
**Guidance on standards available for
preparation and testing of monolithic,
unshaped refractory products**

*Lignes directrices relatives aux normes disponibles pour la préparation
et l'essai des produits réfractaires monolithiques non façonnés*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 21828 was prepared by Technical Committee ISO/TC 33, *Refractories*.

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Introduction

This Technical Report is the first step to providing a set of International Standards and regional and national standards relating to the testing of unshaped refractory materials in a convenient framework for easy access and use.

The intention is to draw on the best practice used worldwide considering the standards available in Asia, the Americas and Europe.

These test methods can be used for quality control purposes at point of manufacture or reception by the user, including testing to confirm published data or installed material from site.

It is intended that quality control at reception and final control of the lining be considered as two different issues.

The control at reception, sampling and test piece preparation are generally done with greater accuracy with clean equipment in carefully controlled conditions.

Properties are unavoidably influenced in site installations as a result of the equipment type, climatic conditions and, often, by specific site factors (target date for completion, job site access).

Sampling and test pieces prepared in industrial site conditions are, therefore, subject to a greater degree of variance due to the previously mentioned factors.

Unshaped refractory products used in industrial linings are not fired in kilns before installation, such that the subsequent sample appraisal can be more complex due to the induced temperature gradients in returned samples after placement or commissioning.

Differences in results can be seen for the same material tested in two different laboratories due simply to the efficiency of the mixing process, mixer type, power or degree of filling, independently of the test method chosen.

The single most determining step in unshaped testing is test piece preparation.

This can be true even when the instructions given by the manufacturer are used in conjunction with the selected standard.

The comments given in each section are to provide objective information to compare standards or methods from different origins. Because of the extreme importance of test piece preparation, it is intended that unity of source be maintained when selecting standards in these preparation sections in order to minimize differences.

If not carried out with agreement between the parties, it is intended that testing at reception use the same methods as those used by the manufacturer, if known, or allowances be made in the appraisal using the guidelines given in the comments sections of this Technical Report.

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Guidance on standards available for preparation and testing of monolithic, unshaped refractory products

1 Scope

This Technical Report gives guidance on the International Standards and regional and national standards which apply to the testing of unshaped refractory materials, including, but not limited to, sampling, forming, obtaining test specimens or pieces and physical testing.

The parties involved in selecting the standard to be used should agree in advance on the standard or standards to be used and their applicability to the information to be generated by the standard.

The listing of standards by their title and scope in this Technical Report does not imply the correctness of those standards or their fitness of purpose. The listing was determined based on the title and scope as provided by the originating standards body.

2 Terms and definitions

Terms and definitions for the preparation and testing of unshaped refractory products should be used in accordance with those given in the standards listed in Table 1.

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Table 1 — Standards giving terms and definitions

Publisher	International Standard, regional or national standard	Comment
ISO International Organization for Standardization	ISO 836:2001, <i>Terminology for refractories</i> Scope: This International Standard describes terms used in International Standards dealing with refractory materials and products and assists in the understanding of the terms and the standards themselves. The descriptions are those generally understood with the refractories industry and should not be taken as absolute definitions.	
CEN European Committee for Standardization	EN 1402-1:2003, <i>Unshaped refractory products — Part 1: Introduction and classification</i> Scope: This part of this European Standard defines terms relating to unshaped refractory products and establishes the classification for the various types of products. Raw materials and crushed or granulated refractory materials which do not contain any binder are excluded.	

Table 1 (continued)

Publisher	International Standard, regional or national standard	Comment
ASTM International	C71, <i>Standard Terminology Relating to Refractories</i> Scope: This terminology covers terms particularly related to refractories and encompasses raw materials, manufacture, finished products, applications, and testing procedures.	When any of the definitions in this terminology are quoted or published out of context, editorially insert the limiting phrase "in refractories" after the dash following the term to properly limit the field of application of the term and definition.
	C401, <i>Standard Classification of Alumina and Alumina-Silicate Castable Refractories</i> Scope: This classification covers alumina and alumina-silicate castable refractories that, when tempered with water, will develop structural strength by chemical action.	The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.
Standards Australia	AS 2780-2003, <i>Refractories and refractory materials — Glossary of terms</i>	

3 Classification

Unshaped refractory products should be classified in accordance with the standards listed in Table 2.

