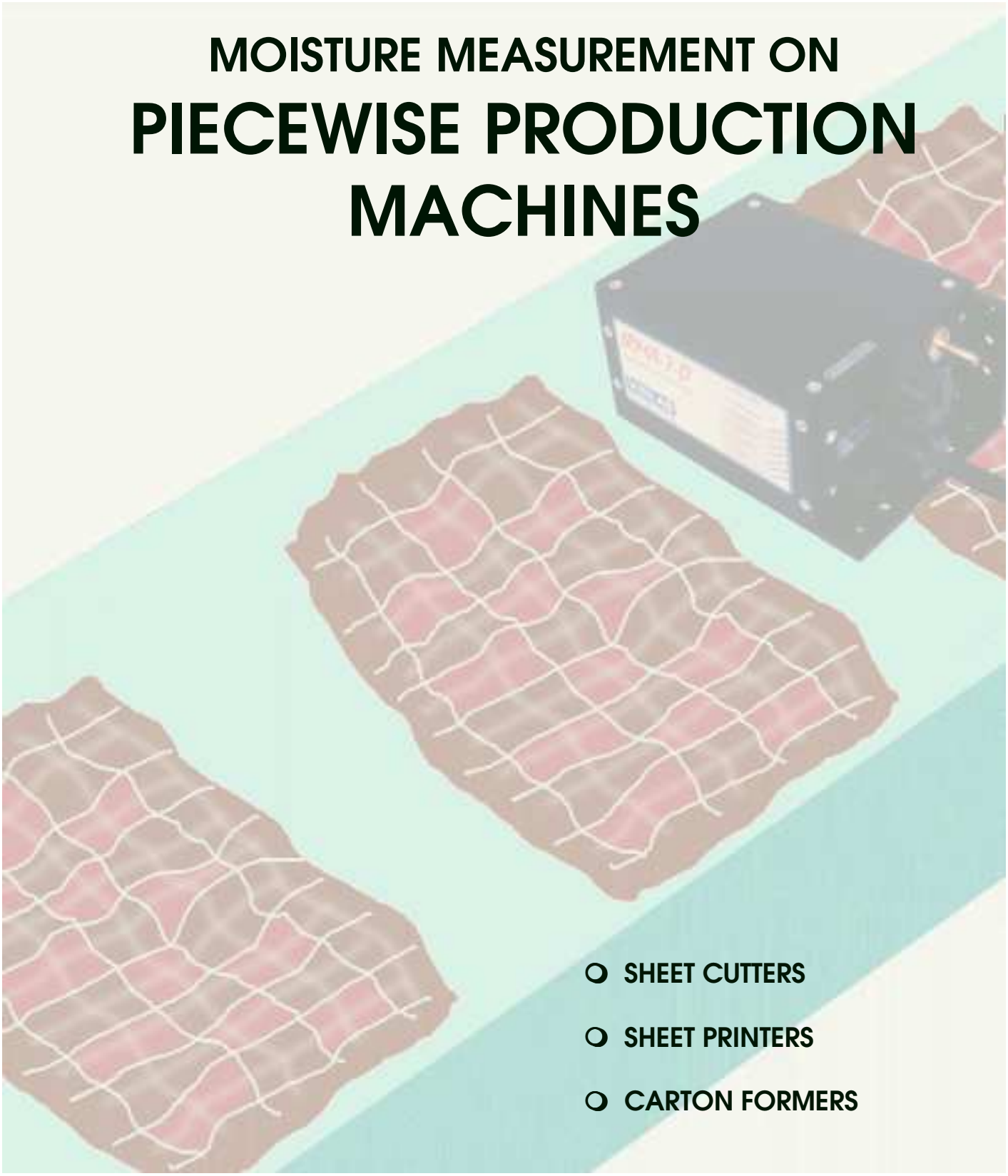
APPLICATION EXAMPLE FOR THE MOISTURE METER IRMA-7-D
TECHNICAL NOTES FOR USERS - NOTE #015

MOISTURE MEASUREMENT ON PIECEWISE PRODUCTION MACHINES



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Problem to Solve

A challenging problem in industry is measurement in a running machine or production line where the material to be measured is piecewise. Examples are a sheet cutter, sheet feeder for packing, sheet printer, packing carton cutter, a former and dryer combination. A good example of an off-line application is a high-speed strength testing device where speed requirements on the moisture meter are of highest level.

The production speed is usually so high that conventional NIR-based moisture meters are impractical to use due to their low sampling speed and slow response to both to moving items and to varying conditions on the conveyor. Especially, old-fashioned rotating-filter meters are not capable of handling fast items in difficult conditions. In addition, the varying ambient lighting (DC and 100 Hz fluorescent) and large temperature variations create insurmountable problems. The result would be a series of noise peaks with no usable signal at any conditions, except with a stalled conveyor.

