ASTM Special Technical Publication No. 248

REPORT ON
PROPERTIES OF CAST IRON
AT ELEVATED TEMPERATURES

Issued under the Auspices of

THE STEAM POWER PANEL

of

THE ASTM-ASME JOINT COMMITTEE ON

EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

Prepared for the Panel by

J. R. KATTUS AND BRYAN MCPHERSON

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AMERICAN SOCIETY FOR TESTING MATERIALS

1916 RACE STREET, PHILADELPHIA 3, PA.

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FOREWORD

Fifty years ago unexpected failures led the ASME to support a research investigation at Cornell University to determine safe temperature and pressure limits for cast iron for valves, pumps and similar pressure castings. The limits fixed at that time survived for 40 years. Cast iron was regarded as a single material bracketed in a broad specification. Time and independent research expanded its range of properties and usage, established control measures over different grades, and extended the knowledge defining its modern refined forms. Enterprising manufacturers established, individually, applications requiring load carrying ability at temperatures above the 450 F limit set a half century ago.

Fifteen years ago, the urgent need to use cast iron for the wartime steam propulsion of cargo vessels precipitated a survey of the then current usage which culminated in the Burgess-Barlow report, reference 16. Five years more went into the preparation and trial by usage of a tentative ASTM Specification A 278.[1] Ultimately the need arose to justify its contents by a study of the important qualifying factors that could make cast iron eligible for use at temperatures up to 650 F and perhaps above this temperature.

The Boiler and Pressure Vessel Committee of the ASME pressed for this information and the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals approved the work in 1952. A research subcommittee of ASTM Committee A-3 on Cast Iron was charged to formulate a program of investigation. Cast irons for test were obtained from commercial sources.[2] Basically, the eligible cast irons were to conform to the terms of Specification A 278 for cast irons suitable for use at temperatures up to 650 F. This included limits upon heat treatment which would be confined to relatively low, stress-relief annealing temperatures. Alloys No. 1, 5, 10, and 13 survived the rigors of the test program and met the original terms.

The work was expanded to include more extensive heat treatments and special compositions, These helped to round out the initial program and to inspire future investigations upon those cast irons which still show promise of exceeding prevailing service temperature limitation.

Some changes in the committee personnel are inevitable in a program extending over so long a period of time. The Chairman of Project SP-2 is especially indebted to committee survivors, namely, R. K. Atkin, R. J. Allen, H. Bornstein, William A. Hambley, D. J. Henry, J. T. MacKenzie, C. G. Russell and R. H. VanPelt; to Paul Brister, Chairman of the Steam Power Panel of the Joint Committee; former Joint Committee Chairmen F. B. Foley and V. T. Malcolm, and members N. L. Mochel and H. C. Cross who carried the brunt of the work. From all of us, appreciation goes to J. R. Kattus and his associates for a difficult job, well done.

For Project SP-2 Committee

J. S. Vanick, *Chairman*

[1] 1958 Book of ASTM Standards, Part 1.

[2] See acknowledgments p. 85 for list of organizations who furnished the test metals.

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ABSTRACT

The properties of six commercial low-alloy gray irons and of one unalloyed ferritic nodular iron were evaluated at 800 F and at 1000 F by means of tensile tests, creep-rupture tests, thermal-shock tests, growth tests, and metallographic examinations. Both as-cast structures and annealed structures were investigated. In general, the alloys are promising for long-time load-carrying applications and for applications involving thermal shock at temperatures up to 800 F, but not at 1000 F. The test results indicate, however, that the development of low-alloy cast-irons suitable of use at 1000 F is quite conceivable.

Variations in alloying have marked effects upon the properties of cast iron at elevated temperatures. Molybdenum appears to be the most potent alloying element for improving creep-rupture properties, nickel for improving thermal-shock properties, and chromium for improving structural stability.

The results of creep-rupture tests indicate that five representative test alloys could be expected to sustain the following loads in tension for 10 years at 800 F:

Test No. 14	Cr-Mo-alloyed gray iron	30,000 psi
Test No. 1	Mo-alloyed gray iron	25,000 psi
Test No. 10	Cr-Ni-Mo-V-alloyed gray iron	25,000 psi
Test No. 8	Unalloyed ferritic nodular iron	17,000 psi
Test No. 13	Unalloyed gray iron	15,000 psi