



higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

WELDING

NQF LEVEL 4

IMPLEMENTATION: JANUARY 2015

INTRODUCTION

A. What is the subject *Welding Level 4* about?

This subject extends the welding knowledge and skills gained from completion of the National Certificate (Vocational): Level 3 Welding programme. The programmes at Levels 2 and 3 have attempted to expose students to a progressively wide range of welding technologies available within the manufacturing and engineering industry.

Additional welding processes and techniques are introduced at this level. They include cored-wire welding of carbon steel pipe, and welding different materials.

Due to the prevalence of skills shortages affecting the specialised welding industry sectors, the welding of stainless steel and aluminium using the gas tungsten arc welding (TIG) (ferrous and non-ferrous materials) process is included in this programme.

B. Why is the subject *Welding Level 4* important in the Engineering and Related Design learning programme?

On completion of the Further Education Certificate (Vocational) Level 4 programme, students should be adequately prepared to choose a career as an artisan welder.

Alternatively, students may elect to continue to study at NQF Level 5. Available programmes include, but are not limited to:

- Metallurgy;
- Quality assurance in welding (welding inspection); and
- Structural steel detailing

Welding is regarded as a scarce skill in South Africa.

C. The link between the Learning Outcomes for *Welding* and the Critical and Developmental Outcomes

• Identify and solve problems:

Problems must be identified and solved during planning and preparation procedures, and during inspection of completed welds. It is also important to recognise hazards and defects and respond appropriately.

• Work effectively with others:

Welders are usually part of a team. Working with others is an important part of a career in engineering.

• Organise and manage themselves and their activities responsibly and effectively:

Preparation of the welding equipment and the work environment.

Planning the welding work by reading and interpreting the work instructions or welding procedure specifications.

• Collect, organise and evaluate information and take appropriate action:

Interpretation of engineering drawings, work instructions and welding procedure specifications.

• Communicate effectively:

Communication in a high noise-level environment

Completion of welding reports and task documentation
Delivery of verbal reports at work and site meetings.

- **Use science and technology effectively and critically showing responsibility towards the environment and the health of others:**

The laws of physics apply to all engineering occupations

Exposure to health, safety and environmental hazards demands a sound knowledge of science and technology.

- **Demonstrate understanding of subject content through the application of acquired knowledge:**

Welding is only one part of the manufacturing and engineering industry. Its role is integrated with occupations such as fabricators (boilermakers or sheet-metalworkers), fitters, machinists, electricians, and others.

The design of engineered products or machines integrates with various technologies. The welding task also integrates with various parts of the design and manufacturing process.

To work effectively in this environment, students should be able to:

- Reflect and explore a variety of strategies to learn more effectively
- Participate as responsible citizens in this life of local, national and global communities
- Be culturally and aesthetically sensitive across a range of social contexts
- Explore education and training opportunities
- Develop entrepreneurial opportunities.

D. Factors that contribute to achieving the *Welding* Learning Outcomes

Students choosing to enter a career in welding, require:

- Mechanical technology orientation
- Associated hand skills, dexterity and mental alertness
- The ability to work in a team
- Communication skills.

WELDING - LEVEL 4

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1 DURATION AND TUITION TIME

This is a one-year instructional programme comprising 200 teaching and learning hours. The subject may be offered on a part-time basis provided the student meets all the assessment requirements.

Students with special education needs (LSEN) must be catered for in a way that eliminates barriers to learning.

2 SUBJECT LEVEL OUTCOMES AND FOCUS

SAQA QUALIFICATION ID: 50440

On completion of this subject students will be able to:

Exit Level Outcome 1:

- Explain and discuss the principles of welding with specific reference to pipe welding

Exit Level Outcome 2:

- Explain and perform welding on carbon steel pipe (grooves) using the shielded metal arc welding process

Exit Level Outcome 3:

- Explain and perform welding on ferrous and non-ferrous materials using the gas tungsten arc welding (TIG) method

Exit Level Outcome 4:

- Explain and perform weld on carbon steel using the metal inert gas welding (MIG)

Associated Assessment Criteria:

- The principles and techniques for welding on pipes are described and demonstrated.
- A variety of fillet and groove welding processes to weld carbon steel work pieces are explained and demonstrated.
Range: Shielded metal arc, gas and gas metal arc methods in vertical, inclined and flat rotational positions.
- Welding on ferrous and non-ferrous materials using the gas tungsten arc welding (TIG) method is explained and performed.
- Welding on carbon steel using the metal inert gas welding (MIG) is explained and performed.