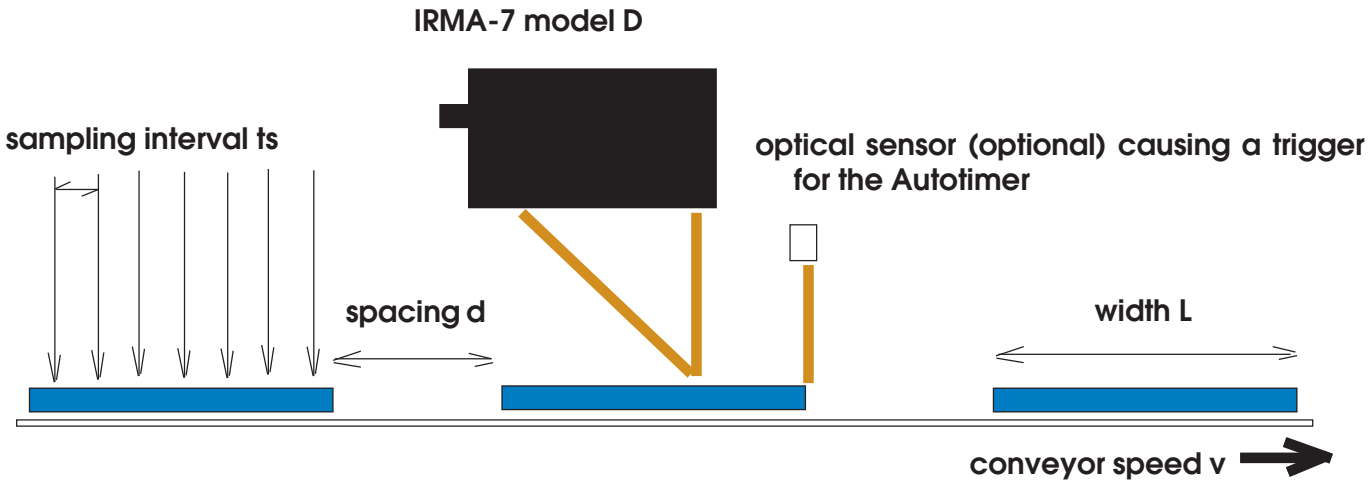


Figure 1. General view of measuring arrangement for piecewise production lines

Tools to Offer

IRMA-7 model D is worlds fastest NIR process moisture meter with 400 Hz sampling speed. IRMA-7-D uses the so-called same-spot principle to collect data of all measuring and reference wavelengths at the same time. This makes it possible to measure webs of any speed in general and to monitor separate items on a conveyor with a very high speed. The resulting data is fed to several interfaces, like the **voltage output**, **Profibus DP fieldbus**, **RS232 for PC** or an optional **keyboard and display unit**. They are all provided with the latest moisture value. The voltage output is updated at full speed (400 Hz) and the Profibus DP too. Sampling rates of the order of 200 Hz should be attainable without problems with 12 Mbaud bus speed. The serial port is limited by its 9600 or 38400 bauds rate to a speed like 10 - 30 samples/s. The keyboard and display unit is suitable only for slow following of the signal. One can, however, use the Autotimer and banks to apply the maximum speed.

A unique feature both in **IRMA-7-D** is the internal **Autotimer** and **memory banking system**. It makes possible to sample signal values at any rate from 400 / 700 Hz down to one sample/10 hours. Data is saved into non-volatile memory and can be downloaded to a PC or to the fieldbus master afterwards. The Autotimer can be triggered by an external electrical signal (isolated TTL input, falling edge) or by a software command from the PC or the fieldbus master. The bank sizes are 4096 points and 4 X 1024 points in memory banks called **Series** and **Bank1 - 4**. They all are independent of each other. This feature enables collection of either a predefined number of data points (**Batch mode**) or continuous sampling until specifically ended (**Continuous mode**).

Another unique feature both in **IRMA-7-D** is the **Burst mode.** It overrides the normal use of the meter in many ways. The Autotimer is set up as normally, its time interval and the suitable memory bank. The Batch mode is not important at all. The **Burst count** is matched to cover the incoming sheet or piece length with regular sampling. Likely you would need some sort of optical sensor to detect the incoming edge of the sheet causing a triggering pulse for the Autotimer. Connect it properly (TTL 5V logic, falling edge sensitive). Then the Burst mode is turned ON and you can start measuring as soon as you can get trigger pulses from the sheets.

