

Technical Description

# CNC Milling

Manufacturing and Engineering Technology



WorldSkills International, by a resolution of the Competitions Committee and in accordance with the Constitution, the Standing Orders and the Competition Rules, has adopted the following minimum requirements for this skill for the WorldSkills Competition.

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# 1 INTRODUCTION

## 1.1 NAME AND DESCRIPTION OF THE SKILL COMPETITION

1.1.1 The name of the skill competition is

CNC Milling

1.1.2 Description of the associated work role(s) or occupation(s).

Computer Numerical Control (CNC) technology has reached the stage of having become omnipresent. Most people cannot imagine how important these technologies are in their lives. There is nothing that we use that hasn't in its manufacturing utilized CNC technology. It is present in products and objects of everyday life as e.g. cars, airplanes, components of machines of all types, moulds for tools used for household machines, medical prosthetics, cell phones, and toys etc.

CNC milling machines are machine tools which are used for the shaping of metal and other solid materials. These machines exist in two basic forms: horizontal and vertical. This refers to the orientation of the cutting tool spindle. Early milling machines were manually or mechanically automated, but technological advances have led to the development of Computer Numerical Control, such as CNC machining centre. CNC refers to a computer ("control") that reads and stores instructions. This numerical information generally "G and M" codes (a programming language) is then used to control and drives a machine tool, a powered mechanical device ("machining centre"). A machining centre is used to fabricate components using cutting tools for removal of material.

To form the finished part, the cutting process can be started from a solid block, pre-machined part, casting, or forgings. For those scenarios, the skill requires the CNC milling machinist to read and interpret complex technical drawings and specifications and work to a high degree of precision and detail; to be proficient at metal work skills and understand how metals react to various processes; to be a skilled computer operator in order to use industry specific software; to be highly skilled machine operator.

A programme is required to operate the machine tool, can be generated manually or using Computer Aided Design/Computer Aided Manufacture (CAD/CAM) software.

To achieve the finished part, the CNC milling machinist professionals undertake a sequence of essential activities:

- Interpret engineering drawings and follow the specifications;
- Generate a process and programme (logical process plan) with a CAD/CAM system and/or G and M-codes;
- Set up the tooling, work holding device and work piece on the CNC milling centre;
- Manipulate cutting conditions, based on the properties of the material and tooling used;
- Operate, inspect and maintain the accuracy of dimensions within the specified tolerances.
- Optimize the process taking into account the production type: large quantities of one part, small batches or one-of-a-kind items.

Today a wide range of industries require CNC milling machinists professionals to programme, operate, and keep sophisticated machining centre's running in an efficient and reliable way. Large enterprises such as automobile plants, medium sized enterprises such as mould making and small enterprises in the maintenance field are some of many examples of where the CNC milling machinist professional plays a key, integral role to the success of the metalwork industries.

1.1.3 Number of Competitors per team

CNC Milling is a single Competitor skill competition.

1.1.4 Age limit of Competitors

The Competitors must not be older than 22 years in the year of the Competition.

## 1.2 THE RELEVANCE AND SIGNIFICANCE OF THIS DOCUMENT

This document contains information about the standards required to compete in this skill competition, and the assessment principles, methods and procedures that govern the competition.

Every Expert and Competitor must know and understand this Technical Description.

In the event of any conflict within the different languages of the Technical Descriptions, the English version takes precedence.

## 1.3 ASSOCIATED DOCUMENTS

Since this Technical Description contains only skill-specific information it must be used in association with the following:

- WSI – Competition Rules
- WSI – WorldSkills Standards Specification framework
- WSI – WorldSkills Assessment Strategy
- WSI Online resources as indicated in this document
- WorldSkills Health, Safety, and Environment Policy and Regulations

## 2 THE WORLDSKILLS STANDARDS SPECIFICATION (WSSS)

### 2.1 GENERAL NOTES ON THE WSSS

The WSSS specifies the knowledge, understanding and specific skills that underpin international best practice in technical and vocational performance. It should reflect a shared global understanding of what the associated work role(s) or occupation(s) represent for industry and business ([www.worldskills.org/WSSS](http://www.worldskills.org/WSSS)).

The skill competition is intended to reflect international best practice as described by the WSSS, and to the extent that it is able to. The Standards Specification is therefore a guide to the required training and preparation for the skill competition.

In the skill competition the assessment of knowledge and understanding will take place through the assessment of performance. There will only be separate tests of knowledge and understanding where there is an overwhelming reason for these.

The Standards Specification is divided into distinct sections with headings and reference numbers added.

Each section is assigned a percentage of the total marks to indicate its relative importance within the Standards Specification. This is often referred to as the “weighting”. The sum of all the percentage marks is 100.

The Marking Scheme and Test Project will assess only those skills that are set out in the Standards Specification. They will reflect the Standards Specification as comprehensively as possible within the constraints of the skill competition.

The Marking Scheme and Test Project will follow the allocation of marks within the Standards Specification to the extent practically possible. A variation of five percent is allowed, provided that this does not distort the weightings assigned by the Standards Specification.

## 2.2 WORLDSKILLS STANDARDS SPECIFICATION

SECTION		RELATIVE IMPORTANCE (%)
1	<b>Work organization and management</b>	<b>10</b>
	<p>The individual needs to know and understand:</p> <ul style="list-style-type: none"> <li>• The extent and impact of CNC-milling on modern life and industry</li> <li>• Quality standards for materials and quality of metals</li> <li>• Standards for the environment, safety, hygiene, and prevention of accidents at work</li> <li>• Computer operating systems</li> <li>• Mathematics, especially accurate and detailed calculations, and trigonometry</li> <li>• Properties and behaviours of materials, especially steel and aluminium</li> <li>• Principles of technical design and process planning</li> <li>• CNC equipment technology (Vertical and Horizontal Machining Centre) – programming and operating</li> <li>• Programming by hand or CAM system software</li> <li>• Cutting technology according to the cutting parameters, the material, and the equipment and cutting tools</li> <li>• Health and safety regulations, legislation, and best practice</li> <li>• The importance of adhering to manufacturer’s operating instructions</li> <li>• Ensure the maintenance of sophisticated milling machines to promote efficient and reliable working</li> <li>• The importance of effective communications and team-work</li> <li>• The importance of effective working methods with other professionals related to the CNC-milling process</li> </ul>	
	<p>The individual shall be able to:</p> <ul style="list-style-type: none"> <li>• Use computer related professional software effectively</li> <li>• Interpret and apply quality standards and regulations</li> <li>• Promote and apply health and safety regulations and best practice</li> <li>• Effectively use IT and related professional software</li> <li>• Consistently apply mathematical and geometrical principles accurately for the preparation and programming processes for CNC-milling</li> <li>• Develop creative solutions to complex design or technology challenges</li> </ul>	

