worldskills

Standards and Assessment Guide

CNC Milling

v1.1
@WorldSkills International

Introduction

Welcome to the Standards and Assessment Guide (SAG), a comprehensive resource designed to support excellence in assessment practices for all skills competitions hosted at the WorldSkills Competition. A key component of the SAG is the commitment to continuous improvement through ongoing review, ensuring that these guides consistently reflect the latest industry innovations and high standards of assessment in an open and transparent manner.

Purpose

The primary purpose of this guide is to provide a structured framework for the consistent and fair assessment of each skill competition. It aims to ensure that all assessments are conducted with a high degree of accuracy, reliability, validity, and reflect global industry standards. By adhering to these guidelines, assessors can maintain the integrity of the competition and uphold the high standards associated with WorldSkills.

Note: this guide is not a replacement for the Marking Scheme and should only be used as a reference when required during the assessment process. Competitors are not allowed to have a copy of this SAG in the workshop in either digital or paper form.

Scope

This document covers general assessment practices applicable to a diverse range of industry sectors including:

- Manufacturing and Engineering Technology
- Information and Communication Technology
- Construction and Building Technology
- Transportation and Logistics
- Social and Personal Services
- Creative Arts and Fashion

Each skill competition has its unique requirements and benchmarks, which are detailed within sections of this guide. The consistency of assessment across each skill is the overarching principle, ensuring a unified approach to evaluating Competitor performance to the highest standards.

Key Components

The guide is structured into several key components, each addressing critical aspects of the assessment process:

Assessment Principles and Objectives

- Emphasis on fairness, transparency, and objectivity in assessments.
- Alignment with global industry standards and best practices.

Assessment Methods and Tools

- Description of various assessment methods in Measurement and Judgement.
- Guidance on the application of appropriate assessment tools and equipment (if applicable).

Criteria and Benchmarks

- Examples of assessment criteria and aspects for each skill, outlining the expected competencies and performance standards.
- Benchmarks for different levels of proficiency i.e. Judgement award range 0, 1, 2, 3 or Yes/No criteria alongside clear measurable descriptors.

Expert assessment requirements

- Completion of the Access Programme.
- Approved Curriculum Vitae (CV).
- Reaching **100%** Expert preparedness.
- Full participation of online and in-person Mandatory Assessment Training (MAT).
- Completion of practical assessment testing at the Competition.

Quality Assurance and Improvement

- Monitoring and evaluation: Ensuring assessments are carried out correctly and produce reliable results.
- Continuous improvement: Using feedback from Experts and Skill Competition Managers to enhance future assessments.
- Periodic review: Regularly updating processes to reflect current industry and WorldSkills standards.

Implementation

For effective implementation, this guide should be used for guidance purposes only and in parallel with the Technical Description for each skill. Experts are encouraged to familiarize themselves thoroughly with both the general guidelines and the particular requirements of their respective skill areas. Collaborative efforts between the Skill Management Team, Experts, and Competitors are vital for achieving the ultimate goal of global skills development.

Conclusion

The Standards and Assessment Guide embodies the commitment of the WorldSkills movement to nurturing talent and promoting the highest standards of vocational education and training worldwide. By providing clear and comprehensive guidance, we aim to empower Experts to conduct marking and assessment practices that are not only rigorous and equitable but also inspiring and transformative for all participants.

Thank you for your dedication to upholding these standards and contributing to the success of the WorldSkills Competition. Together, we can continue to champion skills excellence and celebrate the achievements of talented individuals from around the globe.

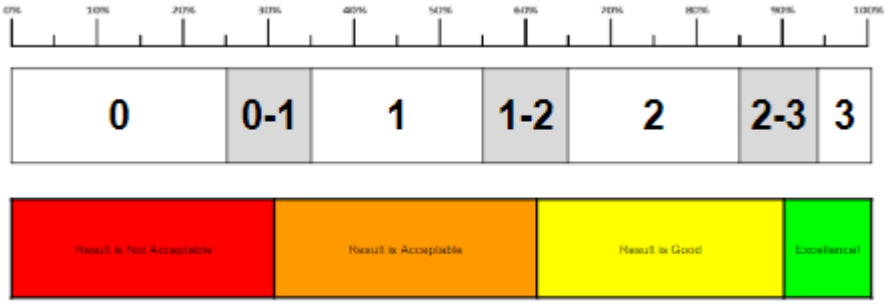
Contents

Maximum Judgement Marks

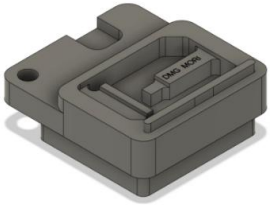
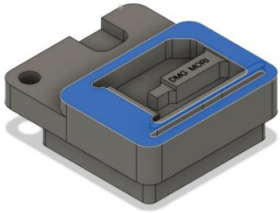
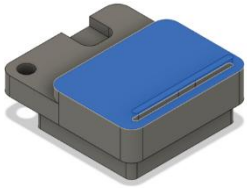
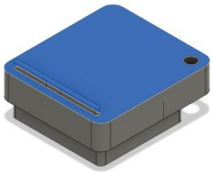
Before judging commences, you must decide on what percentage of total work has been carried out on the part, how close has it been to finished. This may differ between each component submitted by the competitors.

On a 4-sided part, machining 1 side does not necessarily mean 25% of the work has been done. There could be some sides that have more features, the part should be assessed as a whole, taking into account what % of total machining has been is completedd.
Suggested % boundaries for all aspects / projects are shown below.
These figures should be seen as a guidance on the maximum judgement mark allowable - lower marks can be awarded if the part does not meet the judgement criteria.