The advantage of this feature is that it does not measure the gaps between the sheets at all, only the sheet itself. The result is an average value calculated from the samples taken and that particular value is offered to all interfaces, not the current moisture signal. That value is also added to the current memory bank. The signal trend line consists entirely of averages of sheets and the gaps do not interfere. The same reading is found in the Profibus DP and voltage output. This is an extremely good feature offering the possibility of creating a simple low cost measuring system. An economical DVM (digital voltmeter) numeric display panel can be connected to the voltage output in the simplest form. One can also take full use of the **Advanced** program's Numeric display (ref. to Fig. 6). **The burst mode method is the best method for all problems introduced in this report solving all problems in the simplest way possible.**

In the following we show some examples of how to harness these features up to measure piecewise production lines. We refer to the settings of the meter and the **IRMA7Basic, IRMA7Mini** or **Advanced** programs. Refer to their manuals for background information. We assume that you have at least a superficial knowledge of them before you try to apply the following guidelines in practice. The Profibus DP master system is always tailored and no specific directions can be given for its setup at this time. That must be checked by your local expert on the fieldbus. Check also the Profibus DP manuals delivered with your meter. They offer you a good amount of meter-specific data.

Example Cases

In the following we present the different example cases of piecewise production lines which can be solved with the moisture meters in various ways. The best standard solution to all of them is, as expressed above, the Burst mode method. Due to that, it is introduced first before any other solutions and will not be repeated. The other cases are more cumbersome and may not produce as good results.

1. Slow piecewise line, large or medium-sized items
2. Fast piecewise line, small or medium-sized items
3. Piecewise line with dense layer of small-sized particles (like wood chips)

Best solution: Burst mode and PC Acquire operation

The optimum solution is to use the burst mode. The PC program will then track the slowly varying average signal with no difficulty if the sheet arrival rate is not too fast. For very fast rates, use either as short interval in the Acquire or use some other faster interface, like the Profibus DP or

the voltage output. They can track even faster events. Set the data acquisition up as follows. We touch here the vital settings only. The target is an automatic system with no user interference after setup and start.

Program setup on the Acquire page:

Interval 0.05 s or slower, depending on the rate of incoming sheets
Conditional OFF
Web temp ON only if you really need it (then use interval 0.2 s or longer)
On-line filter: OFF

Program setup on the Memory banks page:

Burst mode ON
Burst count = NNN

NNN is the required number of samples to cover the minimum length of sheet running at the maximum speed. Try differing values.

Program setup on the Status page:

meter:

Filter: Use FAST or NONE, perhaps MEDIUM. SLOW and SPECIAL are available. Check the edge slopes to see how much useful data they allow you to have.

1. Slow piecewise line, large or medium-sized items

In this example the line speed is not too high (< 1 m/s) making it possible to do measurements with all of the interface choices available in the meter. Select the one most comfortable of the suggestions A to C below.

1.A. PC Acquire operation

The PC program can easily follow the signal as such. The same applies for the Profibus DP. Set the data acquisition up as follows. We touch here the vital settings only.

Program (setup on the Acquire page):

Interval 0.05 s or 0.1 s
Conditional OFF
Web temp ON only if you really need it (then use interval 0.1s or longer)
On-line filter: OFF

meter:

Filter: MEDIUM recommended, NONE, FAST available

1.B. PC Acquire operation, conditional

There may be interfering noise between the items when the meter sees the dark background. If this needs to be removed, install an optical sensor (for instance, **SICK** and **Omron**) to detect the edge of the item after it has arrived under the moisture meter's beam. It should send a falling TTL level pulse to the trigger input of the meter to start the Autotimer in Batch mode. The Batch size is adjusted so that the item will always be under the beam while sampling. The important general formula for estimating correct detection timing is the following:

$$NBatch < \frac{L}{ts * v}$$

Here **L** is the minimum width of the item along the conveyor, **v** is the line speed and **ts** the sampling interval which is likely equal to 0.0025 s (IRMA-7-D). Refer to Fig. 1.

For instance, if the line speed is 100 cm/s and the item width is always greater than 20 cm and we use the 400 Hz rate, the resulting maximum Batch size is 80. The settings for the program and the meter would be:

program (setup on the Acquire page):

Interval 0.05 s or 0.1 s
Conditional ON
Web temp ON only if you really need it (then interval 0.1s or longer)
On-line filter: OFF

meter:

Autotimer settings: interval = 0.0025s, Batch mode, Batch size = 80 or less
Bank: Use Series, clear before use
Connect the optical trigger output to the isolated input connector. Adjust the proper working distances.
Filter: MEDIUM recommended, NONE, FAST available

Settings for the memory banks, autotimer and the burst mode.