<b>2</b>	<b>Interpret engineering drawings and follow the specification</b>	<b>10</b>
	<p>The individual needs to know and understand:</p> <ul style="list-style-type: none"> <li>• ISO 1 and/or ISO 3 (European and American) drawing representation</li> <li>• Technical terms and symbols used in drawings and plans</li> <li>• Standards, standards symbol and tables</li> <li>• Drawing legend</li> </ul>	
	<p>The individual shall be able to:</p> <ul style="list-style-type: none"> <li>• Interpret and apply engineering drawings and follow the specification</li> <li>• Locate and identify main dimensions and secondary dimensions</li> <li>• Locate and identify ISO standards for surface finish</li> <li>• Locate and identify ISO standards for geometrical form and positional tolerances</li> </ul>	
<b>3</b>	<b>Process planning</b>	<b>15</b>
	<p>The individual needs to know and understand:</p> <ul style="list-style-type: none"> <li>• The importance of good planning for the successful execution of Programming and operation/machining</li> <li>• How to plan, based on the type of operation and the sequence (machining strategy) of the data that must be specified</li> <li>• Types of machining tools used in CNC technology including lathes, multi-axis spindles, wire electrical discharge machines, and milling machines</li> <li>• Methods of work holding according to the shape of the base material</li> </ul>	
	<p>The individual shall be able to:</p> <ul style="list-style-type: none"> <li>• Identify and set the different machining features</li> <li>• Correctly identify the most efficient work holding solution to clamp the base material into the machine that best suits the operational requirements</li> <li>• Correctly select the cutting tools for machining the required material and operation</li> <li>• Define the cutting parameters as a function of the operation sequence, material type, and type of operation</li> </ul>	

<b>4</b>	<b>Programming</b>	<b>20</b>
	<p>The individual needs to know and understand:</p> <ul style="list-style-type: none"> <li>• Programming as the creation of a logical process plan</li> <li>• Different methods and techniques to generate a programme (CAM/CAD or manual)</li> <li>• CAM system programming</li> <li>• Skill related software</li> </ul>	
	<p>The individual shall be able to:</p> <ul style="list-style-type: none"> <li>• Select the best methods according to the production type and part specification</li> <li>• Effectively use skill specific software and related hardware</li> <li>• Generate a programme using a CAD/CAM system taking into account the format of the initial data</li> <li>• Start with a drawing in paper format – creation of the geometry in wireframe and/or surface and/or solid</li> </ul>	
<b>5</b>	<b>Metrology</b>	<b>10</b>
	<p>The individual needs to know and understand:</p> <ul style="list-style-type: none"> <li>• Range of tools and gauging instruments and their applications</li> <li>• The main measuring techniques</li> </ul>	
	<p>The individual shall be able to:</p> <ul style="list-style-type: none"> <li>• Select appropriate measuring tools or gauging instruments and use them correctly</li> <li>• Make measurements on threaded elements</li> </ul>	
<b>6</b>	<b>Operating</b>	<b>15</b>
	<p>The individual needs to know and understand:</p> <ul style="list-style-type: none"> <li>• The different steps that lead to the setup of the machine</li> <li>• The different modes of machine operation</li> </ul>	
	<p>The individual shall be able to:</p> <ul style="list-style-type: none"> <li>• Prepare, make measurements and record cutting tools</li> <li>• Identify and designate the functional parameters for operation on the CNC milling machine</li> </ul>	
<b>7</b>	<b>Machining</b>	<b>20</b>
	<p>The individual needs to know and understand:</p> <ul style="list-style-type: none"> <li>• The different types of machine features</li> <li>• The machining sequence</li> </ul>	



	<p>The individual shall be able to:</p> <ul style="list-style-type: none"> <li>• Identify and designate the different machining processes on a CNC-milling machine</li> <li>• Optimize the machining strategy</li> <li>• Define and adjust the cutting parameters as a function of the operation sequence, material type, type of operation, and CNC machine tool</li> <li>• Start the cutting process form</li> <li>• Solid block</li> <li>• Perform the following machining operations:           <ul style="list-style-type: none"> <li>• Facing</li> <li>• Roughing and finishing               <ul style="list-style-type: none"> <li>• External contours</li> <li>• Island milling</li> <li>• Milling channels</li> <li>• Pocket (figurative)</li> <li>• Pocket (circular and rectangular)</li> <li>• Taper ribs</li> </ul> </li> <li>• Thread milling               <ul style="list-style-type: none"> <li>• Internal</li> <li>• External</li> </ul> </li> <li>• Canned cycles               <ul style="list-style-type: none"> <li>• Through hole boring</li> <li>• Blind hole boring</li> <li>• Reaming</li> <li>• Tapping</li> <li>• Drilling</li> </ul> </li> <li>• 3D machining operations               <ul style="list-style-type: none"> <li>• Roughing</li> <li>• Finishing</li> </ul> </li> </ul> </li> <li>• Tapping</li> <li>• Drilling</li> <li>• 3D machining operations</li> <li>• Roughing</li> <li>• Finishing</li> </ul>	
	<b>Total</b>	<b>100</b>

## 3 THE ASSESSMENT STRATEGY AND SPECIFICATION

### 3.1 GENERAL GUIDANCE

Assessment is governed by the WorldSkills Assessment Strategy. The Strategy establishes the principles and techniques to which WorldSkills assessment and marking must conform.

Expert assessment practice lies at the heart of the WorldSkills Competition. For this reason, it is the subject of continuing professional development and scrutiny. The growth of expertise in assessment will inform the future use and direction of the main assessment instruments used by the WorldSkills Competition: the Marking Scheme, Test Project, and Competition Information System (CIS).

Assessment at the WorldSkills Competition falls into two broad types: measurement and judgement. For both types of assessment, the use of explicit benchmarks against which to assess each Aspect is essential to guarantee quality.