3 ASSESSMENT

Information provided in this document on internal and external assessment aims to inform, assist and guide lecturers to plan the effective teaching of the subject.

The *Assessment Guidelines* accompanying this document provide detailed information for planning and conducting internal and external assessments.

3.1 Internal assessment (50 percent)

Detailed information regarding internal assessment and moderation is outlined in the current Internal Continuous Assessment (ICASS) Guideline document provided by the Department of Higher Education and Training (DHET).

3.2 External assessment (50 percent)

A national examination is conducted annually in October or November by means of a paper(s) set and moderated externally. A practical component, the Integrated Summative Assessment Task (ISAT) will be included in the external assessment.

Detailed information regarding external assessment and moderation is outlined in the 'National Policy on the Conduct, Administration and Management of the Assessment of the National Certificate Vocational', Gazette Number 30287, dated 12 September 2007.

4. WEIGHTED VALUES OF TOPICS (Topic weighting and time allocation)

TOPICS	WEIGHTED VALUE	*TEACHING HOURS
1. Principles and techniques of welding (pipe)	10%	11
2. Shielded metal arc welding (pipe)	30%	33
3. Gas tungsten arc welding (TIG) (ferrous and non-ferrous materials)	40%	44
4. Metal inert gas welding (MIG) (carbon steel)	20%	22
TOTAL	100%	110

*Teaching Hours refers to the minimum hours required for face to face instruction and teaching. This excludes time spent on revision, tests and internal and external examinations or assessment. The number of allocated teaching hours is influenced by the topic weighting, complexity of the subject content and the duration of the academic year.

5. CALCULATION OF FINAL MARK

Internal assessment mark: $\text{Student's mark}/100 \times 50 = \text{a mark out of } 50 \text{ (a)}$

Examination mark: $\text{Student's mark}/100 \times 50 = \text{a mark out of } 50 \text{ (b)}$

Final mark: (a) + (b) = a mark out of 100

All marks are systematically processed and accurately recorded to be available as hard copy evidence for, among others, reporting, moderation and verification purposes.

6. PASS REQUIREMENTS

A student must obtain at least fifty percent (50%) in ICASS and fifty percent (50%) in the examination to achieve a pass in this subject.

7. SUBJECT AND LEARNING OUTCOMES

Topic 1: Principles and techniques of welding (pipe)

Subject Outcome 1.1: Identify and describe welded joints in pipes

Range: Butt welds in pipes; in line and at an angle; the importance of gas backing.

Learning Outcomes

The student is able to:

- Identify and discuss types of pipe weld connections.
- Identify joint preparations
- Describe the methods of joint preparation of pipes
- Explain the adaptation of joint preparation methods of pipes.
- Identify and draw tube to plate welds and branch connections.
- Describe the method of performing tube to plate welding.
- Describe branch connections (set-on, set-in and set through).

Subject Outcome 1.2: Explain welding problems associated with alloyed steels.

Range: Stainless steels; Aluminium alloys; Copper alloys; Nickel alloys; Titanium and other special materials

Learning Outcomes

The student is able to:

- Explain the influence of welding on steel.
- Describe the differences between non-alloy, stainless steels and other alloy steels.
- Briefly explain the effects of alloying elements on the properties of steel.
- Describe and explain the basic properties of stainless steel, aluminium and other alloys, their welding processes and health aspects.
- Explain the addition of elements to create alloys.
- Explain the weld-ability, welded joints and distortion related to the alloys.
- Explain the effects of welding on steel.
- Explain the basis of ISO (TR) 15608.
- Identify materials according to ISO (TR) 15608.
- Identify and discuss types of joints (butt; "T"; lap and corner – EN 12345, ISO [(DIS) 17659]).
- Identify and explain types of welding (butt and fillet).
- List and identify various welding consumables and their backing gases.
- Explain corrosion and post weld treatment of alloys.
- Describe typical welding problems associated with stainless steels and other alloys.

Subject Outcome 1.3: Explain the causes and consequences of weld failures

Learning Outcomes

The student is able to:

- Explain the safety requirements relating to welded products.
- Provide examples of failures and explain their causes and consequences
- Describe and explain product failures due to bad welding.
- Explain the role of the welder in avoiding failures.
- Explain the implications of failure and product liability.

Subject Outcome 1.4: Explain the harmonised system of international standards

Learning Outcomes

The student is able to:

- Describe and explain the role and operation of CEN and ISO and their relationship with National Standards Organisations.
- Describe and explain important international and national standards for welding equipment and welding consumables.
- Explain important international and national standards for welding practice and product standards that contain welding requirements.
- Describe and explain standards for quality and co-ordination in welding.

