Triggering Robustness of ePAT 601 Blend Monitor

Revision History

Date	**Revision**	**Change Agent**
22 May 2006	Rev. A; First draft for comment	Sheelagh Halsey
29 Aug 2006	Rev. B; Additional data added and information linked to risk assessment	Sheelagh Halsey
25 Sep 2006	Rev. C; Revision history and approval added	Sheelagh Halsey

Approvals

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Reviewer/Approver:	Peter Bennett	[illegible]	25 Sep 2006

Purpose

This document describes the testing of the ePAT 601 with regard to triggering robustness. Document 601-RR-20-0011-C in section 8.0 Risks and Failure Mode, identified triggering as a potential risk as the whole data acquisition process on a blender is dependant on the correct operation of the trigger.

Scope

Previous designs of trigger switch were sometimes unreliable, so a new trigger switch was designed with a slotted optical switch through which a pendulum moves. The width of the pendulum determines the angle of triggering. The system was set to acquire data at $+30^{o}$ and stop acquisition at -30^{o}. The NovaPAC software was updated to be able to directly trigger the Axsun spectrometer, i.e. a hardware trigger, to minimize latency. To test the robustness of the triggering, the reliability of data logging was checked at different rotation speeds. Blender rotation speeds in the industry are up to 20 rpm, hence the system was tested at typical rotation speeds of 6, 12 and 20 rpm. To test robustness, the system was tested beyond typical speeds at 25 rpm. In addition, the positional robustness of the trigger was tested to prove that the trigger only actuated at the inverted point. Triggering was also tested over a period of time to prove its mechanical robustness.

Test Procedures

The unit was bolted (4 bolts) on to a rotating table using the mounting plates. Battery power was used throughout. The head was clamped (hygienic clamp) to a holder incorporating a suitable material for the test being carried out. For the reliability of data logging, the head was clamped to a VisNIR standard to collect spectra. The table was rotated at 6, 12, 20 and 25 rpm. Data was collected at every rotation using the trigger switch and the frequency of data logging noted. This data was collected in the NovaPAC software in spectrometer configuration mode. Each test was run for one hour or more.

To check that the unit was triggering in the correct position, a mini blender was manufactured with a sapphire window in its lid. The blender was half filled with flour so that when the blender was inverted material would cover the window. The window was clear when the blender was not inverted. The blender was inverted a number of times prior to the experiment to check that the window was not fouling. The trigger switch was set to collect data when the blender was inverted. The head was clamped to the mini blender and the table was rotated at 6, 12, 20 and 25 rpm. This data was collected in the NovaPAC software in run mode using the trigger to collect data every rotation. The collected spectra were overlaid to check a good spectrum was obtained on each rotation and that no spectra were taken from an empty blender. Each test was run for one hour or more.

In addition to the testing described above for which the instrument was run for several days, the unit was run continuously using the trigger at the highest rotation speed of 25 rpm for 7 hours on battery power until the batteries stopped working. This was envisaged as the most difficult combination of running parameters to test the instrument with.

Test Results

1. Reliability of Data Logging at Different Rotation Speeds

Testing was carried out with spectrometer 138/probe BP007 and 154/BP006. The wavelength reference standard was used as a sample. The data logging intervals expected for each rotation speed were:

Rotation Speed	Logging Interval (Secs)
6 rpm	10
12 rpm	5
20 rpm	3
25 rpm	2.4

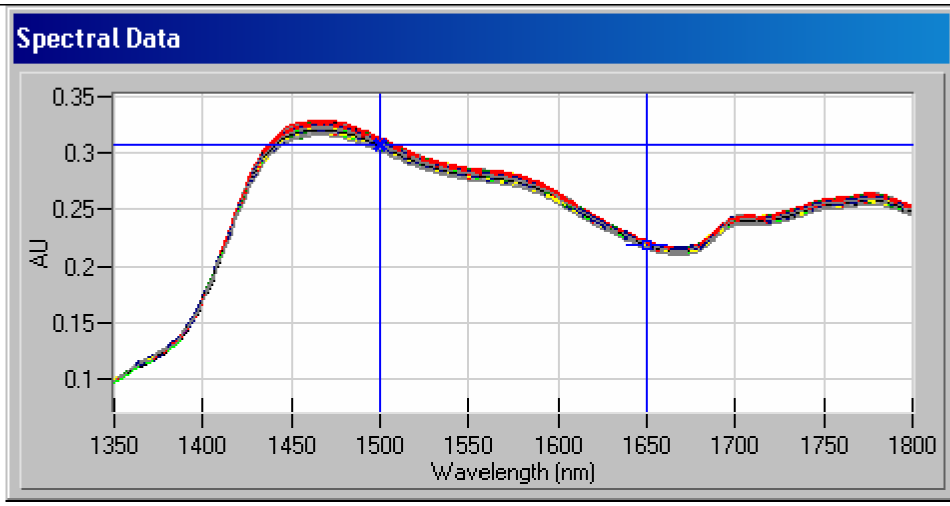
The typical data logging intervals recorded are shown in the table below:

Spectrometer/Probe	Rotation Speed	Data Point	Seconds
154/BP006	6 rpm	1	10
	6 rpm	2	20
	6 rpm	3	29
138/BP007	12 rpm	1	6
	12 rpm	2	11
	12 rpm	3	17
138/BP007	20 rpm	1	3
	20 rpm	2	6
	20 rpm	3	10
154/BP006	25 rpm	1	2
	25 rpm	2	5
	25 rpm	3	7

At 6 rpm, the data was logged every 9-10 seconds, at 12 rpm, data was logged every 5-6 seconds, at 20 rpm, data was logged every 3-4 seconds and at 25 rpm data was logged at every 2-3 seconds. Spectra were only logged to the nearest second in the NovaPAC software, so there is some inaccuracy in the recording procedure. This shows that the trigger switch is activating at the correct time interval for each rotation speed used.

2. Data Acquisition at Inverted Point

For each rotation speed, 6, 12, 20 and 25 rpm, the spectra were displayed in NovaMath and overlaid. The results from the worst case 25 rpm experiment are shown below (367 spectra):



These spectra are typical of all the plots obtained at each rotation speed; no bad spectra were collected with the blender in the incorrect position. This indicates that spectra were collected properly at each inversion point.

3. Mechanical Robustness of Triggering

Two systems have been run for a period of 8 days and 6 nights performing various triggering experiments described above. System 154/BP006 was run for 7 hours on battery power at 25 rpm with continuous triggering. Data was collected faultlessly and at the correct timings for all experiments performed.

Conclusions

The probability of failure of the trigger switch during both normal and fast rotation speeds has been shown to be low. The triggering system has been shown to be reliable over a long period of time using two different systems at various rotation speeds and using two modes of data acquisition in the NovaPAC software. The trigger has also been shown to acquire data correctly at the inversion point. The severity of failure is deemed to be high, as the system would be unusable if the trigger switch failed. The detectability of a problem should also be high as the user would immediately see that spectra were not being acquired on the base station PC.

Document 601-RR-20-0011-C in section 11.0 Mitigation Plan, stated that engineering change notice, diagnostics, maintenance and process would be used to monitor triggering performance. Recommendations are that the triggering should be monitored by the user on start up of the blending run to check that spectra are being acquired correctly. The trigger switch should be inspected during service visits to make sure that no mechanical faults have developed. If any faults are discovered over the medium to long term, the design should be re-evaluated and an engineering change made if necessary.