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## **Alloy and composition dependence of hydrogen embrittlement susceptibility in high-strength steel fasteners**

Brahimi, S V; Yue, S; Sriraman, K R

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The following page contains the abstract of a journal article based on long-term research on the susceptibility to hydrogen embrittlement of martensitic steels used for manufacturing fasteners being conducted at McGill University's Hydrogen Embrittlement Facility (MHEF). The lead author, Salim Brahimi, is co-founder of the MHEF and the current Director of Engineering Technology of the Industrial Fasteners Institute (IFI). The research presented in this paper was funded in part by the IFI.

The complete article citation is given below and may be purchased directly from The Royal Society <http://dx.doi.org/10.1098/rsta.2016.0407>

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Research on Fastener Hydrogen Embrittlement at McGill University in Montreal, Canada began in 2006 as a collaborative effort, co-sponsored by industry and the Government of Canada through the Natural Sciences and Engineering Research Council (NSERC). Industrial partnership was led by the Industrial Fasteners Institute (IFI) and the Canadian Fasteners Institute (CFI), Boeing, Infasco, Nucor Fasteners, Research Council on Structural Connections (RCSC), and ASTM Committee F16.96 on Bolting Technology. The ongoing research follows two distinct tracks: (i) fastener materials susceptibility to HE, and (ii) interactions of fastener materials with coatings and coating processes.

For more information on McGill University's Hydrogen Embrittlement Facility (MHEF), see <http://mhef.lab.mcgill.ca>.

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6363 Oak Tree Blvd, Independence, Ohio, 44131-2500  
Phone: 216-241-1482, Fax: 216-241-5901, [www.indfast.org](http://www.indfast.org)

## Research



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### Author for correspondence:

S. V. Brahimi  
e-mail: [salim.brahimi@mcgill.ca](mailto:salim.brahimi@mcgill.ca)

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# Alloy and composition dependence of hydrogen embrittlement susceptibility in high-strength steel fasteners

S. V. Brahimi<sup>1,2</sup>, S. Yue<sup>1</sup> and K. R. Sriraman<sup>1</sup>

<sup>1</sup>Department of Mining and Materials Engineering, McGill University, Montreal, QC H3A 0E8, Canada

<sup>2</sup>Industrial Fasteners Institute, Cleveland, OH 44131, USA

High-strength steel fasteners characterized by tensile strengths above 1100 MPa are often used in critical applications where a failure can have catastrophic consequences. Preventing hydrogen embrittlement (HE) failure is a fundamental concern implicating the entire fastener supply chain. Research is typically conducted under idealized conditions that cannot be translated into know-how prescribed in fastener industry standards and practices. Additionally, inconsistencies and even contradictions in fastener industry standards have led to much confusion and many preventable or misdiagnosed fastener failures. HE susceptibility is a function of the material condition, which is comprehensively described by the metallurgical and mechanical properties. Material strength has a first-order effect on HE susceptibility, which increases significantly above 1200 MPa and is characterized by a ductile–brittle transition. For a given concentration of hydrogen and at equal strength, the critical strength above which the ductile–brittle transition begins can vary due to second-order effects of chemistry, tempering temperature and sub-microstructure. Additionally, non-homogeneity of the metallurgical structure resulting from poorly controlled heat treatment, impurities and non-metallic inclusions can increase HE susceptibility of steel in ways that are measurable but unpredictable. Below 1200 MPa, non-conforming quality is often the root cause of real-life failures.

This article is part of the themed issue 'The challenges of hydrogen and metals'.