Manufacturing Skills Australia

Metal and Engineering Training Package

User Guide

MEM80111 Vocational Graduate Diploma of Engineering

INDUSTRY SKILLS COUNCILS
Creating Australia's Future

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Forward

This guide provides general advice to industry, Registered Training Organisations (RTOs) and students on the MEM80111 Vocational Graduate Diploma of Engineering. In addition, Manufacturing Skills Australia (MSA) has produced specific implementation advice for a range of units of competency in this qualification.

(For the complete version of this qualification click on: http://training.gov.au/Training/Details/MEM80111)

The MEM80111 Vocational Graduate Diploma of Engineering was developed in response to requests to MSA from industry for a Training Package based qualification to align to the occupational title of Principal Technical Officer. This qualification will also align to the Engineering Technologist membership level of Engineers Australia. For convenience, this guide uses the term Principal Technical Officer when referring to the occupational level aligned to the qualification. Further information on industrial and professional recognition is given later in this guide.

In most states and territories the MEM80111 Vocational Graduate Diploma of Engineering will be the first vocational qualification at this level of engineering. The exception is Victoria where the MEM80111 Vocational Graduate Diploma of Engineering will replace the state accredited Advanced Diploma of Engineering – Principal Technical Officer qualification.

The MEM80111 Vocational Graduate Diploma of Engineering meets two broad needs. One was for a qualification that provided training and recognition for technically qualified individuals who are required to perform a technical leadership role in industry. The other need was to provide an opportunity for specialist vocational level study above that available in Advanced Diploma engineering qualifications. These needs often blend in different ways in industry and for this reason MSA decided not to provide formal streams in the qualification but instead to provide maximum flexibility through the choice of electives and to provide additional examples and advice outside of the formal qualification packaging rules as to how different needs can be met. This is one of the main purposes of this guide.

Scope and application of the Vocational Graduate Diploma of Engineering

The qualification notes for the MEM80111 Vocational Graduate Diploma of Engineering state:

> *The MEM80111 Vocational Graduate Diploma of Engineering is a qualification for people with responsibility and accountability for engineering-related design and/or development, leadership or operations across a range of industries and disciplines. The work environment may be project based or relate to an ongoing senior paraprofessional role as a technical specialist or technical leader.*
>
> *The MEM80111 Vocational Graduate Diploma is designed to build upon existing expertise and provides high level specialist engineering design and engineering technical and project management skills.*
>
> *The MEM80111 Vocational Graduate Diploma of Engineering can also provide an articulation pathway to professional qualifications.*

The above description indicates that the qualification is wide ranging across both engineering and technical leadership skills. The following additional comments may also be useful in determining if the MEM80111 Vocational Graduate Diploma of Engineering qualification is appropriate for an individual.

- The MEM80111 Vocational Graduate Diploma of Engineering will enable graduates to take responsibility and accountability for engineering-related work, including time-limited projects and continuous engineering-related operations (e.g. manufacturing). The work can be related to current or emerging technologies and be in a new or established engineering-related context.
- The application of the MEM80111 Vocational Graduate Diploma of Engineering is not limited to work environments where the individual is the senior engineering-related person on a project or in an engineering leadership role. For example, the MEM80111 Vocational Graduate Diploma of Engineering would also be suitable for a Principal Technical Officer providing support to a professional engineer in a project or management role, or where the person is performing a technical specialist role (e.g. calibration and testing; and managing compliance with performance-based criteria for quality, regulatory and performance requirements). In addition, most MEM80111 Vocational Graduate Diploma of Engineering units have as part of their competency requirement the ability to identify and manage situations where additional expert supervision or opinion is required (e.g. from a professional engineer, architect or scientist). In other words, the concept of accountability includes interacting effectively with other disciplines, professions and people. Both core units and several electives are based on this concept of accountability.

- The phrase '... *across a range of industries and disciplines ...'* in the qualification notes refers to the range of electives available in the qualification and is not indicating a requirement that a Vocational Graduate Diploma student must be working across different industries or disciplines.

- The qualification is not an entry level qualification in engineering. As the notes state, it is assumed that an individual has existing engineering-related expertise. For this reason the MEM80111 Vocational Graduate Diploma of Engineering is not suitable for school leavers. However, there are some units in the qualification that may be suitable for importing into other qualifications being undertaken by school leavers seeking articulation to professional study (e.g. the mathematics related units).

Specific qualification advice for the MEM80111 Vocational Graduate Diploma of Engineering
The MEM80111 Vocational Graduate Diploma of Engineering is a qualification that stands on its own right as a high level vocational qualification providing industry relevant engineering skills and knowledge. It may also provide graduates with recognition and credit outside of the vocational education and training (VET) sector through alignment to Awards and Agreements, through recognition by Engineers Australia and credit arrangements with universities. These forms of recognition are not determined by MSA but they have been taken into account in the development of the MEM80111 Vocational Graduate Diploma of Engineering.

Industry recognition

The MEM80111 Vocational Graduate Diploma of Engineering has been developed to meet the minimum training requirements of the C2 (b) Principal Technical Officer classification in the *Manufacturing and Associated Industries and Occupations Award 2010*. MSA anticipates that an application will be made to Fair Work Australia for formal recognition of the MEM80111 Vocational Graduate Diploma of Engineering in this Award. There may also be other Awards and Agreements that will apply similar recognition to that gained in the *Manufacturing and Associated Industries and Occupations Award 2010*. Advice on the relationship of the MEM80111 Vocational Graduate Diploma of Engineering to the Principal Technical Officer classification can be gained from the Australian Industry Group (Ai Group) or the Australian Manufacturing Workers Union (AMWU).

Professional recognition

Engineers Australia is the largest professional body for engineers in Australia. It offers professional recognition through levels of membership each linked to internal competency standards developed by Engineers Australia.

MSA has developed the MEM80111 Vocational Graduate Diploma of Engineering with the support of Engineers Australia (see letter of support Appendix 1). The common aim is to allow graduates of the MEM80111 Vocational Graduate Diploma of Engineering to be able to apply for recognition under the Engineering Technologist category of membership of Engineers Australia. The MEM80111 Vocational Graduate Diploma of Engineering is designed to assist applicants gain skills and knowledge to meet the Engineers Australia Stage 1 Competencies for Engineering Technologist. Gaining a MEM80111 Vocational Graduate Diploma of Engineering along with appropriate experience may also assist in gaining higher level recognition from Engineers Australia as a Chartered Engineering Technologist (CEngT).

The MEM80111 Vocational Graduate Diploma of Engineering does not automatically grant Engineers Australia recognition as an Engineering Technologist, as the criteria include requirements beyond the endorsed qualification (e.g. the MEM80111 Vocational Graduate Diploma of Engineering must be gained from an Engineers Australia accredited educational institution). Engineers Australia also considers the professional and personal attributes of the individual in particular compliance with the Code of Ethics which is published on the Engineers Australia website (http://www.engineersaustralia.org.au/).

University recognition

University recognition of the MEM80111 Vocational Graduate Diploma of Engineering will most commonly relate to progression of a Vocational Graduate Diploma graduate to study in a Bachelor of Engineering Degree. University recognition can be of two types:

1. Entry recognition, that is, a graduate of a MEM80111 Vocational Graduate Diploma of Engineering is recognised as meeting the requirements for entry to a Bachelor of Engineering Degree.

2. Credit recognition, which means, a university grants the holder of a MEM80111 Vocational Graduate Diploma of Engineering credit for some or all of the units completed in the MEM80111 Vocational Graduate Diploma of Engineering, therefore reducing the amount of university study required to gain a Bachelor of Engineering Degree.

Recognition of the MEM80111 Vocational Graduate Diploma of Engineering is decided individually by each university usually after application by a RTO that is delivering the MEM80111 Vocational Graduate Diploma of Engineering. MSA will post information on individual university recognition arrangements on its website as information becomes available from individual universities.

General delivery advice

RTOs should carefully consider their strategies for delivery of the MEM80111 Vocational Graduate Diploma of Engineering. In particular, the complementary nature of many MEM80111 Vocational Graduate Diploma of Engineering units to other units in the qualification should be considered through clustering of units for delivery and project-based delivery.

When planning delivery of units RTOs should consider the following points:

- Most units have been developed assuming a project-based delivery as the most desirable form of training delivery.
- There are many possibilities for co-delivery of units (e.g. the core units and the mathematics units with the specialist technical design units).
- MSA encourages workplace-based delivery or, if this is not possible, projects that simulate as closely as possible workplace conditions and activities. However, when using workplace delivery or simulations, RTOs should ensure that the individual effort of the learner is able to be assessed across all elements and performance criteria.
- Some Group B elective units in the MEM80111 Vocational Graduate Diploma of Engineering have prerequisites, and this should be taken into account when selecting electives and planning delivery.
- Incorporation of sustainability into delivery of most units and not just the core unit MSAENV672B Develop workplace policy and procedures for environmental sustainability.
- Because the MEM80111 Vocational Graduate Diploma of Engineering is aimed at individuals with prior study or work experience there may be more opportunities for recognition of prior learning (RPL) than most other qualifications.

When planning for assessment, reference should be made to the Method of Assessment and Critical Aspects of Assessment section in each unit of competency. In addition, where credit transfer to higher education or Engineers Australia recognition is sought by the learner, RTOs should be aware that particular forms of evidence relating to individual units may be required by these organisations.

Units of competency

The MEM80111 Vocational Graduate Diploma of Engineering consists of 35 units of competency. Specific user advice has been developed for the following 29 units:

MEM234001A Plan and manage engineering-related projects or operations

MEM234002A Integrate engineering technologies

MEM234003A Design machines and ancillary equipment

MEM234004A Design for engineering-related noise and vibration mitigation

MEM234005A Design hydrodynamic pumping systems

MEM234006A Evaluate and select thermodynamic systems or subsystems

MEM234007A Design fluid power systems

MEM234008A Design plant using computer simulations

MEM234009A Design computer-integrated manufacturing systems

MEM234010A Design microcontroller applications

MEM234011A Design programmable logic controller applications

MEM234012A Design integrated maintenance management systems

MEM234013A Plan and design engineering-related manufacturing processes

MEM234014A Design a robotic system

MEM234015A Design hydronic heat exchanger systems

MEM234016A Design refrigeration systems

MEM234017A Design exhaust, ventilation and dust collection systems

MEM234018A Design heating, ventilation, air conditioning and refrigeration control systems

MEM234020A Coordinate small lot manufacture using rapid manufacture processes

MEM234026A Develop and coordinate engineering-related contingency plans

MEM234027A Plan and manage materials supply for an engineering project or manufacturing operation

MEM234028A Produce and manage technical documentation

MEM234029A Produce and manage technical publications

MEM234030A Provide specialised technical and engineering guidance to other technical employees

MEM234031A Manage installation, commissioning or modification of machines and equipment

MEM234032A Manage fluid power related technologies in an enterprise

MEM234033A Lead engineering-related quality operations in an enterprise

MEM234034A Manage heating, ventilation, air conditioning and refrigeration systems or projects

MEM234035A Maintain and apply technical and engineering skills

When reading the advice for individual units for the MEM80111 Vocational Graduate Diploma of Engineering it is very important that the material be read in conjunction with the relevant unit and

not used alone for delivery-related purposes. Links are provided for each unit to the unit on training.gov.au (TGA). In addition, RTOs and learners should keep in mind the following points:

- The information contained in this guide is advice only and does not substitute for properly developed curriculum. Teachers/lecturers must still produce or access additional non-endorsed materials, such as teacher notes, student handouts and other documentation required for Australian Quality Training Framework (AQTF) compliance.
- This guide includes advice on entry requirements, required skills and knowledge, training delivery and co-delivery/assessment.
- While use of this guide is recommended, it is not mandatory.

The range of units in the MEM80111 Vocational Graduate Diploma of Engineering have been developed to cater for the variety of skills and knowledge individuals working as Principal Technical Officers in industry will require. Some individuals will be technical specialists often having responsibility for the design of various processes, equipment or machinery. This work may be done individually or as part of a team. The MEM80111 Vocational Graduate Diploma of Engineering recognises the skills and knowledge that these technical specialists require through a large number of units that have a focus on applying technical skills and knowledge to specific engineering-related design or modification or other related tasks.

The MEM80111 Vocational Graduate Diploma of Engineering also recognises that many Principal Technical Officers have engineering-related responsibilities not related to design or modification tasks, including responsibility for engineering projects, services, functions and facilities within a technology domain; for specific interactions with other aspects of an overall operating context; and for managing the contributions of their specialist work and that of others to a broader engineering system, solution or engineering-related operation. These duties can include leading a team or teams responsible for the implementation, operation, quality assurance, safety and sustainability of management; and maintenance of projects, plant, facilities or processes within their technical specialist practice area. These responsibilities and the associated skills and knowledge to be able to carry them out have also been recognised in both the core units of the MEM80111 Vocational Graduate Diploma of Engineering and a number of the electives.

Introduction to the units

This guide provides implementation advice for users of the endorsed units of competency in the MEM80111 Vocational Graduate Diploma of Engineering.

Please note:

- This guide is of a general nature and does not substitute for specific advice from Registered Training Organisations (RTOs) on their facilities, mode of delivery, or assessment arrangements, including arrangements for recognition of prior learning (RPL).
- MSA cannot anticipate all potential workplace applications and contexts for each unit. If a potential workplace application is not specifically mentioned in the unit or in this guide, this does not mean that the unit is not appropriate. These situations are best addressed through discussion between a learner, employer and the RTO.
- This guide does not provide advice on all sections of the endorsed unit. Advice is only included where additional information beyond what is already included in the unit is regarded as useful to trainers, assessors and learners.
- Assessment of competence for formal vocational education and training (VET) recognition must be based on the endorsed unit and cannot be based on this guide.
- This guide is aimed at an engineering occupational level often called Principal Technical Officer, Engineering Technologist and other related titles. The term Principal Technical Officer is used in this guide and it should be read as interchangeable with other titles used in industry and in the engineering profession.

MEM234001A Plan and manage engineering-related projects or operations

MEM234001A Plan and manage engineering-related projects or operations.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills associated with high level planning and management of engineering-related projects or operations. The unit covers the skills required to plan, establish, maintain and manage complex engineering systems and resources associated with time-defined engineering-related projects or high level engineering operations management in a manufacturing or engineering-related organisation.

Application statement

This unit applies to the planning and management of engineering-related projects or operations. Activities include significant project or operations management responsibilities and may require personal and electronic communication, self-directed and group activities, business planning, project or operations planning and scheduling, and an understanding of the technology, skills and techniques, and quality aspects required by the project or operations.

MSA comments

The unit descriptor gives an indication of the scope of planning and management using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly a candidate is not expected to be able to apply their skills in all application areas listed in the application statement.

Typical work situations where this unit could apply include:

- a product design engineer coordinating design for manufacture and customer acceptance for the product with production, sales, marketing, field service and installation personnel ensuring that the final design meets quality, cost and delivery objectives
- a manufacturing or plant engineer directing the selection and installation of significant equipment to meet a specified requirement, including establishing maintenance procedures, critical spares and training of personnel to maintain and operate the equipment.

In planning for the delivery of this unit it is important that RTOs do not approach the unit solely as a management skills unit. In particular, the unit is distinguished from general management type units found in other qualifications by the requirement to integrate engineering skills and knowledge with management skills as illustrated by the following extracts from the required skills section of the unit:

- investigating and validating the suitability of performance analysis, modelling and simulation software
- managing the interrelationships between concurrent engineering techniques, electronic data control and supervisory systems
- managing complex engineering-related projects and operations.

Complex engineering-related projects and operations are not defined specifically in the unit because of the wide range of projects or operations occurring in industry. Operations may be of a day-to-day nature (e.g. a fabrication shop producing car bodies) or of a specific area requiring technical support (e.g. quality assessment and measurement).

The range statement indicates that the distinguishing feature for the engineering-related project or operation as it applies to this unit is that the project or operations management requires high level paraprofessional engineering skills in an established engineering discipline or area, as outlined in the Required Knowledge section of the unit. The engineering skills and knowledge must be able to be applied autonomously or as part of a team and show sound judgment based upon the application of engineering and scientific principles.

In addition, it is expected that the engineering skills and knowledge are able to be applied effectively in conjunction with typical financial planning, accounting and legal processes which may relate to an engineering project or operation, together with human resource aspects. The unit also requires effective communication and engineering leadership with other professionals, tradespersons and stakeholders involved in the project or operation who may depend on the individual's engineering skills and knowledge.

Based on the above, it is unlikely that the unit will be suitable for someone who does not have prior experience in or an opportunity to concurrently gain experience in engineering projects or operations.

Required skills and knowledge

MSA recognises that for high level units such as MEM234001A Plan and manage engineering-related projects or operations, comprehensive engineering skill and knowledge is expected by industry. However, any one individual is unlikely to be demonstrating all aspects of planning and managing a project or operation in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required skills and knowledge sections of the unit indicate the requirements to be able to effectively plan and manage projects or operations using not only management skills but particular engineering skills and techniques where required. As already mentioned, this differentiates this unit

from more general management units that are found in other qualifications. Particular attention is drawn to the required skills of:

- investigating and validating the suitability of performance analysis, modelling and simulation software
- managing the interrelationships between concurrent engineering techniques, electronic data control and supervisory systems.

These technical skills need to be properly integrated with the more management-related skills to generate an appropriate engineering focus in the delivery of this unit.

The required knowledge listed in the unit covers a range of knowledge from other professional and technical areas that a person would need to know to be able to effectively manage an engineering-related project or operation. However, it is important to realise that this knowledge should be applied in conjunction with the ability to discern when technical and professional assistance from other specialists should be sought (see Performance Criteria 1.4).

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on planning and managing projects or operations that require significant engineering input and be preferably projects that will give opportunities for determining when assistance from other technical and professional specialists is required. For example, projects based on the work situations described previously could be used.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as management, OHS and sustainability). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234001A Plan and manage engineering-related projects of operations, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234002A	Integrate engineering technologies
MEM234013A	Plan and design engineering-related manufacturing processes

MEM234027A	Plan and manage materials supply for an engineering project or manufacturing operation
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234002A Integrate engineering technologies

MEM234002A Integrate engineering technologies.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills required to integrate technologies, processes, components or equipment for projects or operations. Apart from engineering considerations the unit encompasses sustainability, occupational health and safety (OHS) and regulatory requirements and implications of the project.

Application statement

This unit applies to individuals working as a Principal Technical Officer or in an equivalent engineering-related position who are required to integrate different technologies, processes, components or equipment. The unit applies to all forms of manufacturing and engineering operations. It is suitable for persons with system design, installation, commissioning and project or operational management responsibilities who have to integrate different technologies. The technologies may be all in one discipline or technical field or across engineering and related disciplines. For installation, commissioning and project or operational management application, the unit assumes that discretion as to the type and level of integration applies and the actual level of integration must be determined.

Prior or concurrently developed experience in the application of scientific principles, mathematics, materials, manufacturing processes, computer software for computer-aided design (CAD), system analysis, modelling and simulation, project work and risk management and experience in the technologies to be integrated is required.

MSA comments

The unit descriptor gives some examples of the scope of design using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly a learner is not expected to be able to apply their skills and knowledge in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above, the range statements and other sections in the unit.

