



**GE Energy**  
Materials and Processes Engineering

**PROCESS SPECIFICATION**

**P14A-AL-0220**

**Page 1 of 24**

**GENERAL REQUIREMENTS - HIGH STRENGTH WIND FASTENERS**

**DOCUMENT REVISION STATUS: DETERMINED BY THE LAST ENTRY IN THE "REV" AND "DATE" COLUMN**

| REV. | DESCRIPTION  | SIGNATURE  | REV. DATE   |
|------|--|------------|-------------|
| -    | THIS PROCESS SPECIFICATION SUPPLEMENTS ENGINEERING REQUIREMENTS CONTAINED IN THE APPLICABLE MATERIAL SPECIFICATIONS AND DRAWINGS FOR THE MANUFACTURE AND INSPECTION OF ROLL-THREADED BOLTS AND STUDS, NUTS AND WASHERS FOR WIND APPLICATIONS. THIS SPECIFICATION GIVES THE GENERAL REQUIREMENTS FOR QUALIFICATION AND PRODUCTION OF SAID PRODUCTS, INCLUDING DESTRUCTIVE AND NON-DESTRUCTIVE TESTING; DCI NO. 06007844. (S. SATHIAN) | CR TRIPEPI |             |
| A    | UPDATED REFERENCES TO EUROPEAN FASTENER STANDARDS AND INCLUDED ADDITIONAL COMMENTS AND REQUIREMENTS; DCI NO. 08024555. (S. SATHIAN)  | CR TRIPEPI | 2008 JUL 24 |
|      |  |            |             |

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PREPARED BY:

**S. SATHIAN**

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**GENERAL REQUIREMENTS - HIGH STRENGTH WIND FASTENERS**

**1. SCOPE**

1.1 This process specification supplements requirements for threaded high strength fasteners for Wind Energy applications. This specification gives the general requirements for qualification.

\* 1.1.1 This specification is applicable to all safety critical (Type A commodity) GE Energy Wind Turbine fasteners that excludes Anchor foundation fasteners. Fasteners that are grade M30, property class 10.9 and above are considered as high strength fasteners and shall meet the requirements given in current GE specification. Other grades/class of fasteners may be applied to High Strength Fastener category if called out in the related drawings/documents or in PO.

1.2 Communication

1.2.1 External Supplier (See Definition) - General Electric Company - Energy Sourcing Organization is the authorized interface for all communication between GE Energy and the External Supplier. All questions or requests for additional information shall be submitted to Sourcing for clarification. Conflicts between applicable Specifications and/or drawings shall be submitted to GE Sourcing - for resolution by Engineering.

1.2.2 Internal Supplier - All communication, including questions or requests for additional information, shall be submitted to Materials & Processes Engineering or the appropriate Design Engineering component.

**2. APPLICABLE DOCUMENTS**

2.1 The following documents shall form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue shall apply.

2.1.1 General Electric Company

E50A119                      Testing of Metallic Materials

P3A-AG1                      Magnetic Particle Testing

\* P10A-AG2                      Heat Treatment and Process Control

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P14A-AL-0218 Acceptance Requirements for Delta MKS and Similar Corrosion Resistant Coating for Wind Turbine Fasteners

P28A-AL-0001 Critical to Quality Process Capability Data Collection

P28A-AL-0002 Supplier Quality Requirements

CTQ 10000 CTQ Bolting

\* P23E-AL-0255 General Requirements - Marking, Preservation, Packaging and Shipping

2.1.3 American Society for Testing of Materials

A 143 Standard Practice for Safeguarding Against Embrittlement of Hot Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

A 370 Mechanical Testing of Materials

2.1.4 Society for Automotive Engineers

AMS 2750 Heat-Treatment Requirements

2.1.5 American Society for Non destructive Testing

SNT-TC-1A Recommended Practice for Personnel Qualification

**3. DEFINITIONS**

3.1 Personnel

3.1.1 Purchaser - The GE Energy or its Business Associate.

3.1.2 External Supplier - The corporation, company, partnership, sole proprietorship or individual engaged to perform the process covered by this specification.

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3.1.3 Internal Supplier - Any GE Energy Manufacturing Department.

3.1.4 Supplier - As used herein, unless specifically designated, refers to either an External or an Internal Supplier.

3.2 Specification Deviation Documents

3.2.1 Applicable to External Supplier

3.2.1.1 Supplier Deviation Request (SDR) - A method for the documentation, approval and control of a waiver for materials, processes, or dimensions, which deviate from Purchase Order documents (drawings, specifications, engineering instructions, etc.).

