Chapter 26

Sterile Compounding Technology

Bruce A. Erickson and Craig A. Boyce

Introduction

This chapter will assist you in understanding why automation of the sterile compounding process is important and the types of automated sterile compounding technology systems that are available in the United States. The term *systems* in this context is used to mean the combination of hardware and software that provides safety mechanisms for the sterile compounding processes. It is not the attempt of this chapter to cover every automated sterile compounding technology on the market because of the continuous changes and new product introductions in this technology segment. Some sections of this chapter may not be applicable to all types of sterile compounding technology. At the time of this publication, the *United States Pharmacopeia* (USP) does not yet contain explicit guidance on the types of automated technologies discussed within this chapter; references to USP chapters that may be applicable are included where appropriate.

This chapter is intended to bring knowledge about the available types of technology that can assist in the sterile compounding processes, the advantages and limitations of the different system types, and the considerations for adding automated compounding technologies based on your compounding processes and workload volume. The goal of sterile compounding automation technology is to provide a controlled sterile compounding process with an electronic record for each finished dose. The electronic record should ideally include all ingredients and consumables used in preparation, the lot number and expiration date of each ingredient entered by the user or captured from a barcode scan, the finished dose amount and diluent volume, positive identification of the personnel performing the compounding activities, and a date-time stamp showing when each activity occurred. This chapter will elaborate on these goals and how automation can help you achieve these goals.

Implementing sterile compounding technology requires knowledge and understanding of the chapters in Part I: Sterile Preparation and Part II: Quality Management. This chapter does not cover parenteral nutrition compounding (Chapter 5), primary engineering controls (Chapter 9), handling and compounding hazardous drugs (Chapter 12), labeling sterile preparations (Chapter 15), storage and beyond-use dating (Chapter 14), documenta-

tion of compounded sterile preparations (Chapter 16), and sterility assurance of compounded sterile preparations (Chapter 17).

Evolution of Automation

The application of automation to repetitive and complex tasks has a well-established history. Mechanization of manufacturing began in the late 1800s and early 1900s using simple devices to perform repetitive tasks. In the 1930s and 1940s, more complex programming and control systems enabled true automation by allowing these mechanized systems to adjust output without human involvement. Introduction of the industrial multiaxis robotic arm in the 1970s coupled to computerized programming advanced automation to the point that humans could be removed from many manufacturing processes. Using automation in error-prone or dangerous processes enables improvements in the quality of the manufacturing output by eliminating human error and allows employers to protect the work force from harm. Over the last three decades, these same principles have been recognized as needs in the healthcare sector as well and have been driving forces behind automating the pharmacy compounding service.

The evolution of automated compounding began in 1987 with the commercial introduction of a manually controlled peristaltic fluid transfer pump for preparation of oral liquid doses.[1] The peristaltic pump was quickly adopted for transfer of sterile fluids from bulk containers to patient-specific bags. The next major step forward in automation of sterile compounding occurred in 2002 with software control of the pump and integration of a scale to check the weight of each ingredient after the addition of the sterile compounding product.[2] The connection of multiple fluid sources joined by a valved transfer set that is controlled by the compounding recipe software has become the generally accepted standard for compounding complex admixtures such as parenteral nutrition (Chapter 5) or cardioplegia solutions.

By the early 2000s, the first automated syringe fillers became available.[3] These devices combined a peristaltic pump with actuator controllers to move a bandolier of syringes through a filling and capping station, then to a labeler, cutter, and output trough. These systems were the first truly automated sterile compounding systems that were available to hospitals, and that allowed doses to be prepared without human intervention after the source container was connected to the peristaltic pump tubing. A limitation for some of these systems is the ability to prepare only specific syringe sizes due to the available proprietary bandolier systems.

In the mid-2000s, systems that automated most or all of the manual compounding processes for both syringes and bags became available and have come to be referred to as *compounding robots* or *automated compounding systems* (ACSs). These systems differed from the existing automated compounding devices both in design and intended use. ACSs incorporate software control of multiple mechanical manipulators and six-axis robotic arms, racks for holding bags and vials, precision balances for gravimetric validation during the compounding processes, and barcode readers or imaging systems to inspect raw materials and finished products. ACSs enclose the compounding area within a high-efficiency particulate air (HEPA)-filtered air chamber and may also have dedicated material loading bays to separate the compounding area from the location where compounding materials are placed into the storage racks. The airflow in some systems can be configured to operate under positive or negative pressure, making these systems applicable for use in compounding hazardous drugs. The ACS represented a significant advancement for sterile compounding because they introduced the capability for highly accurate compounding of syringe and bag doses in both batch mode (compounding many doses of the same preparation) or patient-specific mode (making a specific dose for a specific patient through an interface to the pharmacy information system).

Another technology adapted from manufacturing to the sterile compounding process is the use of software to manage workflow and guide manual processes. Sterile compounding workflow systems (SCWSs) were first introduced in 2008, and the number of systems has grown to more than eight different vendors.[4] Some pharmacy information systems also include compounding workflow management functionality. These software systems