

## Appendix C: Checklist for Learning Outcomes - Basic Mechanical

Note: The color-coding is showing the connection between Objectives, Learning Outcomes and Elements.

Objectives	Learning outcomes in lessons	Elements (section 1.8)	Direct observation points for each participant (from section 1.8 Elements)
<p>(a) Have the knowledge and the skills to use safety procedures specific to mechanical systems and to use the necessary PPE and appropriate tools.</p> <p>(b) Have general knowledge of the construction components; Foundation, Towers, Nacelle, Rotor and Blades, Platforms, Ladders and Lifts.</p> <p>(c) Have general knowledge of the mechanical systems and their</p>	<p><b>Lesson 2: Mechanical introduction</b></p> <ol style="list-style-type: none"> <li>1) Understand the different designs of wind turbines, their applications, advantages and disadvantages.</li> <li>2) Explain the main components of the structure</li> <li>3) Explain the main mechanical systems</li> <li>4) Explain how a wind turbine works, including the physics which influence the output of wind turbines. Including power, energy, wind velocity and wind direction.</li> <li>5) Comply with the safety procedures for working on a wind turbine and the importance of working to approved working procedures. Including correct use of the required PPE for working on a wind turbine.</li> </ol>	<p>2.1 Types of wind turbine.</p> <p>2.2 Main components of the structure.</p> <p>2.3 Main mechanical systems.</p> <p>2.4 How a turbine works and the physics involved.</p> <p>2.5 Safe Working Procedures on a wind turbine.</p>	<p>Element 2.2 Main components of the structure. Participants will <b>engage in discussions of:</b> 2.2.7 Construction components of a wind turbine.</p> <p>Element 2.3 Main mechanical systems. Participants shall <b>engage in discussions of</b> 2.3.7 The basic mechanical systems in a wind turbine</p> <p>Element 2.4 How a turbine works and the physics involved. Participants shall <b>engage in discussions of</b> 2.4.6 Power, Energy, Wind velocity and Wind direction</p> <p>Element 2.5 Safe Working Procedures on a wind turbine. Participants shall <b>practice and demonstrate</b> 2.5.4 Safe working procedures, using the necessary PPE and appropriate tools</p>

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<p>components. Pitch system, Yaw system, Drive train, Gearbox, Coupling, and Generator.</p> <p>(d) Have knowledge of the lubrication systems the types of oil and grease used and their disposal to environmental standards. They will understand Oil Cleanliness rating and its impact on component performance.</p> <p>(e) Understand the principles of threads and threaded components; and the maintenance processes for bolted connections.</p> <p>(f) Understand Force, Torque, Power,</p>	<p><b>Lesson 3: The principle of threads, threaded components and the maintenance of bolted connections.</b></p> <ol style="list-style-type: none"> <li>1) Explain the principles of threaded components</li> <li>2) List the location of important bolted and welded connections and explain the importance of maintaining bolted connections</li> <li>3) Explain the hazards and risks associated with maintaining bolted and welded connections.</li> <li>4) Explain how a damaged weld is recognized.</li> <li>5) Check the tightness of a bolt and use a torqueing tool safely and correctly.</li> <li>6) Recognize other damage by visual inspection (paint damage, corrosion, leaks and cracks)</li> </ol>	<p>3.1 The principles of threaded components.</p> <p>3.2 The locations of important bolted and welded connections.</p> <p>3.3 Hazards and risks associated with bolted and welded joints.</p> <p>3.4 The inspection of welded joints.</p> <p>3.5 Checking bolt connections and correct tools to tighten them.</p> <p>3.6 Recognize damage by visual inspection.</p>	<p>Element 3.1 The principles of threaded components. Participants shall <b>engage in discussions of:</b> 3.1.11 Bolts, threads, and strengths of materials. 3.1.12 Force and torque</p> <p>Element 3.2 The locations of important bolted and welded connections. Participants shall <b>engage in discussions of:</b> 3.2.9 Importance of Maintenance and maintenance processes for bolted connections.</p> <p>Element 3.3 Hazards and risks associated with bolted and welded joints. Participants shall <b>engage in discussions of:</b> 3.3.4 Safety issues concerned with inspection of connections.</p> <p>Element 3.4 The inspection of welded joints. Participants shall <b>practice and demonstrate:</b> 3.4.5 Recognition of damaged welded joints. 3.4.6 Cleaning paint from a weld and using a dye penetrant spray using safe working practices.</p> <p>Element 3.5 Checking bolt connections and correct tools to tighten them. Participants are to <b>practice and demonstrate:</b> 3.5.4 Setting and using a torqueing tool for checking the tightness of a bolt.</p>