3.2.1.2 SDRs shall be submitted through GE Energy Sourcing Quality.

3.2.1.3 SDRs shall include all of the applicable information available (i.e. test properties, dimensions, heat treatment history, etc.) which would be required by the Purchaser for prompt disposition

3.2.1.4 SDRs, which have been properly approved, shall become a part of the records for all parts involved. SDRs, which have been approved by the Purchaser, shall be attached to the Certificates of Conformance herein required.

3.2.1.5 Applicable to Internal Supplier: Quality Control Report (QCR) - GE Energy Manufacturing Department non-conformance report initiated during processing through the factory. Used by Manufacturing to document non-conformance to governing documents and request corrective action.

3.3 Documentation

3.3.1 Manufacturing Process Plan (MPP) - A GE-approved, detailed, chronological step-by-step list of operations by which the parts are planned to be processed, tested and inspected. In-process and final inspection operations associated with the various manufacturing operations shall be included. Each step in the process shall include a brief description of that operation.



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- 3.3.2 Once the process is qualified, the MPP completely describes the process that was utilized to manufacture the part for first piece qualification. This process is considered frozen and shall not be changed without GE approval.
- 3.3.3 Manufacturing operations that are considered proprietary to the Supplier need not be described in the MPP. Objective evidence is required to verify that written procedures for proprietary operations exists. Review of all manufacturing operations may be required for First Piece Qualification and for audit purposes.
- 3.3.4 Qualification Package - First Piece Qualification (FPQ) documentation containing the results of the tests and inspections performed as required for qualification.
- 3.3.5 Product Quality Plan (PQP) - A detailed, step-by-step list of operations and requirements by which a supplier identifies a process of how, what, why, when and who will perform tests or inspections. PQP shall also list reviews, tests, inspections, and any other documents maintained to ensure quality during production, as applicable. This may also be referred to by some businesses as an Inspection and Test Plan (I.T.P.).
- 3.3.6 Technical Terms
- 3.3.6.1 CAV: Characteristic Accountability Verification. A reporting of all drawing characteristics to confirm compliance to specification and determine future measurement frequency.
  - 3.3.6.2 Cpk: Represent the potential short-term capability of the process. These formulas used in Minitab analysis assumes that the process is centered on the target or on the midpoint between specs. Cpk uses short-term variability.
  - 3.3.6.3 Decarburization Layer: Surface layer of a metallic part made of steel with reduced carbon content due to loss of carbon (see ISO 898-1 for fasteners)
  - 3.3.6.4 HDG: Hot Dip Galvanizing
  - 3.3.6.5 Hydrogen Embrittlement: Embrittlement of steel caused by absorption of hydrogen during processing such as acid pickling and electroplating.



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- 3.3.6.6 In-Feed Process: A roll-threading process wherein the die and work piece geometries are such that the die axes are parallel, have a helical thread geometries, and closes on the work-piece, resulting in essentially no longitudinal translation between the dies and work-piece.
- 3.3.6.7 Pilot Lot: The Pilot Lot is defined as parts from the same Master Heat, formed in a common forming operation of a common Drawing.
- 3.3.6.8 Rolled Thread: Thread that has been manufactured by a rolling process with tools showing the negative thread geometry. Threads are produced by rolling rather than machining.
- 3.3.6.9 Through - Feed Process: Roll-threading processes wherein the dies have annular thread geometry, and their axes are skewed when mounted in the thread-rolling machine. When the dies close on the work-piece, the work-piece is drawn into the dies, forming the threads during the longitudinal translation of the work-piece through the dies.

**4. QUALIFICATION REQUIREMENTS**

- 4.1 A comprehensive evaluation for Qualification shall be required of a new Supplier, or when there is a significant change in the approved MPP, or if a Supplier has not performed this process within the two years prior to Purchase Order placement.
- 4.2 The Qualification shall, as a minimum, include the following for the FPQ:
  - 4.2.1 A MPP shall be approved by MPE and SQE prior to initiation of the FPQ.
  - 4.2.2 Product Quality Plan (PQP), documenting the way of characteristic verification during production. (The PQP can be combined with the dimensional inspection information on the CAV form.)
- 4.3 Qualification Package - The Supplier shall submit two (2) copies of the FPQ documentation for review/approval.
- 4.4 Upon receipt of written notification of approval of FPQ, the Supplier is approved for production of the qualified part. The MPP shall be "FROZEN", not to be changed without approval of a new MPP.
- 4.5 The following are the additional requirements to Production Process Requirements to be met by the suppliers for the process qualification.