The Marking Scheme must follow the weightings within the Standards Specification. The Test Project is the assessment vehicle for the skill competition, and also follows the Standards Specification. The CIS enables the timely and accurate recording of marks, and has expanding supportive capacity.

The Marking Scheme, in outline, will lead the process of Test Project design. After this, the Marking Scheme and Test Project will be designed and developed through an iterative process, to ensure that both together optimize their relationship with the Standards Specification and the Assessment Strategy. They will be agreed by the Experts and submitted to WSI for approval together, in order to demonstrate their quality and conformity with the Standards Specification.

Prior to submission for approval to WSI, the Marking Scheme and Test Project will liaise with the WSI Skill Advisors in order to benefit from the capabilities of the CIS.

## 4 THE MARKING SCHEME

### 4.1 GENERAL GUIDANCE

This section describes the role and place of the Marking Scheme, how the Experts will assess Competitors' work as demonstrated through the Test Project, and the procedures and requirements for marking.

The Marking Scheme is the pivotal instrument of the WorldSkills Competition, in that it ties assessment to the standards that represent the skill. It is designed to allocate marks for each assessed aspect of performance in accordance with the weightings in the Standards Specification.

By reflecting the weightings in the Standards Specification, the Marking Scheme establishes the parameters for the design of the Test Project. Depending on the nature of the skill and its assessment needs, it may initially be appropriate to develop the Marking Scheme in more detail as a guide for Test Project design. Alternatively, initial Test Project design can be based on the outline Marking Scheme. From this point onwards the Marking Scheme and Test Project should be developed together.

The Marking Scheme and Test Project is developed by an independent agency, and should be checked by a third party, preferably by a non-competing Member. They should also supply a detailed CMM procedure report and programme. CMM Programme are made by MiCAT Planner Software by Mitutoyo.

Section 2.1 above indicates the extent to which the Marking Scheme and Test Project may diverge from the weightings given in the Standards Specification, if there is no practicable alternative.

The Marking Scheme and Test Project may be developed by one person, or several, or by all Experts. The detailed and final Marking Scheme and Test Project must be approved by the whole Expert Jury prior to submission for independent quality assurance. The exception to this process is for those skill competitions which use an independent designer for the development of the Marking Scheme and Test Project. Please see the Rules for further details.

Experts and independent designers are required to submit their Marking Schemes and Test Projects for comment and provisional approval well in advance of completion, in order to avoid disappointment or setbacks at a late stage. They are also advised to work with the CIS Team at this intermediate stage, in order to take full advantage of the possibilities of the CIS.

In all cases a draft Marking Scheme must be entered into the CIS at least eight weeks prior to the Competition using the CIS standard spreadsheet or other agreed methods.

### 4.2 ASSESSMENT CRITERIA

The main headings of the Marking Scheme are the Assessment Criteria. These headings are derived in conjunction with the Test Project. In some skill competitions the Assessment Criteria may be similar to the section headings in the Standards Specification; in others they may be totally different. There will normally be between five and nine Assessment Criteria. Whether or not the headings match, the Marking Scheme as a whole must reflect the weightings in the Standards Specification.

Assessment Criteria are created by the person(s) developing the Marking Scheme, who are free to define criteria that they consider most suited to the assessment and marking of the Test Project. Each Assessment Criterion is defined by a letter (A-I). It is advisable not to specify either the Assessment Criteria, or the allocation of marks, or the assessment methods, within this Technical Description.

The Mark Summary Form generated by the CIS will comprise a list of the Assessment Criteria.

The marks allocated to each Criterion will be calculated by the CIS. These will be the cumulative sum of marks given to each Aspect within that Assessment Criterion.

## 4.3 SUB CRITERIA

Each Assessment Criterion is divided into one or more Sub Criteria. Each Sub Criterion becomes the heading for a WorldSkills marking form. Each marking form (Sub Criterion) contains Aspects to be assessed and marked by measurement or judgement, or both measurement and judgement.

Each marking form (Sub Criterion) specified both the day on which it will be marked, and the identity of the marking team.

## 4.4 ASPECTS

Each Aspect defines, in detail, a single item to be assessed and marked together with the marks, or instructions for how the marks are to be awarded. Aspects are assessed either by measurement or judgement.

The marking form lists, in detail, every Aspect to be marked together with the mark allocated to it.

The sum of the marks allocated to each Aspect must fall within the range of marks specified for that section of the skill in the Standards Specification. This will be displayed in the Mark Allocation Table of the CIS, in the following format, when the Marking Scheme is reviewed from C-8 weeks. (Section 4.1)

	CRITERIA								TOTAL MARKS PER SECTION	WSS MARKS PER SECTION	VARIANCE	
	A	B	C	D	E	F	G	H				
STANDARDS SPECIFICATION SECTION	1	5.00								5.00	5.00	0.00
	2		2.00					7.50		9.50	10.00	0.50
	3								11.00	11.00	10.00	1.00
	4			5.00						5.00	5.00	0.00
	5				10.00	10.00	10.00			30.00	30.00	0.00
	6		8.00	5.00				2.50	9.00	24.50	25.00	0.50
	7			10.00				5.00		15.00	15.00	0.00
TOTAL MARKS	5.00	10.00	20.00	10.00	10.00	10.00	15.00	20.00	100.00	100.00	2.00	

## 4.5 ASSESSMENT AND MARKING

There is to be one marking team for each Sub Criterion, whether it is assessed and marked by judgement, measurement, or both. The same marking team must assess and mark all competitors, in all circumstances. The marking teams must be organized to ensure that there is no compatriot marking in any circumstances. (See 4.6.)

## 4.6 ASSESSMENT AND MARKING USING JUDGEMENT

Judgement uses a scale of 0-3. To apply the scale with rigour and consistency, judgement must be conducted using:

- benchmarks (criteria) for detailed guidance for each Aspect (in words, images, artefacts or separate guidance notes)
- the 0-3 scale to indicate:
  - 0: performance below industry standard
  - 1: performance meets industry standard
  - 2: performance meets and, in specific respects, exceeds industry standard
  - 3: performance wholly exceeds industry standard and is judged as excellent

Three Experts will judge each Aspect, with a fourth to coordinate the marking and acting as a judge to prevent compatriot marking.

