22312VIC

Course in the Use of Carbon Fibre in Composite Manufacturing

Accredited for the period:

1 January 2016 to 31 December 2020

under Parts 4.4 and 4.6 of the *Education and Training Reform Act 2006.*

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Section A: Copyright and course classification information

1. Copyright owner of the course	Copyright of this document is held by the Department of Education and Training, Victoria. © State of Victoria 2015
2. Address	Department of Education and Training Higher Education and Skills Group Executive Director, Training System Performance and Industry Engagement GPO Box 4367 Melbourne Victoria 3001 **Organisational Contact:** Manager Training Products Higher Education and Skills Group Telephone: (03) 9637 3688 Day to day contact: Engineering Industries - Curriculum Maintenance Manager Box Hill Institute Private Bag 2014 Box Hill VIC 3128 Email: g.adda@bhtafe.edu.au Telephone: 03 9286 9999
3. Type of submission	Accreditation
4. Copyright acknowledgement	Copyright of this material is reserved to the Crown in the right of the State of Victoria. © State of Victoria (Department of Education and Training) 2015 Copyright of the following units of competency from nationally endorsed training packages is administered by the Commonwealth of Australia. © Commonwealth of Australia and can be accessed from Training.gov at www.tga.gov.au **MEM05 Metals and Engineering Training Package** MEM26002A Lay up composites using vacuum closed moulding techniques MEM26003A Lay up composites using pressure closed moulding techniques MEM26007A Select and use reinforcing appropriate for the product MEM26008A Select and use resin systems appropriate for product

	MEM26010A Store and handle composite materials MEM26013A Select and use composite processes or systems appropriate for product MEM26015A Select and apply repair techniques MEM26016A Select and use joining materials MEM26020A Identify and interpret required standards for composites
5. Licensing and franchise	
6. Course accrediting body	**Victorian Registration and Qualifications Authority (VRQA)** Website : http://www.vrqa.vic.gov.au/
7. AVETMISS information	***ANZSCO Code*** *(Australian and New Zealand Standard Classification of Occupations)* — *399999 Technician and Trades Worker Nec* ***ASCED Code – 4 digit*** (Field of Education) — *0307 Manufacturing and Industrial Engineering and Technology* ***National course code*** — *To be provided by the VRQA when the course is accredited*
8. Period of accreditation	1 January 2016 – 31 December 2020

Section B: Course information

1. **Nomenclature**	***Standard 1 AQTF Standards for Accredited Courses***
1.1. Name of the qualification	Course in the Use of Carbon Fibre in Composite Manufacturing
1.2. Nominal duration of the course	150-190 hours
2. Vocational or educational outcomes	**Standard 1 AQTF Standards for Accredited Courses**
2.1. Purpose of the course	The course will provide participants with the enhanced skills and techniques to be used in the field of composite materials focusing on Carbon Fibre and Carbon Fibre manufacturing. Graduates of the course will be able to work as qualified practitioners in the carbon fibre product manufacturing industry in roles such as: • Carbon fibre process operator • Carbon fibre process technician • Carbon fibre process maintenance trades person • Carbon fibre manufacturing sales representative • Carbon fibre quality controller • Carbon fibre manufacturing trades/post trades
3. **Development of the course**	**Standards 1 and 2 AQTF Standards for Accredited Courses**
3.1. Industry / enterprise/ community needs	Structural industrial change in Australia has been driven by economic reform, technological developments, increasing demand for services and the industrialisation of East Asia. Given Victoria's relative strength in manufacturing, which is a trade-exposed sector vulnerable to global competition and increases in the Australian dollar, Victoria has suffered more from structural change than any other state in Australia. The Barwon-Western District, which includes Geelong, Hamilton and Warrnambool, has experienced higher levels of structural change than most of the other regions in Victoria. According to Deloitte Access Economics analysis, between 2005 – 2007 and 2008 – 2010, the rate of structural change for the region was 8.1 per cent, and from 2008 – 2010 to 2011 – 2013, the rate was 4.5 per cent. The implication for the region is that wealth generation and employment, which has in the past been in traditional manufacturing, is shifting towards other industries such as advanced manufacturing. This requires different workforce skills and training requirements. Skilling the Bay, a Victorian State Government funded entity initiated and established by The Gordon and Deakin University in response to the economic and industry changes impacting Geelong, conducted initial research and industry consultations and identified the growing use of

	carbon fibre technology in composite materials as an important and developing industry sector in Geelong. Following further consultations with carbon fibre industry groups, manufacturers and employers, a need was established to develop a course that met the unique skills needs of this emerging sector. A summary of the skills and knowledge outcomes was developed through Industry Roundtable meetings and workshop that was held in May 2015. The summary of the skills and knowledge outcomes and resulting report is provided as Appendix 1. Entrants to the *Course in Use of Carbon Fibre in Composite Manufacturing* will generally be production workers, qualified tradespersons or engineers, who want to undertake, or who have responsibilities for carbon fibre and carbon fibre composite manufacturing. A Steering Committee was established to oversee the course development, which consisted of: Carl Dekoning (Chair) — Quickstep Automotive Pty Ltd Roger Cater — Composites Australia Jill Mitchell — Skilling the Bay Fraser Nelson — Manufacturing Skills Australia (MSA) Matthew Allsopp — The Gordon Carl Hitchings/Lilli Ruiz — Carbon Revolution Derek Buckmaster — Carbon Nexus, Deakin University Ian Thomas — The Gordon Jeff Lawrence/ Lee Charlton — Sykes Racing <u>In attendance:</u> Linda Vaughan — Department of Education and Training (DET) Dr. John Flett — The Gordon Rory McNamara — The Gordon George Adda — CMM-Engineering Industries Sam McCurdy — Dewhurst Consultancy Pty Ltd This course: • does not duplicate, by title or coverage, the outcomes of an endorsed training package qualification • is not a subset of a single training package qualification that could be recognised through one or more statements of attainment or a skill set • does not include units of competency additional to those in a training package qualification that could be recognised through statements of attainment in addition to the qualification • does not comprise of units that duplicate the units of competency of a training package qualification.
3.2. Review for re-accreditation	Not applicable