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<p>Energy, Wind Velocity and Wind direction.</p> <p>(g) Use spanners, torque wrenches, screwdrivers, mallets, a Laser alignment tool, feeler gauges, calipers and dial gauges to carry out prescribed checks.</p> <p>(h) Understand and use technical drawings and diagrams, maintenance repair and service manuals.</p> <p>(i) Inspect the various components for wear, leaks, damage, corrosion and malfunction.</p> <p>(j) Perform basic planned maintenance operations</p>			<p>Element 3.6 Recognize damage by visual inspection.</p> <p>Participants are to <b>engage in discussions of:</b></p> <p>3.6.6 Recognition of damage, corrosion and leaks of bolted or welded connections and the consequences of not repairing them.</p>
	<p><b>Lesson 4: Use of tools and measuring equipment for wind turbine maintenance</b></p> <ol style="list-style-type: none"> <li>1) Select and use the correct spanners for bolted connections.</li> <li>2) Select and use the correct screw drivers for screwed connections.</li> <li>3) Correctly set and use a torque wrench.</li> <li>4) Select and use the correct mallet for freeing components.</li> <li>5) Accurately gauge gaps between components using feeler gauges.</li> <li>6) Measure thickness of components and bore sizes using a caliper.</li> <li>7) Check the run out of a disc using a dial indicator.</li> </ol>	<p>4.1 Select and use the correct spanners for bolted connections.</p> <p>4.2 Select and use the correct screw drivers for screwed connections.</p> <p>4.3 Correctly set and use a torque wrench.</p> <p>4.4 Select and use the correct mallet for freeing components.</p>	<p>Element 4.1 Select and use the correct spanners for bolted connections.</p> <p>Participants shall <b>practice and demonstrate:</b></p> <p>4.1.5 Selecting and using spanners</p> <p>Element 4.2 Select and use the correct screw drivers for screwed connections.</p> <p>Participants shall <b>practice and demonstrate:</b></p> <p>4.2.4 Selecting and using screw drivers</p> <p>Element 4.3 Correctly set and use a torque wrench.</p> <p>Participants shall <b>practice and demonstrate:</b></p> <p>4.3.4 Setting and using torque wrenches.</p> <p>Element 4.4 Select and use the correct mallet for freeing components.</p> <p>Participants shall <b>practice and demonstrate:</b></p> <p>4.4.4 Correct use of mallets.</p>

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<p>(k) Document the condition of components and communicate the information to the appropriate personnel.</p>	<p>8) Align a shaft to a gear box using a laser alignment tool.</p>	<p>4.5 Accurately gauge gaps between components using feeler gauges</p> <p>4.6 Measure thickness of components and bore sizes using a caliper.</p> <p>4.7 Check the run out of a disc using a dial indicator.</p> <p>4.8 Align a shaft and gear box using a laser alignment tool.</p>	<p>Element 4.5 Accurately gauge gaps between components using feeler gauges Participants shall <b>practice and demonstrate:</b> 4.5.3 Correct use and care of feeler gauges.</p> <p>Element 4.6 Measure thickness of components and bore sizes using a caliper. Participants shall <b>practice and demonstrate:</b> 4.6.4 Measuring thicknesses and bores using a caliper.</p> <p>Element 4.7 Check the run out of a disc using a dial indicator. Participants shall <b>practice and demonstrate:</b> 4.7.3 Using a dial indicator.</p> <p>Element 4.8 Align a shaft and gear box using a laser alignment tool. Participants shall <b>practice and demonstrate:</b> 4.8.3 Using a laser alignment tool to align a gearbox and shaft.</p>
	<p><b>Lesson 5: Gearbox and (Main-) Bearing</b></p> <p>1) Describe the main function of the gearbox and the (main-) bearing. The importance of correct alignment and the measuring tools used to achieve it.</p>	<p>5.1 The function of the gearbox and the importance of alignment with the main shaft</p>	<p>Element 5.3 Damage that can occur to a gearbox. Participants shall <b>engage in discussions of</b> 5.3.4. The damages that may occur, and how to communicate it</p>

