

Date of Issue: 25 January 2007

High tensile bolt connections on tower cranes – Technical Alert to the Construction Industry

The HSE is making this information available to the construction industry as supplementary guidance to that contained in BS 7121 Part 2:2003 “Code of practice for safe use of cranes – Inspection, testing and examination”, and comes as a result of ongoing work with the tower crane industry. This information is issued without prejudice to any ongoing investigation.

The HSE is issuing this technical alert to remind those who own, operate and hire tower cranes that they should ensure that high tensile bolt connections, including those on masts, jibs and slew rings of their tower cranes, are correctly installed and pre-loaded (tensioned). Failure to do so could lead to the bolt connection failing, with catastrophic consequences.

Those responsible for the installation, thorough examination, inspection, maintenance and operation of tower cranes should ensure that:

Use of correct bolt connections

1. They use high tensile bolt connections purchased from the original crane manufacturer, or from a quality assured vendor to the original manufacturer’s specification. It is important that the replacement parts are to the correct strength grade and the thread specification is rolled rather than cut.
2. High tensile bolt connections are replaced in accordance with the manufacturer’s recommendations. The manufacturer normally specifies a maximum period that the components may remain in service before replacement. Components should be replaced prior to this period elapsing. Components will have to be replaced more frequently in adverse environmental conditions.
3. High tensile bolt connection components are not reused unless permitted by the manufacturer. Components that have been continuously immersed in water should not be reused unless subjected to 100% non-destructive testing (NDT), using appropriate techniques for the application. Components to be reused should be stored in a dry secure location until required. Components should be protected against corrosion by a suitable rust inhibitor.

Examination of bolt connections before assembly

4. High tensile bolt connections that are to be used are thoroughly cleaned and visually examined for wear, damage and corrosion before they are installed. This is because the fatigue life of components is significantly reduced by surface defects and imperfections. The examination should confirm that:

- Bolt and nut threads are free of damage and have a good tolerance fit, whilst still being free running;
- Bolt shanks are free of defects;
- Nut and bolt heads and bearing faces are free of damage or scuffing; and
- Washers and spacers are free of defects.

Correct assembly of bolt connections

5. High tensile bolt connections are assembled in accordance with the crane manufacturer's instructions. Particular attention should be paid to ensure that:
 - Components are fitted in the correct sequence, location, and orientation;
 - Components are lubricated before installation, as specified by the manufacturer;
 - Bolted connections are tightened in accordance with the method and sequence specified by the manufacturer. The manufacturer's instructions should advise how a crane should be loaded when the joint is tightened. For example, this may require the crane to be placed in balance with a load on the hook or the jib slewed to a certain position. Failure to follow the manufacturer's instructions could result in the bolted connection being incorrectly pre-loaded, with very short service life before failure;
 - The tightening torque is applied to the nut rather than the bolt head, unless the manufacturer specifies otherwise. Tightening a bolt at the head can give rise to variability in bolt pre-loading as a result of variable friction between the bolt head and bearing surface and/or contact of the bolt shank with the hole; and
 - On completion, the components are protected against corrosion and plastic caps, if specified by the manufacturer, fitted over threads and nuts to exclude water from the threads.
6. Any equipment used to tighten high tensile bolt connections (e.g. torque wrench or hydraulic tensioning device) is maintained and calibrated in accordance with the manufacturer's instructions. Tensioning devices should be stored in a secure location when not in use. Where the accuracy of the device relies on springs, the adjuster should be set when being stored to the lowest setting to avoid damage to springs. The device should be marked with a unique identification mark and a copy of the current calibration certificate for the device should be held on file.

Re-tensioning of bolt connections

7. All high tensile bolt connections are re-tensioned within the period specified by the manufacturer. This period is typically 3-6 weeks

following installation. This is because following installation and entering into service high tensile connections may bed in and the pre-load in the bolt may reduce.

Regular inspection and examination of bolt connections

8. High tensile connections are regularly inspected by a competent person to check that pre-load on the bolts has not been reduced. Loss of pre-load can result in movement of the joint under load. The frequency of inspection should be in accordance with the manufacturer's instructions. During this inspection, particular attention should be paid to checking that:
 - There is no visual movement at joints as a load is taken off and on the crane;
 - There are no rust stains, indicating movement at the joint; and
 - Nuts have not worked loose or bolts have stretched.
9. A competent person undertakes an investigation if a high tensile joint is found to have come loose in service, or bolts / nuts are stretched or broken. The investigation should:
 - Examine the joint faces to check that they are flat, free of distortion, corrosion, damage and wear;
 - Check that the components had been correctly assembled in accordance with the manufacturer's instructions; and
 - Confirm whether the person who first assembled the joint tightened the connection in the correct sequence and to the correct pre-load or torque.
10. Supplementary tests should be undertaken if, during inspection or thorough examination of the crane, the competent person completing the examination has any concerns regarding the integrity of the high tensile joint connections. The supplementary tests may include:
 - Physical checks that the bolts are to the correct preload or torque;
 - Disassembly of the joint to allow the connection components and joint faces to be more closely examined; and
 - Non-destructive testing (NDT) of all or a sample number of the components. NDT should be specifically requested where bolts have been subject to continuous or intermittent immersion in water on crane foundations or used on travelling rails.
11. The competent person may also decide that the frequency of thorough examinations should be increased until the crane is dismantled, at which time all high tensile bolt components are examined in detail and any suspect components disposed of so that they cannot re-enter service.

Taking crane out of service when bolt connection problems occur

12. The crane is taken out of service if there are concerns regarding the integrity of the high tensile bolt connections, such as it is suspected that a high tensile connection may have come loose or the pre-load may have been lost. If high tensile bolt connections are insufficiently pre-loaded, or the pre-loading is partially or fully lost the bolted connection can be subjected to considerably higher levels of cyclic strain (extension) with a significant risk that the connection will fail as a result of fatigue with catastrophic consequences.

13. If it is suspected that a bolted connection has failed in fatigue, or has been overloaded, all components making up the joint are replaced. The old parts should be quarantined so that a detailed examination can be undertaken and so that they cannot re-enter service. The crane manufacturer should be consulted for bolt / nut/ washer replacement criteria and for the specific installation procedures that should be followed.

Notes

High tensile bolt connections are used on tower crane joints, including those on mast, jib and slew rings bearings. They consist of a bolt, nut, and hardened washer, and on occasions a spacing sleeve. All of the components should be manufactured from high strength materials. Bolts and nuts are typically manufactured to BS EN ISO 898-1 and BS EN 20898-2, and are marked with a manufacturer's logo or name, strength grade and a batch number. Only components of the same strength grade should be used together. For example a Bolt of Grade 10.9 should only be used with nut of Grade 10.

High tensile bolt connections are subject to repeated cyclic loading as the crane lifts and lowers loads and slews. When correctly installed and pre-loaded high tensile bolt connections can transmit very large loads.

Since summer 2006, HSE has been undertaking a programme of visits to tower crane companies incorporating site and head office visits to discuss health and safety management of the supply, erection, operation and dismantling of tower cranes. During these visits the HSE will be discussing procedures to ensure that high tensile bolt connections on masts, jibs and slew rings of their tower cranes are correctly installed and pre-loaded.

This technical alert provides supplementary information, and should be acted upon in conjunction, to that recently issued by HSE to the construction industry on the importance of the safe erection, operation, maintenance and dismantling of tower cranes. This can be found at www.hse.gov.uk/construction/pdf/towercranes.pdf .

Construction Division

Health and Safety Executive

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