

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

REFRACTORY BRICKS AND SHAPE

PTS 44.24.90.31

FEBRUARY 2010



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PTS Circular 2010 - 1



PTS No:	PTS 44.24.90.31
PTS Title:	REFRACTORY BRICKS AND SHAPE

This revision of **PTS 44.24.90.31, REFRACTORY BRICKS AND SHAPE (February 2010)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic font*.

The previous version of this **PTS 44.24.90.31 (March 2001)** will be removed from PTS binder / e-repository from herein onwards.

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Revision History

Rev No.	Reviewed by	Approved by	Date
1	HT/ ZBM	M K Shrivastava	12 Feb 2010

PREFACE

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TABLE OF CONTENTS

1.	INTRODUCTION	4
1.1	SCOPE	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	4
1.3	DEFINITIONS	4
1.4	CROSS-REFERENCES	5
1.5	SUMMARY OF CHANGES SINCE LAST EDITION	5
2.	USE AND CLASSIFICATIONS OF SHAPED REFRACTORY MATERIALS	6
2.1	USE OF SHAPED REFRACTORY MATERIALS	6
2.2	CLASSIFICATIONS OF SHAPED REFRACTORY MATERIALS	6
3.	QUALITY ASSURANCE/QUALITY CONTROL	8
4.	DESIGN	9
4.1	DESIGN PARAMETERS	9
4.2	TYPES OF LINING	9
4.3	SELECTION OF SHAPED REFRACTORY MATERIALS	10
5.	SUPPLY	12
5.1	MANUFACTURE OF REFRACTORY MATERIALS	12
5.2	REFRACTORY SHIPMENT AND STORAGE	12
6.	TRANSPORT OF BRICK-LINED EQUIPMENT	13
7.	INSTALLATION OF REFRACTORY BRICK CONSTRUCTIONS	14
7.1	GENERAL	14
7.2	TEMPERATURE CONTROL DURING INSTALLATION	14
7.3	BRICKED CONSTRUCTIONS	14
7.4	ANCHORS	15
8.	INSPECTION, MAINTENANCE AND START-UP	17
8.1	INSPECTION	17
8.2	MAINTENANCE	18
8.3	START-UP AND OPERATION	18
9.	REFERENCES	19

APPENDICES

APPENDIX 1	SPECIFICATION FOR SHAPED REFRACTORY MATERIALS	21
APPENDIX 2	SPECIFICATION FOR SAMPLING AND TESTING OF SHAPED REFRACTORY MATERIALS	25
APPENDIX 3	TYPES AND NAMES OF REFRACTORY BRICK SHAPES	32

1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and give recommendations for the design, supply and installation of insulating, dense, special composite and acid-resistant refractory bricks and special (pre-formed) shapes.

Refractory bricks and shapes are often used in combination with monolithic refractory materials of similar compositions. For these monolithic refractory applications, reference is made to PTS 44.24.90.31 which should be read in conjunction with this PTS.

Refractory bricks and shapes for linings in equipment for Claus and SCOT sulphur recovery units (SRUs) are covered by PTS 44.24.90.31. However, the QA/QC requirements are covered in this PTS.

Non-refractory acid-resistant bricks and tiles are excluded from the scope of this PTS, but are covered by PTS 44.24.90.31.

This PTS is a revision of the PTS of the same number dated March 2001; a summary of the main technical changes is given in (1.5).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this document is confined to companies forming part of or managed by the PETRONAS, and to Contractors nominated by them

This PTS is intended for use in oil refineries, chemical plants, gas plants, supply/marketing installations and exploration and production facilities.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this document as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction and commissioning for a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

The **Applicator** is the party which applies the refractory linings specified by the Contractor.

The term **bricks** includes both bricks and special shapes.

The term **refractory** materials/products/linings includes dense, insulating, acid-resistant and/or special composite refractory materials.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (9).

