Laser Institute of America

CLSOs' Best Practices in Laser Safety

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Chapter 1 Introduction

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The laser is a potent tool for manufacturing, research, and medicine. However, there are potential hazards associated with laser use, particularly where Class 3B and 4 lasers are concerned. This book concentrates on how to address the hazards associated with these two laser classes. To ensure the safe operation of laser equipment, a competent person must conduct a hazard evaluation of the laser installation. Such an evaluation needs to consider the laser's or laser system's capability of injuring personnel, the environment in which the laser or laser system is used, and the personnel who may use the laser or be exposed to its hazards – including non-beam hazards as well as those hazards associated with the laser's beam. This essential service can and will prevent incidents that could result in serious injury, equipment and product losses, or both. The performance of the hazard evaluation is the function of the laser safety officer (LSO) or other technically qualified individual.

By meeting the requirements set forth by the Board of Laser Safety in order to become a Certified Laser Safety Officer (CLSO), an individual helps ensure that he or she possesses the necessary training and experience to perform a competent evaluation so that laser hazards are properly identified and controlled. The continued use of the CLSO designation requires the individual to maintain certification through continuing education and practice. To do this, one needs to improve his or her laser safety skills through self-study, training course attendance, continued practice, and peer interface. The latter can be achieved in a variety of ways. Networking at professional association meetings and conferences is one way. Interacting with other professionals through the Internet is another. Reading materials written by other laser safety practitioners who wish to share their experiences is one of the better ways of learning from one's peers and sharpening one's laser safety skills. This book, *CLSOs' Best Practices in Laser Safety*, is one such set of reading materials.

Produced by the Laser Institute of America (LIA), this book is a compendium of procedures, policies, and practical advice to be used by laser safety professionals. The CLSOs' 'Best Practices' are based on the standards and regulations of several major authorities including the American National Standards Institute (ANSI), the United States Occupational Safety and Health Administration (OSHA), the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO), and the United States Food and Drug Administration, in addition to other national and international regulatory and/or advisory organizations.

In order to develop these Best Practices, an international team of twenty laser safety experts and Certified Laser Safety Officers from industry and academia volunteered their time and effort to create this benchmark reference handbook to assist others in facilitating the safe use of lasers. These expert volunteers have reviewed how laser safety standards are best applied in various environments in which lasers and laser-containing devices are used. The different chapters in this handbook cover areas of laser safety practice that are typically needed in the anticipation, recognition, evaluation, and control of laser hazards.

Chapter 2 of this book provides guidance on how to prepare and conduct an initial evaluation of a laser installation and then perform necessary follow-up. The chapter's authors discuss the "what" and "how" of pre-inspection preparation, including the creation of an inspection checklist. Each of the sections covering the different aspects of the inspection process includes specific questions to be asked in order to conduct a complete evaluation. Finally, this chapter includes a sample laser safety equipment checklist.

Building on Chapter 2's guidance on initial assessment of a laser installation, the authors of Chapter 10 discuss the self-audit as a tool for determining whether or not one's laser safety program is effective – that is achieving its dual objectives of laser-related injury prevention and adherence to regulatory standards and/or accepted guidelines. Using the table of laser hazard control measures from the ANSI Z136.1 standard as the rationale for what to cover in a self-audit checklist, this chapter's authors present a series of brief questions and short statements that explain those control measures. This explanatory summary of control measures is followed by four self-audit checklists: the first for generic use, the second for an academic institution, the third for an industrial setting, and the fourth for a medical setting. A discussion of the measure of a successful audit, the follow-up on its findings, and the evaluation of training follows the checklists.

While the conduct of inspections and audits, including self-audits, needs to be a part of every laser safety program, the inclusion of a Laser Safety Committee (LSC) in the program may or may not be warranted. In recognition of this fact, Chapter 3 begins by asking the question "Do you need a workplace Laser Safety Committee?" and explaining the considerations that need to go into answering that question. A description of the structure of the LSC, who might serve on it, and the responsibilities of those serving on it follows the just-referenced question and responses to it. The chapter authors also review those portions of consensus (the series of ANSI Z136.1 standards) and regulatory standards that may trigger a decision to form and operate a functioning LSC.

While the extent of laser activities, even if those activities include the operation of Class 3B and/or Class 4 lasers, may not warrant the formation of a laser safety committee as part of the laser safety program, rarely would such a program not need to include at least some aspect of protective equipment use. While focusing on beam-related protective equipment (e.g., eye protection), Chapter 4 takes a comprehensive approach in its treatment of this important laser safety topic. This chapter provides a detailed explanation of the concepts and technology behind filters used in laser protective eyewear and the national (e.g., ANSI Z136) and international consensus (e.g., EN207 and EN208) standards that apply to such eyewear. The chapter's coverage of protective equipment extends to protective windows, viewing portals, barriers, and curtains and includes some discussion of non-beam hazard-related protective equipment: for example, respiratory protection and other personal protective equipment worn to protect against exposure to laser generated air contaminants (LGAC), including nanoparticles – a class of LGAC covered in greater detail in Chapter 7.

