# CONFIGURATION OF SPOT AL EQS ACCORDING TO ALLOY TYPE

INTRODUCTION

The SPOT algorithms have been developed and tested on many different alloys, from all series 1000 up to 8000. During site trials, we found that one algorithm could be used to cover the whole emissivity / temperature / radiance band for all alloys, on *freshly formed* surfaces.

However, some algorithm tuning is likely to be required for different alloys if the oxide layer has spent longer than a few seconds at high temperature.

We investigated the reason behind this finding in collaboration with Bridgnorth Aluminium Ltd, while performing site trials at their hot rolling mill. Spectroscopic measurements revealed that despite relatively small differences in nominal composition from alloy to alloy, the type of surface oxide film formed in a preheat furnace over many hours varied dramatically with alloy type, with magnesium diffusing towards the surface. Layer thickness increased with temperature and duration of the preheating. In contrast, freshly formed films of all alloy types exhibited nearly identical amorphous surface oxide films of thickness 15-20Å.

The graph below shows oxide layer composition for three different alloys and two different sizes of slab - wider slabs are preheated for longer and at higher temperatures. After rolling to plate gauge, the surface area has increased to around 40x its original size, so the surface can be considered to be freshly formed.
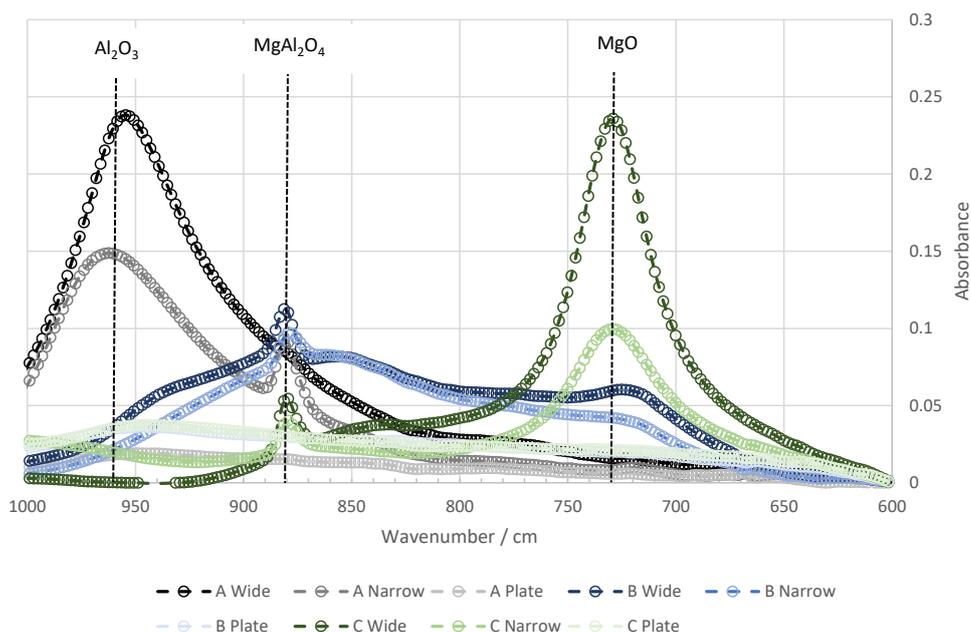
These results were published in the Proceedings of the Aluminium Two Thousand World Congress 2017 [S.F. Turner, R.W. Gagg, D.C. King, P. Drögmöller, L.K. Muman, R.D. Hunt: *Practical Infrared Thermometry for Aluminium Hot Rolling*]

The results explain why for extrusion applications where the surface is freshly formed, the AL E algorithm can work 'out of the box'. Where we have seen algorithm offsets required in extrusion applications, they tend to reflect (literally!) ambient lighting. The same is usually true for post-quench measurements using the AL Q algorithm, where the profile is cooled before the oxide layer can mature.

For strip applications, the uncorrected AL S algorithm was shown to work on all alloys after at least two passes through the reversing mill. However, an alloy-specific algorithm offset was required for accurate temperature measurement of initial slabs straight out of the preheat furnace.

ALLOY-SPECIFIC CONFIGURATION METHODS

The SPOT can calculate its own algorithm correction if you enter a thermocouple calibration value.   This can be entered using the webserver, by a direct Modbus TCP write instruction, or using SPOTViewer. SPOTViewer offers the advantage of compiling a database of different alloys and facilitating the later change from one to the other. All three methods are explained.