Table 2 — Classification standards

Publisher	International Standard, regional or national standard	Comment
ISO International Organization for Standardization	ISO 1927-1, <i>Unshaped refractory materials — Part 1: Introduction and classification</i> Scope: This part of ISO 1927 defines terms relating to unshaped refractory products and establishes the classification for the various types of products. It does not apply to raw materials and crushed or granulated refractory materials which do not contain any binder.	
CEN European Committee for Standardization	EN 1402-1:2003, <i>Unshaped refractory products — Part 1: Introduction and classification</i> Scope: This part of this European Standard defines terms relating to unshaped refractory products and establishes the classification for the various types of products. Raw materials and crushed or granulated refractory materials which do not contain any binder are excluded.	

Table 2 (continued)

Publisher	International Standard, regional or national standard	Comment
ASTM International	C401, <i>Standard Classification of Alumina and Alumina-Silicate Castable Refractories</i> Scope: This classification covers alumina and alumina-silicate castable refractories that, when tempered with water, will develop structural strength by chemical action.	The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.
	C673-97, <i>Standard Classification of Fireclay and High-Alumina Plastic Refractories and Ramming Mixes</i> Scope: This classification covers fireclay and high-alumina plastic refractories and ramming mixes that can be pounded or rammed into place to form a monolithic structure. The terms "plastic" and "ramming mix" are generally intended to describe the workability of the material. In this regard, plastics are considered to be materials having a workability index of more than 15 % in accordance with Test Method C181, while ramming mixes generally have less than 15 % workability by the same procedure.	

4 Sampling

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Sampling and sample preparation of unshaped refractory products should be carried out in accordance with the standards listed in Table 3.

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Table 3 — Standards giving procedures and sampling and sample preparation

Publisher	International Standard, regional or national standard	Comment
ISO International Organization for Standardization	ISO 8656-1:1988, <i>Refractory products — Sampling of raw materials and unshaped products — Part 1: Sampling scheme</i> Scope: This part of ISO 8656 specifies methods and conditions of sampling for raw materials and prepared unshaped refractory products, in order to indicate the mean values of a consignment and the interval of sampling. It does not apply to products in the form of large static quantities or cargoes from which reliable samples cannot be taken. The type of sampling equipment, and the preparation and reduction of the samples, which should not alter the properties to be tested, are to be agreed between the interested parties.	Difficulties can be encountered when sampling certain types of unshaped products, for example mouldables.
CEN European Committee for Standardization	EN 1402-2:2003, <i>Unshaped refractory products — Part 2: Sampling for testing</i> Scope: This part of this European Standard gives guidance on the sampling of unshaped refractory materials for the purpose of inspection and testing for quality and general information on the reduction and treatment of samples prior to testing. It covers all materials formulated as unshaped refractory materials.	

Table 3 (continued)

Publisher	International Standard, regional or national standard	Comment
ASTM International	C862, <i>Standard Practice for Preparing Refractory Concrete Specimens by Casting</i> Scope: This practice covers the mixing, casting and curing of monolithic refractory concrete specimens for use in further testing. It does not apply to monolithic castable refractories intended primarily for gunning applications.	The values given in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only. Various specimen sizes are required for specific test methods. Refer to these test methods to determine the size and number of specimens which will be required from the sample.
Standardization Administration of China	GB/T 17617-2004, <i>Refractory products — Sampling of raw materials and unshaped products</i> Scope: This standard specifies definition, method and conditions of sampling for raw materials and unshaped refractory products.	
Standards Australia	AS 2497, <i>Sampling procedures for acceptance testing of shaped refractory products</i>	
	AS 4433.2, <i>Guide to the sampling of particulate materials — Part 2: Preparation of samples</i>	

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5 Formation of test specimens/pieces

5.1 Casting

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Formation of test specimens/pieces by casting should be carried out in accordance with the standards listed in Table 4.

Table 4 — Standards giving procedures for formation of test specimens/pieces by casting

Publisher	International Standard, regional or national standard	Comment
CEN European Committee for Standardization	EN 1402-5:2003, <i>Unshaped refractory products — Part 5: Preparation and treatment of test pieces</i> Scope: This part of this European Standard specifies methods for the preparation and treatment (curing, drying and firing) of test pieces from unshaped refractory materials. The dimensions of the test pieces are specified. The methods are applicable to dense and insulating castables and to ramming materials with the four types of chemical compositions defined in EN 1402-1. The dimensions of the test pieces are stated and the preparation of the mixture, compaction methods, storage and post-treatment of the test pieces are described.	