Typical work situations where this unit could apply include:

- supervising the installation of new and/or an upgrade of computer and control technologies where the new technologies will affect the operations of multiple processes and equipment, including effects on production, maintenance and quality

- leading a project team in a jobbing engineering business charged with developing a response to an enquiry from a new customer for manufacture of a one-off large machine. The machine will require mechanical, hydraulic, electrical and electronic systems and have large structural components.

While there are many delivery options for this unit, it is ideal as the basis of a major workplace or simulated project requiring knowledge and skills across a number of technologies and situations. Examples include installation and commissioning tasks, introduction of a new product manufacturing line, major overhaul tasks, and so on. In addition, when exercising supervisory responsibilities, many Principal Technical Officers will also be responsible not only for work within their own speciality or discipline but also for the technical work of technicians, tradespersons and other employees.

While this unit can be contextualised for complex formal systems integration tasks and responsibilities, users should be aware that MSA intends to develop additional units covering systems engineering procedures and configuration management especially where the design of complex systems that require the integration of subsystems and/or components by a multi-discipline engineering team is required. Further information will be posted on the MSA website once work on these units commences.

As MEM234002A Integrate engineering technologies is a core unit, every opportunity should be made to co-deliver and co-assess this unit with other MEM80111 Vocational Graduate Diploma of Engineering units.

Required skills and knowledge

MSA recognises that for high level units such as MEM234002A Integrate engineering technologies, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of the unit in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required knowledge section of the unit indicates what is required to be able to effectively integrate engineering technologies. The following is intended to elaborate the required knowledge section of the unit and should be should be read in conjunction with that section of the unit.

The unit does not specify a level of required knowledge in any one engineering discipline. Instead the focus is on skills and knowledge related to particular engineering-related techniques across disciplines (e.g. interpreting standards, drawings and designs; modelling and calculation techniques; and performance analysis). When read in conjunction with the elements and performance criteria, it is apparent that a key requirement is for the learner to be able to determine when to apply their own engineering skills and knowledge and when to obtain input from specialists in other fields and disciplines (see P.C. 2.5). This decision is not meant to be random but part of a carefully considered integration strategy (Elements 2, 3 and 4).

Principal Technical Officers, depending upon their area of focus, may work with engineering graphics, engineering materials and mechanics, hydraulics and pneumatics, or electronics and electric power. They will probably use CAD or computer-aided manufacturing (CAM) equipment, robotics, and other planning and modelling tools to evaluate the integration task with an eye to increasing productivity, reducing costs, and maintaining or improving the quality or function of the project. Principal Technical Officers may also provide technical customer service, or work in technical sales and marketing because of their strong knowledge of equipment and processes.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on an integration task as outlined in the range statement. The integration must require application of engineering skills and knowledge across a range of engineering technologies and systems. The integration task may or may not go across disciplines or technical fields of work.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as OHS, sustainability and risk assessment). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234002A Integrate engineering technologies, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234030A	Provide specialised technical and engineering guidance to other technical employees
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234003A Design machines and ancillary equipment

MEM234003A Design machines and ancillary equipment.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of machines and ancillary equipment. It includes sustainability implications, occupational health and safety (OHS), modelling and calculations, use of software, product analysis and product life cycle design, investigating, generating ideas, synthesis, prototype completion and manufacture and evaluation.

Application statement

This unit applies to the design of any significant machinery and ancillary equipment for domestic, commercial, industrial, medical, military or entertainment purposes. Design activities may also include reverse engineering, design rectification or modifications of an existing design. Activities include the design of specific machine elements, such as shafts, bearings, brakes, clutches, springs, pressure vessels, flywheels, and may also include selection of ancillary equipment, such as motors, pumps and valves.

MSA comments

The unit descriptor gives some examples of the scope of design using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their machine and ancillary equipment design skills in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit. This indicates that the unit:

- can apply to the design of a whole machine or a machine element
- applies to the design of significant machinery and ancillary equipment
- applies where there is a broad scope to the design task and a high level of responsibility is included especially in terms of taking into account sustainability, OHS and other regulatory requirements, life cycle servicing, maintainability, cost, manufacturability and assembly and ease of operation.

Significant is not defined specifically in the unit because of the wide range of machinery and equipment used in industry. However, the range statement indicates that parameters of a design brief at this level may include:

- determination of the degree of innovation and creativity expected by the client
- design process limits and budgets
- product cost limits and budgets
- performance specifications
- equipment availability, capacities and restrictions
- specified administrative, communication and approval procedures
- other special features and limits in the design brief.

Based on the above it is unlikely that the unit will be suitable to someone who does not have prior or concurrently developed experience with complex machinery, equipment or equipment element design briefs. The skills and knowledge covered by the unit are further explained later in this guide. However, as a guide to unit selection, the unit should be seen as requiring prior experience in the application of scientific principles; analysis of loads on machine elements; selection of components; higher level mathematics, including calculus; manufacturing processes; computer software, including computer-aided design (CAD); and knowledge of the properties of materials sufficient to allow for appropriate material selection. In addition, knowledge and experience in electrical, fluid power, hydrodynamic and thermodynamic disciplines, as applied to machines and equipment, will be required for most applications.

Required knowledge

MSA recognises that for high level units such as MEM234003A Design machines and ancillary equipment, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of machine and ancillary equipment design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required knowledge section of the unit indicates the broad mechanical and machinery and equipment knowledge required to be able to effectively design machines and ancillary equipment including significant elements. The following advice is intended to elaborate the required knowledge section of the unit should be should be read in conjunction with that section of the unit.

Design criteria

Design criteria should be relevant to the brief or task and should take into account:

- environmental and sustainability considerations
- life cycle performance

- cost/benefit
- required controls
- system responsiveness and stability
- fitness for purpose
- safety
- failure modes and effects.

Mechanical knowledge

Delivery of this unit should include or emphasise:

- simple harmonic motion:
  - equations of simple harmonic motion
- systems having inertia and elasticity:
  - forced vibrations
  - resonance
  - vibration isolation
  - transmissibility
- statically indeterminate beams:
  - support reactions and deflections by methods, such as:
    - three moment equation
    - slope and deflection by area-moment method
    - Macauley's method for slope and deflection
- stress concentration and alternating stresses:
  - stress raisers and stress concentration factors
  - fatigue, endurance limit and endurance strength
  - endurance limit diagrams and the Soderberg diagram.

Mechanical elements and applications

- uniform pressure and uniform wear analysis of brakes and clutches
- differential and additive action band brakes
- flywheels for single and multi-cylinder engines, provision for engine speed and delivered power variations
- dynamic balancing of rotating machine elements and multi-cylinder reciprocating engines

- whirling of shafts:
  - vibration of mass-spring systems
  - whirling of a single disc system
  - Rayleigh's method for first critical speed
  - Dunkerley's equation for first critical speed
- basic knowledge of factors affecting the choice of prime mover 'type', including:
  - internal combustion, steam engines/turbines, electric motors and geared motors
  - power required based on start up and running conditions.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management– Principles and guidelines
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems
- AS IEC 61511 Functional safety – Safety instrumented systems for the process industry sector
- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- AS 2550 Cranes, hoists and winches – Safe use
- ISO 2374 Lifting Appliances – Range of maximum capacities for basic models
- BS 2573 Rules for the design of cranes
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS 1403 Design of rotating steel shafts
- AS 2938 Gears – Spur and helical – Guide to specification and rating
- AS 1472 Carbon steel spring wire for mechanical springs
- ISO 606 Short-pitch transmission precision roller and bush chains, attachments and associated chain sprockets

- BS ISO 487 Steel roller chains, types S and C, attachments and sprockets
- DIN 8192 Chain wheels for roller chains
- ISO 281 Rolling bearings – Dynamic load ratings and rating life
- ISO 76 Rolling bearings – Static load ratings
- ISO/TS 16281 Rolling bearings – Methods for calculating the modified reference rating life for universally loaded bearings
- ISO 12168 Plain bearings –- Hydrostatic plain journal bearings without drainage grooves
- ISO 12167 Plain bearings – Hydrostatic plain journal bearings with drainage grooves
- ISO 12130 Plain bearings – Hydrodynamic plain tilting pad thrust bearings
- ISO 4863 Resilient shaft couplings
- DIN 740 Power transmission engineering; flexible shaft couplings; technical delivery conditions
- AGMA 922 Load classification and service factors for flexible couplings
- AS 1418 Cranes, hoists and winches
- AS 4100Steel structures
- AS 1755 Conveyers – Safety requirements
- AS 1735 Lifts, escalators and moving walks
- AS/NZS 3947 Low-voltage switchgear and controlgear
- AS 4024.3301 Safety of machinery – Robots for industrial environments – safety requirements
- AS 3533 Amusement rides and devices.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on machine and machine elements design using fundamentals of design, materials, stress, strain, deflections and failure theories to design specific machine elements, such as springs, gears, shafts, and so on; and the and integration of them into larger practical machine assemblies. Examples of machine assemblies could be 2-D and 3-D motion controllers, drive systems, material handling machines, simulated production lines, and so on.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as OHS, sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234003A Design machines and ancillary equipment, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234004A Design for engineering-related noise and vibration mitigation

MEM234004A Design for engineering-related noise and vibration mitigation.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below:

Unit descriptor

This unit of competency covers the design of noise and vibration mitigation systems for product, plant and equipment to ensure satisfactory operation, safety and comfort of people using, or in the proximity of the product, plant and equipment.

Application statement

This unit applies to the design of products, plant and equipment across all forms of manufacturing and engineering. Design activities may also include reverse engineering, design rectification or modifications of an existing design. The unit includes the selection and use of appropriate measuring and monitoring equipment, modelling and calculations, and incorporation of noise and vibration mitigation techniques into designs.

This unit does not cover structural or civil engineering-related noise mitigation techniques, such as the design of noise barriers and anechoic chambers.

Prior experience in application of scientific principles, mathematics, measurement and evaluation of noise and vibration, computer software and file handling is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their engineering-related noise and vibration mitigation design skills in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit.

- The noise or vibration must be engineering related. For example, the noise generated by a truck engine during normal operation would be regarded as engineering related, while the noise generated by overly aggressive driving would not be regarded as engineering related.

- The emphasis is on vibration and noise measuring and monitoring and incorporation of vibration and noise mitigation into the design process.

- The design and erection of physical barriers or special environments to house equipment after installation may be an important mitigation technique but these techniques are not covered by this unit.

Required knowledge

MSA recognises that for high level units, such as MEM234004A Design for engineering related noise and vibration mitigation, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of designing for noise and vibration mitigation in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. MSA is providing the following advice to assist RTOs in determining the scope of their delivery. The advice is intended to elaborate the required knowledge section of the unit of competency and should be should be read in conjunction with that section of the unit.

Design criteria

Design criteria should be relevant to the brief or task and should take into account:

- vibration mitigation and shock control, including:
  - anti-vibration gloves, tools and operating policies
  - vibration isolation
  - shock isolation
  - vibration damping
  - types of isolation materials and mounting devices
  - spring and elastomeric mountings and resilient pads
  - vibration damping and damping treatments
- machine design and noise reduction options, such as:
  - economical use of attenuation
  - balancing strategies for:
    - fine balancing with extra low ‘centre of mass’ eccentricity
    - reciprocating piston, con-rod and crank multi-cylinder engines
    - multiple, in-line bearing shafts and flexible shafts
    - balancing standards for various machine rotors
  - further options for noise and vibration, such as:
    - condition monitoring for plant
    - acoustic emissions for fault detection
    - modal analysis of dynamic properties of structures or room acoustics
    - correlation of modal analysis with finite element analysis

- statistical energy analysis

- vibration from misalignment and unbalanced rotating machines, including.
  - misalignment of coupled shafts:
    - alignment variables
    - alignment methods
  - rotor balance
  - rotor bearing positioning
- risk factors for types and degrees of hearing loss
- loudness, duration, and relationship to personal hearing protection.

Equipment and testing

Training in selecting relevant equipment and testing procedures should be included and should cover appropriate selection and use of:

- sound measurement and testing techniques:
  - data required related to test requirements (spectrum analysis or simple noise measurement of linear sound pressure levels)
  - microphones and preamplifiers (specialist applications requiring supplementary transducers to locate source of noise)
  - noise meters (handheld, A-weighted, noise dose and precision options)
  - recording techniques and equipment for various environments and sound characteristics
  - calibration
- appropriate vibration measurement equipment and testing techniques, for example:
  - electrodynamic exciter
  - sinusoidal and random excitation
  - sub and super harmonics
  - force testing and structural response
  - simulated and real environment testing of shock
  - calibration.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 2670 Evaluation of human exposure to whole-body vibration - General requirements
- AS/NZS 1269 Occupational noise management
- AS 1055.1 Acoustics – Description and measurement of environmental noise – General procedures
- NOHSC:1007 National Standard for Occupational Noise
- Safe Work Australia 2011 Managing noise and preventing hearing loss at work – Code of practice
- ISO 18437 – Mechanical vibration and shock.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

- This unit can be delivered through project-based delivery, simulation or workplace-based delivery.
- Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as occupational health and safety (OHS), sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234004A Design for engineering-related noise and vibration mitigation, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234003A	Design machines and ancillary equipment
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234005A Design hydrodynamic pumping systems

MEM234005A Design hydrodynamic pumping systems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of new or modified hydrodynamic pumping systems, including the layout; choice of motor and pumps, pipes and valves; the fluid source and delivery requirements of the system. It includes sustainability implications, occupational health and safety (OHS) and regulatory requirements.

Application statement

This unit applies to the design of hydrodynamic pumping systems across all forms of manufacturing and engineering. Design activities may also include reverse engineering, design rectification or modifications of an existing design. It applies to pumping system designers and maintenance personnel, and those pursuing engineering or related qualifications and careers.

Prior experience in the application of scientific principles, evaluation of hydrodynamic systems, mathematics, computer software and file handling is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their hydrodynamic pumping systems design skills in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit.

- The unit applies to the design of hydrodynamic pumping systems and not just components.
- The ability to design hydrodynamic pumping systems for a variety of fluids, including special fluids, is required.
- A high level of responsibility is included in the design especially in terms of taking into account OHS, regulatory and sustainability requirements.

It is also important to realise that the unit does not limit the design task other than it must be at a complex system level. For example, the unit should not be interpreted as only applying to

hydrodynamic pumping systems for new equipment. It could also apply to design required for updating, converting or modifying hydrodynamic pumping systems for new tasks or to increase performance or reliability.

Required knowledge

MSA recognises that for high level units, such as MEM234005A Design hydrodynamic pumping systems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of hydrodynamic pumping system design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The following advice should be read in conjunction with the required knowledge section of the unit of competency.

Pumping system design criteria

Design criteria should be relevant to the brief or task and should take into account:

- pumping systems:
  - system head equation
  - pump performance curves for pumps
  - duty point, flow rate, head, power and efficiency
  - energy cost of pumping
  - valves for flow control
- practical pump installations and operation problems:
  - mounting, alignment and balancing, preventative/proactive maintenance
  - pump instability, surging, vapour locks, priming, and priming methods
  - inlet design, strainer blockage, submergence, wet and dry sumps
  - pump drives, installation, troubleshooting and maintenance
  - fluid compatibility with pump materials
  - pressure surge due to fluid flow interrupts (water hammer) or direction change
- requirements for pumping of special fluids:
  - viscous fluids and effects on characteristic curves
  - slurries and slurry rheology
  - Newtonian and non-Newtonian fluids
  - critical carrying velocities and the Durand equation
  - slurry head corrections, abrasion and erosion

- pump placement in the system
- cavitation control:
  - causes and effects
  - net positive suction head available (NPSHA) and net positive suction head required (NPSHR)
  - temperature and altitude effects
  - Thoma cavitation parameter (sigma) vs. the pump-specific speed and the suction-specific speed.

Design and/or selection of pumps

- rotodynamic pump performance:
  - inlet and outlet velocity diagrams
  - Euler (theoretical) head equation
  - difference between theoretical and actual head developed:
    - head and flow losses
    - circulatory and viscous friction
    - mechanical friction and shock losses
    - internal leakage and fluid disk friction
    - actual pump power
- series and parallel pumps:
  - serial and parallel arrangements
  - piping and valve arrangements
  - reflux valves
  - similarity laws
  - geometrically similar pumps
  - specific speed
  - flow coefficient
  - head coefficient
  - power coefficient and the effect of density change
  - flow, head and power relationships:
    - for a given impeller diameter
    - for a constant speed and fluid density
  - the prediction of new duty points for changes in speed and impeller size
  - determination of operating speed to give a specific duty point.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS 2417 Rotodynamic pumps – Hydraulic performance acceptance tests
- AS 4041 Pressure piping
- AS IEC 61511Functional safety – Safety instrumented systems for the process industry sector.

Training delivery

- While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.
- This unit can be delivered through project-based delivery, simulation or workplace-based delivery.
- RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.
- If workplace delivery of this unit is followed or a workplace is used the RTO should check that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as occupational health and safety (OHS), sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234005A Design hydrodynamic pumping systems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234003A	Design machines and ancillary equipment
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234006A Evaluate and select thermodynamic systems or subsystems

This guide provides implementation advice for users of the endorsed unit of competency MEM234006A Evaluate and select thermodynamic systems or subsystems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering qualification, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the evaluation of performance, efficiency and the selection of appropriate thermodynamic plant and equipment using thermodynamic principles, including the Law of Entropy and the Second Law of Thermodynamics, as applied to gas cycles and vapour cycles, flow-through nozzles and blade passages, impulse and reaction stages of turbines. It includes generation and transfer of heat energy using solid, liquid and gas mediums and application of software.

Application statement

This unit applies to the evaluation of performance, efficiency and selection of appropriate thermodynamic plant and equipment across all forms of manufacturing and engineering. It is suitable for Principal Technical Officers and people in equivalent positions working with heat transfer, air conditioning, solar, geo-thermal and other power generation applications involving thermal energy transfer.

Prior experience in the application of scientific principles, evaluation of thermodynamic system components, mathematics and computer techniques, is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their skills in evaluation and selection of thermodynamic systems in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit.

Required knowledge

MSA recognises that for high level units, such as MEM234006A Evaluate and select thermodynamic systems or subsystems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of skills and knowledge in thermodynamic systems evaluation in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. The advice should be read in conjunction with the required knowledge section of the unit of competency.