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**TABLE 1 - LIST OF ADDITIONAL QUALIFICATION REQUIREMENTS**

| List | Description                          | Comments  |
|------|--------------------------------------|---|
| *1   | Metallography of Rolled thread       | <ul style="list-style-type: none"> <li>- According to ISO 898-1, DIN EN 14399 and ISO 6157-3.</li> <li>Finished product:               <ul style="list-style-type: none"> <li>- Flow lines observed on cross sections inspected shall be continuous and shall follow the general thread contour with a maximum flow line density at the bottom of the root radius (see Figure 1).</li> <li>- Root imperfections such as notches, slivers, folds, roughness or oxide scale are not allowed (see Figure 2).</li> <li>- Laps on the flanks of threads are <u>not</u> permitted regardless of the propagation direction (see Figures 3 and 4).</li> <li>- A single lap at the thread peak is allowed, providing it occurred as a result of the roll-threading operation, according to the recommendations of ISO 6157-3.</li> <li>- Slight deviations from thread contour are allowed at the crest of the thread within the major diameter limits (see Fig. 5). Note that the maximum major diameter is less than the diameter of a “fully formed” thread.</li> </ul> </li> </ul> |
| 2    | Samples for FPQ testing              | <ul style="list-style-type: none"> <li>- Required from the first, middle and last thread rolled pieces of the batch.</li> </ul>   |
| *3   | Decarburization layer                | <ul style="list-style-type: none"> <li>- In accordance with ISO 898-1 or DIN EN 14399.</li> </ul>   |
| *4   | Heat treatment & Furnace Calibration | <ul style="list-style-type: none"> <li>- Furnace Calibration: AMS 2750, P10A-AG2 OR proof of tests to meet temperature tolerances in working zones</li> <li>- Uniformity test: Once in every 6 months</li> <li>- Hold Temperature tolerance: +/-25°F (+/-14°C) maximum</li> <li>- Hold Time tolerance: +/-15 minute (maximum)</li> <li>- Any additional heat-treating or Annealing or reheat-treatment steps are not permitted.</li> </ul>  |

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**TABLE 1 - LIST OF ADDITIONAL QUALIFICATION REQUIREMENTS - Continued**

| List | Description                 | Comments   |
|------|-----------------------------|--|
| 5    | Hydrogen Embrittlement Test | <ul style="list-style-type: none"> <li>- According to ISO 15330</li> <li>OR</li> <li>- Fasteners which have surface hardness greater than Rockwell C 31 which are Hot Dip Galvanized, acid pickled, and or electroplated shall be tested for hydrogen embrittlement per ASTM 143.</li> <li>- One galvanized and/or plated piece from each lot of galvanized/plated parts and one non coated part should be bent in same manner until cracking of the (base) steel occurs, or to 90 degrees whichever is less. The galvanized and /or plated piece should withstand substantially the same degree of bending as the non-galvanized and/or non-plated piece. Flaking or spalling of the coating is not to be construed as embrittlement failure. The tests shall be made on the unthreaded portions. If one test specimen should be found embrittled, two additional tests should be conducted. Failure of either the second or the third specimen shall be cause for rejection of the lot.</li> </ul> |
| 6    | Qualification Document      | <ul style="list-style-type: none"> <li>- Documents shall be stored at the supplier and shall be provided on request.</li> <li>- All qualification documents submitted to GE for review shall be in English or translated into English.</li> </ul>  |

4.6 The following is a partial list of items that, when changed, will require comprehensive evaluation for FPQ.





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**TABLE 2 - PARTIAL LIST OF ITEMS WHEN CHANGED REQUIRES  
COMPREHENSIVE EVALUATION OF FPQ**

| Item | Description   |
|------|---|
| 1    | - New bar stock Supplier  |
| 2    | - New thread roll Supplier and/or changes to that process   |
| 3    | - Significant change in part dimensions   |
| 4    | - Significant change in roll-thread dimensions (e.g.; pitch, diameter)                            |
| 5    | - New plant or new facility for a current Supplier  |
| 6    | - Change of location of equipment   |
| 7    | - New forging source and/or changes to that process   |
| 8    | - New heat treating source and/or changes to that process   |
| 9    | - New source for mechanical property testing  |
| 10   | - New machining source and/or changes to that process - For journal surface and adjacent undercut |
| 11   | - New plating /coating source and/or changes to that process                                      |
| 12   | - New NDT source and/or changes to that process   |

