Measuring bath properties using the STARprobe™

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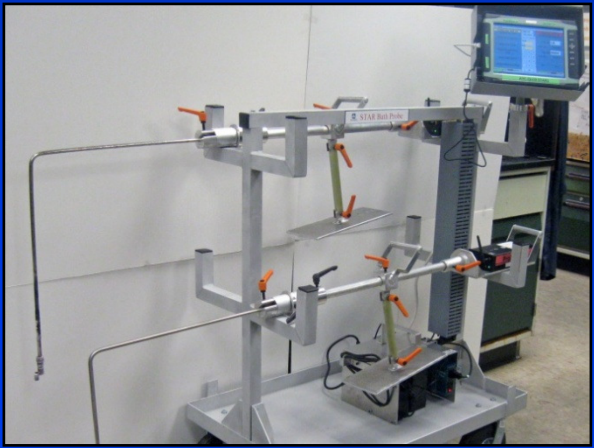
Plan of the Presentation

- Introduction
- First measurement campaign
  - First repetitivity test
  - Second repetitivity test
- Second measurement campaign
- Conclusions

Introduction

The STARprobe™ is a portable device that takes real time measurements of bath properties, such as Superheat, Temperature, Alumina concentration and bath Ratio or acidity (STAR), in electrolysis cells. This synchronicity of measurements is a most important step forward in improving the control and efficiency of electrolysis cells.



Introduction

Same Replaceable Probe tips

GENISIM

STAS

Introduction

Probe Head (Box)

Introduction

Tablet PC

Introduction

Considering the great advantages of the STARprobe™, Alcoa has decided to share the technology with the rest of the aluminium industry starting from 2012. In this regard, Alcoa has just appointed STAS, a well recognized leader in the aluminium industry (www.stas.com), to commercialize the new STARprobe™ analyzing system.

GENISIM STAS

First measurement campaign

First repetitivity test

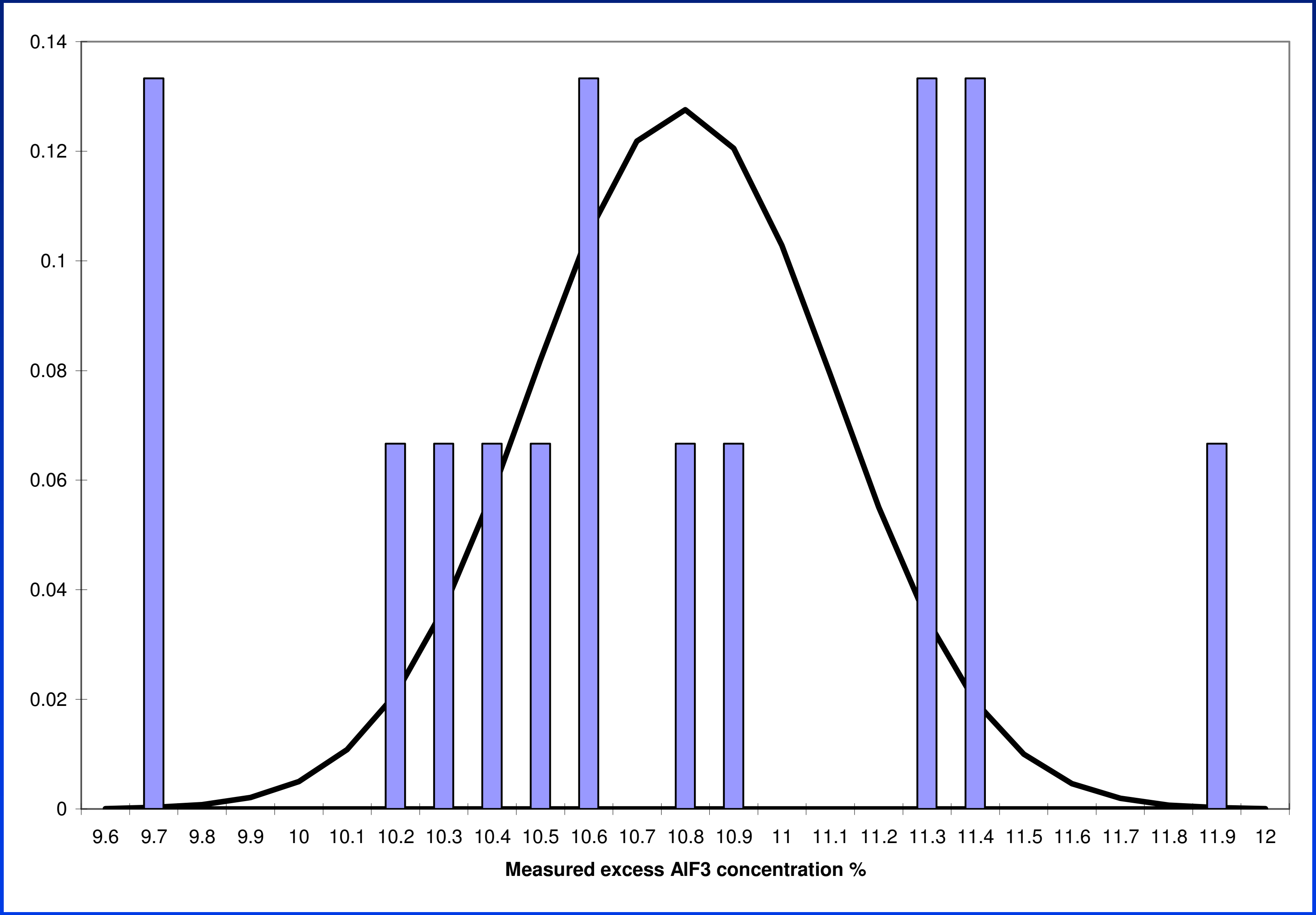
One big question that is typically set aside when bath samples are taken for bath chemistry control purposes is how homogenious is the bath and hence how representative is a small localised bath sample of the average composition of the bath.