Evaluation and selection of thermodynamic systems or subsystems should aim for a thermodynamic system that is relevant to the tasks required and regulatory and occupational health and safety (OHS) requirements. The evaluation and selection should take into account:

- Law of Entropy and the Second Law of Thermodynamics:
  - reversibility and irreversibility
  - Clausius' statement on the Second Law related to refrigerators and heat pumps
  - Kelvin-Plank statement on the Second Law related to heat engines
  - entropy change for ideal gases undergoing arbitrary processes
  - entropy change for ideal gases undergoing isentropic processes
  - entropy change for incompressible substances and pure substances
  - the increase in entropy principle
  - the Carnot cycle and the Second Law
- Second Law analysis of thermodynamic systems:
  - general expression for the rate of change of entropy for systems or processes
  - reversible and irreversible work, maximum work and availability
  - Second Law analysis of closed systems
  - Second Law analysis of open, steady state and transient systems
- conduction:
  - Fourier Law of Conduction, Conductivity of Materials, Thermal Conductance and Resistance
  - conduction through flat plates, composite materials and 'parallel-series' composite walls
  - radial conduction through thin and thick pipes, temperature distribution in a thick hollow cylinder, composite materials, lagged pipes, and critical insulation thickness
  - systems with heat sources and sinks
  - transients in heat flow
- convection:

  - convection heat transfer coefficient and factors affecting the coefficient
  - fluid velocity profile (boundary sub-layer, transition layer and turbulent flow)
  - fluid flow characteristics (geometry of convection surfaces, natural and forced convection, and flow regime)
  - unit analysis and dimensionless numbers, kinematic viscosity and dynamic viscosity
  - heat exchangers (enthalpy 'balance', arithmetic mean and log mean temperature difference, parallel, counterflow and cross flow heat exchangers)
- radiators, emission, absorption and reflection:
  - thermal radiation and the electromagnetic wave spectrum
  - radiation intensity at a distance from the source
  - radiation properties, black, grey and real bodies, emittance, absorption and reflectivity
  - solar energy, heating, power generation and efficiency of conversion
- radiant energy on surfaces
- variations, such as:
  - Azimuth and zenith angles, path length, cloud cover and water vapour
- combined heat transfer:
  - conduction, convection and radiation
  - cooling fins, combustion chambers and rocket engines
- actual and ideal gas cycles:
  - air standard assumptions
  - gas Carnot, Stirling and Ericsson cycles
  - ideal Otto, Diesel, Brayton and jet propulsion cycles
  - ideal Brayton cycle with reheat, regeneration and intercooling
  - ideal gas refrigeration cycle
  - actual gas cycles
- actual and ideal vapour cycles:
  - ideal Rankine cycle
  - ideal Rankine cycle modified with reheat and regeneration
  - ideal vapour-compression refrigeration cycle
  - actual vapour cycles
- flow-through nozzles and blade passages, including nozzle and diffuser coefficients.

Standards and codes

Standards refers to Australian and overseas standards relevant to thermodynamic systems and the design task. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS/NZS 1200 Pressure equipment
- AS 2593 Boilers – Safety management and supervision systems
- AS 1228 Pressure equipment – Boilers
- AS 1210 Pressure vessels
- AS 2971 Serially produced pressure vessels
- AS 3920 Assurance of product quality – Pressure equipment manufacture
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS/NZS 3666 Air-handling and water systems of buildings – Microbial control.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

- This unit can be delivered through project-based delivery, simulation or workplace-based delivery.
- RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.
- If workplace delivery of this unit is followed or a workplace is used the RTO should check that the work tasks cover a suitable scope in the evaluation and system selection tasks (e.g. technical as well as OHS, sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234006A Evaluate and select thermodynamic systems or subsystems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234003A	Design machines and ancillary equipment
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234007A Design fluid power systems

MEM234007A Design fluid power systems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of fluid power systems, including pneumatic multi-actuator control systems; hydraulic systems, including hydrostatic transmissions, proportional and servo valve control, and programmable logic controllers (PLC). It includes occupational health and safety (OHS), regulatory requirements, automation safety and systematic design processes. Design considerations include dynamic loads and optimised control system response and stability.

Application statement

This unit applies to fluid power systems across all forms of manufacturing and engineering. Design activities may also include reverse engineering, design rectification or modifications of an existing design. It is suitable for fluid power system and automation designers and maintenance personnel, and those pursuing engineering or related qualifications and careers.

Prior experience in evaluation of fluid power systems and hydrodynamics, mathematics, computer techniques, basic electrical and controllers is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their fluid power system design skills in all application areas listed in the application statement. However, as guidance statements on selection some useful points are made in both sections:

- the unit applies to fluid power design of fluid power **systems** and not just components
- the systems covered are complex systems especially in terms of their control systems
- a high level of responsibility is included in the design especially in terms of taking into account OHS and regulatory requirements. For example, at this level design would be expected to automatically include considerations of automation safety, such as locking state of the system in the event of failure.

It is also important to realise that the unit does not limit the design task other than it must be at a complex system level. For example, the unit should not be interpreted as only applying to fluid power systems for new equipment. It could also apply to fluid power design required for updating, converting or modifying equipment for new tasks or to increase performance or reliability.

Required knowledge

MSA recognises that for high level units, such as MEM234007A Design fluid power systems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of fluid power design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The following advice should be read in conjunction with the required knowledge section of the unit of competency.

Concepts of fluid power

Delivery of this unit should include or emphasise:

- typical components of fluid power systems, including actuators, valves, pipes, pumps and hoses
- control systems
- fluid types and properties
- graphical representations of fluid power systems
- velocities, forces and pressures due to friction, gravity and accelerations
- conservation of mass and energy principles.

Design criteria

Design criteria should be relevant to the brief or task and should take into account:

- velocities, forces and pressures due to friction, gravity and accelerations
- fluid power and automation safety issues, such as pressure limits for components, including pressure intensifications and system decompression, and accumulator unloading valves
- required controls
- automation safety
- system responsiveness and stability
- fitness for purpose.

Hydraulics and designing with hydraulic components

Delivery of this unit should include or emphasise:

- accumulators for emergency, shock buffering, and supplementary flow for complex sequences
- power and energy conserving circuits, features, function and applications:
  - high-low, pre-fill and regenerative
  - pressure controlled pump flow circuits
  - load sensing and power control circuits
- proportional DC solenoids:
  - linear stroke/current types for direction, flow and pressure control
  - force/current types for direction and pressure control
- open and closed loop operation:
  - accuracy, hysteresis, repeatability, response, pressure drop and cost
- valve and spool types, overlap ('dead zone')
- direct and pilot operated valves
- servo valves
- installation, system construction, sealing, position in system relative to actuator, fluids and filtering, breather filter, pilot pressure limit, solenoid venting and maintenance requirements
- other hydraulic systems and components relevant to the design task.

Applications and characteristics of servo valves

Delivery of this unit should include or emphasise:

- low power torque motor functions
- velocity, position, force control functions and spools to suit servo valves
- closed loop operations, accuracy (transducer dependent), hysteresis, repeatability, response and pressure drop
- feedback transducers (potentiometers, inductors, scales, lasers, strain gauges, angle encoders, tacho-generators, and differentiating position for velocity)
- valves and spool descriptions
- other servo valve applications relevant to the design task.

Electronic controllers for proportional and servo valves

Delivery should emphasise state of current technology. Examples could include:

- set point, ramp generator and ramp time

- feedback (optional), error signal and pulse generation
- voltage to current converter, and solenoid current
- effect of proportional, integrator and differential gains on system response.

Sensors/transducers/amplifiers

Sensors/transducers/amplifies should include:

- pneumatic, contact and non-contact, normal and low pressure
- electrical and electronic.

Pneumatics and designing with pneumatic components

Delivery of this unit should include or emphasise multiple actuator control circuits using:

- pneumatic cascade control
- pneumatic step-sequencer (equivalent of cascading individual actuations)
- PLC 'step-sequencer'
- timer, counter and event driven options
- modular programming, for emergency stop, cycle selection, start, automatic retract and other machine 'fringe' conditions
- structured programming, isolating logic, fringe condition modules, timing and counting, and output sections of controller and programs
- logic simplification techniques, such as intuitive, Boolean algebra and Karnaugh mapping
- other pneumatic systems and components relevant to the design task.

Compressed air system design

Delivery of this unit should include or emphasise:

- work of compression, effect of inter and after cooling, and Standard Reference Air (SRA) 'free air' conditions
- sizing air compressor and receiver based on outlet pressures, flows and demand cycles at multiple outlets
- unloading compressor for energy saving
- piping and fitting arrangements to limit pressure drop
- filtering and dehumidifying
- energy cost.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirement.

This unit can be delivered through project-based delivery, simulation or workplace-based delivery. Examples of simulated or actual projects include:

- design and build of a robot
- design of a transfer station for a production process
- design of a vehicle braking system.

The aim should be to cover a good cross-section of applications for different industries (e.g. food/pharmaceuticals manufacturing, process manufacturing, mining/quarrying and resources, vehicle production, vehicle design including earthmoving, and so on).

Workplace delivery of this unit should include the RTO checking that the work tasks cover both hydraulic and pneumatic design opportunities. Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems – General requirements.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234007A Design fluid power systems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234031A	Manage installation, commissioning or modification of machines and equipment

MEM234032A	Manage fluid power related technologies in an enterprise
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234008A Design plant using computer simulations

MEM234008A Design plant using computer simulations.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the use of computer simulations to develop engineering solutions for the design of plant, equipment and manufacturing processes. It includes mathematical models and computer simulation models, sensitivity estimation and optimisation to ensure reliability, validity and robustness of simulations.

Application statement

This unit applies to the use of computer simulation for design of significant plant, equipment or manufacturing processes across all forms of manufacturing and engineering. Design activities may also include reverse engineering, design rectification or modifications of an existing design. It is suitable for plant and process designers and maintenance personnel, and those pursuing engineering or related qualifications and careers.

Prior experience in the evaluation of plant and processes; scientific principles; analysis of loads on machine elements; selection of components; mathematics, including calculus and differential equations, materials, manufacturing processes and computer-aided design (CAD) is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their plant design skills in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit:

- the term plant is used to encompass the design of the physical equipment and/or the manufacturing process
- the design task may be for a new design or a modification of an existing design
- the design task can include fault analysis.

Required knowledge

MSA recognises that for high level units, such as MEM234008A Design plant using computer simulations, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of plant design using computer simulation in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. In particular, for MEM234008A Design plant using computer simulations, the following section on software selection and co-delivery is very important and should be considered by RTOs in determining the scope of their delivery.

The required knowledge section indicates that knowledge of a range of mathematical models is required. Mathematical models describe a system as a set of equations with operators controlling the relationship between state variables, constants and random variables, the inputs, outputs and decisions made. These are:

- linear and non-linear
- deterministic and stochastic
- steady-state and dynamic
- lumped and distributed parameter models.

The following additional definitions and comments on the various mathematical models and equations are offered to assist in determining the scope and consistency of delivery.

Linear and non-linear

Linear equations contain only linear dependant variables or linear derivatives. If they contain more complex functions, such as f(x)3, ef(t) or cos [F(t)], they are non-linear.

Deterministic and stochastic models

Deterministic simulations perform in a manner uniquely 'determined' by state variable parameters and initial conditions. For deterministic computer models:

- response surfaces are theoretical constructs
- assumptions and approximations have to be made in order to generate a response surface where perhaps only a scattered cloud of points exists
- partial derivatives are calculated in order to move along response surfaces
- simulation model uses an objective function
- a mathematical algorithm determines the performance.

Stochastic models have:

- variable states described by probability distributions and are therefore subject to randomness

- use a randomly generated scatter of data (Monte-Carlo, random inputs for maximum scatter)
- use a correlation matrix based on the influence of system parameters on each other
- have a desired performance target specified instead of an objective function
- require engineering judgement and experience
- the correlation matrix shows how the design variables influence the performance variables and shows dependencies among the performance variables. Realistic and reachable targets can be defined
- uncertainty in the performance of the simulated system is quantifiable.

Steady-state and dynamic models

- Steady-state models attempt to define systems in equilibrium.
- Dynamic simulations usually involve partial or ordinary differential equations. At intervals the solutions of the equations are used to reset state and output variables (e.g. flight simulators use dynamic simulation). Dynamic models can be lumped parameter or distributed parameter models. They can be continuous or discrete.

Lumped and distributed parameter models

- Lumped parameter models have interconnected elements with homogeneous parameters that are immediately responsive to disturbances.
- Distributed parameter models have elements with heterogeneous parameters linked so that a disturbance propagates a wave-like response through the model. Models are typically represented by partial differential equations.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

This unit should be delivered through project-based delivery using either workplace-based projects or simulated work projects using the facilities of the RTO.

A wide variety of commercial plant and process design simulation software may be used as the basis of instruction in this unit. Features to look for include:

- simulation of complex plant, process and control systems
- object-oriented, hierarchical models of plant or production processes, encompassing business, logistic and production processes
- modelling of plant and processes using libraries of standard and specialised components
- generation of graphs and charts of performance

- animation for 3-D visualisation of plant or process
- automatic optimisation of system parameters
- simulation performance analysis tools
- open system architecture supporting multiple interfaces (e.g. activex, CAD, Oracle SQL, ODBC, xml and socket).

Work-based or simulated projects should be selected that maximise the use of features available in the simulation software, including the testing of features for suitability to the design task.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems – General requirements.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234008A Design plant using computer simulations, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234003A	Design machines and ancillary equipment
MEM234009A	Design computer-integrated manufacturing systems
MEM234011A	Design programmable logic controller applications
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234009A Design computer-integrated manufacturing systems

MEM234009A Design computer-integrated manufacturing systems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of a computer-integrated manufacturing (CIM) system, including control of machine and processes and the generation of manufacturing information. It includes occupational health and safety (OHS), automation safety and risk management.

Application statement

This unit applies to the design of automated plant and equipment, control and data sharing systems across all forms of manufacturing and engineering. Design activities may also include reverse engineering, and design rectification or modifications of an existing design. It is suitable for automated manufacturing system designers and maintenance personnel, and those pursuing engineering or related qualifications and careers.

Prior experience in the application of computing technology, mathematics, scientific principles and techniques, electrical principles and techniques, programming of computers and controllers, methods, processes and mechanical construction techniques, manufacturing plant and processes, and evaluation of CIM systems is required.

MSA comments

The unit descriptor gives some examples of the scope of design activities using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their design skills for a CIM system in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit. This indicates that the unit is appropriate when:

- the manufacturing system design goes beyond simple automation and includes additional design features, including:
  - design of data collection and sharing

- failure mode analyses
- OHS requirements including automation safety
- design for servicing, maintainability, cost, manufacturability and assembly and ease of operation

- a range of CIM solutions and practices needs to be investigated
- responsibility to sign-off stage is required.

Required knowledge

MSA recognises that for high level units, such as MEM234009A Design computer-integrated manufacturing systems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of CIM system design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required knowledge section of the unit indicates the broad knowledge required to be able to effectively design a CIM system, including significant elements. The required knowledge section should also be carefully read in conjunction with the range statement, in particular the hardware and software options and the network topology and communications protocols sections, to ensure that a broad approach to training delivery is undertaken.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems – General requirements
- AS IEC 61511 Functional safety – Safety instrumented systems for the process industry sector
- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- AS 2550 Cranes, hoists and winches – Safe use
- ISO 2374 Lifting Appliances – Range of maximum capacities for basic models
- AS 1418 Cranes, hoists and winches
- AS 1755 Conveyers –Safety requirements

- AS 1735.1-2003 Lifts, escalators and moving walks – General requirements
- AS/NZS 3947 Low-voltage switchgear and controlgear
- AS 4024.3301 Safety of machinery – Robots for industrial environments – Safety requirements
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on projects that include requirements for research, adherence to a brief, consultations with stakeholders and responsibility to sign-off. Projects should not be narrow in their technology focus and should include mechanical, electrical, fluid, electronic and information technologies in the manufacturing system.

Projects maybe based on original design, design rectification or modifications of an existing design and the design process and brief should include non-technology design factors, including:

- design cost, system capital cost
- maintainability, and product life cycle cost
- durability, function, performance and aesthetics
- energy and environmental sustainability and social issues
- equipment availability and worksite restrictions.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as occupational health and safety (OHS), sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234009A Design computer-integrated manufacturing systems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A Plan and manage engineering-related projects or operations

MEM234002A	Integrate engineering technologies
MEM234008A	Design plant using computer simulations
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234010A Design microcontroller applications

MEM234010A Design microcontroller applications.

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of an automated device for a machine or equipment using a microcontroller. The automated device may use digital or analog input/output (I/O) and may involve feedback control. The microcontroller application may be an autonomous device or it may be integrated into a local area network (LAN) or distributed control system (DCS) using wired or wireless communications. It includes sustainability implications, occupational health and safety (OHS) and automation safety.

Application statement

This unit applies to the design of automated devices using microcontrollers across all forms of manufacturing and engineering. Design activities may also include reverse engineering, and design rectification or modifications of an existing design. The unit is suitable for automated device or systems designers and maintenance personnel, and those pursuing engineering or related qualifications and careers.

Prior experience in the application of basic computing, controllers, mathematics, electrical, electronic, and evaluation of microprocessor systems and safety procedures is required. Mechanical, fluid power, thermodynamic, manufacturing methods and processes experience may be required by particular system designs

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their design skills of microcontroller applications in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit. Such a reading indicates that:

- design does not always have to be related to a new application and can also include reverse engineering and rectification or modification of an existing design
- the unit can apply to both digital and analog applications
- design includes selection of appropriate components

- design for the purposes of the unit includes prototyping, testing and the monitoring of installation and commissioning.

Users are also referred to the definition of microcontroller in the range statement which states:

> *A microcontroller is based on a microprocessor with 'peripherals' such as clock, I/O ports, reset and ram in the 'package'. Peripherals may be added, such as ADC, DAC and external memory and communications modules.*

Required knowledge

MSA recognises that for high level units, such as MEM234010A Design microcontroller applications, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of microcontroller application design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. For MEM234010A Design microcontroller applications, the following advice will assist RTOs in determining the scope of their delivery. The advice should be read in conjunction with the required knowledge section of the unit of competency.

Types of controllers and applications

- digital and analog options using add-on modules
- open and closed loop control
- proportional-integral-derivative (PID) controller
- pulsed width modulation (PWM) controllers
- human machine interface (HMI)
- graphical user interface (GUI)
- other network and remote control/communications options and controllers
- interface and signal conditioning
- data communications and telemetry
- modems and networking topology
- sensor/transducers
- analog to digital techniques
- shielding
- multiplexing
- actuators and power interfaces.

Control options

Control options should be viewed broadly and include:

- sufficient control options for achieving process and/or product specifications (fitness for purpose)
- automation safety requirements, including failsafe, redundancy and, emergency stop
- compliance with standards and regulations
- open and closed loop control
- negative feedback, positive feedback and feed forward.

Inputs

The scope of possible inputs and input purposes should be covered, including:

- digital inputs
- analog transducer options
- analog modules as analog to digital converter (ADC) signal conditioners (e.g. 0 to 5V, 0 or 4 to 20 mA, -10 to 10 V)
- measured variables, such as force, level, pressure, flow rate, temperature, velocity and displacement
- calibration requirements
- transducer parameters (accuracy, sensitivity, precision/repeatability, scale factor, range and span, linearity, hysteresis and frequency response)
- sampling time, sampling period = 1/sampling frequency
- block diagrammatic view of ADC for conversion of analog signal to an integer value
- integer values in decimal, hex and binary coded decimal (BCD)
- resolution of ADC (absolute and relative) and quantising error
- aliasing and aliasing avoidance using sf = 4 x signal frequency
- Nyquist criterion sampling frequency = > 2 signal frequency
- electromagnetic interference (EMI) and cable shielding, twisted pair methods
- sample delay
- multiplexing (e.g. 2 input channels sharing ADC)
- signal conditioners to filter or amplify transducer signal to ADC

- ADC high input impedance for minimum affect on signal
- single ended inputs (single common) vs. double ended (reduces noise but may reduce inputs available
- operational amplifiers as signal conditioners to amplify and convert signals.

