Unit 138: Rubber Technology

Unit code: J/602/3504

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit provides learners with a knowledge of additives and the classification, properties and applications of rubbers. Learners will be able to explore the use of additives in the rubber mix design and will gain an understanding of the construction and use of processing equipment.

Unit introduction

This unit builds on the concepts of rubber technology and provides learners with an opportunity to develop an understanding of high consumption rubbers, their applications and processing methods. Learners will develop a knowledge of the structure of natural rubber and their ability to stretch and return to their original shape as elastomers. They will also develop a knowledge of vulcanisation (discovered by Charles Goodyear) by cross-linking chains with sulfur atoms.

The disposal of rubbers and the effects on the environment and recycling of rubbers are also studied. Learners will also develop a knowledge of mix additives, mix design, processing, vulcanisate properties and applications of the high tonnage rubbers. The unit provides opportunities for learners to develop their understanding and skills through practical investigation.

Learning outcomes

On completion of this unit a learner should:

1 Know the classification, properties and applications of rubbers

2 Know the effects of additives used in rubber mix design

3 Be able to investigate the use of additives in the mix design in the processing, costs and property modification of rubbers

4 Understand the construction and use of processing equipment for the manufacture of rubber products.

Unit content

1 Know the classification, properties and applications of rubbers

Natural rubbers: growing conditions; conversion of latex to dry rubber; structure; elasticity; Tg; grading systems; processing and vulcanisate properties; cost; applications

Styrene butadiene rubber: manufacture; grading systems; processing and vulcanisate properties; cost; applications

Acrylonitrile butadiene rubber: manufacture; grading systems; processing and vulcanisate properties; cost; applications

Polychloroprene rubber: manufacture; grading systems; processing and vulcanisate properties; cost; applications

Ethylene propylene diene modified: manufacture; grading systems; processing and vulcanisate properties; cost; applications

Isobutylene isoprene rubber: manufacture; grading systems; processing and vulcanisate properties; cost; applications

Recycling rubbers: processing; grading systems; cost; applications

2 Know the effects of additives used in rubber mix design

Fillers: classification of reinforcing; classification of non-reinforcing; carbon black; mineral fillers; effect of particle size and structure; choice for application/rubber; costing calculations

Cross-linking agents: classification; sulfur-based; characterisation of organic accelerators; activators; EV and semi-EV systems; organic peroxides; metal oxides; choice for application/rubber

Antidegradents: classification; antoxidants; antiozanants; waxes choice for application/rubber

Plasticisers: classification; aliphatic; aromatic; synthetic; polymeric; mode of action; choice for application/rubber

Process aids: reason for use; factice; reclaim rubber; tackifiers; resins; proprietary materials; choice for application/rubber

3 Be able to investigate the use of additives in the mix design in the processing, costs and property modification of rubbers

Use of additives: factors eg low cost, maximum tensile strength, high/low modulus, maximum oil/fuel resistance, maximum age resistance, electrical insulation/conductivity, resilience, minimum compression and tension set, flame resistance, low temperature flexibility, food quality, low toxicity

4 Understand the construction and use of processing equipment for the manufacture of rubber products

Mixing: mechanism; open mill construction and operation; internal mixer construction and operation; mastication; comparison of machines; quality; mixing specifications; safety

Extrusion: screw characteristics; feed design; die design; die swell; haul off; temperature control; ram extruders; safety

Calendering: roll configuration; roll correction devices; topping; skim coating; rubber sheet; ancillary equipment; safety

Vulcanisation: cure characteristics and terminology; selection of cure temperature; moulding (compression, transfer, injection); mould design; mould release; mould cleaning; mould shrinkage; open cures; continuous cures; safety

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the classification, properties and applications of rubbers [RL6]	**M1** explain rubber processes	**D1** justify the use of particular rubbers for specified applications
	M2 discuss the operation of processing equipment	
P2 describe the effect of additives used in rubber mix design [RL6]	**M3** explain the main factors that influence mix design	**D2** compare and contrast the mix additives used in rubber mixes for different applications
	M4 justify the use of mix additives for particular property requirements	
P3 carry out investigations into the use of additives in the mix design, using safe working practices [IE1, IE2, IE4, TW1, TW2, TW3, SM3, CT1]	**M5** suggest alternatives in designing mixes for different purposes	**D3** justify appropriate corrective action for mix designs failing to meet specification
P4 explain the construction of processing equipment for the manufacture of rubber products [RL6]	**M6** discuss the merits and limitations of rubber processing equipment.	**D4** justify the most appropriate process for the production of different components or products for particular purposes.
P5 explain the use of processing equipment for the manufacture of rubber products. [RL6]		

PLTS: This summary references where applicable in the pass criteria, in the square brackets, the elements of the personal, learning and thinking skills. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

The concepts covered by this unit should be delivered through a programme of tuition and practical work in the laboratory. Delivery should be based on a well-structured programme of practical exercises to develop learners' skills and the evidence necessary to meet the assessment and grading criteria. Learners should build on the concepts covered in *Unit 45: Basic Polymer Technology*.

If it is appropriate to use facilities other than those in the centre (for example, facilities on employer or university premises), arrangements to use those facilities should ensure that the necessary formative activities can be undertaken; one-off use of equipment will not meet the outcomes of this unit.