Topic 2: Shielded metal arc welding (pipe)

Subject Outcome 2.1: Explain the shielded metal arc welding (SMAW) process for welding pipe in all positions

Learning Outcomes

The student is able to:

- Explain the terminology associated with shielded metal arc welding procedures.
- Use terms and definitions that are consistent with generally accepted welding terminology as recorded in national and international welding standards.
- Identify basic and major components of shielded metal arc welding equipment and explain their function and purpose.
- Explain the importance of correct assembly of the shielded metal arc welding equipment, and the consequences of incorrect assembly.
- Explain the importance of the correct setting of the power source and choice of electrode and the consequences of incorrect selection.
- Explain the thickness of materials in relation to size and type of welding electrode used, and the influence of electrode manipulation during the welding process.
- Explain the chemical and mechanical processes that take place during welding.
- Describe the shielded metal arc welding (SMAW) process.
- Demonstrate setting up procedures.
- Identify and describe welding consumables, their misuse, mishandling, and baking procedures.
- Describe the welding characteristics of low carbon steel and identify unsafe welding conditions and their implications.

Subject Outcome 2.2: Plan and prepare for the welding process

Learning Outcomes

The student is able to:

- Explain the safety aspects of Shielded Metal Arc Welding (SMAW) in the welding workshop.
- Identify, select and prepare the shielded metal arc welding (SMAW) equipment.
- Inspect and prepare the pipe in accordance with drawing prior to the welding process.
- Check dimensions and alignment as specified on drawing and the welding process.
- Prepare the welding environment.
- Identify and rectify possible welding hazards in accordance with standard work site practices.

- Carry out pre-operational checks in accordance with specifications.
- Tack-weld pipes into position as specified on drawing.
- Adhere to safety precautions.

Subject Outcome 2.3: Weld materials in all positions

Learning Outcomes

The student is able to:

- Adhere to safety precautions applicable to the shielded metal arc welding (SMAW) process in accordance with OHS Act.
- Establish welding parameters and conform to requirements.
- Select and use welding consumables as per requirements.
- Use the shielded metal arc welding (SMAW) process in all positions to weld carbon steel pipe.
- Weld pipes in position in accordance with instruction sheet and drawing requirements.
- Inspect welded work-piece for defects using visual and non-destructive inspections, and apply quality checks on process.
- Inspect the end product for conformance to specifications as reflected on drawing or job requirement.
- Identify welding defects and take corrective action.

Subject Outcome 2.4: Care for and store welding equipment and consumables

Learning Outcomes

The student is able to:

- Clean pipes after welding.
- Explain the care and storage procedures for tools, equipment and consumables in accordance with worksite practices and specifications.
- Dismantle shielded metal arc welding equipment according to workshop procedures.
- Pack and store the welding equipment, hand tools and consumables neatly and safely in accordance with laid down procedures.

Topic 3: Gas tungsten arc welding (TIG) (ferrous and non-ferrous materials)

Subject Outcome 3.1: Describe the gas tungsten arc welding (GTAW) process for welding ferrous and non-ferrous material in all positions

Learning Outcomes

The student is able to:

- Use and explain the terminology associated with the gas tungsten arc welding process.
- Identify components of GTAW equipment used for welding ferrous and non-ferrous material and explain their function and purpose.
- Explain the importance of the correct equipment assembly, setting of the power source and choice of electrode and the consequences of incorrect selection.
- Explain the chemical and mechanical processes that take place during welding.
- Explain the gas tungsten arc welding (GTAW) method in all positions.
- Explain the thickness of materials, in relation to size and type of welding electrode used, and the influence of electrode manipulation during the welding process.
- Describe and explain the misuse, mishandling, and baking procedures of welding consumables.

- Describe the welding characteristics of different materials and identify unsafe welding conditions and their implications.
- Demonstrate setting up procedures

Subject Outcome 3.2: Plan and prepare for the gas tungsten arc welding (GTAW) process

Learning Outcomes

The student is able to:

- Explain and implement the safety aspects of gas tungsten arc welding (GTAW) in the welding workshop.
- Identify, select and prepare the gas tungsten arc welding (GTAW) equipment for the welding process.
- Identify potential causes of welding defects or imperfections prior to welding, and take action to meet requirements.
- Identify welding hazards and eliminate in accordance with standard working practices.
- Check dimensions and alignment as specified on the drawing.
- Inspect and prepare the work-piece/s (including groove preparation) according to drawings and working practices, for gas tungsten arc welding.
- Check task dimensions and work-piece alignment as specified on drawing.
- Carry out pre-operational checks in accordance with manufacturers' specifications.
- Prepare the welding environment.
- Tack-weld work-piece into position as specified as per drawing.