Outputs

- actuation options
- display devices
- output power interfaces/actuator drivers
- principles of power interfaces, such as pulse width modulation (PWM) drivers, transistor, silicon-controlled rectifier, or semiconductor-controlled rectifier(SCR), thyristor, and zero voltage switching

For analog I/O:

- configuring output channels (4 to 20 mA, 0 to 10 V, 0 to 20 mV, -10 to 10 V)
- block diagrammatic view of DAC for conversion of binary integer to analog output
- resolution of the DAC (absolute and relative) and quantising error
- output current limit of DAC
- PWM outputs.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems – General requirements
- NOHSC:1010 National Standard for Plant.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on projects that include requirements for research, adherence to a brief, consultations with stakeholders and responsibility to sign-off. Projects should not be narrow in their technology focus and should include a wide range of control options, including safety and compliance requirements. Projects should also be selected that require a wide range of input and outputs and design responsibility through to commissioning.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as occupational health and safety (OHS), sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234010A Design microcontroller applications, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234009A	Design computer-integrated manufacturing systems
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234011A Design programmable logic controller applications

MEM234011A Design programmable logic controller applications.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of an engineering application using a programmable logic controller (PLC). It includes sustainability implications, occupational health and safety (OHS) and automation safety.

Application statement

This unit applies to the control of machines, equipment or processes that may have thermodynamic, hydrodynamic, fluid power or mechanical system elements using a PLC. Control functions may be digital and analog and may include feedback. Network and remote control may be used. The unit is suitable for mechatronics and automated systems designers, systems maintenance, machine and process control, or computer-integrated manufacturing (CIM) designers. Design activities may also include reverse engineering, and design rectification or modifications of an existing design.

Prior experience in the evaluation of PLC systems, application of computing, controllers, mathematics, and basic electrical and electronics safety procedures is required. Additionally, experience in mechanical, fluid power, thermodynamic, manufacturing methods and processes may be required by particular system designs.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply design skills of an engineering application using a programmable logic controller in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit:

- the unit relates to engineering related PLC control applications with an emphasis on machine, equipment and industrial processes

- communication networks, other networking and remote control applications are also covered
- design does not always have to be related to a new application can also include reverse engineering and rectification or modification of an existing design
- design for the purposes of the unit includes prototyping, testing and the monitoring of installation and commissioning
- PLC control function applications may be both digital and analog.

Required knowledge

MSA recognises that for high level units, such as MEM234011A Design programmable logic controller applications, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of PLC controller application design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. For MEM234011A Design programmable logic controller applications, the following advice will assist RTOs in determining the scope of their delivery. The advice should be read in conjunction with the required knowledge section of the unit of competency.

Inputs

The scope of possible inputs and input purposes that are recommended to be covered in delivery include:

- configuring input channels (e.g. 0 to 5 V, 0 or 4 to 20 mA, -10 to 10 V)
- measured variables, such as force, level, pressure, flow rate, temperature, velocity and displacement
- transducer options
- calibration requirements
- transducer parameters (accuracy, sensitivity, precision/repeatability, scale factor, range and span, linearity, hysteresis and frequency response)
- sampling time, sampling period = 1/sampling frequency
- block diagrammatic view of analog to digital converter (ADC) for conversion of analog signal to an integer value
- integer values in decimal, hex and binary coded decimal (BCD)
- resolution of ADC (absolute and relative) and quantising error
- aliasing and aliasing avoidance using SF = 4 x sig freq
- Nyquist criterion sampling freq => 2 sig freq

- cable shielding method
- sample delay
- multiplexing (e.g. 2 input channels sharing ADC)
- signal conditioners to filter or amplify transducer signal to ADC
- ADC high input impedance for minimum effect on signal
- single ended inputs (single common) Vs Double ended (reduces noise but may reduce inputs available
- operational amplifiers as signal conditioners to amplify and convert signals.

Outputs

- Configuring output channels (e.g. 0 or 4 to 20 mA, 0 to 10 V, -10 to 10 V)
- block diagrammatic view of DAC for conversion of binary integer to analogue output
- resolution of the DAC (absolute and relative) and quantising error
- output current limit of DAC
- actuation options
- output power interfaces/actuator drivers
- principles of power interfaces, such as pulse width modulation (PWM), frequency inverters, silicon-controlled rectifier, or semiconductor-controlled rectifier (SCR), thyristor and zero voltage switching.

Testing of sensor/transducer options

- PLC functions and programming options
- output/actuator options
- actuator control signal and power requirements
- signal conditioning
- actuator interfacing and connection requirements,
- PLC power supply options
- human machine interface (HMI)
- graphical user interface (GUI)
- network and remote control/communications options and protocols,
- methods for analogue control using ADC and DAC I/O modules

- PWM options.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024.1-2006 Series Safety of machinery
- AS/NZS ISO 31000:2009 Risk management – Principles and guidelines
- AS 61508.1-2011 Functional safety of electrical/electronic/programmable electronic safety-related systems – General requirements
- AS IEC 61511.3-2004 Functional safety – Safety instrumented systems for the process industry sector – Guidance for the determination of the required safety integrity levels
- AS 62061-2006 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- NOHSC:1010 (1994) National Standard for Plant
- NOHSC:1014 (2002) National Standard for the Control of Major Hazard Facilities
- IEEE 802 Wireless PAN, LAN, MAN and WPAN standards
- AS 1755-2000 Conveyers – Safety requirements
- AS 1735.1-2003 Lifts, escalators and moving walks – General requirements
- AS/NZS 3947.3:2009 Low-voltage switchgear and controlgear – Switches, disconnectors, switch-disconnectors and fuse-combination units
- AS 4024.3301-2009 Safety of machinery – Robots for industrial environments – Safety requirements
- IEC 61131-1 Ed. 2.0 Programmable controllers - Part 1: General information
- IEC 61131-3 Ed. 2.0 Programmable controllers - Part 3: Programming languages
- IEC 61499-1 Ed. 1.0 Function blocks - Part 1: Architecture

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on projects that include requirements for research, adherence to a brief, consultations with stakeholders and

responsibility to sign-off. Projects should not be narrow in their technology focus and should include a wide range of control options, including safety and compliance requirements. Projects should also be selected that require a wide range of input and outputs and design responsibility through to commissioning.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as occupational health and safety (OHS), sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234011A Design programmable logic controller applications, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234009A	Design computer-integrated manufacturing systems
MEM234010A	Design microcontroller applications
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234012A Design integrated maintenance management systems

MEM234012A Design integrated maintenance management systems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills required for the systematic design of integrated maintenance processes to complement engineering and business objectives through the maximisation of plant utilisation. It includes consideration of quality aspects, design for reliability and maintainability and the generation of system data which is analysed and used to aid continuous improvement processes.

Application statement

This unit applies to the design of integrated maintenance systems for existing plant and for new plant and processes in all areas of manufacturing and engineering. Design activities may also include reverse engineering, and design rectification or modifications of an existing design. It is suitable for maintenance personnel and system designers involved in engineering, manufacturing and related asset maintenance systems, and those pursuing engineering or related qualifications and careers.

Prior or concurrent experience in evaluation of maintenance systems, mathematics, mechanical, electrical, fluid, thermal, production methods and processes, materials handling and automated systems, repair techniques, occupational health and safety (OHS) and risk management is required.

This unit applies where substantial engineering-related skills are required to design the maintenance management system.

Where the emphasis is on competitive manufacturing related skills, such as lean manufacturing, reliability centred maintenance (RCM), proactive or total productive maintenance (TPM), and the engineering support is provided by other personnel, then the unit MSACMT681A Develop a proactive maintenance strategy should be considered.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their design skills of integrated maintenance processes in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit, especially the definition of integrated maintenance management systems given in the range statement. Points to consider in selecting MEM234012A Design integrated maintenance management systems include:

- the unit takes a broad view of issues to consider when designing a maintenance management system, hence the use of the word integrated. In the design process learners are expected to consider the performance, reliability and maintainability of physical assets and to take into account asset performance and cost during all phases of the asset life, including installation, commissioning, operation, maintenance, modification, replacement, reuse and disposal

- the emphasis in the unit is on integration of substantial engineering-related skills with skills and knowledge from other disciplines

- where the need is primarily for training in preventative maintenance techniques and the engineering-related skills are either already possessed or are supplied by other personnel then the learner should be directed to the appropriate units from the competitive systems and practices qualifications

- the design task does not have to be for a new maintenance system. The unit can also apply to existing systems requiring rectification or modification.

It should also be noted that in Defence and other large systems engineering-related environments, units covering skills and knowledge in configuration management and integrated logistic support (ILS) may be required in addition to the skills and knowledge covered by this unit.

Required knowledge

MSA recognises that for high level units such as MEM2340012A Design integrated maintenance management systems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of integrated maintenance management design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required knowledge section of the unit indicates the broad mechanical and machinery and equipment knowledge required to be able to effectively design integrated maintenance management systems, including significant elements. The following advice is intended to supplement the required knowledge section of the unit of competency and should be read in conjunction with that section of the unit.

Data management, generation, recording, analysing, storing and use of software

Modern integrated approaches to maintenance management depend heavily on appropriate gathering, processing, interpreting and recording of data. Providers should ensure that training delivery reflects this need. It is recommended that the following topics be considered in planning delivery:

- manual and instrument based data collection
- networking options and techniques
- data requirements for different life cycle stages of assets
- data storage options, including accessibility and suitability to different user groups (e.g. operators, maintenance trades, engineering staff, management, contractors and equipment suppliers)
- data category, such as:
  - asset identification
  - covered by warranty or maintenance contract
  - cost-related data, including purchase cost, depreciation, lease costs and running cost
  - asset history
  - type, location and level of parts, reserve or spare equipment, consumables, and so on
  - scheduled preventative maintenance activities, including mandatory and regulatory inspections (e.g. for boilers and lifts)
  - work request templates
  - safe work method statements (SWMS)
  - material safety data sheets (MSDS)
  - work permits (WP)
  - manually entered or instrument generated monitoring and maintenance data.

Prioritisation of assets and maintenance-related tasks

The wide variety of business operations and their equipment and processes means that a number of different methods of prioritising assets and maintenance tasks should be covered during delivery of the unit. Examples include:

- importance to safety and operations, for example:
  - critical assets, such as assets which on failure:
    - cause an emergency, potential critical safety incident or major negative environmental impact
    - halt production
    - immediately cause a product or process to be out of specification

    - are unable to be replaced or repaired easily because of lack of parts or spares or availability of skilled personnel
  - semi-critical assets:
    - failure causes a potential safety risk if not repaired promptly
    - partial loss of capacity
    - some spare parts available
    - repair is difficult or time consuming
  - remainder of plant:
    - no safety risk
    - good availability of spares and parts
    - production is not stopped or can easily be re-routed
    - skills for maintenance and repair are available onsite.

Depending on the nature of an operation and its equipment design for maintainability, techniques should include a number of approaches, for example:

- modular design
- redundancy
- bypass opportunities
- design for quick changeover
- standardisation of procedures, tools and monitoring.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS 2670.1 Evaluation of human exposure to whole-body vibration – General requirements
- AS/NZS 1269 Occupational noise management
- AS61508 Functional safety of electrical/electronic/programmable electronic safety-related systems
- AS IEC61511 Functional safety – Safety instrumented systems for the process industry sector
- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems

- AS 2550 Cranes, hoists and winches – Safe use
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS 1418 Cranes, hoists and winches
- AS 4100 Steel structures
- AS 1755 Conveyors – Safety requirements
- AS 1735 Lifts, escalators and moving walks
- AS/NZS 3947 Low-voltage switchgear and controlgear
- AS 4024.3301 Safety of machinery – Robots for industrial environments – Safety requirements
- AS3533 Amusement rides and devices
- AS/NZS ISO 14000 Environmental management
- AS/NZS ISO 14040 Environmental management – Life cycle assessment – Principles and framework
- AS/NZS 3788 Pressure equipment – In-service inspection.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based as much as possible. However, the unit allows for some simulation assessment depending on the facilities of the training provider.

> *Assessment of some elements of the maintenance system design process may be possible off the job providing full plant simulation facilities and software are available that reflect realistic workplace situations.*

In all situations the assessment strategy should allow for evaluation of the success of the maintenance design over a reasonable period. In particular, attention is drawn to the advice in the method of assessment section of the unit:

> *Assessment methods must confirm consistency and accuracy of performance (over time and in a range of workplace relevant contexts) together with application of underpinning knowledge.*

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. engineering and cost-based evaluation and design tasks, including consideration of occupational health and safety (OHS), sustainability and life cycle analysis).

Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234012A Design integrated maintenance management systems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234003A	Design machines and ancillary equipment
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234013A Plan and design engineering-related manufacturing processes

MEM234013A Plan and design engineering-related manufacturing processes.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills and knowledge required to plan and design engineering-related manufacturing processes, including consideration of client requirements, process control, sustainability, lean systems, product manufacturability, system maintainability, facilities, services, plant and tooling requirements, supply chains, material and product flow, continuous improvement and constraint and contingency management, occupational health and safety (OHS) and regulatory requirements.

Application statement

This unit applies to the design of manufacturing processes across all forms of manufacturing and engineering. Design activities may also include design rectification or modifications of an existing engineering-related manufacturing process. It is suitable for manufacturing system designers or manufacturing operations personnel, and those pursuing engineering or related qualifications and careers.

Prior or concurrent experience in production control techniques, manufacturing plant and processes, product and process improvement techniques, manufacturing plant and processes and evaluation of business performance, computing technology and mathematics is required.

The unit does not apply to technical leadership in project, operational or engineering management. Where these skills are required see unit MEM234001A Plan and manage engineering-related projects or operations.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their planning and design skills of engineering-related manufacturing processes in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit.

- The unit is not about production planning involving planning of daily, weekly or cycle production targets for a process where the steps in the manufacturing process have already been determined.
- The unit is appropriate where the design task involves the planning and design of manufacturing facilities, services, plant, tooling and process, and process control systems, including researching and matching engineering and technical considerations to other design parameters (e.g. quality, volume and regulatory requirements).
- Situations requiring modification or rectification of an existing manufacturing process can also be covered by this unit.

Required knowledge

MSA recognises that for high level units such as MEM234013A Plan and design engineering-related manufacturing processes, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of engineering-related manufacturing process design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required knowledge section of the unit indicates the broad knowledge required to be able to effectively design an engineering-related manufacturing process. The following advice is intended to elaborate the required knowledge section of the unit of competency and should be should be read in conjunction with that section of the unit as well as the range statement.

Use of automated design tools and other software

Use of automated design tools and other software should take into account:

- process design requirements
- risk management
- budgeting, financial and business planning
- project planning
- maintenance
- process controllers
- integration with pre-existing or required systems for:
  - systems control and data acquisition (SCADA)
  - distributed control system (DCS)
  - enterprise resource planning (ERP)
  - manufacturing resource planning (MRPII).

Lean manufacturing principles

The design process should take into account lean principles, including facilitating effective implementation of:

- value stream mapping and management
- 5S housekeeping
- flow principles and customer pull systems, including just in time (JIT) and kanban
- minimisation of waste
- mistake proofing
- process mapping by users
- setting of key performance indicators/metrics
- quick changeovers
- implementation of standardised work.

Designs that inhibit effective implementation of any of the above should be avoided.

Maintenance management system options

Maintenance management system options, including systems and approaches, such as:

- break down
- preventive
- predictive
- precision
- proactive
- reliability centred
- total productive.

Facilities, services and process design or modification

Facilities, services and process design or modification should consider:

- facilities for employees and visitors
- interaction if any with the public
- plant and process layout:
  - plant and tools to suit production processes
  - plant and equipment for logistics, materials handling, transfer and transport

- visual metrics, displays and controls
- assets maintainability and reliability
- warehousing and stores, emergency and buffer stock
- regulatory requirements
- OHS
- environmental and sustainability factors.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS IEC 61511 Functional safety – Safety instrumented systems for the process industry sector
- AS/NZS ISO 14000 Environmental management.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on a realistic brief that integrates engineering and technical process design requirements with budget, efficiency, and regulatory and OHS considerations. The project should be of sufficient duration to allow detailed evaluation of the manufacturing process design's performance.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as OHS, sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234013A Plan and design engineering-related manufacturing processes, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A Plan and manage engineering-related projects or operations

MEM234002A	Integrate engineering technologies
MEM234003A	Design machines and ancillary equipment
MEM234012A	Design integrated maintenance management systems
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234014A Design a robotic system

MEM234014A Design a robotic system.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of an engineering application employing a robot and integrating it with other equipment and systems. It includes the use and integration of actuators, sensors, end effectors, including tactile effectors, dynamic analysis of strength and stability, programming and protocols for communications and networking, as appropriate.

Application statement

This unit applies to the design of a robotic system across all forms of manufacturing and engineering. Design activities may also include reverse engineering, design rectification, integration of off the shelf components, or modifications of an existing design. It is suitable for robotic system designers or maintenance technologists, and those pursuing qualifications and careers in engineering design involving robotics and automation.

Prior experience in the application of computing technology, mathematics, scientific principles and techniques, including kinematics and kinetics, electrical and fluid power principles and techniques, programming of computers and controllers, robotic systems evaluation and mechanical construction techniques is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their design skills of a robotic system in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit. This indicates that the unit is appropriate when:

- the design task is not confined to the robot or robotic system but also requires integration with other equipment and systems

- the design brief does not supply all required technical information and options for application of robots, robot functions, and programming must be explored, including technical, commercial and environmental parameters
- the unit covers the ability to monitor installation and commissioning, when required, as well as undertake design tasks.

Required knowledge

MSA recognises that for high level units such as MEM234014A Design a robotic system, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of robotic system design in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required knowledge section of the unit indicates the broad knowledge required to be able to effectively design a robotic system, including significant elements. The required knowledge section should also be carefully read in conjunction with the range statement, in particular the definition of a robotic system to ensure that a broad approach to training delivery is undertaken.

The following advice should be read in conjunction with the required knowledge section of the unit of competency.

Robotic systems should include consideration of options (including their advantages and disadvantages) for:

- actuators:
  - AC electric motors
  - brushed and brushless DC electric motors
  - steppers and servos
  - hydraulic
  - pneumatic
  - cable and wire

  reactive polymers
- manipulators and end effectors:
  - industrial end effectors, such as weld, vacuum, magnetic and grasping effectors
  - tactile feedback end effectors.

Object detection and sensor options

Object detection and sensor options may include:

- contact, proximity and interrupted beam
- distance sensing

- pressure and temperature
- relative and absolute encoders
- vision and smart cameras
- tilt sensing
- global positioning system (GPS) positioning.

Communication protocols

Communication protocols area the set of standardised rules for data and signal syntax, checking and error detection. Where robotic systems communicate with other equipment and sites they will generate data in accordance with a protocol that allows understanding or translation of the data as information, control signals integrity and error checks. Communication protocols can change rapidly and providers should include in their delivery methods of verifying currency of a protocol.

Communication protocols include:

- layered communications and networking protocols:
  - OSI Model – Open Systems Interconnection Model – 7 layers
  - TCP/IP Internet Protocol Suite {Transmission Control Protocol (TCP) and the Internet Protocol (IP)} – 4 or 5 layers
- IEEE 802 LAN/MAN group of standards, including IEEE 802.3 Ethernet standard, and IEEE 802.11 Wireless Networking standard
- interface standards, such as RS232 and RS485, Fieldbus, Modbus and DNP3.0.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS 61508 Functional safety of electrical/ electronic/programmable electronic safety-related systems
- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- AS IEC 61511 Functional Safety – Safety instrumented systems for the process industry sector
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities

- AS 2550 Cranes, hoists and winches – Safe use
- ISO 2374 Lifting appliances – range of maximum capacities for basic models
- AS 1418 Cranes, hoists and winches
- AS/NZS 3947 Low-voltage switchgear and controlgear
- AS 4024.3301 Safety of machinery – Robots for industrial environments – Safety requirements.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on projects that include requirements for research, adherence to a brief, consultations with stakeholders and responsibility to sign-off. Projects should not be narrow in their technology focus and should include mechanical, electrical, fluid, electronic and information technologies in the manufacturing system.