**5. PRODUCTION PROCESS REQUIREMENTS**

- 5.1 It shall be the responsibility of the Supplier to understand thoroughly the work scope and all documentation needed to complete the work. This responsibility shall apply to the prime Supplier for any or all operations performed by sub-tier Supplier (s).
- 5.2 This process shall be conducted in accordance with a documented Frozen MPP. The Supplier shall monitor the actual process, compare the process to the MPP and report to the Purchaser any variances using the SDR/QCR. The MPP shall include as a minimum, information detailing and describing the following items and processes, as applicable:



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**TABLE 3 - LIST OF ITEMS, AS A MINIMUM SHALL BE INCLUDED IN MPP**

| Item | Description  |
|------|--|
| 1    | Supplier Name, GE Supplier Vendor Code                                   |
| 2    | Date   |
| 3    | Applicable GE Energy Drawing Numbers, including revision level           |
| 4    | All Material and Process Specifications, including revision level        |
| 5    | Supplier documents (indicate proprietary, non-proprietary)               |
| 6    | Identification of Sub-tier Suppliers - Name, address, MPP documentation  |
| 7    | Description of the identification marking system used for finished parts |
| 8    | Heat Treatment   |
| 9    | Machining  |
| 10   | Tests and Inspection   |
| 11   | Straightening  |
| 12   | NDT Procedures   |
| 13   | Roll-Threading Machine Control Settings and Ranges                       |
| 14   | Plating Procedures   |
| 15   | Any crest polishing or other process used                                |

- 5.3 Deviations - Any deviation from the requirements of this Specification shall be submitted by SDR/QCR and approved by Engineering disposition before the item is shipped.
- 5.4 All the fasteners shall comply to the following codes / standards unless otherwise specified in the drawing:



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**\*TABLE 4 - CODES/STANDARDS**

| Item | Code Name        | Description   |
|------|------------------|---|
| 1    | DIN 50602        | Metallographic test methods; microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions |
| 2    | DIN EN 473       | Non destructive testing – Qualification and certification of NDT personnel – General principles   |
| 3    | DIN EN 10204     | Metallic products – Types of inspection documents   |
| 4    | DIN EN 14399:1-6 | High Strength structural bolting assemblies for pre-loading   |
| 5    | ISO 148          | Steel – Charpy impact test (V-notch)  |
| 6    | ISO 898-1        | Mechanical properties of fasteners made of Carbon steel and alloy steel – Part 1: Bolts, screw and studs  |
| 7    | ISO 4759-1       | Tolerance for fasteners Part 1: Bolts, screws, studs and nuts – Product grades A, B and C   |
| 8    | ISO 4759-3       | Tolerance for fasteners Part 3: Plain washers for bolts, screws and nuts – Product grade A and C  |
| 9    | ISO 6157-1       | Fasteners; Surface discontinuities; Part 1: Bolts, screws and studs for general requirements  |
| 10   | ISO 6157-3       | Fasteners: Surface discontinuities; Part 3 : Nuts   |
| 11   | ISO 6892         | Metallic materials – Tensile testing at ambient temperature   |
| 12   | ISO 8992         | Fasteners – General requirements for bolts, screws, studs and nuts  |
| 13   | ISO 9227         | Corrosion tests in artificial atmospheres – Salt spray test   |
| 14   | ISO 9934:1-3     | Non-destructive testing – Magnetic particle testing   |
| 15   | ISO 10683        | Fasteners – Non electrolytically applied Zinc flake coatings  |
| 16   | ISO 10684        | Fasteners – Hot dip galvanized coatings   |
| 17   | ISO 15330        | Fasteners – Preloading test for the detection of hydrogen embrittlement   |
| 18   | ISO 16047        | Fasteners – Torque / Clamp force testing  |
| 19   | ISO 20898-2      | Mechanical properties of fasteners – Part 2: Nuts with specified proof load values  |

- \* 5.5 DIN 6914, DIN 6915 and DIN 6916 codes have been superseded by DIN EN 14399: 1-6 and the requirements form DIN EN 14399: 1-6 shall apply. The suppliers may procure the fasteners to ASME 18.2.2.3 1-4 and ASTM A 568, however the fasteners shall meet the mechanical properties in accordance with ISO codes (ISO 898-1 / ISO 20898-2) and shall be qualified to this current GE specification.