For that purpose, 15 consecutive STARprobe^{TM} measurements were carried out in the tap hole of the same pot over a period of 90 minutes averaging one measurement every 6 minutes.

First repetitivity test

Position	Excess	Al2O3	Temp	Super
tap	10.25	2.93	969.18	6.21
tap	9.67	2.53	971.02	2.05
tap	10.78	2.85	966.68	6.35
tap	10.51	2.6	970.72	8.8
tap	10.89	2.49	970.16	5.87
tap	10.38	2.13	969.98	2
tap	11.31	2.4	971.18	6.72
tap	10.55	2.76	966.51	5.6
tap	10.2	2.5	970.34	3.8
tap	10.48	2.86	968.13	4.9
tap	11.81	2.12	972.61	5.54
tap	11.37	2.08	967.42	2.67
tap	11.27	2.72	963.65	4.24
tap	9.69	3.21	967.3	4.44
tap	11.26	2.7	965.93	4.98
Mean	10.69466667	2.592	968.7206667	4.944667
StdDev	0.625446888	0.321696396	2.443067354	1.84237

First repetitivity test



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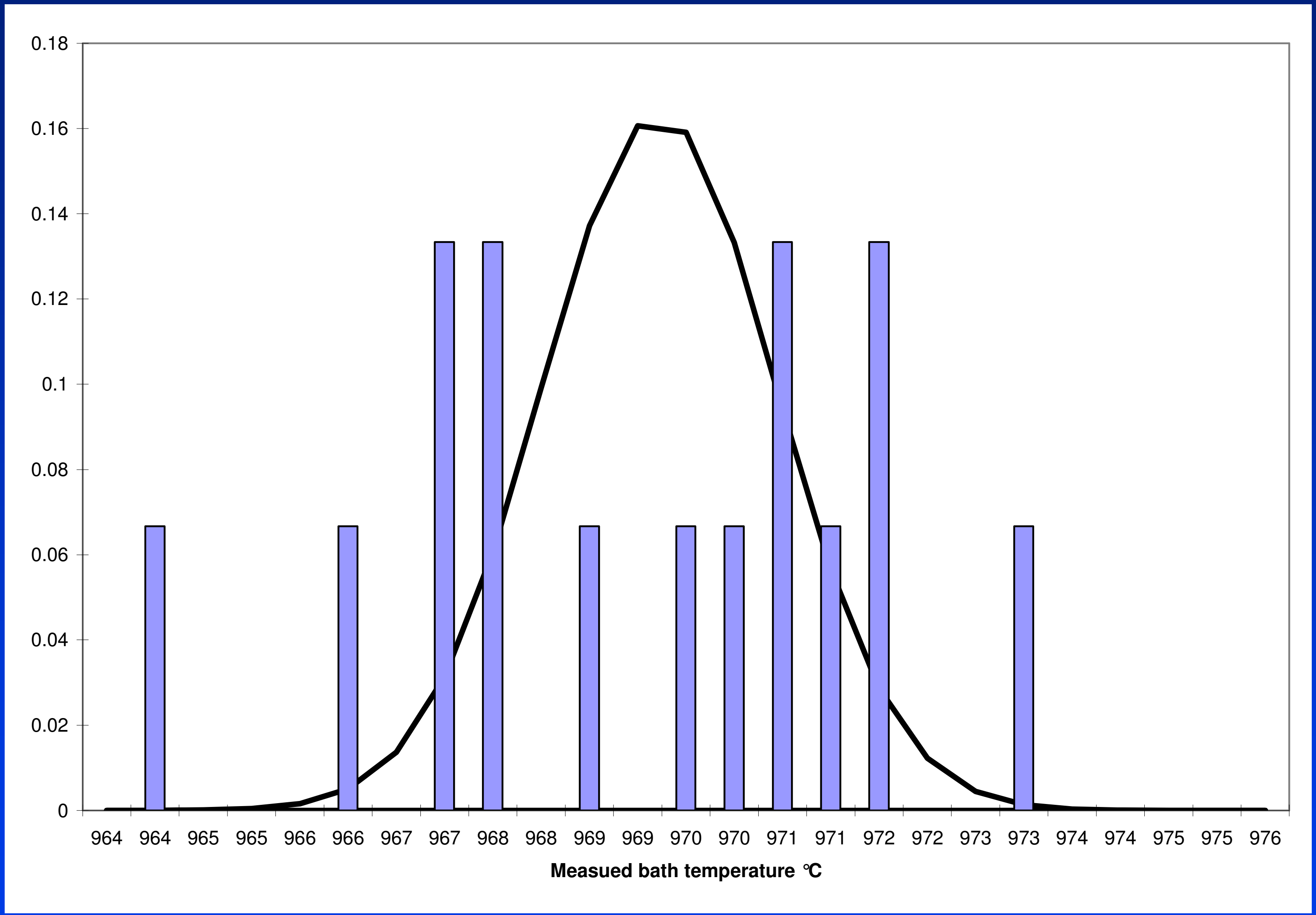
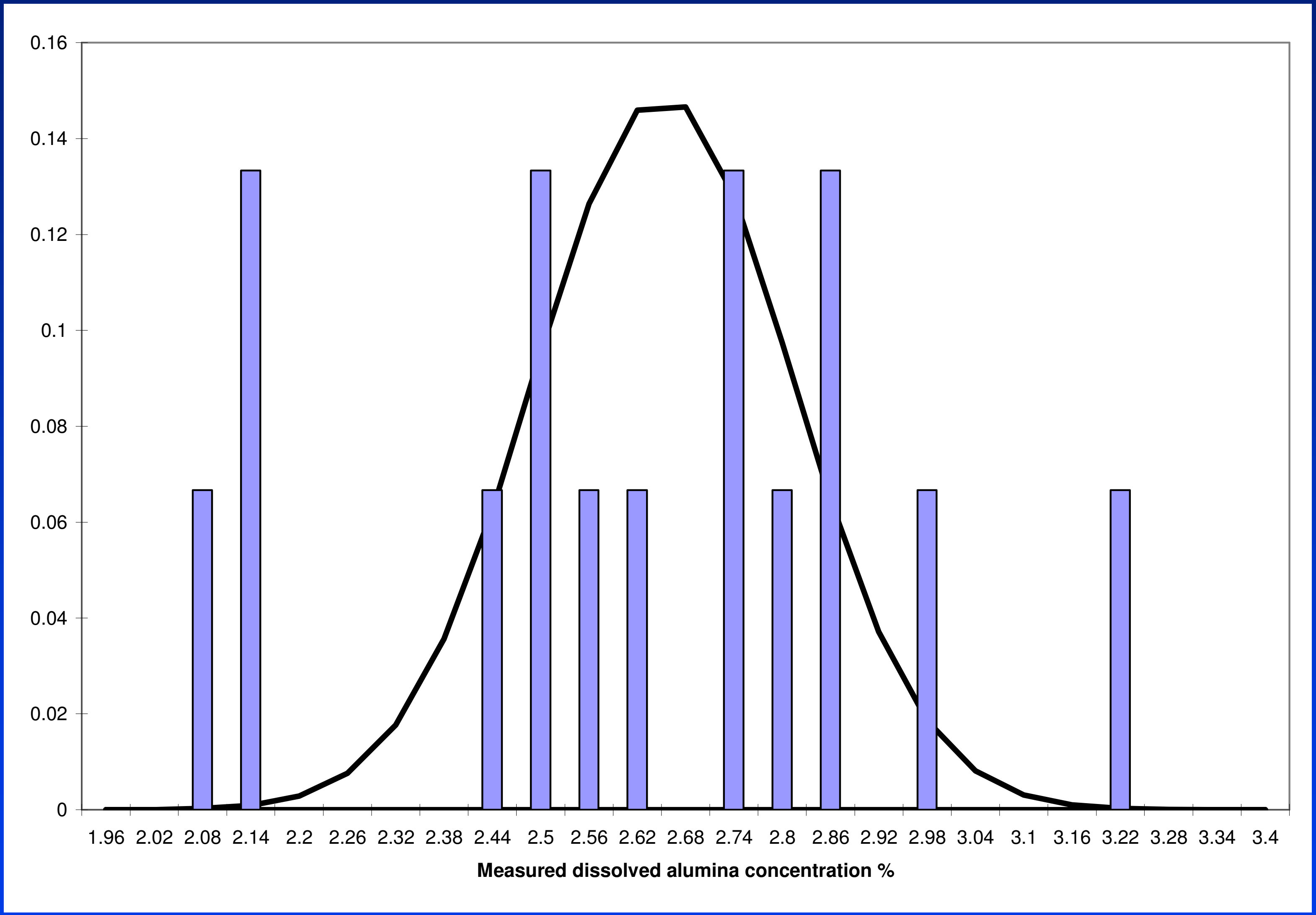
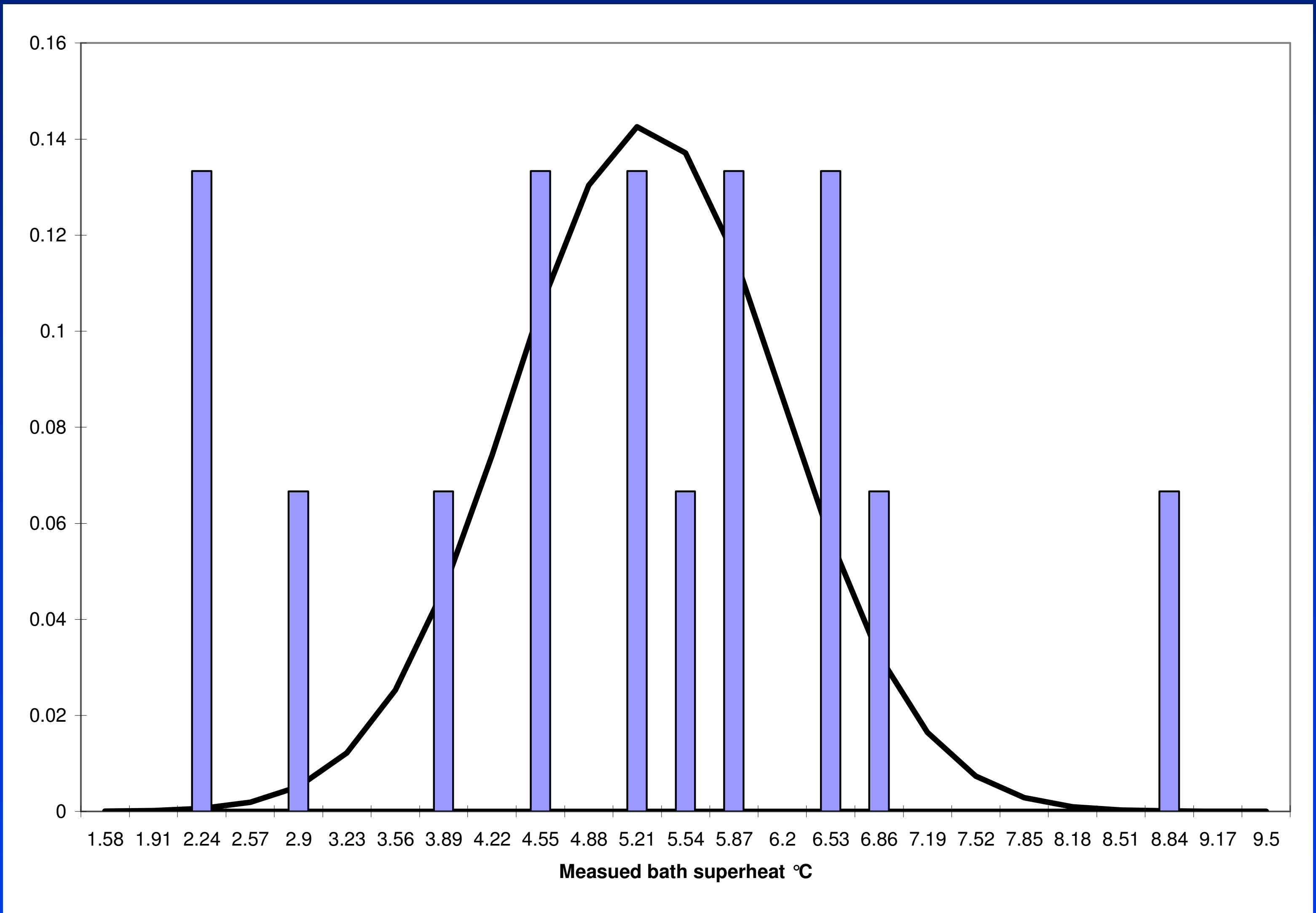
First repetitivity test