1.5 SUMMARY OF CHANGES SINCE LAST EDITION

This PTS is a revision of the PTS of the same number dated March 2001; a summary of the main technical changes is give below:

Old section	New section	Change
2.2	2.2	Correct from four to five subgroups
8.1	8.1	Modify/ delete sentence and add new title for Table: Inspection list
8.3	8.3	Correct Inspection (6.1) to Inspection (8.1)
9.0	9.0	Modify following the format and delete Amended per Circular 32/01
Appendix 1 (4.3)	Appendix 1 (4.3)	Add new title for table product types and its application
Appendix 2 (3.24)	Appendix 2 (3.24)	Add new clause defining warpage and new title for table limit of tolerance
Appendix 2 (3.25)	Appendix 2 (3.25)	Add new title for table allowable deviation based on radial height
Appendix 2 (3.3.2)	Appendix 2 (3.3.2)	Word Table 4 change to Table 5
Appendix 3	Appendix 3	Modify title following the format

2. USE AND CLASSIFICATIONS OF SHAPED REFRACTORY MATERIALS

2.1 USE OF SHAPED REFRACTORY MATERIALS

The design and application of refractory linings is required to protect equipment (such as radiant and convection sections of furnaces including burners, waste heat boilers, flue ducts and fluidised bed installations) from process conditions.

Refractory linings are used:

- to enclose a space in which processes take place at high temperatures, giving protection to the steel enclosure and the environment. Examples: furnaces, kilns, (fluid bed) incinerators, waste heat boilers, ducts, stacks.
- in installations in which solids or gases are processed at high temperatures. Examples: reactors, strippers, regenerators.

Refractory materials need to have:

- resistance to high temperatures and temperature fluctuations;
- chemical/mechanical resistance against those substances which come in contact with the refractory material, e.g. gases, slag, etc.;
- sufficient mechanical strength to be part of the construction of the installation and to withstand loads during maintenance operations.

The specifications to obtain satisfactory service from refractory materials depend strongly on the location(s) where they are to be used. A substantial investment in refractory products designed to handle high temperatures and destructive operations can be lost by inadequate design or careless construction/installation.

All shaped (insulating, dense, special composite or acid-resistant) refractory materials are classified in terms of the chemical and mineralogical nature of the main constituents according to ISO 1109, as follows:

high alumina products	(Group HA);
fireclay and low fireclay products	(Group FC and LF);
siliceous and silica products	(Group SS and SL).

NOTE: Siliceous and silica products are rarely used in refinery equipment.

2.2 CLASSIFICATIONS OF SHAPED REFRACTORY MATERIALS

Refractory bricks are divided into *five* sub-groups:

2.2.1 Shaped insulating refractory materials

Insulating refractory materials are manufactured from base refractory materials, fired and with a total porosity of at least 45% determined in accordance with ISO 5016.

NOTE: This definition results from the fact that thermal insulating products all have a low thermal conductivity and a small thermal capacity, properties which are related to the total porosity of the product. The bulk density, which for a given product is directly linked with porosity, can therefore be chosen as a criterion for classification.

2.2.2 Dense shaped refractory materials

Dense refractory materials are manufactured from base refractory materials with a total porosity of less than 45% and with a pyrometric cone equivalent (P.C.E.) of at least 1500 °C. The main constituents are alumina silicates.

In the manufacturing process the method of bonding and the process of shaping the materials define to a great extent the ultimate properties of refractory bricks and shapes. A distinction may therefore be drawn between, plastic, semi-dry and dry formed products.

2.2.3 Pre-cast refractory shapes

Pre-cast modular concrete and plastic shapes can be manufactured in a controlled environment with superior physical and chemical properties, especially if use is made of Low or Ultra-low cement refractory and the products are shaped by pump-cast, vibrate-cast or self-flow methods.

Generally, these products are classified as monolithic refractory materials and can be manufactured from the full range of base refractory materials. However, in practice pre-cast shapes are mainly used for customised shapes with tailored properties, based on high alumina ($>50\% \text{Al}_2\text{O}_3$) or special compositions.

After drying, a firing procedure could be executed to:

- remove free (mixing) water;
- make the prefab products inert for water vapour/moisture pickup and possible degradation during prolonged storage;
- bring the prefab products to an elevated temperature to eliminate or prevent irreversible volume changes after installation and during start-up.

The required drying and firing procedures shall be executed in accordance with Manufacturer's recommendations.

2.2.4 Special compositions

Special compositions are mainly manufactured from refractory base materials other than the alumina silicate group, i.e. basic compositions (magnesia), silicon carbide and zirconium silicate, for special applications.