4. Course outcomes	Standards 1, 2, 3 and 4 AQTF Standards for Accredited Courses
4.1. Qualification level	*Standards 1, 2 and 3 AQTF Standards for Accredited Courses* Although this course meets an identified industry/enterprise or community need, it does not have the breadth, depth or volume of learning of a full qualification and consequently does not align with any specific level of the Australian Qualifications Framework (AQF).
4.2. Employability skills	*Standard 4 AQTF Standards for Accredited Courses* Not applicable
4.3. Recognition given to the course	*Standard 5 AQTF Standards for Accredited Courses* Not applicable
4.4. Licensing/ regulatory requirements	*Standard 5 AQTF Standards for Accredited Courses* There are no licensing or regulatory requirements relating to this course.
5. Course rules	**Standards 2, 6,7 and 9 AQTF Standards for Accredited Courses**
5.1. Course structure	To be eligible for the *Course in the Use of Carbon Fibre in Composite Manufacturing* participants must successfully complete all three core units and one of the elective units listed in Table 1. Participants who do not complete requirements of the full course will be awarded a Statement of Attainment listing those units that they have successfully completed.

Table 1: Course in the Use of Carbon Fibre in Composite Manufacturing

Unit of competency code	Field of Education code	Unit of competency title	Pre-requisite	Nominal hours
Core Units				
VU21860	030199	Apply the principles of using carbon fibre composites in manufacturing products	None	40
VU21861	030199	Investigate carbon fibre composite processes and terminology	None	60
VU21862	030199	Employ basic chemistry knowledge in the use of a polymer matrix	None	30
Elective units (Select one unit)				
VU21863	030199	Optimise carbon fibre composite processing applications	None	60
MEM26002A		Lay up composites using vacuum closed moulding techniques	None	60

MEM26003A		Lay up composites using pressure closed moulding techniques	None	80
MEM26007A		Select and use reinforcing appropriate for the product	None	40
MEM26008A		Select and use resin systems appropriate for product	None	40
MEM26010A		Store and handle composite materials	None	20
MEM26013A		Select and use composite processes or systems appropriate for product	None	40
MEM26015A		Select and apply repair techniques	None	60
MEM26016A		Select and use joining materials	None	60
MEM26020A		Identify and interpret required standards for composites	None	20
			Total nominal hours	**150-190**

5.2. Entry requirements	*Standard 9 for Accredited Courses* There are no formal entry requirements for this course, although participants would be best equipped to achieve the course outcomes if they have the learning, reading, writing and oracy, and numeracy competencies to Level 3 of the Australian Core Skills Framework (ACSF). Learners with language, literacy and numeracy skills at lower levels than those suggested will require additional support to successfully undertake the course.
6. **Assessment**	**Standards 10 and 12 AQTF Standards for Accredited Courses**
6.1. Assessment strategy	*Standard 10 AQTF Standard for Accredited Courses* All assessment, including Recognition of Prior Learning (RPL), must be compliant with: • Element 1.5 of Standard 1 of the AQTF: *Essential Conditions and Standards for Continuing Registration* or • Standard 1, Clauses 1.1 and 1.8 of the *Standards for Registered Training Organisations* 2015, or • The relevant standards for Registered Training Organisations (RTOs) in effect at the time of assessment. Assessment strategies should be flexible, valid, reliable and fair. Course providers will be required to adopt an assessment strategy that: • incorporates continual feedback of individual progress toward, and achievement of competency; • addresses skills, attitudes and knowledge underpinning performance appropriate to the workplace;

	• gathers sufficient evidence to judge achievement of progress towards determining competence; • utilises a variety of different processes/sources; • recognises achievement of elements/competencies regardless of where the enabling learning took place (RPL); • fosters a collaborative and co-operative relationship between the learner and assessor; • is flexible in regard to the range and type of evidence provided by the learner; • provides opportunity for the learner to challenge assessment provisions and participate in re-assessment; • is equitable and fair to all learners; • does not unnecessarily restrict the progress of a learner through the course; • adapts assessment tools to suit the needs of particular clients or client groups (e.g. clients with special needs). Assessment methods must include the demonstration of practical skills and may also include: • oral or written questioning • simulated workplace activities • case study/scenario analyses • research projects
6.2. Assessor competencies	*Standard 12 AQTF Standards for Accredited Courses* Assessors must have competencies compliant with: • Element 1.4 of Standard 1 of the AQTF: *Essential Conditions and Standards for Continuing Registration* or • Clauses 1.13, 1.14, 1.15, 1.16 and 1.17 of the *Standards for Registered Training Organisations 2015* (SRTOs), or • The relevant Standards for Registered Training Organisations in effect at the time of assessment. or Assessors for the imported endorsed units of competency must meet the requirements specified in the relevant Training package.
7. Delivery	**Standards 11 and 12 AQTF Standards for Accredited Courses**
7.1. Delivery modes	*Standard 11 AQTF Standards for Accredited Courses* This course may be delivered in a variety of modes including: • Educational setting • Workplace or simulated workplace • Flexible delivery Where possible, participants should be exposed to real work environments and examples/case studies. Delivery strategies should actively involve the learner and learning should be experiential, relevant and age appropriate.”

