WRC Bulletin 588

ISSN 2372-1057

WRC | PVRC • MPC

Welding Research Council, Inc.

Bulletin

Development and Use of a Simple Test Method to Evaluate Reheat Cracking Sensitivity in the Weld Deposit Region of a Submerged Arc Weld

"Notched C-Ring Reheat Cracking Test" "NCRRCT"

C.D. Lundin, Ph.D.
M. Trent
J. Henning
J. Bohling
University of Tennessee

M. Prager, Ph.D.
Welding Research Council, Inc.

Intentionally Left Blank

WRC BULLETIN 588

DEVELOPMENT AND USE OF A SIMPLE TEST METHOD TO EVALUATE REHEAT CRACKING SENSITIVITY IN THE WELD DEPOSIT REGION OF A SUBMERGED ARC WELD

"NOTCHED C-RING REHEAT CRACKING TEST"

C.D. Lundin, Ph.D.
M. Trent
J. Henning
J. Bohling

The Materials Joining Group

Materials Science & Engineering Department of the University of Tennessee

M. Prager, Ph.D.

Materials Property Council of the Welding Research Council, Inc.

WRC – Welding Research Council, Inc. (WRC) brings together science and engineering specialists in developing the solutions to problems in welding and pressure vessel technology. They exchange knowledge, share perspectives, and execute R and D activities. As needed, the Council organizes and manages cooperative programs.

MPC – A Council of the WRC, the Materials Properties Council is dedicated to providing industry with the best technology and the best data that can be obtained on the properties of materials to help meet today's most advanced concepts in design and service, life assessment, Fitness-For-Service, and reliability and safety.

PVRC – A Council of the WRC, the goal of the Pressure Vessel Research Council is to encourage, promote and conduct research in the field of pressure vessels and related pressure equipment technologies, including evaluation of materials, design, fabrication, inspection, and testing.

For more information, see www.forengineers.org.

WRC Bulletins contain final reports from projects sponsored by the Welding Research Council, Inc. important papers presented before engineering societies and other reports of current interest and lasting value to engineers and scientists.

ISSN 2372-1057
Library of Congress Catalog Number: 85-647116

Welding Research Council, Inc.
20600 Chagrin Blvd.
Suite 1200
Shaker Heights, OH 44122
www.forengineers.org

FOREWORD

The initial research into to the "*Study the Transformation, Metallurgical Response and Behavior of the Weld Fusion Zone and Weld Heat Affected Zone in Cr-Mo Steels for Fossil Energy Applications*" was conducted under the auspice of the U.S. Department of Energy and ORNL, subcontracted to the University of Tennessee Materials Engineering Department over the period of four years, from 1985 to 1989. Several traditional tests were performed to define the sensitivity of the welds to Hydrogen and Reheat Cracking. A special test based on "*ASTM G38 Standard Practice for Making and Using C-Ring Stress Corrosion Test Specimens*", was developed to survey the sensitivity of the various weld heat affected regions in conventional and experimental steels. The C-Ring Test uses only conventional machining, heat treating, and microstructural examination; therefore, costly equipment is not required and the evaluation of a variety of Cr-Mo steels with V, Ti, B alloys in this study could easily be undertaken and the results ranked. The primary author on the development of a suitable C-Ring test method evaluation was reported in the Master's Thesis authored by John A. Henning, "*Transformation and Post Weld Heat Treatment Cracking in Modified Chromium-Molybdenum Steels*" and is discussed in this Bulletin for background.

More recently, cracking in the weld deposit zone of a Cr-Mo-V steel (22V) during the fabrication of a petroleum pressure vessel was found. Weld fusion deposit zone cracking is normally not encountered in this alloy. Therefore, cracking research was sponsored by the Materials Properties Council of the Welding Research Council, Inc. and undertaken to provide an assessment using a modified Weld C-Ring test. Lincoln Electric (David C. Lincoln Technology Center) provided narrow groove SAW welds doped with Pb, Sb, and Bi, and also provided the chemistry of the weld deposit by the most sensitive methods as the doping levels were in the PPM range. The weld deposit cracking was found in the weld deposit coarse grained overlapped beads.

The Master's Thesis program conducted by Maxwell Trent "*Development and Use of a Simple Test Method to Evaluate Reheat Cracking Sensitivity in the weld Deposit Region of a Submerged Arc Weld*" is reported in this document. In this work, the Pb level was found to be the most egregious tramp element in regard to weld deposit cracking in the coarse-grained regions in the narrow groove overlapped SAW weld beads. The other researcher's laboratories testing came to a similar conclusion and traced the Pb to a specific SAW Flux. However, the researchers using the Notched C-Ring method was faster and the test method could be employed by most any laboratory at lower cost. The C-Ring Methods used are discussed in depth in this document.

Dr. Carl D. Lundin
The Materials Joining Group
Materials Science & Engineering Department of the University of Tennessee