Health and safety should be a recurring theme throughout the delivery and assessment of this unit. Learners must be taught the nature of hazards and where to find appropriate information on them. Learners are not 'competent persons' under the COSHH regulations; they should not, therefore, be expected to carry out full risk analyses for practical work to be undertaken.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to unit.
Formal input: terminology, natural rubber and its growth, latex.
DVD/Video on natural rubbers.
Formal input: vulcanisation of natural rubber and structure.
Demonstration showing different types of rubbers, properties and their applications.
Research on recycling rubbers.
Learners compare costs of rubber products.
Learner-initiated study on a sample of rubbers.
Visit to rubber manufacturer.
Assignment 1: Classification, Properties and Applications (P1, M1, M2, D1)
Formal input: rubber mix designs and the effects of additives.
Demonstration showing different types of mix designs.
Learners compare factors that effect mix design.
Learners formulate their own mix designs.
Assignment 2: Additives in Mix Design (P2, M3, M4, D2)
Formal input: processing, costs and property modification.
Formative practical investigations.

Topic and suggested assignments/activities and/assessment
Assignment 3: Investigating Processing (P3, M5, D3)
Formal input: processing equipment.
Demonstration of processing and recycling equipment.
Visit to manufacturer to inspect processing and recycling.
Assignment 4: Processing Equipment for Manufacture (P4, P5, M6, D4)
Review of unit and overview of assessment.

Assessment

The focus of assessment should be on learners carrying out the required tasks. Learners could produce reports as evidence to meet the assessment and grading criteria. Alternatively, learner presentations, supported by assessor witness testimony, would also form a suitable assessment method. Tutors should observe learners undertaking practical activities and clearly record assessment decisions using an appropriate assessor's observation record, retained for audit purposes.

Safety requirements must be applied to all activities. Learners must work safely and accurately within supplied methods; this must be applied rigorously to all activities.

The pass assessment criteria require practical methods to be followed safely and correctly in order for learners to describe the structure and properties of rubbers and vulcanisation, their classification, recycled rubbers, applications and the use of additives. Learners need to be able to describe the use of additives in the mix design and to explain the construction and use of processing equipment. Unit delivery should be based on the development of skills in industrially relevant methods to meet these criteria.

For the merit criteria, learners need to explain and justify the use of additives and other processes employed in the production of rubber products. This requires delivery of the underlying principles, which may be introduced before or during the practical work, but should be emphasised throughout the formative programme preceding assessed exercises.

For the distinction criteria, learners need to adopt a more evaluative approach to rubber technology and to be able to justify corrective actions to problems with processing. It may be appropriate to analyse one activity in detail as a group exercise. Thereafter, these activities may be left to independent study, with appropriate guidance from tutors. If group work is undertaken, tutors must ensure that each learner individually produces sufficient evidence to meet the assessment and grading criteria and that assessment decisions are clearly recorded using an appropriate observation sheet.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, M1, M2, D1	Classification, Properties and Applications	The training officer has been asked to produce an induction leaflet on natural and synthetic rubbers for new apprentices.	Leaflet. Poster.
P2, M3, M4, D2	Additives in Mix Design	The rubber technologist has been requested to report on the influence of additives in mix design.	Report.
P3, M5, D3	Investigating Processing	The rubber senior technician has been given an assignment to investigate mix designs for particular specifications and any corrective actions.	Practical report.
P4, P5, M6, D4	Processing Equipment for Manufacture	The rubber process engineer needs to explain the latest processing equipment as part of quality control.	Report.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Applied Science sector suite. This unit has particular links with the following unit titles in the BTEC Applied Science suite:

Level 2	Level 3
Chemistry and Our Earth	Basic Polymer Technology
Applications of Chemical Substances	Plastics Processing
	Rubber Products and Specialist Elastomers
	Plastics Materials
	Polymer Process Engineering
	Scientific Practical Techniques
	Fundamentals of Science
	Industrial Applications of Organic Chemistry
	Industrial Chemical Reactions

Essential resources

Learners need access to appropriate laboratory facilities and specialist resources to cover the contextualisation of the underlying concepts to their polymer specialism for example plastics, rubber or related areas. Site visits to relevant industrial facilities to see practical techniques in operation would be beneficial. Input from industry experts as guest speakers would enhance unit delivery.

Employer engagement and vocational contexts

British Plastics Federation

Cogent – Sector Skills Council

Network for Science, Technology, Engineering and Maths – Network Ambassadors Scheme

The Polymer Society

The Rubber in Engineering Group

Indicative reading for learners

Journals

British Rubber and Plastics

Materials Foresite

Materials World

Plastics, Rubber and Composites

Websites

www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/polymers.htm	Chemistry
www.bpf..co.uk	British Plastics Federation
www.cia.org.uk	Chemical Industries Association
www.cogent-ssc.com	Sector Skills Council
www.en.wikipedia.org/wiki/Natural_rubber	Natural Rubber
www.en.wikipedia.org/wiki/Synthetic_rubber	Synthetic Rubber
www.iom3.org	The Institute of Materials, Minerals and Mining (The Rubber in Engineering Group)
www.rsc.org.uk	The Royal Society of Chemistry
www.stemnet.org.uk	Network for Science, Technology, Engineering and Maths – Network Ambassadors Scheme

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	obtaining data and using results to predict properties
Team Workers	carrying out investigations
Reflective learners	communicating to different audiences
Self-managers	planning and completing experiments
Creative Thinkers	exploring mix designs.