

**BROADBENT REFRACTORY INDUSTRIAL TRAINING SERVICES**

**ADVANCED CERTIFICATE**

**OF**

**COMPETENCE**

**IN**

**GENERAL REFRACTORIES ENGINEERING**

**STUDENT COURSE BOOKLET**



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## COURSE BACKGROUND

The refractory industry has experienced many changes during the past 40 years, following advancements in industrial processes and the conversion from solid to liquid and gaseous fuels. These changes have resulted in a reduction in the use of refractory materials and subsequent drop in skilled labour force. The number of apprenticeships fell considerably. As a result, post craft training courses waned and courses leading to City and Guilds Certificate in Furnace Bricklaying lapsed - the long established booklet 608 (Furnace Brickwork) ceased to be available.

It became apparent in 1974 that appropriate steps must be taken to re-establish craft training courses and to offer residential and in-company technological courses on the subject of "REFRATORIES ENGINEERING". This led to a 5 day residential course on the subject of "GENERAL REFRATORIES ENGINEERING", which took place in 1978. The above annual six week course took place on six occasions, but the course had been held, more often than not, twice a year ever since and continues to attract delegates from all over the world. Unfortunately, in-company courses - tailored to suit specific training needs, did not materialise until 1986.

## COURSE OBJECTIVE

To provide, through learning material:

1. A general theoretical knowledge of refractory materials and their uses.
2. An understanding of the up-to-date methods of preparations, application and installation of materials.
3. An appreciation of widely accepted techniques for design and construction of furnace linings, with due regards to safe working procedures and safety precautions.
4. A sound basis for the task of supervising and inspecting new installations and repairs.

## COURSE OF STUDY

The course of study is based on a modular system, the programme of which contains four units with support arrangements forming a flexible method of study. The content of each has been drawn up in a broad basis to cover the technical requirements of the Refractories Engineer and others who are heavily engaged in the design and construction of refractory furnace linings.

The four units are intended to occupy two hundred hours of study time - including work on assignments – and are to be completed within a two year period, but with a minimum of one years study. It is understood that the actual time to complete the course will depend on the ability and experience of the student.

### ENTRY TO THE COURSE

1. The selection of students shall be at the discretion of BRITS-Online and in consultation with sponsored parties.
2. It is a recommendation but not necessary that the student has at least one year of relevant industrial site experience.
3. The course of study does not rely on previous technical knowledge but assumes a reasonable standard of competency.

### THE COURSE IS INTENDED FOR

1. Refractories engineers and affiliated staff who have little experience and technical knowledge of general refractories engineering.
2. Craft persons who require a broad understanding of general refractories engineering.
3. Managers, engineers, engineering technicians and other personnel who have a responsibility for maintenance and repair of specific furnaces.

### COURSE ASSESSMENTS

Each assessment will be marked by a nominated invigilator and/or a trained assessor nominated by BRITS-Online.

The appointed qualified assessor will arrange for the final assessment to be completed in person to ensure that the student achieves the required competency standard.

### ASSIGNMENTS

Students are required to complete *four* written assignments that a tutor marks and comments on.

Each of the *four* assignments - one for each unit - should only be completed when the relevant aspects of the syllabus have been adequately covered.

The content of each assignment will determine the timetable and the suitable atmosphere under which the work is to be carried out.

Assignments are to be assessed as a *whole* component. A student who is unable to achieve competency in any component (see EXAMINATION) may be given a second opportunity of the same assignment(s). Should the student not achieve competency then he or she will be guided through and advised accordingly.

Course tutors(s) are at liberty to guide and advise students as to their *general* performance in each assignment.

## EXAMINATION

### *Components*

The examination for the award of the Advanced Certificate of Competence will compromise of two components

- (a) Assessment of the four course assignments
- (b) Written examination paper of one and half hours duration compromising of sixty multiple-choice type questions.

Setting and the marking of components (a) and (b) are delegated by BRITS-Online. A copy of the above documents will be sent to the “sponsored group” for validation.

