Full Condition Assessment Report

Customer: Northern Ireland Water	**Reason for assessment: First full assessment, and Condition assessment after control change at Drummer Road**
FAO:	**Analyst: Rob Pietruszkiewicz & Geoff Walker**
Date: 22 March 2010	**Last report: 12 Feb 2010 (Initial interim report on Drummer Road Inverter issues)**

MCM#	Machine	Condition	Trend	Diagnosis	Action	Urgency	Details
1	Drummer Rd, pump 6	●	▶	Slight loose foundation. Previous High-current problems now cured, by clamping inverter frequency to correct limits	None required – except to confirm reasons for it not running (assumed simply to be control system not calling for it)	Low	A1
2	Hunters Crescent, transfer pump 3	●	▶	Generally good condition. Some indications of possible loose foundation. Not a deteriorating trend. Power reduced on 18 March	Confirm impeller design – has it got 4 blades? Identify reason for power decreasing on 18 March.	Low	A2
3	Duncrue Road, Return Active Sluge pump 1	●	▶	Good condition But Low power factor 0.5 – 0.6	Assess whether duty will at times require full power. If not, consider reducing size of motor to save power. If full power will occasionally be required, consider fitting a variable speed drive	Low	A3
4	Culmore Road, Screw pump A	●	▶	High level of looseness and rubbing. Possible indications of motor stator faults. But not a deteriorating trend	Keep an eye on it, particularly on the developing trends. Confirm design details of screw – how many starts are there – ie is it a single or double helix?	Low	A4

A1: Detailed assessment for Drummer Rd Pump 6	
Customer: Northern Ireland Water	Reason: Condition assessment after control change
FAO:	Analyst: Rob Pietruszkiewicz
Date: 22 March 2010	MCM#: 1 (Dromer Rd)

Condition summary:

The overall condition of this pump looks good, with no obvious problems visible, apart from signs of a soft foundation. This appears to be confirmed by the reports of very significant vibration when the speed was set to anything outside a narrow range. The overall picture can be deduced from the diagram below, which shows in blue the signal coming from the motor analysis, and in red the acceptable threshold level. This shows that the blue line is below the red in virtually all areas except the very low frequency end, which corresponds to the foundation problem.

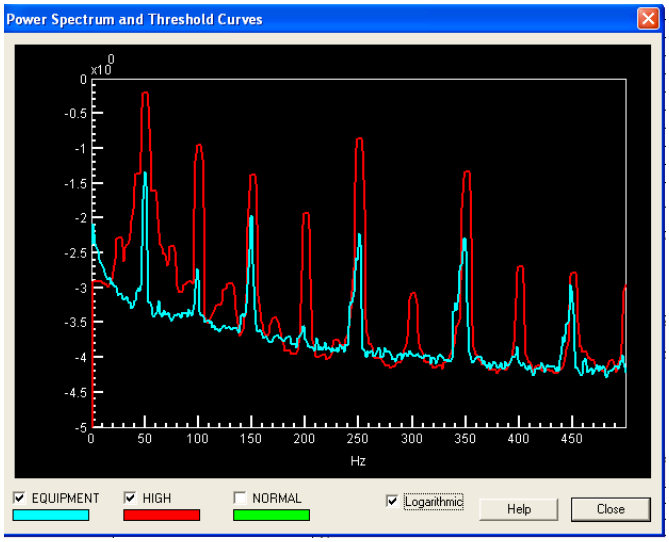

Figure 1: Power Spectral Density (PSD) curve showing soft foundation.

Our initial interim report, dated 12 February, identified a problem of speed control varying outside these set limits, with a clear correlation between high speed resulting in the motor drawing too high a current, resulting in the inverter tripping out on high current alarm, with the motor drawing 700A (compared to rated full load current of 535A) when the input frequency was 48Hz. We recommended that the inverter control system be set to a maximum of 45Hz.