Table 4 (continued)

Publisher	International Standard, regional or national standard	Comment
ASTM International	<p>C860, <i>Standard Practice for Determining the Consistency of Refractory Castable Using the Ball-In-Hand Test</i></p> <p>Scope: The amount of water used in a castable has a significant influence on its performance. This practice covers the procedures for determining the consistency of a castable using the ball-in-hand test.</p> <p>This practice applies to regular weight castable refractories and insulating castable refractories which are described in Classification C401. It also applies to such castables containing metal fibres.</p>	<p>This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. (See 6.2.3 for a specific safety warning.)</p>
	<p>C862, <i>Standard Practice for Preparing Refractory Concrete Specimens by Casting</i></p> <p>Scope: This practice covers the mixing, casting and curing of monolithic refractory concrete specimens for use in further testing. It does not apply to monolithic castable refractories intended primarily for gunning applications.</p> <p>The values given in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.</p> <p>Various specimen sizes are required for specific test methods. Refer to these test methods to determine the size and number of specimens which will be required from the sample.</p>	<p>This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.</p>
	<p>C974, <i>Standard Practice for Preparing Test Specimens from Basic Refractory Castable Products by Casting</i></p> <p>Scope: This practice covers a procedure for preparing test specimens from a basic refractory castable by casting prepared material in a mold. Specimens prepared in accordance with this procedure are intended for use in ASTM test methods.</p>	<p>This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.</p>
	<p>C1445, <i>Standard Test Method for Measuring Consistency of Castable Refractory Using a Flow Table</i></p> <p>Scope: This test method covers the procedure for determining the consistency of castable refractory mixes by the flow table method.</p> <p>This test method applies to regular weight castable refractories, insulating castable refractories, and castable refractories that require heavy vibration for forming, which are described in Classification C401. They also apply to such castables containing metal fibres.</p> <p>The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.</p>	<p>This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.</p>
	<p>C1446, <i>Standard Test Method for Measuring Consistency of Self-Flowing Castable Refractories</i></p> <p>Scope: This test method covers the determination of the consistency (degree of self-flow) and working time of self-flowing castable refractories.</p> <p>The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.</p>	<p>This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.</p>

Table 4 (continued)

Publisher	International Standard, regional or national standard	Comment
Standardization Administration of China	YB/T 5202-1:2003, <i>Preparation of specimen for unshaped refractories — Part 1: Refractory castables</i>	
Standards Australia	<p>AS 1774.4.1, <i>Refractories and refractory materials — Preparation of test pieces — By casting</i></p> <p>Applies to dense, medium weight and lightweight castables containing either hydraulic cements or other binders. It applies to conventional and low-cement castables and any other type of refractory castable that can be installed by a casting process.</p> <p>A method for measuring the consistency of unshaped castable refractories is given in Appendix A.</p> <p>Castable refractory samples are mixed with water or other specified liquids until a specified consistency is achieved. They are then consolidated in a mould and allowed to cure and dry under defined conditions prior to testing.</p>	
	<p>AS 1774.4.1-Appendix A, <i>Methods for measuring consistency of unshaped castable refractories</i></p> <p>Describes procedures for measuring the consistency of castable mixes by determining a tap flow, vibration-flow or self-flow value.</p> <p>Tap flow method: a castable sample, mixed with a measured amount of liquid (usually water) and moulded to shape, is placed on a metal surface which is then raised and dropped through a known height a given number of times. The resulting average increase in the diameter of the base of the sample is then measured and the value (i.e. tap flow value) used as a measure of consistency.</p> <p>Vibration-flow method: a castable sample, mixed with a measured amount of liquid (usually water) and moulded to shape, is placed on a vibration table which is then vibrated for a prescribed period of time. The resulting average increase in the diameter of the base of the sample is then measured and the value (i.e. vibration-flow value) used as a measure of consistency.</p> <p>Self-flow method: a castable sample, mixed with a measured amount of liquid (usually water) and moulded to shape, is placed on a metal surface and allowed to flow undisturbed for a prescribed period of time. The resulting average increase in the diameter of the base of the sample is then measured and the value (i.e. self-flow value) used as a measure of consistency.</p>	

5.2 Gunning

Formation of test specimens/pieces by gunning should be carried out in accordance with the standards listed in Table 5.