### *Eligibility for Entry*

A student must enter for both components at their first attempts. Students who are successful in one component but not both components may carry forward their success and retake the component in which they didn't achieve competency at a later date.

Students that reside overseas will take component (b) at their place of work and in the presence of an invigilator nominated by their employer and approved by BRITS-Online. All other students will take component (b) at an examination centre geographically situated to minimise travelling.

## AWARD OF CERTIFICATE

The Advanced Certificate of Competence will be awarded to students successful in obtaining each of the following:

1. Not less than 48% of the total possible marks in each of the four assignments in component (a);
2. Not less than 50% of the total marks in the written examination paper in component (b);

## RESULTS

Where the employer is sponsoring the candidate then both the employer and the student will receive a record of performance in components (a) and (b) from BRITS-Online.

The certificate will be delivered by registered post

### TUTOR CONTACT

The course co-ordinator, on receipt of an application, will contact the prospective student to discuss

- a. Starting dates
- b. Course time schedule
- c. Course requirements
- d. Experience profile
- e. Industrial support
- f. Tutors requirement and support
- g. Examination details

### DELIVERY OF COURSE MATERIAL

Students will receive their respective components and assignments by the following methods

1. The student can download/print off the units and assignments from a web site with username and login (preferred).
2. The units and assignments can be sent to the students by post.
3. The units and the assignments can be emailed direct to the student

### COST OF THE COURSE

AU\$2500.00 excluding GST

### WHAT THE COST INCLUDES

1. Total package of Unit components with support from BRITS-Online
2. Written assignments with BRITS-Online support
3. Written examination
4. Course certificate

Note: The cost does not include any form of course expenses incurred by the student.



### ACKNOWLEDGMENT

The course was established in 1981 by M G H Fox. George Henry Fox is a retired Senior Lecturer and a Past president of the Guild of Bricklayers. He is the author of the following;

- International Distance Learning Course leading to the award of the Advanced Certificate of Competence in 'General Refractories Engineering'
- Bonding of Furnace & Civil Engineering Brickwork
- Inspection of Refractory Installations as Work Proceeds

His achievements over the years and lectures both in the UK and Overseas have earned him an international reputation.

### DISCLAIMER

The information and guidance given in this course are, to the best of the author's knowledge, correct and accurate at the time of publication. Any representations and opinions expressed by course tutors during this course are their own and not those of Brits-Online itself. The contents of learning material prepared by appointed consultants are their own and not those of Brits-Online. Brits-Online cannot accept any liability (including that for negligence) for any losses resulting from such representation, opinions and learning material.

## THE SYLLABUS TOPICS

### UNIT 1

1. GLOSSARY OF TERMS
2. CLASSIFICATION OF MATERIALS
3. MANUFACTURE
4. REFRACTORY BLOCK (Design)
5. GENERAL FURNACE DESIGN
6. WORKINGS OF A FURNACE
7. FORCES
8. SCAFFOLDING
9. HOISTING OF MATERIALS
10. MECHANICS
11. TIMBERING/TRENCHES
12. REINFORCED CONCRETE

### UNIT 2

1. BRICKWORK
2. COATINGS
3. BRICK/BLOCK ARCHES
4. THERMAL EXPANSION
5. CURVED WORK
6. LINING OF ROTARY KILNS
7. THERMAL INSULATION

### UNIT 3

1. MONOLITHIC LININGS
  - Castables
  - Guniting
  - Mouldable/Plastics
  - Ramming Bodies
2. STEEL FIBRE
3. ANCHORS
4. FORMWORK FOR REFRACTORY
5. PRECAST UNITS

### UNIT 4

1. REPAIR WORK
2. FAULTS & DEFECTS DIAGNOSIS
3. CERAMIC FIBRE
4. SELECTION OF MATERIALS
5. SITE PROCEDURE
6. DRYING AND FIRING
7. WORKING DRAWINGS
8. FURNACE ATMOSPHERES & INDUSTRIAL FUELS

## Unit 1 – SYLLABUS

The syllabus objectives should be understood to be prefixed by the words “*The student is expected to*”

The subject of “HEALTH & SAFETY” should form an integral part of the learning material.