This problem has now clearly been resolved – the input frequency can now clearly be seen to be limited to a maximum of 45.1 Hz. The trace below shows that the inverter gives a stepped output, with a frequency of either 42.7Hz, 43.95Hz or 45.15Hz with the resulting motor current reaching a maximum of around 520A

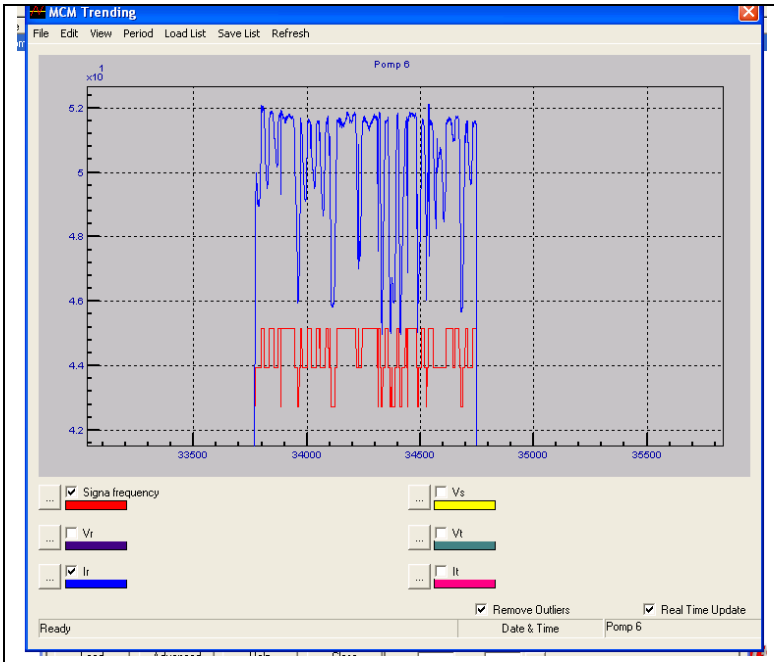

Figure 2: Motor Current and Frequency showing both within acceptable limits

Now that this issue has been resolved, we see no electrical or mechanical faults in the motor or pump (other than the pre-existing foundation fault previously reported – which has not deteriorated further).

However we note that the pump is not always running. We see no data to suggest that it should be tripping out for any reason, and assume that it is simply being switched on and off by the control system.

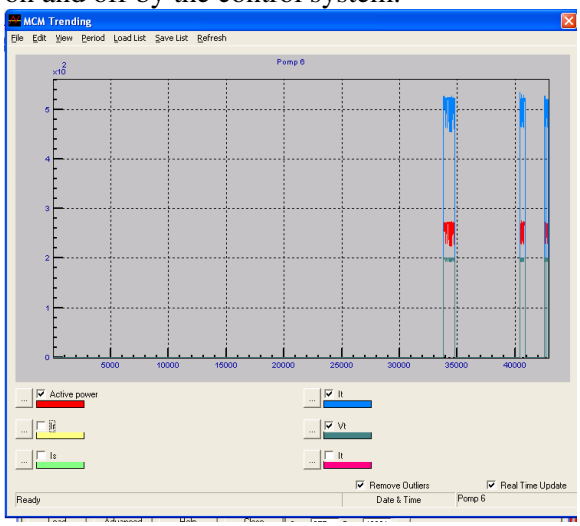

Figure 3 Power, Current and voltage trends – showing very intermittent operation

Trends:
No discernible trends of deterioration

However, trend line for Power, Voltage and Current shows that motor is only running intermittently. We have no way of telling why this is, but there are no identifiable reasons that we can see that would lead to the pump tripping out or not running correctly.

Actions:

None required – except to confirm that the reason for the pump not running more frequently is simply the control system not calling for it.

Comments:

Change to inverter setting has worked effectively. Avoided costs in having to change more significant items, such as control system, foundations, etc. Mention has been made of avoided costs of several 10s of thousands of £.

(The data for this pump shows a rotational speed of 1489 rpm, ie a 4 pole motor, and that is what this analysis has been based on. However, there are some elements of the signals seen by MCM that would be consistent with a 2 pole, ie 3000 (or 2980) rpm motor. If this can be confirmed, we will review / redo this analysis.)