Projects may be based on original design, design rectification or modifications of an existing design and the design process and brief should also include consideration of design factors, including:

- design cost and system capital cost
- maintainability and product life cycle cost
- durability, function, performance and aesthetics
- energy and environmental sustainability and social issues
- equipment availability and worksite restrictions.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as occupational health and safety (OHS), sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234014A Design a robotic system, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A Plan and manage engineering-related projects or operations

MEM234002A	Integrate engineering technologies
MEM234008A	Design plant using computer simulations
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234015A Design hydronic heat exchanger systems

MEM234015A Design hydronic heat exchanger systems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of hydronic heat exchanger systems using steam or water as the heat transfer medium. It includes boilers for heat generation, cooling towers and chillers for heat dissipation.

Application statement

This unit applies to the design of hydronic heat exchanger systems across all forms of manufacturing and engineering. Design activities may also include reverse engineering, and design rectification or modifications of an existing design. It is suitable for hydronic system contractors, building heating, ventilation and air conditioning (HVAC) consultants, designers and maintenance personnel.

Prior experience in the evaluation of hydronic systems, application of heating, ventilation, air conditioning and refrigeration (HVAC/R) principles, mathematics and computer techniques is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their hydronic design skills in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit:

- the unit applies to fluid power design of hydronic heat exchanger systems and not just components
- a high level of responsibility is included in the design especially in terms of taking into account occupational health and safety (OHS) and regulatory requirements.

Required knowledge

MSA recognises that for high level units, such as MEM234015A Design hydronic heat exchanger systems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of hydronic heat exchanger design in one task or employment situation. In order to ensure that a broad capability is covered by training in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

To ensure adequate coverage of the required knowledge listed in the unit, MSA recommends that delivery of this unit should include or emphasise the points listed below. This advice should be read in conjunction with the required knowledge section of the unit of competency.

Theoretical concepts related to hydronic heat exchangers

- Law of Entropy and Second Law analysis of thermodynamic systems, including:
  - general expression for the rate of change of entropy for systems or processes
  - reversible and irreversible work, maximum work and availability
  - Second Law analysis of closed systems
  - Second Law analysis of open, steady state and transient systems
- ideal or actual vapour compression refrigeration cycle.

Heat transfer: conduction, convection and radiation

- property tables for conductivity, convection and radiation coefficients
- conduction:
  - Fourier Law of conduction, conductivity of materials, thermal conductance and resistance
  - conduction through flat plates, composite materials and ‘parallel-series’ composite walls
  - radial conduction through thin and thick pipes, temperature distribution in a thick hollow cylinder, composite materials, lagged pipes and critical insulation thickness
  - spherical shell conduction
  - variation of thermal conductivity over large temperature ranges
  - systems with heat sources and sinks
  - two and three-dimensional steady state conduction
  - systems using surface protrusions with temperature gradients
  - transients in heat flow
- convection:
  - convection heat transfer coefficient and factors affecting the coefficient

  - fluid velocity profile: boundary sub-layer, transition layer and turbulent flow
  - fluid flow characteristics: geometry of convection surfaces, natural and forced convection, and flow regime
  - unit analysis and dimensionless numbers, kinematic viscosity and dynamic viscosity
  - Reynolds Number, Prandtl Number, Nusselt Number and Grashof Number
  - convective heat transfer coefficients for conduit and annular flow, and hydraulic diameter
  - heat exchangers: enthalpy 'balance', arithmetic mean and log mean temperature difference, parallel, counterflow and cross flow heat exchangers
- radiators, emission, absorption and reflection:
  - thermal radiation and the electromagnetic wave spectrum
  - monochromatic emissive power at various temperatures as a function of wavelength
  - Wien's Displacement Law
  - Kirchhoff's Law
  - radiation intensity at a distance from the source
  - radiation properties, black, grey and real bodies, emittance, absorptance and reflectivity
  - radiation surface geometry
  - radiation in black and grey enclosures
- combined heat transfer:
  - conduction, convection and radiation
  - cooling fins, combustion chambers and rocket engines
- heat flow solutions by analytical, electrical analogy, graphical, numerical, finite element analysis (FEA) and graphical software solution techniques.

Heat exchangers

- optimisation of hydronic equipment selection and arrangement
- transient conditions and system stability
- minimising heat loss
- piping options: series, parallel and primary-secondary.

Water chillers

- chiller components
- refrigeration cycle
- cooling load

- equipment and piping sizing configuration.

Pumping systems

- system head, pump performance curve, duty point, speed control, pump optimisation, system component and materials selection
- friction loss, suction head, optimisation, static and dynamic system head
- valve and piping optimisation
- pumping system options: series, parallel, trimming impellers, two speed and variable speed control.

Cavitation

- causes and effects
- net positive suction head available (NPSHA) and net positive suction head required (NPSHR)
- temperature and altitude effects
- Thoma cavitation parameter (sigma) vs. the pump specific speed and the suction specific speed
- pump placement in the system.

Rotodynamic pump performance

- inlet and outlet velocity diagrams
- Euler (theoretical) head equation
- difference between theoretical and actual head developed:
  - head and flow losses
  - circulatory and viscous friction
  - mechanical friction and shock losses
  - internal leakage and fluid disk friction
  - actual pump power.

Series and parallel pumps

- serial and parallel arrangements
- piping and valve arrangements
- reflux valves
- similarity laws
- geometrically similar pumps

- specific speed
- flow coefficient
- head coefficient
- power coefficient and the effect of density change
- flow, head and power relationships:
  - for a given impeller diameter
  - for a constant speed and fluid density
- duty point variations with changes in speed and impeller size
- determination of operating speed to give a specific duty point.

Practical pump installations and operation problems

- mounting, alignment and balancing, preventative/proactive maintenance
- pump instability, surging, vapour locks, priming and priming methods
- inlet design, strainer blockage, submergence, wet and dry sumps
- pump drives, installation, troubleshooting and maintenance
- fluid compatibility with pump materials
- pressure surge due to fluid flow interrupts (water hammer) or direction change.

Standards and codes

An understanding of relevant standards and codes is an important part of competency. However, standards can change and different standards may apply for different engineering tasks. The onus is on the RTO to ensure that standards referred to in delivery are appropriate for the application and context. Particular standards and codes at the time of writing of MEM234015A Design hydronic heat exchanger systems that may apply are listed below. The list is not meant to be exhaustive. Users should ensure they use the latest version.

- AS 1668 The use of ventilation and airconditioning in buildings
- EU Guidelines on ventilation
- ASHRAE 62 Ventilation for acceptable indoor air quality
- Australian Uniform Building Regulation Coordinating Council (AUBRCC) or Building Council of Australia (BCA) standards and codes
- AS/NZS 3666 Air-handling and water systems of buildings – Microbial control
- AS/NZS 3896 Waters – Examination for Legionella spp. including Legionella pneumophila

- AS 4254 Ductwork for air-handling systems in buildings
- AS 1324 Air filters for use in general ventilation and airconditioning
- AS 5013 Food microbiology
- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – principles and guidelines
- AS 61508 Functional safety of electrical/ electronic/programmable electronic safety-related systems
- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- AS IEC 61511 Functional Safety – Safety instrumented systems for the process industry sector
- AS/NZS 1200 Pressure equipment
- AS 2593 Boilers – Safety management and supervision systems
- AS 1228 Pressure equipment – Boilers
- AS 1210 Pressure vessels
- AS 2971 Serially produced pressure vessels
- AS 3920 Assurance of product quality – Pressure equipment manufacture
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS/NZS ISO 14001 Environmental management systems
- Air quality and emissions standards set by individual states and territories.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

- This unit can be delivered through project-based delivery through simulation or workplace based delivery.
- Workplace delivery of this unit should include the RTO checking that the work tasks cover a sufficient range of hydronic heat exchanger design opportunities to ensure valid assessment. Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234015A Design hydronic heat exchanger systems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234018A	Design heating, ventilation, air conditioning and refrigeration control systems
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234016A Design refrigeration systems

MEM234016A Design refrigeration systems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of industrial and commercial refrigeration systems and system components. It includes industrial systems with multiple evaporators and compressors, moderate and low temperature, indirect refrigeration and flooded systems, commercial refrigeration and food storage technology, and compliance with safety and regulatory requirements.

Application statement

This unit applies to the design of refrigeration systems across all forms of manufacturing and engineering. Design activities may also include reverse engineering, design rectification or modifications of an existing design. It is suitable for refrigeration system contractors, heating, ventilation, air conditioning and refrigeration (HVAC/R) consultants, designers and maintenance personnel.

Prior experience in the application of HVAC/R principles, evaluation of HVAC/R systems and thermal loads, mathematics and computer techniques is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their design skills of refrigeration systems in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit:

- the unit applies to industrial and commercial systems and system components
- the unit does not only apply to design of new systems and components but can also apply to modification or rectification of an existing design brief.

Required knowledge

MSA recognises that for high level units such as MEM234016A Design refrigeration systems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of refrigeration system design in one task or employment situation. In order to ensure that a broad capability is covered by training in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

To ensure adequate coverage of the required knowledge listed in the unit, MSA recommends that delivery of this unit should include or emphasise the points listed below. This advice should be read in conjunction with the required knowledge section of the unit of competency.

Environmental factors

The design process should take into account OHS and general environmental factors, including:

- air quality
- energy and water conservation
- carbon pricing and minimisation of CO^2 and fluorocarbon gas emissions.

Theoretical concepts related to refrigeration systems

- concepts of thermodynamics, refrigeration vapour compression process, properties of substances, and conservation of mass and energy principles
- law of Entropy and the Second Law of Thermodynamics, including:
  - *Clausius' statement on the Second Law related to refrigerators and heat pumps*
- Carnot and the temperature scale
- Gibbs T ds equations
- entropy change for ideal gases undergoing arbitrary processes and isentropic processes
- entropy change for incompressible substances and pure substances
- increase in entropy principle
- Carnot Cycle and the Second Law
- Second Law analysis of thermodynamic systems:
  - general expression for the rate of change of entropy for systems or processes
  - reversible and irreversible work, maximum work and availability
  - Second Law analysis of closed systems and open, steady state and transient systems
- ideal and actual vapour-compression refrigeration cycle.

Heat transfer: conduction, convection and radiation

- property tables for conductivity, convection and radiation coefficients
- conduction:
  - Fourier Law of Conduction, conductivity of materials, thermal conductance and resistance
  - conduction through flat plates, composite materials and 'parallel-series' composite walls
  - radial conduction through thin and thick pipes, temperature distribution in a thick hollow cylinder, composite materials, lagged pipes and critical insulation thickness
  - spherical shell conduction
  - variation of thermal conductivity over large temperature ranges
  - systems with heat sources and sinks
  - two and three-dimensional steady state conduction
  - systems using surface protrusions with temperature gradients
  - transients in heat flow
- convection:
  - convection heat transfer coefficient and factors affecting the coefficient
  - fluid velocity profile: boundary sub-layer, transition layer and turbulent flow
  - fluid flow characteristics: geometry of convection surfaces, natural and forced convection and flow regime
  - unit analysis and dimensionless numbers, kinematic viscosity and dynamic viscosity
  - Reynolds Number, Prandtl Number, Nusselt Number and Grashof Number
  - convective heat transfer coefficients for conduit and annular flow, and hydraulic diameter
  - heat exchangers: enthalpy 'balance', arithmetic mean and log mean temperature difference, parallel, counter flow and cross flow heat exchangers
- radiators, emission, absorption and reflection:
  - thermal radiation and the electromagnetic wave spectrum
  - monochromatic emissive power at various temperatures as a function of wavelength
  - Wien's Displacement Law
  - Kirchhoff's Law
  - radiation intensity at a distance from the source
  - radiation properties, black, grey and real bodies, emittance, absorptance and reflectivity

- radiation surface geometry
- radiation in black and grey enclosures

- combined heat transfer:
  - conduction, convection and radiation
  - cooling fins, combustion chambers and rocket engines
- heat flow solutions by analytical, electrical analogy, graphical, numerical, finite element analysis (FEA) and graphical software solution techniques
- general refrigeration systems components and features:
  - heat exchangers and calculation of their capacity
  - evaporators
  - condensers
  - compressors
  - liquid expansion devices
  - system load balance point
  - line sizing
  - refrigerants
  - refrigeration cycle
  - full and partial load performance requirements
- commercial and industrial system automatic controls:
  - commercial refrigeration – functions of an energy management system (E.M.S)
  - E.M.S. control components and the function and operating parameters
  - E.M.S system design, applications, operation and maintenance
- design requirements for food storage systems:
  - controlling and managing risks associated with food storage
  - food processing techniques, including types of heat and chill processing techniques
  - food handling and storage legislative and regulatory requirements
  - food spoilage and possible causes
  - food preservation
  - microorganisms
  - cold storage chain
  - controlled atmosphere storage
  - refrigerant choice

- energy usage
- refrigeration plant
- insulation

- industrial refrigeration systems:
  - design criteria
  - full and partial load performance requirements
  - moderate and low temperature industrial refrigeration systems
  - multiple evaporators and multiple compressors
  - indirect refrigeration systems
  - flooded systems
  - cryogenic systems
  - basic control sequences.

Standards and codes

An understanding of relevant standards and codes is an important part of competency. However, standards can change and different standards may apply for different engineering tasks. The onus is on the RTO to ensure that standards referred to in delivery are appropriate for the application and context. Particular standards and codes at the time of writing of MEM234016A Design refrigeration systems that may apply are listed below. The list is not meant to be exhaustive. Users should ensure they use the latest version.

- AS/NZS 1668 The use of ventialtion and airconditioning in buildings
- ASHRAE 62 Ventialtion for acceptable indoor air quality
- Australian Uniform Building Regulation Coordinating Council (AUBRCC) or Building Council of Australia (BCA) standards and codes
- AS/NZS 3666 Air-handling and water systems of buildings – Microbial control
- AS/NZS 3896 Waters – Examination for Legionella spp. including Legionella pneumophila
- AS 4254 Ductwork for air-handling systems in buildings
- AS 1324 Air filters for use in general ventilation and airconditioning
- AS 5013 Food microbiology
- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS 61508 Functional safety of electrical/ electronic/programmable electronic safety-related systems

- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- AS IEC 61511 Functional Safety – Safety instrumented systems for the process industry sector
- AS/NZS 1200 Pressure equipment
- AS 2593 Boilers – Safety management and supervision systems
- AS 1228 Pressure equipment – Boilers
- AS 1210 Pressure vessels
- AS 2971 Serially produced pressure vessels
- AS 3920 Assurance of product quality – Pressure equipment manufacture
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS/NZS ISO 14001 Environmental management systems
- Air quality and emissions standards set by individual states and territories.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

This unit can be delivered through project-based delivery, through simulation or workplace-based delivery.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a sufficient range of refrigeration design opportunities to ensure valid assessment. Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234016A Design refrigeration systems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234015A	Design heat exchanger systems
MEM234035A	Maintain and apply technical and engineering skills

MSAENV672B Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234017A Design exhaust, ventilation and dust collection systems

MEM234017A Design exhaust, ventilation and dust collection systems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of commercial and industrial exhaust, ventilation and dust extraction systems, in accordance with standards, codes and regulatory requirements. It includes fluid dynamic principles and selection of system components such as ducting, fans and filters.

Application statement

This unit applies to the design of exhaust, ventilation and dust collection systems across all forms of manufacturing and engineering. Design activities may also include reverse engineering, and design rectification or modifications of an existing design. It is suitable for exhaust, ventilation and dust collection system contractors, consultants, designers and maintenance personnel.

Prior experience in the application of thermo and fluid dynamic principles, mathematics and computer techniques is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their design skills of exhaust, ventilation and dust collection systems in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit, for example:

- the design process includes required simulations and it is expected that arrange of solutions to a brief are able to be generated and evaluated
- the unit can apply to new systems or existing systems requiring modification or rectification. However, it should be noted that the skills and knowledge covered by this unit are expected to be able to be applied to exhaust, ventilation and dust collection systems.

Where a new or existing system does not include exhaust, ventilation and dust collection, RTOs should ensure that similarities and differences between all three applications are effectively covered and assessed

- the unit applies to commercial and industrial systems where specific design skills are required, including matching of components to a design brief. The unit does not cover selection of off-the-shelf equipment in situations where analysis of fluid dynamics and simulation and analysis of performance across a variety of options is not required.

Required knowledge

MSA recognises that for high level units, such as MEM234017A Design exhaust, ventilation and dust collection systems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of exhaust, ventilation and dust collection design in one task or employment situation. In order to ensure that a broad capability is covered by training in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. For MEM234017A Design exhaust, ventilation and dust collection systems, the following advice will assist RTOs in determining the scope of their delivery.

To ensure adequate coverage of the required knowledge listed in the unit, MSA recommends that delivery of this unit should include or emphasise the points listed below. This advice should be read in conjunction with the required knowledge section of the unit of competency.

Fluid dynamics

- static, velocity and total pressure in air distribution ducts
- laminar and turbulent flow
- moody diagram
- friction and dynamic pressure loss
- Colebook–White formula.

Fans selection and application

- fan laws
- fan types
- motor ratings
- vibration and noise isolation.

Ducting design

- parameters determining duct design, such as:
  - buckling behaviour

  - hanger spacing
  - vibration and noise damping
  - air volumetric flow and velocity
  - transitions and junctions
- dual and single duct constant volume air systems
- system sizing and balancing methods
- air diffusers, outlet design and location.

Dust collection systems: selection and application

- reverse-jet fabric filter dust collector
- cyclone collectors
- shaker-type
- filter types:
  - replaceable filter bag cabinets
  - filtration media cartridges for collection of mist generated by coolants and machining oils
- air emission levels
- waste capture hoods
- dust collector design issues, such as:
  - material fallout, leading to duct blockage
  - capture and dust suspension velocity
  - discharge system choking, due to positive pressure in the compactor
  - fire prevention.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 1668 The use of ventilation and airconditioning in buildings
- EU Guidelines on ventilation
- ASHRAE 62 Ventilation for acceptable indoor air quality
- Australian Uniform Building Regulation Coordinating Council (AUBRCC) or Building Council of Australia (BCA) standards and codes

- AS/NZS 3666 Air-handling and water systems of buildings – Microbial control
- AS/NZS 3896 Waters – Examination for Legionella spp. including Legionella pneumophila
- AS 4254 Ductwork for air-handling systems in buildings
- AS 1324 Air filters for use in general ventilation and airconditioning
- AS 5013 Food microbiology
- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – principles and guidelines
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems
- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- AS IEC 61511 Functional Safety – Safety instrumented systems for the process industry sector
- AS/NZS 1200 Pressure equipment
- AS 2593 Boilers – Safety management and supervision systems
- AS 1228 Pressure equipment – Boilers
- AS 1210 Pressure vessels
- AS 2971 Serially produced pressure vessels
- AS 3920 Assurance of product quality – Pressure equipment manufacture
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS/NZS ISO 14001 Environmental management systems
- Air quality and emissions standards set by individual states and territories.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on projects that include requirements for research, adherence to a brief, consultations with stakeholders and responsibility to sign-off. Projects may be based on original design, design rectification or

modifications of an existing design and the design process and brief should also include consideration of design factors, including:

- design cost and system capital cost
- maintainability and product life cycle cost
- durability, function, performance and aesthetics
- occupational health and safety (OHS), energy and environmental sustainability and social issues
- equipment availability and worksite restrictions.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as OHS, sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234017A Design exhaust, ventilation and dust collection systems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234003A	Design machines and ancillary equipment
MEM234004A	Design for engineering-related noise and vibration mitigation
MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234018A Design heating, ventilation, air conditioning and refrigeration control systems

MEM234018A Design heating, ventilation, air conditioning and refrigeration control systems.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the design of heating, ventilation, air conditioning and refrigeration (HVAC/R) control and energy management systems. It includes the selection of control system elements to suit HVAC/R environmental and hardware control requirements and development of an energy management plan.