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### OBJECTIVES

#### U1-1 GLOSSARY OF TERMS

U1-1-1 Define the meaning of the following terms:

- |   |                               |                 |                  |
|---|-------------------------------|-----------------|------------------|
| a. Spalling   | b. Ringing, or ring formation | c. Creep        | d. Heat capacity |
| e. Thermal shock resistance                               | f. Slag                       | g. Gas tracking |                  |
| h. Refractoriness in terms of temperature and under load. |                               |                 |                  |

U1-1-2 Define *general terms* relating to furnace design

#### U1-2 CLASSIFICATION OF REFRACTORY MATERIAL

U1-2-1 Classify refractories based on essential components

U1-2-2 Discuss the range of properties that characterise refractory materials and related to their uses in manufacturing of refractory products

U1-2-3 Describe the following materials:

- |   |                       |
|---|-----------------------|
| a. Brick  | b. Mortar             |
| c. Ramming  | d. Thermal insulation |
| e. Coating  | f. Mouldable          |
| g. Castable (general, freeflow, plastic, low cement & ultra low cement) |                       |

#### U1-3 MANUFACTURE

U1-3-1 Describe the mining and preliminary treatment of raw materials for refractory products

U1-3-2 Describe the manufacture of

- |              |             |              |           |
|--------------|-------------|--------------|-----------|
| a. Pre-fired | b. Castable | c. Mouldable | d. Mortar |
|--------------|-------------|--------------|-----------|

## Unit 1 – SYLLABUS

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### OBJECTIVES

#### U1-4 BLOCKS

U1-4-1 Recognise and name a wide range of blocks and illustrate their use.

U1-4-2 Demonstrate a knowledge in the design of special shapes

U1-4-3 Outline methods of handling, stacking, protection and storage

#### U1-5 GENERAL FURNACE DESIGN

U1-5-2 Draw, to a suitable scale, detailed plans and cross-section through a furnace lining

U1-5-3 Demonstrate a knowledge in the reading of working drawings

#### U1-6 WORKING OPERATION OF A FURNACE

U1-6-1 Demonstrate a knowledge of a working furnace

#### U1-7 FORCES

U1-7-1 Define the following terms and demonstrate a knowledge in the use of appropriate formula

- |           |               |                     |
|-----------|---------------|---------------------|
| a. Load   | b. Force      | c. Stress           |
| d. Strain | e. Elasticity | f. Factor of safety |

## Unit 1 – SYLLABUS

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### OBJECTIVES

#### U1-8 SCAFFOLDING

U1-8-1 State the safety measures and basic requirements

U1-8-2 Describe the correct method of erecting and securing a ladder

U1-8-3 Outline the reasons for *barriers* and *notices*

U1-8-4 Identify the following types of scaffolds & state the safe use and inspection of each

- a. Trestle    b. Tower    c. Putlog    d. Independent

#### U1-9 HOISTING OF MATERIALS

U1-9-1 Describe the safe use of

- a. Scaffold crane/gin wheel    b. Elevator    c. Fixed hoist

#### U1-10 MECHANICS

U1-10-1 Explain the mechanics involved in the use of the following equipment

- a. Levers    b. Screwjacks    c. Pulleys

U1-10-2 Calculate beam reactions involving *distributed loads* and *point loads*

#### U1-11 TIMBERING / TRENCHES

U1-11-1 Describe, with aid of sketches, the methods and equipment used for temporary support to excavations.