A2: Detailed assessment for Hunters Crescent, transfer pump 3	
Customer: Northern Ireland Water	Reason: Initial Report
FAO:	Analyst: Geoff Walker
Date: 24 March 2010	MCM#: 2

Condition summary:

The overall condition of this pump looks good, with little obvious problem visible. The traces we can see would appear to indicate a vane pass frequency consistent with a 4 bladed impeller. The overall picture can be deduced from the diagram below, which shows in blue the signal coming from the motor analysis, and in red the acceptable threshold level. This shows that the blue line is below the red in virtually all areas except the very low frequency end, which could correspond to a foundation problem, or possibly some misalignment, but the specific shape and location of the peaks on it are more consistent with a vane pass of a 4 bladed impeller.

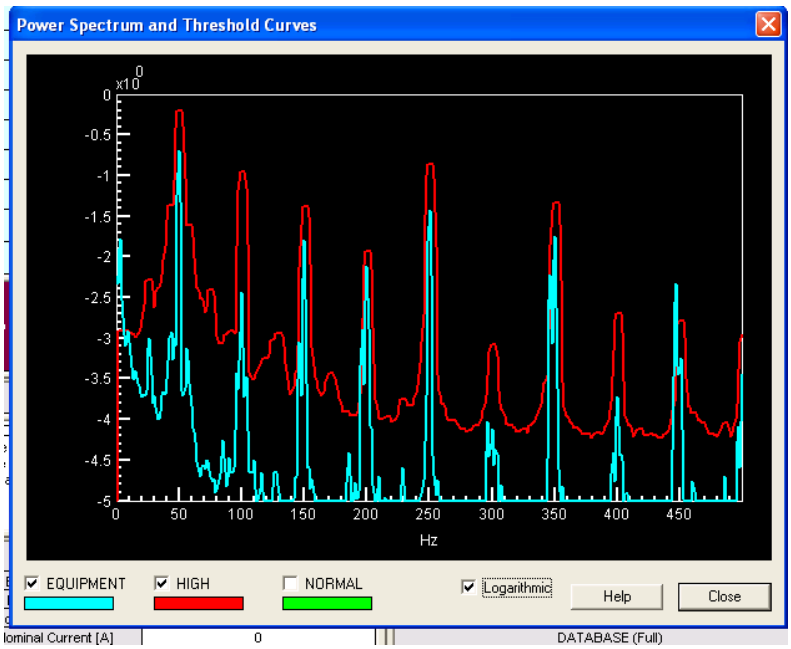

Figure 4: Power Spectral Density (PSD) curve.

Looking at overall pump usage and performance, the recent traces show that something has changed on the pump between 16th March and 18th March, in that the pump was out of action for 36 hours, and when put back into action, the power consumed by the pump was reduced by around 10-15%. The power factor is pretty constant before and after, the power reduction is simply associated with the motor drawing less current. Although this is a variable speed motor, it is being operated at constant 50Hz almost all the time, and there is no change in supply frequency which would have led to a change in speed of the pump corresponding to the time of this reduction in power,. So we can only assume that there has been something else leading to a change in load in the pump – perhaps adjustment of a valve somewhere in the system, changing the flow through the pump.

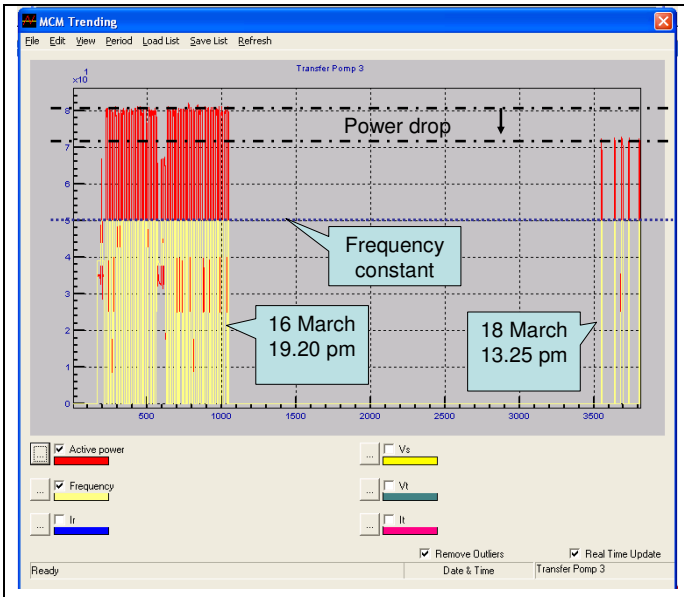

Figure 5: plot of power consumption and frequency, showing reduction in load on 17/18 March whilst frequency, and therefore pump speed, remains constant

