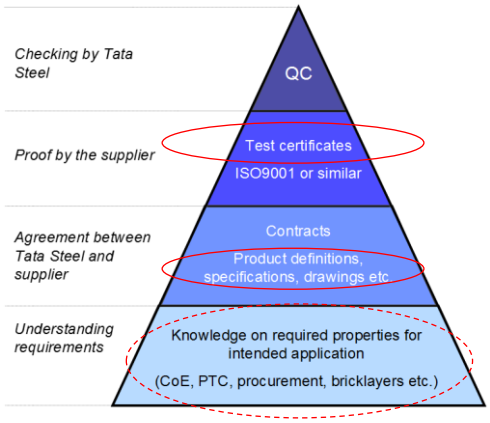
Online Training Event 2021
PROPERTIES, TESTING AND DATA SHEETS

Online Training Event 2021
Refractory Data Sheets and Specifications

'The Customer's Perspective'
Matthew C Davies – Tata Steel UK

Data Sheets & Specifications – Why?

- The Refractory Products are integral to the Steel production process and therefore need to be of stable quality to achieve predictable results [1]
- Tata Steel has set up a QA system to check that the right materials are used and that the properties are stable
- A 4-step process has been established to ensure this stable performance
- Data Sheets and Specifications are integral to this process



[1] - ***"QUALITY CONTROL OF REFRACTORY MATERIALS AT TATA STEEL EUROPE"*** W Tesselaar, M Hogenboom, R Siebring

Technical Data Sheets (1)

USED FOR:

- New application
- New product proposed by supplier
- Existing product not performing
- Existing product, better value product required

Technical Data Sheets (2)

- Useful for initial comparison of properties against existing product or company standard.
- May be called Data Sheet, Product Information, Technical Information etc.
- Not confidential

- Not a guarantee of material properties, typical data only.
- May cover a group of products.
- Not a controlled document

Typical Technical Data Sheet Format

Refcon Refractories Ltd

1 Main Road
Sheffield
SH2 6BX

TECHNICAL DATA SHEET

Product Name: Mag96/C12
Brief Description: Magnesia carbon brick, for steel ladles.

	Unit	Typical Analysis
As received		
Bulk density	Kg/m3	2950
Cold crushing strength	MN/m2	30
Apparent porosity	%	8
Residual carbon	%	12
Permanent linear change	%	0.15
Al2O3	%	0.4
SiO2	%	0.8
Fe2O3	%	1
CaO	%	0.8
MgO	%	97

Refractory materials contain raw material which are subject to natural variation. Therefore the right is reserved to change the information included in this data sheet.

Date: 27/8/2021

Product Definitions (1)

- Guarantee of material properties (quality and consistency)
- Prepared by refractory supplier
- May form part of contract between supplier and customer – 'the LEGAL document'
- Forms part of quality system for supplier and customer. Controlled document. Revisions must be communicated to customer, and quality system updated.
- 'Provisional' (where there is insufficient test data) or 'Full'
- Specific Product Definition for each product (possibly each size).
- Confidential

Product Definitions (2)

Should include:

- The title 'Product Definition'
- The Product Name and Supplier
- Typical and limit values (minimum, maximum or both) for critical/guaranteed/controlled properties – generally:
  - 3 chemical properties
  - 3 physical properties
  - 1 Hot property
- Supplementary properties (typical only, no limit values)
- Testing Standard used e.g. ISO, ASTM, JIS, DIN
- Date & Revision number
- Plant of Origin / Production Location

Product Definitions (3)

TYPICAL VALUES

- Usually determined by manufacturer's average of process test data.

LIMIT VALUES

- Minimum, maximum or both
- Usually determined using statistical data from manufacturer's process test data (standard deviations or T values).

Typical Product Definition

Refcon Refractories Ltd

1 Main Road
Sheffield
SH2 6BX

PRODUCT DEFINITION
Confidential

Product Name: Mag96/C12
Brief Description: Magnesia carbon brick, for steel ladles.