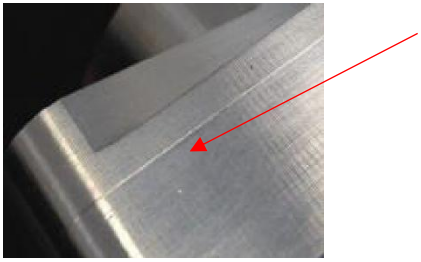
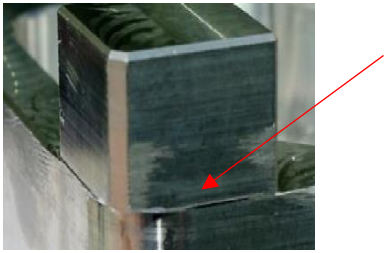
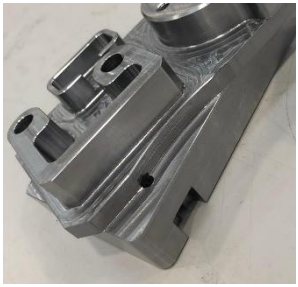
For example, to judge the criterion "Handling Damage", you must give a score from 0-3, based on the percentage of work done and how much damage is observed.

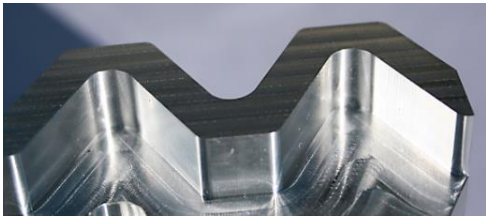
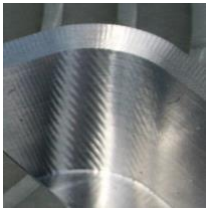
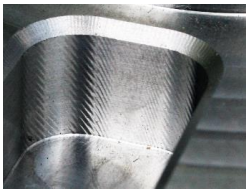
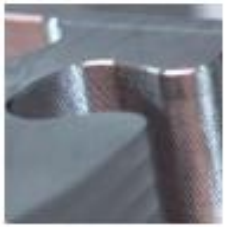
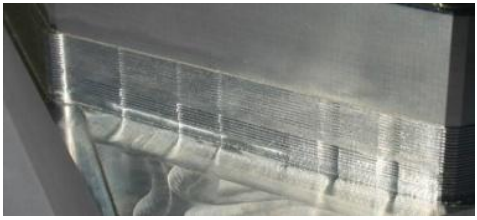


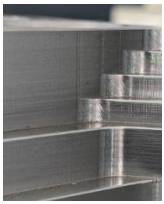
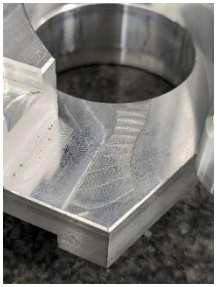
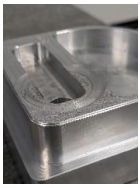
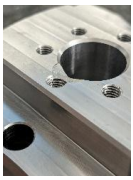
The grey areas in the boxes above represent the area where judges own subjective assessment may differ from others.
This is allowed, as long as judges' marks do not differ by more than one point.

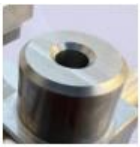
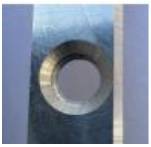
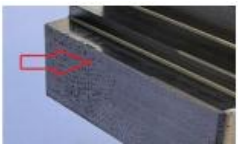
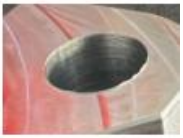
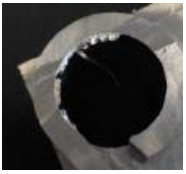
Score	Conformity to Drawing Does the part conform visually to the drawing, look for missing features and extra features	
3	Excellence! No feature missing and No extra features All features visually correct	
2	Good Minor features missing / visually incorrect. No extra features Example Minor features: Threaded / Reamed Holes Chamfers Small slots (<10mm width)	
1	A few Minor features missing or visually incorrect and/or 1 major feature missing. Example Major feature: Large Boss / Pocket / Slot (>10mm Width / Diameter) Some extra features are visible.	
0	Inis completed component: Majority of features missing from one side or more.	

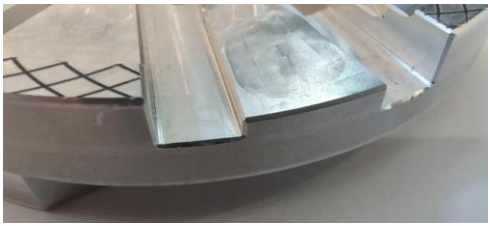
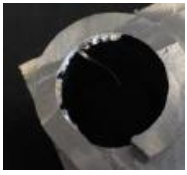
Score	**Handling Damage** Damage from mishandling of parts, swarf impact marks, vice marks, scratches from handling, dropping or hand tools. Damage NOT caused by machine cutting tools and / or measuring equipment.	
3	Excellence! Over 85% of project is completed No damage to part	
2	Over 55% of project is completed Minor damage from the following: vice marks, scratches, swarf impact. Very few instances of damage. (opposite vice/clamp marks may be considered as one incident)	  
1	Over 25% of project is completed. Minor damage, but multiple instances of the following: vice marks, scratches, swarf impact (opposite vice/clamp marks may be considered as one incident)	  
0	Major damage: vice marks, scratches, swarf impact	 

Score	Mismatch Mismatch from different set-ups or sides of machining. Tooling mismatches	
3	Excellence! Over 85% of project is completed No mismatch on the component	
2	Good Over 55% of project is completed. Slight discrepancy, can be felt by hand (**Not** Vice mark)	
1	Over 25% of project is completed. Easily visible step in component	
0	Component not machined in the correct orientation and /or major step.	

Score	Chatter Marks Marks from vibration of tool or work piece.	
3	Excellence! Over 85% of project is completed No visible marks from cutters in radiuses and lines. All edges and radiuses look the same as contouring.	
2	Over 55% of project is completed. Slight Incidents of chatter marks (One incident of chatter includes the whole features, Eg. A pocket may have 4 corners with chatter = 1 incident)	 
1	Over 25% of project is completed. Multiple incidents of visible chatter marks per side. (One incident of chatter includes the whole features, Eg. A pocket may have 4 corners with chatter = 1 incident)	 
0	Serious chatter marks per side. Chatter is evident in many features on the part.	