## 4.7 ASSESSMENT AND MARKING USING MEASUREMENT

Three Experts will be used to assess each aspect. Unless otherwise stated only the maximum mark or zero will be awarded. Where they are used, the benchmarks for awarding partial marks will be clearly defined within the Aspect.

## 4.8 THE USE OF MEASUREMENT AND JUDGEMENT

Decisions regarding the selection of criteria and assessment methods will be made during the design of the competition through the Marking Scheme and Test Project.

## 4.9 COMPLETION OF SKILL ASSESSMENT SPECIFICATION

### A – Main dimensions

Dimensions range from 0.02 to 0.04; Reamed bores: IT7; Hollow out bores: IT7; inside thread and outside thread: IT6

Form and positional tolerances as per DIN ISO 1101

### B – Secondary dimensions

Dimensions with general tolerance should be  $\pm 0.04$  oriented of the nominal size; e.g. 73.8 mm should be in between 73.76 mm and 73.84 mm.

Depth of hole and thread:  $0/+2$  mm; e.g. Depth size 16 should be 16.00 mm to 18.00 mm

Depth of bore:  $0/+0.5$  mm; e.g. Depth size 22 should be 22.00 to 22.50 mm

Radius:  $\pm 0.2$ ; e.g. R12 should be R11.8 mm to 12.2 mm

Angle:  $\pm 0.5^\circ$ ; e.g.  $30^\circ$  should be  $29.5^\circ$  to  $30.5^\circ$

### C – Surface quality

Surface quality = Ra 0.8 to 3.2

### D – Judgment

Judgement aspects are described in Experts Pocket Guide. In this guideline the independent Test Project development agency can choose 11 aspects depending of the modules. The total mark for Judgement is 10 marks. As per module minimum amount of aspects must be 6. As per module maximum aspects can be 9.

Experts Pocket Guide in the appendix page.

## 4.10 SKILL ASSESSMENT PROCEDURES

The definitive Judgement and Measurement Marking Forms will be finalized by an Independent Designer.

Makeup of the marking groups and use of data;

Measurement marking - A, B, C and E;

Coordinate measuring machine – CMM, measurement marking - A and B;

Judgement marking - D

Three Experts for the evaluation

One spare Expert and minute keeping

For judgement marking the Experts will be divided in three working groups.

Formation of Expert groups: The groups shall be nominated by the Chief Expert and the Deputy Chief Expert. The group must be a mix of experienced senior Experts and Experts who are new in their functions.

Each group is responsible for the complete assessment of one module realized by all Competitors.

CMM Team work in the workshop; Experts can supervise their work.

### **Assessment/Marking**

Three Experts shall be assigned to assess each aspect of judgement, whether or not attempted. Each Expert shall award a score between 0 and 3 based on the given benchmarks, and displayed on flashcards. To do this correctly, each expert shall first assess the work by himself by comparing the Competitor's performance with these benchmarks and prepare the flashcard hidden. After, they display their scores at the same time as directed by the assessment team leader who is appointed by the Chief Expert.

## 5 THE TEST PROJECT

### 5.1 GENERAL NOTES

Sections 3 and 4 govern the development of the Test Project. These notes are supplementary.

Whether it is a single entity, or a series of stand-alone or connected modules, the Test Project will enable the assessment of the skills in each section of the WSSS.

The purpose of the Test Project is to provide full, balanced and authentic opportunities for assessment and marking across the Standards Specification, in conjunction with the Marking Scheme. The relationship between the Test Project, Marking Scheme and Standards Specification will be a key indicator of quality, as will be its relationship with actual work performance.

The Test Project will not cover areas outside the Standards Specification, or affect the balance of marks within the Standards Specification other than in the circumstances indicated by Section 2.

The Test Project will enable knowledge and understanding to be assessed solely through their applications within practical work.

The Test Project will not assess knowledge of WorldSkills rules and regulations.

This Technical Description will note any issues that affect the Test Project's capacity to support the full range of assessment relative to the Standards Specification. Section 2.2 refers.

### 5.2 FORMAT/STRUCTURE OF THE TEST PROJECT

The Test Project will be comprised of three separately assessed modules.

### 5.3 TEST PROJECT DESIGN REQUIREMENTS

DETAILS OF MODULE ONE MILLING		
<b>Initial Data</b>	<ul style="list-style-type: none"> <li>Material: Aluminium AIMG1SICU (6061-T6) HB90</li> <li>Maximum raw size: 150mm x 100mm x 50mm</li> <li>The minimum size for a finished part is not smaller than 50mm x 50mm x 30mm</li> <li>Time Allowed: 4.15 hrs.</li> <li>2D Finished Drawing with a 3D shaded view (paper);</li> <li>Work on two or three faces.</li> </ul>	
<b>Machining Process:</b>	<b>The following features must be included:</b> Milling Channels, figurative pocket, external contour, through hole boring, internal or external thread milling	<b>The following features may be Included (optional):</b> circular pocket, rectangular pocket, Drilling, Reaming and Tapping
<b>Additional Information</b>	<ul style="list-style-type: none"> <li>The total of aspects for criterion A- Main dimensions must be between 20min.-23max;</li> <li>The total of aspects for criterion B- Secondary dimensions must be between 17min.-20max, (the remaining dimensions are assessed in criterion D - conformity to drawing).</li> <li>The total aspects for criterion C- Surface quality must be between 5min. - 8max. (must be possible to check all aspect with surface roughness tester similar to Mitutoyo - 178-954-3A)</li> </ul>	

<b>Tasks schedule</b>	<b>Part Programming and Machining 4 hour 15 minutes</b>
	<b>Par CAM Activity</b> <b>Tool Preparation</b> <b>Machining</b> Competitors can access both CAM and CNC machine at all times during the complete module.