First repetitivity test



First repetitivity test



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First measurement campaign

First repetitivity test

Figures highlight the relative variability or lack of strict repetitivity of the measurements which in turn highlight the lack of homogeneity of the bath. This is particularly true for the dissolved alumina concentration and the bath superheat which is directly affected by the dissolved alumina concentration in the bath sample analysed by the STARprobe™.

Nevertheless, the averaged results give a very consistent picture of the cell conditions as the average measured excess AlF_3 concentration of 10.69%, the average measured dissolved alumina concentration of 2.6%, the line average CaF_2 concentration of 4.9% and the measured average bath temperature of 968.72 °C can be use to calculate a bath superheat of 4.97 °C using the Solheim equation [3] while the measured average bath superheat is 4.94 °C.

First measurement campaign

Second repetitivity test

In order to ensure that the above results are really typical, a second repetivity test was performed the next day again repeating STARprobe™ measurements in a single cell, this time 22 measurements in total over the same period of 90 minutes averaging 4 minutes per measurement. This time, bath sample have been taken in 2 different locations, the taping hole and in a hole opened for that purpose in the side channel quite far from the tapping hole.

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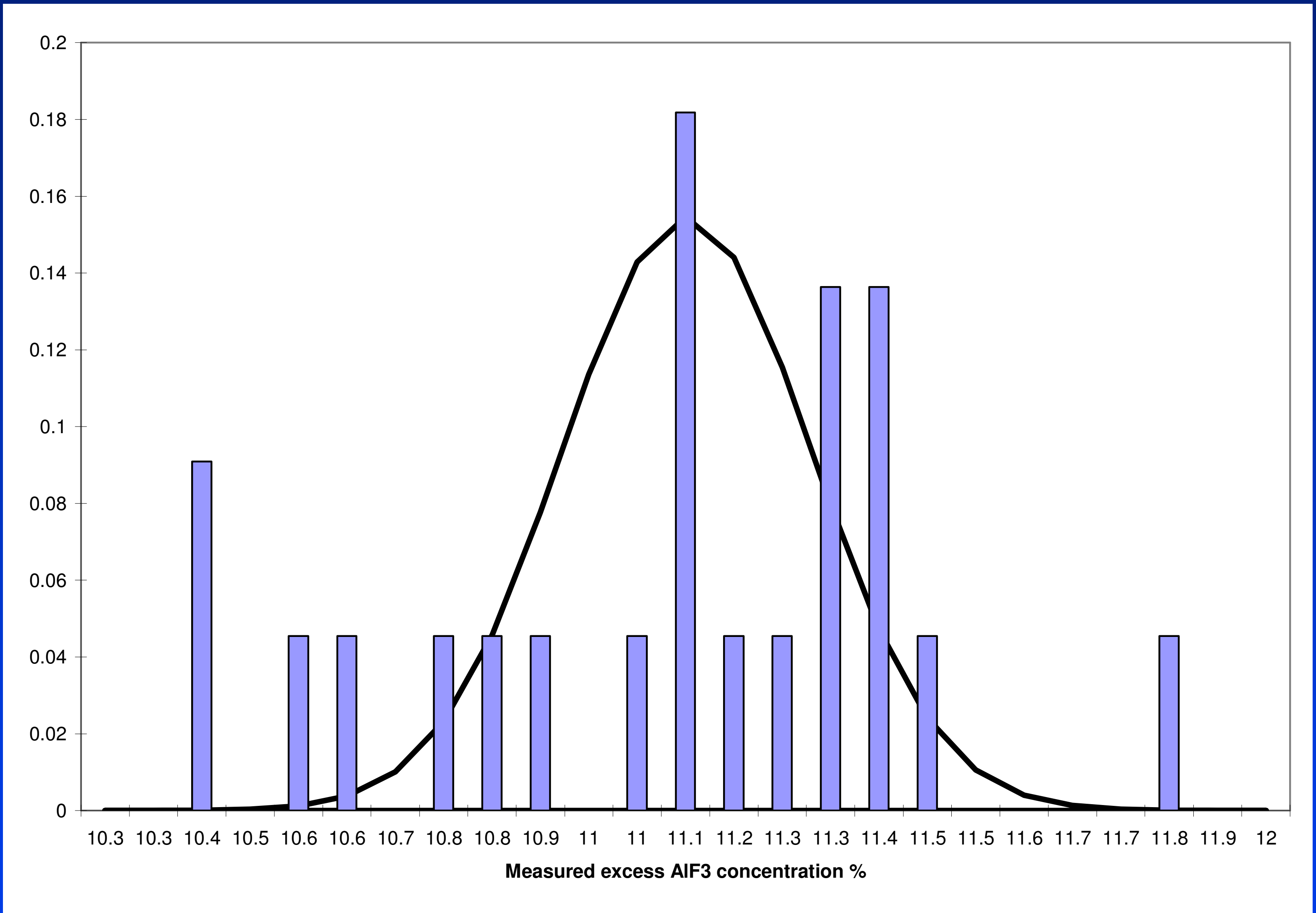
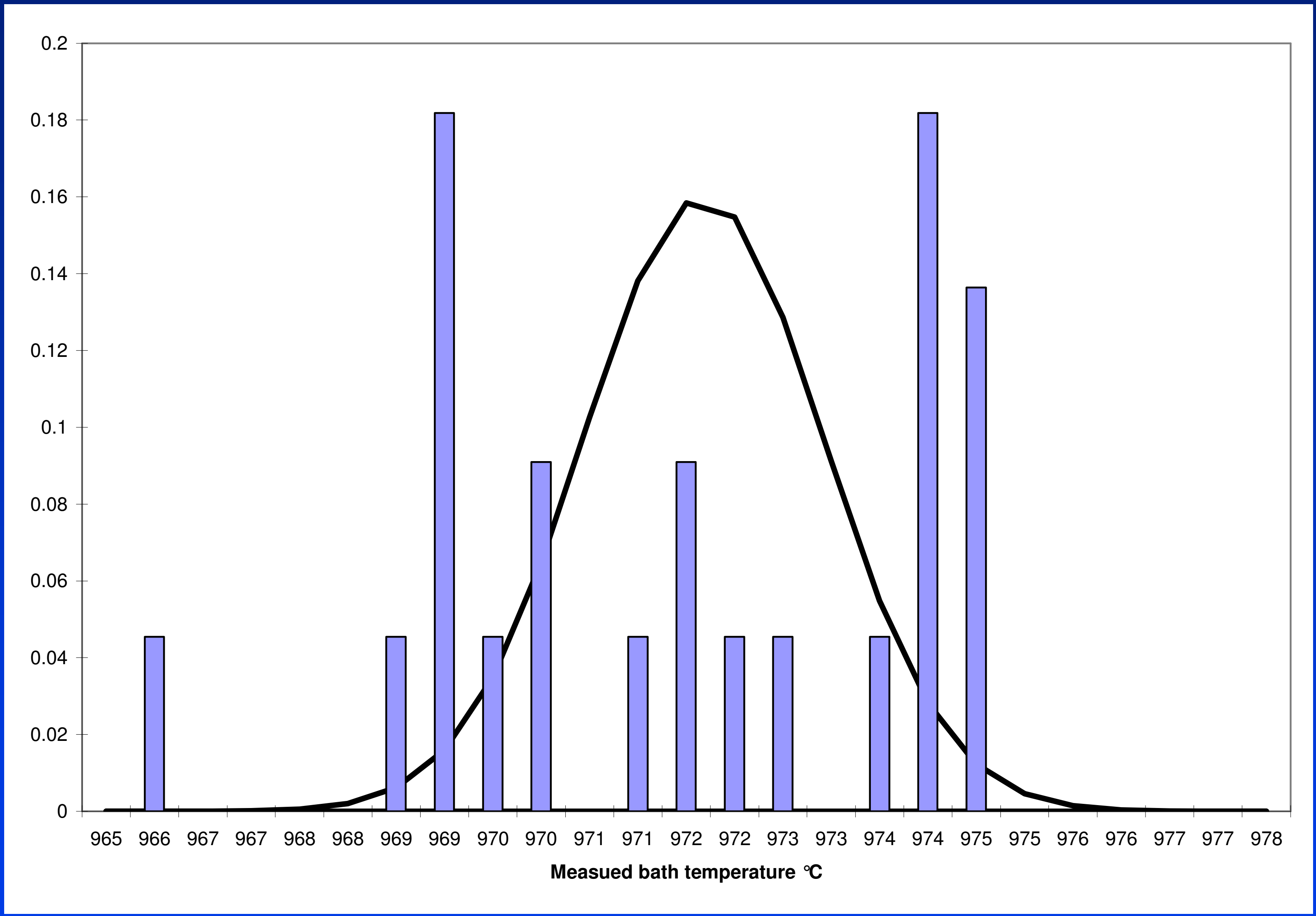
Second repetitivity test

Position	Excess	Al2O3	Temp	Super
tap	11.28	3.7	965.91	12.43
tap	11.39	3.61	968.02	12.23
tap	11.08	3.24	968.83	14.98
tap	10.81	3.65	968.59	13.53
tap	11.06	3.4	968.82	13.55
tap	11.19	3.92	969.65	16.66
side	10.98	3.32	973.66	18.25
tap	11.43	3.09	970.89	11.65
side	10.38	3.14	973.92	9.64
tap	10.51	2.16	972.09	2.69
tap	11.06	2.51	971.22	8.64
side	10.37	2.69	973.77	7.54
tap	11.12	2.72	971.63	9.91
side	11.3	3.13	974.09	12.52
tap	10.59	3.45	969.7	12.92
side	11.06	2.16	973.93	8.59
side	11.28	2.7	974.31	11.47
tap	10.71	3.71	968.89	11.84
side	11.35	2.7	974.36	11.02
tap	10.88	3.23	971.26	12.78
side	11.34	2.7	973.14	10.83
tap	11.75	3.26	969.2	10.68
Mean	11.0418182	3.09954546	971.176364	11.56136
StdDev	0.36109142	0.49763706	2.49308099	3.20755

