

## STRINGER INCLUSIONS ANALYSIS

### Sample Description

Six prepared maraging steel samples are submitted for inclusions analysis.

### Purpose of Analysis

Demonstrate the ability of the Clemex Inclusion Rating system (CIR) can discriminate the inclusions present in the samples including TiN ones and measure them according to the certain standards (ASTM E45, ASTM E1122, JIS G 0555 and DIN 50602).



**Figure 1:** Example of stringer found in Sample 5.



**Figure 2:** The inclusion was reconnected and classified as an alumina stringer (OA).

### Procedure

As specified, the magnification is set to 200X instead of the standard 100X. The second step is to adjust the light and the Threshold to include the TiN inclusions with the oxide category.

Next step is to define the 6 samples specifying they are all part of the same heat.

For each sample, a focus plan is specified, the orientation of the inclusions (for reconnection purpose), and a field pattern is automatically defined to cover the whole area.

### Equipment

<b>Image Analysis System:</b>	Clemex CIR
<b>Microscope:</b>	Leica DM LM
<b>Camera:</b>	Sony DXC 950P
<b>Magnification:</b>	200X
<b>Stage:</b>	Marzhauser EK32IM 75x50mm

### Results<sup>1</sup>

Once the analysis is completed, the Results window appears. The map of each category of inclusion appears in the Image window for the current selected sample. Squares of a specific color shows the worst fields (thin and heavy) for each category. When right click on the worst fields to validate the results, the stage moves back to the corresponding position and shows the detected inclusions. If a dust or a polishing scratch remaining from preparation process is detected as an inclusion, it is possible to remove it from the results by a single click. In the same way, it is also possible to change a detected inclusion from one category to another.

If an inclusion covers more than one field, the CIR system rebuilds the complete inclusion from the different parts and the entire length is considered in the ratings.

The TiN inclusions were included with the oxides through the Thresholding setting. By doing so, the assumption that no sulfides would be found is necessary. Thus, it is necessary to analyze samples first to make sure they do not present sulfides.

The same analysis was also performed at 100X. The results obtained were considerably lower partly because of the lower resolution (1.277  $\mu\text{m}/\text{pixel}$ ) but also because the yellow particles showed less contrast at that magnification.

The complete results are presented in the appendix.

<sup>1</sup>. Complete results are available in appendix



## Appendix: Results

### Heat 1 - Information

Sample ID	Width (inch)	Height (inch)	Area (inch <sup>2</sup> )	Calibration	Magnification
Sample 1	0.57	0.53	0.30	0.634	200 X
Sample 2	0.61	0.54	0.33	0.634	200 X
Sample 3	0.61	0.53	0.32	0.634	200 X
Sample 4	0.61	0.54	0.33	0.634	200 X
Sample 5	0.61	0.53	0.32	0.634	200 X
Sample 6	0.61	0.54	0.33	0.634	200 X

### Heat 1 - ASTM E45-97 A

Sample ID	Sulfide A		Alumina B		Silicate C		Globular D	
	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Sample 1	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.5
Sample 2	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.5
Sample 3	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.5
Sample 4	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.5
Sample 5	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.5
Sample 6	0.0	0.0	1.5	1.0	0.0	0.0	1.0	0.5
<b>Final Rating</b>	0.0	0.0	1.6	0.2	0.0	0.0	1.0	0.5

### Heat 1 - Information

Sample ID	Width (inch)	Height (inch)	Area (inch <sup>2</sup> )	Calibration	Magnification
Sample 1	0.57	0.53	0.30	0.634	200 X
Sample 2	0.61	0.54	0.33	0.634	200 X
Sample 3	0.61	0.53	0.32	0.634	200 X
Sample 4	0.61	0.54	0.33	0.634	200 X
Sample 5	0.61	0.53	0.32	0.634	200 X
Sample 6	0.61	0.54	0.33	0.634	200 X

### Heat 1 - ASTM E45-97 C

Sample ID	Oxide O		Silicate S	
	Rating	Length	Rating	Length
Sample 1	1	225	0	0
Sample 2	1	232	0	0
Sample 3	1	163	0	0
Sample 4	1	226	0	0
Sample 5	2	275	0	0
Sample 6	1	150	0	0



**Heat 1 - Information**

Sample ID	Width (inch)	Height (inch)	Area (inch <sup>2</sup> )	Calibration	Magnification
Sample 1	0.57	0.53	0.30	0.634	200 X
Sample 2	0.61	0.54	0.33	0.634	200 X
Sample 3	0.61	0.53	0.32	0.634	200 X
Sample 4	0.61	0.54	0.33	0.634	200 X
Sample 5	0.61	0.53	0.32	0.634	200 X
Sample 6	0.61	0.54	0.33	0.634	200 X