	Unit	Typical	Range
Critical Properties			
As received			
Bulk density	Kg/m3	2960	2840 Min
Coked 2 hours 1000oC			
Apparent porosity	%	9.8	12.0 Max
Residual carbon	%	12	10.0 Min
Permanent linear change	%	0.15	-0.5 to 0.8
Al2O3	%	0.3	1.0 Max
SiO2	%	1.0	1.6 Max
Fe2O3	%	0.8	1.2 Max
CaO	%	1.4	2.2 Max
MgO	%	96.5	95.5 Min
Supplimentary Properties			
As received			
Cold crushing strength	MN/m2	30	25 Min
Apparent porosity	%	8.0	9.5 Max
Coked 2 hours 1000oC			
Bulk Density	Kg/m3	2850	2790 Min
Cold crushing strength	MN/m2	25	15 Min

Plant of Origin: Sheffield

Revision Number: 0
Date: 27/8/2021

Prepared by: A Smith
Checked by: J Jones

RAGB Guidelines

- Guidelines on information required on a Product Definition
- Requested information specific to refractory type.
- 86 material types, e.g. Fired Magnesia Brick, Refractory Mortar, Ladle and Tundish Wellfillers
- Information on how to prepare a Product Definition
- Available online via the British Ceramic Confederation (https://www.ceramfed.co.uk/)

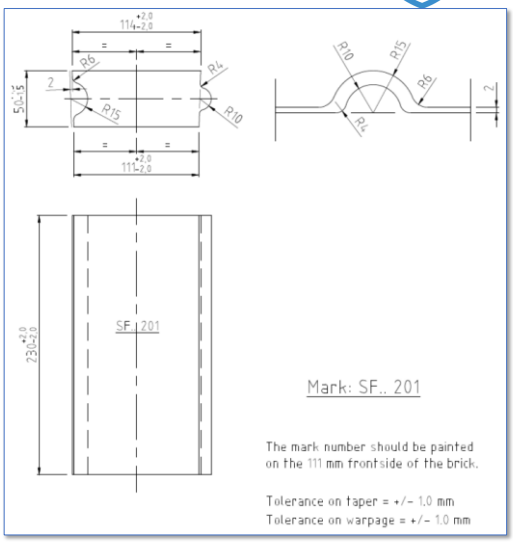
Chemical Properties

Chemistry Basis

- 'As received' (chemical components add up to approx 100 % including loss on ignition)
- 'Ignited' (chemical components add up to 100% without loss on ignition)
- Loss on ignition can include water, carbon, Sulphur and other volatile (or oxidisable) components which are lost from the sample at <1000ºC

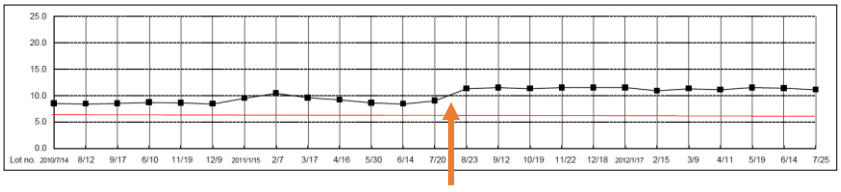
Product Definition Drawings

- For complex Shapes
- Include tolerances for critical dimensions
- Drawing number
- Revision number
- Controlled document (part of quality system of manufacturer and supplier.
- Cross referenced to material Product Definitions



Test Certificates

- Required for every batch
- Tests required for Critical Properties
- Category 1 properties (Control Properties) tested for each batch
- Category 2 properties (Supplementary Properties) tested less frequently (due to cost/complexity of testing)
- If the Category 1 properties are in specification the Category 2 Properties should be also!
- Large Data set enables trend spotting



Section Summary

Technical Data Sheet – useful for initial information and comparison of properties.

Product Definition – controlled document which guarantees material properties.