Second repetitivity test



Second repetitivity test



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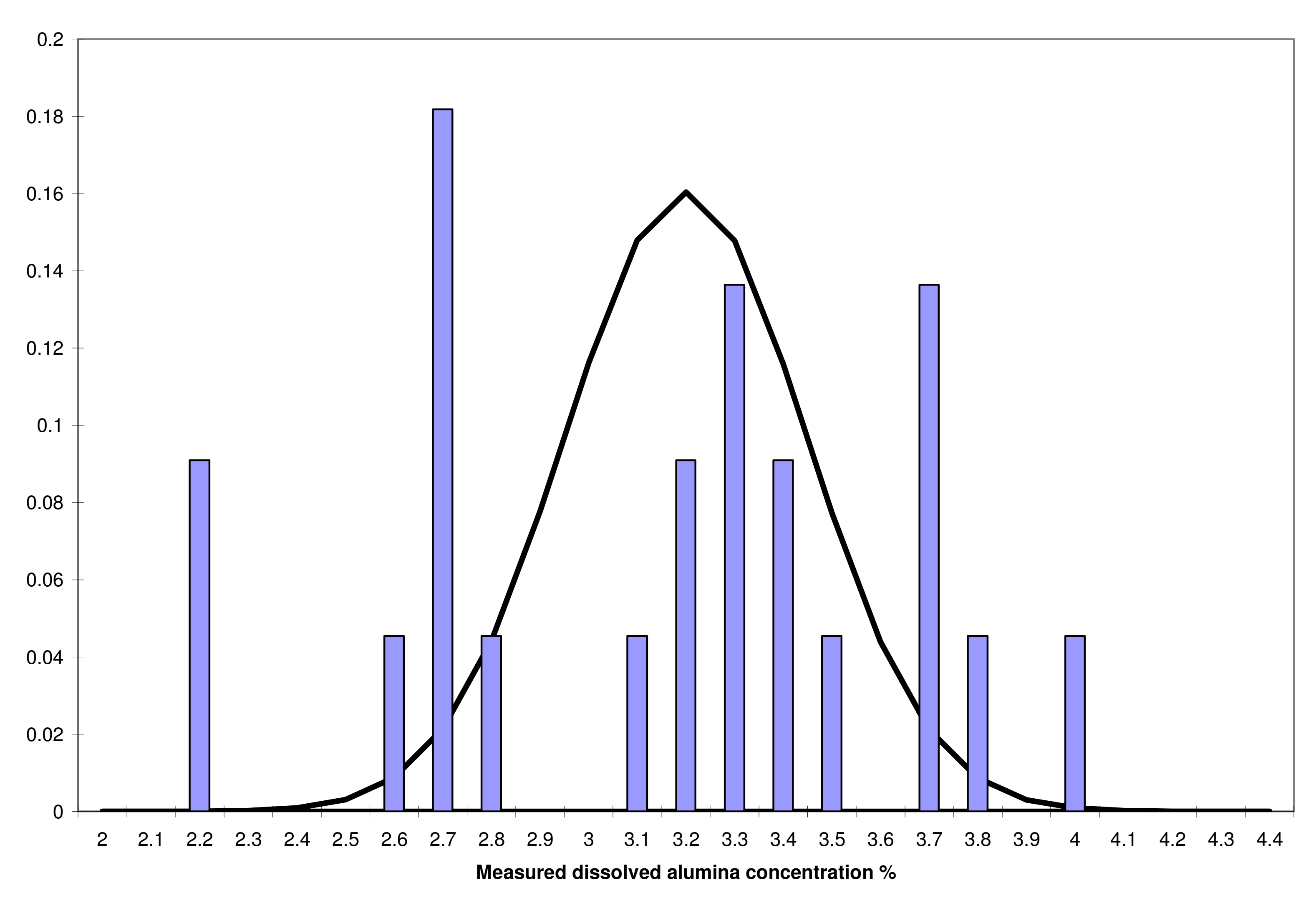
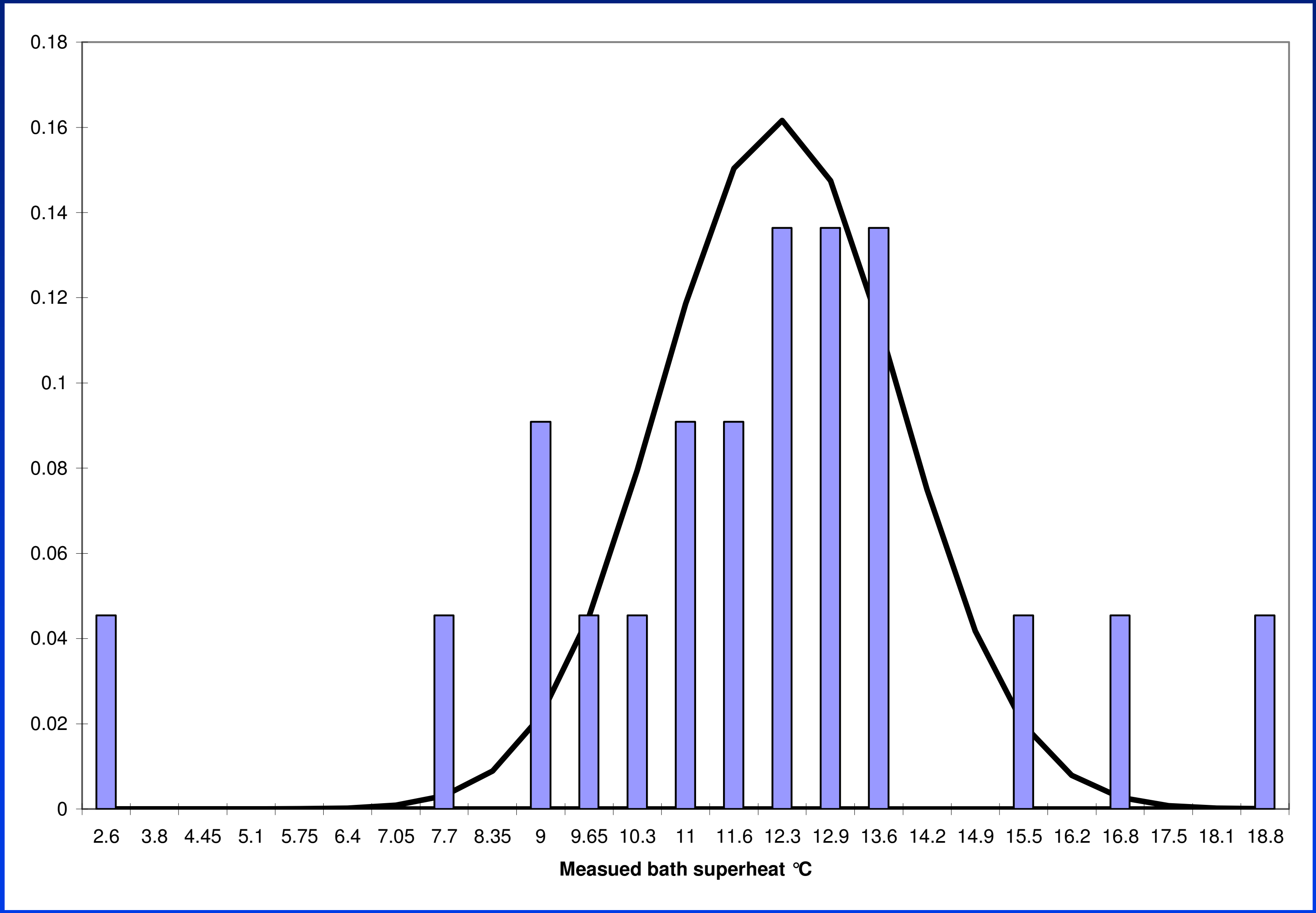


