22332VIC Graduate Certificate in Tool Design for Plastics

This course has been accredited under Part 4.4 of the Education and Training Reform Act 2006.

Accreditation period: 1st July 2017 to 30th June 2022

Contents

Section A: Copyright and course classification information

1. Copyright owner of the course	Copyright of this course is held by the Department of Education and Training, Victoria © State of Victoria (Department of Education and Training) 2017.
2. Address	Executive Director Industry Engagement And VET Systems Higher Education and Skills Group Department of Education and Training PO Box 4367 Melbourne, Victoria, 3001 **Organisational Contact:** Manager: Training Products Unit Higher Education and Skills Group Telephone: (03) 9637 3092 Email: course.enquiry@edumail.vic.gov.au **Day to day contact:** Curriculum Maintenance Manager Service - General Manufacturing Chisholm Institute 2 New Holland Drive Cranbourne VIC 3977 PO Box 684 Dandenong VIC 3175 T +61 3 9238 8448 Email: paul.saunders@chisholm.edu.au
3. Type of submission	This course is submitted for reaccreditation.
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) 2017 Copyright of the following unit of competency from nationally endorsed training packages is administered by the Commonwealth of Australia and can be accessed from Training.gov at www.training.gov.au Imported unit: PMBTECH505 Choose polymer materials for an application from PMB Plastics, Rubber and Cablemaking Training Package.

5. Licensing and franchise	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) 2017 This work is licensed under a Creative Commons Attribution-NoDerivs 3.0 Australia licence (http://creativecommons.org/licenses/by-nd/3.0/au/). You are free to use, copy and distribute to anyone in its original form as long as you attribute Higher Education and Skills Group, Department of Education and Training (DET) as the author and you license any derivative work you make available under the same licence. Request for other use should be addressed to: Executive Director Industry Engagement and VET Systems Higher Education and Skills Group Department of Education and Training (DET) Email: course.enquiry@edumail.vic.gov.au Copies of this publication may be downloaded, free of charge, from the DET website: http://www.education.vic.gov.au/training/providers/rto/Pages/courses.aspx#link100
6. Course accrediting body	Victorian Registration and Qualifications Authority: http://www.vrqa.vic.gov.au
7. AVETMISS information	**ANZSCO** (Australian and New Zealand Standard Classification of Occupations) 233500 Industrial Mechanical and Production Engineers The course also covers the following occupational areas: 233511 Industrial Engineers 233512 Mechanical Engineers 233914 Engineering Technologists **ASCED code – 4 digit** (Field of Education) 0307 Mechanical and Industrial Engineering and Technology National course code **22332VIC**
8. Period of accreditation	1st July 2017 to 30th June 2022

Section B: Course information

1. Nomenclature	Standard 1 AQTF Standards for Accredited Courses
1.1 Name of the qualification	22332VIC Graduate Certificate in Tool Design for Plastics
1.2 Nominal duration of the course	380 – 500 hours.
2. Vocational or educational outcomes	Standard 1 AQTF Standards for Accredited Courses

2.1 Purpose of the course	Graduates of the qualification will be able to meet the current and future industry requirements to work effectively across the plastics product and tool design industry with the skills and knowledge to:
	• manage appropriate application of tool design methodologies and principles to meet product specifications
	• incorporate emerging additive manufacturing technologies to facilitate rapid prototyping and rapid tool fabrication for plastics processing
	• manage optimisation of production methodologies and principles
	• develop frameworks for achieving project outcomes
	• manage tool design within:
	  ○ injection moulding specialisation
	  ○ manage tool design within blow moulding specialisation
	  ○ manage tool design within extrusion specialisation
	• evaluate systems and outcomes
	• Maintain knowledge of local and international industry and position of Australian tool design.

3. Development of the course	Standards 1 and 2 AQTF Standards for Accredited Courses
3.1 Industry / enterprise/ community needs	This qualification provides the specialist skills in tool design for plastics that are vital for many enterprises to gain, and maintain niche markets in manufacturing within Australia and overseas. Emerging technologies are providing opportunities for Australian manufacturers to onshore production to supply local and international demand. Local tool design and tool fabrication is essential for the plastics industry to enhance flexibility, enable innovation and provide for rapid response to market demand.

Australian manufacturers will be successful if their products are world leading, innovative and produced using the latest tooling design and tooling technology.

Personnel require the highly specialised skills of this qualification. Consultation with industry has confirmed that the balance of sophisticated skills in CAD, the latest in engineering software, melt flow analysis software, and other technologies, such as rapid prototyping technologies, coupled with a strong emphasis on the decision-making, consultation and evaluation functions of tool design are required now and into the future.

Tool design for plastics remains very much a niche area but it requires support in skills development if Australia is to combat the trend to send manufacturing off-shore. Indeed, this qualification addresses the observed need for specialist training in order to keep abreast of contemporary industry practices and remain relevant.

The main target groups comprise:

- materials and/or mechanical engineers looking for specialisation in tool design for plastics
- experienced tool makers / moulding technicians who wish to upgrade their qualification to tool design
- experienced plastics product designers / industrial designers who wish to add tool design to their portfolio

This qualification supports the Victorian Government's manufacturing strategy, the accreditation of which was initiated by the Victorian Department of Education and Training The strategy - "A More Competitive Manufacturing Industry: New Directions for Industry Policy and Manufacturing" (Department of Economic Development, Jobs, Transport and Resources) states:

"Niche and specialist skills"

> Manufacturers will be supported with a systematic and structured approach to identifying and addressing priority specialist skill needs for key trades and other occupations critical for the future manufacturing workforce."

The skills and knowledge content of this course meets this call for skills development for manufacturing.

Anticipated employment opportunities are within industry fields such as packaging, building and construction and the more advanced manufacturing and precision engineering sectors e.g. medical and composites applications.

Employment roles include:

- industrial engineer
- mechanical engineer
- plastics product or part engineer

	• tool designer for plastics product within any one or combination of:
	  o injection moulding tool design
	  o blow moulding tool design
	  o extrusion tool design
	
	Industry consultation in consideration of the accreditation of this qualification commenced with site visits to and / or telephone conversations or meetings with a number of manufacturing enterprises/specialists across the Melbourne metro area: Plastool International, Diecraft Australia, Dolphin Products, Forme Technologies, Modfix, Caps and Closures, E3 & Associates. Society of Plastics Engineers, Australia
	
	Representatives of these organisations were then invited to form the accreditation Steering Committee. Prior to the initial Steering Committee meeting invitees were asked to provide a skills and knowledge profile for manufacturing industry tool designers.
	
	Members of the steering committee were:
	
	• Gary Down, Managing Director, *Plastool*
	• Danny Tasmakis, Senior Designer, *Diecraft* Australia
	• Wilhelm Morgan, *Wilhelm Morgan Institute* (Private RTO)
	• Stefano Stefani, Engineering Design Manager, *Dolphin*
	• Eric Weiqin Poh, *Caps and Closures*
	
	At the initial Steering Committee meeting the skills and knowledge provided by 22181VIC Graduate Certificate in Tool Design for Plastics were reviewed. The Steering Committee determined that 22181VIC required updating and the additional skills and knowledge were now required in the workplace.
	
	Minor amendments to the current units were called for and the addition of coverage of :
	
	• Selection of polymer materials
	• 3D printing for prototyping
	• 3D printing for fabrication of production tools / part tools
	
	In addition the Steering Committee required that consideration be given to ensuring that graduates had experience of actual practical production of plastic products.
	
	Skills and knowledge profiles were developed for these three aspects of tool design for plastics.
	
	The skills and knowledge required relating to the selection of polymer materials has been provided for by the importation of the unit of competency:
	
	PMBTECH505 Choose polymer materials for an application

	Two new units have been written to provide the skills and knowledge required in the plastics processing industry to utilise emerging additive manufacturing technologies (3D printing): VU21986 Utilise 3D printing for plastic product manufacturing VU21987 Utilise 3D printing for plastic product prototyping The new course structure provides for all identified skills and knowledge outcomes. The skills and knowledge provided through this course are not covered by a qualification and / or units of competency within a Training Package.
3.2 Review for re-accreditation	This course replaces 22181VIC Graduate Certificate in Tool Design for Plastics which expired 31/12/2016. (*Refer to Appendix 1: Transition table, page 19*).
4. Course outcomes	Standards 1, 2, 3 and 4 AQTF Standards for Accredited Courses
4.1 Qualification level	This qualification is consistent with the criteria and specifications of the AQF Graduate Certificate as outlined in the Australian Qualification Framework Second Edition 2013, as follows: • **Purpose and Summary:** Graduates at this level will apply a body of knowledge in a range of contexts to undertake professional and highly skilled work and as a pathway for further learning in an emerging professional area through: o recalling and application of a complex and specialised range of design, engineering and scientific principles and knowledge to a wide range of plastics product and tool design applications o development of optimal design solutions for complex and varied tool design problems, through the creative application of specialised technical and scientific knowledge and skills o application of evaluation, selection and management methodologies and systems to meet optimum outcomes required of design briefs
	• **Knowledge:** Graduates at this level will have specialised knowledge within a systematic and coherent body of knowledge that may include the acquisition and application of knowledge and skills in a new or existing discipline or professional area, namely: o tool design, such as: complex and specialised range of design, engineering and scientific principles and knowledge applicable to a wide range of tool design projects o planning, such as: project management planning; risk and contingency planning; evaluation planning; resource planning

	○ management and communication, such as: oversight of implementation and evaluation of projects; liaison with range of stakeholders and interdependent roles to achieve optimal design solutions ○ research, such as: relevant methodologies, principles and systems and their application to a wide range of design • **Application of knowledge and skills:** Graduates at this level will apply knowledge and skills to demonstrate the following as a practitioner: ○ autonomy, through leadership in design and oversight of implementation, promulgation, monitoring and review of plastics product and tool design projects ○ well-developed judgement required to analyse tool design briefs: plan and manage the projects; initiate, execute and evaluate design decisions; to evaluate materials, technologies and systems and review capabilities and applications of same ○ adaptability through development of quality and sustainability ○ procedures to minimise waste and optimise outcomes: manage complex projects in time and within budget; development and execution of risk and contingency management procedures ○ responsibility through managing non-routine situations in procedure development, risk and contingency management and oversight of own and others' contributions in plastics product and tool design contexts • **Volume of learning**: meets the specification of being typically 0.5 to 1 year ○ Additional unsupervised self-directed learning, including research, work experience and/or industry-based learning to support successful course completion is required.
4.2 Employability skills	This qualification has been mapped to national employability skills. Refer to Appendix 2: Employability skills summary.
4.3 Recognition given to the course (if applicable)	*Standard 5 AQTF Standards for Accredited Courses* Not applicable
4.4 Licensing/ regulatory requirements (if applicable)	*Standard 5 AQTF Standards for Accredited Courses* At the time of accreditation no licensing or regulatory requirements apply.

5. Course rules	Standards 2, 6,7 and 9 AQTF Standards for Accredited Courses
5.1 Course structure	To be eligible for the award of 22332VIC Graduate Certificate in Tool Design for Plastics, learners must successfully complete a total of seven (7) units comprising o three (3) core units o four (4) electives, with at least three (3) units being selected from one of the following three streams: • Injection Moulding • Blow Moulding • Extrusion Note: In Addition one elective unit may be selected from an endorsed Training Package qualification or accredited course, at AQF Level 8 as part of the four elective unit streams. The unit selected should relate to the vocational outcomes of the 22332VIC Graduate Certificate in Tool Design for Plastics. A Statement of Attainment will be issued for any unit of competency completed if the full qualification is not completed.

Unit of competency/ module code	Field of Education code (six-digit)	Unit of competency/module title	Pre-requisite	Nominal hours
Core units				
VU21972	030705	Design plastics product or part	Nil	80
VU21973	030705	Manage plastics tool design	Nil	80
PMBTECH505	030705	Choose polymer materials for an application	Nil	50
Elective units				
Complete four elective units with at least three selected from one of streams one, stream two or stream three.				
Stream One – Injection Moulding				
VU21974	030705	Implement plastics injection moulding tool design	Nil	40
VU21975	030705	Manage plastics injection moulding tool design application	Nil	70
VU21976	030705	Implement injection moulding tool design for plastics product details	Nil	70
VU21977	030705	Implement plastics injection moulding temperature control	Nil	70
Stream Two – Blow Moulding				
VU21978	030705	Implement plastics blow moulding tool design	Nil	40
VU21979	030705	Manage plastics blow moulding tool design application	Nil	70
VU21980	030705	Implement blow moulding tool design for plastics product design details	Nil	70
VU21981	030705	Implement advanced blow moulding tool design	Nil	70
Stream Three – Extrusion				
VU21982	030705	Implement plastics extrusion tool design	Nil	40
VU21983	030705	Manage extrusion sheet and film tool design	Nil	70
VU21984	030705	Manage extrusion pipe, tube and cable tool design	Nil	70
VU21985	030705	Manage extrusion profile tool design	Nil	70
Stream Four – Additive Manufacturing				
VU21986	030705	Utilise 3D Printing for plastic product manufacturing	Nil	80
VU21987	030705	Utilise 3D printing for plastic product prototyping	Nil	50
		Total nominal hours		380-500

5.2 Entry requirements	*Standard 9 AQTF Standards for Accredited Courses* Applicants for the **22332VIC Graduate Certificate in Tool Design for Plastics** are expected to have: • a demonstrated capacity in learning, reading, writing, oracy and numeracy competencies to Level 4 of the Australian Core Skills Framework (ACSF). See https://www.education.gov.au/ and have: • obtained a Diploma/ Advanced Diploma qualification in related fields of study (e.g. engineering) and 2 years' equivalent full-time relevant vocational practice or • obtained a Bachelor degree or Advanced Diploma in related fields of study (e.g. mechanical/materials engineering; industrial design) and I year equivalent full-time relevant vocational practice or Three year's equivalent full-time relevant vocational practice.

6. Assessment	Standards 10 and 12 AQTF Standards for Accredited Courses
6.1 Assessment strategy	All assessment will be consistent with the Australian Quality Training Framework Essential Conditions and Standards for Initial/Continuing Registration Standard 1.2 (Initial) and Standard 1.5 (Continuing). See: AQTF User guides to the Essential Conditions and Standards for Initial/Continuing Registration: or Standard 1: Clauses 1.1 and 1.8 of the Standards for Registered Training Organisations (SRTOs) 2015 or relevant Standards for Registered Training Organisations in effect at the time of assessment. Assessment methods and collection of evidence will involve application of knowledge and skills to plastics product and tool design workplaces or simulated environments. All assessment activities will be related to a plastics product and tool design context. A range of assessment methods will be used, such as: • action learning projects in real, or simulated plastics product and tool design settings • research projects in plastics product and tool design • portfolio • practical exercises • observation • direct questioning • presentation • third party reports Assessment strategies must therefore ensure that: • all assessments are valid, reliable, flexible and fair • learners are informed of the context and purpose of the assessment and the assessment process • feedback is provided to learners about the outcomes of the assessment process and guidance given for future options • time allowance to complete a task is reasonable and specified to reflect the industry context in which the task takes place. A holistic approach to assessment may be used, by combining the assessment of more than one unit, where it better replicates working practice and reduces the potential for over assessment. RTOs must ensure that Recognition of Prior Learning (RPL) is offered to all applicants in determining competency for Credit. There is no mandatory workplace assessment.

6.2 Assessor competencies	*Standard 12 AQTF Standards for Accredited Courses* The Australian Quality Training Framework Essential Conditions and Standards for Initial/Continuing Registration, Standard 1.4 states the requirements for the competence of persons assessing the course See AQTF User guides to the Essential Conditions and Standards for Initial/Continuing Registration: or Standard 1: Clauses 1.1 3,1.14, 1.15, 1.16,and 1.17 of the Standards for Registered Training Organisations (SRTOs) 2015 or relevant Standards for Registered Training Organisations in effect at the time of assessment. Assessment of the imported unit PMBTECH505 Choose polymer materials for an application, must reflect the requirements of the Assessment Requirements for the relevant Training Package. (From PMB Plastics, Rubber and Cablemaking Training Package)

7. Delivery	Standards 11 and 12 AQTF Standards for Accredited Courses
7.1 Delivery modes	*Standard 11 AQTF Standards for Accredited Courses* Delivery of units of competency will take into consideration the individual needs of students and will involve • workshops • individual assignments • team-based assignments • applied learning in the workplace or simulated plastics product and tool design environment Learners may be supported through: on-line (internet, social media, email and telephony); face-to-face conferencing, mentoring and interviews; ad hoc arrangements, and regular progress monitoring, particularly for practical work. The course may be delivered part-time or full-time. There is no mandatory workplace delivery.
7.2 Resources	*Standard 12 AQTF Standards for Accredited Courses* Resources must include: - Equipment and materials relevant to the units of competency - Relevant range of texts, references and/or audio/visual material - Workplace documentation - Relevant organisational OHS/WHS policies and procedures • teachers/trainers who meet the *Australian Quality Training Framework Essential Conditions and Standards for Initial/Continuing Registration* Standard 1.4. See AQTF User guides to the Essential Conditions and Standards for Initial/Continuing Registration: or • Standard 1: Clauses 1.1 3,1.14, 1.15, 1.16,and 1.17 of the Standards for Registered Training Organisations (SRTOs) 2015 or relevant Standards for Registered Training Organisations in effect at the time of assessment and, • access to computers and internet • access to workplace or simulated plastics product and tool design environment Refer to Appendix 3: Recommended references. Generally, arrangements for articulation into higher education qualifications will need to be undertaken individually and on a case by case basis. When RTOs are arranging articulation they should refer to the AQF Second Edition 2013 Pathways Policy.