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5.6 All the fasteners shall also comply to the following additional requirements to codes /specifications unless otherwise specified in the drawing:

**TABLE 5 - ADDITIONAL REQUIREMENTS**

| List | Description                                    | Requirements   |
|------|--|--|
| 1    | Raw Material                                   | <ul style="list-style-type: none"> <li>- Bolts and Studs shall be capable of meeting mechanical requirements per ISO 898-1 after subsequent heat-treatments in the finished product.</li> <li>- Nut shall be capable of meeting mechanical requirements from ISO 20898-2, DIN EN 14399 after subsequent heat-treatments in the finished product.</li> </ul> <p><u>Bar Stock</u></p> <ul style="list-style-type: none"> <li>- Bar material used for manufacturing shall be obtained from an approved source to the requirements of the applicable material specification and additional requirements as follows:</li> <li>- S: 0.02 wt % maximum</li> <li>- P: 0.02 wt % maximum</li> <li>- Aggregate P+S &lt; or = 0.03 wt % maximum</li> <li>- Decarburization layer per ISO 898-1</li> <li>- Cleanliness per DIN 50602 K3&lt;20</li> </ul>   |
| * 2  | Mechanical properties of the finished products | <p>Bolts &amp; Studs: ISO 898-1, DIN EN 14399<br/>Nuts: ISO 20898-2, DIN EN 14399</p> <p>Additional requirements for bolts and studs:</p> <ul style="list-style-type: none"> <li>- The minimum value for impact strength determined at -40° C on the Charpy-V sample according to ISO 148 is 27 Joules for property classes 8.8 and 10.9.</li> <li>- Tensile Testing: Strain rate per GE specification E50A119 OR ISO 6892 &amp; Yield Strength determination per 0.2% offset method.</li> <li>- The limits for surface decarburization specified in DIN EN ISO 898-1 for property class 12.9 also apply to property classes 8.8 and 10.9.</li> <li>- Any type of surface carburization detectable by means of a metallographic section or microhardness measuring is unacceptable.</li> <li>- To demonstrate a surface carburization, more than 20 Vickers hardness points difference in hardness between core and</li> </ul> |



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|--|--|--|
|  |  | <p>surface hardness, both measured with HV 0.3, are regarded as carburization.</p> <ul style="list-style-type: none"><li>- Presence of <math>\delta</math>-ferrite which can be detected metallographically is not acceptable.</li><li>- For property class 10.9:<ul style="list-style-type: none"><li>- Maximum tensile strength of 1170 N/mm<sup>2</sup> (test specimen tensile method)</li><li>- Maximum surface hardness 375 HV 0.3</li></ul></li></ul> <p>Additional requirements for Nuts:<br/>-40°C (-40°F) Charpy V Notch impact test is required only if specified in the GE drawing.</p> |
|--|--|--|



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**TABLE 5 - ADDITIONAL REQUIREMENTS - Continued**

| List | Description   | Requirements  |
|------|---|---|
| 3    | Dimensional data  | <ul style="list-style-type: none"> <li>- Dimensional Data, typically documented on a Characteristic Accountability and Verification (CAV) form.</li> <li>- The CAV form shall include, at a minimum, the following items:                             <ul style="list-style-type: none"> <li>(1) Identification of components</li> <li>(2) Characteristics and feature accountability</li> <li>(3) Inspection and test results</li> <li>(4) Manufacturing Planning</li> <li>(5) Production Product Acceptance Criteria</li> </ul> </li> <li>- Product acceptance criteria shall be established during the qualification process review of the CAV form. Once the level of inspection and product acceptance requirement has been determined and specified on the CAV form, it shall be applied to all production components hereafter to ensure controlled processes for maintaining drawing features and characteristics.</li> <li>- 100% of the dimensions on the FPQ Lot are required to be documented on the CAV forms.</li> <li>- Submit a completed Characteristic Accountability and Verification form.</li> </ul> |
| *4   | Surface Inspection - Visual and Magnetic Particle Inspection (Before surface treatment) | <ul style="list-style-type: none"> <li>- 100% part inspection per ISO 6157-3 for bolts/studs and Nuts.</li> <li>- MT procedure per P3A-AG1 or ISO 9934.</li> <li>- Shall be done prior to surface treatment / coating.</li> <li>- Reduced to sampling plan only with the written consent from Materials &amp; Processes Engineering.</li> <li>- NDT procedures shall be approved by Level III in appropriate method (SNT-TC-1A or EN 473 qualified). The inspection can be performed by qualified Level I or II personnel.</li> <li>- NDT shall be qualified in accordance with GE specification P28A-AL-0203</li> </ul>  |