Subject Outcome 3.3: Weld materials using the gas tungsten arc process in all positions

Range:

Welding positions: Fillet Weld: Flat rotated; Horizontal, Vertical; Overhead.

Groove weld: Flat rotated, Horizontal, Vertical, Inclined at 45°.

Defects include excessive slag, spatter and irregular weld finish (bead).

Hazards include fire, electrocution; incorrect set-up procedures and unsafe use of power tools is explained.

Material to be used:

Carbon Steel Pipe:

Size of pipes to be welded should be: Nominal bore (NB) - 10mm (minimum).

Minimum wall thickness of pipe -1mm.

Select from range of Carbon Steels (Material Group 1, 2, 3 or 11, according to CR/ISO TR 15608).

Aluminium:

Range of materials: aluminium and aluminium alloys.

Materials group: To be selected from groups 21, 22, 24 or sub-group 23.1 [ISO (TR) 15608; Table 2] for the purpose of assessment.

Minimum plate thickness: 1,6mm.

Stainless Steel:

Range of materials: stainless steel and stainless steel alloys.

Materials group: To be selected from groups 21, 22, 24 or sub-group 23.1 [ISO (TR) 15608; for the purpose of assessment.

Minimum plate thickness: 1,6mm.

Observations applicable to the welding process: Heat input, electrode size, joint preparation, welding technique, consumable usage, handling and gas shielding.

Learning Outcomes

The student is able to:

- Adhere to all safety precautions according to workshop requirements and OHS Act.
- Select and use welding consumables as per requirements for welding carbon steel, aluminium and stainless steel plate.
- Use the gas tungsten arc welding (GTAW) process in all positions.
- Weld the work-piece material in accordance with work instruction sheet and drawing requirements.
- Apply quality checks on process.
- Inspect welded work-piece for defects (use visual and non-destructive testing), conforming to specifications as reflected on drawing or job requirement.
- Identify welding defects and take corrective action.

Subject Outcome 3.4: Care for and store welding equipment and consumables

Learning Outcomes

The student is able to:

- Clean work-pieces/pipes after welding.
- Perform post-cleaning of welded joint.
- Explain the care and storage procedures for tools, equipment and consumables in accordance with worksite practices and specifications.
- Dismantle and store the gas tungsten arc welding equipment and consumables in accordance with manufacturer's specifications and requirements.
- Pack away the welding equipment, hand tools and consumables neatly and safely in accordance with laid down procedures.

Topic 4: Metal inert gas welding (carbon steel)

Subject Outcome 4.1: Describe the metal inert gas welding (MIG) process for welding carbon steel in all positions

Learning Outcomes

The student is able to:

- Use terms and definitions for MIG welding consistently with generally accepted terminology as recorded in national and international welding standards.
- Identify components of MIG equipment used for welding carbon steel and explain their function and purpose.
- Identify welding characteristics of carbon steel and describe the implications for unsafe conditions.
- Briefly explain the chemical and mechanical processes that take place during welding.
- Explain the gas metal arc welding (MIG) process for carbon steel.
- Identify the various welding parameters, in relation to the thickness of materials (steel) being welded.
- Explain the consequences of misuse and/or mishandling of welding consumables.
- Demonstrate setting up procedures.

Subject Outcome 4.2: Plan and prepare for the welding process

Learning Outcomes

The student is able to:

- Explain the safety aspects of metal inert gas welding (MIG) in the welding workshop.
- Identify, select and prepare the metal inert gas welding (MIG) equipment for the welding process.
- Inspect and prepare work-piece/s prior to welding as specified on drawing and as required by standard working practices.
- Check task dimensions and work-piece alignment as specified on the drawing.
- Prepare the welding environment.
- Carry out pre-operational checks in accordance with welding equipment manufacturer's specifications.
- Identify and rectify welding hazards in accordance with standard working practices.
- Tack-weld the work-piece into position as specified per welding procedure.
- Adhere to safety precautions.

Subject Outcome 4.3: Weld materials in all positions

Range:

Welding positions include: Fillet welding: Flat/Horizontal, Vertical, Overhead.

Groove welding: Flat/Horizontal, Vertical.

Overhead Welding positions.

Includes destructive test methods.

Range: Defects include excessive slag, spatter and irregular weld finish (bead).