U1-11-2 Appreciate the need for safe working procedures and inspection

#### U1-12 REINFORCED CONCRETE

U1-12-1 State the basic principles of reinforced concrete

## Unit 2 – SYLLABUS

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### OBJECTIVES

#### U2-1 BRICKWORK

U2-1-1 Identify and name standard brick shapes and illustrate where each would be used

U2-1-2 Explain the terms related to a piece of bonded brickwork, i.e. perpends, brick-on-edge, arris.

U2-1-3 Describe the purpose of bonding brickwork

U2-1-4 Recognise and name the following face bonds and explain, with the aid of sketches, the conditions governing their use:

- a. Stretcher   b. Header   c. English   d. English Garden Wall

U2-1-5 Demonstrate a knowledge of the bonding arrangements for :-

- a. right angle quoins up to 1 ½ - brick thick
- b. straight walls up to 1 ½ - brick thick incorporating stopped end and recessed reveals
- c. 'T' junctions and intersecting walls up to 1 ½ brick thick
- d. Obtuse and acute angles up to 1 ½ brick thick
- e. ¼ - brick corbels
- f. isolated and attached piers
- g. chimney stacks
- h. curved walls up to 1 ½ - brick thick

U2-1-6 Demonstrate a knowledge of setting out obtuse and acute angled quoins

U2-1-7 Demonstrate a knowledge of setting out curved walls and preparation of templates and trammels.

U2-1-8 Explain the use of mortars and describe the pointing of a wall.

## Unit 2 – SYLLABUS

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### OBJECTIVES

#### U2-1 COATINGS

U2-2-1 Describe their uses and demonstrate a knowledge in the application techniques

#### U2-3 BRICK/BLOCK ARCHES

U2-3-1 Define the following terms:

- |                   |                        |             |             |
|-------------------|------------------------|-------------|-------------|
| a. Rise           | b. Clear span          | c. Haunch   | d. Crown    |
| e. Key brick      | f. Intrados            | g. Extrados | h. Spandrel |
| i. Springing line | j. Radius of curvature |             |             |

U2-3-2 Identify and name a range of arches and explain the purpose of each

U2-3-3 State the advantage and disadvantage of

- a. Bonded roof construction
- b. Single ring construction

U2-3-4 Describe the construction of a typical

- a. Semi-circular brick arch
- b. Bulls-eye.

U2-3-5 Demonstrate a knowledge of the geometrical setting out of the following arches:

- a. Segmental
- b. Camber (jack arch)
- c. Three-centred ellipse

U2-3-6 Differentiate between standard and special skewbacks

U2-3-7 Calculate the number of brick/blocks for a camber arch of a 1m span.

U2-3-8 Apply the use of *Arch and Radial Formula*.

## Unit 2 – SYLLABUS

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### OBJECTIVES

#### U2-4 THERMAL EXPANSION

U2-4-1 Define the meaning of B.S. terms relating to expansion

U2-4-2 Sketch and describe the construction of straight and staggered joints in walls and arches.

U2-4-3 Calculate the expansion for a given lining

U2-4-4 Appreciate the need for the strict control on position and measurement of joints.

#### U2-5 CIRCULAR BRICK / BLOCK LININGS

U2-5-1 Describe

- a. the preparation and setting out of a vertical lining
- b. the method of maintaining accuracy as work proceeds

U2-5-2 Describe

- a. the preparation and setting out of  $\frac{1}{2}$  brick lining for a horizontal steel tube of 1.225m diameter.
- b. the methods of maintaining accuracy as work proceeds and recognise the need for equipment for safe working.

U2-5-3 Demonstrate a knowledge of the bonding arrangements for furnace bottoms.



## Unit 2 – SYLLABUS

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### OBJECTIVES

#### U2-6 BRICK/BLOCK LININGS OF ROTARY KILNS

U2-6-1 Identify and name main elements of structure

U2-6-2 Describe the method of repairing the following defects:

- a. Distorted steel shell
- b. Protruding welds, plates etc

U2-6-3 Demonstrate a knowledge of installation techniques.

U2-6-4 Explain the use of laser beam technology for setting out and maintaining accuracy as work proceeds.