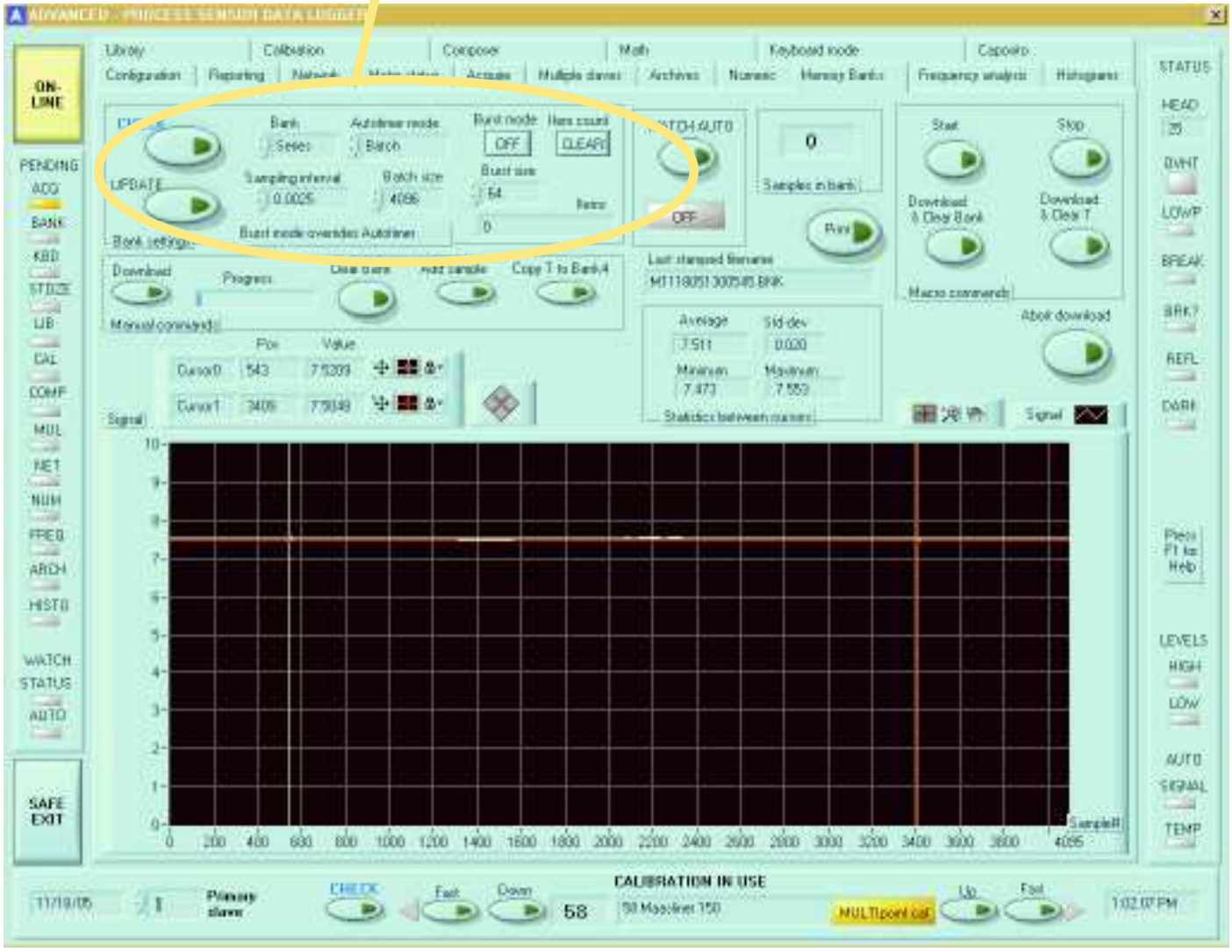


Figure 2 The program settings for the memory banks and autotimer.

