Specified Methods of Installation for Preloaded Bolts to EN 1090-2

	Torque method	***Combined method***	***Direct tension indicator method***	***TCB method (HRC)***
General	Before commencement of preloading the connected components shall be fitted together.			
	Each bolt assembly shall be brought at least to snug-tight condition with special care being given to avoid over-tightening. The tightening process shall be carried out from bolt to bolt of the group starting from the most rigid part of the connection and moving progressively towards the least rigid part. To achieve a uniform snug tight condition, more than one cycle of tightening may be necessary.			
Tooling	The bolts shall be tightened using a torque wrench offering a suitable operating range. Impact wrenches may be used for the first step of tightening only. Torque wrenches used in <u>all steps</u> shall be capable of +/-4% accuracy and checked weekly.	For torque wrenches used in the <u>first step</u> of the combined installation method an accuracy of +/-10% is required with annual testing.	Bolts fitted to snug-tight using a normal size spanner. Bolts tightened using appropriate tooling to achieve compression of the DTI.	Shear wrenches do not require calibration.
First tightening step	For the first step the wrench shall be set to a torque value to achieve about 0.75 $M_{r,i}$ with $M_{r,i} = M_{r,2}$ or $M_{r,test}$. This first step shall be completed for all bolts in one connection prior to commencement of the second step		The first step of tightening to reach a uniform snug-tight condition of the fastener assembly shall be when initial deformation of the DTI protrusions begins.	The first tightening step is achieved using the shear wrench. When the outer socket stops turning and the gearing backtracks, it allows the tool to be taken off the bolt.
Second tightening step	For the second step , a torque wrench shall be set to a torque value of $1.1M_{r,i}$ with $M_{r,i} = M_{r,2}$ or $M_{r,test}$ The torque reference values $M_{r,i}$ to be used for a nominal minimum preloading force Fp,C are determined for each type of bolt and nut combination used by one of the following options: 1) values based on *k*-class declared by the fastener manufacturer 2) values determined by Annex H of EN 1090-2 (test to determine torque values for preloaded bolts under site conditions)	The second tightening step involves a specified part turn to be applied to the bolt assembly. The position of the nut relative to the bolt thread shall be marked after the first step using a marking crayon or paint so that the final rotation of the nut relative to the bolt thread can be easily determined. The additional rotation during the second step shall be in accordance with values given in table 21 of EN 1090-2:2008	The second step of tightening bolts shall be as EN 14399-9 and annex J of EN 1090-2; Indicators are usually applied under the bolt head and the bolt is usually tightened by rotation of the nut. A feeler gauge (as specified in table J.1 of EN 1090-2) shall be used to determine whether the DTI has compressed in accordance with the requirements. No more than 10% of the indicators in a connection bolt group shall exhibit full compression of the indicator.	The second tightening step is achieved when the spline end of the bolt shears off.

Specified Methods of Inspection for Preloaded Bolts to EN 1090-2

<table>
<tr><th></th><th>Torque method</th><th>Combined method</th><th>Direct tension indicator method</th><th>TCB method (HRC)</th></tr>
<tr><td>Inspection tooling</td><td colspan="2">Torque wrenches used for inspections shall be calibrated and have a +/-4% accuracy.</td><td>Feeler gauge used as a “no-go” inspection tool</td><td>NA</td></tr>
<tr><td rowspan="6">Inspection of bolts during and after tightening

<u>General</u></td><td colspan="4">All connections with preloaded fasteners shall be visually checked after they are initially bolted up and before commencement of preloading.</td></tr>
<tr><td colspan="3">The number of bolts inspected at random depends on the Execution Class specified EXC1 to EXC4
If the inspection leads to rejection, all of the bolting assemblies in the group shall be checked.</td><td rowspan="5">The inspection shall be carried out on 100% of the bolting assemblies by visual inspection.</td></tr>
<tr><td colspan="3">Overall number of bolts to be checked in a class EXC2 structure – 5% for the second step</td></tr>
<tr><td>EXC3 and EXC4 - 10% for the second step</td><td>EXC3 and EXC4 - 5% for the first step and 10% for the second step</td><td>EXC3 and EXC4 - 10% for the second step</td></tr>
<tr><td colspan="3">Inspection shall be carried out using a sequential sampling plan according to annex M of EN 1090-2. If the result of inspection to sequential type A is negative, the inspection may be enlarged to sequential type B.</td></tr>
<tr><td colspan="3">If fasteners are not applied in accordance with the defined method, the removal and re-installation of the whole bolt group shall be witnessed.</td></tr>
<tr><td>Inspection at first step

<u>Specific</u></td><td>Identification of bolt assembly lot locations
Checking the bolt tightening procedure for each bolt group.</td><td>For EXC3 and EXC4 the first step shall be controlled before marking using the same torque conditions as used to reach the 75% condition.</td><td>Connections shall be inspected to ensure they are properly packed as per specification.</td><td></td></tr>
<tr><td>Inspection at second step

<u>Specific</u></td><td>The inspection of a bolt assembly shall be carried out by the application of a torque to the nut using a calibrated torque wrench. The objective is to check that the torque value necessary to initiate rotation is at least equal to the torque value $1.1M_{r,i}$ with $M_{r,i} = M_{r,2}$ or $M_{r,test}$.</td><td>After the second step the marks shall be inspected with the following requirements:
1) If the rotation angle is less than 15° below specified value, the angle shall be corrected
2) If the rotation is more than 30° over specified angle or the bolt has failed, the assembly shall be replaced.</td><td>After final tightening, assemblies selected for inspection shall be checked to establish that the final indicator settings are in accordance with the requirements specified in EN 14399-9 and Annex J of EN 1090-2</td><td>Fully tightened assemblies are identified as those with the spline sheared off.</td></tr>
<tr><td>Note</td><td>Inspections shall be carried out between 12 and 72 hours after final completion of tightening of the bolts concerned.</td><td></td><td></td><td></td></tr>
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