[0008] In another embodiment, a system for inspecting tubular vessels post stoppering may include a digital image data acquisition device and a digital image processing engine. At least a portion of the tubular vessel may be at least partially transparent. The digital image data acquisition device may include an image sensor and a backlight. The digital image data acquisition device may be configured to cause the backlight to emit light having a predetermined intensity. The digital image data acquisition device may also be configured to acquire image data from the image sensor while at least a portion of the tubular vessel and at least a portion of the plunger are positioned between the image sensor and the backlight while the backlight emits light. The image data may be representative of a silhouette of at least the portion of the tubular vessel and at least the portion of the plunger within the tubular vessel. The system may also include a digital image processing engine configured to determine a depth of the plunger within the tubular vessel based on the image data.

[0009] There is disclosed a method of inspecting a tubular vessel may include providing a plurality of tubular vessels in a tray and an intermediate holder. The method may also include aligning the intermediate holder with the tray and transferring the plurality of tubular vessels from the tray to the intermediate holder. The method may further include placing the plurality of tubular vessels and the intermediate holder between an image sensor and a backlight. The method may yet further include acquiring image data from the image sensor while at least a portion of the tubular vessel and at least a portion of the plunger are positioned between the image sensor and the backlight while the backlight emits light at a predetermined intensity. The image data may be representative of a silhouette of at least the portion of the tubular vessel and at least a portion of a plunger within the tubular vessel.

[0010] In yet a further embodiment, a non-transitory computer-readable medium may include computer-readable instructions stored thereon that, when executed by a processor, cause the processor to implement a tubular vessel inspection post stoppering. At least a portion of the tubular vessel may be at least partially transparent. The computer-readable medium may include a backlight control module that, when executed by the processor, may cause the processor to cause a backlight to emit light having a predetermined intensity. The computer-readable medium may also include a digital image data acquisition module that, when executed by the processor, may cause the processor to acquire image data from an image sensor while at least a portion of the tubular vessel and at least a portion of a plunger within the tubular vessel are positioned between the image sensor and the backlight while the backlight emits light. The image data may be representative of a silhouette of at least the portion of the tubular vessel and the at least the portion of the plunger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] It is believed that the disclosure will be more fully understood from the following description taken in conjunction with the accompanying drawings. Some of the drawings may have been simplified by the omission of selected elements for the purpose of more clearly showing other elements. Such omissions of elements in some drawings are not necessarily indicated of the presence or absence of particular elements in any of the exemplary embodiments, except as may be explicitly delineated in the corresponding written description. Also, none of the drawings are necessarily to scale.

[0012] Fig. 1 depicts an example prefilled syringe inspection system;

[0013] Fig. 2 depicts an illustration of an example prefilled syringe;

[0014] Fig. 3 depicts an example silhouette of portions of two prefilled syringes in a tray;

[0015] Figs. 4A-F depict various example prefilled syringe inspection apparatuses, systems, and methods;

[0016] Figs. 5A-H, J and K depict an example tray of prefilled syringes, an intermediate holder, a removal tool, and method of transferring the prefilled syringes from the tray to the intermediate holder;

What is claimed is:

1. A system for inspecting tubular vessels post stoppering, wherein at least a portion of the tubular vessel is at least partially transparent, the system comprising:

a digital image data acquisition device having an image sensor and a backlight, wherein the digital image data acquisition device is configured to cause the backlight to emit light having a predetermined intensity, wherein the digital image data acquisition device is configured to acquire image data from the image sensor while at least a portion of the tubular vessel and at least a portion of the plunger are positioned between the image sensor and the backlight while the backlight emits light, wherein the image data is representative of a silhouette of at least the portion of the tubular vessel and at least the portion of the plunger within the tubular vessel; and

a digital image processing engine configured to determine a depth of the plunger within the tubular vessel based on the image data.

2. The system of claim 1, wherein the image data is representative of at least a portion of a flange of the tubular vessel, and wherein the digital image data acquisition device is further configured to control an intensity of the backlight based on a transparency of at least the portion of the flange.

3. The system of any one of the previous claims, wherein the digital image data acquisition device is further configured to control an integration period of the image sensor based on the intensity of the backlight.

4. The system of any one of the previous claims, wherein the image data is representative of at least a portion of a flange of the tubular vessel, and wherein the digital image data acquisition device is further configured to control an integration period of the image sensor based on a transparency of at least the portion of the flange.

5. The system of any one of the previous claims, further comprising:

a tray, wherein at least a portion of the tray is positioned between the backlight and the at least the portion of the tubular vessel and the at least the portion of the plunger.

6. The system of any one of the previous claims, further comprising:

an intermediate holder, wherein an optically unimpeded portion of the intermediate holder is positioned between the backlight and the at least the portion of the tubular vessel and the at least the portion of the plunger.

7. The system of any one of the previous claims, further comprising:

a stage, wherein the stage passes the at least the portion of the tubular vessel and the at least the portion of the plunger under imaging optics of the digital image data acquisition device.

8. A non-transitory computer-readable medium having computer-readable instructions stored thereon that, when executed by a processor, cause the processor to implement a tubular vessel inspection post stoppering, wherein at least a portion of the tubular vessel is at least partially transparent, the computer-readable medium comprising:

a backlight control module that, when executed by the processor, causes the processor to cause a backlight to emit light having a predetermined intensity; and

a digital image data acquisition module that, when executed by the processor, causes the processor to acquire image data from an image sensor while at least a portion of the tubular vessel and at least a portion of a plunger within the tubular vessel are positioned between the image sensor and the backlight while the backlight emits light, wherein the image data is representative of a silhouette of at least the portion of the tubular vessel and the at least the portion of the plunger.

9. The computer-readable medium of claim 8, further comprising:

an inspection data generation module that, when executed by the processor, causes the processor to generate inspection data based on the image data, wherein the inspection data is representative of a distal edge of the tubular vessel.

10. The computer-readable medium of any one of claims 8 or 9, further comprising:

an inspection data generation module that, when executed by the processor, causes the processor to generate inspection data based on the image data, wherein the inspection data is representative of a distal edge of the plunger.

11. The computer-readable medium of any one of claims 8 - 10, further comprising:

an inspection data generation module that, when executed by the processor, causes the processor to generate inspection data based on the image data, wherein the inspection data is representative of a depth of the plunger within the tubular vessel.

12. The computer-readable medium of any one of claims 8 - 11, wherein the image data is representative of at least a portion of a flange of the tubular vessel, and wherein the processor controls an intensity of the backlight based on a transparency of at least the portion of the flange.

13. The computer-readable medium of any one of claims 8 - 12, wherein an integration period of the image sensor is based on the predetermined intensity of the backlight.

14. The computer-readable medium of any one of claims 8 - 13, wherein the image data is representative of at least a portion of a flange of the tubular vessel, and wherein an integration period of the image sensor is based on a transparency of at least the portion of the flange.