Settings for the acquisition

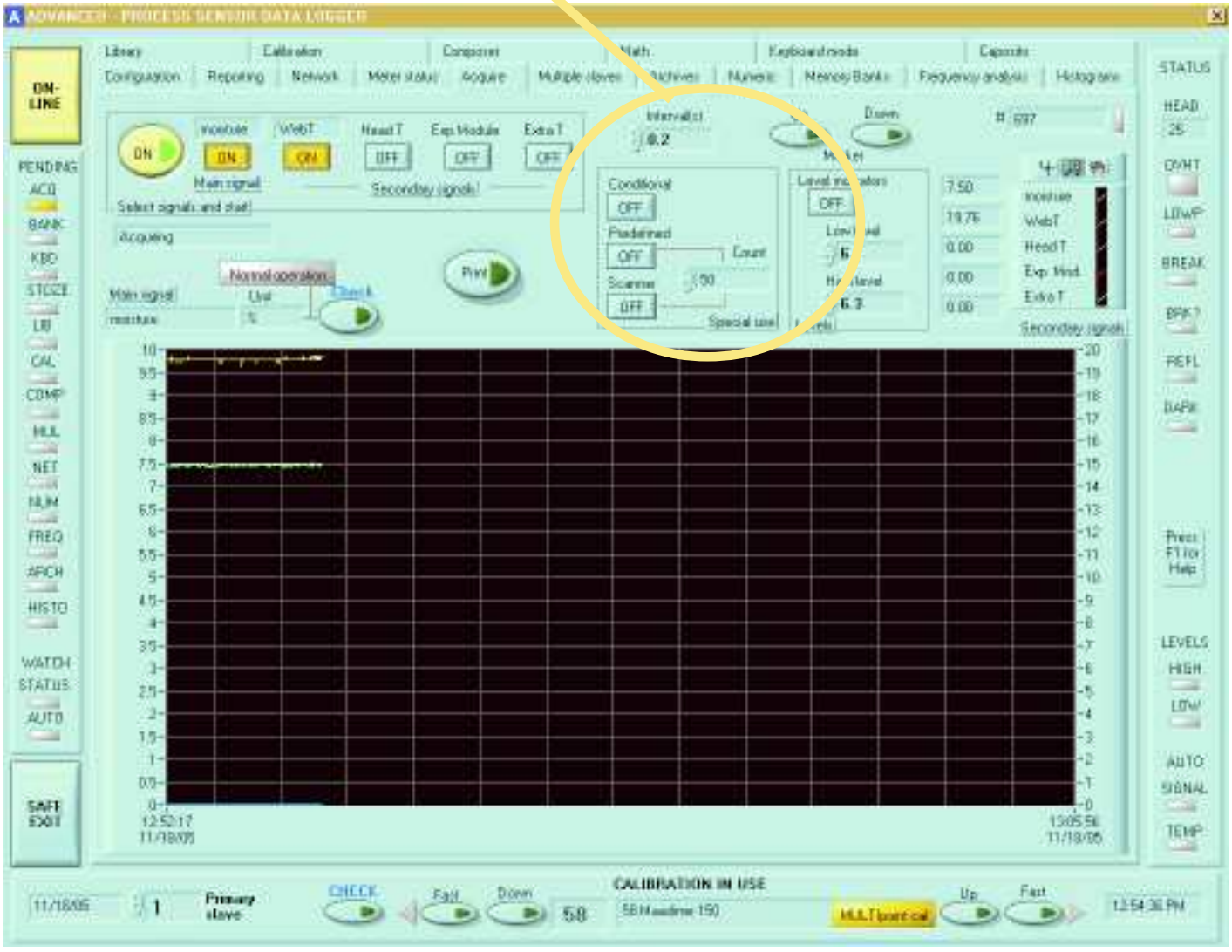


Figure 3 The program settings for the acquisition.

