Overview

It has been generally accepted practice when writing material specifications to indicate limits or ranges, or both, of individual elements in the tables of chemical compositions. Normally, only those elements pertinent to a particular alloy designation or grade of material were listed with appropriate limitations.

There existed a general understanding among knowledgeable producers and users of steel products that there would always be present some minute levels of trace, residual, or unspecified elements orginating from the basic ores during melting and from additions during the subsequent metal refining processes. ASTM Methods, Practices, and Definitions for Chemical Analysis of Steel Products (A 751) addressed the permissive reporting analyses of these elements as well as the impracticality of establishing limits for all possible elements.

ASTM held its first symposium on the subject of residual elements in 1966. *Effects of Residual Elements on the Properties of Austenitic Stainless Steel* (Special Technical Publication [STP] 418) contains the papers presented at the symposium. There were a combination of influencing factors taking place in the steel industry resulting in an increasing interest in the subject of residual and unspecified elements at this time. First, there was the proliferation of steel alloys, grades and specifications. Not only were these new alloys being specified in standards writing bodies, but also, corporate and government specifications were equally being developed. Second, within these new specifications were narrower and more restrictive limitations on certain elements to satisfy the end product-oriented needs of the user. Third, steelmaking changes were taking place not only aimed at satisfying the new requirements but also aimed at improving efficiency of operations brought on by competitive pressures.

One of the first technical subcommittees of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys to address the subject of residual and unspecified elements originating in 1968 was Steel Forgings. When it was brought to the attention of the subcommittee, certain ASTM standards have tables of chemical composition wherein not all the elements have limitations specified, it may be construed that those unspecified elements may be present in any amount or they are neither permitted nor prohibited. This was certainly not the intent since the specification addressed only those elements pertinent to the grade of steel. Other technical subcommittees soon initiated task groups to discuss residual and unspecified elements, for example, Steel Castings, Pressure Vessel Plates, Valves, Fittings and Bolting, Pipe and Tubular Products, Bar, Stainless Steel and Structural Steel.

Acknowledgment of the contribution by Mr. Vernon W. Butler, who deceased during the preparation of this volume, is particularly noted for his leadership on residual and unspecified elements as Subcommittee Chairman of Boiler and Pressure Vessel Steel Plates.

As the interest in residual and unspecified elements in steel grew among the various technical subcommittee, so did an interest in Committee A-1 to sponsor a symposium to address the concerns of those producing, specifying, designing, manufacturing, testing, examining, joining and evaluating the properties of steel products.

In this volume of the papers presented at the symposium, are technical examples of the broad range of interest in the subject of residual and unspecified elements in steel. Raw materials used in steelmaking were covered by the scrap metal industry indicating how that industry has taken steps to segregate raw materials for the steel producers to improve their chemical composition requirements. Steel producers presented papers detailing the progress that has been made in their internal manufacturing processes for controlling residual and unspecified elements not

only to meet specification requirements but also for economic advantages. How the steelmaking industry has responded to the challenges of controlling residual and unspecified elements is well exemplified by these papers.

Not only were the controls for residual and unspecified elements covered, but also papers in this volume addressed very low, or ultra-low, levels of certain elements. Steel manufacturing technology, mechanical property effects, and metal joining characteristics of steels with extremely low levels of certain elements have been included.

Machinability of steels as affected by individual and combined effects of certain residual and unspecified elements was also addressed by authors in this volume. Microstructural constituents and inclusion morphology examples were presented.

There were quite a few papers presented by authors interested in the effects of residual and unspecified elements on specific material behavior characteristics. Covered in this volume are properties, such as temper embrittlement, corrosion resistance, elevated temperature creep-rupture strengths, fracture toughness, and room-temperature tensile strengths. Some of the papers dealt with steels in nuclear applications.

Welding processes and post-weld heat treatments affected by residual and unspecified elements were discussed by several authors. Not only were the base materials of concern but also the welding consumables.

In summary, this volume treats the broad spectrum of residual and unspecified elements in steel from the raw materials used for steelmaking through machining and welding to the long-term effects on properties. Very specific technical data are included for future reference by those concerned from all phases of the steel industry.

ASTM Committee A-1 has already reflected many of the issues presented in this volume through its published books of standards. Residual and unspecified elements in steel is a dynamic subject and will continue to be evaluated by the ASTM technical committees as the need arises.

Albert S. Melilli

Raytheon Company; Lowell, MA 01853; symposium chairman and editor.