Second repetitivity test



First measurement campaign

Second repetitivity test

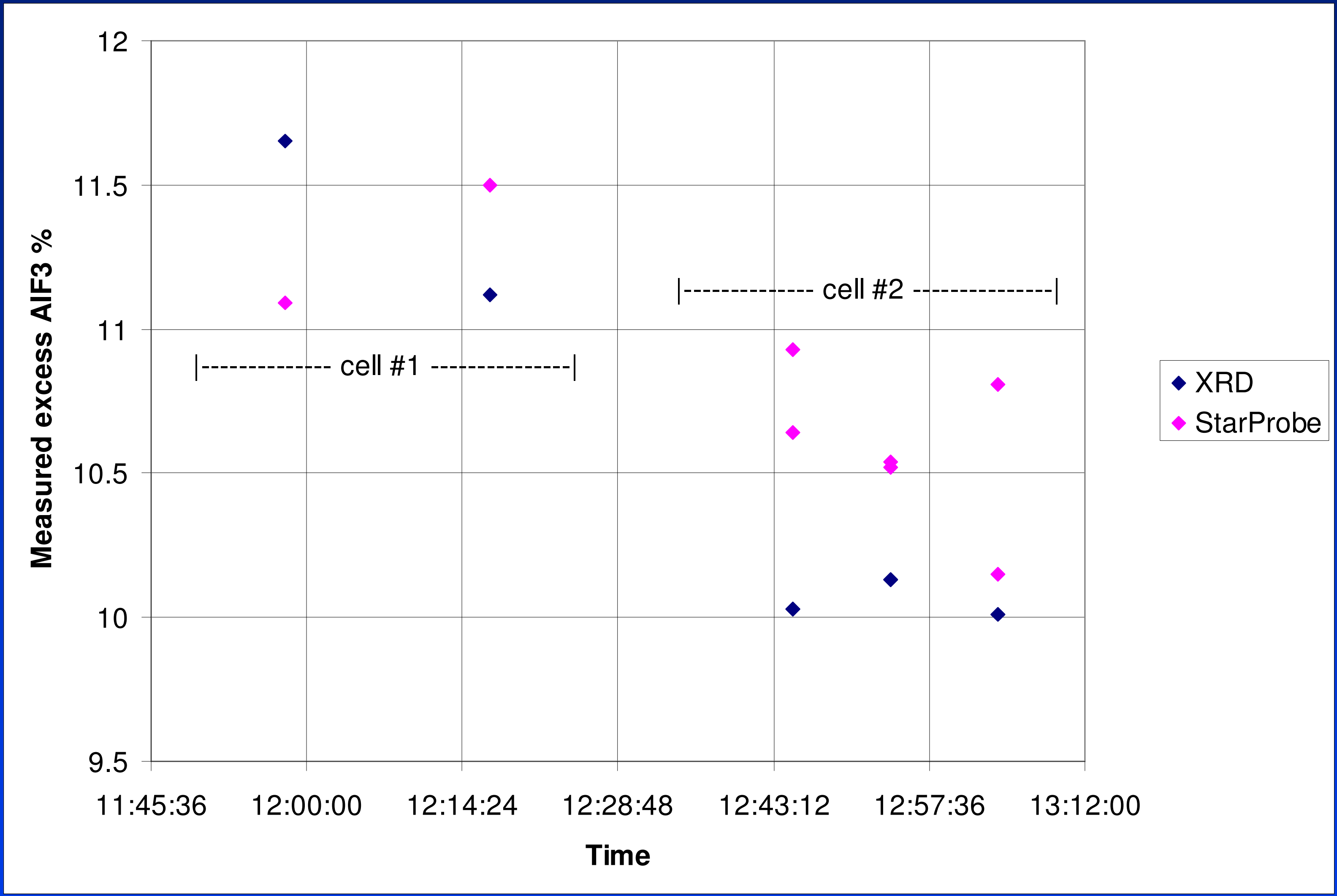
Results from the second test are very similar to those of the first test again highlighting the lack of homogeneity of the bath. The tapping hole seems to be as good a location as anywhere else to take bath samples.

Again the averaged results give a very consistent picture of the cell conditions as the average measured excess AlF_3 concentration of 11.04%, the average measured dissolved alumina concentration of 3.1%, the line average CaF_2 concentration of 4.9% and the measured average bath temperature of 971.18 °C can be use to calculate a bath superheat of 11.88 °C using the Solheim equation [3] while the measured average bath superheat is 11.56 °C

Second measurement campaign

The second measurement campaign was carried out in another smelter operated by another aluminium producer in order to demonstrate the STARprobe™ technology. So the aim of that very short measurement campaign was to quickly verify that the STARprobe™ can replace the bath sampling/XRD lab analysis of the excess AlF_3 concentration and can measure the bath superheat as well as the other commercial method available.