Trends:
No discernible trends of deterioration

The trend line for Power, Voltage and Current shows that motor is only running intermittently. We have no way of telling why this is, but there are no identifiable reasons that we can see that would lead to the pump tripping out or not running correctly. The total time monitored so far is quite short to expect to see any meaningful trends emerging. These trends should appear over time.

Actions:

No urgent action required. Next time someone is on site, it would be helpful to check whether there is any sign of either loose foundations (which would indicate itself as a loud rattling type of noise) or of misalignment (which at the levels shown would probably only be detectable with laser alignment type of equipment). We expect that neither of these problems will be significant, and their absence will confirm that the signals we are looking at probably correspond to a 4 blade impeller. It would also be useful to have someone confirm the details of the impeller – number of vanes and geometry – to allow future diagnoses to be much more specific.

Comments:

See under Actions heading.

A3: Detailed assessment for Duncrue Road, Return Active Sludge pump 1	
Customer: Northern Ireland Water	Reason: First Report
FAO:	Analyst: Geoff Walker
Date: 24 March 2010	MCM#: 3

Condition summary:

The overall condition of this pump looks good. The blue line in the graph below is at all times well below the upper threshold indicated by the red line, and is below the green line at almost all points, ie it is in a better than a normal condition

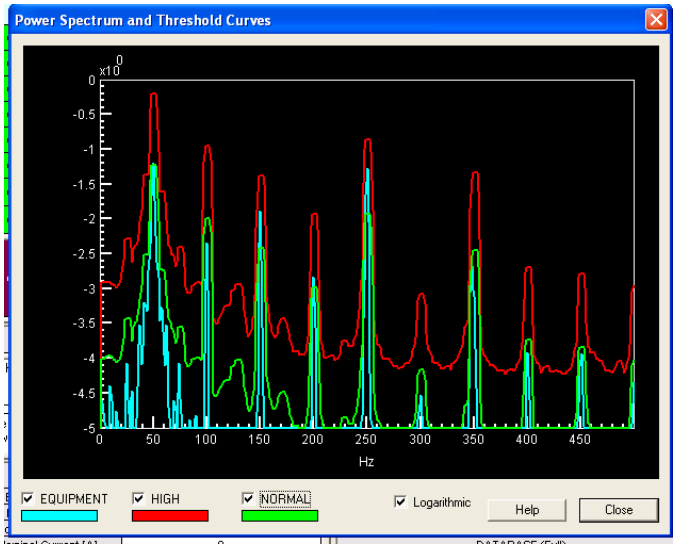

Figure 6: PSD curve for Duncrue Road – virtually all below Green line

The one area that is abnormal is the power factor – which is very low, at around 0.5 – 0.6. This is shown in the graph below as the red line, together with the current, which is shown as the blue line. (Note: to make the lines more easily comparable, the power factor line has been scaled by a factor of 300; so 1.5 x10^2 corresponds to a power factor of 0.5)