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**TABLE 5 - ADDITIONAL REQUIREMENTS - Continued**

| List | Description                         | Requirements  |
|------|-------------------------------------|---|
| 5    | Threading / straightening operation | <ul style="list-style-type: none"> <li>- Threading operation shall be done by thread rolling after heat-treatment at room temperature unless otherwise approved by Materials &amp; Processes Engineering</li> <li>- Straightening: Not permitted without Materials &amp; Processes Engineering approval as part of MPP.</li> </ul> <p><u>Roll Threading</u></p> <ul style="list-style-type: none"> <li>- Threads shall be fully formed by a <u>single cold rolling operation</u> on material that is fully heat-treated per the requirements of the applicable material specification and no secondary rolling is permitted.</li> <li>- Threads shall be rolled on the smooth cylindrical surface of a precisely prepared journal surface. No pre-grooving of the surface to be rolled is permitted.</li> <li>- Secondary thread rolling processes to correct external threads or to eliminate nicks on the threads without change of pitch diameter is acceptable with written approval from Materials &amp; Processes Engineering.</li> <li>- Post surface coating operation may be permitted for surface improvements.</li> <li>- Only the In-Feed Roll threading process is acceptable. Through-Feed or hybrid In-Feed/Through Feed processes are not permitted.</li> <li>- Roll threaded profile shall be characterized by a slightly under filled thread crest contour (non fully packed thread) within the major diameter limitations for the particular thread size.</li> </ul> |
| 6    | Thread Forming                      | <ul style="list-style-type: none"> <li>- Bolts: Thread tolerance prior to Hot Dip Galvanizing: 6g</li> <li>- Nuts: 6H without coating.</li> <li>- 6AZ for nuts with HDG.</li> <li>- Enlarged radius underneath head (HV standard &amp; DIN, EN 14399 codes apply).</li> </ul>   |
| 7    | Machining / Grinding                | <ul style="list-style-type: none"> <li>- All grinding, machining, and abrasive wheel cutting operations shall be controlled so that they do not cause burning and discoloration.</li> <li>- Post process grinding on bolt head after HD Galvanizing near shank areas is not permitted.</li> </ul>   |



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**TABLE 5 - ADDITIONAL REQUIREMENTS - Continued**

| List | Description                                      | Requirements   |
|------|--|--|
| 8    | Coating Type                                     | <ul style="list-style-type: none"> <li>- Coating type is in accordance with drawing / component. Supplier shall contact GE-SQE if there is any conflict or needs clarification.</li> </ul>   |
| 8.1  | Hot Dip Galvanizing (HDG)                        | <ul style="list-style-type: none"> <li>- Process according to ISO 10684.</li> <li>- Galvanization bath temperature is in accordance with ISO 10684.</li> <li>- Fasteners having hardness &gt; 31 Rc require a baking at 300 C for 4 hrs after acid pickling option to eliminate/minimize Hydrogen embrittlement problems. Alternative methods may be used and require a written approval from GE-Materials &amp; Process Engineering.</li> <li>- Baking operation may not be necessary if the supplier use alkaline cleaning instead of acid cleaning operation prior to galvanizing process.</li> <li>- Hot Dip Galvanizing is not permitted on 12.9 grade fasteners</li> <li>- Fasteners may be abrasive blast cleaned followed by flash pickling to reduce detrimental effects of pickling. Such flash pickling should be of very short duration (less than one minutes) and in well inhibited and controlled baths.</li> </ul> |
| 8.2  | Other coating processes                          | <ul style="list-style-type: none"> <li>- Any coating processes other than HDG needs written approval from GE - Materials &amp; Processes Engineering.</li> </ul>   |
| 8.3  | Inorganic surface protection                     | <ul style="list-style-type: none"> <li>- DIN EN ISO 10683 is applicable to inorganic surface protection.</li> </ul>  |
| 8.4  | Delta MKS and other similar Corrosion Protection | <ul style="list-style-type: none"> <li>- Protection coating in black with a GZ lubrication additive, friction in thread between <math>\mu=0.08-0.14</math>.</li> <li>- Coating containing minimum 2x Delta Seal and 2x Delta Tone as corrosion protection, total thickness of coating 15-25 <math>\mu\text{m}</math> unless otherwise specified in drawing.</li> <li>- Curing temperature between 180-220°C, unless otherwise mentioned in drawing.</li> <li>- Requirements for corrosion protection according to ISO 9227.</li> <li>- Acceptance Requirements for Delta MKS and Similar Corrosion Resistant Coating for Wind Turbine Fasteners in accordance with GE specification P14A-AL-0218.</li> </ul>   |