7.2. Resources	*Standard 12 AQTF Standards for Accredited Courses* The course should be delivered in an environment appropriate to the assessment task, that is either on-the-job, or in a simulated workplace environment Other resources required to deliver the course include: • Equipment and materials relevant to the units of competency • Relevant range of texts, references and audio/visual material • Workplace documentation • Relevant organisational WHS policies and procedures **Trainers:** Trainer competencies must be compliant with: • Element 1.4 of Standard 1 of the AQTF: *Essential Conditions and Standards for Continuing Registration* or • Standard 1: Clauses 1.13.1.14, 1.15, 1.16 and 1.17 of the *Standards for Registered Training Organisations 2015* (SRTOs), or • The relevant Standards for Registered Training Organisations in effect at the time of assessment. Units of competency imported from endorsed training packages or accredited curriculum must reflect the requirements for trainers specified in that Training Package or accredited curriculum.
8. Pathways and articulation	*Standard 8 AQTF Standards for Accredited Courses* Individuals may receive credit for units of competency through the Recognition of Prior Learning (RPL) process. Individuals will receive automatic recognition for those units identified from the MEM05 Metals and Engineering Training Package that they have already completed. Individuals will receive credit for any units completed as part of this course, if they enrol in further training where the units are part of the qualification. There are no formal articulation arrangements at present.
9 Ongoing monitoring and evaluation	*Standard 13 AQTF Standards for Accredited Courses* This course will be maintained and monitored by the Curriculum Maintenance Manager, Engineering Industries. A review of the course will take place at the mid-point of the accreditation period. Feedback will be sought from industry and students, the Department of Education and Training (DET) and those Registered Training Organisations (RTOs) offering the course, as part of the review process.

	Processes for gathering evaluation data may include: • student feedback questionnaires • client and stakeholder feedback • trainer and assessor feedback, • industry changes and updates Recommendations for any significant changes will be reported to the Victorian Registration and Qualifications Authority (VRQA).

Section C: Units of competency

Core Units

VU21860	Apply the principles of using carbon fibre composites in manufacturing products
VU21861	Investigate carbon fibre composite processes and terminology
VU21862	Employ basic chemistry knowledge in the use of a polymer matrix

Elective units

VU21863	Optimise carbon fibre composite processing applications

and

Nationally imported elective units

MEM26002A	Lay up composites using vacuum closed moulding techniques
MEM26003A	Lay up composites using pressure closed moulding techniques
MEM26007A	Select and use reinforcing appropriate for the product
MEM26008A	Select and use resin systems appropriate for product
MEM26010A	Store and handle composite materials
MEM26013A	Select and use composite processes or systems appropriate for product
MEM26015A	Select and apply repair techniques
MEM26016A	Select and use joining materials
MEM26020A	Identify and interpret required standards for composites

Nationally accredited units are available to download from the national data base –

http://training.gov.au/

Training.gov.au is the National Register on Vocational Education and Training (VET) in Australia. To download a unit of competency, enter the unit code in the Quick search window. Units that have a Unit Code commencing with the letter “V” are Victorian accredited units and are reproduced in the following pages of this document.

VU21860 Apply the principles of using carbon fibre composites in manufacturing products

Unit Descriptor

This unit describes the outcomes required to identify the unique qualities that carbon fibre composites provide when used in the manufacture of products. It also addresses the workplace health and safety effects of working with carbon fibre composites, as well as waste disposal issues.

No licensing, legislative, regulatory or certification requirements apply to this unit at the time of publication.

Employability Skills

Not applicable

Application of the Unit

This unit applies to a range of industry situations where carbon fibre composites are used in the manufacture of products.

ELEMENT	PERFORMANCE CRITERIA
Elements describe the essential outcomes of a unit of competency.	*Performance criteria describe the required performance needed to demonstrate achievement of the element. Where bold/italicised text is used, further information is detailed in the required skills and knowledge and/or the range statement. Assessment of performance is to be consistent with the evidence guide.*
1. Compare the characteristics of different composite materials	1.1 Determine the ***range of composite materials*** currently being manufactured 1.2 Identify the components of each composite material and the special characteristics that result from the composition 1.3 Outline the manufacturing process for different composite materials 1.4 Utilise the correct terminology in communications relating to the composite materials industry 1.5 Confirm health risks associated with the manufacture and handling of each composite material 1.6 Compare the ***anisotropic*** and ***isotropic properties*** of different composite materials 1.7 Establish ***common uses*** for each composite material as a result of its mechanical properties 1.8 Identify the advantages of using carbon fibre composites compared to other materials such as metals, ceramics and wood
2. Select an appropriate composite material for a specified use	2.1 Clarify the particular characteristics required of a composite material for a specified use 2.2 Specify relevant ***workplace health and safety issues*** in the use of the selected composite material 2.3 Justify the choice of a selected composite material in terms of its availability, cost and mechanical properties 2.4 Determine if a carbon fibre composite material would meet the functional requirements 2.5 Identify industries where carbon fibre composites are currently used and list the main applications in each