Application statement

This unit applies to the design of control systems and energy management plans across all forms of manufacturing and engineering. Design activities may also include reverse engineering, and design rectification or modifications of an existing design. It is suitable for refrigeration system contractors, HVAC/R consultants, designers and senior maintenance personnel.

Prior or concurrent experience in the evaluation of HVAC/R control systems, hydronic and refrigeration systems and thermal loads, electrical principles, controller programming and computing is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their design skills of heating, ventilation, air conditioning and refrigeration control systems in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit, for example:

- the major design focus of the unit is on designing the HVAC/R control system. For the unit to apply, the design brief for the control system should be sufficiently complex, including requiring environmental and energy management design aspects as well as the normal hardware control functions

- the design process includes modelling and evaluation of a number of solutions to the brief. Design tasks should be evaluated to ensure that there is sufficient complexity to meet the requirements of the unit otherwise a lower level unit may be appropriate

- the unit does not only apply to design of new control systems or existing control systems but also to the design of modifications or rectification of an existing design

- the unit applies to control systems where specific design skills are required, including matching of components to a design brief. The unit does not apply to off-the-shelf or package systems that include predesigned control systems. In particular, care should be taken when applying this unit to domestic and small commercial environments to ensure that the design brief will incorporate the skills and knowledge covered in this unit.

Required knowledge

MSA recognises that for high level units, such as MEM234018A Design heating, ventilation, air conditioning and refrigeration control systems, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of exhaust, ventilation and dust collection design in one task or employment situation. In order to ensure that a broad capability is covered by training in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. For MEM234018A Design heating, ventilation, air conditioning and refrigeration control systems the following advice will assist RTOs in determining the scope of their delivery.

To ensure adequate coverage of the required knowledge listed in the unit, MSA recommends that delivery of this unit should include an appreciation of the points listed below. This advice should be read in conjunction with the required knowledge section of the unit of competency.

Thermodynamics and energy related topics

- conservation of mass and energy principles

- entropy and the Second Law of Thermodynamics

- reversibility and irreversibility

- Clausius' statement on the Second Law related to refrigerators and heat pumps

- Carnot and the temperature scale

- Clausius' inequality and entropy

- Gibbs T ds equations

- entropy change for ideal gases undergoing arbitrary processes and isentropic processes

- entropy change for incompressible substances and pure substances

- increase in entropy principle

- Carnot Cycle and the Second Law

- Second Law analysis of thermodynamic systems
- general expression for the rate of change of entropy for systems or processes
- reversible and irreversible work, maximum work and availability
- Second Law analysis of closed systems and open, steady state and transient systems.

Refrigeration vapour compression process

- properties of substances
- ideal and actual vapour-compression refrigeration cycle
- property tables for conductivity, convection and radiation coefficients
- conduction:
  - Fourier Law of Conduction, conductivity of materials, thermal conductance and resistance
  - conduction through flat plates, composite materials and 'parallel-series' composite walls
  - radial conduction through thin and thick pipes, temperature distribution in a thick hollow cylinder, composite materials, lagged pipes, and critical insulation thickness
  - spherical shell conduction
  - variation of thermal conductivity over large temperature ranges
  - systems with heat sources and sinks
  - two and three-dimensional steady state conduction
  - systems using surface protrusions with temperature gradients
  - transients in heat flow
- convection:
  - convection heat transfer coefficient and factors affecting the coefficient
  - fluid velocity profile: boundary sub-layer, transition layer and turbulent flow
  - fluid flow characteristics: geometry of convection surfaces, natural and forced convection, and flow regime
  - unit analysis and dimensionless numbers, kinematic viscosity and dynamic viscosity
  - Reynolds Number, Prandtl Number, Nusselt Number and Grashof Number
  - convective heat transfer coefficients for conduit and annular flow, hydraulic diameter
  - heat exchangers: enthalpy 'balance', arithmetic mean and log mean temperature difference, parallel, counterflow and cross flow heat exchangers
- radiators, emission, absorption and reflection:

  - thermal radiation and the electromagnetic wave spectrum
  - monochromatic emissive power at various temperatures as a function of wavelength
  - Wien's Displacement Law
  - Kirchhoff's Law
  - radiation intensity at a distance from the source
  - radiation properties, black, grey and real bodies, emittance, absorptance and reflectivity
  - radiation surface geometry
  - radiation in black and grey enclosures
- components and materials:
  - heat exchangers, including calculation of capacity
  - evaporators
  - condensers
  - compressors
  - liquid expansion devices
  - system load balance point
  - line sizing
  - refrigerants.

Design criteria for commercial and industrial systems

- full and partial load performance requirements
- moderate and low temperature industrial refrigeration systems
- multiple evaporators and multiple compressors
- indirect refrigeration systems
- flooded systems
- cryogenic systems
- automated and manual control sequences, including:
  - commercial refrigeration – functions of an energy management system (E.M.S)
  - E.M.S. control components and the function and operating parameters
  - E.M.S system design, applications, operation and maintenance
  - access, maintenance and clean in place control sequences, where specified.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 1668 The use of ventilation and airconditioning in buildings
- EU Guidelines on ventilation
- ASHRAE 62 Ventilation for acceptable indoor air quality
- Australian Uniform Building Regulation Coordinating Council (AUBRCC) or Building Council of Australia (BCA) standards and codes
- AS/NZS 3666 Air-handling and water systems of buildings – Microbial control
- AS/NZS 3896 Waters – Examination for Legionella spp. including Legionella pneumophila
- AS 4254 Ductwork for air-handling systems in buildings
- AS 1324 Air filters for use in general ventilation and airconditioning
- AS 5013 Food microbiology
- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems
- AS 62061 Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems
- AS IEC 61511 Functional Safety – Safety instrumented systems for the process industry sector
- AS/NZS 1200 Pressure equipment
- AS 1210 Pressure vessels
- AS 2593 Boilers – Safety management and supervision systems
- AS 1228 Pressure equipment – Boilers
- AS 1210 Pressure vessels
- AS 2971 Serially produced pressure vessels
- AS 3920 Assurance of product quality – Pressure equipment manufacture
- NOHSC:1010 National Standard for Plant

- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS/NZS ISO 14001 Environmental management systems
- Air quality and emissions standards set by individual states and territories.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on projects that include requirements for research, adherence to a brief, consultations with stakeholders and responsibility to sign-off. Projects may be based on original design, design rectification or modifications of an existing design and the design process and brief should also include consideration of design factors, including:

- adequate spread of design skills across heating, ventilation, air conditioning and refrigeration systems and controls, including energy management and different load cycles
- integration with other systems (e.g. building management systems)
- design cost and system capital cost
- maintainability and product life cycle cost
- durability, function, performance and aesthetics
- occupational health and safety (OHS), energy and environmental sustainability and social issues
- equipment availability and worksite restrictions.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234018A Design heating, ventilation, air conditioning and refrigeration control systems, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234003A	Design machines and ancillary equipment
MEM234004A	Design for engineering-related noise and vibration mitigation
MEM234015A	Design exhaust, ventilation and dust collection systems

MEM234031A	Manage installation, commissioning or modification of machines and equipment
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234020A Coordinate small lot manufacture using rapid manufacture processes

MEM234020A Coordinate small lot manufacture using rapid manufacture processes.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below:

Unit descriptor

This unit of competency covers the coordination of rapid manufacture (RM), rapid prototyping (RP) and rapid tooling (RT) processes for single or small lot production. It includes choice of materials, machinery and processes, generation of data and post-processing.

Application statement

This unit applies to the RM of components or prototypes across all forms of manufacturing and engineering. It is suitable for manufacturing maintenance technicians, component and tool designers, and those pursuing engineering or related qualifications and careers.

Prior experience in the application of computer-aided design (CAD), computing technology, mathematics, scientific principles and techniques, materials, methods, processes and mechanical construction techniques is required.

MSA comments

The unit descriptor gives some examples of what could be designed using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a learner is not expected to be able to apply their coordination of small lot manufacture using rapid manufacture processes in all application areas listed in the application statement. Some guidance on when it is appropriate to select this unit can be found by a careful reading of the above statements and other sections in the unit, for example:

- RM, RP and RT can all be covered by this unit. However, users need to note that knowledge of all three processes is required sufficient to ensure that the selected process is suitable for the object application. The unit also assumes that advice can be given on whether a more traditional manufacturing process is suitable than the processes covered by this unit
- the unit does not require original authoring of the CAD model, although this can be covered as part of the unit. However, the unit does require the ability to undertake a comprehensive check of CAD files at both pre-processing and post-processing stages.

Required knowledge

MSA recognises that for high level units, such as MEM234020A Coordinate small lot manufacture using rapid manufacture processes, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of coordinating small lot RM, RP or RT processes in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. The required knowledge section of the unit indicates the broad knowledge required to be able to effectively coordinate small lot RM, RP or RT processes. The following advice is intended to elaborate the required knowledge section of the unit of competency and should be should be read in conjunction with that section of the unit.

Factors affecting material, machine and prototype process selection

Factors include:

- raw material properties
- required component or object strength
- component or object function
- component or object finish and aesthetics
- component or object size limitations
- combining components.

Current developments in machine and process capabilities for direct and indirectly manufactured components or tools, including the use of:

- digitisers and reverse engineering processes
- selective laser sintering (SLS)
- fused deposition modelling (FDM)
- stereolithography (SLA)
- laminated object manufacturing (LOM)
- electron beam melting (EBM)
- 3-D printing (3-DP)
- solid freeform fabrication
- sprayed metal deposition
- direct metal deposition (DMD)
- casting: patternless and rapid pattern processes

- vacuum forming
- rapid machining (subtractive) options:
  - computer numeric control (CNC)
  - computer-aided manufacture (CAM)
- rapid cutting options, such as:
  - computer driven gas and laser cutting
- robot and auto welding.

Additive 'printing' process materials

- thermoplastics
- metals:
  - powders, eutectic metals and titanium alloys
- photopolymer
- paper.

Materials for sprayed metal deposition

- printed pattern materials
- ceramic bases
- tool steels, stainless and carbon steels
- copper alloys.

Materials for rapid casting

- printed pattern materials
- mould materials
- sand.

Standards and codes

When delivering this unit, reference to relevant standards and codes should be required. Standards and codes may be Australian or international. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- ISO 9001 Quality management systems
- AS/NZS 4801 Occupational health and management systems

- ISO 13485 Medical devices – Quality management systems
- AS/NZS ISO 14000 Environmental management.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on a realistic brief that integrates engineering and technical process design requirements, choice of process with budget, efficiency, regulatory and occupational health and safety (OHS) considerations. The project should be of sufficient duration to allow detailed evaluation of the selected process performance against design requirements.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing the timeframe and project allow for sufficient rigour.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as OHS, sustainability and life cycle analysis). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234020A Coordinate small lot manufacture using rapid manufacture processes, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234008A	Design plant using computer simulations
MEM234009A	Design computer-integrated manufacturing systems
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234026A Develop and coordinate engineering-related contingency plans

MEM234026A Develop and coordinate engineering-related contingency plans.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance within the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills required to develop and coordinate contingency plans for engineering projects or operations that provide for recovery from a major incident or non-conformance.

Application statement

This unit applies to contingency planning for engineering-related projects or operations across all forms of manufacturing and engineering. Activities covered include systematic analysis of the engineering activity to identify major risks, developing appropriate responses and coordinating the implementation of contingency plans into operations. It embraces personal and electronic communication, self-directed and group activities, business planning, employee briefing and training, project or operations planning and scheduling, and an understanding of the technology, skills, techniques and quality requirements of the project or operations.

This unit does not cover the planning required to contain/remediate an emergency non-conformance, such as a fire or explosion. Relevant emergency management skills from other Training Packages should be accessed for these skills.

MSA comments

The unit descriptor gives an indication of the scope of planning and management using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a candidate is not expected to be able to apply their skills in all application areas listed in the application statement.

Typical work situations where this unit could apply are defined in the application statement. An example might be an individual working in a contractor to an automotive company that is locked into a continuous supply contract with large financial penalties attached to failure to supply on time and at the specified quality level. The individual is asked to prepare contingency plans related to equipment failure and/or failure by suppliers to deliver raw materials, other items and services to the required volume, quality and time.

Some of the risks that could be considered in the contingency plan are outlined in the range statement of the unit. Additional risks may also be included depending on the nature of the engineering operation. Examples could include:

- labour and skill shortages (determined based on calculations of minimum manning levels against current and future orders or scheduling scenarios, and so on)
- external risks that a company has little control over, such as global financial crisis, changes in government legislation or policies, and so on.

In today's business climate even the best prepared plans must be flexible enough to meet and overcome unexpected challenges.

In general, all projects involve some risk, and following the identification of the risk, it is then essential to develop effective response strategies, and contingency plans to deliver projects that meet stakeholder demands. In manufacturing and engineering-related operations, these response strategies and contingency plans will usually involve using engineering skills and knowledge to ensure responses are safe, consistent with capacity, and protect equipment and facilities.

Many of these contingencies/risks can also be planned for or significantly reduced through using practices/concepts/techniques described throughout other Vocational Graduate Diploma units. Examples include:

- MEM234012A Design integrated maintenance management systems
- MEM234013A Plan and design engineering-related manufacturing processes
- MEM234033A Lead engineering-related quality operations in an enterprise.

These units include techniques, such as failure modes and effects analysis (FMEA), mean time between failures (MTBF), capability analysis of equipment (load and speed limits, etc.), condition monitoring, and so on, which can contribute to contingency planning.

For these reasons, every opportunity should be made to co-deliver and co-assess this unit with these other Vocational Graduate Diploma units.

It is expected that the engineering skills and knowledge must be able to be applied autonomously or as part of a team and show sound judgment based upon the application of engineering and scientific principles.

In addition, it is expected that engineering skills and knowledge are able to be applied effectively in conjunction with typical financial planning, accounting and legal processes which may relate to an engineering project or operation, together with human resource aspects. The unit also requires effective communication and engineering leadership with other professionals, tradespersons and stakeholders involved in the project or operation who may depend on the individual’s engineering skills and knowledge.

Based on the above, it is unlikely that the unit will be suitable for someone who does not have prior experience or an opportunity to concurrently gain experience through participation in complex engineering projects or operations.

Required skills and knowledge

MSA recognises that for high level units, such as MEM234026A Develop and coordinate engineering related contingency plans, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of planning and managing a project or operation in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required skills and knowledge sections of the unit indicate the requirements to be able to effectively develop and coordinate engineering-related contingency plans. A combination of engineering and more general skills and knowledge is specified. Particular attention is drawn to the required skills of:

- evaluating solutions for feasibility against engineering design or specification criteria, including relevant engineering calculations and analysis
- using and validating performance analysis, modelling and simulation software for contingency-related analyses.

The above two required skills clearly demonstrate the engineering focus of the unit and are useful in determining appropriate delivery and assessment strategies.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on engineering-related projects or operations that are subject to potential or real disruptions or other potential non-conformances.

RTOs should consider that learners may want to bring their own project or situation from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as management, OHS and sustainability). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234026A Develop and coordinate engineering-related contingency plans, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234002A	Integrate engineering technologies
MEM234012A	Design integrated maintenance management systems

MEM234013A	Plan and design engineering related manufacturing processes
MEM234033A	Lead engineering related quality operations in an enterprise
MEM234035A	Maintain and apply technical and engineering skills
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234027A Plan and manage materials supply for an engineering project or manufacturing operation

MEM234027A Plan and manage materials supply for an engineering project or manufacturing operation.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below:

Unit descriptor

This unit of competency covers the engineering skills and knowledge required to plan and manage all aspects of the supply of materials to an engineering project or operation. It includes managing supplier identification and negotiations, purchasing and scheduling, including the interpretation of client, design, marketing, sales and production requirements to enable matching to available resources, budgets, workforce and contractors. It also includes the control of processes, physical resources, workforce skills and resources to enable the use of assets within budget requirements.

Application statement

This unit applies to people who require significant engineering skills and knowledge to plan and manage supply, scheduling and purchasing of materials across all forms of manufacturing and engineering. Typical applications would be where there are:

- *many material inputs, major assembly lines or manufacturing cells, such as whitegoods and vehicle manufacturing*
- *heavy and light fabrication involving significant use of material*
- *requirements to either determine, select or interpret technical specifications and standards for purchasing, scheduling and production planning.*

The unit can provide technical support training where the planning, scheduling and purchasing is done in an engineering or manufacturing organisation following lean principles. In this situation it is recommended that the unit be co-delivered with appropriate Manufacturing Skills Australia (MSA) Competitive Systems and Practices units of competency.

Prior or concurrently developed capability in personal and electronic communication, self-directed and group activities, planning and scheduling, performance analysis, process control

and improvement, and an understanding of technology, skills and techniques, and quality aspects required by operations is required.

MSA comments

The unit descriptor gives an indication of the scope of planning and management using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a candidate is not expected to be able to apply their skills in all application areas listed in the application statement.

A typical work situation where this unit could apply includes:

- A Principal Technical Officer with the responsibility for:
  - the selection and approval of vendors in accordance with specification and target cost where the process also includes an assessment of engineering capability of the vendor
  - acquisition of materials from selected vendors as required to meet project or production schedules where the sourcing schedule is not supplied or must be calculated using engineering skills and knowledge related to the engineering project or operation.

It is expected that engineering skills and knowledge defined in the unit must be able to be applied autonomously or as part of a team and sound judgment exercised based upon the application of engineering and scientific principles.

In addition, it is expected that the engineering skills and knowledge are able to be applied effectively in conjunction with typical financial planning, accounting and legal processes which may relate to planning and managing materials supply in an engineering environment together with human resource aspects. The unit also requires effective communication and engineering leadership with other professionals, tradespersons and stakeholders involved in the project or operation who may depend on the individual's engineering skills and knowledge.

Based on the above, it is unlikely that the unit will be suitable to someone who does not have prior experience or an opportunity to concurrently gain experience through participation in complex engineering projects or operations.

Required skills and knowledge

MSA recognises that for high level units, such as MEM234027A Plan and manage materials supply for an engineering project or manufacturing operation, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of planning and managing a project or operation in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required skills and knowledge sections of the unit indicate the requirements to be able to effectively plan and manage projects or operations using not only management skills but particular

engineering skills and techniques where required. Particular attention is drawn to the required skills of:

- engineering and manufacturing management systems and philosophies relevant to planning and managing materials supply
- managing supplier contracts and arrangements to meet the needs of an engineering project or manufacturing operation.

These technical skills need to be properly integrated with the more management related skills to generate an appropriate materials supply focus in the delivery of this unit.