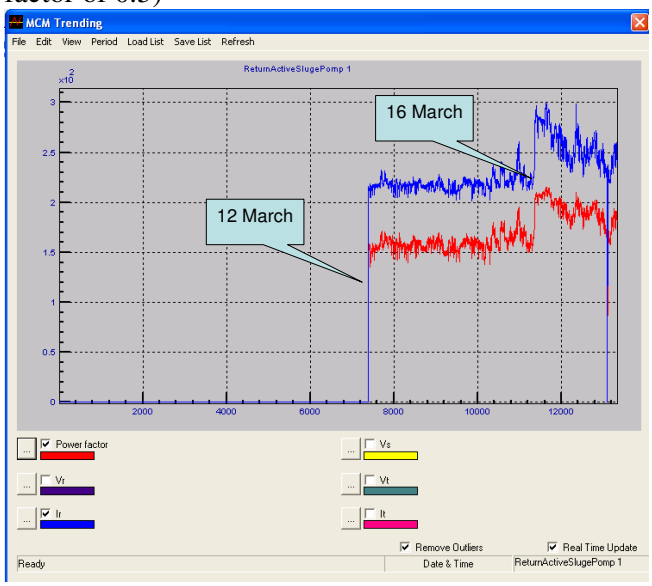

Figure 7: Power Factor and Current consumption – low and varying

The fact that the power factor scales directly with current indicates that this is purely the result of a low and changing load on the pump, or conversely that the motor is oversized for the duty that it is being asked to perform at the time we are observing.

Low power factor is not necessarily a problem, but it does represent a waste of money, in that lower power factor implies that a significant amount of current is being drawn out of phase with voltage, delivering no useful result, but still incurring a cost for supply of electricity.

Without knowing more detail about the duty of the pump, and with only a short record so far we cannot be sure that a smaller motor would be able to handle all of the duty requirements of this pump, but it should be watched with this in mind as a possibility. Alternatively, greater efficiency can be obtained by fitting an inverter drive unit to the existing motor / pump system.

Trends:
No discernible trends of deterioration. Data only available since 8 March.

Actions:

None required – except to review system loading and consider saving energy either by fitting smaller motor or using variable speed drive system.

Comments:

Apart from Low Power Factor resulting from low power demand relative to size of motor, this pump and motor system looks in good condition. Of the four pumps covered by this report, this one is in the best condition relative to our database of norms – which is possibly a result of it being oversized, and therefore understressed.

Information to confirm the rating of the motor and the duty it is likely to see over the course of a typical year would allow us to refine our analyses, and to calculate the financial savings possible from either replacing the motor with a smaller unit, or fitting a variable speed drive.

A4: Detailed assessment for Culmore Road, Screw pump A	
Customer: Northern Ireland Water	Reason: Initial Report
FAO:	Analyst: Geoff Walker
Date: 24 March 2010	MCM#: 4

Condition summary:

The overall condition of this pump appears to show a lot of rubbing contact and looseness, so the blue line in the graph below, which corresponds to the signal coming from the equipment, has a very high "carpet" level, ie it doesn't go very low in between the peaks. This normally corresponds to rubs and general noise and looseness. It is noticeably higher than the red line, which is a normal high limit.

A more detailed analysis of the shape of the curve indicates an energy signal corresponding to a feature occurring twice per revolution, so given this is a screw pump, it might indicate that the screw is a double rather than single helix. It might also indicate misalignment. With no detailed information on this specific pump we cannot be sure which of these phenomena we are seeing, and it may of course be both!

Alternatively, this frequency pattern can indicate a developing problem in the stator windings of the motor. Without a little bit of inside information it is not possible to be certain of this, but our expectation is that it is more likely to be mechanical problems rather than the motor.

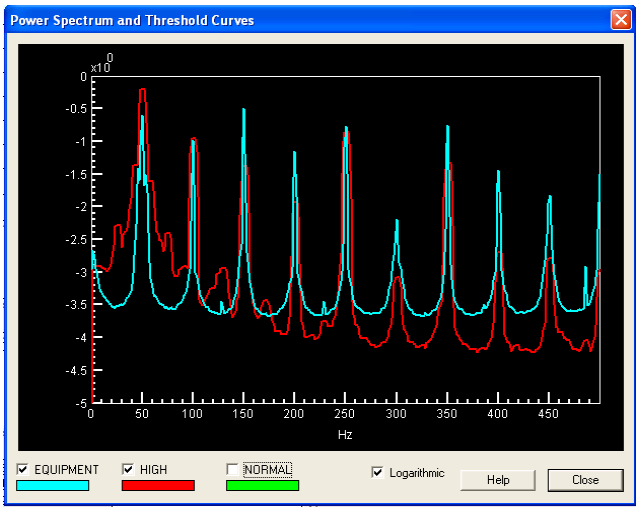

Figure 8 – PSD Curve showing high carpet noise level and high peak levels

The automated condition assessment report produced by MCM at the end of the learn period gives the following comments:

☑ *WATCH EXISTING FAULTS* The operation of the equipment is NORMAL although there are existing fault(s) within acceptable level(s). These faults should be checked for verification and corrective action at the next scheduled maintenance but no later than six (6) months.