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**TABLE 5 - ADDITIONAL REQUIREMENTS - Continued**

| List | Description   | Requirements   |
|------|---|--|
| 9    | Lubrication   | <ul style="list-style-type: none"> <li>- Excessive or too little lubrication is unacceptable. The thickness has to be evaluated and checked by a tightening test according ISO 16047</li> <li>- Excessive lubrication that could cause dripping during torqueing operation is not permitted.</li> <li>- Lubrication should be evenly coated.</li> <li>- Delta MKS coated fasteners shall not be lubricated with MoS<sub>2</sub>.</li> <li>- Other hardware shall only be lubricated upon specific request.</li> <li>- Tower Fasteners: MoS<sub>2</sub> spray coating or equivalent, should be evenly applied 360-degree coverage on the nut thread.</li> </ul> |
| 10   | Tightening  | <ul style="list-style-type: none"> <li>- Fittings (DIN 6914-6918) or DIN EN 14399, tightening in accordance with DIN 18800-7.</li> </ul>   |
| * 11 | Mixing of Nuts, Bolts and Washers and Kitting of Hardware set and | <ul style="list-style-type: none"> <li>- Mixing of bolts and nuts from different sources are not permitted.</li> <li>- Hardware shall be ordered as a complete set from the same supplier, no mix matching of suppliers are permitted.</li> <li>- The kit supplier is responsible for the entire fastener even though the washers may be obtained from a different sub-supplier.</li> </ul>  |

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**TABLE 5 - ADDITIONAL REQUIREMENTS - Continued**

| List | Description    | Requirements   |
|------|----------------|--|
| 12   | Washer Coating | <ul style="list-style-type: none"> <li>- It is required that the Washer shall have the same type of coating as the bolt and nut. The fastener suppliers are permitted to purchase washers from a sub-tier, however it is required that the coating on the washers shall match with fasteners coatings and also meet the mechanical property requirements (e.g: hardness, chemical composition etc). Further, the fastener supplier is required to perform a torque-pre-load check for the suitability of washer to hold the preload requirements. Once, torque-preload check (see Table 6) is established then no additional torque-preload testing is required unless the washer comes from a different source.</li> </ul>                    |
| *13  | Marking        | <ul style="list-style-type: none"> <li>- Each part shall be properly and legibly identified.</li> <li>- The identification shall be in the location specified on the applicable code (DIN 6914-6 or DIN EN 14399, ISO – 898-1) or as specified in the drawing.</li> <li>- Bolts according to DIN 6914, Nuts according to DIN 6915 and other fasteners on request of GE have to be physically lot marked to ensure lot traceability by the manufacturer.</li> <li>- If Suppliers are unsure of which end of a specific stud to stamp, they should refer to the part drawing or contact GE Sourcing Quality Engineer for clarification.</li> <li>- The end opposite of the part identification shall be smooth and free from marking.</li> </ul> |

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**TABLE 5 - ADDITIONAL REQUIREMENTS - Continued**

| <b>List</b> | <b>Description</b>         | <b>Requirements</b>  |
|-------------|----------------------------|--|
| *14         | Traceability               | - Apart from identification in accordance with ISO 898, and individual product standards DIN 6914, DIN 7999, DIN EN 14399 screws and bolts shall be identified with an identification that ensures their traceability to material and heat-treatment batch.  |
| *15         | Packaging                  | - Shall protect the parts against mechanical damage and the introduction of dirt and water in a manner that meets the requirements of GE specification (P23E-AL-0255).   |
| *16         | Shipment                   | - Bolts shall be separated by part number for shipment and shall be packed in such a manner as to be suitably protected from damage or loss during shipment.<br>- Each shipping container shall be legibly marked with the purchase order number, the supplier's name, the purchaser's complete address (including building and door number) and all other information required by the Purchase Order documents and the requirements of GE specification (P23E-AL-0255). |
| 17          | Records of defect removal  | - Shall be maintained and be available for Customer review.  |
| 18          | Purchaser Testing          | - GE reserves the right to pick a part at random from a production run and perform the First Piece Qualification evaluations. Failure to pass any of the "First Piece" requirements shall be cause for the review and possible rejection by the Purchaser of all suspect parts. Any such rejection shall require re-qualification.   |
| 19          | Audit                      | - GE reserves the right to periodically audit the Supplier's facilities and practices. Such audits shall not relieve the Supplier from the responsibility of producing the material in a suitable condition.   |
| 20          | Certificate of conformance | - All special processes, material, mechanical properties, drawing requirements.  |
| 21          | Record Retention           | - 10 years minimum.  |

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- \* 5.6 For Hot Dip Galvanized HV sets consisting of bolts per DIN 6914, nuts per DIN 6915 and washers per DIN 6916 (lubricated with MoS<sub>2</sub>) and respectively, bolts and nuts per DIN EN 14399-4 and washers per DIN EN 14399-6 (lubricated with MoS<sub>2</sub>), the following torque preload relationship has to be met for nut side tightening. Other means of determining Torque – preload relationship shall have approval from Design and MPE.