8. Pathways and articulation	Standard 8 AQTF Standards for Accredited Courses
	There are no formal articulation arrangements at present. 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.
9. Ongoing monitoring and evaluation	Standard 13 AQTF Standards for Accredited Courses
	The Curriculum Maintenance Manager (CMM), General Manufacturing is responsible for monitoring and evaluation of the 22332VIC Graduate Certificate in Tool Design for Plastics The 22332VIC Graduate Certificate in Tool Design for Plastics will be reviewed at mid-point in the accreditation period. Evaluations will involve consultation with:` • course participants • plastics product and tool design industry representatives • teaching staff • assessors Any significant changes to the course resulting from course monitoring and evaluation procedures will be reported to the VRQA through a formal amendment process.

Appendix 1: Transition table

New Qualification title:	**22332VIC Graduate Certificate in Tool Design for Plastics**
Previous Qualification title:	*22181VIC Graduate Certificate in Tool Design for Plastics*
General Comment	All existing units in 22181VIC have been transferred to 22332VIC. 22181VIC Graduate Certificate in Tool Design for Plastics has been reviewed and revised to provide for current industry skills and knowledge requirements. In particular the course has been enhanced to include the application of additive manufacturing technologies to the plastics processing industry.

Unit code and title in this qualification	**Relationship to unit in 22181VIC**	**Comments**
VU21972: Design plastics product or part	VU20732: Design plastics product or part	Equivalent
VU21973: Manage plastics tool design	VU20733: Manage plastics tool design	Equivalent
VU21974: Implement plastics injection moulding tool design	VU20734: Implement plastics injection moulding tool design	Equivalent
VU21975: Manage plastics injection moulding tool design application	VU20735: Manage plastics injection moulding tool design application	Equivalent
VU21976: Implement injection moulding tool design for plastics product details	VU20736: Implement injection moulding tool design for plastics product details	Equivalent
VU21977: Implement plastics injection moulding temperature control	VU20737: Implement plastics injection moulding temperature control	Equivalent
VU21978: Implement plastics blow moulding tool design	VU20738: Implement plastics blow moulding tool design	Equivalent
VU21979: Manage plastics blow moulding tool design application	VU20739: Manage plastics blow moulding tool design application	Equivalent
VU21980 Implement blow moulding tool design for plastics product design details	VU20740 Implement blow moulding tool design for plastics product design details	Equivalent
VU21981: Implement advanced blow moulding tool design	VU20741: Implement advanced blow moulding tool design	Equivalent
VU21982 Implement plastics extrusion tool design	VU20742 Implement plastics extrusion tool design	Equivalent

Unit code and title in this qualification	Relationship to unit in 22181VIC	Comments
VU21983: Manage extrusion sheet and film tool design	VU20743: Manage extrusion sheet and film tool design	Equivalent
VU21984: Manage extrusion pipe, tube and cable tool design	VU20744: Manage extrusion pipe, tube and cable tool design	Equivalent
VU21985: Manage extrusion profile tool design	VU20745: Manage extrusion profile tool design	Equivalent
PMBTECH505: Choose polymer materials for an application	New imported unit – N/A	From PMB Plastics, Rubber and Cablemaking Training Package
VU21986 Utilise 3D Printing for plastic product manufacturing	New Unit – N/A	New
VU21987 Utilise 3D printing for plastics product prototyping	New Unit – N/A	New

Appendix 2: Employability Skills Summary

Victorian Registration & Qualifications Authority

Employability Skills Summary

Qualification Code: **22332VIC**

Qualification Title: **Graduate Certificate in Plastics Product and Tool Design**

The following table contains a summary of the employability skills required for this qualification. This table should be interpreted in conjunction with the detailed requirements of each unit of competency packaged in this qualification. The Employability Skills facets described here are broad industry requirements that may vary depending on the packaging options.

Employability Skill	Industry/enterprise requirements for this qualification include the following facets:
Communication that contributes to productive and harmonious relations across employees and customers	• utilising excellent interpersonal skills to consult, question, clarify and evaluate information • liaising, listening and consulting with colleagues, management and stakeholders to encourage participation, and clarify and evaluate issues • consulting with stakeholders and others on managing a range of project plans • developing and managing formal and informal communication networks • negotiating solutions to new and emerging issues • producing a wide range of reports, visual presentations and charts to document project progress, targets, milestones and outcomes
Teamwork that contributes to productive working relationships and outcomes	• demonstrating high-level leadership and consultation processes with team and stakeholders to foster informed work practices • designing evaluation and feedback from stakeholder consultation • working with, and motivating others, to gather information, prepare plans, and implement projects • seeking expertise from other/s as required
Problem solving that contributes to productive outcomes	• analysing and selecting information for relevance and accuracy • high-level research to provide innovative approaches to design solutions • analysing, co-ordinating and refining budgets • sourcing relevant people to provide consultative assistance and specialised information where required • developing strategies and implementation plans

Initiative and enterprise that contribute to innovative outcomes	• applying learning to flexibility in design and production • applying learning to anticipating opportunities for improved processes • identifying trends in plastics product and tool design sector • identifying improvements to work design and organisation • reviewing processes to inform future activity • participating in industry networks
Planning and organising that contribute to long and short-term strategic planning	• consulting with stakeholders and others on developing and managing a range of plans and projects • contributing to managing project completion through time management, setting priorities, timelines, targets and milestones for self and with others • monitoring and adjusting operations to optimise outcomes and for contingency planning • maintaining information systems, records, inspection and reporting procedures • contributing to continuous improvement and planning processes
Self-management that contributes to employee satisfaction and growth	• planning own work • selecting and prioritising projects within scope of own role • evaluating and monitoring own performance • identifying and acting on professional development opportunities • working within organisational and developing policies, procedures, and legislative requirements
Learning that contributes to ongoing improvement and expansion in employee and company operations and outcomes	• developing and maintaining personal competence in related industry skills and knowledge • relevant legislation, regulations, standards and codes of practice • establishing, implementing and/or managing systems and opportunities for ongoing professional development and training • passing on to broader practice community, lessons learned from implementation of projects
Technology that contributes to the effective carrying out of tasks	• using a range of software to develop diagrams, sketches and plans • using project management specific programs and databases to analyse information • applying OHS technology and learning about ergonomics to using technology safely • using technology to achieve improvements in sustainable energy and resource efficiency technologies outcomes

Appendix 3: Recommended references

- Australian Engineering Drawing Standards AS1100.
- Baird, D & Collias, D. *Polymer Processing: Principles and Design*, Wiley, New York, 1998.
- Beck, R. *Plastics Product Design,* Van Nostrand Reinhold, 1980
- Billatos, S. & Basaly, N. *Green Technology and Design for the Environment*, Taylor & Francis, U.S.A., 1997
- Brauer, D.C. and Cesarone J. *Total Manufacturing Assurance : Controlling Product Reliability, Safety, and Quality*, New York Marcel, 1991
- Buchanan, E.V. *Protecting Research - The Role of Patents and Copyright.* (Materials Australia), March 1988
- Buckleitner, E. *Dubois and Pribble's Plastics Mold Engineering Handbook* 5th Edition, Chapman & Hall, 1995
- Chung, C. *Extrusion of polymers: theory and practice,* Hanser/Gardner, U.S.A., 2000.
- Dubois and Prebless. *Plastics Mould Engineering Book. 1995*
- Fowler, T.C. *Value Analysis in Design*, New York, Van Nostrand Reinhold, 1990
- Gertsakis J. et al. *Design for Plastics Recycling*, Centre for Design, Royal Institute of Technology, Melbourne, 1991.
- Kamm, L.J. *Designing Cost-Efficient Mechanisms : Minimum Constraint Design, Designing with Commercial Components, and Topics in Design Engineering.* New York, McGraw-Hill, 1990.
- Kaye. H. *Inside the Technical Consulting Business: Launching and Building Your Independent Practice.* 2nd Edition. Wiley, New York. 1994. ISBN 0471597198.
- Lee, N. *Understanding Blow Moulding*, Hanser Gardner Publications, Ohio, 2000.
- Lewis, J.P. and Wong, L. *Accelerated Project Management: How To Be The First To Market,* New York, McGraw-Hill, 2004.
- Merrilees, K. *Mechanical Innovations for Injection Mould Designs,* Melbourne, Merrilees Mould Design Pty Ltd, 2006
- Muccio, E.A. *Plastic Part Technology.* ASM International, Ohio. 1991. ISBN. 0871704323.
- Quality Standards Documentation:
  - *Quality System Requirements - QS9000*
  - *Production Parts Approval Process*
  - *Advanced Product Quality Planning*
  - *Quality System Assessment*
  - *Potential Failure Mode and Effects Analysis*
  - Published by American Society for Quality Control and Automotive Industry Action Group.

- Rauwendaal, C. *Statistical Process Control in Injection Molding and Extrusion*, Hanser/Gardner, U.S.A., 2000.
- Rauwendaal, C. *Polymer Extrusion*, Hanser/Gardner, U.S.A., 2001.
- Rauwendaal, C. *Troubleshooting the Extrusion Process: A Systematic Approach to Solving Plastics Extrusion Problems*, Hanser, U.S.A., 2001
- Rosato, D.V. & Rosato, D.V. *Plastics Engineered Product Design*. Elsevier, Oxford. 2003. ISBN 1856174166
- Rosato, D.V., & Rosato D. V., *Plastics Design Handbook* [electronic resource]. Kluwer Academic Publishers, Boston. 2001. ISBN 1591242584.
- Society of Plastics Engineers, *Blow extrusion moulding: primer, machinery, problems and solutions,* The Society of Plastics Engineers, U.S.A., 2000.
- Strong, A.B. *Plastics: Materials and Processing*, Prentice hall, New jersey, 1996
- WJT Associates. *Injection Mold Tooling Standards: A Guide for Specifying, Purchasing and Qualifying Injection Molds.* 1993. ISBN 0-936994-11-8.
- Wood, L. *Rapid Automated Prototyping: An Introduction.* Industrial Press, New York. 1993. ISBN 0831130474.

Section C: Units of Competency

Core units

VU21972: Design plastics product or part

VU21973: Manage plastics tool design

PMBTECH505: Choose polymer materials for an application

Stream One: Injection Moulding

VU21974: Implement plastics injection moulding tool design

VU21975: Manage plastics injection moulding tool design application

VU21976: Implement injection moulding tool design for plastics product details

VU21977: Implement plastics injection moulding temperature control

Stream Two: Blow Moulding

VU21978: Implement plastics blow moulding tool design

VU21979: Manage plastics blow moulding tool design application

VU21980: Implement blow moulding tool design for plastics product design details

VU21981: Implement advanced blow moulding tool design

Stream Three: Extrusion

VU21982: Implement plastics extrusion tool design

VU21983: Manage extrusion sheet and film tool design

VU21984: Manage extrusion pipe, tube and cable tool design

VU21985: Manage extrusion profile tool design

Stream Four: Additive manufacturing

VU21986: Utilise 3D printing for plastic product manufacturing

VU21987: Utilise 3D printing for plastics product prototyping

VU21972 Design plastics product or part

Unit Descriptor

This unit describes the skills and knowledge required to develop and implement plastics product and/or part design to enable the achievement of tooling and production requirements and to meet specified outcomes.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of plastics products and tool design across a broad range of processing applications, such as: injection moulding; blow moulding, and/or extrusion, within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 principles and procedures for plastics product design project	1.1 Current theories, models and methodologies of ***product design*** are researched, analysed and debated for current and future application to ***product design projects*** within ***organisational*** and ***regulatory requirements***
	1.2 ***Manufacture and assembly implications*** of product design project are analysed and findings documented
	1.3 ***Implications and requirements for incorporating product design details*** in product design are delineated and documented
	1.4 ***Quality policies and procedures***, including environmental impact of product design, are delineated and incorporated into project
2 Determine processes for achieving optimal relationship between plastics product design, processing method, material and tool design	2.1 Impact of ***end-use requirements*** and the ***distinctive features*** of plastics products on selection of ***processing method*** and material is analysed

		2.2	Effect of ***properties*** of a range of polymer materials on the performance of plastics products are analysed
		2.3	Impact of ***product design*** and ***production considerations*** on ***tool design*** is investigated
		2.4	***Design fault prevention strategies***, across a range of plastics products and parts, are determined and incorporated into project
3	Implement and evaluate design project	3.1	Product requirements are analysed and appropriate polymer and process/es to meet specified outcomes are determined
		3.2	Product features are designed to optimise function and performance of the product/part
		3.3	Design drawings, incorporating specified distinctive features and design details, are prepared, and ***critically evaluated*** against specified project outcomes, organisational and regulatory requirements in consultation with ***relevant people***
		3.4	Recommendations for improvement are made and agreed upon in consultation with relevant people

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills:

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and analytical skills to identify methodologies to achieve optimal relationship between product or part design and production
- strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer-aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess product and tool design for plastics project and use results to inform future practice

Required Knowledge:

- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- principles and processes of plastics product and tool design
- product design detailing
- implications of product design for tool design
- factors that affect decisions in the design process
- principles of design for manufacture and assembly
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Product design may refer to:

- range of factors to be considered at each main stage of a product design process, such as:
  - product specifications and end-use
  - product fitness for purpose
  - product aesthetics
  - fit with other components
  - production quantity, cost and time requirements
  - quality guidelines in design, such as:
    - simplify
    - optimise
    - innovate
    - reduce waste
  - suitability of material specification
  - quality standards, such as:
    - testing
    - validation
  - available production machinery
  - relevant legislation, regulations and standards
  - post-operation processes, such as:
    - re-grinding
    - finishes
    - labelling
  - environmental issues / product stewardship
- key stages of the product design process, such as:
  - design brief
  - regulatory requirements
  - industry code requirements
  - intellectual property requirements
  - product design proposal
  - design review and verification by relevant people
  - selection of appropriate:
    - materials

- processes
- equipment

- analysis of implications of design features
- design validation
- evaluation of impact on other systems
- design changes as required
- product trialling, evaluation and adjustment
- quality assurance
- Failure Mode and Effects Analysis (FMEA)
- record keeping
- evaluation of product design project process for continuous improvement

- range of processes to develop product design, such as:
  - from engineering drawings and specifications
  - from a product model
  - sketching
  - Computer-Aided Drafting (CAD) techniques
  - rapid prototyping
  - sculpture
  - carving
  - epoxy resin moulding

Product design projects may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Organisational requirements may refer to:	• vision • mission • purpose and values • business strategy and performance plans • Return On Investment (ROI) • operational planning, policies and procedures • processes • resource requirements and financial considerations • risk management policies and procedures • reporting procedures • legal and ethical requirements and codes of practice • quality standards and continuous improvement processes • economic, social and environmental sustainability goals, initiatives, reporting and protocols • knowledge and Intellectual Property (IP) policies • OHS policies, procedures and programs • customer / client satisfaction

Regulatory requirements may refer to:	• Federal, State or Territory legislation and local government regulations and legislation
	• Australian Standards, such as:
	  o technical drawing
	  o quality management processes
	• compliance with relevant International Standards, such as:
	  o technical drawing
	• covenants, such as:
	  o Plastics and Chemicals Industries Associations (PACIA) - Packaging covenant
	• environmental regulations
	• product stewardship legislation
	• Occupational Health and Safety (OHS)
	• food grade requirements
	• poisons
	• dangerous goods
	• structural codes

Manufacture and assembly implications may include:	• product simplification, such as: o design for minimum number of parts • competitive benchmarking of both local and global costs

- early and accurate costing of method of assembly, material, process and tooling to enable optimal design decisions
- updating of costs as tolerances, surface finishes and other part details are determined
- consultation on design, cycle times and costs with suppliers, customer and other stakeholders

Implications and requirements for incorporating product design details refers to:

- holes or slots, such as:
  - moulded holes
  - wall sections in blind holes
  - drilled holes
  - tapped holes
- implications and requirements, such as:
  - spacing and positioning
  - tool design for holes or slots
  - cavity inserts
  - pins and posts
- undercuts:
  - purpose of undercuts
  - alternatives to undercuts
  - collapsible cores
  - tooling requirements
  - precautions for successful results
  - product actuation
- threads, such as:
  - moulded threads
  - internal and external threads
  - tapped threads
- implications and requirements, such as:
  - mould design for threads
  - removal of thread parts from moulds
  - advantages and disadvantages of different types of threads
- inserts, such as:
  - plastic inserts
  - metal inserts
- implications and requirements, such as:
  - positioning of inserts
  - material thickness around inserts
  - mould temperature
  - sealants
  - insert wall thickness
  - press inserts

- rotating moving halves
- multiple material moulding

- robot-assisted de-moulding/de-sprueing
- methods of fastening and joining plastics:
  - mechanical fasteners, such as:
    - thread forming and cutting screws
    - blind rivets
    - speed nuts and clips
    - drive studs
  - welding, such as:
    - hot gas/air welding
    - heat bonding (flange welding)
    - ultrasonic welding
    - high frequency welding
    - induction welding
    - friction welding
  - adhesive and cohesive chemical bonding, such as:
    - solvent cement
    - bodied cement
    - monomeric cement
    - thermosetting cement
  - chemical bonding joint configuration
- hinge types
- methods of decorating plastics, such as:
  - spray painting
  - metallising
  - metal plating
  - screen printing
  - multi colour moulding
  - in mould decorating / labelling
  - hot stamping
  - labels and decals
- implications and requirements, such as:
  - materials suitability
  - surface preparation
  - product and part configuration
- tooling configuration

Quality policies and procedures may include:

- advanced product quality planning
- Production Part Approval Process (PPAP)
- Quality System Assessment (QSA)

- potential Failure Mode and Effects Analysis (FMEA)
- control plans
- Operator Training Requirements

End-use requirements may refer to:

- top load strength
- flexibility
- flexural strength
- impact performance
- gas permeation (PET)
- Environmental Stress Crack Resistance (ESCR)
- UV resistance
- chemical resistance
- burst strength
- visual appearance
- printability
- environmental costs, such as:
  - recycling
  - waste disposal
  - toxicity
- cost

Distinctive features of product design may refer to:

- hollow product
- thin walls
- totally moulded surfaces
- continuous product
- irregular shape
- rigid product
- low cost tooling
- length of run

Processing method may refer to:

- injection moulding
- blow moulding
- extrusion
- assembly methods
- finishing methods

Properties may refer to:

- physical and mechanical properties, such as:
  - thermal behaviour
  - chemical resistance
  - appearance, such as:
    - flash
    - sink marks
    - grain wash out

- gloss levels
- drag marks
- distortion
- harmony with adjacent parts
- grain/gloss/colour matching

- glass transition temperature
- shrinkage

- material flow or viscosity

Production considerations may refer to:

- production capacity
- length of run / number of products
- size and complexity of product
- process equipment available
- dimensional precision of product

Tool design may refer to:

- gating methods, such as:
  - standard gate
  - valve gate
  - edge gate
  - fan gate
  - submarine gate
- taper / draft angles
- ejection / release methods
- tolerance / shrinkage
- moveable cores
- insert moulding
- over moulding

Design fault may refer to:

- premature failure
- radii and chamfers
- wall thickness
- burn marks
- sink marks
- weld lines
- warpage
- shrinkage
- ejection problems

(Design fault) ***Prevention strategies*** may refer to:

- careful initial evaluation of product requirements / specifications
- thorough analysis of the design constraints of different processes, materials and tools

- thorough and ongoing consultation with client / suppliers / other team members and stakeholders
- effective project management
- quality assurance procedures, including:
  - design checklist
  - production checklist
  - failure minimisation
  - zero defects methodology
  - process control

Critically evaluated may include consideration of:

- functionality and fitness for end-use
- manufacturability
- cost of production
- environmental costs and impact of production
- minimising product design complexity
- utilisation of strategies to eliminate or minimise faults

Relevant people may refer to:

- management
- colleagues
- clients
- customers
- suppliers
- stakeholders
- technical experts
- industry professionals
- planners
- advisors
- consultants
- regulators

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

A person who demonstrates competency in this unit must provide evidence of:

- directing, implementing and evaluating plastics product design project/s across a range of distinctive features and details
- determining prevention strategies for design faults in a range of plastics and parts
- knowledge of principles and process of plastics product design including design details and subsequent implications for manufacture, assembly, processing, materials and tool design

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated tooling
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of plastics product design project that meets specific outcomes and that include a range of distinctive features and design details
- evaluation of research project into theories, models and methodologies in plastics product design including fault prevention strategic planning
- evaluation of research project into relevant Australian and international legislation, regulations and industry standards
- practical exercises, such as: manual sketching and Computer-Aided Design (CAD)
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

Unit VU21973: Manage plastics tool design

VU21973 Manage plastics tool design

Unit Descriptor

This unit describes the skills and knowledge required to manage plastics tool design projects, both individually and within a team setting, across a range of local and international industry contexts.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for the development of tool designs for the manufacture of plastics products across a broad range of processing applications, such as: injection moulding; blow moulding, and/or extrusion, within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 principles and procedures for plastics tool design	1.1 Current theories, models and methodologies of ***tool design*** are researched, analysed and debated for current application to ***tool design projects*** within ***organisational*** and ***regulatory requirements***
	1.2 Implications of ***value analysis and value engineering*** on the tool design process is analysed and findings documented
	1.3 ***Quality policies and procedures***, including environmental impact of tool design, are delineated and incorporated into project
2 Develop and oversee tool design project	2.1 ***Own role and responsibilities of tool designer****,* both as a skilled individual and in relation to ***others*** associated with tool design project are delineated and practised
	2.2 ***Project management tools and methodologies*** relevant to supporting efficient, timely and successful completion of tool design projects are evaluated, selected and implemented, in consultation with ***relevant people***
	2.3 Communication strategies, including identification of ***critical consultation points****,* that support project objectives processes and procedures are developed and practised

	2.4	***Risk*** and contingency management is built into tool design project strategy
	2.5	***Performance monitoring and review policies and procedures*** are established, communicated to relevant people and undertaken
3 Evaluate impact of emerging local and international trends on plastics tool design management	3.1	Relevant and up-to-date information on current and emerging trends in plastics tool design is researched through ***key industry organisations*** and professional networks and then evaluated.
	3.2	***Local trends*** are analysed and assessed for their interrelationship and interaction with ***global factors*** and impact on client expectations of tool design.
	3.3	Impact of local and ***global trends*** on the local industry is analysed, findings documented and agreed innovations are incorporated into tool design management strategy in consultation with relevant people.

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills:

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of tool design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer-aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice,
- research and analytical skills to identify and evaluate emerging local and international trends in tool design for plastics and to develop response and innovation

Required Knowledge

- principles and processes of plastics product and tool design
- factors that affect decisions in the design process
- concepts of value analysis and value engineering
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- current and emerging local and global trends in plastics tool design
- current and emerging local and global economic, legislative and political influences on plastics industry
- relevant industry organisations and networks
- safe work practices

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.

Tool design may refer to:

- Range of factors to be considered at each main stage of a tool design process, such as:
  - product specifications and end-use
  - product fitness for purpose
  - product quantity, cost and time requirements
  - environmental issues, such as:
    - recycling
    - waste minimization
    - carbon abatement
  - suitability of material specification
  - available production machinery
  - tool to machine compatibility
  - quality standards, such as those pertaining to:
    - testing and validation
    - dangerous goods
    - food contact
    - poisons
  - post-operation processes, such as:
    - re-grinding
    - finishes
    - labelling
- key stages of the tool design process, such as:
  - design brief
  - action plan and timeline
  - tool design proposal
  - quality assurance and Failure Mode and Effects Analysis (FMEA) procedures
  - design review and verification by all stakeholders
  - confirmation of appropriate materials, process and equipment
  - design validation
  - design changes as required
  - evaluation of impact on other systems
  - prototype tool trialling
  - maintain accurate records
  - evaluation of tool design project process for continuous improvement

- range of processes to develop tool design, such as:
  - from engineering drawings and specifications
  - from a product model
  - sketching
  - Computer Aided Drafting (CAD) techniques
  - rapid prototyping
  - sculpture
  - carving
  - epoxy resin moulding
  - application of flow analysis software

Tool design projects may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Organisational requirements may include:

- vision
- mission
- purpose and values
- business strategy and performance plans
- Return On Investment (ROI)
- operational planning, policies and procedures
- processes
- resource requirements and financial considerations
- risk management policies and procedures
- reporting procedures
- legal and ethical requirements and codes of practice
- quality standards and continuous improvement processes
- economic, social and environmental sustainability goals, initiatives, reporting and protocols
- knowledge and Intellectual Property (IP) policies
- OHS policies, procedures and programs
- customer / client satisfaction

Regulatory requirements may include:

- Federal, State or Territory legislation and local government regulations and legislation
- Australian and International Standards, such as:
  - technical and architectural drawing
  - quality management processes
  - heat treatment
  - electrical
- covenants, such as:
  - Plastics and Chemicals Industries Associations (PACIA) - Packaging covenant
- environmental regulations
- product stewardship legislation
- Occupational Health and Safety (OHS)
- food grade requirements
- poisons
- dangerous goods
- structural codes

Value analysis and value engineering may refer to:

- use of Value Analysis and Value Engineering (VA-VE) job plan
- regular benchmark costings
- quality control and management methods
- defect prevention through good initial design
- 'get it right the first time'
- focus on improved product quality, performance and cost

Quality policies and procedures may include:

- advanced product quality planning
- Production Part Approval Process (PPAP)
- Quality System Assessment (QSA)
- potential Failure Mode and Effects Analysis (FMEA)

Own role and responsibilities of the tool designer may refer to:

- technical competence:
  - tool design proposals: outline and full concept
- professional competence, such as:
  - researched knowledge of current and emerging trends in plastics industry, such as:
    - new commercial polymers
    - waste minimisation
    - recycling technologies
    - CAD and other software
  - professional networks
  - researched knowledge of current and emerging local and global economic, legislative and political influences on plastics industry

- management competence, such as:
  - strategic planning and implementation, such as:
    - projects align with overall organisational strategic planning
    - project management
    - OHS policies and procedures
  - quality management for minimum tool trialling, such as:
    - zero defects
    - quality built into initial design
    - quality built into design processes and stages
    - risk and contingency planning
    - continuous improvement
  - communication and management skills, such as:
    - delegation
    - effective communication of policies and procedures
    - effective problem-solving
    - team-based work methods
    - consultative management approaches
    - participative management approaches
- systems thinking, such as:
  - project evaluation
  - costings and quotations
  - design evaluation and assessment, such as:
    - viability
    - organisational capacity
    - fit for purpose
    - constraints cost
  - operations management, such as:
    - supply
    - resourcing
    - work flow to downstream work areas, such as:
      - *toolmakers*
      - *mould shop technicians*
      - *rapid prototypers*
      - *production engineers*
  - sustainability management, such as:
    - design decision based on environmental impact
    - costs
    - policies and procedures for sustainable energy and resource efficient technologies

- client and stakeholder management, such as:
  - feedback on project brief
  - consultation and briefing on progress
  - consultation and briefing on necessary alterations to project
  - review of project outcomes
  - management of conflicting needs and/or constraints of stakeholders, such as those related to:
    - rapid prototypers
    - raw material suppliers
    - sales engineers
    - production engineers

Others (associated with tool design project) may include*:*

- project team
- product/industrial designers
- production engineers
- inter-department personnel
- OHS personnel
- quality personnel
- operational management personnel
- raw material suppliers
- toolmakers
- sales engineers
- mould shop technicians
- polymer technicians
- rapid prototypers
- client/s
- external stakeholders
- other suppliers

Project management tools may include:

- design checklists
- Key Performance Indicators (KPIs)
- project management software
- timelines
- target review tables
- risk management pro formas
- budgets
- costing spreadsheets
- tool quotation forms
- performance monitoring and review policies and procedures
- Failure Mode and Effects Analysis (FMEA) procedures
- Quality Assurance procedures and processes

Relevant people may include:	• management • colleagues • clients • customers • suppliers • stakeholders • technical experts • industry professionals • planners • advisors • consultants • regulators

Critical consultation points may refer to:	• feedback to client on initial design brief as early as possible
	• consultation with all stakeholders to verify design
	• consultation with all stakeholders when establishing project timeline
	• consultation with client to confirm decisions regarding:
	  o design
	  o materials
	  o process
	  o equipment
	• briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Risk may refer to:	• constraints and obstacles, such as:
	  o flawed product design
	  o poor quality procedures
	  o failure to evaluate the product design initially
	  o failure to communicate effectively with others related to the project
	  o timeline blowouts
	  o excessive numbers of tool trials
	  o containment of costs, including environmental costs
	  o cost overruns
	  o inadequate budget

Performance monitoring and review policies and procedures may include:	• conformance, measuring and assessment methodologies • reporting structures and procedures • regular and timely reporting • record keeping • completion documentation • compliance manuals

- quality assurance manuals policies and procedures
- continuous improvement policy and procedures

Key industry organisations may include:

- Australian Manufacturing Technology Institute Limited (AMTIL)
- Plastics and Chemicals Industry Association (PACIA)
- Society of Automotive Engineering (SAE America and Australia)

Local trends may include:

- increase in rapid prototyping
- shorter timelines
- fewer skilled technicians
- tool design moving offshore
- manufacturing sector contracting and becoming more competitive
- high labour costs
- sub-assembly manufacturers: value added
- design for export: not just local
- collaboration with outside organisations on technology
- impact of National and State economies
- impact of relevant legislative and regulatory reform

Global factors may refer to:

- collaboration with international suppliers
- intellectual property issues
- timelines and delivery implications
- cultural issues and protocols
- quality assurance issues
- implications of differences in legislation and standards

Global trends may refer to:

- increased competition from overseas
- increased offshore production
- increased automation
- new technologies
- increasing sophistication of process control
- ‘end to local loyalty’
- integrated technologies
- integrated companies
- time-to-market pressure
- innovation: demonstrating differentiation of product
- sustainability issues, such as:
  - energy costs
  - recyclability
  - waste minimisation

  - carbon abatement
  - new, or retro-fitted, sustainable energy and resource efficient technologies
- culture-neutral designs
- moving trade agreements
- individual tools with quick change components
- international alliances
- international trading arrangements and protocols
- impact of global organisations, such as:
  - United Nations
  - International Monetary Fund (IMF)
  - World Trade Organisation (WTO)

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

A person who demonstrates competency in this unit must provide evidence of:

- directing, implementing and evaluating plastics tool design project/s across a range of applications
- developing and implementing monitoring and evaluation procedures for plastic tool design project/s including risk and contingency management
- knowledge of principles and process of plastics tool design
- knowledge of relevant legislative and regulatory requirements
- knowledge of current and emerging local and global trends in plastics tool design and their projected consequences for industry

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of plastics tool design project that meets specific outcomes
- evaluation of a research project into the range of different processes for developing tool designs
- evaluation of research project into theories, models and methodologies in plastics tool design including risk management
- practical exercises in leadership; use of project management tools and tool design processes
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)	Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to: *VU21972: Design plastics product or part*

VU21974 Implement plastics injection moulding tool design

Unit Descriptor

This unit describes the skills and knowledge required to make optimal decisions regarding design requirements for plastics injection moulding tools.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of injection moulding tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Research injection moulding tools	1.1 Principles of operation of a range of commonly used ***injection moulding tools*** are researched and delineated
	1.2 Different applications and requirements of a range of ***injection moulding tool components*** are researched and clarified
2 Analyse the interrelationship between injection moulding machines operating functionality and tool design	2.1 ***Design characteristics and functions of injection moulding machines*** are analysed for effect on tool design
	2.2 Importance of ***matching mould design to machine operating functionality*** is researched and evaluated
	2.3 ***Operating cycle of moulds*** are analysed for effect on injection moulding tool design
	2.4 ***Machine factors*** are analysed for effect or limitation on injection moulding tool design

3	Select materials and tool construction methods to achieve production requirements and processing	3.1	Effect of mould design and production requirements is appraised in determining selection of the ***metal materials*** and ***finishing treatments***, according to their particular ***properties***, used in mould construction
		3.2	Effect of mould design and production requirements is appraised in determining selection of ***mould component construction methods***
		3.3	Effect of mould design, production requirements and ***environmental costs*** is appraised in determining selection of raw materials
4	Analyse and evaluate product design to determine tool design requirements	4.1	***Product design specifications*** are evaluated to determine ***injection moulding tool design requirements***
		4.2	Optimal materials for mould construction to meet design and ***production requirements*** is selected
		4.3	Tool design concept proposals are developed and ***critically evaluated*** to achieve specified product outcomes
5.	Implement and evaluate injection mould tool design project	5.1	***Project management methodologies*** and ***communication strategies*** are applied to implementation
		5.2	***Tool design faults*** and their causes are analysed and ***prevention strategies*** established and implemented
		5.3	Project is reviewed against specified outcomes and findings used to inform improved processes, procedures and planning in consultation with ***relevant people***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer-aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics injection moulding tool design
- design features and functions of plastics injection moulding machine operating systems
- implications of product design for tool design
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- factors that affect decisions in the design process
- causes and elimination strategies of common product faults
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Injection moulding tools may include:

- cold runner, two plate
- cold runner, three plate
- hot runner
- insulated hot runner
- hot manifold
- multi-cavity hot runner
- sequential gating
- family
- sizing inserts
- stacked
- gas injection
- prototypes
- flash moulds (thermoset)

Injection moulding tool components may include:

- cavity design
- runner system
- ejection system, such as:
  - return springs
  - gas springs
- temperature control system
- standard part components
- actuating mechanisms
- inserts and cores
- sliding cores and cavities
- clamping systems
- gas injection needles

Design characteristics and functions of injection moulding machines may include:

- injector nozzles
- mould clamping units
- platens, stationary and moveable
- magnetic platens
- tail plates
- magnetic backing plates

- methods of fixing moulds to platens, such as:
  - bolting
  - clamps
  - slides
  - dogs
- toggle systems:
  - single
  - double
  - rotary
- direct hydraulic locking:
  - single
  - multi cylinder
- methods of locking and blocking systems

Matching mould design to machine operating functionality may include:

- selecting type of attachment to platens
- calculating clamp tonnage in relation to mould size for safe machine operation for given materials types
- calculating pillar support requirements to accommodate clamp tonnage for mould bases incorporating 'U' shaped injection housing

Operating cycle of moulds may include:

- die change procedures
- disassembly and assembly procedures
- safe die transport, handling and storage procedures
- die trialling procedures
- resetting machine for new process
- commissioning new tooling into production
- handling the mould during maintenance and servicing operations
- identification and labelling of dies

Machine factors may include:

- opening
- sequence and machine platen
- daylight
- ejector hole positions
- hydraulic coupled ejector systems
- platen size
- bolt pattern
- available stroke
- clamp capacity and mould/part size

Metal materials may include:

- mild steel
- surface hardening steel
- stainless steel
- tool steel

- aluminium
- kirksite
- beryllium copper
- interpretation of mould steel data sheets and property tables

Finishing treatments may include:

- polishing
- texturing
- heat treatment processes, such as:
  - normalising
  - annealing
  - quench hardening
  - carburising
  - nitriding
  - tempering
  - stress relieving
- plating and coating techniques
- etching
- graining

Properties may include:

- tensile strength
- thermal conductivity
- cost
- hardness
- surface finish

Mould component construction methods may include:

- Numerical Control (NC) machining
- Computer Numerical Control (CNC) machining
- Electronic Discharge Machining (EDM) – commonly called spark erosion
- wire cutting
- grinding
- laser cutting
- water jet cutting
- 3D printing

Environmental costs may include:

- recyclability
- waste management
- waste minimisation
- waste disposal
- resource management
- energy consumption used in processing, such as:

- services required for production, such as:
  - cooling supply
  - power supply
  - heating supply
- carbon abatement

Product design specifications may include:

- samples
- drawings
- specifications
- customer requirements
- moulding shop specifications
- environmental issues

Injection moulding tool design requirements may include:

- runner and gate systems for cavity design
- types of gates
- runner, sprue and gate layout for single or multiple cavity moulds
- runner cooling
- runner pressure, runner drop-off
- material viscosity
- thermal conductivity of runner system
- thermal conductivity of part or sections of part
- venting
- temperature control
- ejection methods for products including those with undercuts
- part lines, undercuts, draft angles, shut off witness lines
- allowance for side pressures and deflection of mould components
- clamp pressures
- calculation of part line relief
- calculation of pressure required to keep mould closed
- calculation of mould deformation under pressure and safe work limits
- finishing for application
- shrinkage
- stakeholder requirements
- sustainability issues
- raw materials and their possible limitations
- Failure Mode and Effects Analysis (FMEA)

Production requirements may include:

- production capacity
- production run specifications
- production method
- end-use applications

Critically evaluated may refer to considerations of:

- functionality and fitness for end-use
- manufacturability

- cost of production
- environmental costs and impact of production
- minimising product design complexity
- utilisation of strategies to eliminate or minimise faults

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management
- project evaluation
- stakeholders engagement
- critical consultation points, such as:
  - feedback to client on initial design brief as early as possible
  - consultation with all stakeholders to verify design
  - consultation with all stakeholders when establishing project timeline
  - consultation with client to confirm decisions regarding:
    - design
    - materials
    - process
    - equipment
  - briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Tool design faults may include:

- poor tool design
- selection of inappropriate materials
- poor material preparation
- technical faults within production and processes, such as:
  - runner system
    part lines, undercuts, draft angles, shut off witness lines

- gating
- weld lines
- flow lines
- part position on opening
- burn marks
- sink marks
- depressions
- voids
- high and low temperature cooling
- venting
- jetting
- sticking sprue
- ejection
- radius
- sticking parts
- product retained on fixed or moving side
- moisture
- wall thickness variation
- thick section / thin section

(Fault) ***Prevention strategies*** may include:

- careful initial evaluation of product requirements / specifications
- thorough analysis of the design constraints of different processes, materials and tools
- thorough and ongoing consultation with client / suppliers / other team members and stakeholders
- effective project management
- quality assurance procedures, including:
  - design checklist
  - production checklist
  - failure minimisation
  - zero defects methodology
  - process control

Relevant people may include:

- management
- colleagues
- clients
- customers
- suppliers
- stakeholders
- technical experts
- industry professionals
- planners
- advisors
- consultants
- regulators

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

A person who demonstrates competency in this unit must provide evidence of:

- implementing injection moulding tool design project for a plastics product design concept
- determining prevention strategies for tool design faults
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of injection moulding tool design including: capabilities of injection moulding machine operating systems and requisite materials and tool construction methods

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated injection moulding tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of project in injection moulding tool design that meets specified outcomes of a product design concept.
- evaluation of research project into fundamentals of injection moulding tool design across a range of contexts
- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment

Holistic assessment with other units relevant to the qualification stream, industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

- *VU21975: Manage plastics injection moulding tool design application*
- *VU21976: Implement injection moulding tool design for plastics product details*
- *VU21977: Implement plastics injection moulding temperature control*

VU21975 Manage plastics injection moulding tool design application

Unit Descriptor

This unit describes the skills and knowledge required to develop and implement injection mould tool designs to achieve plastics product specifications across a range of contexts.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of injection moulding tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Apply the principles of cavity mould design to plastics tool design	1.1 ***Methods of translating product dimensions and specifications*** into cavity mould designs are researched and delineated
	1.2 ***Principles and main elements of cavity mould design*** are analysed for their different applications
	1.3 Moulding and cooling conditions for cavity moulds are analysed using ***simulation software***
2 Research optimum runner feed system for multi-cavity mould/s	2.1 ***Principles and process of cavity mould balancing*** are researched and delineated
	2.2 ***Range of data*** required to accurately design an optimum runner system/s is calculated and documented
3 Apply the principles of product ejection to plastics tool design	3.1 ***Actuating mechanisms*** for product ejection from moulds are researched and analysed for their different applications
	3.2 Possible tool design problems and contexts are assessed and corresponding product ejection designs are developed

4	Determine requirements for multiple-plate cavity mould tool design project	4.1	Product end-use requirements are analysed and appropriate material and machine process determined
		4.2	Methods to best meet ***production and design requirements*** are canvassed and selected
		4.3	Product specifications are analysed for possible faults, their causes analysed and ***prevention strategies*** established
		4.4	***Project management methodologies*** and ***communication strategies*** are determined
		4.5	Tool design/s are ***critically evaluated*** against ***tool design requirements***
5	Evaluate design project	5.1	Project is implemented and reviewed against specified outcomes
		5.2	Findings are used to inform improved processes, procedures and planning in consultation with ***relevant people***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer-aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics injection moulding tool design
- design features and functions of plastics injection moulding machine operating systems
- principles and processes of cavity mould tool design
- methods for translating product dimensions and specifications into cavity mould designs
- principles and process of cavity mould balancing and runner system design
- different actuating mechanisms for product ejection from moulds
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- causes and elimination strategies of common product faults
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- simulated
- safe work practices

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.

Methods of translating product dimensions and specifications may refer to:

- product drawings
- material and machine specifications
- product models for which drawings can be produced
- product models for which drawings are too difficult to produce, such as:
  - carving
  - sculpture
- CAD data
- CAD model
- prototype with some working measurements

Principles and main elements of cavity mould design may refer to:

- core and cavity design
- shrinkage and tolerancing
- draft angles
- cores
- splits
- parting surfaces
- part lines
- ejection
- holes and slots
- inserts
- venting
- use of standard parts in moulds
- calculation of cavity and shot size for moulding
- calculation of optimum number of cavities in a mould
- calculation of flow path to cavity thickness ratio
- calculation of size and placement of vents
- CAD system software applications to optimise moulding and cooling conditions for cavity moulds

Simulation software to optimise moulding and cooling conditions, may include:

- Moldflow
- Moldtemp
- Cadmold
- Moldcool
- Fillcalc
- Simcon

Principles and process of cavity mould balancing may refer to:	• using pressure drop in the runner system
	• sprue and runner layout for single and multi-cavity die systems
	• principles of design, such as:
	  o length
	  o cross sectional area
	  o shape
	• balanced and unbalanced systems
	• purpose and types of gates

Range of data may include:	• suitable gate dimensions for a range of common materials and gate types
	• rheological data to calculate optimum and minimum runner sizes
	• pressure drop in sections of runner systems
	• efficiency of a range of cross section shapes of runners
	• data relating to
	  o volumetric flow
	  o shear rate
	  o viscosity
	• shear stress

Actuating mechanisms may refer to:	• manual ejection
	• ejector actuation mechanisms
	• ejector pins or blades
	• ejection sleeves
	• stripper rings
	• stripper plates
	• compressed air
	• hydraulic ejection
	• other devices, such as:
	  o spring loaded ejector pins
	  o gas springs
	• taking account of undercuts and sprue removal in design

Production and design requirements, may refer to:	• large volume moulding • mechanical and thermal properties of the material • part to production requirements • machine types

(Fault) ***Prevention strategies*** may include:	• careful initial evaluation of product design and requirements
	• thorough and ongoing consultation with client / suppliers / other team members and stakeholders
	• adequate mould-proofing
	• effective project management
	• quality assurance procedures, including:
	  o failure minimisation
	  o zero defects methodology

Project management methodologies may refer to:	• description / definition / rationale • outcomes and goal setting • strategic planning • resource requirements and allocation • budget • targets and milestones • completion phases and timelines • quality management policies and procedures • personnel • responsibilities • accountabilities • agreed reporting procedures • communication strategies • stakeholder engagement strategies, including critical consultation points • monitoring and evaluation

Communication strategies may refer to:	• team leadership
	• consultative management
	• participative management
	• project evaluation
	• stakeholders engagement
	• critical consultation points, such as:
	  o feedback to client on initial design brief as early as possible
	  o consultation with all stakeholders to verify design
	  o consultation with all stakeholders when establishing project timeline
	  o consultation with client to confirm decisions regarding:

- design
- materials
- process
- equipment

- briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Critically evaluated may refer to considerations of:

- functionality and fitness for end-use
- manufacturability
- cost of production
- environmental costs and impact of production
- minimising product design complexity
- utilisation of strategies to eliminate or minimise faults

Tool design requirements may include:

- customer requirements
- environmental costs
- raw materials and their possible limitations
- Failure Mode and Effects Analysis (FMEA)

Relevant people may include:

- management
- colleagues
- clients
- customers
- suppliers
- stakeholders
- technical experts
- industry professionals
- planners
- advisors
- consultants
- regulators

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

A person who demonstrates competency in this unit must provide evidence of:

- managing injection moulding tool design project for a multiple-plate cavity mould tool that addresses principles of cavity mould design, runner systems and product ejection systems
- determining prevention strategies for tool design faults
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of injection moulding tool design to meet plastics product design requirements

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated injection moulding tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

- A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:
- evaluation of project in injection moulding tool design application that includes cavity mould design; optimises runner system, and ejection systems for a range of contexts and applications
- evaluation of project in comprehensive investigation of injection mould tools and moulding machinery
- evaluation of investigative project in correlation between product drawings, specifications and mould tool designs and product requirements
- review of portfolio of research into principles and processes of injection moulding tool design

- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

- *VU21976: Implement injection moulding tool design for plastics product details*
- *VU21977: Implement plastics injection moulding temperature control*
- *VU21978: Implement plastics blow moulding tool design*

VU21976 Implement injection moulding tool design for plastics product details

Unit Descriptor

This unit describes the skills and knowledge required to realise the design of injection mould tools that achieve product specifications for products with special design features, such as: split cavities; side cavities and cores; projections; internal or external undercuts, and internal or external screw threads.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of injection moulding tool design across a broad range of product design applications within the plastics industry Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Apply the principles for incorporating screw threads to mould tool design	1.1 ***Applications and methods for incorporating screw threads*** into mould tool design are researched and delineated
	1.2 Range of ***gating and actuating methods*** for removal of products with screw threads are compared and analysed for their different applications
	1.3 Mould tool design sketches that incorporate screw threads are developed in consultation with ***relevant people***
2 Apply the principles for incorporating undercuts to mould tool design	2.1 ***Applications and methods for incorporating undercuts*** into mould tool design are researched and delineated

		2.2	Range of ***methods for parts removal*** of products with undercuts are compared and analysed for their different applications
		2.3	Mould tool design sketches which incorporate undercuts are developed in consultation with relevant people
3	Apply the principles for incorporating standard mould components and inserts to mould tool design	3.1	***Applications and methods for incorporating standard mould components and inserts*** into mould tool design are researched and delineated
		3.2	Sources for, and availability of, standard mould components and inserts are researched and finding documented
		3.3	Mould tool design sketches that incorporate standard mould components and inserts are developed in consultation with relevant people
4	Implement and evaluate injection moulding tool design project for plastic products with design features	4.1	***Product design details*** are determined and ***tool design requirements*** formulated
		4.2	***Project management methodologies*** and ***communication strategies*** are applied to implementation
		4.3	Mould tool design concepts and sketches are developed and ***critically evaluated*** to achieve specified product outcomes
		4.4	Project is reviewed against specified outcomes and findings used to inform improved processes, procedures and planning in consultation with relevant people

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer-aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics injection moulding tool design
- design features and functions of plastics injection moulding machine operating systems
- principles and processes for incorporating screw threads, undercuts, standard components and inserts into mould tool design
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- project management tools and methodologies
- risk management strategies
- quality procedures
- criteria for critically evaluating mould tool design solutions
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Applications and methods for incorporating screw threads may include:

- production of threaded caps:
  - internal
  - external
- rotational and reciprocating methods of unscrewing
- position of threaded cavity in die design
- gating considerations
- methods of rotating threaded core or cavity:
  - rack design
  - sun, wheel and planet design

Gating and actuating methods may include:

- electric motor
- air
- hydraulic
- rack and pinion
- advantages and disadvantages of various mechanisms
- hot runner

Relevant people may include:

- management
- colleagues
- clients
- customers
- suppliers
- stakeholders
- technical experts
- industry professionals
- planners
- advisors
- consultants
- regulators

Applications and methods for incorporating undercuts may include:

- advantages and disadvantages of undercuts in products
- internal and external undercuts
- safety requirements associated with undercut design

Methods for parts removal may include:

- use of:
  - sliders
  - Splits
  - jump ups
- loose inserts
- collapsible cores
- angle pins
- hydraulic cylinders
- springs

Applications and methods for incorporating standard mould components and inserts may include:

- use of:
  - riser plates
  - backing plates
  - cavity plates
  - ejector pins
  - ejector sleeves
  - ejector plates
  - ejector springs
  - guide plates
  - guide bushes
  - sprue bushes
- different applications, such as:
  - innovations
  - different actuators that control part ejection
- advantages and disadvantages of using standard components and inserts

Product design details may refer to:

split cavities,
side cavities and cores
projections,
internal or external undercuts,
internal or external screw threads.

SPLIT CAVITIES:

- guiding and retention
- actuation, such as:
  - finger cams
  - dog-leg cams
  - side cams
  - spring
  - hydraulic
- locking, such as:
  - open channel chase bolster
  - enclosed chase bolster
- safety in operation, such as:
  - spring detent
  - spring loading

- stripper plate design
- angle lift splits

SIDE CAVITIES AND CORES:

- activation
- locking
- safety in operation
- curved side cores

PROJECTIONS:

- external and internal bosses
- staking
- threads
- embossed details
- texture

INTERNAL OR EXTERNAL UNDERCUTS:

- form pin
  - straight action
  - angled action
- split cores
  - straight action
  - angled action
  - stripping internal undercuts

INTERNAL OR EXTERNAL SCREW THREADS:

- fixed core
- stripping internal and external threads
- interchange cores
- unscrewing moulds
  - rotating cores
  - rotating cavities
  - power systems

Tool design requirements may include:

- suitable runner, vent and ejection systems
- preliminary mould designs optimised by using melt flow and cooling analysis techniques
- detailed drawings of tool assembly
- necessary dimensions and labels
- necessary component drawings
- necessary calculations
- tool specifications to achieve the product requirements, such as:

- material
- equipment
- finish
- construction
- details, such as:
  - undercuts
  - projections
  - threads

- description of tool operation
- mould quotation form and design process cost estimate
- finishing for application
- shrinkage
- stakeholder requirements
- sustainability issues
- risk management, including:
  - limitations of raw materials
  - Failure Mode and Effects Analysis (FMEA)
- project timeline
- completed mould design checklist

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management
- project evaluation
- stakeholders engagement
- critical consultation points, such as:

- feedback to client on initial design brief as early as possible
- consultation with all stakeholders to verify design
- consultation with all stakeholders when establishing project timeline
- consultation with client to confirm decisions regarding:
  - design
  - materials
  - process
  - equipment
- briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Critically evaluated may include consideration of:

- functionality and fitness for end-use
- manufacturability
- cost of production, including environmental costs
- minimising mould design complexity
- utilisation of strategies to eliminate or minimise faults

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

A person who demonstrates competency in this unit must provide evidence of:

- implementing injection moulding tool design project that addresses plastics product requirements across a range of particular design details including: undercuts, projections and threads
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of injection moulding tool design that meet plastics product design requirements

Context of and specific resources for assessment

- Assessment must ensure:
- activities are related to a tool design for plastics context
- Resources implications for assessment include:
- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated injection moulding tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of project in applying principles for addressing projections and incorporating screw threads, undercuts, and standard mould components and inserts into mould tool design
- evaluation of calculations made in meeting tool design requirements
- evaluation of research project into current principles and processes of injection moulding tool for plastic product with specific design details
- review of presentation of design project outcomes
- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment	Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to: o *VU21974: Implement plastics injection moulding tool design* o *VU21975: Manage plastics injection moulding tool design application* o *VU21977: Implement plastics injection moulding temperature control*

VU21977 Implement plastics injection moulding temperature control

Unit Descriptor

This unit describes the skills and knowledge required to determine the heating and cooling requirements of plastics injection moulding tools, including the use and application of hot runners.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of injection moulding tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 heating and cooling requirements for a plastics injection mould tool design	1.1 ***Principles for achieving temperature control*** during moulding operations are researched and delineated
	1.2 Different applications and requirements for a range of ***mechanisms for heating and cooling mould tools*** are researched and clarified
	1.3 ***Dimensions of heating and cooling circuits*** to achieve specified heat loss requirements for given mould designs are calculated
	1.4 Designs for heating and cooling circuits that achieve temperature control requirements for mould designs are developed in consultation with relevant people
2 Apply the principles of melt flow and mould cooling analysis to tool design practice	2.1 ***Techniques to optimise flow and cooling behaviour of polymer materials*** during processing are researched and delineated
	2.2 ***Applications of melt flow and mould cooling analysis*** in injection mould tool design are evaluated

	2.3	Melt flow and mould cooling analysis is conducted, results documented and used to improve mould tool design and optimise tool performance
3 Implement and evaluate temperature control system design project for injection moulding tool/s	3.1	Project brief is reviewed for ***production requirements***
	3.2	Project brief is reviewed for hot runner or insulated hot runner system requirements
	3.3	***Project management methodologies*** and ***communication strategies*** are applied to implementation
	3.4	Designs for meeting ***tool design requirements*** for hot runner and insulated hot runner injection moulding tools are developed and ***critically evaluated***
	3.5	Project is reviewed against specified outcomes and findings used to inform improved processes, procedures and planning in consultation with relevant people