Mechanical Fault Indications

☑ Looseness / Foundation. Check for loose motor foundation, loose motor components, looseness or excessive tolerances in driven components.

Electrical Fault Indications

☑ Stator related problem. Check for stator, short circuit, winding slackness, isolation problems, and partial discharge.

Trends:
The power used by the pump varies through time, indicating there is a variable duty cycle:

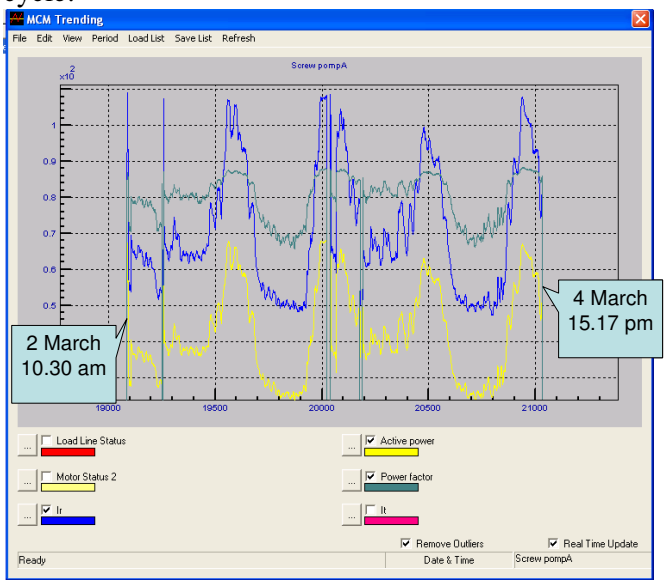

Figure 9: Current, Power and Power Factor vary significantly from hour to hour

The difference in load varies by a factor of more than 2: 1, with the current ranging from around 50A to around 110A, and the associated power consumption ranging from 25 to nearly 70 kW. The power factor follows a similar pattern, as would be expected, with lower currents corresponding to a lower power factor.
However, trend line for Power, Voltage and Current shows that motor is only running intermittently. We have no way of telling why this is, but there are no identifiable reasons that we can see that would lead to the pump tripping out or not running correctly.

Actions:

This pump is not in perfect condition. It should be kept under watch. However, at the moment, there are no indications of significantly deteriorating trends, so we do not see any signs that would lead you to expect imminent failure.

The MCM outputs should continue to be monitored, and any deterioration logged.

Comments:

It would be extremely helpful to have some feedback on this screw pump, and information about its construction, particularly confirmation of the number of starts on the screw (ie is it a single helix or a double helix). This would allow us to significantly refine our diagnosis, and hence give better prognosis of likely future performance.

Appendix 1 – Additional information on Drummer Road, 26 March 2010

It has been reported that pump 6 at Drummer Road continues to trip out, with the Inverter Unit reported to indicate High Current. We have examined this, and cannot see any evidence to support this. Below is a plot based on data taken on 26 March 2010, showing the readings on Wed 24th March, when the unit shut down.
Note: in order to show voltage, current and frequency on a comparable size, the voltage reading has been multiplied by 2.2 and the frequency multiplied by 8. So the values just before shut down were:

- Frequency = 45.166 Hz
- Voltage = 201.16V
- Current = 521.28A

Figure 10: details of Voltage, Currency and Frequency of Drummer Road Pump 6 just before shut down on Wed 24 March.

So from this picture, we have no reason to suspect the inverter is giving high voltage, or high current, or high frequency. We advise that the alarm messages from the inverter be double checked, and the manufacturer be consulted to try to understand how the error message reported could be consistent with the voltages and currents actually being drawn.