as seen by the IRmadillo:

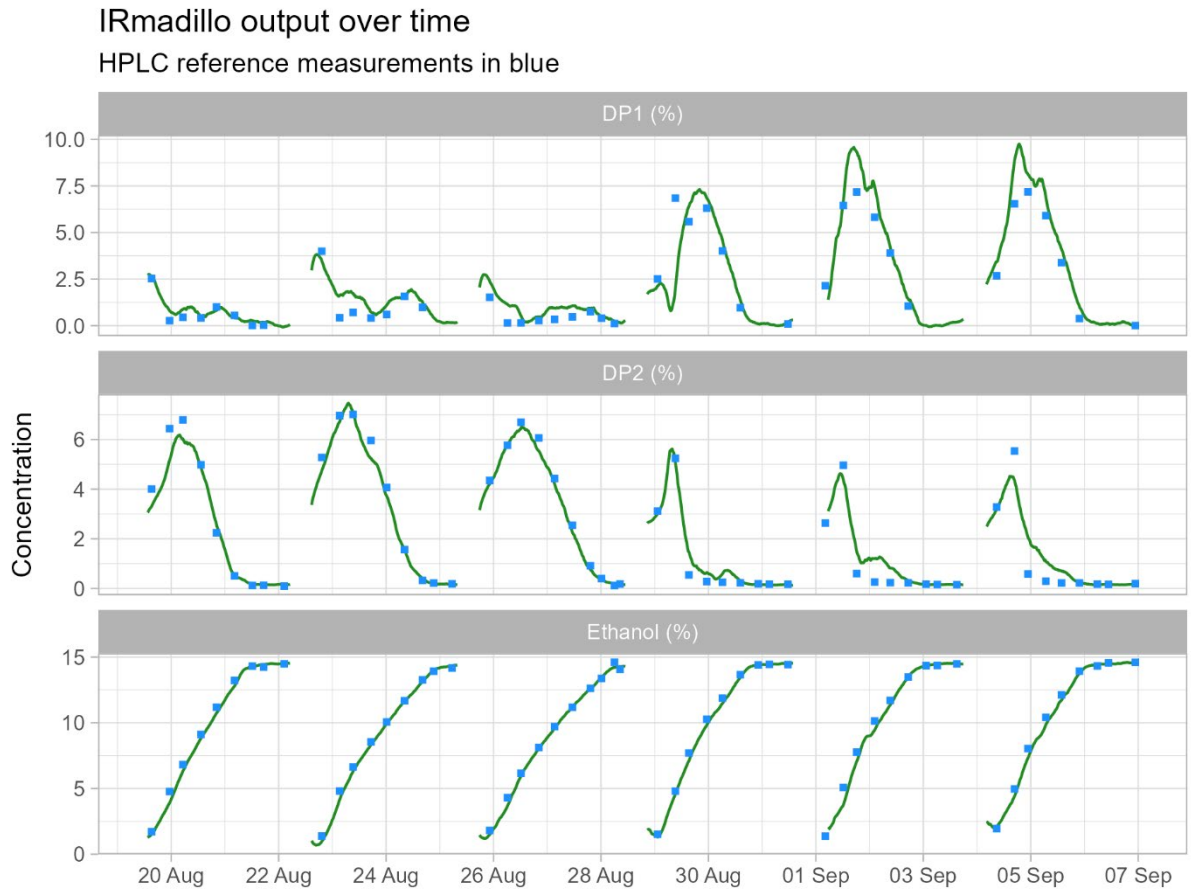


- At the start of the batch, the ethanol and DP4+ concentrations were normal – but the lactic acid concentration started to trend upwards straight away.
- The lactic acid hit the warning limit (here two standard deviations) around 16 hours into the fermentation – this is when you would be alerted to an unusual concentration measurement.
- The fermentation started to slow down at around 18 hours, with the rate of increase of ethanol concentration falling sharply.
- The ethanol concentration fell outside the normal range at about the 24-hour mark – eight hours after the lactic acid warning limit triggered.
- You can even see a deviation in the DP4+ concentration – showing how acid spikes affect the enzyme activity, not just the yeast!

As soon as your IRmadillo starts to see evidence of a lactic acid spike or other unusual process behavior, your operators will be alerted so that they can investigate, find out what's going wrong, and fix the issue. You will be able to see how different failure indicators correlate – for example, different species will change in different ways whenever a batch starts to go wrong, and you will be able to diagnose the problem more easily if you look at the concentrations of multiple species, not just whether your ethanol concentration is increasing as usual.

3.1. Updates to your dashboard

Note that the trends may change significantly depending on your yeast, enzymes and enzyme dosing schedule, so if you make any process changes, you may need to re-calculate your historic batches. For example, here are the trends given by the IRmadillo for a customer who changed their yeast on the 29th August:



The new yeast allows for faster conversion of DP2 to DP1, so both the DP1 and DP2 concentrations show very different trends. The ethanol concentration has also changed shape: the ethanol concentration increases more quickly and flattens off sooner and more sharply. These changes mean that historical batches calculated before the 29th August will no longer be useful for tracking concentration changes after the 29th August. A new set of historical batches are needed.