Online Training Event 2021
Refractory Data Sheets and Specifications

'Application and Validity'
Matthew C Davies – Tata Steel UK

Discussion Areas

- ‘Fitness for Purpose’
- Bespoke Specifications
- Identifying Errors in Specification Sheets

‘Fitness for Purpose’

First Question:

What does ‘fitness for purpose’ mean?

- *‘Something that is fit for purpose when sold’* MacMillan Dictionary
- *‘Appropriate and of a necessary standard for its intended use’* Wiki
- *‘Fitness for purpose equates quality with the fulfilment of a specification or stated outcomes’* www.qualityresearchinternational.com

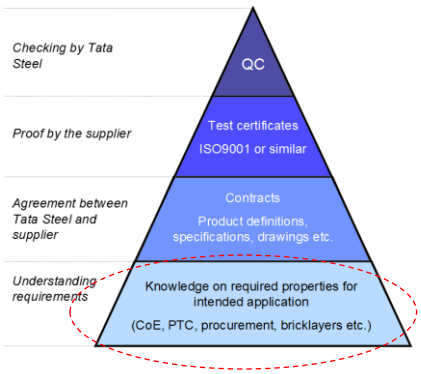
- Legal: When you buy goods you enter into a contract with the seller of those goods. Under the Sale of Goods Act 1979 goods must be:
  - 'as described',
  - ‘of satisfactory quality', and
  - 'fit for purpose' – this means both their everyday purpose, and also any specific purpose that you agreed with the seller

‘Fitness for Purpose’

Second Question:

If a product meets specification does it automatically mean it is fit for the intended purpose?

Not necessarily……



‘Fitness for Purpose’

Third Question:

Can ‘fitness for purpose’ be translated as a specification data set?

- Manufacturing – assesses a product against its intended purpose?
- Marketing – purpose is determined by the customer need?

POTENTIAL requirement for ‘Bespoke’ specification to ensure that supplier’s specification contains all necessary elements to deliver required operational performance

‘Fitness for Purpose’

Last Question:

Who’s responsibility is it to specify

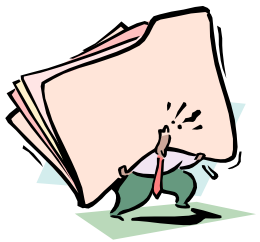
requirements required for ‘fitness for purpose’?

- The Supplier?
- The Customer?
- The OEM?

‘Bespoke Specifications’

- On occasion, the customer may indicate a product requirement which requires a dataset different from the standard product specification in order for the product to be considered ‘fit for purpose’

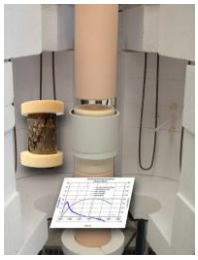
- The specification may (as is the norm in good contract practice) be included as part of the supply contract

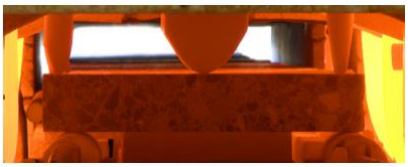


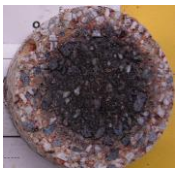
‘Bespoke Specifications’

Changes from standard:

- Typical/Limit values
- Product Description
- Inclusion of ‘supplementary’ properties as controls: eg:
  - Creep
  - RUL
  - HMOR
  - CO resistance
  - Reversable Thermal Expansion
- Inclusion of special ‘non-standard’ testing: eg:
  - Slag resistance
  - Oxidation resistance





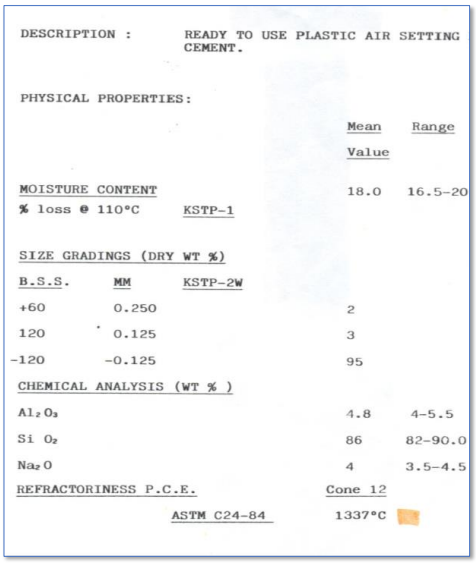


Examples:

Product Description	Fired Andalusite based Solid Brick			
CONTROL PROPERTIES				
Chemical Analysis (Calcined Basis)	Unit By wt	Value		Test Method
		Typical	Limit	
Al_2O_3	%	60.0	≥ 57.0	By XRF
Fe_2O_3	%	1.05	≤ 1.50	
Physical Properties	Unit			
Bulk Density	Kg/m³	2500	≥ 2450	ISO 5017 : 1998
Apparent porosity	Vol. %	16.2	≤ 18.0	ISO 5017 : 1998
CCS	N/mm²	52.0	≥ 40	ISO 10059-2 : 2003
SUPPLIMENTORY PROPERTIES				
SiO_2	%	38.0	≤ 41.0	By XRF
TiO_2	°C	0.41	≤ 0.5	
PLC at 1600°C / 5hrs	%	+0.06	- 0.1 to +0.20	ISO 2478 : 1987 (L = V/3)
Creep (Load = 0.2 MPa, 20-50 hrs at 1400°C)	%	0.20	≤ 0.30	ISO 3187 : 1989
INFORMATIVE PROPERTIES				
Thermal Expansion at 1000°C	%	0.60	-	IS 1528 (Part 1) : 1991
Thermal Conductivity	W/mK	1.70 (at 600°C) 2.0 (at 1200°C)	-	ISO 8894-1 : 1987
Control Dimension	AQL 6.5% for critical dimensions (ISO 5022 Table – 3)			
Sampling/Acceptance	ISO 5022, Table 4 or Table 10(AQL4%)			

Product Description	High Temperature fired Andalusite brick with white tabular alumina.			
Application	Working lining of Torpedo Ladle and working lining of Hot Metal Ladle/ Transfer Ladle – Various Other applications.			
CONTROL PROPERTIES				
Chemical Analysis (Calcined Basis)	Unit By wt	Value		Test Method
		Typical	Limit	
Al_2O_3	%	59.4	≥ 57.5	By XRF – Powder Pallet Method
SiO_2	%	38.2	≤ 40.0	
Fe_2O_3	%	1.21	≤ 1.30	
TiO_2	%	0.42	≤ 0.50	
Alkalis	%	0.68	≤ 1.20	
Physical Properties	Unit			
Bulk Density	Kg/m³	2540	≥ 2420	ISO 5017 : 1998
Apparent porosity	Vol. %	15.6	≤ 17.5	ISO 5017 : 1998
CCS	N/mm²	62.3	≥ 38	ISO 10059-2 : 2003
SUPPLIMENTORY PROPERTIES				
PLC at 1600°C/2hrs. (Min/Max)	%	-0.11	-0.30 / +0.30	ISO 2478 : 1987 (L = V/3)
Control Dimension	AQL 4 % for all dimensions (ISO 5022 Table – 3)			
Sampling/Acceptance	ISO 5022, Table 4 or Table 10(AQL4%) for all control properties			

Product Specification 'Errors'



DESCRIPTION : READY TO USE PLASTIC AIR SETTING CEMENT.

PHYSICAL PROPERTIES:

		Mean Value	Range
MOISTURE CONTENT % loss @ 110°C	KSTP-1	18.0	16.5-20

SIZE GRADINGS (DRY WT %)

B.S.S.	MM	KSTP-2W
+60	0.250	2
120	0.125	3
-120	-0.125	95

CHEMICAL ANALYSIS (WT %)

Al_2O_3	4.8	4-5.5
$Si\ O_2$	86	82-90.0
Na_2O	4	3.5-4.5

REFRACTORINESS P.C.E.	Cone 12	
ASTM C24-84	1337°C	

- No indication of which properties constitute the 'control properties'
- Generally:
  - 3 Chemical Properties
  - 3 Physical Properties