Score	Collision, Contour Damage and Lead in/out Damage from tools, tool holders, wrong toolpaths and lead in / lead out marks (Lead in / Lead out is the movement of the cutter at the start and end of a finish toolpath)	
3	Excellence! Over 85% of project is completed No marks from the lead-in – lead-out process. No crash marks or contour damage. All features are finished with a finishing strategy (No evidence of roughing toolpaths evident)	  
2	Over 55% of project is completed. Good - No collision marks from tools or arbours. Some minor evidence of tools leading in/out, stall	 
1	Over 25% of project is completed. Visual damage from cutting tools or arbours. Any area showing evidence of roughing tool paths that have not been finished. Major evidence of tools leading in/out, stall marks	 
0	Evidence of collision with cutting tools or arbours. Damage must be evident to touch.	 

Score	Deburring and Chamfers by Machine The proximity of the deburring must be assessed with regards to a 10mm Chamfer cutter as per the Technical Description	
3	Excellence! Over 85% of project is completed Is completed deburring, as close to broken edges as possible with the supplied chamfer tool.	  
2	Good. Over 55% of project is completed. Could be closer to broken edges using the supplied tool. Very few edges missing.	 
1	Over 25% of project is completed. Some / Multiple edges missing. Chamfers not present on multiple sides.	  
0	Inis completed component: Majority of features missing from one side or more.	   

Score	Deburring by Hand All edges on part are deburred and blend well to machine deburring	
3	Excellence! Over 85% of project is completed All edges within the defined limit, hand deburring is hard to distinguish from machine chamfers. No sharp edges evident on part.	
2	Good. Over 55% of project is completed. All edges is completed but easily distinguished from machine deburring. Some edges even though deburred feel rough. Could be closer to edges.	
1	Over 25% of project is completed Some edges missing, but no major burrs. The chamfering by hand is clearly different in size / angle and quality.	
0	Inis completed component: Majority of features missing from one side or more.	 

Objective Marking

Feature	Description:	
	The objective evaluation process will be carried out using a Coordinate Measuring Machine. The leadership in execution comes from the technical team, represented here by Mitutoyo. All criteria will be evaluated on coordinate measuring machines, except: Holes 10 H7 and 12 H7, in addition to threads M6, M10, M30 and M42 which must be carried out by Experts using the gauges	
10 H7 **12 H7**	The measurement of holes **10 H7** and **12 H7** will be carried out with gauges. For the holes to be considered correct, evaluators must be able to insert the part of the gauge identified as "**GO"**. The part of the gauge called **"NO GO"** cannot enter the hole	
M6 **M10**	The measurement of threads **M6** and **M10** will be carried out with thread gauges. For the threads to be considered correct, evaluators must be able to insert the part of the gauge identified as "**GO"**. The part of the gauge called **"NO GO"** cannot enter the hole. Gauges must be built to 6H tolerance	

M30 **M42** **(internal)**	The measurement of internal milling threads **M30** and **M42** will be carried out with thread gauges. For the threads to be considered correct, evaluators must be able to insert the part of the gauge identified as "**GO"**. The part of the gauge called **"NO GO"** cannot enter the hole. Gauges must be built to **6H** tolerance	
M30 **M42** **(external)**	The measurement of external threads **M30** and **M42** will be carried out with thread ring gauges. For the threads to be considered correct, evaluators must be able to screw the part of the gauge identified as "**GO"** onto the feature. **"NO GO"** should not fit the feature. Gauges must be built to **6g** tolerance	
Thread Depth **(internal)**	The process for measuring internal thread depth for this production is being standardized. This way, everyone has the same conditions to adapt to the process. The process will be divided into three parts. **Step 1:** Experts must initially measure the total length of the gauge with a digital caliper and reset the instrument with a new origin. **Step 2:** insert the thread gauge into the hole being measured until the end. Use the "GO" side of the gauge. **Step 3:** Now measure the height of the caliper with the caliper to the reference face. This way the caliper will be indicating how much useful thread we have in the evaluated hole. This is the measurement with tolerance 0 + 2 mm that we will consider.	 

Thread Depth (external)	To measure the external milled thread depth, we will follow the following steps: **Step 1:** Measure the thickness of the ring thread gauge with the digital caliper **Step 2:** Insert the thread gauge ring until the end of the thread. **Step 3:** Measure the height from the top of the thread to the thread gauge ring and add the thickness of the gauge. This will be the useful thread measurement.	

Objective Marking only for CMM

This chapter was formulated with the aim of establishing a standardized evaluation method, especially the actions that the measurement professionals will follow during the process of preparing and executing the measurement program at the CMM. We have adopted procedures to ensure that the measurement process runs as objectively and equally as possible for all participating competitors.

The information described in this chapter follows what the competition understands to be best practice and will serve as a guide so that specialists in dimensional metrology can carry out inspection activities with as little external interference as possible and that their actions have no impact, extracting the fairest, most honest and impartial result possible.

Techniques and procedures for setting up and measuring on a Coordinate Measuring Machine.

Technician: A measurement technician will measure all the modules in the competition, following the guidelines described below or the guidelines of the judging panel in exceptional cases.

Uncertainty: 0.003mm is proposal as the uncertainty value for three-dimensional CNC measurements. The final value will be defined by Mitutoyo according to the conditions of machines, equipment and measuring environment to be found in the competition.

Program: One measurement program will be made for each machining side of the part, and for each measurement, an alignment/leveling and orientation plan will be made on the machined faces on the side where the geometries will be measured

Measurement program

Rules: The choice of the side on which the geometry will be measured in the CMM follows the following guidelines on the priority scale:

- On the side where the geometry was milled;
- In the position where the dimension is in the drawing.