**Heat 1 - ASTM E45-97 D**

Sample ID	Type	0.5		1.0		1.5		2.0		2.5		3.0		3.5		4.0		4.5		
		T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	
Sample 1	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	43	0	20	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	161	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 2	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	54	0	23	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	213	3	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 3	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	82	0	24	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	233	8	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 4	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	53	0	20	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	251	6	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 5	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	74	0	20	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	192	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 6	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	46	0	24	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	276	5	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Average</b>	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B	58.7	0.0	21.8	0.2	2.5	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	D	221.0	4.3	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

**Heat 1 - Information**

Sample ID	Width (inch)	Height (inch)	Area (inch <sup>2</sup> )	Calibration	Magnification
Sample 1	0.57	0.53	0.30	0.634	200 X
Sample 2	0.61	0.54	0.33	0.634	200 X
Sample 3	0.61	0.53	0.32	0.634	200 X
Sample 4	0.61	0.54	0.33	0.634	200 X
Sample 5	0.61	0.53	0.32	0.634	200 X
Sample 6	0.61	0.54	0.33	0.634	200 X

**Heat 1 - ASTM E45-97 E**

Type	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
B Thin	-	-	15	1	0	0	0	0	0	0
B Heavy	-	1	0	0	0	0	0	0	0	0
D Heavy	26	0	0	0	0	0	0	0	0	0
<b>SAM Rating</b>	Alumina B:		13	Globular D:		13				



Heat 1 - Information

Sample ID	Width (inch)	Height (inch)	Area (inch <sup>2</sup> )	Calibration	Magnification
Sample 1	0.57	0.53	0.30	0.634	200 X
Sample 2	0.61	0.54	0.33	0.634	200 X
Sample 3	0.61	0.53	0.32	0.634	200 X
Sample 4	0.61	0.54	0.33	0.634	200 X
Sample 5	0.61	0.53	0.32	0.634	200 X
Sample 6	0.61	0.54	0.33	0.634	200 X

Heat 1 - ASTM E1122-96 A

Sample ID	Sulfide A		Alumina B		Silicate C		Globular D	
	Thin	Heavy	Thin	Heavy	Thin	Heavy	Thin	Heavy
Sample 1	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.5
Sample 2	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.5
Sample 3	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.5
Sample 4	0.0	0.0	2.0	0.0	0.0	0.0	1.0	0.5
Sample 5	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.5
Sample 6	0.0	0.0	1.5	1.0	0.0	0.0	1.0	0.5
<b>Final Rating</b>	0.0	0.0	1.6	0.2	0.0	0.0	1.0	0.5

Heat 1 - Information

Sample ID	Width (inch)	Height (inch)	Area (inch <sup>2</sup> )	Calibration	Magnification
Sample 1	0.57	0.53	0.30	0.634	200 X
Sample 2	0.61	0.54	0.33	0.634	200 X
Sample 3	0.61	0.53	0.32	0.634	200 X
Sample 4	0.61	0.54	0.33	0.634	200 X
Sample 5	0.61	0.53	0.32	0.634	200 X
Sample 6	0.61	0.54	0.33	0.634	200 X

Heat 1 - ASTM E1122-96 D

Sample ID	Type	0.5		1.0		1.5		2.0		2.5		3.0		3.5		4.0		4.5	
		T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H
Sample 1	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	43	0	20	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	161	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 2	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	54	0	23	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	213	3	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 3	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	82	0	24	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	233	8	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 4	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	53	0	20	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	251	6	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 5	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	74	0	20	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	192	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sample 6	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	46	0	24	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	276	5	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Average</b>	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	B	58.7	0.0	21.8	0.2	2.5	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	D	221.0	4.3	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



**Heat 1 - Information**

Sample ID	Width (inch)	Height (inch)	Area (inch <sup>2</sup> )	Calibration	Magnification
Sample 1	0.57	0.53	0.30	0.634	200 X
Sample 2	0.61	0.54	0.33	0.634	200 X
Sample 3	0.61	0.53	0.32	0.634	200 X
Sample 4	0.61	0.54	0.33	0.634	200 X
Sample 5	0.61	0.53	0.32	0.634	200 X
Sample 6	0.61	0.54	0.33	0.634	200 X