U2-6-5 Identify hazards in the use of *centres, props, tools and equipment*

#### U2-7 THERMAL INSULATION

U2-7-1 List the properties which characterise insulation materials and relate these properties to use.

U2-7-2 Describe the methods of achieving *back-up* and *hot face* insulation

U2-7-3 Describe the following back-up insulation materials and state the conditions governing their use:

- a. Rigid
- b. Semi rigid
- c. Non-rigid

U2-7-4 Describe methods of handling, stacking, protection and storage of materials.

U2-7-5 Calculate heat loss through single and compound linings

### Unit 3 – SYLLABUS

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#### OBJECTIVES

##### US-1 MONOLITHIC LININGS - Castables

U3-1-1 List the properties that characterise the following castables and relate these properties to the use of the material:

- a. Conventional    b. Low cement    c. Clay bonded    d. Free flow

U3-1-2 Demonstrate knowledge in preparation, mixing, transporting and installation of materials listed in U3-1-1.

U3-1-3 List the variables which affect the quality of the finished product.

U3-1-4 Explain the term *CURING*

U3-1-5 Describe the methods of handling, stacking, protection and storing of materials.

U3-1-6 Demonstrate knowledge in selection and use of mechanical plant and equipment designed for the mixing of materials.

U3-1-7 Calculate the amount of castables required for a given job

## Unit 3 – SYLLABUS

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### OBJECTIVES

#### U3-2 MONOLITHIC LININGS - Guniting

- U3-2-1 List the properties that characterise *gunning* materials.
- U3-2-2 Demonstrate a knowledge of the basic working principles of plant and equipment in current use.
- U3-2-3 State the safe working procedures and safe precautions specific to gunning installations.
- U3-2-4 Explain the need for strict control on application and uniform thickness

#### U3-3 MONOLITHIC LININGS - Mouldable/plastics

- U3-3-1 List the properties which characterise *Mouldables* and relate these properties to use.
- U3-3-2 Demonstrate knowledge of application technique and list equipment used.
- U3-3-3 Make provision for *contraction* and *drying out*.

#### U3-4 MONOLITHIC LININGS - Ramming bodies

- U3-4-1 List the properties which characterise *Ramming Bodies* and relate these properties to the use of the materials.
- U3-4-2 Demonstrate knowledge in preparation and installation.

#### U3-5 STEEL FIBRE

- U3-5-1 Identify and name types
- U3-5-2 List the properties that characterise SF and relate these properties to use.
- U3-5-3 Demonstrate a knowledge in the safe use of SF

### Unit 3 – SYLLABUS

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#### OBJECTIVES

##### U3-6 ANCHORS

- U3-6-1 Identify and name proprietary and other refractory/metal anchors and specify in what situation each would be used.
- U3-6-2 Explain the function of anchors
- U3-6-3 Appreciate the need for quality materials and good design.
- U3-6-4 Describe the setting out and recommend spacings for wall and roof linings.
- U3-6-5 Appreciate the need for strict control on position and correct *linkage*.

##### U3-7 FORMWORK FOR REFRACTORY CONCRETES

- U3-7-1 Outline the use of metal and timber supports, shuttering & formwork.
- U3-7-2 Describe the inspection and treatment of shuttering prior to use.
- U3-7-3 Describe the method for stacking and protection.
- U3-7-4 Describe, with the aid of sketches, the construction and installation of a typical monolithic roof.

##### U3-8 PRECAST REFRACTORY UNITS

- U3-8-1 Demonstrate a knowledge of mould construction.
- U3-8-2 Demonstrate a knowledge in casting techniques

## Unit 4 – SYLLABUS

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### OBJECTIVES

#### U4-1 REPAIR WORK

U4-1-1 Demonstrate a knowledge of preparation and correct working procedures

U4-1-2 Describe the correct use and construction of *dead* and *raking shores*.