Examples

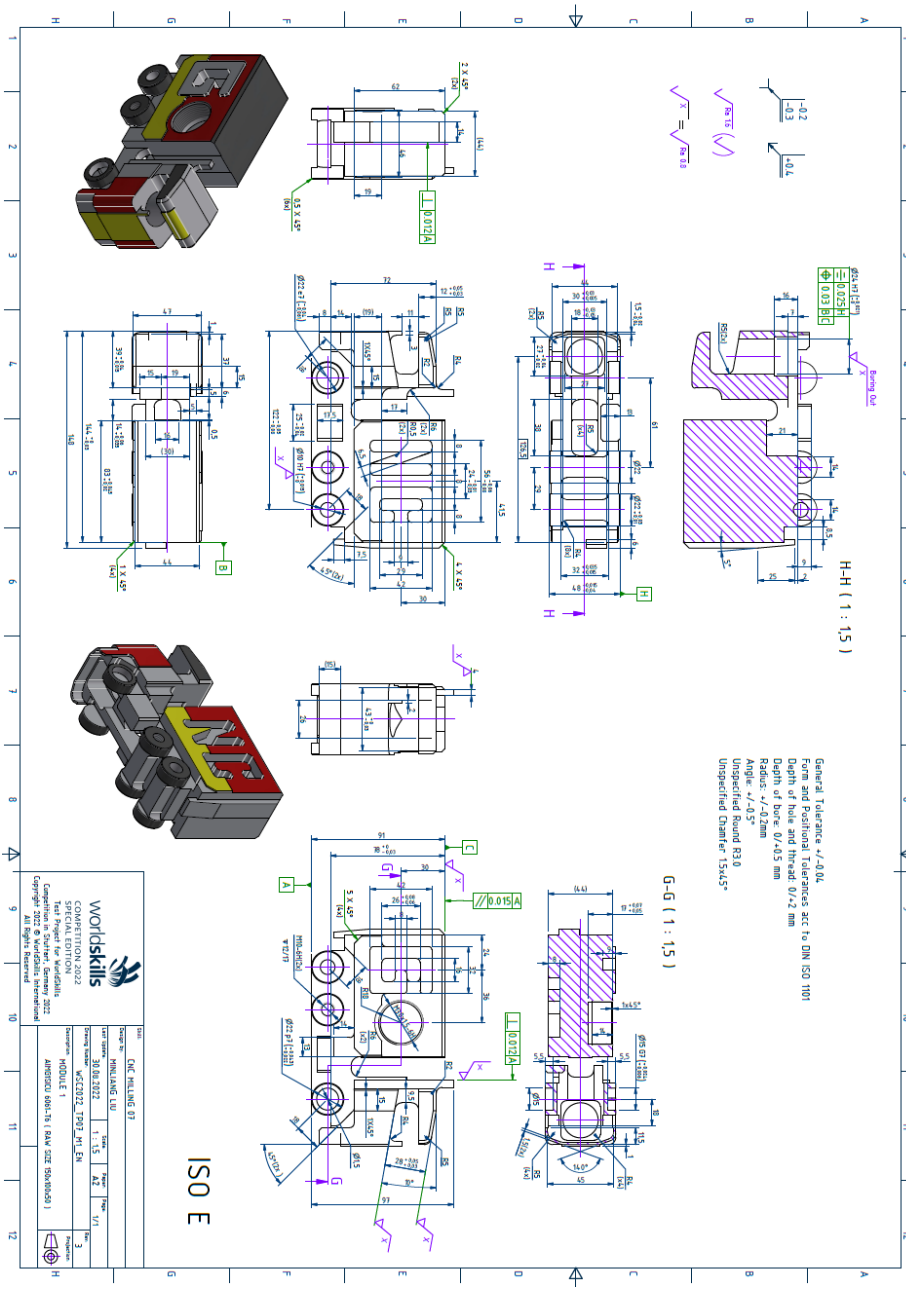
- If the dimension geometries can only be milled on one side: it is measured on the side where it was milled.
- If both dimension geometries can be milled on side A or B: measured on the side where the dimension is shown in the drawing.
- If one of the geometries has necessarily been machined on side A and the other has necessarily been machined on side B: the measurement is taken on the side where the dimension is located in the drawing;
- If one of the geometries has necessarily been machined on side A and the other may have been machined on side A, B, C or D: it is measured on side A.
- If both geometries can be machined on side A, B, C or D: it is measured on the side where the dimension is on the drawing.
- More detailed examples at the end of the document.

- **Alignment/leveling plane:** must be made on one of the faces that have necessarily been machined on the side of the part where the geometries to be measured are located, one plane for each side of the part. The plane must be created manually outside the program using 4 points.
- **Orientation axis:** these should be made on the largest faces parallel to the X and Y axis that have preferably been machined on the side to be measured.
- **Plans for creating datums:** must be measured with 4 points.
- **Length and width measurements**: For these measurements, two lines will be created, each with 3 points, with an approximate length of 10mm, located at a depth of 5mm and ideally in the position where the dimension is on the drawing. If it is not possible to measure to a depth of 5mm, you should preferably measure from 3 to 10mm depending on the geometry of the detail.
- **Measurements of heights, depths and thicknesses:** These measurements will be taken point by point, preferably at the position and side of the part where the dimension is located.
- **Diameter:** measurement will take place with a circle element, with 4 points, preferably at 45°, to avoid machine axis inversions. If the diameter to be measured is not a completed circle geometry, so that it is not possible to measure a point in each quadrant, measure 2 more points in each quadrant that cannot be touched. For example: 3 quadrants, 6 points; 2 quadrants, 8 points; 1 quadrant, 10 points.
- **Geometric tolerance - Parallelism, perpendicularity and inclination:** Must be measured between plane and plane to which it takes the largest possible area of the face
- **Geometric tolerance - Concentricity:** must be measured between two circular elements.
- **Geometric tolerance - Position**: must be measured between the reference plane and a circle element, measured as above.
- **Geometric tolerance - Symmetry:** must be measured between reference planes and lines.
- **Machining collisions:** If there is a machining collision, it must be measured in an adjacent region, ensuring that the criterion inspected is compatible with the one requested in the drawing. If this is not possible, the competitor loses the point.