Objectives	Learning outcomes in lessons	Elements (section 1.8)	Direct observation points for each participant (from section 1.8 Elements)
	<p>2) Describe the operating principle of a gearbox.</p> <p>3) Describe where and how damage can occur, complete the documentation and communicate it to the appropriate personnel.</p> <p>4) Recognize the dangers of working on the gearbox/main bearing and know how to minimize them. Use safe working practices and appropriate PPE to safeguard themselves, colleagues and to protect the environment.</p> <p>5) Carry out an inspection of the gearbox and the (main-) bearing using a technical manual (check hoses, seals, oil level, take oil sample, visual inspection for friction). Complete the necessary documentation.</p>	<p>through the coupling.</p> <p>5.2 The operating principle of a gearbox.</p> <p>5.3 Damage that can occur to a gearbox.</p> <p>5.4 Hazards and risks associated with the gearbox and coupling.</p> <p>5.5 Inspection using the maintenance manual.</p>	<p>Element 5.5 Inspection using the maintenance manual.</p> <p>Participants shall <b>practice and demonstrate 5.5.7 The correct and safe working procedures and the appropriate use of PPE to safeguard themselves, colleagues and to protect the environment</b></p> <p>5.5.8 How to inspect the gearbox and coupling according to a maintenance manual.</p> <p><b>5.5.9 Completing the required documentation.</b></p>
	<p><b>Lesson 6: Braking System (BS) and Coupling</b></p> <p>1) Describe the main task and function of the disc, and the rotor braking system, and to be able to describe the two different types of the rotor brake.</p> <p>2) Describe the task and the function of the coupling.</p>	<p>6.1 The function of the braking system, including the disc brake.</p> <p>6.2 The function of the coupling.</p>	<p>Element 6.4 The position of the brake</p> <p>Participants will <b>engage in discussions of:</b></p> <p>6.4.3 Reasons for the dual brake system and issues surrounding failure.</p> <p>Element 6.7 Inspection of the braking system and coupling using the maintenance manual.</p>

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	<p>3) Describe the functional design and the fail-save system of the brake disc.</p> <p>4) Explain where the disk brake is positioned and why.</p> <p>5) Describe where and how damage can occur (BS and Coupling). Recognize a worn out disc brake. Complete the necessary documentation and inform the appropriate personnel.</p> <p>6) Recognize the dangers of working on the braking system and know how to minimize them. Use safe working practices and appropriate PPE to safeguard themselves, others and to protect the environment.</p> <p>7) Perform the inspection of the BS and the coupling with the aid of a technical manual (a visual inspection to check hoses, fittings, hydraulic fluid, disc surface and general friction). Complete the necessary documentation.</p>	<p>6.3 The fail safe system.</p> <p>6.4 The position of the brake</p> <p>6.5 Wear, damage and documentation of the brake system and coupling.</p> <p>6.6 The hazards and risks associated with the brake system.</p> <p>6.7 Inspection of the braking system and coupling using the maintenance manual.</p>	<p>Participants shall practice and demonstrate:</p> <p>6.7.8 Checking the thickness of the brake pads.</p> <p>6.7.9 Checking the gap between the pads and the disc</p> <p>6.7.10 Measuring thickness of disc</p> <p>6.7.11 Checking for run out of the disc using a dial indicator</p> <p>6.7.12 Correct working practices and use of PPE</p> <p>6.7.13 Completing the necessary documentation.</p>
	<p><b>Lesson 7: Yawing System</b></p> <p>1) Explain what “yawing” means.</p>	<p>7.1 The function of the Yawing system.</p>	<p>Element 7.3 Hazards and risks associated with the Yawing system.</p> <p>Participants are to engage in discussions of:</p>