U4-1-3 State safe working procedures and safety precautions specific to repairs.

U4-1-4 Describe the repair of the damage brick/block and monolithic linings.

#### U4-2 FAULTS AND DEFECTS DIAGNOSIS

U4-2-1 Identify in materials, installation and design.

U4-2-2 State probable causes and suggest remedial action.

U4-2-3 Prepare, compare and file appropriate records.

#### U4-3 CERAMIC FIBRE

U4-3-1 List the properties which characterise CF and relate these properties to the use of the material.

U4-3-2 List the safety factors to be considered during installation.

U4-3-3 Identify and name the various types of linings and describe the installations of each.

## Unit 4 – SYLLABUS

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### OBJECTIVES

#### U4-4 SELECTION OF REFRACTORY MATERIALS

U4-4-1 Demonstrate a knowledge in the basic procedure of selection.

U4-4-2 List the factors that influence choice.

U4-4-3 State the type of materials used in specific elements of structure.

#### U4-5 SITE PROCEDURE

U4-5-1 Demonstrate a knowledge in site and workshop organisation.

U4-5-2 List the sequence of site operations.

U4-5-3 Prepare a simple *Bar Chart* from given information

U4-5-4 Recognise the need for storage and protection of materials.

#### U4-6 DRYING AND FIRING

U4-6-1 Demonstrate a knowledge in the *drying and firing* of a furnace.

U4-6-2 Explain what is meant by *rapid firing*.

U4-6-3 Appreciate the need for strict control.

#### U4-7 WORKING DRAWINGS

U4-7-1 Prepare and read working drawings

U4-7-2 Produce detailed sketches of elements of structure

## Unit 4 – SYLLABUS

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### OBJECTIVES

#### U4-8 FURNACE ATMOSPHERES & INDUSTRIAL FUELS

U4-8-1 Describe a brief understanding of the following furnace atmospheres:

- a. Oxidising
- b. Neutral
- c. Reducing

U4-8-2 Give a general appraisal of the fuels in common use.







REQUEST FOR STUDENT / EMPLOYER APPLICATION FORM

Please use BLOCK CAPITALS

Course Title:       ADVANCED CERTIFICATE OF COMPETENCE IN GENERAL  
REFRACTORIES ENGINEERING

Full name:           \_\_\_\_\_

Position:            \_\_\_\_\_

Home Address:       \_\_\_\_\_

\_\_\_\_\_

Tel. Number:        \_\_\_\_\_ Fax Number \_\_\_\_\_

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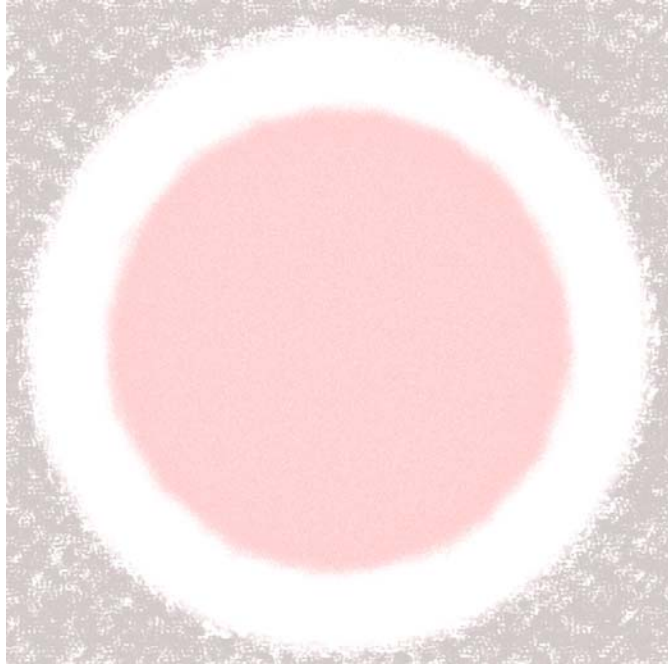
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