	industry
3. Determine the appropriate manufacturing process for selected composite products	3.1 Identify the range of ***manufacturing and finishing processes*** that may be used for carbon fibre composites 3.2 Compare the advantages and disadvantages of each method, including speed, costs and safety issues 3.3 Identify the type and purpose of the polymer matrix used in a specific composite product 3.4 Specify the purpose and range of ***fabrication methods*** used on composite materials 3.5 Identify the ***common faults*** that may appear in the manufacture of composite products 3.6 Determine the uses for which carbon fibre ***reinforcement*** is required for the composite products 3.7 Select the most appropriate manufacturing process for preparing composite products for difficult or convoluted shapes 3.8 Determine the types of carbon fibre materials that are commercially available 3.9 Identify the ***types of carbon fibre composite products*** that are available and give examples of their particular functions
4. Identify cost components arising from customer benefit and other costs	4.1 Identify customer features/benefits in the composite product or process being undertaken 4.2 Identify cost components which deliver customer features/benefits and those which do not

REQUIRED SKILLS AND KNOWLEDGE

This describes the essential skills and knowledge and their level, required for this unit.

Skills:

- Using communication skills appropriate to the culture of the workplace and the individual
- Using correct industry terminology for carbon fibre composite materials
- Selecting appropriate composite materials for specified uses and functions
- Identifying where best to use carbon-fibre composites for particular functions
- Identify and select types of fibres according to their characteristics for a specified use (woven, stitched, etc.)
- Distinguishing between the anisotropic and isotropic properties of different composites
- Selecting appropriate testing methods for composite materials

Knowledge:

- Relevant workplace health and safety procedures in the manufacture and handling of composite materials
- Cost, weight and quality benefits of composites
- Specific advantages of using carbon fibre composites
- Different ways to process / manufacture composite products including.
  - Prepreg fabrication
  - Autoclave
  - Wet Layup
  - Vacuum Bagging
  - Infusion

  - Light and Heavy Resin Transfer Moulding (RTM).
- WHS issues in handling carbon fibre material
- Mechanical properties of different composites
- Applications of different composites
- Moulding techniques and processes
- Design data using Finite Element Analysis (FEA)
- Range of commercially available carbon fibre materials
- Range of carbon fibre composite materials available
- Non-destructive testing methods

RANGE STATEMENT

The Range Statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording in the Performance Criteria is detailed below. Add any essential operating conditions that may be present with training and assessment depending on the work situation, needs of the candidate, accessibility of the item, and local industry and regional contexts

Range of composite materials may include:	• Concrete • Prepregs • Fibre-reinforced plastics • Metal composites • Ceramic composites
Anisotropic properties refers to:	• Properties that are directionally dependent • Different physical or mechanical properties along different axis e.eg tensile strength
Isotropic properties refers to:	• Identical properties in all directions • Most composite materials are not isotropic
Common uses may include:	• Building • Automotive parts • Sporting goods • Structures, such as boat hulls, swimming pools etc. • Aeroplane parts • Spacecraft
Workplace health and safety issues may include:	• Handling fibres may cause mechanical irritation and abrasion • Micro fibres can stick into the human skin or mucous membranes causing irritation • Sizing resins can cause chemical irritation of the eyes and upper respiratory tract, dizziness and vomiting • Personal protective equipment must be used when handling composite materials

Manufacturing and finishing processes include:	• Moulding including:
	  – Prepreg
	  – Compression moulding
	• Vacuum bagging
	• Filament winding
	• Finishing may include painting out of mould

Fabrication methods include:	• Compression moulding • Autoclave moulding • Vacuum bag moulding • Filament winding • Mandrel wrapping • Pultrusion • Wet lay-up • Injection moulding
Common faults include:	• Porosity • Impurities • Fibre misalignment • Poor bonding in sandwich structures • Impact damage
Reinforcement refers to:	• Increasing the rigidity of the material • Preventing crack propagation • Use of short and long fibres attached to the matrix, such as glass, carbon, cellulose and high strength polymers • Use of steel bars in concrete • Layered or laminated structure
Types of carbon fibre composite products include:	• Automotive components • Building structures • Sporting goods • Aerospace components

EVIDENCE GUIDE

The evidence guide provides advice on assessment and must be read in conjunction with the Performance Criteria, Required Skills and Knowledge, the Range Statement and the Assessment Guidelines for this Training Package

Critical aspects for assessment and evidence required to demonstrate competency in this unit	• To be considered competent in this unit the course participant must be able to demonstrate the knowledge and skills required to achieve all of the elements of competency as defined by the associated performance criteria. • Specifically the course participant must be able to: – Identify common composite materials and their uses – Utilise correct terminology for the composite materials – Follow relevant workplace health and safety procedures for the handling of composite materials – Select composite materials suitable for specific purpose – Determine appropriate manufacturing processes for composite products to meet client needs – Confirm suitable finishing processes for composite products, appropriate to functional needs

Context of and specific resources for assessment	• Assessment should be conducted in a real or simulated industry environment. • Resources required for assessment include: – Real or simulated composite material manufacturing environment; – A range of sample composite products. – Suitable texts and/or industry documentation
Method of assessment	• Assessment must include the demonstration of skills and may also include: – Simulated workplace activity; – Assignments – Structured questions; – Case study/scenario analysis

VU21861 Investigate carbon fibre composite processes and terminology

Unit Descriptor

This unit describes the outcomes required to outline the different processes used for the manufacture of products using carbon fibres, the advantages and disadvantages of each process and the industry terminology that is used. It addresses several moulding processes using vacuum and pressure assisted techniques for the manufacture of composite components.