DETAILS OF MODULE TWO MILLING		
<b>Initial Data</b>	<ul style="list-style-type: none"> <li>Material: Steel C45E 1.1191</li> <li>Maximum raw size: 150 mm x 100 mm x 50 mm</li> <li>The minimum size for a finished part is not smaller than 50 mm x 50 mm x 30 mm</li> <li>Time Allowed: 6.15 hrs</li> <li>2D Finished Drawing with a 3D Shaded view (paper)</li> <li>Work on two faces</li> </ul>	
<b>Machining Process</b>	<b>The following features must be included:</b> Milling channels, figurative pocket, external contour, through hole boring, nose, circular pocket, internal thread milling (M30 x 1.5), reaming	<b>The following features may be included (optional):</b> Rectangular pocket, drilling sample, island milling, tapping
<b>Additional Information</b>	<ul style="list-style-type: none"> <li>The total of aspects for criterion A- Main dimensions must be between 25 min.- 28 max.</li> <li>The total of aspects for criterion B- Secondary dimensions must be between 20min.-23max. (the remain dimensions are assessed in criterion D - conformity to drawing)</li> <li>The total aspects for criterion C- Surface quality must be between 5 min. – 8 max. (must be possible to check all aspect with Surface roughness tester similar to Mitutoyo - 178-954-3A)</li> </ul>	
<b>Tasks schedule</b>	<b>Part Programming</b>	<b>Machining</b>
	CAM Activity (2.30h)	Tool Preparation (15 min)
		Machining (3.30h)



DETAILS OF MODULE THREE MILLING		
<b>Initial Data</b>	<ul style="list-style-type: none"> <li>Material: Steel C45E 1.1191</li> <li>Maximum raw size: 150 mm x 100 mm x 50 mm</li> <li>The minimum size for a finished part is not smaller than 50 mm x 50 mm x 30 mm</li> <li>Time Allowed: 7.00 hrs</li> <li>2D Finished Drawing with a 3D Shaded view (paper)</li> <li>Work on three or four faces</li> </ul>	
<b>Machining Operations:</b>	<b>The following features must be included:</b> Drilling, Blind hole boring, external contour, figurative pocket, island milling, external thread milling (M42 x 1.5), tapping, Ribs (***)	<b>The following features may be included (optional):</b> Circular pocket, rectangular pocket, gudgeon
<b>Additional Information</b>	<ul style="list-style-type: none"> <li>The total of aspects for criterion <u>A - Main dimensions</u> must be between 30 min.- 33 max.</li> <li>The total of aspects for criterion <u>B - Secondary dimensions</u> must be between 20 min.-23 max. (the remain dimensions are assessed in criterion D - conformity to drawing)</li> <li>The total aspects for criterion <u>C - Surface quality</u> must be between 5 min. – 8 max. (must be possible to check all aspect with Surface roughness tester similar to Mitutoyo - 178-954-3A)</li> </ul> (***) Rib feature: Thickness = 6-8mm; one or two ribs maximum	
<b>Tasks schedule</b>	<b>Part Programming</b>	<b>Machining</b>
	CAM Activity (2 h 45 min)	Tool Preparation (15 min)
		Machining (4 h)

#### Additional details for the modules

- The following additional details must be included in the module: machine chamfers 0.2 to 0.3mm x 45 degrees;
- Every module must have a minimum of four geometric dimensioning tolerances criteria;
- It must be possible to complete the modules with the machining tools detailed in this Technical Description;
- It must be possible to check the modules with the measuring equipment and checking devices described in this Technical Description;
- Measurements of work pieces will be performed on a coordinate measuring machine (CMM);
- The Competition Organizer will nominate a technician who will be responsible for operating the coordinate measuring machine;
- The depth of the drilled or reamed hole will not be measured. The depth of the thread milling and tapped holes must be measured;
- For M6 and M10, core hole diameter 5.0mm, 8.5mm and the depth will not be measured;
- Tenons are not allowed under the machine vice. The Competitor must align the vice themselves. Machine stops on the vice are allowed;
- The Competition Organizer will try and supply the raw material + 0.15mm/- 0, machined all six faces;
- Competitors can use Mastercam during the machining time.

## Tolerances

The following tolerances apply to the Modules:

- Main dimensions: range from 0.02 to 0.04 mm, IT<sub>7</sub>;
- Reamed bores IT<sub>7</sub>;
- Hollow out bores IT<sub>7</sub>;
- Surface quality N<sub>6</sub> to N<sub>8</sub>/average = Ra 0.8 to 1.6;
- Depth of thread 0+2 mm;
- Form and positional tolerances as per DIN ISO 1101.

## Tool Preparation Time (15 minutes)

- Competitors can set up tool holders;
- Competitors can change tools;
- Competitors can measure tool using the pre-setter provided;
- Competitors can continue to work on Mastercam;

Competitors **cannot** set up the vice, **cannot** put tools or offset data in the CNC Machine.

## 5.4 TEST PROJECT DEVELOPMENT

The Test Project MUST be submitted using the templates provided by WorldSkills International ([www.worldskills.org/expertcentre](http://www.worldskills.org/expertcentre)). Use the Word template for text documents and DWG template for drawings.

### 5.4.1 Who develops the Test Project or modules

The Test Project is developed independently by an independent agency.

The module must meet the following requirements:

- Drawing ISO 1/E (First Angle Projection), Original Inventor model and Inventor Drawing;
- Drawing ISO 3/A (Third Angle Projection), Original Inventor model and Inventor Drawing;
- A STEP file (3D surface model);
- Component model made from Aluminium (conform to drawing);
- Measurement report checked by hand so that the Competitors are able to check all assessed marks;
- Judgement and Measurement Marking Forms in the format MS Excel in one of the three official languages. Aspect description should list both ISO 1/E and ISO 3/A dimensions, with ISO 3/A placed in brackets e.g. C6 (C4);
- The modules must be created with filename conventions (including filename extensions);
- Before the Competition, the modules must NOT be accessible to the Competitors;

(\* ) The version will be determined six months before the Competition

### Important Note:

The list of tools and instruments described in section 8.3 is the reference for the development of the Test Project proposal; this means that it is of utmost importance that all project modules are made in strict accordance with the list of tools described. None of the project proposals submitted by the Expert may use different cutting tools and diameters than those defined in the Technical Description.