<u>WEBSERVER METHOD</u>

Click on the >>> link from the settings page to open the APP page.
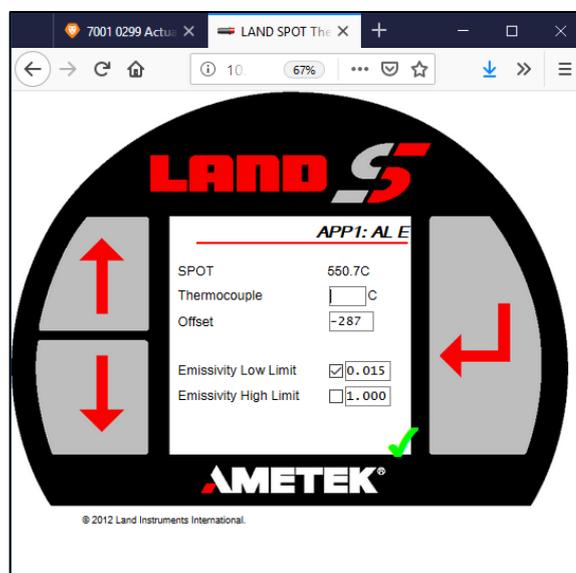
To adjust the pyrometer for the current alloy, take a thermocouple reading, enter the correct temperature in the 'Thermocouple' box and press enter. The instrument will automatically calculate the offset required and show it in the 'Offset' box. The SPOT will immediately start using the new offset value, which you will see reflected in the live 'SPOT' temperature measurement.

Thermocouple entry and automatic offset calculation must be performed while the instrument is reading live temperatures, so that it can work out its own error. However, the offset value can be changed manually at any time. Thus, an offset value recorded for a particular alloy can be re-entered later when that alloy is used again, by typing into the 'Offset' box.

Note that the offset is not a temperature value, it is an offset to the rate of change of non-greyness with emissivity, so the temperature effect cannot be predicted.

MODBUS TCP METHOD

The webserver functionality can be replicated by writing to and reading from Modbus registers directly. The methodology is explained further in the SPOT Modbus User guide, from which this excerpt is taken:

569	App 1 Offset	Offset to the App1 algorithm gradient, used to tune the algorithm to site conditions
581	App 2 Offset	Offset to the App2 algorithm gradient, used to tune the algorithm to site conditions
593	App 3 Offset	Offset to the App3 algorithm gradient, used to tune the algorithm to site conditions
1024	Thermocouple value	Thermocouple value in 10x degrees C or F. Write a value here to autoset emissivity or automatically tune the algorithm in App mode. If the entered value is within the allowed tuning range, the instrument will automatically adjust its emissivity / offset and write 0 to this register. If the entered value is out of range, the instrument will not change its settings and write 0xFFFF to this register.

To adjust the algorithm for the current alloy, write a thermocouple value to register 1024, allow the SPOT time to respond, then read the offset value from the register corresponding to the current algorithm – register 593 for the AL S algorithm. The SPOT will immediately start using this offset value to correct its measurements.

As for the webserver method, a thermocouple value should only be entered during live measurements, but an offset can be written at any time.

To compile a configuration file, record each offset value to a file during calibration, referenced by the alloy name. In the future, when that particular alloy is selected for production use, the file should be read and the average value of all offsets for that alloy written via Modbus TCP to the offset register (593 for the AL S algorithm).

SPOTVIEWER METHOD

In the Devices menu, click on the settings icon ⚙ to open the settings panel.

Select 'Material Calibration' on the Calibration Tab.

During calibration, click ⊞ to set up a new alloy, and enter a name for it in the right-hand panel.

Enter a thermocouple value into the 'Reference Temperature' box and click ⟩ to calculate the required offset. A new row is added to the table and the offset calculated.

Repeat this step to add more values to the table. The table will automatically be stored on the PC where SPOTViewer is running, but you can click on the export icon 🖳 to save it to another file location, or for use on another SPOT pyrometer.

The SPOT will start to use the new offset as soon as it is calculated.

If an incorrect value is entered, click on that row of the table then the delete icon 🗑 to the right of the table to remove that single value.

During production, use the panel on the left to select the alloy that is to be used. Click on the delete icon next to this panel to delete the selected alloy.

Click on the import icon 🖳 to load a new table, for example one compiled on a different SPOT pyrometer.

Each time an alloy is selected, or a new data point is added for that alloy, the best offset is recalculated from the dataset stored in the table.

WHICH METHOD TO USE?

The webserver only allows you to set one value. It is a basic interface to the pyrometer rather than a software package. While the offset value is preserved on power-off, the SPOT has no datalogging functionality, so it does not store any historic data, or sort them according to alloy type.

SPOTViewer stores the original thermocouple and the signals at both wavelengths of the pyrometer so the offset can be recalculated from the raw data every time, using the exact calibration of each instrument. If only one SPOT is used during calibration and then in production, this is just an average of individual offsets for each point as would be calculated by the Modbus TCP method. However, if different SPOTs are used, the offset values will take into account the calibration of each instrument, so the result may be 1-2C more accurate using the full SPOTViewer recalculation than using a simple average via the Modbus TCP method.

The Modbus TCP method is the only one that could be fully automated in production. Even during calibration, the amount of user effort would be minimised as a PLC would already know the alloy name. I would recommend this method to any customer who has the facility to set up and manage their own control system.

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