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer- aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design principles and processes of plastics injection moulding tool design
- design features and functions of plastics injection moulding machine operating systems
- mechanisms for heating and cooling mould tools
- methods for calculating dimensions of heating and cooling circuits to achieve specified heat loss requirements in given mould designs
- criteria to determine the need for hot runners
- techniques used to optimise the flow and cooling behaviour of polymer materials during processing
- methods for interpreting and applying melt flow and mould cooling analysis in injection mould tool design
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Principles for achieving temperature control may include:

- hot runners and insulated hot runners
- cooling the melt, such as:
  - conduction in the mould wall
  - convection cooling in water lines
  - heat expansion on nozzles and manifolds

Mechanisms for heating and cooling mould tools may include:

- heating mechanisms, such as:
  - electric and oil heating systems, including advantages and disadvantages of each
  - heater bands
  - heated manifolds
  - nozzle heaters
  - sheathed resistance wire heaters
  - function and placement of thermocouples
  - insulation materials and their position in mould design
- cooling mechanisms, such as:
  - operations and application of water tower
  - refrigerated and hot water applications
  - open and closed systems of temperature control
  - types of water channels and circuits, their location and position in mould design

Dimensions of heating and cooling circuits may include:

- flow rate / heat transfer
- effect of cooling on cycle time
- effect of location of hot runners

Techniques to optimise flow and cooling behaviour of polymer materials may include:

- modelling of finite element analysis (FEA)
- melt flow analysis, such as:
  - techniques, including computerised flow analysis
  - applications to:
    - product design
    - mould design
    - fill pattern
    - gate locations and numbers

- runner system design
- flow and heat transfer equations
- CAD applications to melt flow analysis, such as:
  - position and dimensions of part walls, weld lines and runner systems
  - runner balancing in multi-cavity moulds
  - flow control to position weld lines
  - analysis of multi gated cavities
  - two dimensional hot sprue modelling

- mould cooling, such as:
  - CAD applications to analyse the cooling requirements of injection mould tooling, such as:
    - mould cooling optimisation
    - heat transfer in moulds
    - design objectives
    - physical dimensions and cooling line layout
    - estimation of heat loads
    - cooling parameters, boundaries
    - meshing of cooling lines
    - analysis of cooling circuits
    - two dimensional modelling of cooling lines
    - cross sectional analysis
    - warpage prediction

Applications of melt flow and mould cooling analysis may include:

- design modelling and analysis techniques using:
  - part creation
  - mass property analysis
  - component parts and sub assembly groups to form assemblies
  - creating cross CAD/CAM system files using 2D and 3D image output files, such as:
    - wire frame construction
    - surface modelling
    - solids modelling
- math model applications

Production requirements may include:

- end-use that requires control over temperature tolerance, such as:
  - food contact
  - pharmaceuticals
  - optical
- optimised material selection
- minimisation of waste and scrap
- number of cavities
- technician ability
- quality assurance
- optimised cycle times
- total tool cost
- budget constraints
- production capacity

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management
- project evaluation
- stakeholders engagement
- critical consultation points, such as:

- feedback to client on initial design brief as early as possible
- consultation with all stakeholders to verify design
- consultation with all stakeholders when establishing project timeline
- consultation with client to confirm decisions regarding:
  - design
  - materials
  - process
  - equipment
- briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Tool design requirements may include:

- end-use requirements of the product
- design fault finding and rectification
- preliminary mould designs optimised using melt flow and cooling analysis techniques
- material selection
- machine selection
- runner, vent and ejection systems
- detailed drawings of tool assembly
- necessary dimensions and labels
- necessary component drawings
- necessary calculations
- tool specifications to achieve the product requirements, such as:
  - material
  - equipment
  - finish
  - construction
  - product design details
- mould quotation form and design process cost estimate
- project timeline
- description of tool operation
- completed mould design checklist
- customer requirements
- environmental costs
- risk management, including:
  - limitations of raw materials
  - Failure Mode and Effects Analysis (FMEA)

Critically evaluated may include consideration of:	• functionality and fitness for end-use • manufacturability • cost of production, including environmental costs • minimising mould design complexity • utilisation of strategies to eliminate or minimise faults

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

A person who demonstrates competency in this unit must provide evidence of:

- implementing injection moulding temperature control system design project across a range of contexts
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of injection moulding tool design for heating and cooling that meet plastics product design requirements

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool for plastics design context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated injection moulding tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of project in the heating and cooling requirements for a tool design; principles of melt flow and mould cooling analysis in tool design; need for a hot runner, or insulated hot runner, injection moulding tool
- evaluation of research project into principles and processes of temperature control
- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

- *VU21974: Implement plastics injection moulding tool design*
- *VU21975: Manage plastics injection moulding tool design application*
- *VU21976: Implement injection moulding tool for plastics product details*

VU21978 Implement plastics blow moulding tool design

Unit Descriptor

This unit describes the skills and knowledge required to make optimal decisions regarding the tool design requirements for a plastics blow moulding tool.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of blow moulding tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 principles and procedures for plastics product design project	1.1 Principles of operation of a range of ***blow moulding tools*** are researched and delineated
	1.2 Different applications and requirements of a range of ***blow moulding tool components and sub systems*** are researched and clarified
2 Analyse the interrelationship between blow moulding machine operating systems and tool design	2.1 ***Design features and functions*** of various types *of* ***blow moulding machines*** are analysed for effect on tool design
	2.2 ***Main features of the blow moulding process*** are analysed for effect on tool design
	2.3 Importance of ***matching mould design and attachment features to machine operating systems*** is researched and evaluated
	2.4 ***Calculation of design requirements*** of a blow moulding tool is conducted

3	Select materials and tool construction methods to achieve production requirements and processing specifications	3.1 Effect of mould design and production requirements is appraised in determining selection of the ***metal materials*** and ***finishing treatments***, according to their particular ***properties***, used in mould construction
		3.2 Effect of mould design and production requirements is appraised in determining selection of ***mould component construction methods***
		3.3 Effect of mould design, production requirements and ***environmental costs*** is appraised in determining selection of raw materials
4	Analyse and evaluate product design to determine tool design requirements	4.1 ***Product design specifications*** are evaluated to determine ***blow moulding tool design requirements*** and to select raw materials
		4.2 Optimal materials for mould construction to meet design and ***production requirements*** are selected
		4.3 Tool design concept proposals are developed and ***critically evaluated*** to achieve specified product outcomes
5	Implement and evaluate blow moulding tool design project	5.1 ***Project management methodologies*** and ***communication strategies*** are applied to implementation
		5.2 ***Tool design faults*** and their causes are analysed and ***prevention strategies*** established and implemented
		5.3 Project is reviewed against specified outcomes and findings used to inform improved processes, procedures and planning in consultation with ***relevant people***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer- aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess product and tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics blow moulding tool design
- design features and functions of plastics blow moulding machine operating systems
- blow moulding construction methods and finishing treatments
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- causes and elimination strategies of common product faults
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Blow moulding tools may include**:**

- two-plate mould tools
- Dome Systems
- multiple heads
- solid neck and flexible neck
- handle wear
- uni neck parison
- moving cores
- co-extruded dies
- three dimensional blow moulding
- new technologies

Mould tool components and sub systems may include:

- cavity design
  - neck ring
- flash pocket
- part removal system
- temperature control system
- standard part components
- actuating mechanism
- inserts and cores
- pinch off sections
- clamping systems
- in-mould functions
- mandrel and die bushing, such as:
  - mandrel
  - choke
  - parison control
  - accumulator
  - spider support arms
  - land length and angle
  - pressure ring
  - hydraulic ram

Design features and functions may include:

- machine components and construction features, such as:
  - multiple heads
  - trimming
  - parison programming
  - in-mould labelling
  - rotary moulds
  - shuttle moulds
  - parison cutting
  - tie bars
- machine control systems, such as:
  - open loop system
  - closed loop system
  - shot size and correction capacity
  - extrusion speed
  - screw position
  - blow pressure
  - clamp pressure
  - blow time, exhaust time, cycle time, pre-blow time
  - screw speed
  - screw back pressure
  - screw back time
  - annular gap
  - temperatures
  - parison programming
  - chokes

Blow moulding machines may include:

- continuous blow moulding machine
- intermittent blow moulding machine
- reciprocal blow moulding machine
- injection stretch blow moulding machine
- injection blow moulding machine

Main features of blow moulding process and their effect on tool design may include:

- extrusion:
  - importance of time, pressure and temperature on melt flow
  - screw/barrel designs
  - tool design features, such as:
    - mandrel and die bushing profiles

- die bushing ovalisation
- die shaping
- land length
- pressure drop

- the relationship between annular gap and part weight
- blow mould die, such as:
  - venting
  - fixture to platens
- chilling and tool temperature, such as:
  - effect on moulded product
  - effect on machine cycle time
  - methods adopted
- part removal, such as:
  - robots
  - take out units
  - post moulding shrinkage (annealing)

Matching mould design and attachment features to machine operating systems may include

- types and role of platens, such as:
  - stationary
  - moveable
- methods of fixing moulds to platens, such as:
  - bolting
  - clamps
  - slides
  - dogs
- purpose and operation of features, such as:
  - single station
  - shuttle
  - rotary systems
- hydraulic pressure features
- use of single and multi-head systems
- clamp force calculations, such as:
  - attachment to platens
  - clamp tonnage in relation to mould size for safe machine operation
  - requirements for mould closure during blow
  - air pressure requirements

Calculation of design requirements may include:	• die swell • parison control • accumulator control • mould deformation under pressure and safe work limits • capacity air pressure • pinch-off compression strength • thermal conductivity (mould cooling) requirements • wall thickness / part weight • mandrel / die bushing
Metal materials may include:	• low carbon steel • tool steel • surface hardened steel • stainless steel • aluminium • steel • kirksite • copper • brass • beryllium copper

Finishing treatments *may include:*	• polishing
	• texturing
	• heat treatment processes, such as:
	  ○ normalising
	  ○ annealing
	  ○ quench hardening
	  ○ carburising
	  ○ nitriding
	  ○ tempering
	  ○ stress relieving
	• plating and coating techniques
	• etching
	• graining

Properties may include:	• tensile strength • thermal conductivity • cost • hardness • surface finish

Mould component construction methods may include:	• Numerical Control (NC) machining • Computer Numerical Control (CNC) machining • Electronic Discharge Machining (EDM) – commonly called spark erosion • masking tools • jigs and fixtures • wire cutting • zinc alloy casting (kirksite) • tool hardening / heat treatment
Environmental costs may include:	• recyclability • waste minimisation • waste disposal • energy consumption used in processing • carbon abatement
Product design specifications may include:	• samples • drawings • specifications • customer requirements • moulding shop specifications • environmental issues
Blow moulding tool design requirements may include:	• die swell • parison control • capacity air pressure • radii / chamfer determination • pinch off compression strength • shrinkage • mould cooling • wall thickness / part weight • mould to machine compatibility • finishing for application • shrinkage • stakeholder requirements • sustainability issues • raw materials and their possible limitations • Failure Mode and Effects Analysis (FMEA)

Production requirements may refer to:	• production capacity • production run specifications • production method • end-use applications
Critically evaluated may refer to considerations of:	• functionality and fitness for end-use • manufacturability • cost of production • environmental costs and impact of production • minimising product design complexity • utilisation of strategies to eliminate or minimise faults
Project management methodologies may refer to:	• description / definition / rationale • outcomes and goal setting • strategic planning • resource requirements and allocation • budget • targets and milestones • completion phases and timelines • quality management policies and procedures • personnel • responsibilities • accountabilities • agreed reporting procedures • communication strategies • stakeholder engagement strategies, including critical consultation points • monitoring and evaluation

Communication strategies may refer to:	• team leadership
	• consultative management
	• participative management
	• project evaluation
	• stakeholders engagement
	• critical consultation points, such as:
	  ○ feedback to client on initial design brief as early as possible
	  ○ consultation with all stakeholders to verify design
	  ○ consultation with all stakeholders when establishing project

timeline

- consultation with client to confirm decisions regarding:
  - design
  - materials
  - process
  - equipment
- briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Tool design faults may include:

- poor tool design
- selection of inappropriate materials
- technical faults within production and processes, such as:
  - mandrel and die bushing:
    - tail length
    - die lines
    - stagnation points
    - part weight
    - curtaining
    - melt fracture
    - diameter swell
    - parison swinging
    - neck section
    - wall thickness
    - sticking parison
    - parison cooling
    - curtaining / webbing
    - mould cooling
    - tooling ovalisation
    - melt fracture
  - mould:
    - weld strength
    - part position on opening
    - venting
    - radius/radii/chamfer
    - pinch off
    - thin sections in wall
    - trimming
    - parts sticking
    - mould misalignment
    - neck damage
    - weak corners
    - shear rates

(Fault) ***Prevention strategies*** may include:	• careful initial evaluation of product requirements / specifications
	• thorough analysis of the design constraints of different processes, materials and tools
	• thorough and ongoing consultation with client / suppliers / other team members and stakeholders
	• effective project management
	• quality assurance procedures, including:
	  ○ design checklist
	  ○ production checklist
	  ○ failure minimisation
	  ○ zero defects methodology
	  ○ process control

Relevant people may include:	• management • colleagues • clients • customers • suppliers • stakeholders • technical experts • industry professionals • planners • advisors • consultants • regulators

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

A person who demonstrates competency in this unit must provide evidence of:

- implementing blow moulding tool design project for a plastics product design concept
- determining prevention strategies for tool design faults
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of blow moulding tool design including: capabilities of blow moulding machine operating systems and requisite materials and tool construction methods

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated blow moulding tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of project in blow moulding tool design that meets specified outcomes of a product design concept
- evaluation of research project into fundamentals of blow moulding tool design across a range of contexts
- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)	Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to: o *VU21979: Manage plastics blow mould tool design application* o *VU21980: Implement blow moulding tool design for plastics products design details* o *VU21981: Implement advanced blow moulding tool design*

VU21979 Manage plastics blow moulding tool design application

Unit Descriptor

This unit describes the skills and knowledge required to develop and implement mandrel and die bushing tool designs to achieve plastics product specifications across a range of contexts.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of blow moulding tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Apply the principles of die bushing and mandrel design to blow moulding tool design	1.1 ***Methods of translating product dimensions and specifications*** into die bushing and mandrel designs are researched and delineated
	1.2 ***Principles of mandrel and die bushing tool design*** are analysed for their different applications
	1.3 Melt flow considerations are analysed using ***simulation software***
2 Research optimum die bushing and mandrel design	2.1 Differing requirements of various ***die bushing and mandrel design types*** in relation to polymer materials are researched and delineated
	2.2 ***Principles and practice of good design*** for die bushing and mandrel tool design are researched and debated
	2.3 ***Range of data*** required to accurately design a mandrel and die bushing tool is calculated and documented

3	Determine requirements for die bushing and mandrel blow	3.1	Product end-use requirements are analysed and appropriate material and machine process determined
		3.2	Methods to best meet ***production and design requirements*** are canvassed and selected
		3.3	Product specifications are analysed for possible ***faults***, their causes analysed and ***prevention strategies*** established
		3.4	***Project management methodologies*** and ***communication strategies*** are determined
		3.5	Die bushing and mandrel ***tool design*** to extrude a uniform parison is developed and ***critically evaluated*** against ***tool design requirements***
4	Evaluate design project	4.1	Project is implemented and reviewed against specified outcomes
		4.2	Findings are used to inform improved processes, procedures and planning in consultation with ***relevant people***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer-aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics blow moulding tool design
- design features and functions of plastics blow moulding machine operating systems
- principles of mandrel and die bushing design
- methods for translating product dimensions and specifications into die bushing and mandrel designs
- various die bushing and mandrel design types and their differing requirements in relation to polymer materials
- principles and practice of design for die bushing and mandrel tool design
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Methods of translating product dimensions and specifications, may include**:**	• product drawings
	• product material and machine specifications
	• product models for which drawings can be produced
	• product models for which drawings are too difficult to produce, such as:
	  o carving
	  o Sculpture
	• CAD data
	• CAD model
	• prototype with some working measurements

Principles of mandrel and die bushing design may include	• thin wall sections • radii / chamfers • no stagnation points in flow channels • progressive increase in velocity along the flow channel • simple approach angles • multi-layer • thickness swell ratio • blow up ratio • parison thickness determination • final wall thickness determination
Simulation software may include:	• Computational Fluid Dynamics (CFD) system • CFD Flow Software • Discrete element modelling (DEM)
Die bushing and mandrel design types may include**:**	• convergent / divergent systems • tooling ovalisation • angles to flow path
Principles and practice of good design may include:	• use of generous internal / external radii on all corners • maintenance of uniform wall thickness • internal walls thinner than external walls for cooling wherever possible • die swell considerations • parison length / parison sag

- parison uniformity
- flow characteristics
- back pressure
- blow ratio
- thickness swell consideration

Range of data may refer to:

- polymer flow in the die, such as:
  - polymer viscoelastic behaviour of the polymer melt
  - shear thinning
  - steady state, isothermic flow
  - viscoelastic properties
  - shear rate
  - flow in the annulus
  - Newtonian and non-Newtonian (power law) fluids
  - use of representative data
- viscosity and temperature distribution in extrusion dies, such as:
  - continuity equation
  - flow channels with variable heights
  - pressure drop

Production and design requirements problems may refer to:

- large volume moulding
- mechanical and thermal properties of the material
- part to production requirements
- machine types
- production capacity

Faults may refer to:

- stagnation points
- restricted and uneven flow paths
- damaged surfaces
- weld lines associated with split flow paths
- performance or physical properties of product
- surface quality and treatment
- thermal control and monitoring

(Fault) ***Prevention strategies*** may include:

- careful initial evaluation of product requirements / specifications
- thorough analysis of the design constraints of different processes, materials and tools
- thorough and ongoing consultation with client / suppliers / other team members and stakeholders
- effective project management
- quality assurance procedures, including:
  - design checklist
  - production checklist
  - failure minimisation
  - zero defects methodology
  - process control

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management
- project evaluation
- stakeholders engagement
- critical consultation points, such as:
  - feedback to client on initial design brief as early as possible
  - consultation with all stakeholders to verify design
  - consultation with all stakeholders when establishing project timeline

- consultation with client to confirm decisions regarding:
  - design
  - materials
  - process
  - equipment
- briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Tool design may address considerations such as:

- circular parison
- incorporation of handles
- continuous or intermittent extrusion
- litre capacity
- weight
- targeted cycle time

Critically evaluated may refer to considerations of:

- functionality and fitness for end-use
- manufacturability
- cost of production
- environmental costs and impact of production
- minimising product design complexity
- utilisation of strategies to eliminate or minimise faults

Tool design requirements may refer to:

- detailed drawings of tool assembly
- necessary dimensions and labels
- necessary component drawings, such as:
  - manual drafting techniques
  - Computer Aided Design (CAD)
- necessary calculations
- tool specifications to achieve the product requirements
  - material
  - equipment
  - finish
  - construction
- tool quotation form and design process cost estimate
- project timeline
- description of operation
- analysis of material melt flow
- required parts list
- completed tool design check list
- customer requirements

- environmental costs
- raw materials and their possible limitations
- Failure Mode and Effects Analysis (FMEA)

Relevant people may include:

- management
- colleagues
- clients
- customers
- suppliers
- stakeholders
- technical experts
- industry professionals
- planners
- advisors
- consultants
- regulators

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

A person who demonstrates competency in this unit must provide evidence of:

- managing blow moulding tool design project that addresses principles of die bushing and mandrel tooling
- determining prevention strategies for tool design faults
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of blow moulding tool design to meets plastics product design requirements

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated blow moulding tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of project in blow moulding tool design application that includes die bushing and mandrel principles
- evaluation of research project into what constitutes good tool design in blow moulding applications
- review of portfolio of research into principles and processes of blow moulding tool design
- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)	Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to: o *VU21978: Implement plastics blow moulding tool design* o *VU21980: Implement blow moulding tool design for plastics products design details* o *VU21981: Implement advanced blow moulding tool design*

VU21980 Implement blow moulding tool design for plastics product design details

Unit Descriptor

This unit describes the skills and knowledge required to develop and implement blow moulding tools designs that address requirements of plastics product design details, such as: thin wall sections; threaded sections, and handle ware.

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

Employability Skills

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of blow moulding tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Apply the principles for incorporating thin wall sections into blow moulding tool design	1.1 ***Applications and methods for incorporating thin wall sections*** into blow moulding tool design are researched and delineated
	1.2 ***Range of data*** required to meet given product specifications is calculated
	1.3 Blow moulding tool design sketches that incorporate thin wall sections are developed in consultation with ***relevant people***
2 Apply the principles for incorporating threaded sections into blow moulding tool design	2.1 ***Applications and methods for incorporating threaded sections*** into moulding tool design are researched and delineated
	2.2 Range of data required to meet given product specifications is calculated
	2.3 Blow moulding tool design sketches that incorporate thin wall sections are developed in consultation with relevant people

3	Apply the principles for incorporating handle ware into blow moulding tool design.	3.1 ***Applications and methods for incorporating handle ware*** into moulding tool design are researched and delineated
		3.2 Range of data required to meet given product specifications is calculated
		3.3 Blow moulding tool design sketches that incorporate thin wall sections are developed in consultation with relevant people
4	Implement and evaluate blow moulding tool design project for plastic products with design details	4.1 ***Tool design requirements*** for blow moulding tools that meet product design details are determined and documented
		4.2 ***Project management methodologies*** and ***communication strategies*** are applied to implementation
		4.3 ***Blow moulding tool design*** concepts and sketches are developed and ***critically evaluated*** to achieve specified product outcomes

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer-aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics blow moulding tool design
- design features and functions of plastics blow moulding machine operating systems
- principles and processes for incorporating thin wall sections, threaded sections, and handle ware into blow mould tool design
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- project management tools and methodologies
- risk management strategies
- quality procedures
- criteria for critically evaluating tool design solutions
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Applications and methods for incorporating thin wall sections may include:

- use of appropriate internal/external radii/chamfers on all corners
- ensuring appropriate wall thickness profile for end-use application
- appropriate pinch-off design
- impact of polymer flow characteristics
- potential problems with flow characteristics
- blow ratio
- material application
- ribbings

Range of data may refer to:

- temperature distribution
- flow channels
- air capacity
- volume capacity
- shrinkage
- blow ratio
- maximum stress of inflated parison
- wall thickness of product
- pinch-off clamp force
- flash pocket depth
- die swell

Relevant people may include:

- management
- colleagues
- clients
- customers
- suppliers
- stakeholders
- technical experts
- industry professionals
- planners
- advisors
- consultants
- regulators

Applications and methods for incorporating threaded sections may include:	• pull-up pre-finish
	• interface with injection moulded closures
	• necks of blow moulded parts
	• calibrated neck finishes
	• inserts, such as:
	  o in-mould labelling
	  o heat transfer between aluminium mould and other metal inserts

Applications and methods for incorporating handle ware may include:	• use of appropriate internal/external radii/chamfers on all corners • ensuring appropriate wall thickness profile for end-use application • appropriate pinch-off design • part removal • impact of polymer flow characteristics • potential problems with flow characteristics

Tool design requirements may include:	• detailed drawings of tool assembly
	• necessary dimensions and labels
	• necessary component drawings, such as:
	  o manual drafting techniques
	  o computer aided design (CAD)
	• necessary calculations
	• finishing for application
	• shrinkage
	• tool specifications to achieve the product requirements, such as:
	  o material
	  o equipment
	  o finish
	  o construction
	  o product / part design details, such as:
	  – thin wall sections
	  – threaded sections
	  – handle ware
	• tool quotation form and design process cost estimate
	• project timeline
	• description of operation
	• analysis of material melt flow
	• required parts list
	• completed tool design check list
	• stakeholder requirements
	• sustainability issues

- risk management, including:
  - limitations of raw materials
  - Failure Mode and Effects Analysis (FMEA)

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management
- project evaluation
- stakeholders engagement
- critical consultation points, such as:
  - feedback to client on initial design brief as early as possible
  - consultation with all stakeholders to verify design
  - consultation with all stakeholders when establishing project timeline
  - consultation with client to confirm decisions regarding:
    - design
    - materials
    - process
    - equipment
  - briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Blow moulding tool design may address considerations of:	• shape
	• incorporation of:
	  o handle
	  o threaded section
	  o snap-on capable section
	  o thin wall section
	• litre capacity
	• single layer extrusion
	• minimum / maximum weight

Critically evaluated may include consideration of:	• functionality and fitness for end-use • manufacturability • cost of production, including environmental costs • minimising mould design complexity • utilisation of strategies to eliminate or minimise faults

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

A person who demonstrates competency in this unit must provide evidence of:

- implementing blow moulding tool design project that addresses plastics product requirements across a range of particular design details including: thin wall sections; threaded sections, and handle ware
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of blow moulding tool design that meet plastics product design requirements

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated blow moulding tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

- A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:
- evaluation of project in applying principles for incorporating thin wall sections, threaded sections and/or handle ware into blow moulding tool design
- evaluation of calculations made in meeting tool design requirements
- evaluation of research project into current principles and processes of blow moulding tool design for plastic product with specific design details
- review of presentation of design project outcomes

- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

- *VU21978: Implement plastics blow moulding tool design*
- *VU21979: Manage plastics blow mould tool design application*
- *VU21981: Implement advanced blow moulding tool design*

VU21981 Implement advanced blow moulding tool design

Unit Descriptor

This unit describes the skills and knowledge required to develop and implement designs for advanced blow moulding tools that address requirements of complex plastics product design details to achieve product intent and specifications.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of managers, leaders and project personnel who are responsible for development of blow moulding tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Apply the principles for incorporating advanced details into blow mould tool design	1.1 **Considerations** for incorporating **advanced details** into blow mould tool design are researched and delineated.
	1.2 Range of ***blow moulding processes*** for incorporating advanced details are compared and analysed for their different applications
	1.3 ***Range of data*** required to meet given product specifications in advance blow mould tool designs is calculated
2 Optimise advanced tool design for a given product specification	2.1 Impact of flow characteristics of different polymers on tool design for advanced details is analysed and documented
	2.2 Impact of melt flow on optimising tool design and material selection is analysed and debated
	2.3 Blow moulding tool design sketches for advanced details are developed in consultation with ***relevant people***

3	Implement and evaluate blow moulding tool design project for plastic products with advanced design details	3.1 ***Product requirements*** are determined and ***tool design*** and ***production requirements*** formulated
		3.2 Product specifications are analysed for possible faults, their causes analysed and ***prevention strategies*** established
		3.3 ***Project management methodologies*** and ***communication strategies*** are applied to implementation
		3.4 Blow moulding tool design concepts and sketches are developed and ***critically evaluated*** to achieve specified product outcomes
		3.5 Project is reviewed against specified outcomes and findings used to inform improved processes, procedures and planning in consultation with relevant people

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer- aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics blow moulding tool design
- range of advanced blow mould features
- principles and processes for incorporating advanced features into blow mould tool design
- design features and functions of plastics blow moulding machine operating systems
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Principles, for incorporating advanced design details, may include:

- moving core sections
- multiple parting lines
- moving sections
- dual wall
- structural shapes
- blow pin construction
- striker plates
- die bushing and mandrel
- square, rectangular or oval shaped part
- one or more handles incorporated into part
- threaded section or snap-on section
- no limit on volume capacity
- multi-layer extrusion
- view stripe incorporated into body of moulded article
- anti-glug neck
- double wall blow moulded products
- plastics product, such as:
    - petrol tanks
    - compartment separators
    - cooler boxes
- high-density polyethylene (HDPE) drums

Blow moulding processes may include:

- multi-layer extrusion
- injection blow moulding
- parison programming
- view stripe co-extrusion
- reciprocal blow moulding
- intermittent blow moulding
- continuous blow moulding
- injection stretch blow mould machine
- sequential blow moulding – multi-material

Range of data may include:	• temperature distribution • flow channels (cooling) • air capacity • clamp pressure • volume capacity • shrinkage • blow ratio • maximum stress of inflated parison • wall thickness of product • pinch off clamp force • flash pocket depth • die swell
Relevant people may include:	• management • colleagues • clients • customers • suppliers • stakeholders • technical experts • industry professionals • planners • advisors • consultants • regulators
Product requirements may refer to:	• product end-use • product intent • product with advanced details • materials selection • process selection

Tool design requirements may include:	• detailed drawings of tool assembly
	• necessary dimensions and labels
	• necessary component drawings, such as:
	  ○ manual drafting techniques
	  ○ computer aided design (CAD)
	• necessary calculations

- finishing for application
- shrinkage
- tool specifications to achieve the product requirements, such as:
  - material
  - equipment
  - finish
  - construction
  - product design details
- tool quotation form and design process cost estimate
- project timeline
- description of operation
- analysis of material melt flow
- required parts list
- completed tool design checklist
- stakeholder requirements
- sustainability issues
- risk management, including:
  - limitations of raw materials
  - Failure Mode and Effects Analysis (FMEA)

Production requirements may include:

- production capacity
- material
- machine process
- large volume moulding
- mechanical and thermal properties of the material
- part to production requirements
- machine types

(Fault) ***Prevention strategies*** may include:

- careful initial evaluation of product requirements / specifications
- thorough analysis of the design constraints of different processes, materials and tools
- thorough and ongoing consultation with client / suppliers / other team members and stakeholders
- effective project management
- quality assurance procedures, including:
  - design checklist
  - production checklist
  - failure minimisation
  - zero defects methodology
  - process control

Project management methodologies may refer to:	• description / definition / rationale • outcomes and goal setting • strategic planning • resource requirements and allocation • budget • targets and milestones • completion phases and timelines • quality management policies and procedures • personnel • responsibilities • accountabilities • agreed reporting procedures • communication strategies • stakeholder engagement strategies, including critical consultation points • monitoring and evaluation

Communication strategies may refer to:	• team leadership
	• consultative management
	• participative management
	• project evaluation
	• stakeholders engagement
	• critical consultation points, such as:
	  ○ feedback to client on initial design brief as early as possible
	  ○ consultation with all stakeholders to verify design
	  ○ consultation with all stakeholders when establishing project timeline
	  ○ consultation with client to confirm decisions regarding:
	  – design
	  – materials
	  – process
	  – equipment
	  ○ briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Critically evaluated may include consideration of:	• functionality and fitness for end-use • manufacturability • cost of production, including environmental costs • minimising mould design complexity • utilisation of strategies to eliminate or minimise faults

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

A person who demonstrates competency in this unit must provide evidence of:

- implementing blow moulding tool design project that addresses plastics product requirements across a range of advanced design details
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of blow moulding tool design that meet plastics product design requirements

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated blow moulding tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of project in applying principles for incorporating advanced design details into blow moulding tool design
- evaluation of research project into current principles and processes of blow moulding tool for plastic product with advanced design details
- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

- *VU21978: Implement plastics blow moulding tool design*
- *VU21979: Manage plastics blow mould tool design application*
- *VU21980: Implement blow moulding tool design for plastics products design details*

VU21982 Implement plastics extrusion tool design

Unit Descriptor

This unit describes the skills and knowledge required to make optimal decisions regarding tool design requirements for plastics extrusion tooling.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of plastics extrusion tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Research extrusion tooling	1.1 ***Principles of operation*** of a range of commonly used ***extrusion tooling*** are researched and delineated
	1.2 Different applications and requirements of a range of ***extrusion tooling components*** are researched and clarified
2 Analyse the interrelationship between extrusion operating systems and tool design	2.1 Design features and functions of ***extrusion machine control systems*** are analysed for effect on tool design
	2.2 Range of ***extrusion measuring instruments*** and ***extrusion service systems*** are analysed for role in optimising extrusion tool design and function
	2.3 ***Machine factors*** are analysed for affect or limitation on extrusion tool design
3 Select materials and tool construction methods to achieve production requirements and processing	3.1 Properties of ***metal materials*** and their ***finishing treatments*** are analysed for effect on extrusion tool design and construction

		3.2	Effect of extrusion tool design and production requirements is appraised in determining selection of ***die construction methods***
		3.3	Impact, on tool design, of ***material preparation*** and ***material melt behaviour*** in the extrusion process is researched, evaluated and debated
		3.4	Effect of extrusion tool design, production requirements and ***environmental costs*** is appraised in determining selection of raw materials
4	Analyse and evaluate product design to determine tool design requirements	4.1	***Product design specifications*** are evaluated to determine ***extrusion tooling design requirements***
		4.2	***Range of calculations*** required to design an extrusion tool are completed and documented
		4.3	Tool design concept proposals are developed and ***critically evaluated*** to achieve specified product outcomes
5	Implement and evaluate injection extrusion tooling design project	5.1	***Project management methodologies*** and ***communication strategies*** are applied to implementation
		5.2	***Tool design faults*** and their causes are analysed and ***prevention strategies*** established and implemented
		5.3	Project is reviewed against specified outcomes and findings used to inform improved processes, procedures and planning in consultation with ***relevant people***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer- aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics extrusion tool design
- functions and operating principles of different types of extrusion dies and their component parts, including operating cycles of dies, properties of metal materials, construction methods and finishing treatments
- design features and functions of plastics extrusion machine operating systems
- implications of product design for tool design
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- factors that affect decisions in the design process
- project management tools and methodologies
- risk management strategies
- quality procedures
- causes of, and elimination strategies for, common product and design faults
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Principles of operation may refer to:

- types and function of extruder and extrusion line
- characteristics and capacity
- machine components and construction features
- importance of time, pressure and temperature on melt flow
- Volumetric Flow Rate (VFR)
- downstream equipment
- temperature rise in die
- rheological models for polymer melt flow
- isothermal flow in channels; Newtonian and non-Newtonian
- heat transfer during polymer processing
- screen packs
- filters
- die adjustment
- temperature prior to extrusion
- pressure versus drag

Extrusion tooling may refer to:

- mono layer extrusion
- multi-layer extrusion
- sheet
- blown film
- cable
- pipe and tube
- profile

Extrusion tooling components may refer to:

- product:
  - surface finish
  - texture
  - laminates
  - weld line
  - wall thickness
  - dimensional stability
  - extrudes / die characteristics
- production:
  - online operations
  - calibration equipment

- vacuum sizing
- forming devices
- internal pressures

Extrusion machine control systems may refer to:

- basic controls
- open loop system
- extrusion speed (line speed)
- screw speed
- screw design versus material
- back, head, die pressure

Extrusion measuring instruments may include:

- ammeters
- temperatures sensing devices
- thermocouples and pyrometers
- pressure transducers
- pressure gauges
- vacuum gauges
- vacuum tanks
- flow meters
- tachometers
- gravimetric material hoppers
- dimensional monitoring and control
- X-ray measuring devices
- thermal imaging devices

Extrusion service systems may refer to:

- water (chilled and ambient)
- electrical
- hydraulic
- compressed air
- heating and cooling (internal and external)
- material handling systems

Machine factors may refer to:

- processability, such as:
  - Length per Diameter (LD) ratio of screws
- size of extruder screws
- weight
- maximum production output capacity