2.2.5 Acid-resistant refractory materials

Acid-resistant materials are manufactured from refractory base materials and comply with the classification criteria of refractory products defined in ISO 1109.

The classification is based on ISO 10080, with respect to resistance against sulphuric acid and apparent porosity of the refractory material.

3. QUALITY ASSURANCE/QUALITY CONTROL

The required properties of the refractory bricks are specified in Appendix 1.

Sampling and testing requirements are specified in Appendix 2.

The application of refractory linings involves several distinct steps from design to installation. Lack of quality control in any of these steps could lead to complete failure of the lining. It is therefore of vital importance for a quality control procedure to be established for each refractory lining application, covering all aspects from refractory material selection up to and including final inspection of the installed lining.

This principle quality control procedural aspects which should be covered as a minimum are as follows:

Base material selection	Clearly specified requirements
Manufacturing of materials	Inspection, testing
Design	Design requirements to enable a sound refractory lining
Refractory shipment and storage	Requirements, inspection, certification
Curing, drying and firing	Requirements, inspection
Installation/application	Requirements, inspection, Applicator's procedure Qualification of equipment and crew
Completed lining	Inspection
Lining repairs	Methods, requirements, inspection

The Contractor shall set up an appropriate quality control programme addressing at least all steps described above.

The Contractor shall provide refractory Suppliers and Applicators with sufficiently detailed specifications for each of their specific activities. In particular the demarcation of responsibilities and the smooth hand-over between parties involved should be duly covered in the quality assurance programme.

Lining details shall be included on drawings. They may also be provided by equipment Suppliers. Any conflicting requirements shall be investigated by the Contractor and referred to the Principal for resolution before bidding or proceeding with the refractory work.

The properties and their applications shall be tested in accordance with ISO or equivalent standards. All refractory materials shall be tested by a recognised and mutually agreed laboratory, experienced in testing refractory materials.

For appropriate testing standards, refer to PTS 64.24.32.30, Table 3-1.

4. DESIGN

4.1 DESIGN PARAMETERS

All expected operating conditions shall be reflected in the refractory design. The design of linings shall also take into consideration the construction and maintenance aspects.

Linings can be single or multi-layered, depending on the operating temperatures. Maximum allowable surface temperatures of refractories may, for instance, necessitate the use of a hot face layer backed up by an insulating layer (multiple lining). Thickness of linings is determined by strength, method of application and insulation properties. Attention shall be paid to proper detailing of joints to compensate for thermal expansion and drying shrinkage.

Table 5-1 of PTS 64.24.32.30 gives a summary of the relation between operating/lining design conditions and refractory characteristics, which should be used as guidance in lining design.

4.2 TYPES OF LINING

The types of refractory lining described below provide a common basis for identification.

- Single layer linings, consisting of dense or insulating refractory bricks;
- Multi-layer linings (commonly 2 or 3 layers), consisting of layers of dense and/or insulating refractory bricks.

The design should normally be such that the outer wall temperature is between 60-80 °C, as specified by the Principal. If sulphur-containing fuels are used for firing, the Contractor shall verify whether or not there is a risk of dew point corrosion, in which case a wall temperature above 150 °C is required. In such cases, the Contractor shall submit relevant calculations to the Principal.

Walls, arches, hearths and other equipment parts should be designed and constructed to ensure structural stability at both ambient and at high temperature operation. Proven material properties and anchorage systems shall be used in the design and determination of lining thickness and stresses.

A similar selection process may be followed as that given for guidance in Table 5-2 of PTS 64.24.32.30.

Bricked constructions should be designed and built so that internationally accepted standard bricks and shapes, such as those specified in ISO 5019, can be used, in order to improve availability, independence from Manufacturers, cost-reduction and ease of maintenance.

Depending on the design of brick constructions, bricks are laid in walls, hearths and arches in so-called 'bonds', whereby the construction is strengthened by a combination of header-and-stretcher courses and staggered cross joints.

Bonds improve the strength and stability of the constructions and depend on:

- thickness of the walls;
- allowable permeability through the joints;
- operating conditions;
- pre-designed ease of maintenance.

To reduce permeability through (mortar) joints, tongue-and-groove bricks should be used.

The mortar used for joining the bricks shall be in accordance with the same design and operational conditions as are valid for the refractory bricks, and it shall be applied in full and consistent thin layers.