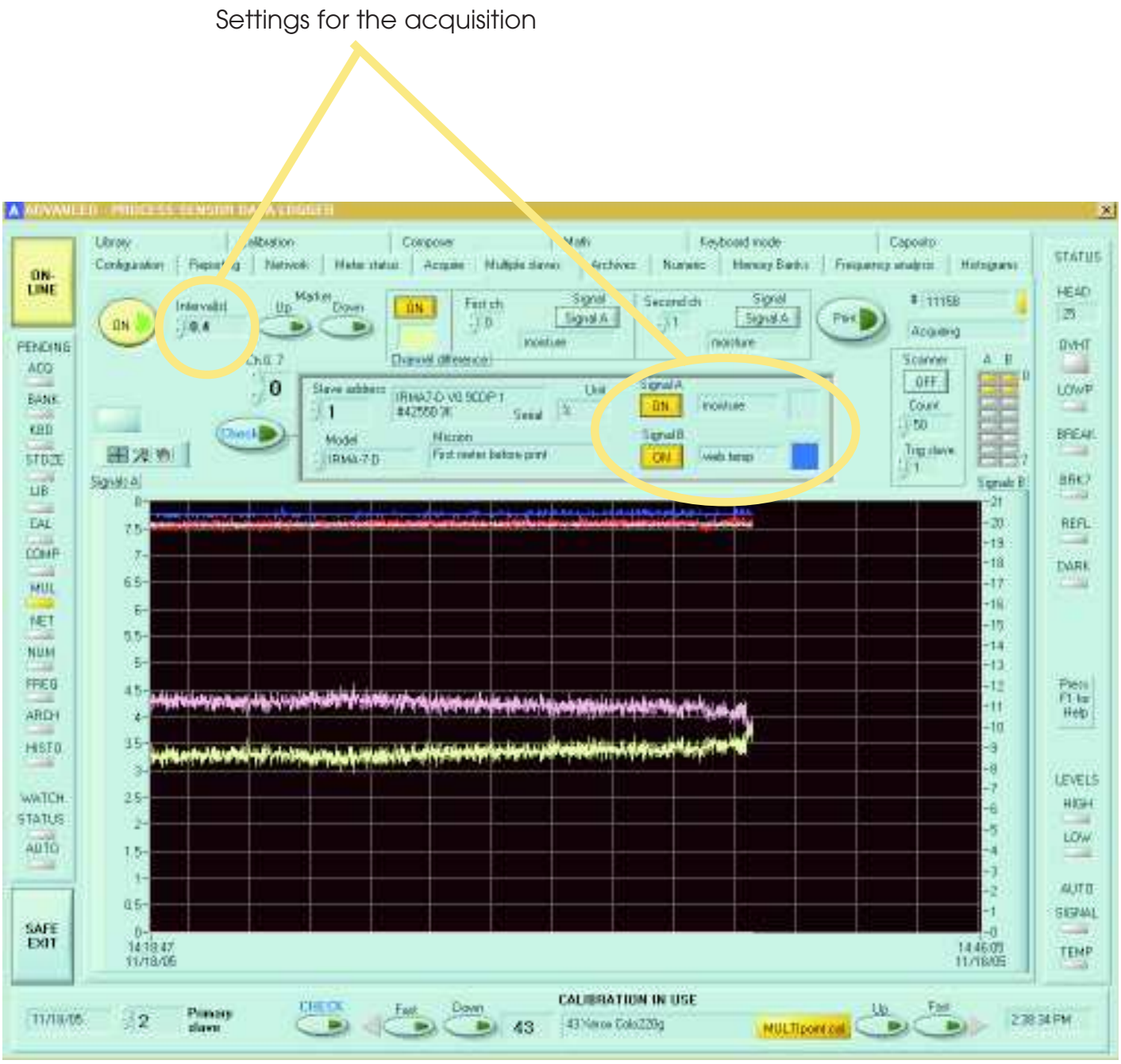


Figure 4 The program settings for the acquisition with multiple meters.

The idea is to use the conditional measuring option of the acquisition which collects data from the meter only when the Autotimer is on. Else, the data is replaced with zero values. This makes the screen look nicer with a few (maybe 10 to 16) sample points of true data. If noise is seen, readjust the optical trigger module and/or the Batch size to match precisely. Needless to say, the data is saved to the memory bank at the same time and can be downloaded afterwards. If not downloaded frequently, it will be overwritten by new data. Refer to Figs 2, 3 and 4 for the program settings.

1.C. Voltage output.

The purpose is to connect the voltage signal to either some data logger system of the mill automation system. The settings for the meter would be:

meter:

Voltage output signal: Moisture
Output scaling: 1.0 or an adjusted value for your system
Output range: 0..+10V, 0..+5V or +/-5V range corresponding to 0...100% of moisture and dictated by data logger input requirements.
Filter: MEDIUM recommended, NONE, FAST available

If only the moisture data from the items themselves is required, use the optical trigger to accurately pinpoint the measuring area. The trigger signal is led to the data logger system for gating actual sampling. If you need the web temperature, acquire it to the PC program.

2. Fast piecewise line, small or medium-sized items

In this example the line speed is high (> 1 m/s) increasing requirements on meter sampling and response times. All of the interfaces can sometimes be used. A few suggestions are below.

2.A. PC Acquire operation.

If the number of items flowing under the meter is smaller than 10/second and the line speed is not so high, you may be able to use the PC directly. Set the data acquisition up as follows. If you need the web temperature, use the voltage output for that purpose. The condition:

$$ts < \frac{L}{v}$$

needs to be valid for the method to work.

Program (setup on the Acquire page):

Interval 0.05 = 20 samples/s
On-line filter: OFF

meter:

Autotimer settings: Not used
Bank: Not used
Filter: MEDIUM, FAST or NONE if the line speed is really high

2.B. Profibus DP

If the number of items flowing under the meter is smaller than 50/second, you may be able to use the Profibus DP. The settings for the master and the meter would be:

DP Master program:

Polling Interval 0.005 s or smaller if supported in practice
On-line filter: OFF if any available
Use some sort of post-filter for the acquired data

meter:

Filter: FAST recommended, NONE if the line speed is really high

Display the data collected on the screen, save or pass it to the automation system at the rate required. Note that the dark space between the items will show as noise peaks. If a higher quality signal is required, use the optical sensor for triggering sampling points. Poll its state as often as practical and accept only simultaneous data.