No licensing, legislative, regulatory or certification requirements apply to this unit at the time of publication.

Employability Skills

Not applicable

Application of the Unit

This unit applies to a range of industry situations where carbon fibres composites are used in the manufacture of products.

ELEMENT	PERFORMANCE CRITERIA
Elements describe the essential outcomes of a unit of competency.	*Performance criteria describe the required performance needed to demonstrate achievement of the element. Where bold/italicised text is used, further information is detailed in the required skills and knowledge and/or the range statement. Assessment of performance is to be consistent with the evidence guide.*
1. Clarify the purpose of the different stages in the manufacture of products using composite materials	1.1 Outline the ***different product formats*** used on carbon fibres in preparation for their use in composite materials 1.2 Identify the storage requirements of different forms of carbon fibre composite materials, particularly storage temperature and shelf life limitations 1.3 Identify a range of carbon fibre composite materials and their uses 1.4 Outline the different surface finishes for composite products 1.5 Identify the ***process steps*** for the manufacture of a product using carbon fibre materials according to a laminate schedule 1.6 Identify the importance of sizing and its relationship to the choice of polymer matrix 1.7 Confirm the ***benefits of using carbon fibre materials*** in the manufacture of composite products 1.8 Select the treatment that has been used on sample carbon fibre composite materials 1.9 Differentiate the ***types of process*** used for manufacturing products using thermosetting polymer matrices in terms of their ***production criteria*** 1.10 Follow relevant workplace health and safety procedures in the handling of carbon fibre composites

2. Determine the finishing processes required to prepare the composite product for a particular function	2.1 Outline the range of ***finishing processes*** that are commonly used on composite products 2.2 Follow relevant workplace health and safety procedures in the finishing of composite materials and products 2.3 Identify the range of ***non-destructive testing methods*** used on composite products

REQUIRED SKILLS AND KNOWLEDGE

This describes the essential skills and knowledge and their level, required for this unit.

Skills:

- Using communication skills appropriate to the culture of the workplace and the individual
- Using correct industry terminology for carbon fibre production
- Interpret a laminate schedule for a composite product
- Perform finishing processes in manufacturing carbon fibre composite products
- Controlling quality control variables at each stage in the manufacturing process
- Perform a wet hand lay up

Knowledge:

- Different methods for manufacture of products using carbon fibre materials
- Manufacturing processes using thermosetting polymer matrices for composite materials and their contribution to the market
- Relevant workplace health and safety procedures for carbon fibre product manufacturing
- Different finishing techniques for manufacture of products using carbon fibre composites

RANGE STATEMENT

The Range Statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording in the Performance Criteria is detailed below. Add any essential operating conditions that may be present with training and assessment depending on the work situation, needs of the candidate, accessibility of the item, and local industry and regional contexts

Different product formats include:	• Woven fabrics including:
	  – Plain
	  – Satin
	  – Twill
	  – Harness
	• Stitched
	• Braid
	• Tow
	• Towpreg

Process steps includes:	• Blank cutting • Blank stacking • Pre-forming • Polymer matrix infusion • Matrix curing • Trimming, • Surface treatment • Painting/coating • Assembly

Benefits of using carbon fibre materials include:	• Strength/lightweight • High impact strength • Design flexibility • Stiffness • Fatigue resistant • Corrosion resistant • Energy dampening • Thermal expansion can be tailored to meet needs • Energy transmission flexibility • Parts consolidation

Types of process include:	• Wet lay-up
	• Autoclave
	• Out-of-autoclave
	• Pultrusion
	• Vacuum bagging
	• Vacuum infusion
	• Resin transfer
	• Moulding
	• Filament winding
	• Compression moulding
	• Resin Transfer Moulding (RTM)
	  – Vacuum assisted
	  – High pressure

Production criteria include:	• Advantages and disadvantages • Annual production volumes • Equipment requirements
Finishing processes may include:	• Cutting • Trimming • Polishing • Sanding • Priming • Painting • Plating
Non-destructive testing methods include:	• Ultrasonics • Thermography • Shearography • X-ray radiography • Surface measurement

EVIDENCE GUIDE

The evidence guide provides advice on assessment and must be read in conjunction with the Performance Criteria, Required Skills and Knowledge, the Range Statement and the Assessment Guidelines for this Training Package

Critical aspects for assessment and evidence required to demonstrate competency in this unit	• To be considered competent in this unit the course participant must be able to demonstrate the knowledge and skills required to achieve all of the elements of competency as defined by the associated performance criteria. • Specifically the course participant must be able to: – Summarise the process steps for the manufacture of products using carbon fibre materials – Utilise correct terminology for the manufacture of products using carbon fibre materials and their finishing processes – Compare the types of processes used for manufacturing products using carbon fibre materials and their respective production volumes – Follow relevant workplace health and safety procedures for the handling of carbon fibre materials – Summarise the benefits that carbon fibre materials provide in the manufacture of products – Summarise the range of non-destructive testing on carbon fibre products
Context of and specific resources for assessment	• Assessment should be conducted in a real or simulated industry environment. • Resources required for assessment include: – Real or simulated composite material manufacturing environment; – A range of sample carbon fibre composite materials. – Suitable texts and/or industry documentation
Method of assessment	• Assessment must include the demonstration of skills and may also include: – Simulated workplace activity; – Assignments – Structured questions; – Case study/scenario analysis

VU21862 Employ basic chemistry knowledge in the use of a polymer matrix

Unit Descriptor

This unit describes the outcomes required to explain the basic chemistry involved in the development of polymer matrices suitable for use in carbon fibre composites. It includes details of the workplace health and safety associated with chemical handling and waste disposal, as well as the advantages and disadvantages of different polymer matrices.

