Hot Dip Galvanized Information Sheet No.7

Hot Dip Galvanizing of Nuts and Bolts

Reference: SANS 121 (ISO 1461:2009) and ISO 100684:2004

Corrosion protection of carbon steel fasteners is generally achieved through the application of a coating (barrier protection), be it in the form of a paint system or through the use of a metallic coating. Metallic coatings comprise of different materials, zinc is usually chosen for reason of economics, ease of application as well as the mechanism of cathodic protection provided by zinc.

Zinc is applied either by an electroplating process (electro-galvanizing) or by immersion in molten zinc (hot dip galvanizing). Corrosion protection provided by zinc is proportional to the coating thickness, i.e. the thicker the coating the longer the service life.

Zinc coating thicknesses achieved using the electroplating process, generally range between 6µm to 10µm (µm = micrometers), while hot dip galvanized coating thicknesses range from 45µm through to about 65µm. It is therefore imperative to specify the specific type of zinc coating required for corrosion protection. The word “galvanized” alone is insufficient and should be avoided. Corrosion protection specifications should clearly state, “electroplated, or electro-galvanized” or “hot dip galvanized”.

Specification

The following specification is restricted to the requirements for Hot Dip Galvanized carbon steel fasteners, comprising bolts, nuts and washers.

Class 4.8 and 8.8 Fasteners

Class 4.8 and 8.8 fasteners shall be hot dip galvanized by the centrifuging process. The coating shall conform to the thicknesses listed in table No.1.

Table No. 1 – Minimum coating thicknesses on samples that are centrifuged (Refer SANS 121 - ISO 1461:2009)

Fastener and Thickness	Local coating thickness (minimum) Note: a µm or gms/m²	Mean coating thickness (minimum) Note: b µm or gms/m²
> 6 mm diameter	40 or 285	50 or 360
≤ 6 mm diameter	20 or 145	25 or 180

Note:

a) Local coating thickness obtained using a magnetic test or preferred single value from a gravimetric test.

b) Mean coating thickness being the average value of the local thicknesses on all the articles in the control sample.

c) Fasteners not commercially available in sizes <6mm diameter.

High Strength Fasteners (Class 10.9) SANS 10684:2004

ISO 10684:2004 specifies material, process, dimensional and some performance requirements for centrifuged hot dip galvanized. Coatings applied to course threaded fasteners from M8 up to M64 and including 10.9 high strength friction grip bolts and grade 12 nuts. It is not recommended for hot dip galvanizing of threaded fasteners smaller than 8mm diameter and/or with pitch < 1.25mm. Class 10.9 fasteners may be hot dip galvanized, provided a certificate of compliance is issued by the galvanizer, stating that the hot dip galvanized coating has been carried out in terms of the ISO 10684:2004 specification.

Table No.2 - Coating Requirements for Class 10.9 Hot Dip Galvanized Fasteners

Threaded articles Class 10.9 Fastener Diameter	Local coating thickness (min.) µm or gms/m²	Mean coating thickness µm or gms/m²
8mm to ≤ 64mm diameter	40 or 285	50 or 360

Excessively thick hot dip galvanized coatings, i.e. zinc immersion times >2 minutes, results in excessive growth of the hard Fe/Zn alloy layers, possible fatigue failure from crack propagation at stress raisers. Excessively thick coatings, on threads, will interfere with thread tolerances. Threads are to be clearly defined and free from excess solidified zinc, allowing for ease of nut fitting and tensioning.

Procedure for Hot Dip Galvanizing of Class 10.9 Fasteners

1) Fasteners subjected to severe work hardening may require stress relief before acid cleaning and hot dip galvanizing.
2) During the cleaning process, hydrogen could be absorbed into the steel. The hydrogen may not effuse completely in the molten zinc and consequently, may lead to brittle failure.
3) Components heat treated or work hardened to a hardness of ≥ 320 HV shall be cleaned using an inhibited acid or a mechanical process.
4) Immersion time in the inhibited acid should be of minimum duration, < 2 minutes.

Note:

1) Light mechanical cleaning (wheelabrate) for < 5 minutes in order to reduce the pickling time to a minimum. Tenacious scale or burnt oil present on the steel surface, light abrasive blast cleaning will assist in reducing extended exposure within the acid pickling solution.
2) A suitable, controlled level of inhibited acid reduces corrosive attack on the steel and absorption of hydrogen.
3) Immediately following the acid pickling and / or mechanical cleaning, components are rinsed in clean water, fluxed and immersed into molten zinc at a temperature of 440 to 460ºc.

