

GUIDELINE FOR HAND SOLDERING PRACTICES

Guideline for Hand Soldering Practices

First Edition

by

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Preface

The origins of soldering can be traced back several thousands of years to Middle Eastern cultures that used it to construct a variety of utensils and elaborate jewelry items. Today, it is recognized that soldering extends well beyond the artisan community; in fact, it has become a technology in its own right. Soldering forms the basis for the manufacturing of electronic products ranging from highly functional, Personal Digital Assistants (PDAs) and cell phones to high-reliability military, space, and satellite systems. Such achievements are the result of advances that have been made in understanding the materials science and engineering of solder alloys, wetting-and-spreading behavior of base material surfaces, interface reactions, as well as monotonic and cyclic deformation modes in assembled solder joints. Concurrently, there have been new developments in assembly automation, process control, and inspection that have allowed for the low-cost manufacturing of a wide range of soldered products.

It is important to realize that there are still a large number of applications—many structural in nature—whereby an operator performs the soldering process manually. That person may be an artisan fabricating expensive jewelry; a plumber constructing a critical piping system in a chemical plant; or an operator repairing life-saving medical electronics. As an important manufacturing process in the electronics community, hand soldering has been supported by a large number of instructional resources, certification programs, and standards that are a resource for operators as well as process development engineers.

Unfortunately, there is a gap in the depth of resources such as guidelines, specifications or standards that address, specifically, hand soldering. The third edition of the *Soldering Handbook* (AWS) contains a wealth of fundamental as well as applied materials, processing, and reliability data for soldering as a technology. However, there remains to be a need to provide operators and process engineers with a “jumping-off point” to develop, and subsequently optimize, hand soldering processes for structural applications.

The objective of this *Guideline for Hand Soldering Practices* is to provide an information resource for developing viable, cost-effective hand soldering processes. This book is not intended to provide in-depth treatises on the fundamental principles of soldering; the reader is referred to the *Soldering Handbook* for those detailed discussions. Rather, the guideline’s chapters and sections provide sufficient information that allows the operator and process engineer to develop a hand soldering process that meets the performance and reliability requirements of the final product.

Chapter 1 (Fundamental Understanding) is a brief introduction into the definitions of wettability and solderability. Also, the role of the heating process is described in order to understand its impact on the hand soldering process.

Chapter 2 (Base Materials) discusses the hand soldering of metallic and nonmetallic materials. Supporting information is provided regarding the synergism between base materials and coatings with respect to achieving the desired solderability behavior. Also, given the fact that hand soldering uses electric irons and torches that are very high-temperature heat sources, there are discussions of the need to consider the temperature sensitivity of base materials, especially the effects of heating and cooling rates.

Chapter 3 (Filler Metals) describes filler metals (solder alloys). There are a large number of filler metals available today and the list continues to grow as manufacturers address the need to build ever-more complex parts, as well as changing alloy availability due to environmental regulations in both the United States and abroad (e.g., Pb- and Cd-free solders). The solder can be available in the form of wire, preforms, or paste. The form of the solder will significantly impact the choice of hand soldering technique and process parameters. The final section in this chapter discusses the importance of selecting filler metals that are listed in approved standards and specifications.

Chapter 4 (Fluxes and Controlled Atmospheres) touches on fluxes and their uniqueness to the soldering process. Unfortunately, there remains a great deal of “mystery” behind their role in soldering. The goal of this chapter is to provide an accurate resource describing the selection and utilization of fluxes in a hand soldering process.

The key content of this book resides in Chapter 5 (Process Development). After a brief introductory section, the following two sections address preassembly cleaning and fixture techniques. The next five sections describe specific types of

hand soldering processes as distinguished by the heating technique: (electric) iron, torch (flame), hot gas, resistance, and induction. Within each section, there is an introduction that is then followed by a brief overview of the equipment. Next, there is the detailed description of the soldering procedures (e.g., soldering with filler metal wire, preforms, butt joints, lap joints, etc.). The ninth section considers two less-common hand soldering processes: laser soldering and infrared soldering. The chapter draws to a close with two sections, the first of which, examines post-assembly cleaning steps. The final section provides information related to the use of hand soldering for the rework and repair of solder joints.

Finally, Chapter 6 (Environmental Safety and Health) offers a brief synopsis of the environmental, safety, and health concerns specific to hand soldering operations. The chapter does not provide a complete listing of federal, state, or local regulations and directives. Besides the ungainly number of such statutes, environmental and safety regulations change on an almost daily basis thereby quickly rendering them obsolete. Rather, the intent of this chapter is to describe “common sense” procedures that should be implemented by the operator or process engineer in order to minimize the likelihood of accidents and/or environmental contamination when using hand soldering procedures.

An important feature of this guideline is the illustrations. The author is all too familiar with the fact that solder joints are not well presented using standard light photography. Shiny surfaces and extraneous shadows cause misleading visual artifacts. Therefore, photographic images are used sparingly. Rather, greater use is made of schematic illustrations to show fixtures as well as solder flow behavior and fillet geometries.

The author would like to express his sincere gratitude to the following individuals who have contributed to this piece. First, I would like to thank Sara Sokolowski, Don Susan, Brian Wroblewski, Edwin Lopez, Mike Hosking, as well as the members of the AWS C3B Subcommittee on Soldering (Chairperson Creed Darling) for their painstaking review of the manuscript. Secondly, I want to acknowledge those folks at Sandia National Laboratories who have worked alongside of me and who have taught me “a-thing-or-two” about soldering materials, processes, and reliability. Jerry (JR) Rejent, together with Mark Grazier and Peter Duran, have performed the experiments and data analysis that is the heart of the research and development successes in Sandia’s soldering technology program. Alice Kilgo, Dick Grant, Gary Zender, and Paul Hlava (ret.) are the metallography and microanalysis “talents” that provided valuable insight into properties of solder alloys and the performance of soldered assemblies.

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