Second measurement campaign

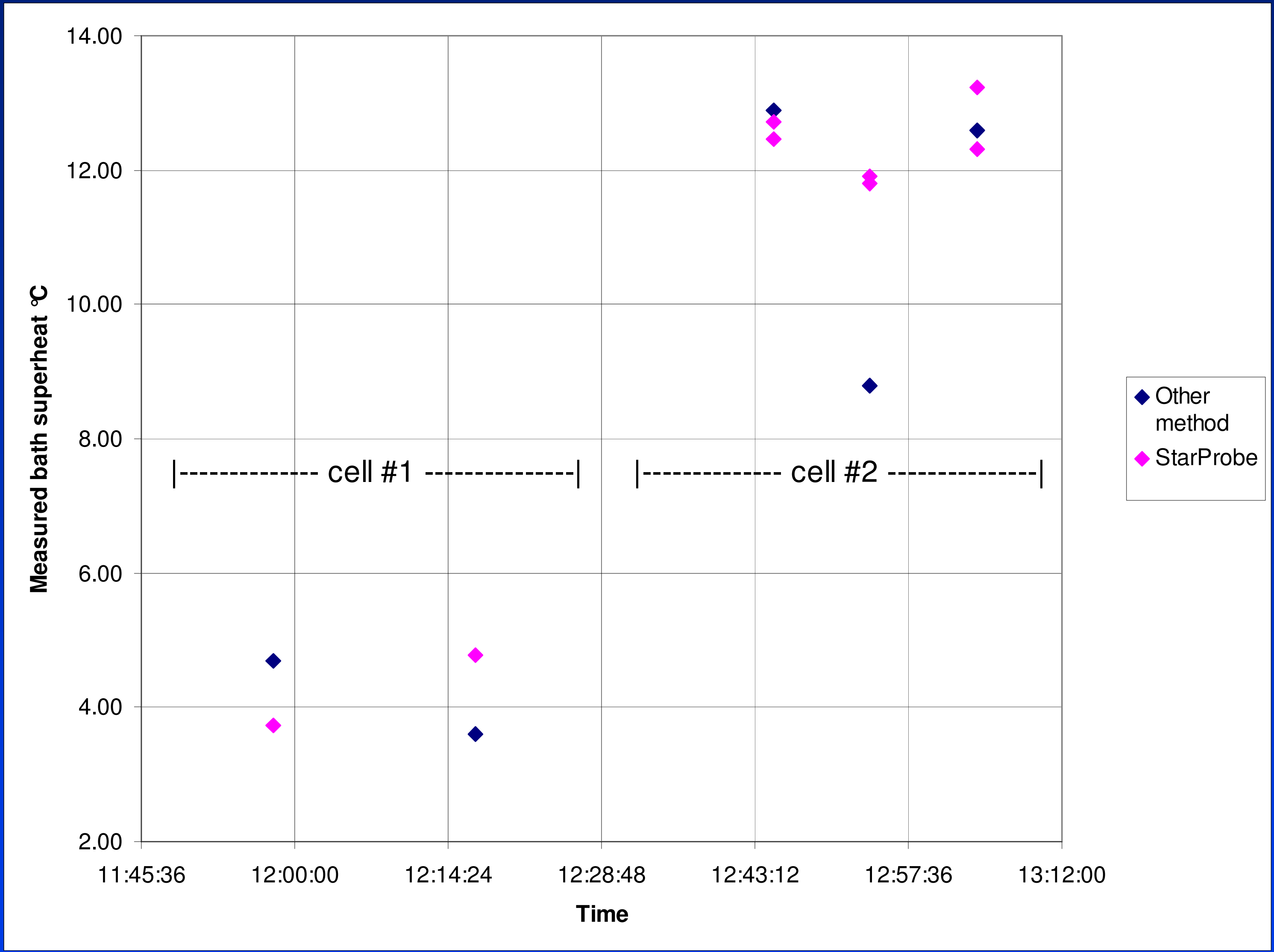


Second measurement campaign

The previous figure presents the results obtained for the parallel measurement of the excess AlF_3 in 2 different cells so in addition of the comparison between the 2 methods, the issue of the lack of strict repetitivity of the measurements can also be observed in both method of analysis.

It is important to notice that the default STARprobe™ calibration parameters have been used in that measurement campaign, per example, the average CaF_2 concentration of the cells in that smelter did not match so the STARprobe™ measured excess AlF_3 concentration is slightly offset for that reason. The next step would have been to carry out a STARprobe™ calibration exercise in order to eliminate the offset between the STARprobe™ and the XRD calculation of the excess AlF_3 concentration, but that would have required more time that was available in that short demonstration measurement campaign. That STARprobe™ calibration exercise has been successfully carried out in a third measurement campaign not presented here.

Second measurement campaign



Second measurement campaign

The previous figure presents the results obtained for the parallel measurement of the bath superheat in 2 different cells. Again enough measurements have been taken to highlight the lack of strict repetitivity of the measurements regardless of the method used.

There were no attempt to try to compare the STARprobe™ measurement of the dissolved alumina concentration with another method in that second measurement campaign.

Conclusions

- Familiarization and demonstration STARprobe™ measurement campaigns have been successfully carried out by STAS since January 2012 in different smelters around the world. Some results from two of them have been presented here.
- Comparison with other methods have been carried out independently of Alcoa and are confirming Alcoa's claims on the capabilities of the STARprobe™ to get instantatenious measurement of bath properties for feedback process control purposes.
- Measurement repetitively tests highlight the relative variability or lack of strict repetitivity of the measurements which in turn highlight the lack of homogeneity of the bath. This is particularly true for the dissolved alumina concentration and the bath superheat which is directly affected by the dissolved alumina concentration in the bath sample.
- One way to address that sampling noise problem is to measure more frequently and to apply some kind of filter on the measured data before taking feedback control action on it, but discussing this was not in the scope of the present paper.