4) Thick hot dip galvanized coatings are avoided by limiting immersion time in the molten to < 2 minutes. Agitation in the molten zinc to ensure that all components are immersed for similar periods of time, followed by efficient centrifuging.
5) Components shall be centrifuged immediately following removal from the molten zinc and quenched in water / passivation or air cooled depending on size. Chromating or phosphating may be applied to reduce the possibility of wet storage stain (white rust).
6) Stripping and re-galvanizing of rejected sub-quality coatings are not allowed.
7) No uncoated areas are acceptable
8) Nuts are hot dip galvanized blank and tapped oversize after processing.
9) Re-tapping shall not be allowed.
10) Dull matt grey surface finish shall not constitute grounds for rejecting. Shiny bright surface finish indicates the presence of relatively pure “soft” zinc, which could lead to gauling and the interference of torque up procedures.

Further Requirements for Tensioning Hot Dip Galvanized High Strength Bolts & Nuts

Hot dip galvanized or plated bolts shall be tightened or torqued by the turn-of-the-nut or by direct-tension-indicator methods.

a) The use of hot dip galvanized Class 10.9S bolts and nuts is permitted provided that a certificate of compliance is issued by the plater that the fasteners have been processed in terms of ISO 10684:2004.
b) In the case of high-tensile bolts, the thread and washers on which tightening is done shall be thoroughly lubricated with molybdenum disulphide or beeswax, prior to tensioning.

NOTE: Users of fasteners shall be aware of dangers during tightening procedures if they are not applied correctly.

Figure No. 1 - Reliability of the turn-of-the-nut method.

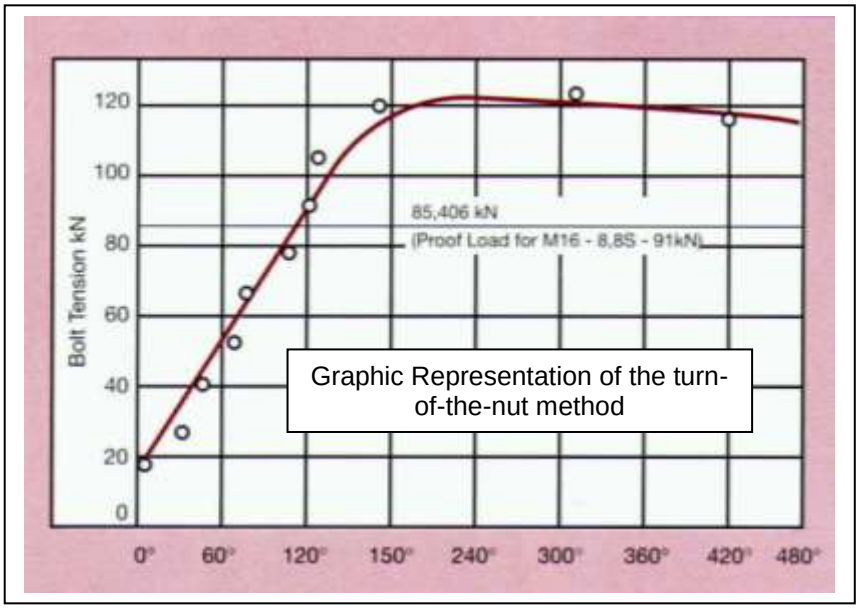


Figure No. 2 - Degree of nut rotation to achieve the minimum tension of fasteners after snug tightening

	Length of bolt, mm	
Nominal bolt diameter	Nut rotation 1/2 turn with 60° tolerance over no tolerance under	Nut rotation 3/4 turn with 60° tolerance over no tolerance under
M16	up to 120mm	120 up to 240mm
M20	up to 120mm	120 up to 240mm
M24	up to 160mm	160 up to 350mm
M30	up to 160mm	160 up to 350mm
M36	up to 160mm	160 up to 350mm

Oversize Tapping Allowance for Hot Dip Galvanized Nuts

The zinc coating on external threads shall be free from lumps and shall not have been subjected to a cutting, rolling or finishing operation that could damage the zinc coating. Hot dip galvanized nuts shall be processed as “blanks” and the oversized internal threads shall be cut after the zinc coating process in accordance with the allowances given in table No.3. Alternatively, undercutting of the bolt threads prior to hot dip galvanizing is permissible. The absence of zinc on the nut thread does not in any way reduce the corrosion free life of a fastener assembly.

Table No.3 – Oversize tapping allowance

Nominal size of thread	Allowance (mm)
M8 to M12	0.33
M16 to M24	0.38
> M24	0.4

Reference Specifications
SANS 121 (ISO 1461:2009) - Hot dip galvanized coatings on fabricated iron and steel articles.
SANS 10684:2004 – The use of high-strength friction-grip bolts.

Hot Dip Galvanizing Procedures for Threaded Articles and Small Components

Zinc Temperature: At the recommended temperature of 440ºC, alloy layer growth during immersion is significantly less than at 450ºC or higher, particularly in the case of reactive steels. Centrifuging after withdrawal from the molten zinc will remove excess zinc (eta layer) from galvanized components, but the overall thickness of the underlying alloy layers of the coating is not reduced by the spinning operation. This is of particular importance in the case of threaded articles where close tolerances between bolt and nut threads apply.