- **Measurement collisions:** If there is a collision during automatic measurement, the measurement must be carried out manually (using the CMM) for that characteristic.

When you define a measurement on one side, but it is not possible due to some problem, and it is possible to measure on the other side (for example, a geometry that passes between two sides, or a height on side 3 that can be accessed from side 1 or 2) you measure on the other side.

EXAMPLE 01


H-H (1 : 1,5)
G-G (1 : 1,5)
ISO E
worldskills
COMPETITION 2022
SPECIFICATION
Competition in Shutten, Germany 2022
Copyright 2022 © WorldSkills International
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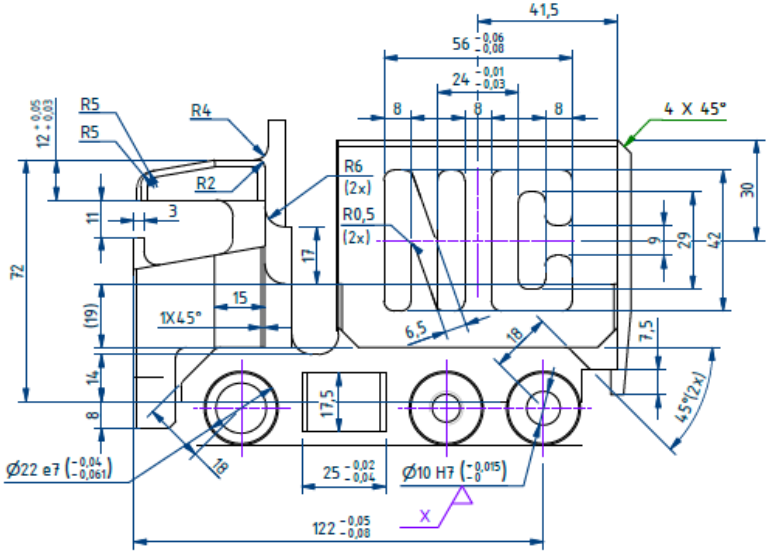
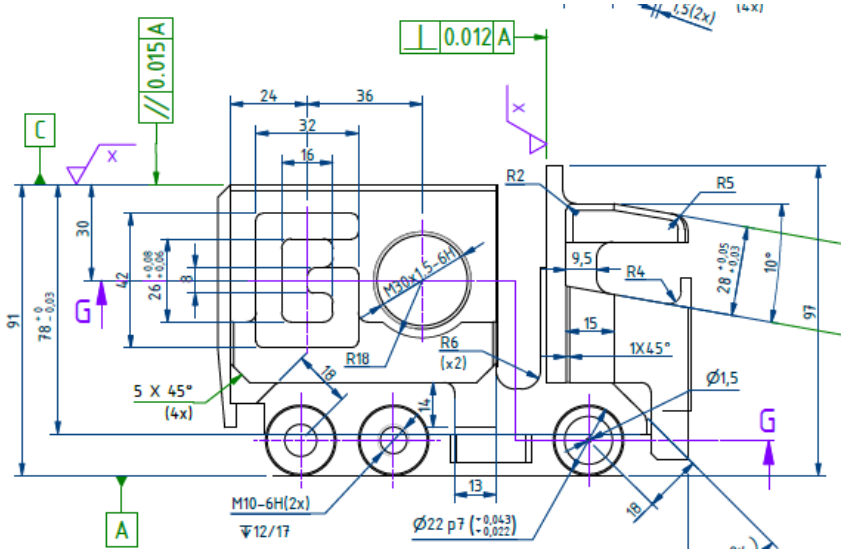
CNC MILLING 07
MINGLIANG LIU
30.08.2022
1 : 1.5
A2
1 / 1
3
WSC2022_T07I_M1_EN
MODULE 1
AlMgSi0,5 6061-T6 (RAW SIZE 150X100X50)
General Tolerance +/-0,04
Form and Positional Tolerances acc to DIN ISO 1101
Depth of hole and thread 0/+2 mm
Depth of bore: 0/+0,5 mm
Radius: +/-0,2mm
Angle: +/-0,5°
Unspecified Round R3,0
Unspecified Chamfer 1,5x45°