No licensing, legislative, regulatory or certification requirements apply to this unit at the time of publication.

Employability Skills

Not applicable

Application of the Unit

This unit applies to a range of industry processes that are used for the production of polymer matrices/resins suitable for use with carbon fibre.

ELEMENT	PERFORMANCE CRITERIA
Elements describe the essential outcomes of a unit of competency.	*Performance criteria describe the required performance needed to demonstrate achievement of the element. Where bold/italicised text is used, further information is detailed in the required skills and knowledge and/or the range statement. Assessment of performance is to be consistent with the evidence guide.*
1. Summarise the role of polymer matrices in composite material manufacturing	1.1 Confirm the ***basic composition*** of carbon fibre composite materials 1.2 Identify the specific ***role of polymer matrices*** 1.3 Determine the ***range*** of polymer matrices that are commonly used to make composite materials and/or products 1.4 Specify the types of chemicals used in developing polymer matrices for carbon fibre composite materials and/or sizing 1.5 Confirm the importance of carbon fibre sizing and its compatibility with different polymer matrices 1.6 Outline the ***criteria*** on which a particular polymer matrix may be selected for manufacturing composite materials and/or products 1.7 Outline the challenges of correct filament wet-out and complete infusion of the polymer matrix into carbon fibre tows 1.8 Follow the relevant ***workplace health and safety procedures*** for handling the chemicals making up polymer matrices
2. Explain the chemical changes occurring in the formation of composite materials	2.1 Outline the role of each component used and the precautions necessary in handling these components 2.2 Summarise the ***chemical processes*** taking place as the matrix is cured 2.3 Clarify the particular ***characteristics*** of each polymer matrix

2.4 Identify the role of the curing process for thermosetting polymer matrices and the importance of exothermic control
2.5 Describe the melting and solidification process for thermoplastic polymer matrices

REQUIRED SKILLS AND KNOWLEDGE

This describes the essential skills and knowledge and their level, required for this unit.

Skills:

- Using communication skills appropriate to the culture of the workplace and the individual
- Using correct industry terminology for polymer matrix use
- Following the safety precautions necessary in handling the chemicals involved, including waste disposal
- Identifying the basic chemistry of the processes involved in using carbon fibre composites to manufacture a product
- Ensuring the complete infusion of polymer matrices into the carbon fibre

Knowledge:

- Workplace health and safety procedures for handling chemicals, including MSDS data and spill control
- Chemicals used in polymer-matrix carbon fibre product manufacturing.
- Differences and types of polymer matrix – Epoxy, Vinylester, Polyester, etc.
- Uncontrolled exothermic reaction, how to avoid and how to handle in an emergency.
- Properties and types of resins used in composite manufacturing
- Importance of carbon fibre sizing and its compatibility with polymer matrices
- Challenges of correct filament wet-out and complete infusion of the polymer matrix into the carbon fibre tow
- Catalysts and promoters
- Resin cure cycles and thermal properties
- Characteristics of common polymer matrices

RANGE STATEMENT

The Range Statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording in the Performance Criteria is detailed below. Add any essential operating conditions that may be present with training and assessment depending on the work situation, needs of the candidate, accessibility of the item, and local industry and regional contexts

Basic composition involves:

- Matrix or resin
- Substrate or reinforcement

Role of polymer matrices is:

- To bind the substrate or reinforcement together to form the composite material
- Partial shaping
- The resin matrix spreads the load applied to the composite between each of the individual fibres
- Protects the fibres from damage caused by abrasion and impact
- UV stability

Range includes:

- Thermoplastic
  - Polyamide

- Polypropylene
- Polyimide
- Polycarbonate
- Polyether ether ketone (PEEK)

- Thermosetting
  - Polyester
  - Vinylester
  - Epoxy
  - Phenolic
- Shape memory polymer (SMP)

Criteria may include:

- Cost
- Ease of handling
- Cure time
- Adhesive properties
- Electrical properties
- Mechanical properties
- Micro-cracking resistance
- Fatigue resistance
- Degradation from water ingress

Workplace health and safety procedures include:

- Exposure controls
- Spill controls
- Ventilation
- Personal Protective Equipment (PPE)
- Management of runaway exothermic reaction situations
- Waste disposal
- Management of styrene monomer outgassing from vinyl ester polymer matrices

Chemical processes include:

- Cross-linking of thermosetting polymer matrices
  - Exothermic reactions
  - Methyl ethyl ketone peroxide (MEKP), used as a hardener
- Melting and cooling of thermoplastic polymer matrices
- Other factors could be:
  - Resin being melded to the substrate
  - Internal mould release agent (IMR) being introduced

Characteristics include:

- Polyester resin
  - Yellowish tint
  - UV sensitive
  - Rigid
  - High cure shrinkage
- Vinyl ester resin
  - Purplish-blue-greenish tint
  - Low viscosity
  - Transparent
  - Flexible
  - Chemically resistant
  - High cure shrinkage
- Epoxy resin
  - Naturally transparent
  - Variable curing time