2.C. Voltage output

Connect the voltage signal to either some data logger system of the mill automation system. The settings for the meter would be:

meter:

Voltage output signal: Moisture
Output scaling: 1.0 or an adjusted value for your system
Output range: 0..+10V, 0..+5V or +/-5V range corresponding to 0...100% of moisture and dictated by data logger input requirements.
Filter: MEDIUM recommended, NONE, FAST available
Use some sort of post-filter for the acquired data

If only data from the items themselves is required, use the optical trigger to accurately pinpoint the measuring area. The trigger signal is led to the data logger system for either gating the actual sampling or triggering a single sample. If you need the web temperature, use the Acquire operation for that purpose. It can also collect a slow noisy version of the moisture data.

2.D. Memory bank

If the number of items flowing under the meter is smaller than 200/second, you may be able to use the memory banks and the Autotimer. Set the data acquisition up as follows. If you need the web temperature, use the voltage output for that purpose.

Program (setup on the Memory Banks page, Acquire OFF):

Interval 0.0025s
Bank: Series
Bank mode: Batch
Batch size: 1 or more depending on the size of the items, adjust as needed
Watch AUTO: ON

On-line filter: OFF

meter:

Filter: MEDIUM, FAST or NONE if the line speed is really high

Use the optical sensor module connected to the trigger input to locate the starting edge of each item under the beam. Try to have as many samples taken as possible from each item (Batch size). Data is saved to the current bank and has to be downloaded before it gets full. The only way to see the filling is to keep the WATCH AUTO button pressed. That will update the count frequently. When the count 4096 is close, press the button **Download and Clear** to display and save the data. Fresh data is collected to the bank after that. This method has gaps in sampling while downloading. You can use the Profibus DP interface for much faster downloading of the data. Programming the DP master may give you a fully automatic system.

3. Piecewise line with dense layer of small-sized particles (like wood chips)

In this example which is mostly targeted for moisture meters, the line speed is not important. However, the particles are randomly scattered and the mass flow height may vary much. Also the moisture content may have great variations between particles in the worst case. The most interesting variable for the user is the slow average moisture reading. It is possible to do measurements with all of the interface choices available in the meter if the filter settings are made correct.

The ratio of signal-to-noise is not good. We need to use all of the available filters to clean up the large variations. The result will be a clean signal but the response time is long (15s to full accuracy). This should be no problem as long as we are interested in the slow average. The PC program can follow the signal as such and the same applies for the Profibus DP and voltage output. Use a mechanical plough for leveling the material stream before the meter. This will lower the noise. Also, a mechanical mixer before the plough would be recommended as it will usually give a representative composition of the process flow. Set the data acquisition up as follows.

Program (setup on the Acquire page):

Interval 0.2s or any other required but not too long
Web temp ON only if you need it
On-line filter: ON

meter:

Autotimer settings: Not used
Bank: Not used
Filter: BOX or SPECIAL
Using some sort of post-filter for the acquired data is recommended

4. Suggestions of Technical Details.

4.A. Gain Locking (Obsolete, in old meters only)

In case the conveyor has a significant vertical movement or the material surface has large height or darkness variations, one would be advised to do the following. **Gain locking** should be turned **ON** instead of the default **Autoranging** setting. As explained in the manuals, autoranging allows varying signal amplifications adapting to varying conditions thus optimizing the signal-to-noise ratio. When the gain is changed, there will be a glitch in the moisture signal and the changing process will take a little while after the need for it arises. This slows down the signal response in strongly varying conditions. In those conditions, it is recommended to **Lock** the gain after letting the meter settle first with a white paper in front of it at the correct working distance. This will make sure that there are no glitches and the meter will adapt to true moisture changes with the specified response times. The locking can be used continuously without any harm. It is done e.g. in the PC program:

