Metal Properties for the Petroleum and Chemical Industries[1]

Preface

This publication is made up of reports which resulted from five projects of The Metal Properties Council, Inc. and the ASTM-ASME-MPC Joint Committee on the Effects of Temperature on the Properties of Metals.

The paper by Messrs. Norris and Sticha represents the results of the first tests made on equipment designed and built by Southwest Research Institute for The Metal Properties Council. The project was developed in the Chemical and Petroleum Panel of the Joint Committee which is chaired by Mr. A. R. Ciuffreda of Exxon Research and Engineering Corp.

Because of the great current interest in the effects of environment on properties, particularly at elevated temperatures, the difficulties as well as the successes in setting up the equipment have been recounted. Further tests are planned in this important area.

Messrs. Smith, Wieser, and Dotson have collaborated in reporting results from an ongoing program of The Metal Properties Council of testing at elevated temperatures. The castings that were tested represent grades included in ASTM standards, and were contributed by members of the Steel Founders' Society of America. These cast steels are commonly used for fittings and internal components of pressure equipment. The tests were conducted at the Vulcan Testing Laboratories.

The Wieser, Beck, Fontana and Schoefer paper extends beyond commercial standard grades in the search for improved characteristics for castings to be used in petroleum refineries. This paper reports another program developed in the Chemical and Petroleum Panel of the Joint Committee, chaired by Mr. Ciuffreda. It was funded jointly by the Steel Founders' Society of America, and The Metal Properties Council, and was carried out at Ohio State University.

Mr. Hodge is a regular consultant of The Metal Properties Council. Charpy V-notch and other fracture toughness test data has been solicited by MPC and has been supplied by foregin countries as well as by companies in the U.S.A. The current paper supplies needed information on the fracture toughness characteristics of our "standard" grades of carbon steel, insofar as such characteristics can be deduced from the data that has been made available.

The analysis of information in this area is an ongoing project of MPC's Subcommittee on Fracture Toughness which is chaired by Mr. Robert Zinkham of the Reynolds Metals Company.

Professor Ebert's Literature Review was prepared for the Steel Founders' Society of America. It has been reviewed and approved by the MPC Subcommittee on Fatigue which is chaired by Mr. Robert Curran of the General Electric Company. It is included here because of its obvious usefulness.

Effect of Hydrogen on the Stress-Rupture Strength of 2-1/4 Cr: 1 Mo Steel, by E. B. Norris, Southwest Research Institute, and E. A. Sticha, Consultant. A facility was developed for conducting stress-rupture tests in high-pressure hydrogen. Data for 2 1/4 Cr: 1 Mo steel quenched and tempered to 104 ksi tensile strength showed hydrogen had no effect on rupture strength within limits of the investigation. Specimens exhibited a small loss of ductility under the less severe (lower temperature/shorter time) exposure conditions and a large loss of ductility under more severe conditions. Although some test conditions were beyond the Nelson curve limits for 2 1/4 Cr: 1 Mo steel, no decarburization or fissuring by hydrogen was produced during the relatively short test exposures.

The Elevated Temperature Tensile Properties of Eight Cast Stainless Steels, by G. V. Smith, Consultant, P. F. Wieser, Steel Founders' Society of America, and C. L. Dotson, Vulcan Testing Laboratories. The results of short-time tensile tests at temperatures ranging from room to 600°C are presented for eight cast corrosion-resistant strainless steels: CA-15, CA-6NM, CD-4MCu, CF-8, CF-8A, CF-8M, CF-8C and CE-30. The temperature dependencies of yield and tensile strengths are developed in a form useful for establishing allowable working stresses. The test program was conducted by The Metal Properties Council (MPC) at the request of the Steel Founders' Society of America (SFSA).

A Survey of Mechanical and Corrosion Properties of Selected Cast, Stainless Steels, by P. F. Wieser, Research Director, Steel Founders' Society of America; M. G. Fontana, Professor Emeritus, Metallurgical Engineering, Ohio State University; F. H. Beck, Professor of Metallurgical Engineering, Ohio State University; and E. A. Schoefer, Consultant, Steel Founders' Society of America. Nine cast alloy types CA-15, CA-6NM (martensitic), CD-4MCU (ferritic-austenitic, precipitation hardening), CE-30, CF-8, CF-20, CF-8C, CF-3M, and CG-8M (austenitic, containing some ferrite) were evaluated to determine the general alloy type most promising for further development of a high strength alloy for service in the petrochemical industry. The evaluation program was conducted on material that had been exposed to elevated temperatures, simulating service conditions, and consisted of room-temperature testing of tensile properties, Charpy V-notch impact properties, stress corrosion resistance in NaCl and polythionic acid environments. Several promising alloys were identified by this evaluation program. A list of alloys showing greatest promise for improved serviceability was compiled based upon these results. Preliminary suggestions on future testing were made for the second phase of the development program.

Impact Characteristics of ASTM Grades of Carbon and Low Alloy Plate Steels, by J. M. Hodge, Consultant. This report presents the results of an analysis of the impact properties of plain carbon and low alloy plate steels, based on test results furnished by steel suppliers of the U. S. A. in response to a solicitation by The Metal Properties Council, Inc. The objectives of this solicitation were: 1 To obtain a general picture of the impact properties of these steels, most of which are normally produced and supplied to specified tensile and bend test requirements, with impact testing or other fracture toughness evaluations being generally not required, or being a supplementary requirement which has not been regularly requested by users usually because of the added cost of such tests. 2 To obtain additional background information for the International Standards Organization (ISO), to supplement that which has been obtained from a similar analysis of test results submitted by steel producers and users out-

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side of the U. S. A., and to facilitate the introduction into International Standards specifications for steels of these U. S. A. types.

A Critical Review of Recent Literature on the Fatigue Properties of Cast Steel, by L. J. Ebert, Professor of Metallurgy and Materials Science, Case Western Reserve University, Cleveland, Ohio. The technical literature on the fatigue characteristics of cast steel has been reviewed critically and analyzed with regard to parametric effects and with regard to wrought steel. Various models, rationalizing the fatigue process, are reviewed and provide a framework for the analysis of cast steel data. The analysis identifies areas where data on fatigue resistance of cast steels are quite complete and points out those where additional documentation is required. Recommendations are presented regarding general areas where test programs are needed.