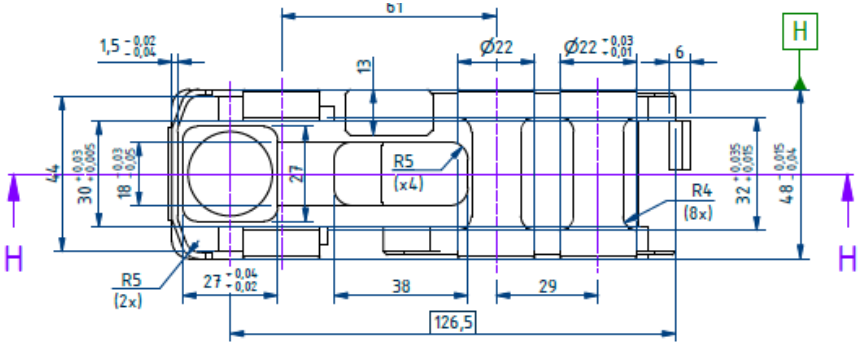
First Side



Second Side

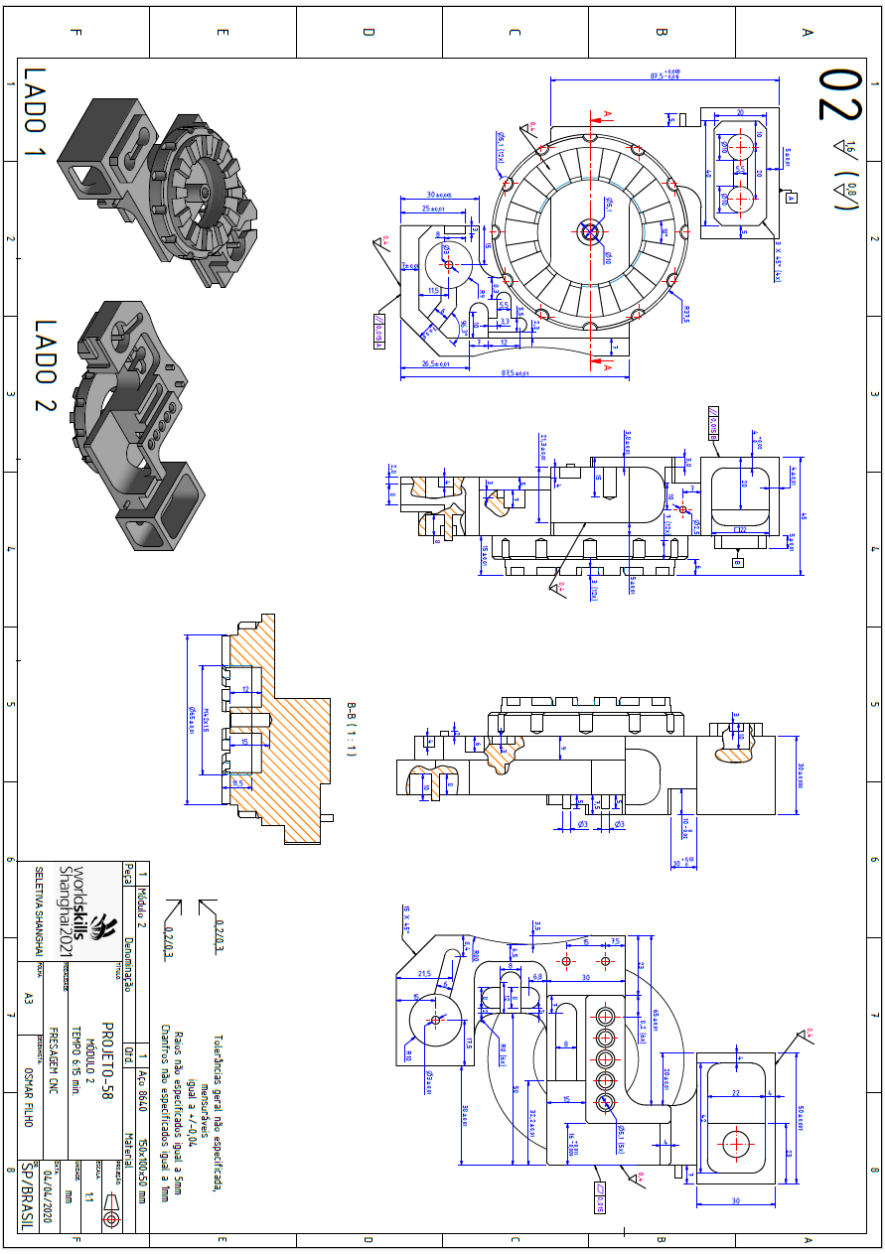


Third side

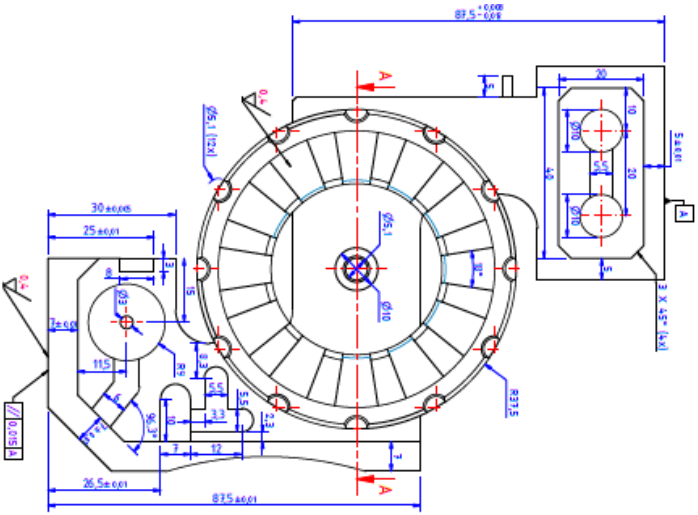


1. The dimensions 25, 24 and 56 can only have been machined on the first side. Therefore, these dimensions will be measured in the measuring program from this side, with planes and orientation axis created on faces machined on this side as well.
2. The dimension of 122 may have been completed on side 1 or 2, because the circle is through and the outer wall can be accessed at any mounting. Therefore, rule 1 does not define which side it will be measured on. Rule 2 follows: the dimension is dimensioned in the view that represents side 1, so it will be measured in the process of measuring side 1.
3. The dimension of 78 is between two elements that have necessarily been machined on different sides. A plane on side 3 and a wall on side 1 or 2. Therefore, rule 1 does not define how this dimension will be evaluated. Therefore, rule 2 is followed and therefore this dimension is evaluated in the measurement program on side 2, because the dimension is represented on side 2.