Metal materials may include:	• low carbon steel • surface hardened steel (nitride hardening) • stainless steel • tool steel • aluminium • kirksite • copper • brass • beryllium copper • interpretation of mould steel data sheets and property tables

Finishing treatments may include	• polishing
	• texturing
	• heat treatment processes, such as:
	  o normalising
	  o annealing
	  o quench hardening
	  o carburising
	  o nitriding
	  o tempering
	  o stress relieving
	• plating and coating techniques
	• etching
	• graining
	• photo-etching
	• spark eroding

Die construction methods may refer to:	• Numerical Control (NC) machining • Computer Numerical Control (CNC) machining • Electronic Discharge Machining (EDM) – commonly called spark erosion • wire cutting • casting • zinc alloy casting (kirksite) • tool hardening / heat treatment
Material preparation may refer to:	• drying • colouring agents • additives and fillers

- pre-heating
- blending
- high speed mixing
- vacuuming volatiles

Material melt behaviour may refer to:

- shrinkage
- impact of die swell and temperature
- extrude quality
- melt temperature ranges

Environmental costs may include:

- recyclability
- waste management
- waste minimisation
- waste disposal
- resource management
- energy consumption used in processing, such as:
  - services required for production, such as:
    - cooling supply
    - power supply
    - heating supply
- carbon abatement

Range of calculations may include:

- melt density
- shear viscosity
- shear modulus
- tensile viscosity
- tensile modulus
- isothermal flow in channels; Newtonian and non-Newtonian fluids

Product design specifications may include:

- samples
- drawings
- specifications
- customer requirements
- moulding shop specifications
- environmental issues

Extrusion tooling design requirements may include:

- detailed drawings of tool assembly
- necessary dimensions and labels
- necessary component drawings, such as:
  - manual drafting techniques
  - computer aided design (CAD)
- necessary calculations
- finishing for application
- shrinkage
- tool specifications to achieve the product requirements, such as:
  - material
  - equipment
  - finish
  - construction
  - product design details
- tool quotation form and design process cost estimate
- project timeline
- description of operation
- analysis of material melt flow
- required parts list
- completed tool design check list
- stakeholder requirements
- sustainability issues
- risk management, including:
  - limitations of raw materials
  - Failure Mode and Effects Analysis (FMEA)

Critically evaluated may refer to considerations of:

- functionality and fitness for end-use
- testing, such as:
  - bursting
  - impact
  - 21 ° and zero
  - hydrostatic; 21 degree to boiling
  - static and dynamic
  - softening point
  - melt flow index
  - X-ray and/or infrared

- manufacturability
- cost of production
- environmental costs and impact of production
- minimising product design complexity
- utilisation of strategies to eliminate or minimise faults

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management
- project evaluation
- stakeholders engagement
- critical consultation points, such as:
  - feedback to client on initial design brief as early as possible
  - consultation with all stakeholders to verify design
  - consultation with all stakeholders when establishing project timeline
  - consultation with client to confirm decisions regarding:
    - design
    - materials
    - process
    - equipment
  - briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Tool design faults may refer to:	• ovality • product weight • pigment dispersion • die lines • weld strength • burn marks • radii • swell • trimming • poor flow • melt fracture • draw down ratio • surface finish • reversion • material degradation • dimension control • thickness variability • methylene dichloride (MDC) attack

Fault) ***Prevention strategies*** may include:	• careful initial evaluation of product requirements / specifications
	• thorough analysis of the design constraints of different processes, materials and tools
	• thorough and ongoing consultation with client / suppliers / other team members and stakeholders
	• effective project management
	• quality assurance procedures, including:
	  o design checklist
	  o production checklist
	  o failure minimisation
	  o zero defects methodology
	  o process control

Relevant people may include:	• management • colleagues • clients • customers • suppliers • stakeholders • technical experts • industry professionals • planners • advisors • consultants • regulators

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

A person who demonstrates competency in this unit must provide evidence of:

- implementing extrusion tool design project for a plastics product design concept
- determining prevention strategies for tool design faults
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of extrusion tool design including: capabilities of extrusion machine operating systems and requisite materials and tool construction methods

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context
- resources implications for assessment include:
- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated extrusion tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

- A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:
- evaluation of project in extrusion tool design that meets specified outcomes of a product design concept
- evaluation of research project into fundamentals of extrusion tool design across a range of contexts
- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)

- Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:
  - VU21983: Manage extrusion sheet and blown film tool design
  - VU21984: Manage extrusion pipe, tube and cable tool design
  - VU21985: Manage extrusion profile tool design

VU21983 Manage extrusion sheet and film tool design

Unit Descriptor

This unit describes the skills and knowledge required to develop and implement sheet and film extrusion tool designs to achieve plastics product specifications across a range of contexts.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of plastics extrusion tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Apply the principles of extruded sheet design to tool design	1.1 ***Methods of translating product dimensions and specifications*** into extruded sheet tool designs are researched and delineated
	1.2 ***Principles and main elements of extrusion sheet tool design*** are analysed for their different applications
	1.3 Appropriate material and machine process are selected based on analysis of ***relevant factors***
2 Apply the principles of blown film tool design	2.1 Methods of translating product dimensions and specifications into blown film tool design are researched and delineated
	2.2 ***Principles and main elements of blown film tool design*** are analysed for their different applications
	2.3 Appropriate material and machine process are selected based on analysis of relevant factors
3 Determine requirements for sheet extrusion and/or blown film tool design project	3.1 Methods to best meet ***production and design requirements*** are canvassed and selected

	3.2	Possible ***faults*** in sheet extrusion and blown film applications, their causes are analysed and ***prevention strategies*** established
	3.3	***Project management methodologies*** and ***communication strategies*** are determined
	3.4	Sheet extrusion and blown film tool designs are developed and ***critically evaluated*** against ***tool design requirements***
	3.5	***Material flow and temperature control*** for sheet extrusion and blown film tool designs are calculated
4 Evaluate design project	4.1	Project is implemented and reviewed against specified outcomes
	4.2	Findings are used to inform improved processes, procedures and planning in consultation with ***relevant people***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer- aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics extrusion tool design including extruded sheet and blown film tool design
- design features and functions of plastics extrusion machine operating systems
- methods for translating product dimensions and specifications into designs for extruded sheet and blown film tools
- operating principles of plastics processing methods, including strategies to optimise extrusion and cooling conditions in extruded sheet and blown film die design
- implications of product design for tool design
- behaviour and applications of polymer materials
- factors that affect decisions in the design process
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Methods of translating product dimensions and specifications may include:

- product drawings
- product material and machine specifications
- product models for which drawings can be produced
- product models for which drawings are too difficult to produce, such as:
  - carving
  - sculpture
- using Computer Aided Drafting (CAD) data
- Computational Fluid Dynamics (CFD) data
- Computer Aided Engineering (CAE)data
- using CAD/ CFD/CAE models
- using a prototype with some working measurements

Principles and main elements of extruded sheet tool design may include*:*

- temperature control
- measuring instruments and their functions
- service systems
- finishing treatments
- tool and calibration temperature control
- roller temperature
- roller pincher
- haul-off equipment
- end product sizing equipment

Relevant factors may include:

- product end-use
- aesthetic requirements
- processing specifications, such as:
  - volume of run
- environmental costs, such as:
  - resource management
  - waste management
  - recycling
  - energy consumption
  - carbon abatement

Principles and main elements of blown film tool design may include:

- types of blown film dies, such as:
  - co-extrusion
  - adaptor type
  - side-fed

- bottom-fed
- air-ring design
- internal cooling pressure control
- internal cooling temperature control
- nip-roller control

Production and design requirements may include:

- large volume
- mechanical and thermal properties of the material
- part to production requirements
- machine types
- cost constraints
- production capacity

Faults may include:

- extruded sheet faults, such as:
  - physical performance of product
  - stagnation spots
  - restricted and uneven flow paths
  - damaged surfaces
  - weld lines associated with split flow paths
  - surface quality and treatment
  - thermal control and monitoring
  - gauge thickness
- blown film faults, such as:
  - physical performance of product
  - stagnation spots
  - gauge thickness
  - bi-axial orientation
  - delamination
  - excessive haul-off
  - die-centring
  - bubble shape
  - bubble variation
  - internal air temperature
  - uneven frost lines
  - nip-roller pressure

(Fault) ***Prevention strategies*** may include:

- careful initial evaluation of product requirements / specifications
- thorough analysis of the design constraints of different processes, materials and tools
- thorough and ongoing consultation with client / suppliers / other team members and stakeholders
- effective project management

- quality assurance procedures, including:
  - design checklist
  - production checklist
  - failure minimisation
  - zero defects methodology
  - process control

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management
- project evaluation
- stakeholders engagement
- critical consultation points, such as:
  - feedback to client on initial design brief as early as possible
  - consultation with all stakeholders to verify design
  - consultation with all stakeholders when establishing project timeline
  - consultation with client to confirm decisions regarding:
    - design
    - materials
    - process
    - equipment
- briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Critically evaluated may refer to considerations of:	• functionality and fitness for end-use • manufacturability • cost of production • environmental costs and impact of production • minimising product design complexity • utilisation of strategies to eliminate or minimise faults

Tool design requirements may refer to:	• detailed drawings of tool assembly
	• necessary dimensions and labels
	• necessary component drawings, such as:
	  o manual drafting techniques
	  o Computer Aided Design (CAD)
	• necessary calculations
	• finishing for application
	• shrinkage
	• tool specifications to achieve the product requirements
	  o material
	  o equipment
	  o finish
	  o construction
	• tool quotation form and design process cost estimate
	• project timeline
	• description of operation
	• analysis of material melt flow
	• required parts list
	• completed tool design check list
	• customer requirements
	• environmental costs
	• raw materials and their possible limitations
	• Failure Mode and Effects Analysis (FMEA)

Material flow and temperature control may include:	• steady state / isothermic flow • flow in an annulus • Newtonian and non-Newtonian (power law) fluids • viscoelastic behaviour of the polymer melt • use of representative data • continuity equation

	• flow channels with variable height • regression equation • apparent viscosity
Relevant people may include:	• management • colleagues • clients • customers • suppliers • stakeholders • technical experts • industry professionals • planners • advisors • consultants • regulators

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

A person who demonstrates competency in this unit must provide evidence of:

- managing extrusion sheet and/or blown film tool design project
- determining prevention strategies for tool design faults
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of extrusion tool design to meet plastics product design requirements

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated extrusion tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of project in tool design solutions for a range of extruded sheet and blown film products
- evaluation of project in selection of appropriate materials for extruded sheet and blown film tooling
- evaluation of calculations necessary to optimise material flow and control temperature in extruded sheet and blown film tooling
- review of portfolio of research into principles and processes of extrusion sheet and blown film tool design
- practical exercises
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)	Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to: o *VU21982: Implement plastics extrusion tool design* o *VU21984: Manage extrusion pipe, tube and cable tool design* o *VU21985: Manage extrusion profile tool design*

VU21984 Manage extrusion pipe, tube and cable tool design

Unit Descriptor

This unit describes the skills and knowledge required to develop and implement extrusion pipe, tube and cable tool designs to achieve plastics product specifications across a range of contexts.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of plastics extrusion tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Apply the principles of extruded pipe and tube to tool design	1.1 ***Methods of translating product dimensions and specifications*** into extruded pipe and tube tool designs are researched and delineated
	1.2 ***Principles and main elements of extruded pipe and tube tool design*** are analysed for their different applications
	1.3 Appropriate material and machine process are selected based on analysis of ***relevant factors***
2 Apply the principles of extruded cable tool design	2.1 **Methods of translating product specifications** into extruded cable designs are researched and delineated
	2.2 ***Principles and main elements of extruded cable tool design*** are analysed for their different applications
	2.3 Appropriate material and machine process are selected based on analysis of relevant factors
3 Determine requirements for extruded pipe, tube and cable tool design project	3.1 Methods to best meet ***production and design requirements*** are canvassed and selected

	3.2	Possible ***faults*** in extruded pipe, tube and cable applications, their causes are analysed and ***prevention strategies*** established
	3.3	***Project management methodologies*** and ***communication strategies*** are determined
	3.4	Extruded pipe, tube and cable tool designs are developed and ***critically evaluated*** against tool design requirements.
	3.5	Material flow and temperature control for extruded pipe, tube and cable tool designs are calculated.
4 Evaluate design project	4.1	Project is implemented and reviewed against specified outcomes
	4.2	Findings are used to inform improved processes, procedures and planning in consultation with ***relevant people***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer- aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics extrusion tool design, including extruded pipe, tube and cable tool design
- design features and functions of plastics extrusion machine operating systems
- methods for translating product dimensions and specifications into designs for pipe, tube and cable extrusion tools
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- causes of, and elimination strategies for, faults in extruded pipe, tube and cable products
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Methods of translating product dimensions and specifications may include:

- product drawings
- product material and machine specifications
- product models for which drawings can be produced
- product models for which drawings are too difficult to produce, such as:
  - carving
  - sculpture
  - toy
- using Computer Aided Drafting (CAD) data
- Computational Fluid Dynamics (CFD) data
- Computer Aided Engineering (CAE)data
- using CAD/ CFD/CAE models
- using a prototype with some working measurements

Principles and main elements of pipe and tube design may include*:*

- temperature control
- measuring devices and their functions
- services
- finishing treatments
- wall thickness
- die swell and draw down
- back pressure
- hollow sections
- sharp radius / edge
- elimination of stagnation points in flow channels
- progressive increase in velocity along the flow channel
- simple approach angles
- mono layer or co-extrusion

Relevant factors may include:

- product end-use
- aesthetic requirements
- processing specifications, such as:
  - volume of run
- environmental costs, such as:

- recyclability
- waste management
- resource management
- energy consumption
- carbon abatement

Principles and main elements of cable tool design may include:

- multi-layer
- foaming
- temperature control
- measuring devices and their functions
- services
- finishing treatments
- wall thickness
- die swell and draw down
- back pressure
- sharp radius / edge
- elimination of stagnation points in flow channels
- progressive increase in velocity along the flow channel
- simple approach angles

Production and design requirements may include:

- large volume
- mechanical and thermal properties of the material
- part to production requirements
- machine types
- cost constraints
- production capacity

Faults may include:

- Common extruded pipe and tube faults, such as:
  - inadequate mechanical and physical performance of product
  - restricted and uneven flow paths
  - damaged surfaces
  - weld lines associated with split flow paths
  - surface quality and treatment
  - thermal control and monitoring
  - thermal degradation
  - thickness variation
- common extruded cable faults, such as:
  - inadequate mechanical and physical performance of product
  - restricted and uneven flow paths

- damaged surfaces
- weld lines associated with split flow paths
- surface quality and treatment
- thermal control and monitoring
- thermal degradation
- thickness variation

(Fault) ***Prevention strategies*** may include:

- careful initial evaluation of product requirements / specifications
- thorough analysis of the design constraints of different processes, materials and tools
- thorough and ongoing consultation with client / suppliers / other team members and stakeholders
- effective project management
- quality assurance procedures, including:
  - design checklist
  - production checklist
  - failure minimisation
  - zero defects methodology
  - process control

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management
- project evaluation
- stakeholders engagement
- critical consultation points, such as:

- feedback to client on initial design brief as early as possible
- consultation with all stakeholders to verify design
- consultation with all stakeholders when establishing project timeline
- consultation with client to confirm decisions regarding:
  - design
  - materials
  - process
  - equipment

- briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Critically evaluated may refer to considerations of:

- functionality and fitness for end-use
- manufacturability
- cost of production
- environmental costs and impact of production
- minimising product design complexity
- utilisation of strategies to eliminate or minimise faults

Relevant people may include:

- management
- colleagues
- clients
- customers
- suppliers
- stakeholders
- technical experts
- industry professionals
- planners
- advisors
- consultants
- regulators

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	• A person who demonstrates competency in this unit must provide evidence of: • managing extrusion pipe, tube and cable tool design project • determining prevention strategies for tool design faults • evaluating project outcomes to inform future practice • knowledge of principles and processes of extrusion tool design to meet plastics product design requirements
Context of and specific resources for assessment	Assessment must ensure: • activities are related to a tool design for plastics context Resources implications for assessment include: • access to suitable simulated or real workplace opportunities • access to a range of plastics products/parts and associated extrusion tooling • access to material specification charts/data sheets • access to Computer Aided Design and Tooling Design software
Method of assessment	A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit: • evaluation of project in tool design solutions for a range of extruded pipe, tube and cable products • evaluation of project in selection of appropriate materials for extruded pipe, tube and cable tooling • evaluation of calculations necessary to optimise material flow and control temperature in extruded pipe, tube and cable tooling • review of portfolio of research into principles and processes of extruded pipe, tube and cable tool design • practical exercises • observation • direct questioning • presentations

Guidance information for assessment (Optional)

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

- VU21982: Implement plastics extrusion tool design
- VU21983: Manage extrusion sheet and blown film tool design
- VU21985: Manage extrusion profile tool design

VU21985 Manage extrusion profile tool design

Unit Descriptor

This unit describes the skills and knowledge required to develop and implement extruded basic and advanced profile tool designs to achieve plastics product specifications across a range of contexts.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for development of plastics extrusion tool design across a broad range of product design applications within the plastics industry. Practitioners are typically engaged in implementing tool design strategies that are responsive to: product intent; stakeholder-specified; regulatory, and sustainability requirements.