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	<p>2) Describe the components and their functions (yawing gear, motors, wind sensor, anti-twist protection).</p> <p>3) Recognize the dangers of working on the yawing system and know how to minimize them. Use safe working practices and appropriate PPE to safeguard themselves, others and to protect the environment.</p> <p>4) Perform an inspection of the yawing system with a technical manual (a visual inspection of the yawing gear, slide bearing, lubrication system). Including to carry out practical checks to gauge the gaps between the gear and driving cog, to recognize any damage, complete the appropriate documentation and inform the correct personnel.</p>	<p>7.2 The components of the yawing system and their functions.</p> <p>7.3 Hazards and risks associated with the Yawing system.</p> <p>7.4 Inspection using the maintenance manual.</p>	<p>7.3.4 The dangers connected with the yawing system and how to minimize them.</p> <p>Element 7.4 Inspection using the maintenance manual. Participants shall <b>practice and demonstrate:</b></p> <p>7.4.6 Correct use of PPE 7.4.7 Use of correct working practices 7.4.8 Checking the gap between gear and pinions. 7.4.9 Completing the documentation.</p>
	<p><b>Lesson 8: Cooling- and Lubrication system</b></p> <p>1) Describe which components in a WT have to be cooled and why.</p> <p>2) Explain the single components of the cooling system and how they are connected to each other.</p>	<p>8.1 Components that require cooling and why</p> <p>8.2 Interconnection of individual components.</p> <p>8.3 Components of the lubrication and</p>	<p>Element 8.4 The effects of malfunctions on the operation of the turbine systems. Participants shall <b>engage in discussions of:</b></p> <p>8.4.5 Consequences of not using the appropriate oil or grease</p> <p>Element 8.5 Hazards and risks associated with the lubrication and cooling systems. Participants shall <b>engage in discussions of:</b></p>

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	<p>3) Describe the single components of the lubrication system and explain which parts need to have oil levels maintained and why.</p> <p>4) Describe how a mal-functioning or damaged cooling / lubrication system influences other parts of a WT.</p> <p>5) Recognize the dangers of working on the cooling/heating system and know how to minimize them. Use safe working practices and appropriate PPE to safeguard themselves, others and to protect the environment.</p> <p>6) Perform an inspection of the cooling and lubrication system using a technical manual (a visual inspection to check hoses and fittings for leaks, the quantity and quality of the cooling liquid, the quantity and quality of the oil, the cleanness of heat exchanger and cooling pipes). Complete the necessary documentation.</p> <p>7) Recognize damaged parts, complete the necessary documentation and inform the appropriate personnel.</p>	<p>the maintenance of levels.</p> <p>8.4 The effects of malfunctions on the operation of the turbine systems.</p> <p>8.5 Hazards and risks associated with the lubrication and cooling systems.</p> <p>8.6 Inspection of the lubrication and cooling systems using the manual.</p> <p>8.7 Recognizing damage, completing the documentation and informing the appropriate personnel.</p>	<p>8.5.6 Reasons for maintenance on the mechanical systems of a wind turbine.</p> <p>8.5.7 Consequences of not following approved working procedures and safe working practices.</p> <p>Element 8.6 Inspection of the lubrication and cooling systems using the manual. Participants are to engage in discussions of 8.6.6 Oil Cleanliness rating and its impact on component performance</p> <p>Participants shall practice and demonstrate:</p> <p>8.6.7 Correct use of PPE and working procedures for inspecting cooling and lubrication systems.</p> <p>8.6.8 Inspection for damage on components of cooling and lubricating systems using a technical manual.</p> <p>Element 8.7 Recognizing damage, completing the documentation and informing the appropriate personnel.</p> <p>Participants shall practice and demonstrate:</p> <p>8.7.5 Completing the necessary documentation.</p>