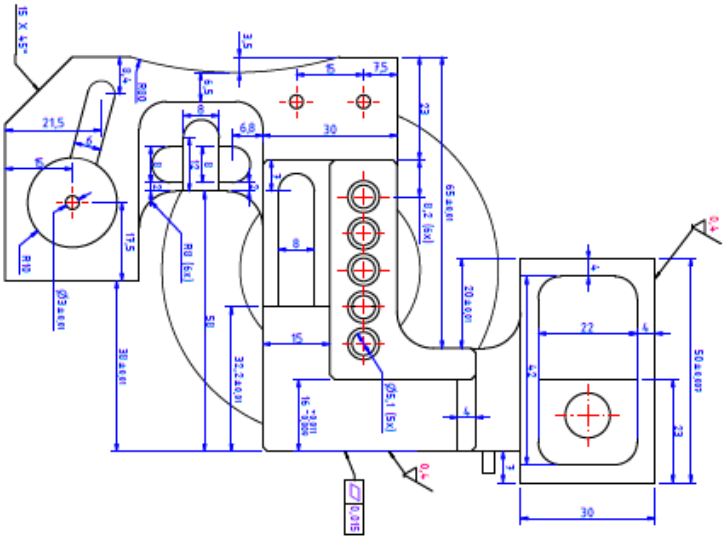
EXAMPLE 02


02
LADO 1
LADO 2
B-B (1 : 1)
Tolerâncias geral não especificada, mensuráveis igual a +/-0,04
Raios não especificados igual a 5mm
Chanfros não especificados igual a 1mm
PROJETO-58
MÓDULO 2
TEMPO 6:15 min.
FRESAGEM CNC
OSMAR FILHO
SELETIVA SHANGHAI
SP/BRASIL
worldskills Shanghai 2021