- High temperature resistance
- Structural glue
- Low cure shrinkage

- Shape Memory Polymer resin (SMP)
  - Varying visual characteristics
  - Can be shaped an re-shaped repeatedly without losing their material properties

EVIDENCE GUIDE

The evidence guide provides advice on assessment and must be read in conjunction with the Performance Criteria, Required Skills and Knowledge, the Range Statement and the Assessment Guidelines for this Training Package

Critical aspects for assessment and evidence required to demonstrate competency in this unit

- To be considered competent in this unit the course participant must be able to demonstrate the knowledge and skills required to achieve all of the elements of competency as defined by the associated performance criteria.
- Specifically the course participant must be able to:
  - Identify the role of polymer matrices in composite material and/or product manufacture
  - Identify common polymer matrices and their characteristics
  - Identify the chemical processes occurring during the curing process
  - Follow relevant workplace health and safety procedures when handling chemicals

Context of and specific resources for assessment

- Assessment should be conducted in a real or simulated industry environment.
- Resources required for assessment include:
  - Real or simulated composite material manufacturing environment;
  - A range of sample carbon fibre composite materials.
  - A range of polymer matrices
  - Suitable texts and/or industry documentation

Method of assessment

- Assessment must include the demonstration of skills and may also include:
  - Simulated workplace activity;
  - Assignments
  - Structured questions;
  - Case study/scenario analysis

VU21863 Optimise carbon fibre composite processing applications

Unit Descriptor

This unit describes the outcomes required to control the variables contributing to quality control during the manufacture of products using carbon fibre composite materials. It includes several moulding processes using vacuum and pressure assisted techniques.

No licensing, legislative, regulatory or certification requirements apply to this unit at the time of publication.

Employability Skills

Not applicable

Application of the Unit

This unit applies to a range of industry processes that are used for carbon fibre composite processing.

ELEMENT	PERFORMANCE CRITERIA
Elements describe the essential outcomes of a unit of competency.	*Performance criteria describe the required performance needed to demonstrate achievement of the element. Where bold/italicised text is used, further information is detailed in the required skills and knowledge and/or the range statement. Assessment of performance is to be consistent with the evidence guide.*
1. Determine the critical control variables at each stage of carbon fibre composite production	1.1 Summarise the ***industrial processes*** for manufacturing products from carbon fibre composites 1.2 Confirm the ***processing variables*** at each stage of the production process 1.3 Outline the implications for the product if these processing variables are not controlled 1.4 Address relevant workplace ***health and safety concerns*** for each stage of production
2. Control processing variables to ensure high quality manufactured products	2.1 Select a suitable ***fabrication process*** for the intended manufactured product, consistent with the carbon fibre composite being used 2.2 Summarise the ***quality controls*** necessary for the carbon fibre product 2.3 Control the heating and cooling cycles for the polymer matrix infusion process and allow sufficient time for the curing process 2.4 Conduct appropriate tests at each stage of the manufacturing process to ensure quality outcomes
3. Investigate routine production and product faults	3.1 Identify the ***types of defects*** that may occur in carbon fibre composites 3.2 Determine the processing variables that create specific carbon fibre composite defects 3.3 Identify the causes of production faults and take appropriate corrective or reporting action

	3.4 Determine if the faults are due to inappropriate production methods, or faulty materials quality
4. Compare the actual performance of the production process with the required performance	4.1 Identify the production ***performance measures*** required to meet customer needs and those of the production team 4.2 Evaluate the actual performance resulting from the production process 4.3 Analyse the measures of the production process and determine those that are under the control of the production team 4.4 Control the performance measures to minimise cost and waste 4.5 Complete relevant workplace documentation and reports

REQUIRED SKILLS AND KNOWLEDGE

This describes the essential skills and knowledge and their level, required for this unit.

Skills:

- Using communication skills appropriate to the culture of the workplace and the individual
- Using correct industry terminology for carbon fibre production
- Taking appropriate safety precautions in handling the chemicals involved, including waste disposal
- Identifying the critical process measures at each stage of the production process of carbon fibre products
- Recognising the importance of material properties and qualities
- Recognising the importance of process conditions
- Identifying potential areas to reduce production costs, while maintaining product quality
- Taking appropriate action to resolve faults or report faults to appropriate personnel
- Applying established workplace procedures

Knowledge:

- Workplace health and safety procedures for handling chemicals, including MSDS data and spill control
- Production process for the manufacture of products using carbon fibre composites
- Process variables and their implications for causing defects
- Common defects in carbon fibre products
- Different fabrication methods for carbon fibre composite
- Importance of temperature controls
- Impact of incorrect or faulty materials
- Impact of changes to raw materials during production
- Impact of changes to process steps during production

RANGE STATEMENT

The Range Statement relates to the unit of competency as a whole. It allows for different work environments and situations that may affect performance. Bold italicised wording in the Performance Criteria is detailed below. Add any essential operating conditions that may be present with training and assessment depending on the work situation, needs of the candidate, accessibility of the item, and local industry and regional contexts

Industrial processes involve:

- Fabrication
  - Compression moulding
  - Autoclave moulding
  - Vacuum bag moulding
  - Filament winding
  - Mandrel wrapping
  - Pultrusion
  - Wet lay-up
  - Injection moulding

Processing variables may include:

- Treatment of carbon fibre, such as tow, woven etc
- Choice of polymer matrix
- Selection and effectiveness of the polymer matrix infusion process
- Selected fabrication method
- Temperature
- Humidity
- Pressure
- Vacuum
- Contaminants
- Moulding materials
- Moulding temperature and times
- Ratio of hardener to base

Health and safety concerns include:

- Chemical handling
- Dust inhalation
- Skin irritation
- Dizziness
- Drowsiness
- Nausea
- Vomiting
- Effect of airborne fibres on electrical equipment

Fabrication process may include:

- Compression moulding
- Autoclave moulding
- Vacuum bag moulding
- Filament winding
- Mandrel wrapping
- Pultrusion
- Wet lay-up
- Injection moulding

Quality controls include:

- Incoming goods inspection
- Shelf life
- Tooling maintenance

- Inspection
  - Process
  - Product

Types of defects include:

- Pits or poor surfaces
- Print through
- Cracking
- Poor lamination
- Dry fabric
- Poor bonding properties
- Distortion and misalignment
- Gaps and undulations
- Orange peel

Performance measures may include:

- Production yield
- Cycle time
- Quality
- Scrap rate

EVIDENCE GUIDE

The evidence guide provides advice on assessment and must be read in conjunction with the Performance Criteria, Required Skills and Knowledge, the Range Statement and the Assessment Guidelines for this Training Package

Critical aspects for assessment and evidence required to demonstrate competency in this unit

- To be considered competent in this unit the course participant must be able to demonstrate the knowledge and skills required to achieve all of the elements of competency as defined by the associated performance criteria.
- Specifically the course participant must be able to:
  - Summarise the purpose and sequence of production processes for the manufacture of products using carbon fibre materials
  - Identify critical process variables
  - Identify the methods of controlling the critical process variables at each stage of production
  - Follow the workplace health and safety procedures necessary in manufacturing products using carbon fibre materials
  - Identify and correct production faults and product faults, if possible
  - Conduct process performance evaluations

Context of and specific resources for assessment

- Assessment should be conducted in a real or simulated industry environment.
- Resources required for assessment include:
  - Access to a real composite material manufacturing environment;
  - A range of sample carbon fibre composite materials.
  - Samples of process faults
  - Suitable texts and/or industry documentation

Method of assessment	• Assessment must include the demonstration of skills and may also include: – Simulated workplace activity; – Assignments – Structured questions; – Case study/scenario analysis

Appendix 1

Course in the use of carbon fibre in Composite Manufacturing – Accreditation Project
Skills and Knowledge Outcomes

Outlined below is a summary of the skills and knowledge outcomes of the course.

The process for the consultation and validation in identifying the required skills and knowledge outcome was as follows:-

- Conversations and interviews with Industry groups using a skills needs analysis tool to provide feedback to the Industry Roundtable meeting.
- Industry Roundtable meeting and workshop
- Steering committee meetings using the industry expertise
- Support letters

Skills and Knowledge	
	Skills
	Using communication skills appropriate to the culture of the workplace and the individual
	Using correct industry terminology for carbon fibre composite materials/polymer matrix use
	Selecting appropriate composite materials for specified uses and functions
	Identifying where best to use carbon-fibre composites for particular functions
	Identify and select types of fibres (woven, stitched, etc.)

	Distinguishing between the anisotropic and isotropic properties of different composites
	Selecting appropriate testing methods for composite materials
	Interpret a laminate schedule for a composite product
	Perform finishing processes in manufacturing carbon fibre composite products
	Controlling quality control variables at each stage in the manufacturing process
	Perform a hand lay up
	Following the safety precautions necessary in handling the chemicals involved, including waste disposal
	Identifying the basic chemistry of the processes involved in using carbon fibre composites to manufacture a product
	Ensuring the complete infusion of polymer matrices into the carbon fibre
	Taking appropriate safety precautions in handling the chemicals involved, including waste disposal
	Identifying the critical process measures at each stage of the production process of carbon fibre products
	Recognising the importance of material properties, qualities and process conditions
	Identifying potential areas to reduce production costs, while maintaining product quality
	Taking appropriate action to resolve faults or report faults to appropriate personnel
	Applying established workplace procedures
	Knowledge

	OHS/WHS issues in handling carbon fibre material
	Relevant workplace health and safety procedures in the manufacture and handling of composite materials including MSDS date and spill control
	Cost, weight and quality benefits of composites
	Specific advantages of using carbon fibre composites
	Different ways to process/manufacture composite products
	Manufacturing processes using thermosetting polymer matrices for composite materials
	Different finishing techniques for manufacture of products using carbon fibre composites
	Process variables and their implications for causing defects
	Importance of temperature controls
	Impact of changes to raw materials and process steps during production
	Common defects in carbon fibre products
	Mechanical properties of different composites
	Applications of different composites
	Moulding techniques and processes
	Design data using Finite Element Analysis (FEA)
	Range of commercially available carbon fibre materials
	Range of carbon fibre composite materials available

	Non-destructive testing methods
	Chemicals used in polymer-matrix carbon fibre product manufacturing
	Differences and types of polymer matrix – Epoxy, Vinylester, Polyester, etc.
	Uncontrolled exothermic reaction, how to avoid and how to handle in an emergency
	Properties and types of resins used in composite manufacturing
	Importance of carbon fibre sizing and its compatibility with polymer matrices
	Challenges of correct filament wet-out and complete infusion of the polymer matrix into the carbon fibre tow
	Catalysts and promoters
	Resin cure cycles and thermal properties
	Characteristics of common polymer matrices