The required knowledge listed in the unit covers a range of knowledge from other professional and technical areas that a person would need to know to be able to effectively manage material supply in an engineering-related project or operation. However, it is important to realise that this knowledge should be applied in conjunction with the ability to discern when technical and professional assistance from other specialists should be sought (see Performance Criteria 1.4).

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on the planning and managing of materials supply for an engineering project or manufacturing operation that requires significant engineering input and be preferably a project that will give opportunities for determining when assistance from other technical and professional specialists is required. For example, projects based on the work situations described previously could be used.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the engineering-related supply tasks (e.g. technical as well as management, OHS and sustainability). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234027A Plan and manage materials supply for an engineering project or manufacturing operation, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234002A	Integrate engineering technologies
MEM234030A	Provide specialised technical and engineering guidance to other technical employees
MEM234035A	Maintain and apply technical and engineering skills

MSAENV672B	Develop workplace policy and procedures for environmental sustainability
MSS405023A	Develop a levelled pull system for operations and processes
MSS407009A	Facilitate improvements in the external value stream
MSS408004A	Develop the value stream

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234028A Produce and manage technical documentation

MEM234028A Produce and manage technical documentation.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills and knowledge required to develop and produce engineering-related technical documentation and to manage documentation distribution and use within an organisation.

Application statement

This unit applies where engineering skills and knowledge are required for the production and management of technical documentation for use within an organisation and by other users, such as contractors and dealers. Technical documentation may include production control records, work instructions and standard operating procedures, process specifications, occupational health and safety (OHS) procedures, quality procedures, contractor instructions, and documentation required to comply with legislative and regulatory requirements.

MSA comments

There are two key criteria for this unit to apply:

1. The documentation being produced and managed must be technical in content.

2. Engineering skills and knowledge are required for the production and management of the documentation. This rules out situations where technical documentation is being managed by a person (e.g. by a librarian), but engineering skills and knowledge are not required to undertake the work.

Where the above criteria do not apply, it may be more appropriate to select more general document control units such as those found in the BSB07 Business Services Training Package or the CUL11 Library, Information and Cultural Services Training Package.

The range statement indicates the broad range of technical documentation covered by the unit. An important aspect of the selection of this unit is understanding when this unit applies as opposed to the related but distinct unit MEM234029A Produce and manage technical publications. The choice of unit will depend on a careful evaluation of the each situation and type of information and

communication desired. While not an exclusive list, situations where the unit MEM234028A Produce and manage technical documentation could apply are when one or more of the following considerations are present:

- the engineering-related information is not going to be widely distributed outside the organisation as a formally published document
- the target group for the documentation is internal or in a direct relationship to the enterprise (e.g. a contractor)
- distribution and copying is fully under the control of the organisation and layout and presentation is not critical (i.e. a normal level of word processed documentation as used in the organisation is required)
- the publication is unlikely to be formally catalogued and referenced by external organisations. However, the content must be accurate and capable of being relied upon by readers.

A learner is not expected to be able to apply their skills and knowledge in all application areas listed in the range statement. A typical work situation where this unit could apply would be:

- A Principal Technical Officer who is required to research design information, equipment manufacturer's instructions and regulatory requirements, and then operating procedures and process documentation for use by maintenance and production personnel in a manufacturing enterprise. The Principal Technical Officer must investigate the technical requirements of customers, regulators and manufacturers (in order to maintain warranties) and then interpret and analyse these requirements in order to effectively present the required technical information in a manner that encourages understanding and compliance by the target groups.

Required skills and knowledge

MSA recognises that for high level units, such as MEM234028A Produce and manage technical documentation, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of the unit in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required skills and knowledge sections of the unit indicate the requirements to be able to effectively produce and manage technical publications using particular engineering skills and techniques, where required. Particular attention is drawn to the following points in the required skills and knowledge sections:

- typical sources for researching engineering and technical data for applications and discipline area
- analysing, designing, planning, executing and verifying content requirements against engineering and other technical data from original sources.

The above two points indicate why engineering skills and knowledge are critical to the technical documentation processes covered by this unit.

A key requirement also is for the learner to be able to determine when to apply their own engineering skills and knowledge and when to obtain input from specialists in other fields and disciplines. This decision is not meant to be random but part of a carefully considered strategy.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on an integration task as outlined in the range statement. The integration must require application of engineering skills and knowledge across a range of engineering technologies and systems and include researching and analysing any required regulatory impact on the engineering operation. The integration task may or may not go across disciplines or technical fields of work.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope (e.g. technical as well as OHS, sustainability and risk assessment). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234028AProduce and manage technical documentation, there are many units in the MEM80111 Vocational Graduate Diploma of Engineering where co-delivery can occur and which may add to the learning experience. In particular co-delivery could occur where responsibilities and required skills cover technical publications as well as technical documentation. In this case co-delivery could occur with the unit MEM234029A Produce and manage technical publications.

Other suggestions for co-delivery include the technically focused Vocational Graduate Diploma design units where the designer is responsible for accurately ensuring technical publications adequately convey all elements of the design. An example would be the unit MEM234003A Design machines and ancillary equipment.

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234029A Produce and manage technical publications

MEM234029A Produce and manage technical publications.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills and knowledge required to develop and produce engineering-related technical publications and to manage publications within the organisation

Application statement

This unit applies where engineering skills and knowledge are required for the production and management of technical publications for use within the organisation and by downstream users, such as contractors and final customers.

Applications include workshop manuals, operating instructions, parts catalogues, procedures manuals and related technical publications.

MSA comments

There are two key criteria for this unit to apply:

1. The publications and documents being produced and managed must be technical in content.

2. Engineering skills and knowledge is required for the production and management of the publications. This rules out situations where technical documentation is being managed by a person (e.g. by a librarian), but engineering skills and knowledge are not required to undertake the work.

Where the above criteria do not apply, it may be more appropriate to select more general document control units such as those found in the BSB07 Business Services Training Package or the CUL11 Library, Information and Cultural Services Training Package.

The Range Statement indicates the broad range of publications covered by the unit. A learner is not expected to apply their skills and knowledge in all application areas listed in the range statement. A typical work situation where this unit could apply would be:

- A product engineer whose responsibilities include researching, writing, laying out, editing and revising user's manuals, installation guides, field service and troubleshooting manuals, including planning the presentation of illustrations, graphics and photographs and then

managing publication, issue control and amendments in accordance with organisation policies.

Required skills and knowledge

MSA recognises that for high level units, such as MEM234029A Produce and manage technical publications, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of the unit in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required skills and knowledge sections of the unit indicate the requirements to be able to effectively produce and manage technical publications using particular engineering skills and techniques where required. Particular attention is drawn to the critical aspects for assessment of:

- conduct research and gather required data from engineering records and relevant engineering staff and managers
- select appropriate publication media and publication style and format
- use selected software packages to draft technical publications
- manage the production and devise distribution, amendment and version control systems.

A key requirement also is for the learner to be able to determine when to apply their own engineering skills and knowledge and when to obtain input from specialists in other fields and disciplines. This decision is not meant to be random but part of a carefully considered strategy.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on an integration task as outlined in the range statement. The integration must require application of engineering skills and knowledge across a range of engineering technologies and systems. The integration task may or may not go across disciplines or technical fields of work.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as OHS, sustainability and risk assessment). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234029A Produce and manage technical publications, there are many units in the MEM80111 Vocational Graduate Diploma of Engineering

where co-delivery can occur and which may add to the learning experience. In particular co-delivery could occur where responsibilities and required skills cover documentation as well as technical publications. In this case co-delivery could occur with the unit MEM234028A Produce and manage technical documentation.

Other suggestions for co-delivery include the technically focused Vocational Graduate Diploma design units where the designer is responsible for accurately ensuring technical publications adequately convey all elements of the design. An example would be the unit MEM234003A Design machines and ancillary equipment.

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234030A Provide specialised technical and engineering guidance to other technical employees

MEM234030A Provide specialised technical and engineering guidance to other technical employees.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the provision of technical advice, including mentoring to other technical and paraprofessional employees, usually but not always, working in the same technical field or discipline.

Application statement

This unit applies across all forms of manufacturing and engineering where an individual is using their professional skills and knowledge to provide engineering and technical guidance to other technical employees within the organisation. Examples of technical guidance situations include acting as a technical resource person to other technical employees or teams, or mentoring of other technical employees because of specialised skill and knowledge.

The emphasis in this unit is on the provision of technical advice usually as part of day-to-day operations where the person is not in a formally designated managerial or leadership role. The unit assumes technical competence to Advanced Diploma of Engineering level or equivalent industrial experience.

Where formal leadership and management of engineering and related projects or operations applies see the unit MEM234001A Plan and manage engineering-related projects or operations or other subject specific engineering leadership units, such as:

- *MEM234031A Manage installation, commissioning or modification of machines and equipment*
- *MEM234032A Manage fluid power related technologies in an enterprise*
- *MEM234033A Lead engineering-related quality operations in an enterprise.*

This unit does not cover the giving of general advice associated with conditions of employment, such as career planning and wages.

MSA comments

The key indicators for the application of this unit are:

- the advice given must be technical in nature
- the person giving the advice must be using their own specialised engineering skills and knowledge
- the advice must be given to other technical employees.

Typical work situations where this unit could apply include:

- A Principal Technical Officer who is providing engineering leadership for an engineering project, service, function or facility and who identifies a risk factor because another technical employee may not have sufficient skills and knowledge in a particular engineering area. The Principal Technical Officer would be expected to explore the engineering issue with the other technical employee to gauge whether the situation can be resolved together or more specialist assistance is required. The Principal Technical Officer would be expected to use their own engineering skills and knowledge to make this judgment.
- A fluid power expert engineering technologist working in a multi-disciplinary and multi-level engineering team undertaking the design of a complex machine. The person must guide other fluid power members of the team who are qualified at a lower level as well as providing guidance to specialists in other disciplines.
- Mentoring and guidance to a new technical employee, including ensuring risks are identified and quality of engineering operations are maintained during the settling in period of the new employee.

In planning for the delivery of this unit it is important that RTOs do not approach the unit solely as a generalist training/coaching unit. In particular, the unit is distinguished from other units by the requirement to integrate engineering skills and knowledge with good oral and written communication while at the same time demonstrating an orderly management of situations and good professional conduct. This is illustrated by the following extracts from the required skills section of the unit:

- *identifying a range of information sources to develop and strengthen present engineering knowledge of other technical employees*
- *proposing options to achieve engineering solutions within discipline area*
- *proposing means of testing, measuring and evaluating solutions that fit with organisation objectives and accepted engineering practice*
- *providing advice on engineering-related costs and risks*
- *encouraging learning and professional practice in other engineering and technical employees, including adherence to legislative and regulatory requirements and ethical, OHS and quality standards.*

Required skills and knowledge

MSA recognises that for high level units, such as MEM234030A Provide specialised technical and engineering guidance to other technical employees, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to possess technical skills and knowledge covering every situation where they provide advice. In particular, the advice given may be to assist in a professional and structured determination of whether other engineering or professional assistance is needed. For example, after working through an issue with another technical employee, a decision may be reached that a professional engineer should be consulted or a specialist in another area consulted (e.g. a legal practitioner may be asked to evaluate a liability issue before engineering design work proceeds). In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery. This is particularly relevant in the context of assessment against performance criteria 1.4) '*Identify whether request is within own discipline and skills and knowledge or should be referred to other expert technical or professional assistance'.*

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on advice situations that meet the key indicators mentioned previously and be preferably projects that will give opportunities for determining when assistance from other technical and professional specialists is required. For example, projects based on the work situations described in this guide could be used.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope. Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234030A Provide specialised technical and engineering guidance to other technical employees, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234031A Manage installation, commissioning or modification of machines and equipment

MEM234031A Manage installation, commissioning or modification of machines and equipment in an engineering project or manufacturing operation.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills and knowledge required to provide the technical leadership role in the installation, commissioning or modification of machines and equipment. It includes interpreting manufacturer specifications, implications of relevant regulations, internal or external client brief, liaison with designers, and ensuring that team members are aware of technical and performance requirements.

Application statement

This unit applies to the installation, commissioning or modification of significant machines and equipment across all forms of manufacturing and engineering. The unit applies to individuals who are required to provide high level technical leadership to other members in the installation, commissioning or modification team. The other members of the team will normally include engineering tradespersons and may also include technicians and production personnel.

The unit complements the more general technical leadership and management skills found in MEM234001A Plan and manage engineering-related projects or operations. Informal technical or engineering advice situations are covered by the unit MEM234030A Provide specialised technical and engineering guidance to other technical employees.

This unit does not supply all technical skills and knowledge required for machine and equipment installation, commissioning or modification tasks. The required technical skills will depend on the particular task and will normally be covered through selection of relevant technical units as well as the combined skills and knowledge of the team. However, the unit presumes engineering skills and knowledge to at least Advanced Diploma level.

MSA comments

The unit descriptor gives an indication of the scope of planning and management using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. It is important to note the reference to application to the installation, commissioning or modification of significant machines and equipment. Significant is not defined specifically in the unit because of the wide range of machinery and equipment used in industry. However, guidance on what is significant is given through the definition in the range statement of installation, commissioning or modification. This definition states:

- *Installation, commissioning or modification refers to machinery and equipment projects that have the following features:*
  - *the performance of the whole machine or equipment must be verified against drawings, client brief and manufacturer specifications at the conclusion of the project*
  - *skills and knowledge above the trade level are required for planning and supervising the installation, commissioning or modification project*
  - *work is conducted against a formal design.*

Machines and equipment that do not require the verification or technical skills mentioned in the above definition are unlikely to be sufficiently significant for this unit to apply.

Listed below are typical work situation where this unit could apply:

- A manufacturing or plant engineer directing the installation and commissioning of a new boiler supplying steam throughout a factory. The installation and commissioning is to include a range of tests, including:
  - testing of temperature and pressure of delivered steam at selected test points in the factory
  - testing of start-up and shutdown procedures including emergency shutdown procedures
  - identification with supplier of preventative and breakdown maintenance procedures, critical spares that need to be held and operator training procedures.

Other examples could be:

- a new product or order volume requires major modification to existing machines and equipment
- a company is moving to new premises and existing machinery and equipment needs to be relocated to the new premises including connection of services and testing after relocation.

It is expected that engineering skills and knowledge defined in the unit must be able to be applied autonomously or as part of a team and sound judgment exercised based upon the application of engineering and scientific principles.

In addition, it is expected that engineering skills and knowledge are able to be applied effectively in conjunction with typical human resource aspects, financial planning, accounting, legal and safety processes which may relate to managing the installation, commissioning or modifications of equipment in an engineering environment. The unit also requires effective communication and engineering leadership with other professionals, tradespersons and stakeholders involved in the project or operation who may depend on the individual's engineering skills and knowledge.

Based on the above, it is unlikely that the unit will be suitable to someone who does not have prior experience or an opportunity to concurrently gain experience through participation in installation, modification or commissioning tasks

Required skills and knowledge

MSA recognises that for high level units, such as MEM234031A Manage installation, commissioning or modification of machines and equipment, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of installation, commissioning or modification in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required skills and knowledge sections of the unit indicate the requirements to be able to effectively manage installation, commissioning or modification of machines and equipment. These tasks require both management skills and engineering skills and knowledge. Particular attention is drawn to the required engineering skills and knowledge as it is these that distinguish this unit from more management focused units. Examples include:

- identifying problems that require solutions involving computations, such as rate of change, moments of inertia and friction forces, and arranging for, or undertaking, the required computations
- purpose of and range of systems typically found in modern machinery and equipment, including:
  - hydraulics
  - pneumatics
  - electrical motors, electrical supply and associated equipment

- electronics, mechatronics and other control systems
- mechanical transmissions, including gears, shafts and clutches

- force and stress analysis techniques.

Other engineering skills and knowledge may be required for the installation, commissioning or modification task. These should come from prior or concurrent study or work experience or from other members of the team. In particular, the required skill of 'identifying situations and issues that require additional technical or professional assistance' needs to be taken into account when preparing training delivery and assessment.

These technical skills need to be properly integrated with the more management related skills to generate an appropriate focus in the delivery of this unit.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on the management of installation, commissioning or modification of machines and equipment that require significant engineering input and preferably be projects that will give opportunities for determining when assistance from other technical and professional specialists is required. For example, projects based on the work situations described previously could be used. In selecting projects, the capacity to meet the following critical aspects of evidence requirements should be considered.

- determining steps and processes needed for machine and equipment commissioning
- determining steps and processes needed for machine and equipment installation
- verifying machine and equipment performance to specifications after installation, commissioning or modification.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as management, OHS and sustainability). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234031A Manage installation, commissioning or modification of machines and equipment, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies

MEM234012A Design integrated maintenance management systems

MEM234013A Plan and design engineering-related manufacturing processes

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234032A Manage fluid power related technologies in an enterprise

MEM234032A Manage fluid power related technologies in an enterprise.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below:

Unit descriptor

This unit of competency covers the skills required to provide a technical leadership role in the installation, maintenance and productivity, quality enhancement of fluid-related technologies in an enterprise.

It includes awareness of current options and trends in fluid power design, interpreting manufacturer specifications, production requirements, implications of relevant regulations, internal or external client brief, liaison with designers and ensuring that team members are aware of technical and performance requirements.

Application statement

This unit applies to a technician who is providing technical leadership in the installation, maintenance and quality, productivity enhancement of fluid-related technologies in an enterprise, including fluid power control systems; hydraulic systems, including hydrostatic transmissions, proportional and servo valve control; and programmable logic controller (PLC) control.

The unit covers the fluid power technologies in equipment, such as robotics; fluid power drives; mobile equipment using fluid power; such as earthmoving equipment, compressors, pumps, and compressed air distribution systems across all forms of manufacturing and engineering.

The unit applies to individuals who are required to provide high level technical leadership to other members in the installation, commissioning or modification team. The other members of the team will normally include engineering tradespersons and may also include technicians and production personnel.

The unit complements the more general technical leadership and management skills found in MEM234001A Plan and manage engineering-related projects or operations. Informal technical or engineering advice situations are covered by the unit MEM234030A Provide specialised technical and engineering guidance to other technical employees.

This unit does not supply all technical skills and knowledge required for fluid power related tasks. The required technical skills will depend on the particular task and will normally be covered through the combined skills and knowledge of the team. However, the unit presumes engineering skill and knowledge to at least Advanced Diploma level.

MSA comments

The unit descriptor gives an indication of the scope of planning and management using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency.

The unit is focused on technical management of fluid power systems, including technical supervision during installation, commissioning and modification of systems. In addition, the unit also focuses on how engineering-related skills and knowledge of fluid power can contribute to enterprise performance. This is not only referenced in the application statement but also in other sections of the unit, for example:

- both performance and production requirements of fluid power equipment must be taken into account (PC 1.2)
- performance analysis and modelling, including use of appropriate software is required (required skills section).

Interpretation of the scope of the unit can also be assisted by reading the range statement definition for fluid power related technologies which covers hydraulic and pneumatic systems used for both industrial and mobile applications.

Listed below are typical work situation where this unit could apply:

- supervising the installation of pneumatic conveying systems in flour and stock feed mills
- managing fluid power maintenance across a fleet of earthmoving equipment, including preventative and breakdown maintenance, as well as supervising any required modifications
- development of risk management and regulatory compliance procedures for use of robotics in an enterprise.

