



Standard Practice for Finite Element Analysis (FEA) of Non-Modular Metallic Orthopaedic Hip Femoral Stems¹

This standard is issued under the fixed designation F2996; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice establishes requirements and considerations for the numerical simulation of non-modular (that is, limited to monolithic stems with only a femoral head / trunnion taper interface) metallic orthopaedic hip stems using Finite Element Analysis (FEA) techniques for the estimation of stresses and strains. This standard is only applicable to stresses below the yield strength, as provided in the material certification.

1.2 *Purpose*—This practice establishes requirements and considerations for the development of finite element models to be used in the evaluation of non-modular metallic orthopaedic hip stem designs for the purpose of prediction of the static implant stresses and strains. This procedure can be used for worst case assessment within a family of implant sizes to provide efficiencies in the amount of physical testing to be conducted. Recommended procedures for performing model checks and verification are provided to help determine if the analysis follows recommended guidelines. Finally, the recommended content of an engineering report covering the mechanical simulation is presented.

1.3 *Limits*—This practice is limited in discussion to the static structural analysis of non-modular metallic orthopaedic hip stems (which excludes the prediction of fatigue strength).

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ISO Standards*:²

[ISO 7206-4 \(2010\) Implants for Surgery—Partial and Total Hip Joint Prostheses—Part 4: Determination of Endurance Properties and Performance of Stemmed Femoral Components](#)

3. Significance and Use

3.1 This practice is applicable to the calculation of stresses seen on a femoral hip stem when loaded in a manner described in ISO 7206-4 (2010). This method can be used to establish the worst case size for a particular implant. When stresses calculated using this practice were compared to the stresses measured from physical strain gauging techniques performed at two laboratories using two different methods, the results correlated to within 8 %.

4. Geometric Data

4.1 Finite element models are based on a geometric representation of the device being studied. The source of the geometric details can be obtained from drawings, solid models, preliminary sketches, or any other source consistent with defining the model geometry. In building the finite element model, certain geometric details may be omitted from the orthopaedic implant geometry shown in the CAD model if it is determined that they are not relevant to the intended analysis. Engineering judgment shall be exercised to establish the extent of model simplification and shall be justified.

4.2 It is most appropriate to consider the “worst case” stress condition for the orthopaedic implant being simulated. The “worst case” shall be determined from all relevant engineering considerations, such as stem geometry, dimensions, and head offset. If finite element analysis is being used for determining the worst case, then the worst case head offset may not be known. It may be necessary to run several variants of head offset, in order to determine this.

¹ This practice is under the jurisdiction of ASTM Committee F04 on Medical and Surgical Materials and Devices and is the direct responsibility of Subcommittee F04.22 on Arthroplasty.

Current edition approved July 15, 2013. Published August 2013. DOI: 10.1520/F2996-13.

² Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, <http://www.iso.org>.