Hazards include fire, electrocution; incorrect set-up procedures, and unsafe use of power tools is explained.

Range of materials: carbon steel

Observations applicable to the welding process: (Information on heat input range, electrode diameter, filler material, gas composition, gas flow, joint preparation from welding procedure): Heat input, metal transfer mode, electrode size, joint preparation, welding technique, consumable usage, handling and gas shielding.

Learning Outcomes

The student is able to:

- Adhere to all safety precautions in accordance with workshop requirements and OHS Act.
- Select and use welding consumables as per procedure requirements for job.
- Identify and remove or control potential causes of welding imperfections and defects prior to welding and take precautions as per welding practices.
- Use the metal inert gas welding (MIG) process in all positions to weld the work-piece in accordance with work instruction sheet and drawing requirements.
- Inspect welded work-piece for defects (use destructive testing) and apply quality checks on process.
- Identify welding defects and take corrective action.

Subject Outcome 4.4: Care for and store welding equipment and consumables

Range:

Care and storage practices should conform to manufacturer's requirements and be conducive to preventative maintenance schedules.

Defective equipment to be dealt with in accordance to accepted worksite practices.

Consumables and equipment are to be stored in a usable condition for the next user.

Learning Outcomes

The student should be able to:

- Perform post-cleaning of welded joint.
- Explain the care and storage procedures for tools, equipment and consumables in accordance with worksite practices and specifications.
- Dismantle and store the metal inert gas welding (MIG) equipment and consumables in accordance with manufacturer's specifications and requirements.
- Pack away the welding equipment, hand tools and consumables neatly and safely in accordance with laid down procedures.

8 RESOURCE NEEDS FOR THE TEACHING OF WELDING - LEVEL 4**8.1 Physical resources**

All specific equipment and consumables required for the development of students' skills including

- A training workshop dedicated to welding, accommodating separate arc-welding, oxy-acetylene welding and cutting facilities;
- Adequate ventilation or an extraction system is important health and safety factor.
- Hand and power tools;
- Marking-off and measuring tools;
- Metal cutting machine;
- AC or DC welding machines for shielded metal arc welding, metal inert gas welding (GMAW/ MIG), tungsten inert gas welding (TIG);
- Shielding gases (argo-CO₂/CO₂ – MIG); (pure argon/helium – TIG);
- Oxygen and acetylene gas cylinders; Welding electrodes (2mm/12 gauge wire for 3mm plate); Cutting nozzles (0.8mm nozzles); Extension cables (20m); Grinding discs (115mm and 230mm); Steel cutting discs (115mm and 230mm);
- Non-destructive test materials (dye-penetrant) for assessing weld-quality;
- Adequate equipment for implementation of safety measures: Protective sight screens; personal protective equipment; suitably ventilated workspace;
- Fire extinguishers;
- Suitable welding power source, shielding screen, wire-feeder, shielding gas, regulator, flow-meter, gas-hoses, hose-clamps, earth-clamp, cable, welding torch, cooling hoses and water, foot control and related components;
- Personal Protective Equipment for lecturers and students.

8.2. Human resources

- Lecturing staff who are capacitated with the necessary knowledge, skills and reflexive approach to ensure that students are kept up to date with the latest technologies and changing trends in their specialist field;

- Students need to have the necessary generic skills indicating their potential to be successful in achieving the qualification;
- Assistance in the setting up and managing of the workshops in terms of ordering equipment and consumables, preparing demonstrations and the maintenance of equipment.

8.3. Other resources

- Increased access and exposure to industry for both students and lecturing staff in a variety of ways that include longer and more intense work experience.
- Staff development is required in an industrial environment for the purposes of acquiring new skills and updating existing skills where new technologies have been introduced. Lecturers are required to spend a structured and routine period annually in an industrial environment for these purposes.
- Staff development in terms of updating teaching and learning and assessment skills is required on an annual basis, particularly for staff who move from industry into the educational environment of an FET college.
- Increased interaction with industry in terms of visits from industry representatives and active artisans working in the industry.
- Organisational documentation in the form of policies and procedures, OHS policies and procedures, authentic Work Instructions, to which learners must adhere and comply.
- Opportunities for students to work in simulated work environments that replicate industry working conditions.
- Academic support in the colleges to ensure that the attrition rate at the first year level of learning is not compromised by a lack of prerequisite skills. This support should be both of an educational nature and a skills development nature.
- Supportive and interactive learning materials of a high quality are required to support the learner during the learning process.
- Learning materials for NC(V): Welding Level 4.