It is expected that the engineering skills and knowledge defined in the unit must be able to be applied autonomously or as part of a team and sound judgment exercised based upon the application of engineering and scientific principles. In addition, it is expected that engineering skills and knowledge are able to be applied effectively in conjunction with typical human resource aspects, financial planning, accounting, legal and safety processes which may relate to managing the installation, commissioning or modifications of fluid power systems.

Based on the above, it is unlikely that the unit will be suitable to someone who does not have prior or an opportunity to concurrently gain fluid power engineering experience.

Required skills and knowledge

MSA recognises that for high level units, such as MEM234032A Manage fluid power related technologies in an enterprise, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of the unit in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery to ensure that the elements, performance criteria and required skills and knowledge are adequately covered.

Particular attention is drawn to the required engineering skills and knowledge as distinct from more general management-focused units. Examples include:

- interpreting fluid power design and detailed drawings
- identifying sustainability and environmental issues and implications for the fluid power system
- selecting and using software and validation techniques, including 2-D and 3-D modelling
- principles of fluid power systems
- dimensions, capacity and position of system components
- electrical and mechanical behaviours of fluid power systems and system responsiveness
- hydraulics and hydraulics components
- applications and characteristics of servo valves
- electronic controllers for proportional and servo valves
- sensor/transducer/amplifiers
- pneumatics and designing with pneumatic components
- multiple actuator control circuits
- compressed air system design.

Other engineering-related skills and knowledge may be required for the installation, commissioning or modification task. These should come from prior or concurrent study or work experience or from other members of the team. In particular, the required skill of 'identifying situations and issues that require additional technical or professional assistance' needs to be taken into account when preparing training delivery and assessment.

These technical skills need to be properly integrated with the more management-related skills to generate an appropriate focus in the delivery of this unit.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

This unit should preferably be delivered through workplace-based projects and be based preferably on projects that give opportunities for determining when assistance from other technical and professional specialists is required. Examples of projects include:

- managing fluid power technologies across a production facility, including industrial robots, transfer and conveyor. Responsibilities could include supervision of maintenance, modifications, installation and commissioning
- managing fluid power equipment testing and calibration
- ensuring fluid power services and facilities comply with relevant standards, workplace health and safety and environmental regulations and enterprise procedures
- liaison with fluid power equipment suppliers and contractors over technical requirements.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope. Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Standards and codes

When delivering this unit, reference to relevant standards and codes may be required. Users should ensure they use the latest version. Examples include:

- AS 4024 Safety of machinery
- AS/NZS ISO 31000 Risk management – Principles and guidelines
- NOHSC:1010 National Standard for Plant
- NOHSC:1014 National Standard for the Control of Major Hazard Facilities
- AS 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems – General requirements.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234032A Manage fluid power related technologies in an enterprise, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations

MEM234002A	Integrate engineering technologies
MEM234030A	Provide specialised technical and engineering guidance to other technical employees
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234033A Lead engineering-related quality operations in an enterprise

MEM234033A Lead engineering-related quality operations in an enterprise.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills and knowledge required to provide a technical leadership role in the coordination of quality operations in an enterprise on an ongoing or project basis.

It includes knowledge of relevant regulations, interpreting internal or external client brief, liaison with designers and other professional and technical specialists, and ensuring that organisation members are aware of technical and performance requirements.

Application statement

This unit applies to a Principal Technical Officer or equivalent who is providing high level technical leadership in the coordination of engineering-related quality operations and quality-related projects across all forms of manufacturing and engineering, including small run/single lot production. The technical officer may provide this leadership working alone or with a team in which case other members of the team may include technicians, production personnel and engineering tradespersons.

The leadership situations covered by this unit include quality project or quality operations responsibilities that require significant understanding of the technologies, procedures and equipment used in the enterprise and the skills and capabilities required by the quality team in order to be effective.

The unit complements the more general technical leadership and management skills found in MEM234001A Plan and manage engineering-related projects or operations. Informal technical or engineering advice situations are covered by the unit MEM234030A Provide specialised technical and engineering guidance to other technical employees.

This unit does not supply engineering and mathematical skills and knowledge required for quality-related tasks. The required engineering and mathematical skills will depend on the particular processes and technologies used in the enterprise and will normally be covered

through the combined skills and knowledge of the team. However, the unit presumes engineering skills and knowledge to at least Advanced Diploma level.

MSA comments

The unit descriptor gives an indication of the scope of the engineering-related planning and management using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a candidate is not expected to be able to apply their skills in all application areas listed in the application statement.

A typical work situation where this unit could apply includes a Principal Technical Officer with responsibility for:

- aligning enterprise outputs products or services with customer requirements
- identifying defective processes or procedures
- establishing the engineering-related key process input/output variables
- establishing action plans and putting control systems in place
- contributing to current or new product, process or procedure design.

It is expected that engineering skills and knowledge defined in the unit must be able to be applied autonomously or as part of a team and sound judgment exercised based upon the application of engineering and scientific principles.

In addition, it is expected that engineering skills and knowledge are able to be applied effectively in conjunction with typical financial planning, accounting and legal processes which may relate to leading engineering-related quality operations together with human resource aspects. The unit also requires effective communication and engineering leadership with other professionals, tradespersons and stakeholders involved in the project or operation who may depend on the individual's engineering skills and knowledge.

Based on the above, it is unlikely that the unit will be suitable to someone who does not have prior experience or an opportunity to concurrently gain experience through participation in engineering-related quality operations in an enterprise.

Required skills and knowledge

MSA recognises that for high level units, such as MEM234033A Lead engineering-related quality operations in an enterprise, comprehensive engineering skills and knowledge are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of leading engineering-related quality operations in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required skills and knowledge sections of the unit indicate the requirements to be able to effectively lead engineering-related quality operations using not only management skills but

particular engineering skills and techniques, where required. The required skills and knowledge sections along with the elements and performance criteria identify key engineering skills and supporting knowledge that must be included in the delivery of this unit.

Particular attention is drawn to:

- analysis of drawings, specifications, procedures and regulatory requirements for project, product or process
- use of process quality management and improvement procedures, employee involvement, establishment of key input/output requirements, zero defects, six sigma or similar programs
- assessment of equipment, technologies and procedures for impact on quality, including appropriateness of maintenance strategies
- problem solving, root cause identification and elimination techniques
- showing leadership in quality functions and monitoring, including capability studies of raw material and suppliers.

These technical skills need to be properly integrated with the more management-related skills to generate an appropriate quality leadership focus in the delivery of this unit.

The required knowledge listed in the unit covers a range of knowledge from other professional and technical areas that a person would need to know to be able to effectively manage material supply in an engineering-related project or operation. However, it is important to realise that this knowledge should be applied in conjunction with the ability to discern when technical and professional assistance from other specialists should be sought.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based. Project specifications should focus on the leadership and supervision of engineering-related quality operations that requires significant engineering input and preferably be a project that will give opportunities for determining when assistance from other technical and professional specialists is required. For example, projects based on the work situations described previously could be used.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in leading engineering-related quality operations (e.g. technical as well as management, OHS and sustainability). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234033A Lead engineering-related quality operations in an enterprise, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234002A	Integrate engineering technologies
MEM234030A	Provide specialised technical and engineering guidance to other technical employees
MSACMG712A	Lead a problem solving process to determine and solve root cause
MSACMG807A	Develop problem solving capability of a manufacturing organisation
MSL976003A	Evaluate and select appropriate test methods and procedures

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234034A Manage heating, ventilation, air conditioning and refrigeration systems or projects

MEM234034A Manage heating, ventilation, air conditioning and refrigeration systems or projects.

Entry requirements

This unit has no formal prerequisites. However, as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills and knowledge required to provide a technical leadership role in the installation, modification, commissioning or ongoing management of heating, ventilation, air conditioning and refrigeration (HVAC/R) systems.

It includes awareness of current options and trends in (HVAC/R) design, analysis of existing sites and systems, interpreting manufacturer specifications, implications of relevant regulations, internal or external client brief, liaison with designers, and ensuring that team members are aware of technical and performance requirements.

Application statement

This unit applies to all forms of manufacturing and engineering where a technician is providing technical leadership in HVAC/R system projects or management. The unit assumes that the system or modification has already been designed.

The unit applies to individuals who are required to provide high level technical leadership to other members in HVAC/R installation, commissioning, modification, maintenance or management. The other members of the team will normally include engineering tradespersons and may also include technicians and production personnel.

Prior or concurrent experience in the HVAC/R control systems, hydronic and refrigeration systems and thermal loads, electrical principles, controller programming and computing is required.

The unit complements the more general technical leadership and management skills found in MEM234001A Plan and manage engineering-related projects or operations. Informal technical or engineering advice situations are covered by the unit MEM234030A Provide specialised technical and engineering guidance to other technical employees.

This unit does not supply all technical skills and knowledge required for HVAC/R related tasks. The required technical skills will depend on the particular task and will normally be covered

through the combined skill and knowledge of the team. However the unit presumes engineering skills and knowledge to at least Advanced Diploma level.

MSA comments

The unit descriptor gives an indication of the scope of MEM234034A Manage heating, ventilation, air conditioning and refrigeration systems or projects using the skills and knowledge covered by the unit. It is not meant to be either a comprehensive statement of everything covered by the unit or interpreted as requirements for competency. Similarly, a candidate is not expected to be able to apply their skills in all application areas listed in the unit descriptor

A typical work situation where this unit could apply includes:

- A manufacturing or plant engineer directing a technical team during the installation and commissioning of a new air conditioning system supplying air throughout an office complex, with responsibility for safe integration with other systems, including mechanical, electrical and fuel fired equipment and final adjustments to meet performance requirements.

In planning for the delivery of this unit, it is important for training providers to note that as outlined in the application statement the unit is meant to complement the more general technical leadership and management skills found in MEM234001A Plan and manage engineering-related projects or operations. Informal technical or engineering advice situations are covered by the unit MEM234030A Provide specialised technical and engineering guidance to other technical employees.

The need for technical skills is also reinforced in the range statement which states that HVAC/R system work requirements include specific installation, commissioning, modification and maintenance projects, as well as regular scheduled operation and maintenance tasks identified in the HVAC/R system management schedule.

It is expected that engineering skills and knowledge defined in the unit must be able to be applied autonomously or as part of a team and sound judgment exercised based upon the application of engineering and scientific principles.

In addition, it is expected that engineering skills and knowledge are able to be applied effectively in conjunction with typical human resource aspects, financial planning, accounting, legal and safety processes which may relate to managing the HVAC/R systems or projects. The unit also requires effective communication and engineering leadership with other professionals, tradespersons and stakeholders involved in the project or operation who may depend on the individual's engineering skills and knowledge.

Based on the above, it is unlikely that the unit will be suitable to someone who does not have prior experience or an opportunity to concurrently gain experience through participation in installation, modification or commissioning tasks.

Required skills and knowledge

MSA recognises that for high level units, such as MEM234034A Manage heating, ventilation, air conditioning and refrigeration systems or projects, comprehensive engineering skills and knowledge

are expected by industry. However, any one individual is unlikely to be demonstrating all aspects of managing a system or project in one task or employment situation. In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery.

The required skills and knowledge sections of the unit indicate the requirements to be able to effectively manage HVAC/R systems or projects. These tasks require both management skills and engineering skills and knowledge. Particular attention is drawn to the engineering skills and knowledge required that distinguish this unit from more management-focused units. Examples include:

- current options and trends in HVAC/R system modelling and simulation software, including underpinning program techniques and software validation techniques
- principles of HVAC/R systems
- types of control equipment
- common HVAC/R system hardware, including industrial and commercial refrigeration systems, hydronic systems and automated controls
- building management systems (BMS) principles
- electrical, electronic and mechanical features of HVAC/R systems, including interface principles and techniques for electrical, electronic, pneumatic and hydraulic sensors and actuators interface principles for HVAC/R system components.

These technical skills need to be properly integrated with the more management-related skills to generate an appropriate HVAC/R focus in the delivery of this unit.

The required knowledge listed in the unit covers a range of knowledge from other professional and technical areas that a person would need to know to be able to effectively manage a HVAC/R system or project. However, it is important to realise that this knowledge should be applied in conjunction with the ability to discern when technical and professional assistance from other specialists should be sought.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

The training delivery should be project based and preferably clustered with other related units. Project specifications should focus on management of HVAC/R systems or projects that require significant engineering input and preferably be projects that will give opportunities for determining when assistance from other technical and professional specialists is required. For example, projects based on the work situations described previously could be used.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope in the design tasks (e.g. technical as well as management, OHS and sustainability). Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

While specific co-requisites are not listed in MEM234034A Manage heating, ventilation, air conditioning and refrigeration systems or projects, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234027A	Plan and manage materials supply for an engineering project or manufacturing operation
MEM234030A	Provide specialised technical and engineering guidance to other technical employees

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

MEM234035A Maintain and apply technical and engineering skills

MEM234035A Maintain and apply technical and engineering skills.

Entry requirements

This unit has no formal prerequisites. However as part of the MEM80111 Vocational Graduate Diploma of Engineering, the unit has been written in accordance with the overall qualification targeting individuals with prior relevant qualifications or relevant extensive vocational practice.

When should this unit be selected?

Guidance on the application of this unit is given in both the unit descriptor and application statement section of the unit. These sections are reproduced below.

Unit descriptor

This unit of competency covers the skills and knowledge required by a Principal Technical Officer, or someone in an equivalent position, to plan and manage their own technical role and development in their field of engineering for the benefit of themselves and their organisation. It covers the technical, analytical, communication and system skills to ensure effective performance in complex technical and engineering environments.

Application statement

This unit applies to Principal Technical Officers and others in equivalent engineering and engineering-related positions in an organisation. The unit covers the skills required for an individual to manage their engineering role and provides the core underpinning skills for an individual to appropriately apply technical skills gained from other units of competency in the MEM80111 Vocational Graduate Diploma of Engineering. This unit applies to an individual performing high level engineering-related work whether in a project management, supervisory or technical specialist role in an organisation. The unit covers skills associated with ensuring that the individual's skills and knowledge in their chosen discipline or area of responsibility are up to date and appropriate for their work.

The unit applies across all forms of manufacturing and engineering. The unit covers high level technical, analytical, communication and system thinking skills.

MSA comments

For a Principal Technical Officer to function effectively and ethically, they must demonstrate a capacity and willingness to maintain their skills and knowledge through a structured approach to lifelong learning and professional development. This ability to manage their own development and learning is a key skill and is the focus of this unit. The unit requires the same analytical and monitoring skills from a Principal Technical Officer as are required for other technical units in the MEM80111 Vocational Graduate Diploma of Engineering.

In planning for the delivery of this unit it is important that RTOs do not approach the unit solely as a generalist training/coaching unit. In particular the unit is distinguished from other units by the

requirement to integrate engineering skills and knowledge with good oral and written communication.

This is illustrated by the following performance criteria:

- *Use modelling, prototyping, tests and/or experiments to support problem solving*(1.4)

  This indicates that developing and maintaining a capacity for analysis requires using and maintaining the typical test and problem solving procedures used in engineering-related tasks.

- Determine properties, performance, safe working limits, failure modes, and/or other inherent parameters of materials, components and systems relevant to specialist area of expertise (1.6)

  This performance criteria again refers to the type of engineering-related analytical capacity that must be maintained by the Principal Technical Officer as part of their own skill base.

- Show familiarity with current state of development and recent applications in area of specialist knowledge or discipline (4.2).

Required skills and knowledge

The required skills section of the unit is necessarily comprehensive as it identifies the particular skills that are characteristic of a Principal Technical officer in their discipline area. However, more than most units, the required skills need to be carefully read against other sections of the unit in order to properly identify the context and scope of the skills required. In particular, they need to be applied against a careful reading of the required knowledge points especially the points relating to the context and limitations of delegated responsibilities and the role and responsibilities of others. However, this is not say that the unit applies in a rigid way bounded by the individual's current job descriptions and work context. The required skills and knowledge sections should also be read against the elements and performance criteria especially PC 4.4 which states 'Apply, adapt and manage engineering knowledge and practice in a variety of contexts and applications'.

In order to ensure that a broad capability is achieved in this unit, RTOs need to determine the extent of applications and contexts they should include in their training delivery to ensure that an individual is capable of determining and managing their immediate and likely future technical and engineering skill development.

Training delivery

While delivery of training is primarily the responsibility of the RTO, the following advice is provided to assist in effective delivery and assessment against the unit requirements.

Training delivery should be project based and take into account current and future scenarios where an individual must manage their own self-development as a Principal Technical Officer. Projects should relate to current work situations or be an effective simulation of situations where an individual must assess their own capability against the engineering and technical needs of a project.

Projects should also include opportunities for determining when assistance from other technical and professional specialists is required.

RTOs should consider that learners may want to bring their own project from the workplace and negotiate a timeframe for completion providing it has sufficient rigor.

Workplace delivery of this unit should include the RTO checking that the work tasks cover a suitable scope. Additional simulation or other delivery strategies may be needed to cover where a learner would not have the opportunity to gain all elements and performance criteria.

Co-delivery and assessment

It is strongly recommended that this unit be delivered in conjunction with technical units relating to the learner's own area of engineering and technical practice. While specific co-requisites are not listed in MEM234035A Maintain and apply technical and engineering skills, there are a number of units where co-delivery can occur and which may add to the learning experience. Suggestions include:

MEM234001A	Plan and manage engineering-related projects or operations
MEM234002A	Integrate engineering technologies
MEM234026A	Develop and coordinate engineering related contingency plans
MSAENV672B	Develop workplace policy and procedures for environmental sustainability

The choice of units for co-delivery and assessment should be made in conjunction with the student and should aim to maximise the workplace relevance of all units. The choice of units should also promote integrating technical skills and knowledge with more generic engineering-related skills.

Appendix 1:

Peter H. Hoffmann
Associate Director, Accreditation
Australian Engineering Accreditation Centre
Suite 206, 21 Bedford Street,
North Melbourne VIC 3051

ENGINEERS
AUSTRALIA

1 May, 2012

Mr Bob Paton
Chief Executive Officer
Manufacturing Skills Australia

Re: Vocational Graduate Diploma of Engineering

Dear Bob,

We have considered in detail the competency-based Vocational Graduate Diploma of Engineering (VGD) qualification package developed by MSA.

We understand that the package will lead to professional development pathways for:

- recent Advanced Diploma graduates, as well as for
- industry practitioners and managers with leadership responsibility seeking advanced knowledge and skills in their field of practice.

With this diversity of intake it will be essential to provide tailored learning and assessment through core and elective units of competency choices as well as systematic approaches for the evaluation of existing knowledge and skills. For some candidate backgrounds, formal bridging studies may well be necessary, prior to commencement of the VGD.

The VGD package will provide a sound framework for the development of learning and assessment programs delivering the designated competencies. The Australian Engineering Accreditation Centre supports this initiative and confirms the potential for such learning and assessment programs to achieve Engineers Australia accreditation in the occupational category of Engineering Technologist.

Such accreditation will be dependent on the delivery of graduate outcomes which satisfy the Stage 1 Competency Standard for Engineering Technologist, as published by Engineers Australia. For any given program development, the Stage 1 Competencies should steer the selection of units of competency from the VGD package and also should be a key reference for the learning and assessment design processes.

We look forward to monitoring the progress of the Vocational Graduate Diploma of Engineering qualification package and the subsequent consideration for accreditation of program implementations from individual RTOs.

Yours sincerely,

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