**\*TABLE 6 - TORQUE- PRELOAD RELATIONSHIP**

| Thread diameter | Minimum preload / kN | Nominal torque / Nm |
|-----------------|----------------------|---------------------|
| M30             | 350                  | 1650                |
| M36             | 510                  | 2800                |
| M42             | 710                  | 4500                |
| M48             | 930                  | 6500                |
| M56             | 1280                 | 10000               |
| M64             | 1680                 | 15000               |

5.7 Critical To Quality (CTQs)

Here is the list of critical to quality (CTQ) for fasteners that needs to measured/ reported. Most of the acceptable CTQ specification limits are found in ISO 898-1 and EN 14399.

1. Chemical composition of Raw material, Decarburization layer and Cleanliness
2. Mechanical properties of fasteners (YS, UTS, %E, RA, CVN etc)
3. Thread dimensions (lot basis)
4. Finish dimensions: CTQs are identified in the specification CTQ10000 need to be measured:
  - a. General Fasteners: Hardness (lot basis) + Thread pitch
  - b. Studs and bolt: Straightness + Stud diameter + Threaded length + Overall length + Thread form
  - c. Nuts: Pressure face flatness + Face perpendicularity
5. Baking for hydrogen relief if applicable
6. Surface quality
7. Lubrication
8. Correct pre-load achieved at prescribed torque

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9. Finish Dimensions: For production parts, the suppliers can reduce the 100% measurement frequency level of CTQs to a sampling plan. However, this would have to be addressed in the specific MPP and PQP. FPQ parts shall be measured to establish the process and determine process capability cpk and sigma levels. CTQs on production parts shall be tracked and cpk levels reported.

**6. INSPECTION / TEST PROCEDURES AND REQUIREMENTS**

6.1 Certificate of Conformance - Internal and External Suppliers shall promptly submit the Certificate of Conformance to GE Manufacturing Quality Assurance or to the Purchaser address shown on the Purchase Order, respectively.

6.2 External Suppliers, after performing all of the required testing, shall promptly submit to the Purchaser a Certificate of Conformance (CC) for each lot of parts supplied. The CC shall state that the parts were processed by the Supplier in complete conformance with the requirements of this GE specification, Approved Process Plan and Purchase Order. The Certificate of Conformance duly signed and dated by an authorized representative of the Supplier shall include the following information:

1. Supplier Name, Address and Vendor Code
2. GE Energy Purchase Order Number and date
3. GE Energy Drawing /Part Number including Revision Letter or Number
4. Quantity of Parts identified by Drawing Part Number and heat/heat treat lot identification.
5. Serial identification numbers
6. Heat Number(s), Material Source
7. Statement of conformance with the requirements of this specification.
8. Supplier Process Plan Identification Including Revision Level, Revision Date and Sourcing Quality Number
9. All required Test Data
10. Attachments: SDR(s)/QCR (s) - As Applicable
11. Certificate of Test for the raw material
12. Preload testing results (verified to achieve right pre-load)
13. Surface quality, in particular, head-shank radius, undercut and threaded areas



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- 6.3 Audit: the purchaser reserves the right to periodically audit the supplier's facilities and practices. Such audit shall not relieve the supplier from the responsibility of producing the material in suitable condition.

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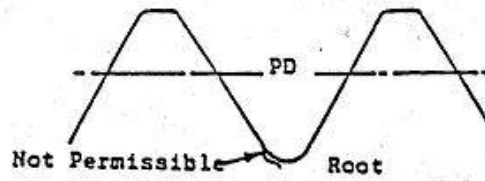


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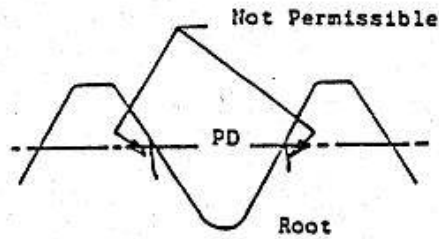
**FIGURE 1 - Rolled Thread Flow Lines**



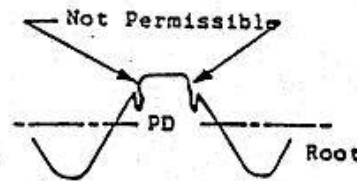
**FIGURE 2 - Rolled Thread**



**FIGURE 3 - Rolled Thread**



**FIGURE 4 - Rolled Thread**





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**FIGURE 5 - ROLLED THREAD CONTOUR DEVIATIONS**  
**PD: PITCH DIAMETER**

