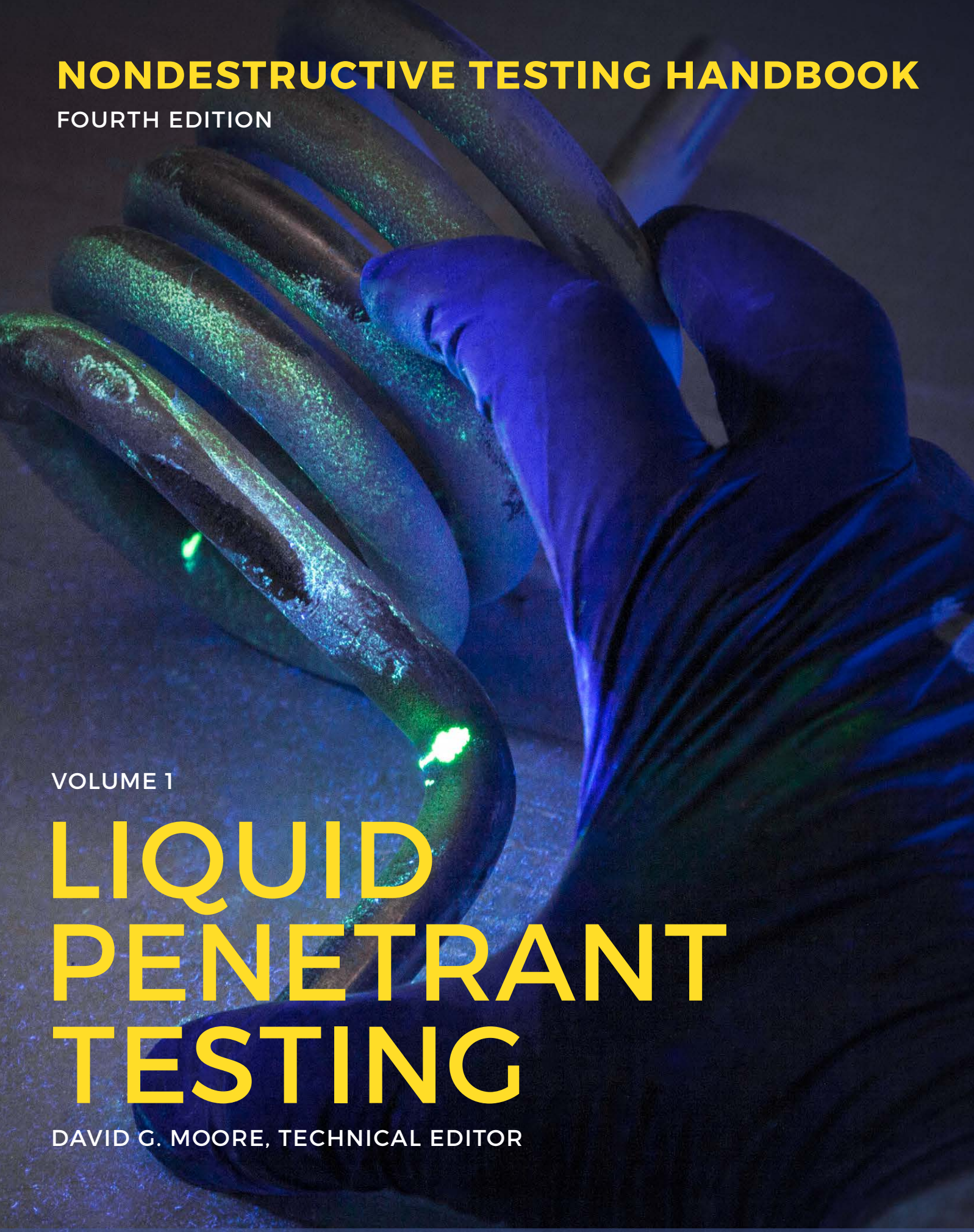
NONDESTRUCTIVE TESTING HANDBOOK

FOURTH EDITION



VOLUME 1

LIQUID PENETRANT TESTING

DAVID G. MOORE, TECHNICAL EDITOR

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ASNT exists to create a safer world by advancing scientific, engineering, and technical knowledge in the field of nondestructive testing.

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FOREWORD

AIMS OF NDT HANDBOOK

The publication of another volume in the *NDT Handbook* is a good occasion to reflect on the goals of that series.

Handbooks exist in many disciplines of science and technology, and certain features set them apart from other reference works. A handbook should ideally give the basic knowledge necessary for an understanding of the technology, including both scientific principles and means of application. Handbooks are reference documents, rarely read cover to cover but consulted for specific information

The *NDT Handbook* is written for a broad audience but includes technical details up through college physics. Assumptions about the reader vary according to the subject in any given chapter. Computer science requires a different sort of background from nuclear physics, for example. It is not possible for the handbook to give all the background ancillary to nondestructive testing.

A handbook offers a view of its subject at a certain period in time. Even before it is published, it starts to get obsolete. The authors and editors do their best to be current but the technology will continue to change even as the book goes to press. Moreover, the *NDT Handbook* reflects technology that is being used by industry, not every undeveloped idea that might be implemented.

Standards, specifications, recommended practices, and inspection procedures may be discussed in a handbook for instructional purposes, but at a level of generalization that is illustrative rather than comprehensive. Standards writing bodies take great pains to ensure that their documents are definitive in wording and technical accuracy. People writing contracts or procedures should consult real standards when appropriate.