#### 5.4.2 How and where is the Test Project or modules developed

The independent designers develop the Test Project modules independently according to the requirements in section 5.3 and 5.4.1

#### 5.4.3 When is the Test Project developed

The Test Project is developed according to the following timeline:

TIME	ACTIVITY
Ten (10) month before the Competition	A WorldSkills International Member or an Expert from that skill identify and investigate possible external agencies which are capable of and willing to develop the Test Project modules.
Nine (9) months prior to the Competition	The Director of Skills Competitions enters into an Agreement with the independent agency.
Eight (8) month before the Competition	Initial meeting with independent agency
Seven (7) month before the Competition	Second meeting with Independent Designer. After this, no Expert is allowed to communicate directly with independent designer. The independent designers start to develop the TP modules in accordance with the TD and IL.
Three (3) month before the Competition	Independent agencies to complete the design of the Test Project and Marking Scheme. The final files and photos/files of the prototype are emailed to Jane Stokie, Director of Skills Competitions – <a href="mailto:jane.stokie@worldskills.org">jane.stokie@worldskills.org</a> .
At the Competition	Where applicable the independent agency makes themselves available to present their Test Project modules to the Experts on the first preparation day at the current Competition.

## 5.5 TEST PROJECT VALIDATION

The Test Project module must comply with the project design requirements as is detailed in paragraphs 5.3 and 5.4.

## 5.6 TEST PROJECT SELECTION

The Test Project is selected by the independent designer.

## 5.7 TEST PROJECT CIRCULATION

The Test Project is circulated via the website as follows:

The Test Project, and the Marking Form, is not circulated prior to the Competition.

## 5.8 TEST PROJECT COORDINATION (PREPARATION FOR COMPETITION)

Coordination of the Test Project will be undertaken by the Skill Competition Manager.

## 5.9 TEST PROJECT CHANGE AT THE COMPETITION

Not applicable.

## 5.10 MATERIAL OR MANUFACTURER SPECIFICATIONS

Specific material and/or manufacturer specifications required to allow the Competitor to complete the Test Project will be supplied by the Competition Organizer and are available from [www.worldskills.org/infrastructure](http://www.worldskills.org/infrastructure) located in the Expert Centre.

The Competition Organizer undertakes to provide information on the following equipment the Competition as per the Competition Rules:

- The machines;
- The machine control systems;
- The tool holders (e.g. Sk40 DIN 69871, BT 40);
- Release bolts for the tool holders;
- Machine vice;
- CAM programming station, software version, PC keyboard;
- Machine control training software;
- Possibility of practicing operating the machines intended for the Competition.

## 6 SKILL MANAGEMENT AND COMMUNICATION

### 6.1 DISCUSSION FORUM

Prior to the Competition, all discussion, communication, collaboration, and decision making regarding the skill competition must take place on the skill specific Discussion Forum (<http://forums.worldskills.org>). Skill related decisions and communication are only valid if they take place on the forum. The Chief Expert (or an Expert nominated by the Chief Expert) will be the moderator for this Forum. Refer to Competition Rules for the timeline of communication and competition development requirements.

### 6.2 COMPETITOR INFORMATION

All information for registered Competitors is available from the Competitor Centre ([www.worldskills.org/competitorcentre](http://www.worldskills.org/competitorcentre)).

This information includes:

- Competition Rules
- Technical Descriptions
- Marking Schemes
- Test Projects
- Infrastructure List
- WorldSkills Health, Safety, and Environment Policy and Regulations
- Other Competition-related information

### 6.3 TEST PROJECTS [AND MARKING SCHEMES]

Circulated Test Projects will be available from [www.worldskills.org/testprojects](http://www.worldskills.org/testprojects) and the Competitor Centre ([www.worldskills.org/competitorcentre](http://www.worldskills.org/competitorcentre)).

### 6.4 DAY-TO-DAY MANAGEMENT

The day-to-day management of the skill during the Competition is defined in the Skill Management Plan that is created by the Skill Management Team led by the Skill Competition Manager. The Skill Management Team comprises the Skill Competition Manager, Chief Expert and Deputy Chief Expert. The Skill Management Plan is progressively developed in the six months prior to the Competition and finalized at the Competition by agreement of the Experts. The Skill Management Plan can be viewed in the Expert Centre ([www.worldskills.org/expertcentre](http://www.worldskills.org/expertcentre)).

## 7 SKILL-SPECIFIC SAFETY REQUIREMENTS

Refer to the WorldSkills Health, Safety, and Environment Policy and Regulations for Host country or region regulations.

- All Competitors must use safety glasses when using any hand, power, or machine tools or equipment likely to cause or create chips or fragments that may injure the eyes;
- Experts will use the appropriate personal safety equipment when inspecting, checking, or working with a Competitor's project;
- The documentation "Safety and Fairness" will be prepared by the Experts;
- The Competitor must comply with the machine manufacturer's safety instructions.

## 8 MATERIALS AND EQUIPMENT

### 8.1 INFRASTRUCTURE LIST

The Infrastructure List details all equipment, materials and facilities provided by the Competition Organizer.

The Infrastructure List is available at [www.worldskills.org/infrastructure](http://www.worldskills.org/infrastructure).

The Infrastructure List specifies the items and quantities requested by the Experts for the next Competition. The Competition Organizer will progressively update the Infrastructure List specifying the actual quantity, type, brand, and model of the items. Items supplied by the Competition Organizer are shown in a separate column.

At each Competition, the Experts must review and update the Infrastructure List in preparation for the next Competition. Experts must advise the Director of Skills Competitions of any increases in space and/or equipment.







At each Competition, the Technical Observer must audit the Infrastructure List that was used at that Competition.









The Infrastructure List does not include items that Competitors and/or Experts are required to bring and items that Competitors are not allowed to bring – they are specified below.

### 8.2 COMPETITOR`S TOOLBOX

The maximum external size of the toolbox must be within 1.2m<sup>3</sup>. The maximum number of toolboxes allowed is two units. The total volume of all the toolboxes combined must be within 2m<sup>3</sup>.