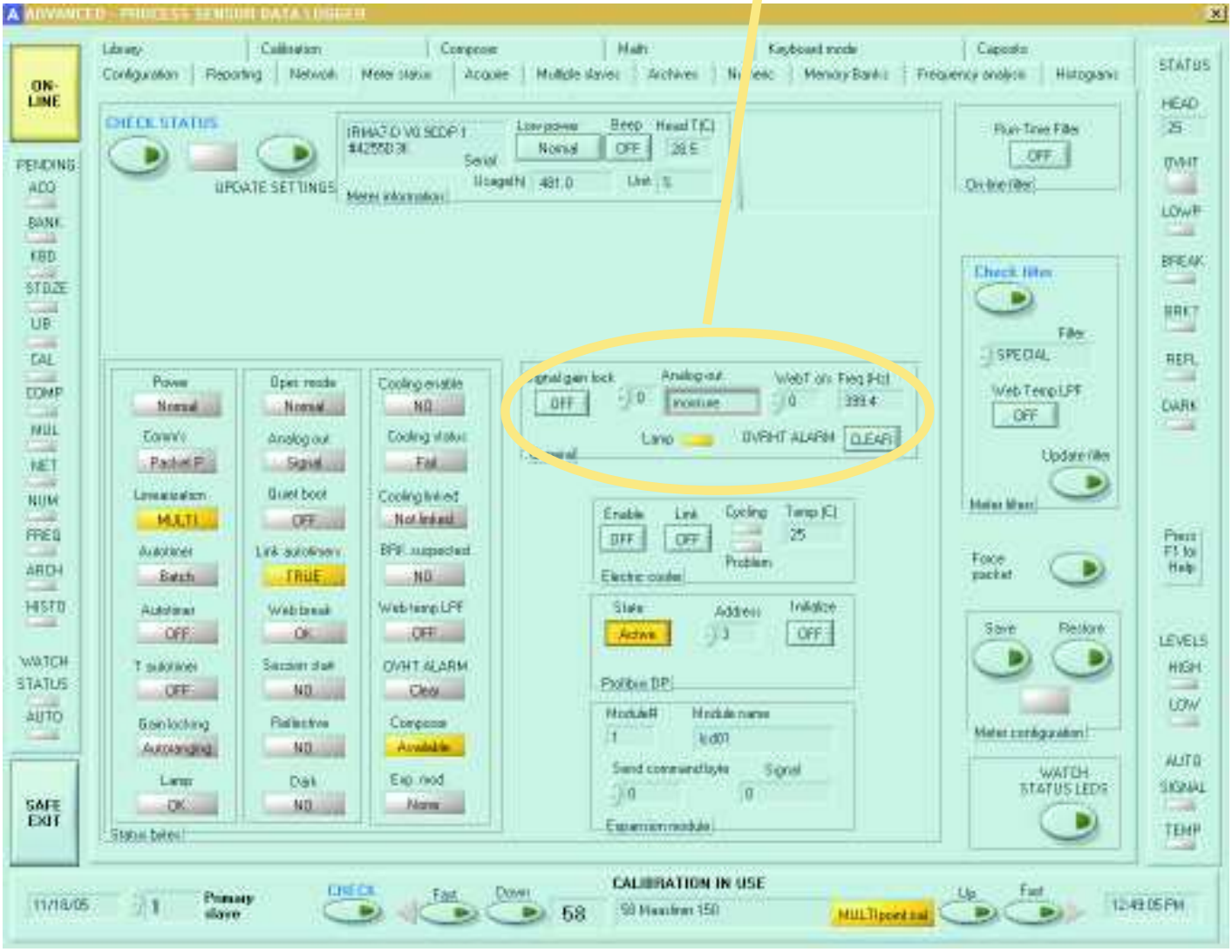
Program (setup on the Meter Status page):

Signal gain lock:ON

First, CHECK the settings, then perform UPDATE SETTINGS after changing this. Using the locking gives some advantage also in cases where the background is glossy or affects otherwise when there is no material under the meter. Refer to Fig. 5 for the program settings.

Please note that the gain locking is not used in present meters. That feature can be found in older units only.

Settings for the gain locking and voltage output redirection.



Refer to Fig. 5 The program settings.

Refer to Fig. 6 The Numeric display page. It is usually visible at a distance of some 15 to 20 meters minimum.

4.B. Angle

When the meter is installed to the conveyor, observe the angle to web surface, especially if the material is glossy. The angle is not important for crude materials, like minerals or flour as long as they do not contain particles with glossy surfaces.

4.C. Background

Installation of moisture meters also calls for checking the background behind the material to be measured. If measuring thick papers and boards (> 120 g/m2), wood veneers, pellets etc., the background is not important. For thin papers and films, the background may contain varying and unknown moisture which may be seen through the material. If you have a thin paper over a board whose moisture is nonzero, most probably that moisture is added to the reading with a great weight. The apparent basis weight is then really much higher and should be taken into account when the calibrations are considered. In cases like that, it would be recommended either to look for another mounting position along the conveyor or to install a matte metal plate under the material to isolate the moist background.

The background may also be reflective sending back an unexpected light signal thus distorting the moisture reading. Reflections are the most difficult to predict. It is much easier to prevent them than to correct them. Prevention can be done by either installing the meter to an angle to the web for it not to receive the reflected light or to find another location where to put it. One easy way to solve it is to put a matte plate under the web.

4.D. Models

Information in this technical note refers to IRMA-7 model D. Most of this data can be used for other models, like **AK30**, with some modifications depending on the lower sampling speed and reduced set of features.

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