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 Apply the principles of extruded basic profile to tool design	1.1 ***Methods of translating product specifications*** into ***extruded basic profile*** tool designs are researched and delineated
	1.2 ***Principles and main elements of extruded basic profile tool design*** are analysed for their different applications
	1.3 Appropriate material and machine process are selected based on analysis of ***relevant factors***
2 Apply the principles of extruded advanced profile to tool design	2.1 ***Methods of translating product specifications*** into ***extruded advanced profile*** tool designs are researched and delineated
	2.2 ***Principles and main elements of extruded advanced profile tool design*** are analysed for their different applications
	2.3 Appropriate material and machine process are selected based on analysis of ***relevant factors***

3	Determine requirements for extruded basic and advanced profile tool design project	3.1	Methods to best meet ***production and design requirements*** are canvassed and selected
		3.2	Possible ***faults*** in extruded pipe, tube and cable applications, their causes are analysed and ***prevention strategies*** established
		3.3	***Project management methodologies*** and ***communication strategies*** are determined
		3.4	Extruded pipe, tube and cable tool designs are developed and ***critically evaluated*** against ***tool design requirements***
		3.5	***Material flow and temperature control*** for extruded pipe, tube and cable tool designs are calculated
4	Evaluate design project	4.1	Project is implemented and reviewed against specified outcomes
		4.2	Findings are used to inform improved processes, procedures and planning in consultation with ***relevant people***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate design concepts, implications, requirements and parameters to stakeholders
- leadership and organisational skills to manage implementation and evaluation of design project
- research and strategic thinking skills to evaluate design methodologies for application to specific project outcomes
- manual and computer- aided design and drafting skills to develop, test and simulate designs
- calculation skills to determine tool design requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design for plastics project and use results to inform future practice

Required Knowledge

- principles and processes of plastics product and tool design
- principles and processes of plastics extrusion tool design
- principles and processes of basic and advanced profile tool design
- methods for translating product dimensions and specifications into designs for basic and advanced profile tools
- design features and functions of plastics extrusion machine operating systems
- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- implications of product design for tool design
- factors that affect decisions in the design process
- causes of, and elimination strategies for, faults in basic and advanced profile extrusion products
- project management tools and methodologies
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Methods of translating product dimensions and specifications may include:

- product drawings
- product material and machine specifications
- product models for which drawings can be produced
- product models for which drawings are too difficult to produce, such as:
  - carving
  - sculpture
  - toy
- using Computer Aided Drafting (CAD) data
- Computational Fluid Dynamics (CFD) data
- Computer Aided Engineering (CAE)data
- using CAD/ CFD/CAE models
- using a prototype with some working measurements

Extruded basic profile may refer to:

- J sections
- U sections (or channel sections)
- L sections

Principles and main elements of basic profile design may include:

- temperature control
- measuring devices and their functions
- services
- finishing treatments
- wall thickness
- die swell and draw down
- back pressure
- hollow sections
- sharp radius / edge
- elimination of stagnation points in flow channels
- progressive increase in velocity along the flow channel
- simple approach angles
- plate dies / button dies
- tuning of the die
- downstream processes

Relevant factors may include:	• product end-use
	• aesthetic requirements
	• processing specifications, such as:
	  o volume of run
	• environmental costs, such as:
	  o waste minimisation
	  o waste disposal
	  o recycling
	  o energy consumption
	  o carbon abatement

Extruded advanced profile may refer to:	• co-extrusion profiles
	• other complex profiles , such as equipment that may change the initial profile, such as:
	  o external corrugation over smooth pipe
	  o complex shape of windscreen wiper blades
	  o corflute (plastic cardboard)

Principles and main elements of advanced profile design may include:	• co-extrusion • downstream equipment • profile gauge • die swell and draw down • back pressure • hollow sections • sharp radius / edge • elimination of stagnation points in flow channels • progressive increase in velocity along the flow channel • simple approach angles
Production and design requirements may include:	• large volume • mechanical and thermal properties of the material • part to production requirements • machine types • cost constraints
Faults may include:	• mechanical and physical performance of product • stagnation points • restricted and uneven flow paths • damaged surfaces

- weld lines associated with split flow paths
- surface quality and treatment
- thermal control and monitoring
- thermal degradation
- thickness variation

(Fault) ***Prevention strategies*** may include:

- careful initial evaluation of product requirements / specifications
- thorough analysis of the design constraints of different processes, materials and tools
- thorough and ongoing consultation with client / suppliers / other team members and stakeholders
- effective project management
- quality assurance procedures, including:
  - design checklist
  - production checklist
  - failure minimisation
  - zero defects methodology
  - process control

Project management methodologies may refer to:

- description / definition / rationale
- outcomes and goal setting
- strategic planning
- resource requirements and allocation
- budget
- targets and milestones
- completion phases and timelines
- quality management policies and procedures
- personnel
- responsibilities
- accountabilities
- agreed reporting procedures
- communication strategies
- stakeholder engagement strategies, including critical consultation points
- monitoring and evaluation

Communication strategies may refer to:

- team leadership
- consultative management
- participative management

- project evaluation
- stakeholders engagement
- critical consultation points, such as:
  - feedback to client on initial design brief as early as possible
  - consultation with all stakeholders to verify design
  - consultation with all stakeholders when establishing project timeline
  - consultation with client to confirm decisions regarding:
    - design
    - materials
    - process
    - equipment
- briefing of all stakeholders of necessary changes to design in time to minimise cost and loss of time

Critically evaluated may refer to considerations of:

- functionality and fitness for end-use
- manufacturability
- cost of production
- environmental costs and impact of production
- minimising product design complexity
- utilisation of strategies to eliminate or minimise faults

Tool design requirements may refer to:

- preliminary tool designs optimised by using melt flow and cooling analysis techniques
- detailed drawings of tool assembly
- necessary dimensions and labels
- necessary component drawings, such as:
  - manual drafting techniques
  - Computer Aided Design (CAD)
- necessary calculations
- finishing for application
- shrinkage
- tool specifications to achieve the product requirements
  - material
  - equipment
  - finish
  - construction
- tool quotation form and design process cost estimate
- project timeline

- description of operation
- analysis of material melt flow
- required parts list
- completed tool design check list
- stakeholder requirements
- sustainability issues
- raw materials and their possible limitations
- Failure Mode and Effects Analysis (FMEA)

Material flow and temperature control may include:

- steady state / isothermic flow
- flow in an annulus
- Newtonian and non-Newtonian (power law) fluids
- viscoelastic behaviour of the polymer melt
- material suppliers' data
- continuity equation
- flow channels with variable height
- isothermal flow in channels – Newtonian and non-Newtonian fluids
- regression equation
- apparent viscosity

Relevant people may include:

- management
- colleagues
- clients
- customers
- suppliers
- stakeholders
- technical experts
- industry professionals
- planners
- advisors
- consultants
- regulators

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

A person who demonstrates competency in this unit must provide evidence of:

- managing extrusion tool design project for basic and advanced profile contexts
- determining prevention strategies for tool design faults
- evaluating project outcomes to inform future practice
- knowledge of principles and processes of extrusion tool design to meet plastics product design requirements

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to a tool design for plastics context

Resources implications for assessment include:

- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts and associated extrusion tooling
- access to material specification charts/data sheets
- access to Computer Aided Design and Tooling Design software

Method of assessment

Guidance information for assessment (Optional)

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

- *VU21982: Implement plastics extrusion tool design*
- *VU21983: Manage extrusion sheet and film tool design*
- *VU21984: Manage extrusion pipe, tube and cable tool design*

VU21986 Utilise 3D printing for plastic product manufacturing

Unit Descriptor

This unit describes the skills and knowledge required to design and fabricate tools / tool parts by additive manufacturing processes (3D printing) for plastics product production.

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for the development of plastics products and the design and fabrication of tools for manufacturing. It has application across a broad range of plastics processing methodologies, such as: injection moulding; blow moulding, and/or extrusion. Practitioners are typically engaged in implementing tool design and tool fabrication strategies utilising additive manufacturing technologies.

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 Analyse plastic product characteristics and production parameters	1.1 Design for ***plastic product*** is analysed to determine ***tool requirements***
	1.2 ***Production parameters*** are analysed to determine tool requirements
	1.3 ***Manufacture and assembly implications*** are analysed to determine tool requirements
2 Enhance plastic product design for manufacture	2.1 Alterations to plastic product design are recommended and communicated with ***relevant people*** to enable tool fabrication by ***additive manufacturing technologies***
	2.2 Agreed modifications are incorporated into product design
3 Determine suitability of additive manufacturing for tool fabrication	3.1 Additive manufacturing technologies are analysed to determine suitability for ***tool fabrication*** for the production of plastic product
	3.2 Additive manufacturing technology suitable for tool fabrication for the production of plastic product is selected

4	Design tool for fabrication by additive manufacturing	4.1	***CAD software*** is utilised to develop tool design from plastic product design
		4.2	***Translation software*** is utilised to prepare additive manufacturing machine files
		4.3	***Additive manufacturing machine parameters*** are confirmed
5	Commission tool fabrication by additive manufacturing	5.1	***Additive manufacturing machine files*** are sent to **in-house or external fabrication facility**
		5.2	Completed tool is ***verified*** to ensure compliance with product design and ***specifications***

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills:

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate opportunities presented by emerging additive manufacturing processes in relation to tool fabrication
- leadership and organisational skills to manage implementation and evaluation of additive manufacturing processes of tool fabrication
- research and analytical skills to identify methodologies to achieve optimal tool fabrication
- strategic thinking skills to evaluate emerging additive manufacturing methodologies for application to specific project outcomes
- computer-aided design and drafting skills to develop, test and simulate tool designs
- calculation skills to determine tool requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design and tool fabrication for plastics manufacturing and use results to inform future practice

Required Knowledge:

- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- principles and processes of plastics product and tool design
- product design detailing
- implications of product design for tool design
- factors that affect decisions in the design process
- principles of design for manufacture and assembly
- capabilities and limitations of additive manufacturing technologies
- additive manufacturing file types, printing parameters, support requirements
- aspects of tool design; cooling, mounting
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Plastic product	Products produced from polymer materials across a broad range of processing applications, such as: injection moulding; blow moulding, and/or extrusion, within the plastics industry.

Tool requirements	The tools or part tools required to form plastics products which may include details of:
	• gating methods, such as:
	  ○ standard gate
	  ○ valve gate
	  ○ edge gate
	  ○ fan gate
	  ○ submarine gate
	• taper / draft angles
	• cooling
	• ejection / release methods
	• tolerance / shrinkage
	• moveable cores
	• insert moulding
	• over moulding

Production parameters may refer to:	• production capacity • length of run / number of products • size and complexity of product • process equipment available • dimensional precision of product
Manufacture and assembly implications may include:	• product simplification, such as: • design for minimum number of parts • competitive benchmarking of both local and global costs • early and accurate costing of method of assembly, material, process and tooling to enable optimal design decisions • updating of costs as tolerances, surface finishes and other part details are determined • consultation on design, cycle times and costs with suppliers, customer and other stakeholders

Relevant people may refer to:	• management • colleagues • clients • customers • suppliers • stakeholders • technical experts • industry professionals • planners • advisors • consultants • regulators
Additive manufacturing technologies may include:	Fused deposition modelling (FDM) or Fused filament fabrication (FFF), Electron-beam melting (EBM), Selective laser melting (SLM), Selective laser sintering (SLS), Direct metal laser sintering (DMLS), Directed Energy Deposition
Tool fabrication	The creation of tools or part tools required to form plastics products which may include details of: • materials • surface finish
CAD software	Computer Aided Design software
Translation software	Software used to convert CAD files to files utilised by additive manufacturing equipment
Additive manufacturing machine parameters	Machine settings
Additive manufacturing machine files	Files utilised by additive manufacturing equipment
In-house or external fabrication facility	Tooling may be fabricated in the facility where design has been undertaken or sent to a specialist additive manufacturing facility
Verified	The completed tool is measured, scanned or in other ways checked to ensure specification is met
Specifications may include	tolerances surface finish cooling attributes

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	A person who demonstrates competency in this unit must provide evidence of: • knowledge of principles and process of plastics product design including design details and subsequent implications for manufacture, assembly, processing, materials and tool design • working from designs for plastic products to develop appropriate tool design • selecting an additive manufacturing technology suitable for tool fabrication • preparing CAD of tooling to enable fabrication by additive manufacturing technology • verifying tool meets requirements
Context of and specific resources for assessment	Assessment must ensure: • activities are related to a tool design for plastics context Resources implications for assessment include: • access to suitable simulated or real workplace opportunities • access to a range of plastics products/parts and associated tool • access to Computer Aided Design and Tool Design software
Method of assessment	A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit: • evaluation of tools produced by additive manufacturing to produce plastics products • practical exercises, such as: Computer-Aided Design (CAD), tool fabrication • observation • direct questioning • presentations • third party reports
Guidance information for assessment (Optional)	Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to: *VU21973: Manage plastics tool design*

VU21987 Utilise 3D printing for plastic product prototyping

Unit Descriptor

This unit describes the skills and knowledge required to produce prototype plastics products by additive manufacturing processes (3D printing).

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

Employability Skills

This unit contains Employability Skills.

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit is included will assist in identifying employability skill requirements.

Application of the Unit

This unit supports the work of designers, managers, leaders and project personnel who are responsible for the development of plastics products. It has application across a broad range of plastics processing methodologies, such as: injection moulding; blow moulding, and/or extrusion. Practitioners are typically engaged in plastics product design utilising additive manufacturing technologies.

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 Confirm product requirements	1.1 ***Product requirements*** are discussed with ***relevant people*** to confirm design parameters
	1.2 ***Specifications*** are confirmed and documented according to organisational requirements
	1.3 ***Product prototype*** is designed using ***CAD software***
	1.4 Product prototype design is reviewed with relevant people to ensure it meets specifications
2 Determine suitability of additive manufacturing to produce product prototype	2.1 ***Additive manufacturing technologies*** are analysed to determine suitability
	2.2 Additive manufacturing technology to produce product prototype is selected
3 Prepare to produce product prototype by additive manufacturing	3.1 ***Translation software*** is utilised to prepare machine files
	3.2 ***Additive manufacturing machine parameters*** are confirmed

4	Commission production of product prototype by additive manufacturing	4.1	***Additive manufacturing machine files*** are sent to **in-house or external fabrication facility**
		4.2	Completed prototype is ***verified*** to ensure compliance with product design and specifications
5	Review product design	5.1	Product prototype is presented to relevant people
		5.2	Required modifications are confirmed as required
		5.3	Product design and specification are amended
		5.4	Amended prototype is produced
		5.5	Final design is confirmed and documented.

REQUIRED SKILLS AND KNOWLEDGE

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

Required Skills:

- interpersonal skills to work with clients, colleagues, management and stakeholders either under direction, independently, or within a team
- leadership and interpersonal skills to communicate opportunities presented by emerging additive manufacturing processes in relation to tool fabrication
- leadership and organisational skills to manage implementation and evaluation of additive manufacturing processes of tool fabrication
- research and analytical skills to identify methodologies to achieve optimal tool fabrication
- strategic thinking skills to evaluate emerging additive manufacturing methodologies for application to specific project outcomes
- computer-aided design and drafting skills to develop, test and simulate tool designs
- calculation skills to determine tool requirements
- problem-solving skills to identify potential barriers to projected outcomes, analyse risks and establish prevention strategies
- analytical and evaluation skills to assess tool design and tool fabrication for plastics manufacturing and use results to inform future practice

Required Knowledge:

- behaviour and applications of polymer materials
- operating principles of plastics processing methods
- principles and processes of plastics product and tool design
- product design detailing
- implications of product design for tool design
- factors that affect decisions in the design process
- principles of design for manufacture and assembly
- capabilities and limitations of additive manufacturing technologies
- additive manufacturing file types, printing parameters, support requirements
- aspects of tool design; cooling, mounting
- risk management strategies
- quality procedures
- relevant Federal, State or Territory legislation and local government legislation, regulations and standards
- sustainability implications for tool design for plastics
- safe work practices

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.

Product requirements may include:	
Relevant people may refer to:	• management • colleagues • clients • customers • suppliers • stakeholders • technical experts • industry professionals • planners • advisors • consultants • regulators
Specifications may include:	• tolerances, surface finish, cooling attributes
Product prototype	• a facsimile of the finished plastic product
CAD software	Computer Aided Design software
Additive manufacturing technologies may include:	Fused deposition modeling (FDM) or Fused filament fabrication (FFF), Composite Filament Fabrication (CFF), Stereolithography (SLA), Digital Light Processing (DLP), Powder bed and inkjet head 3D printing (3DP), Selective heat sintering (SHS)
Translation software	Software used to convert CAD files to files utilised by additive manufacturing equipment
Additive manufacturing machine parameters	Machine settings
Additive manufacturing machine files	Files utilised by additive manufacturing equipment
In-house or external fabrication facility	Prototype may be fabricated in the facility where design has been undertaken or sent to a specialist additive manufacturing facility
Verified	The completed prototype is measured, scanned or in other way checked to ensure specification is met

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

A person who demonstrates competency in this unit must provide evidence of:

- working from a plastic product design to produce a prototype of the design utilising additive manufacturing technologies
- knowledge of principles and process of plastics product design including design details and subsequent implications for manufacture, assembly, processing, materials and tool design

Context of and specific resources for assessment

Assessment must ensure:

- activities are related to design for plastics context
- resources implications for assessment include:
- access to suitable simulated or real workplace opportunities
- access to a range of plastics products/parts
- access to Computer Aided Design and additive manufacturing equipment

Method of assessment

A range of assessment methods should be used to assess practical skills and knowledge. The following assessment methods are appropriate for this unit:

- evaluation of plastics product prototype that meets specific outcomes and that includes a range of distinctive features and design details
- practical exercises, such as: Computer-Aided Design (CAD)
- observation
- direct questioning
- presentations
- third party reports

Guidance information for assessment (Optional)

Holistic assessment with other units relevant to the industry sector, workplace and job role is recommended. Suggested units may include but are not limited to:

VU21973: Manage plastics tool design