### 8.3 MATERIALS, EQUIPMENT, AND TOOLS SUPPLIED BY COMPETITORS IN THEIR TOOLBOX

ITEM	DESCRIPTION	DIMENSIONS	EXAMPLE PHOTO
1	NC Centre Drills 90°	Ø10.00	
2	Drills (DIN338/345)	Ø5.00, Ø8.50, Ø9.80, Ø10.00, Ø11.80, Ø20.00	
3	Machine Reamer	Ø10H7, Ø12H7	
4	Machine Tap (Blind Holes)	M6 x 1, M10 x 1.5	
5	Machine Tap (Through Holes)	M6 x 1, M10 x 1.5	
6	End Mill (roughing) (DIN844)	Ø6x13, Ø8x19, Ø10x22, Ø12x26, Ø16x32, Ø20x38	

ITEM	DESCRIPTION	DIMENSIONS	EXAMPLE PHOTO
7	End Mill (finishing) (DIN844)	Ø6x13, Ø8x19, Ø10x22, Ø12x26, Ø16x32, Ø20x38	
8	Ball Nosed End Mills	Ø12	
9	Chamfering cutters 90°	Ø10	
10	Internal thread mill, pitch 1.5mm	M30x1.5 (max. length = 1.5 x Ø)	
11	External thread mill, pitch 1.5mm	M42x1.5 (max. length = 1.5 x Ø)	
12	Boring head	Ø20 to 40 mm	
13	Surface Milling Head	Ø63	
14	Right-angle milling head	Ø20, Ø50	
15	Spare reversible carbide tips		

## Reference list for Test and measurement instruments

ITEM	DESCRIPTION	DIMENSIONS
1	Vernier calliper DIN 862	0-150mm
2	Depth micrometre	0-75mm
3	Depth Vernier calliper	0-150mm
4	Outside micrometres DIN 863/1	0-25, 25-50, 50-75, 75-100, 100-25, 125-150mm
5	Inside micrometres	5-25, 25-50mm
6	Disc micrometres	0-25, 25-50mm
7	Three-point hole micrometres	5-25, 25-50mm
8	(M30x1.5, M42x1.5)	



ITEM	DESCRIPTION	DIMENSIONS
9	Thread plug gauges for good and rejected products	M6, M10, M30x1.5
10	Thread ring Gauges	M30 x 1.5, M42 x 1.5
10	Chamfering tester 45°	
11	Instrument for angular measurement, plain protractor	
12	Set of slip gauges	
13	Indicating micrometre with magnetic stand	
14	Dial indicator with magnetic stand	
15	Radius gauge R3-25 mm	
16	High-accuracy 90°angle, arm length 80 mm	
17	Straight edge 100 mm	

#### Important Notes:

A) Please note that Competitors must bring their own tooling (tool holder, cutting tools, test and measurement Instruments) to the Competition. The Competition Organizer will not be providing these infrastructure items for the Competitors. The same items described and available in Infrastructure List are only spares.

B) As mentioned in A) the Competitors must carry their own tool holders. However, these must be compatible with the clamping system of the machine (Specifications of the machine to be supplied are to be considered.)

C) The Competitors are allowed to bring additional tools in relation to the list described in TD. Be aware of the maximum diameter permitted by the machine tool manufacturer. Must be careful to bring enough spares. Please see the paragraph 7.4 for particular restrictions. The Infrastructure List is a good source of inspiration.

D) The Competition Organizers will supply pulls studs for the CNC machine at the competition.

## 8.4 MATERIALS, EQUIPMENT, AND TOOLS SUPPLIED BY EXPERTS

Not applicable.

## 8.5 MATERIALS AND EQUIPMENT PROHIBITED IN THE SKILL AREA

IT-based information (e.g. data, programmes etc.) and equipment allowing wireless contact outside the skill area (mobile-phones, laptops, etc.):

- Are prohibited for Competitors;
- May be used by Experts in the Skill Area as defined by the Chief Expert before the Competition.

The use of any other PC than that provided during the Competition is strictly prohibited.

Competitors must only work with the software provided.

Only the keyboards supplied by the Competition Organizer can be used.

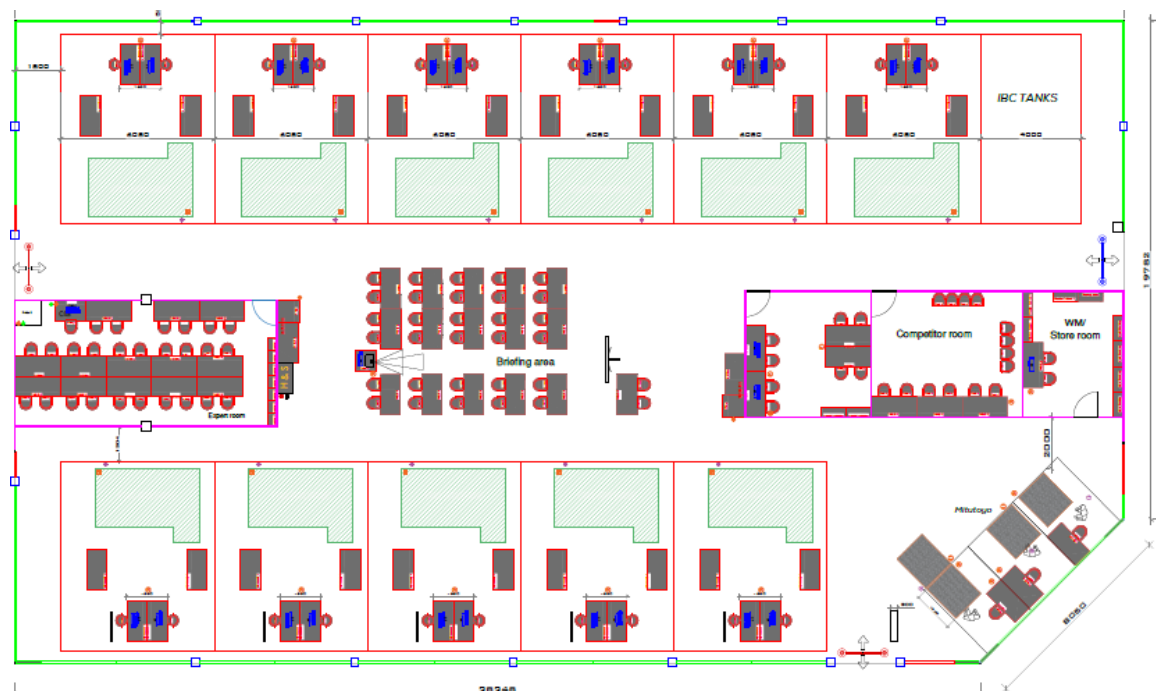
### Important Information

- The using of angular machine vices is NOT ALLOWED;
- The Competitors are only allowed to bring machine reamers for Dia.10H7 and Dia. 12H7;
- The Competitors are not allowed to bring their own linear height gauge or digital height gauges;
- No external tool presetter is allowed in CNC Milling. The Competition Organizer does not provide this item and Competitors cannot bring external tool presetters.