Chapter 5 addresses another key element of the laser safety effort – laser safety training. Using the ANSI Z136.1 standard as their primary source, this chapter's authors provide a detailed outline of laser safety training-related requirements: who must be trained, who is responsible for providing training, what types of training must be provided at what frequency, and what topics must be covered for each training type. Describing different types of laser safety training (e.g., laser user, incidental personnel awareness, and refresher) and their contents, the authors refer to initial and refresher PowerPoint™ presentation modules for laser user training that are included on the CD-ROM enclosed with each Best Practices handbook. Following the author's discussion of the examination of laser training recipients in order to measure their comprehension of the material presented during training sessions are nearly forty examples of examination questions. The authors conclude this chapter by briefly describing what training-related records should be kept and include two forms: one to verify the provision of laser safety training and a second to document the receipt by laser users of both laser safety-related training and eye examinations.

Going well beyond the laser eyewear-related Optical Density (OD) calculations presented in Chapter 4, Chapter 6 uses specific examples to explain in detail how to calculate important laser hazard parameters including the maximum permissible exposures (MPEs) per ANSI Z136.1 for eye exposure to different wavelengths of laser radiation emitted from continuous wave (CW) and pulsed (single and repetitively) lasers. Examples of how to perform calculations of the Nominal Ocular Hazard Zone (NOHZ), the Nominal Hazard Zone (NHZ) and the OD based on the ANSI Z136.1 standard are also provided. Calculations according to IEC 60825-1 Edition 2.0 for the above laser hazard parameters are also included in Chapter 6. The ability to calculate these parameters allows the CLSO to determine what laser eyewear is suitable for specific laser applications as well as where to place physical barriers, safety lock-outs, or safety zones boundaries.

Continuing and extending the discussion begun in Chapter 4 about non-beam hazards and the protective equipment applicable to such hazards, the authors of Chapter 7 examine non-beam hazards in greater detail. Starting with a review of the concerns associated with laser generated air contaminants (LGAC), including nanoparticles, the authors describe the steps one might follow to conduct an LGAC risk assessment and then explore the hierarchy of available LGAC controls. While the use of personal protective equipment, such as respiratory protection, may be a necessary interim control option, hazards should be engineered out of a process whenever possible and work practice improvements made as an adjunct to such engineering controls. The chapter discusses the components of the most often used LGAC engineering control – local exhaust ventilation (LEV) systems – for both industrial and medical facilities. General dilution ventilation as an adjunct to LEV systems is also covered. Non-beam hazards other than LGAC are also addressed. Each description of a non-beam hazards class (electrical, fire, chemical, nonionizing and ionizing radiation, noise, and mechanical) is followed by a list of applicable preventative measures.

The laser safety considerations unique to high powered laser installations are treated in Chapter 8. This chapter points out the hazards associated with such installations and what the appropriate control measures are. The use of high powered lasers for material processing not only increases the potential for excessive laser radiation exposure but may also exacerbate non-beam hazards associated with such processing such as the previously mentioned hazard of LGAC exposure.

The contents of Chapters 9 and 11 are of special interest to CLSOs. The authors of Chapter 9 begin their discussion of laser safety regulations with an explanation of what activities trigger an organization's coverage by regulations applicable to laser manufacturers, laser users, or both. A summary of and background on both types of regulations precedes a review of international, national, and state laser safety regulations, standards, and guidelines. The authors briefly address efforts being made to harmonize national regulatory and consensus standards with those that are international in their coverage. The location of laser-related activities of an organization will determine the regulations and standards with which it needs to concern itself.

Chapter 11 begins with an introduction to sources of laser-related accident case histories and the value such histories have as training tools, "lessons learned" sources, and incident contributing factor illustrators. The chapter includes eighteen case histories: four each from medical, industrial, and research settings plus two miscellaneous accidents. Each case history includes a description of the incident, its injury outcome, and recommendations for preventing similar incidents. The chapter concludes with a discussion of how implementation of an incident learning system can result in improved laser safety. The system's cyclic process follows a stepwise progression: incident identification and response, reporting, investigation, causal analysis, and finally corrective action and learning. Should a laser-related incident occur in a CLSO's facility, he or she can prevent similar incidents in the future by implementing the steps of the learning system described. Chapter 10 also gives examples of how a CLSO can prevent the above-mentioned accidents. The chapter focuses on auditing the laser safety program to determine its effectiveness in order to prevent accidents.

In concluding this introduction, it is important to note that this initial edition of *CLSOs' Best Practices in Laser Safety* is the first and only book of its kind to be published by the Laser Institute of America. Covering more than just standards and detailing policies, procedures, safety equipment, and hazards, this book is a must-have for the CLSO, whether new to the task or wearing the patina of experience. Of course, best practices are only effective when implemented. The Laser Institute of America hopes that this book, *CLSOs' Best Practices in Laser Safety*, containing material distilled from the collective experience of 20 CLSOs and their associates, will help those who read it (CLSOs and other laser safety professionals) to better facilitate the safe use of lasers everywhere.