Those who design qualifying examinations or study for them draw on the *NDT Handbook* as a quick and convenient way of approximating the body of knowledge. Committees and individuals who write or anticipate questions are selective in what they draw from any source. The parts of the *NDT Handbook* that give scientific background, for instance, may have little bearing on a practical examination. Other parts of a handbook are specific to a certain industry. The *NDT Handbook* cannot include everything on its subject but does try to cover as much as practical.

Volunteer activity including peer review draws on the expertise in ASNT's Technical and Education Council and is coordinated through the Handbook Development Committee.

Richard H. Bossi
Handbook Development Director
June 2016

PREFACE

LIQUID PENETRANT TEST METHOD

What could be simpler than directly viewing a part with a suitable light to see an indication of a discontinuity produced by dipping the part in a colored liquid, washing excess off with a water hose, and drying the part? As one gains experience with liquid penetrant testing, a more appropriate question may come to mind: how can a simple technique be so complex?

Liquid penetrant testing is fundamentally a simple technique. The equipment is easy to operate in field conditions, and untrained observers usually think they can save time and money by borrowing some penetrant materials and performing the test themselves. However, as training and experience demonstrate, the best materials are worthless without adherence to guidelines and standards that direct and control the test from the preparation of the test surface, to the visual examination of the part to locate an indication. Furthermore, the materials themselves require some basic care so that they don't get contaminated with dirt, oil, or water. Even experienced inspectors must avoid the trap of apparent simplicity, which breeds complacency. Inattention to processing details and materials maintenance will result in a test that will fail the customer's expectation and place the inspected part into question. This volume emphasizes these issues.

Perhaps complex is the wrong word to describe the test; methodical is a better descriptor. Apparent disadvantages of the test can usually be overcome by modifying a step or applying a different set of steps. For example, inspectors could work in tandem when testing large areas, for which process control is more difficult, or use liquid penetrant that requires more than just water to remove it if removal from shallow cracks is a concern. In another situation, strict process control may be turned into an advantage: methodical adjustments in the process can adjust the sensitivity of the test so that only the relevant discontinuities are detected.

Despite its subtlety, liquid penetrant testing does work. Large areas, small areas, smooth or multifaceted surfaces — all can be inspected quickly and economically. Because of this advantage, it is tempting to use liquid penetrant testing in place of other, more expensive point sensitive techniques such as eddy current testing. However, in some applications, especially where residual compressive stresses exist, the surface opening of a discontinuity may be too small for reliable liquid penetrant testing. A good example is a small fatigue crack under compressional loads.

Liquid penetrant materials are constantly being improved to meet general or specific application requirements, to make the test process more efficient, or to satisfy environmental concerns. In some applications, water washable liquid penetrants are as sensitive as postemulsifiable types. Equipment is also improving. Systems can carefully control the liquid penetrant test process while alleviating the monotony of repetitive steps.

The technology of liquid penetrant testing now offers a robust technique for evaluating the sensitivity of a liquid penetrant test. Photometers have been used in the laboratory to assign arbitrary sensitivity levels to liquid penetrant systems by measuring the luminance of fluorescent indications. The supersession of United States military standards by industry consensus standards is complete. Even with precisely controlled processing parameters, however, the luminance measurements on a set of low cycle fatigue cracks have been reproducible only within 20 percent. This methodology has been shared through ASNT conferences and is now accepted worldwide.

One problem has been the difficulty of correlating the physical and chemical phenomena and properties of liquid penetrants to practical penetrant test sensitivity. This difficulty influenced the decision to limit the theoretical discussions in this volume to the practical characteristics of penetrant materials and their irradiation. Because an inspector is ultimately concerned about relevant indications, the more that is understood about how the test process affects those practical characteristics, the more likely a visible indication will be produced. To this end, several chapters have been rewritten and color photographs have replaced black and white.

ACKNOWLEDGMENTS

The fourth edition of the *Nondestructive Testing Handbook* begins with this volume on liquid penetrant testing. This fourth edition volume is indebted to preceding editions in many ways. Much of the text is the same, despite significant additions and alterations.

The Technical Editor is indebted to the committee members, contributors, reviewers who volunteered to help assemble this book. The aim was to build on the work of those who contributed to previous editions, updating the technical content while preserving the technological story line of lessons learned.

The technical content of this fourth edition volume differs in several ways from that of the third. (1) A new chapter has been added on the fluorescent technique and ultraviolet radiation. (2) Sections on safety, materials, and probability of detection have been significantly revised. (3) Citations to applicable standards have been updated throughout. (4) Wherever possible, black and white photographs have been replaced with color. There are more than 200 new color photographs, and many came from ASNT members overseas. Sources of illustrations are listed in the back of the book.

The contributors and reviewers all brought their gifts individually to this project — collectively they made it better than a product of one person could be. The guidance and assistance of the ASNT staff is also gratefully acknowledged. ASNT is indebted to all the technical experts listed at the end of this preface. People listed as contributors were also reviewers but are listed only once, as contributors.

The working group honors the service of Samuel J. Robinson (1946-2013) to the inspection community. His reviews of many chapters have made this handbook more accurate and useful.

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Technical Editor
June 2016

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