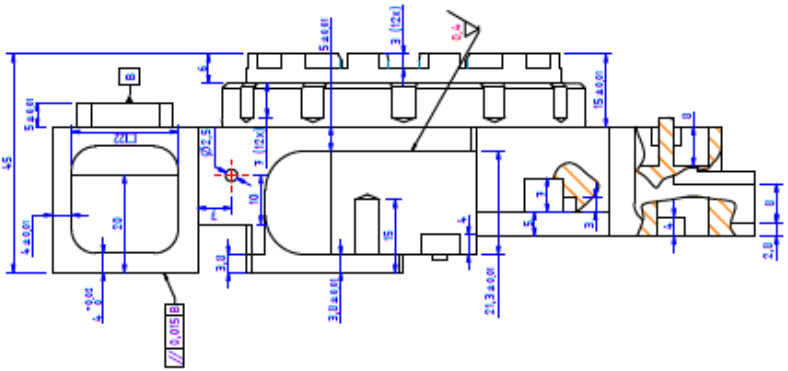
First Side



Second Side

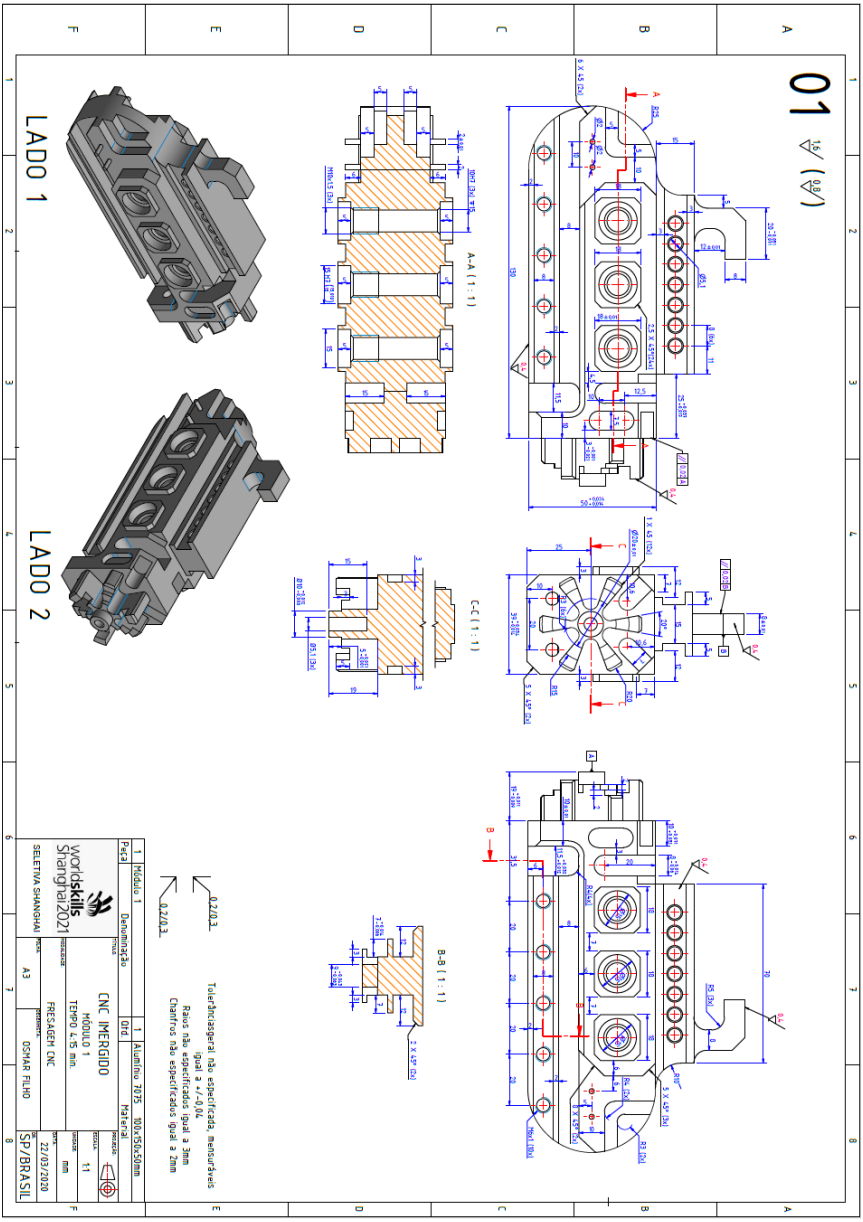


Third side

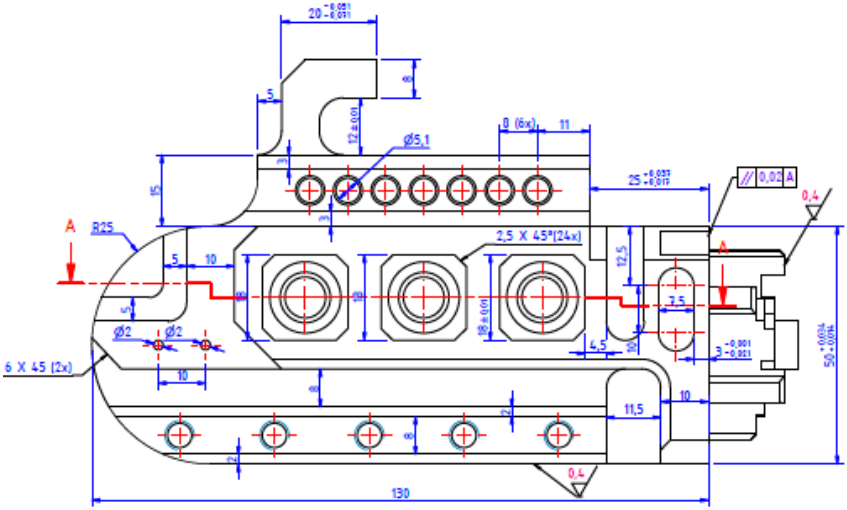


1. In this part, the measurement of 87.5 on B1 and C3 is dimensioned on side 1. However, one of the walls of each can only be machined on side 2. Therefore, these dimensions must be measured in the measurement process on side 2, having been leveled and oriented by planes and lines also machined on side 2.
2. The dimensions of 38 and 16, both in C8, are dimensioned on side 2. However, 1 of the planes of these measurements can only be machined on side 3, and the other can have been machined on side 1, 2 or 3. Therefore, these measurements are assessed as heights on side 3.
3. The dimension of 32.2 in C8 is dimensioned on side 2. However, both planes on which it is evaluated can only be machined on side 3. Therefore, this dimension must be measured in the measurement process on side 3, having been levelled and aligned by planes and lines also machined on this side.

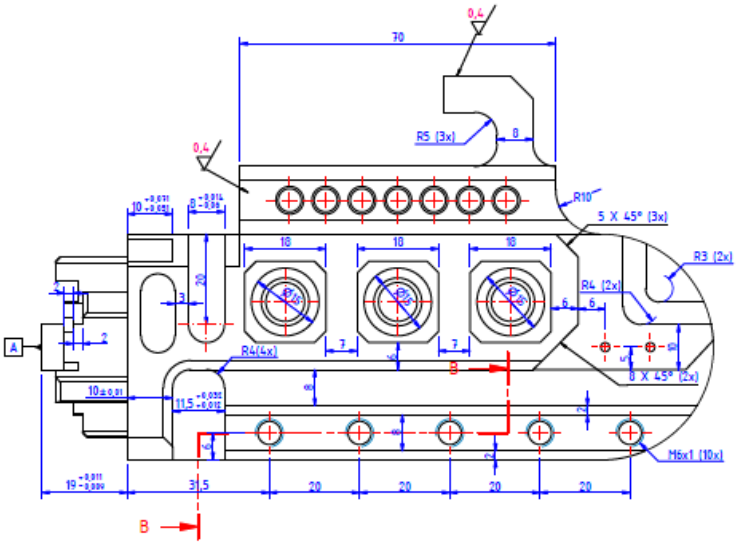
EXAMPLE 03


01
LADO 1
LADO 2
A-A (1 : 1)
C-C (1 : 1)
B-B (1 : 1)
0.2/0.3
0.2/0.3
Tolerância geral não especificada, mensuráveis
igual a +/-0.04
Raios não especificados igual a 3mm
Chanfros não especificados igual a 2mm
worldskills
Shanghai2021
CNC IMERGIDO
MÓDULO 1
TEMPO 4.5 min.
FRESAGEM CNC
SELETIVA SHANGHAI
Módulo 1
Denominação
Alumínio 7075
90x56x30mm
DSHAR FILHO
SP/BRASIL
22/03/2020
A3
mm
1:1

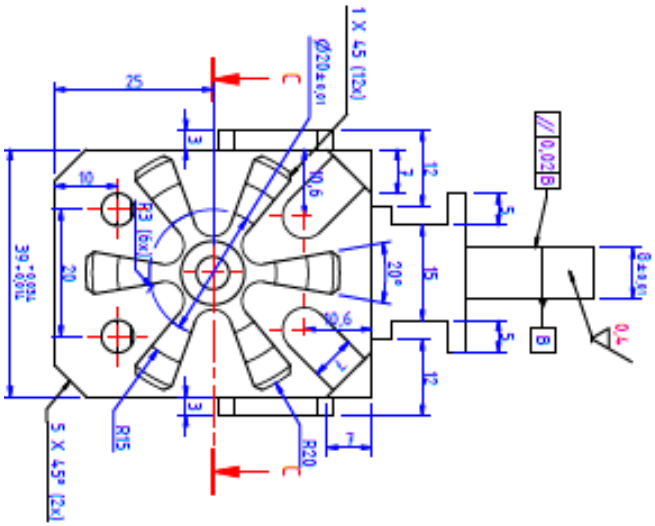
First Side



Second Side



Third side



1. On this part, the measurement of 18 at B3 can only have been machined on side 1. Therefore, according to rule 1, it must be measured in the process of measuring side 1, with the part aligned and leveled by planes measured on faces also machined on that side
2. The dimension of 25 in B3 is dimensioned on side 1, but the two planes can only have been machined on side 3. It must therefore be measured in the measurement process on side 3
3. The geometries of dimension 50 in B4 were necessarily machined on different sides. One plane on side 1 or 2, and the other necessarily on side 3. Therefore, it must be measured where the dimension is in the drawing.
4. The geometries of dimension 39 in C5 and 9 in A5 are dimensioned on side 3, but they are thicknesses measured between planes that have necessarily been machined on sides 1 and 2. Therefore, although it is easier to measure on side 3, it must be measured in the measurement processes on side 1 or 2 by indexing the CMM head and probing 2 points.
5. The dimensions of 12 and 20 in A2 may have been calibrated on side 1 or side 2. But as it is dimensioned on side 1, it must be measured in the measurement process on side 1