## 8.6 PROPOSED WORKSHOP AND WORKSTATION LAYOUTS

Workshop layouts from previous competitions are available at [www.worldskills.org/sitelayout](http://www.worldskills.org/sitelayout).

Example workshop layout:



## 9 SKILL-SPECIFIC RULES

Skill-specific rules cannot contradict or take priority over the Competition Rules. They do provide specific details and clarity in areas that may vary from skill competition to skill competition. This includes but is not limited to personal IT equipment, data storage devices, internet access, procedures and work flow, and documentation management and distribution.

TOPIC/TASK	SKILL-SPECIFIC RULE
Use of technology – USB, memory sticks	<ul style="list-style-type: none"> <li>Competitors are only allowed to use memory sticks provided by the Competition Organizer. No other memory sticks are to be inserted into the Competitor computers.</li> <li>Memory sticks or any other portable memory devices cannot be taken outside the workshop.</li> <li>Memory sticks or other portable memory devices are to be submitted to the Chief Expert at the end of each day for safe keeping and must not be taken out of the workshop.</li> </ul> <p>Note: spy software may be used on computers.</p>
Use of technology – personal laptops, tablets and mobile phones	<ul style="list-style-type: none"> <li>Competitors, Experts, and Interpreters are not allowed to bring personal laptops, tablets or mobile phones into the workshop.</li> </ul>
Use of technology – personal photo and video taking devices	<ul style="list-style-type: none"> <li>Competitors, Experts, and Interpreters are allowed to use personal photo and video taking devices in the workshop at the conclusion of the competition only.</li> </ul>
Tools/infrastructure	<ul style="list-style-type: none"> <li>Competitors must use the mouse and keyboard provided by the Competition Organizers.</li> <li>Tenons are not allowed underneath the machine vice, the Competitor must align the machine vice manually.</li> <li>Competitors are not allowed to bring their own linear height gauges. There are some supplied by the Competition Organizer which can be used during the competition.</li> <li>The machine parameters must not be changed.</li> <li>The post processor cannot be changed by the Competitor.</li> </ul>
Templates, aids, etc.	<ul style="list-style-type: none"> <li>The Competitor may bring one sheet (A4 size) with tool speeds and feeds for information only.</li> </ul>
Drawings, recording information	<ul style="list-style-type: none"> <li>No drawings or information regarding the Test Project can be taken out of the workshop.</li> <li>The Competitor cannot bring their own drawings. During familiarization, drawings will be supplied.</li> </ul>
Equipment failure	<ul style="list-style-type: none"> <li>In the event of CNC machine failure, the Competitors will be moved onto one of the spare CNC Machines</li> <li>In the event of a computer failure, the Competitors may use one of the spare computers</li> </ul>
Health, Safety, and Environment	<ul style="list-style-type: none"> <li>Refer to the WorldSkills Health, Safety, and Environment policy and guidelines document</li> </ul>

TOPIC/TASK	SKILL-SPECIFIC RULE
Assessment	<ul style="list-style-type: none"><li>• The Competitors part will be engraved with their country ID, then it will be covered and assigned a random number during assessment</li></ul>

## 10 VISITOR AND MEDIA ENGAGEMENT

The following ideas may be considered to maximize visitor and media engagement:

- Display screens (video of CNC milling machining);
- A show spot with a complete Test Project (description, parts, and drawings) from past Competitions that make easy the understanding of Competitor activity;
- Competitor profiles - provide a sticker with the national flag, the name of the Competitor, and a brief description of their studies;
- Daily reporting of Competition status;
- A demonstration area for Competitors to interact with visitors to explain their skill;
- Demonstration videos provided by the machine and CAD/CAM sponsors showing parts machining which are of interests to visitors: aerospace, automotive, etc.;
- Small exhibits around the competition venue where various objects of everyday life such as a bottle; a mobile telephone; a toy; automotive part; aerospace part are exhibited with an explanation how it is produced and the role of CNC milling machines;
- A person who has detailed knowledge about CNC milling explains our competition with samples and videos. (Using former completed projects and technical drawings and a video showing a dry machining process of one module.);
- Terminals nearby the Competitors work place showing the CAM activity;
- Live web cam in the machine with projection to a big screen. E.g. GoPro Cameras.

## 11 SUSTAINABILITY

The following ideas may be considered:

- At the end of the Competition create several individual project sets (part, drawing and programmes) from the parts machined by the Competitors and donate them to vocational schools as teaching materials. (The programme is chosen from the highest scorer of each module);
- Demonstration parts;
- Each country/region is required to bring demonstration parts that the public can easily identify to be used during the demonstration time. (A geometric 3D file of the part is required as well.)

## 12 REFERENCES FOR INDUSTRY CONSULTATION

WorldSkills is committed to ensuring that the WorldSkills Standards Specifications fully reflect the dynamism of internationally recognized best practice in industry and business. To do this WorldSkills approaches a number of organizations across the world that can offer feedback on the draft Description of the Associated Role and WorldSkills Standards Specification on a two-yearly cycle.

In parallel to this, WSI consults three international occupational classifications and databases:

- ISCO-08: (<http://www.ilo.org/public/english/bureau/stat/isco/isco08/>)
- ESCO: (<https://ec.europa.eu/esco/portal/home>)
- O\*NET OnLine ([www.onetonline.org/](http://www.onetonline.org/))

The WSSS in Section 2 appears most closely to relate to: *Milling and Planing Machine Setters, Operators and Tenders*: <https://www.onetonline.org/link/summary/51-4035.00>

or *Milling Machine Operator*: <http://data.europa.eu/esco/occupation/a1c9f8b7-c4ce-4b15-ac3c-3378c300d8f2>

These links also enable a review of adjacent occupations.

The following table indicates which organizations were approached and provided valuable feedback for the Description of the Associated Role and WorldSkills Standards Specification in place for WorldSkills Kazan 2019.

ORGANIZATION	CONTACT NAME
Hamilton Bonaduz AG, Switzerland	Silvio Tönz, Mechanical Operator
Siemens AG	Karsten Schwarz, Head of Training
Moldegama Industries, Portugal and Spain	Gonçalo Cordeiro, Chief Operating Officer
SICK STEGMANN GmbH	Stefan Mueller, Vocational Trainer
Prototyp-Werke GmbH	Wolfgang Lehmann, Team Leader Vocational Education