Immersion Time Cycle in the Molten Zinc: This should be kept as short as possible in order to avoid excessive alloy layer growth. The following procedures are essential if extended immersion is to be avoided.

Perforated galvanizing baskets should never be overloaded as the "bulk-density" has a significant influence on the final quality. This applies in particular to threaded articles. When the content of the basket enters the molten zinc, the zinc in contact with the contents of the basket solidifies into a lump of zinc and steel. As this melts down, the outer components are exposed to molten zinc before those in the centre of the solid lump. This can result in inconsistent alloy layer growth between the components in the centre of the solidified lump and outer components exposed to molten zinc for a longer period. Ideally, perforated galvanizing baskets should be fabricated with a cone shaped bottom when threaded articles are galvanized. This increases the overall surface area of work load exposed to zinc. The cone shape also strengthens the basket and renders it more durable.

In order to provide a more consistent coating, the perforated galvanizing basket must be agitated during the immersion period. This is achieved manually with the aid of what is generally referred to as a rooting bar or rod used to agitate the contents of the basket. It can also be achieved as effectively by rotating the basket and or lowering and lifting underneath the molten zinc surface. This latter procedure is used in semi-automatic plants.

As soon as the basket is free from solid zinc, it must be removed from the galvanizing bath for centrifuging.

Centrifuging: Overloading of baskets not only extends immersion times undesirably, but it can also impact adversely on effective centrifuging. Typical basket loads range between 20 to 30 Kgs with between 30 to 35 baskets processed per hour.

Rapid acceleration up to a peak speed of about 750 RPM within 2 to 3 seconds, followed within seconds by a rapid deceleration (positive braking) of the centrifuge. This cycle is an essential requirement for good quality coatings. The speed of rotation of the centrifuging equipment is of far less significance than the jolting effect of rapid acceleration and positive braking. Most of the excess zinc is removed within the first few seconds of rotation and little is gained by centrifuging for longer times.

Water Quenching: After centrifuging, the contents of baskets are deposited onto a steel plate mounted just above the water level, which is designed to "break-up" the bulk of the load before reaching the quench water. This will prevent the formation of surface scars and touch marks, which are likely to occur if material falls directly into the water. Quench water should be maintained at a temperature of between 40ºC to 50ºC in order to dry out components and avoid the formation of white rust.

Excessively high quench water temperatures must be avoided since a high water temperature adversely affects coating surface finish and appearance. Small additions of soluble oil to the quench water will assist in preventing white rust formation. Alternatively sodium dichromate should be used.

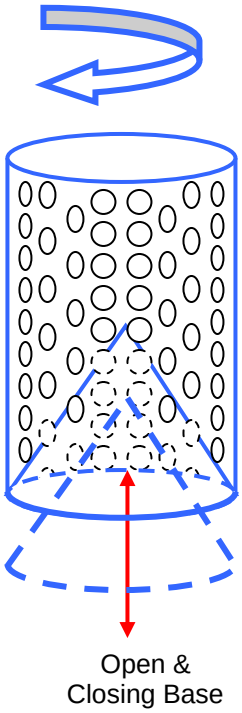
Aluminium Additions to Molten Zinc: Aluminium tends to reduce the surface tension of the zinc melt thus encouraging effective removal of excess zinc. Aluminium also tends to retard Fe / Zn alloy layer growth.

Aluminium (Al) is ideally added in alloy form (20% Al and 80% Zn). The level of Al in the zinc melt should be maintained at 0.005%. This is achieved by adding in small quantities three times during every shift. This is because the aluminium content is reduced rapidly by way of oxidation while excessive single additions will retard the coating formation to such an extent that uncoated steel surfaces will be encountered, particularly if the flux solution is weak. Aluminium levels up to 0.007% can be maintained if the flux solution is kept at the required concentration. The Aluminium content of the zinc provides an attractive shiny silver appearance to the coating.

Thread Lubrication: In the case of high strength fasteners, thread lubrication is recommended after galvanizing in order to prevent gauling during tensioning. The use of either beeswax or molybdenum disulphide is generally recommended.

Inspection of Galvanized Articles: The preferred method of quality control in the case of centrifuged components is to have quality surveillance at the bath itself directly after galvanizing. This is best achieved by depositing components onto a conveyor belt directly after quenching. In this way a poor quality coating can be detected immediately and the galvanizer alerted before large quantities of rejects are produced. In line inspectors should be provided with a range of hardened oversize nuts required to test the fit of galvanized bolts selected at random from the inspection conveyor belt. If test nuts are not hardened, they will wear out of tolerance over a period of time.

For further information concerning the hot dip galvanizing of fastener assemblies and the tensioning procedures for hot dip galvanized fasteners, please refer to the Association's Steel Protection Guide by Hot Dip Galvanizing and Duplex Systems.



Sketch of a perforated basket for centrifuge galvanizing

Annex A

Quality Control Flow Diagram for High Tensile Hot Dip Galvanized Fasteners