Product Specification 'Errors'

Product Description: (classification, main components and nature, additives, bonding, additional treatment)

Magnesia-chromite brick of group MCr60 based on rebonded fused grain with low iron content, ceramic bond

Application: Mainly for degassing vessels

CRITICAL PROPERTIES * controlled properties max. 3 chemical components and 3 physical properties

Chemical Analysis *	Unit by wt	Mean Value		Sigma	Individual Value			Test Method
		Typical	Guaranteed		Ti	Ts	AQL	
SiO2	%	1,3				1,7	6,5	XRF
Fe2O3	%	9,0						DIN 51001
Al2O3	%	6,0				7,5	6,5	
Cr2O3	%	19,0						
CaO	%	0,7						
MgOdiff	%	63				60,0	6,5	
Physical Properties	Unit							
Bulk Density	g/cm³	3,18			3,11		6,5	EN 993-1
Apparent Porosity	%	17				18,5	6,5	EN 993-1
CCS	N/mm²	55			30		6,5	EN 993-5

- Ts MgO?
  - Should be Ti!
  - Would this affect a potential claim?

Product Specification 'Errors'

Refcon Refractories Ltd

1 Main Road
Sheffield
SH2 6BX

PRODUCT DEFINITION
Confidential

Product Name: Mag97/C12
Brief Description: Magnesia carbon brick, for EAF.

	Unit	Typical	Ti	Ts
Critical Properties				
As received				
Bulk density	Kg/m3	2960	2840	3000
Coked 2 hours 1000oC				
Apparent porosity	%	9.8		12
Residual carbon	%	12	10	
Permanent linear change	%	0.15	-0.5	0.8
Al2O3	%	0.3		1
SiO2	%	1.0		1.6
Fe2O3	%	0.8		1.2
CaO	%	1.4		2.2
MgO	%	97.5	96.5	
Supplimentary Properties				
As received				
Cold crushing strength	MN/m2	30	25	
Apparent porosity	%	8.0		9.5
Coked 2 hours 1000oC				
Bulk Density	Kg/m3	2850	2790	2900
Cold crushing strength	MN/m2	25	15	

Plant of Origin: Sheffield

Revision Number: 0
Date: 27/8/2012

Prepared by: A Smith
Checked by: J Jones

- Is limit data appropriate?
- Is the range too wide?
- Is the typical skewed?
- What would be your response?

Section Summary

Fitness for purpose:

- Consider requirements of the application and suitability of the data in terms of 'guaranteeing' performance requirements. Also 'Responsibility'

Bespoke Specifications:

- Usefulness for both supplier and customer
- Dialogue required to work effectively

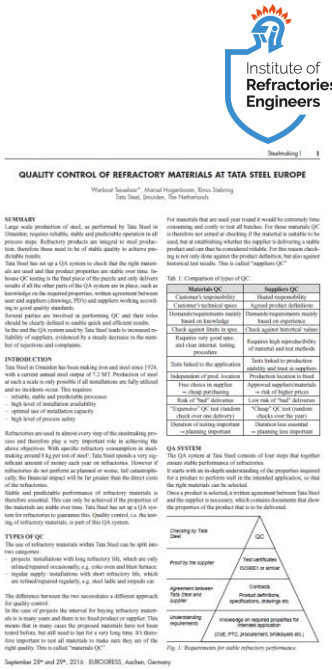
Specification Errors:

- Learn to recognise common errors to ensure coverage in event of performance issues.

Acknowledgments

Thanks to:

- Martyn Frith - Liberty Speciality Steels
- Rinus Siebring - Tata Steel, Netherlands



QUALITY CONTROL OF REFRACTORY MATERIALS AT TATA STEEL EUROPE

Further reading:

"QUALITY CONTROL OF REFRACTORY MATERIALS AT TATA STEEL EUROPE"

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Final Slide

https://irengineers.co.uk/

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