**Heat 1 - JIS G 0555**

Sample ID	Sulfide A1	Alumina B	Silicate A2	Globular C
Sample 1	0.0000%	0.0071%	0.0000%	0.0036%
Sample 2	0.0000%	0.0067%	0.0000%	0.0048%
Sample 3	0.0000%	0.0071%	0.0000%	0.0062%
Sample 4	0.0000%	0.0072%	0.0000%	0.0068%
Sample 5	0.0000%	0.0081%	0.0000%	0.0043%
Sample 6	0.0000%	0.0060%	0.0000%	0.0088%
<b>Final Rating</b>	0.0000%	0.0070%	0.0000%	0.0058%

**Heat 1 - Information**

Sample ID	Width (inch)	Height (inch)	Area (inch <sup>2</sup> )	Calibration	Magnification
Sample 1	0.57	0.53	0.30	0.634	200 X
Sample 2	0.61	0.54	0.33	0.634	200 X
Sample 3	0.61	0.53	0.32	0.634	200 X
Sample 4	0.61	0.54	0.33	0.634	200 X
Sample 5	0.61	0.53	0.32	0.634	200 X
Sample 6	0.61	0.54	0.33	0.634	200 X

**Heat 1 - DIN M**

Sample ID	SS	OA	OS	OG
Sample 1	-	5	-	3
Sample 2	-	3	-	3
Sample 3	-	4	-	4
Sample 4	-	4	-	4
Sample 5	-	4	-	3
Sample 6	-	4	-	4
<b>Average</b>	-	<b>4.0</b>	-	<b>3.5</b>

**Heat 1 - DIN K**

Sample ID	Type	Rating Number													
		0	1	2	3	4	5	6	7	8					
Sample 1	SS	0	0	0	0	0	0	0	0	0					
	OA	23	8	8	5	0	1	0	0	0					
	OS	0	0	0	0	0	0	0	0	0					
	OG	44	35	26	3	0	0	0	0	0					
Sample 2	SS	0	0	0	0	0	0	0	0	0					
	OA	17	10	9	5	0	0	0	0	0					
	OS	0	0	0	0	0	0	0	0	0					
	OG	62	47	33	8	0	0	0	0	0					
Sample 3	SS	0	0	0	0	0	0	0	0	0					
	OA	24	9	9	4	1	0	0	0	0					
	OS	0	0	0	0	0	0	0	0	0					
	OG	67	61	40	15	1	0	0	0	0					
Sample 4	SS	0	0	0	0	0	0	0	0	0					
	OA	16	13	8	6	2	0	0	0	0					
	OS	0	0	0	0	0	0	0	0	0					
	OG	66	70	37	19	1	0	0	0	0					
Sample 5	SS	0	0	0	0	0	0	0	0	0					
	OA	18	11	14	5	1	0	0	0	0					
	OS	0	0	0	0	0	0	0	0	0					
	OG	52	44	34	6	0	0	0	0	0					
Sample 6	SS	0	0	0	0	0	0	0	0	0					
	OA	11	17	11	1	1	0	0	0	0					
	OS	0	0	0	0	0	0	0	0	0					
	OG	78	82	69	25	1	0	0	0	0					
Sample ID	S	K0		S	K1		S	K2		S	K3		S	K4	
		O	O		O	O		O	O		O				
Sample 1	0.0	20.4	0.0	17.1	0.0	12.8	0.0	6.0	0.0	2.0	0.0	6.0	0.0	2.0	
Sample 2	0.0	24.6	0.0	20.6	0.0	14.9	0.0	6.5	0.0	0.0	0.0	6.5	0.0	0.0	
Sample 3	0.0	32.9	0.0	28.3	0.0	21.3	0.0	11.5	0.0	2.0	0.0	11.5	0.0	2.0	
Sample 4	0.0	36.9	0.0	32.8	0.0	24.5	0.0	15.5	0.0	3.0	0.0	15.5	0.0	3.0	
Sample 5	0.0	25.1	0.0	21.6	0.0	16.1	0.0	6.5	0.0	1.0	0.0	6.5	0.0	1.0	
Sample 6	0.0	45.4	0.0	40.9	0.0	31.0	0.0	15.0	0.0	2.0	0.0	15.0	0.0	2.0	
<b>Total Index</b>	0.0	148.5	0.0	129.3	0.0	96.7	0.0	48.9	0.0	8.0	0.0	48.9	0.0	8.0	
<b>Overall</b>		<b>148.5</b>		<b>129.3</b>		<b>96.7</b>		<b>48.9</b>		<b>8.0</b>		<b>48.9</b>		<b>8.0</b>	