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CTS™ Xenon™ Electroporation System

USER GUIDE

For electroporation of primary and stem cells for cell therapy development and manufacturing

Catalog Number A52727

Publication Number MAN0025488

Revision C.0

For Research Use or Manufacturing of Cell, Gene, or Tissue- Based Products. CAUTION: Not intended for direct administration into humans or animals.

ThermoFisher SCIENTIFIC

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Revision	Date	Description
C.0	7 July 2023	Added CTS™ Xenon™ Lower Conductivity Electroporation Buffer.
B.0	4 April 2022	Addition of guidelines for using Xenon buffer kits, and update of post-transfection instructions.
A.0	11 November 2021	New user guide for CTS™ Xenon™ Electroporation Instrument.

The information in this guide is subject to change without notice.

Contents

1 Product information

Product description

The CTS™ Xenon™ Electroporation System is a novel, benchtop device consisting of the CTS™ Xenon™ Electroporation Instrument, single-use consumables for performing transfection of cells, and specialized buffers.

The CTS™ Xenon™ Electroporation Instrument efficiently delivers gene editing payloads (DNA, RNA and proteins) into all mammalian cell types including primary and stem cells with a high cell survival rate. Protocols are optimized for ease of use and simplicity, and conditions can be optimized for your payload and cell type. See “System components” on page 8 for details on various parts of the system.

Two types of consumable are used for performing transfection.

- The SingleShot format uses an electroporation chamber to process 2×10^7 to 1×10^8 cells in a 1 mL sample volume. See “SingleShot electroporation chamber” on page 10.
- The MultiShot format uses a cartridge and sample bags to process 1×10^8 to 2.5×10^9 cells in a 5–25 mL sample volume. See “MultiShot electroporation cartridge” on page 11

The system includes proprietary buffers that are compatible with various cell types including primary lymphocytes and stem cells. See “CTS™ Xenon™ buffer kits” on page 12.

- The CTS™ Xenon™ Electroporation Buffer is compatible with a wide variety of mammalian cell types, eliminating the need to determine an optimal buffer for each cell type.
- The CTS™ Xenon™ Genome Editing Buffer is designed to improve performance with gene editing specific payloads (Talen, Cas9) in mammalian primary and stem cells.
- CTS™ Xenon™ Lower Conductivity Electroporation Buffer is designed for use with cell types that require higher energy electroporation settings to achieve successful transfection.

Product contents

CTS™ Xenon™ system contents

The contents of the CTS™ Xenon™ Electroporation System are listed in the following table. The system is shipped at room temperature.

See page 8 for specifications and description of the CTS™ Xenon™ Electroporation Instrument, and page 28 to set up the instrument.

Product	Quantity
CTS™ Xenon™ Electroporation Instrument	1
Region specific power cord (for US/Canada/Taiwan/Japan, Europe, or UK)	1
Cat 5 Ethernet cable	1
USB memory device (containing user guide)	1
Quick reference	1
Install guide	1
Bubble level	1

CTS™ Xenon™ buffer kit contents

The CTS™ Xenon™ buffer kits are used with the CTS™ Xenon™ Electroporation System for efficient transfection of mammalian cells and are available as standalone products (see “Accessory products” on page 71).

CTS™ Xenon™ buffer kit components are listed in the following table, and are shipped on blue ice.

After receiving the kit, **store buffers at 2–8°C**. Do not allow buffers to undergo warming and cooling cycles, or excessive shaking.

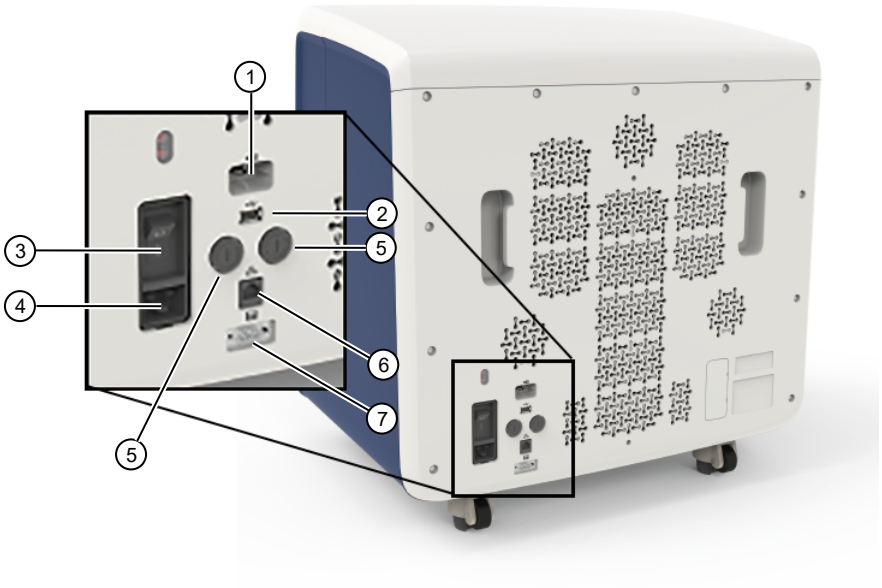
Item	Format
CTS™ Xenon™ Electroporation Buffer	100 mL (bottle) 100 mL (bag)
CTS™ Xenon™ Genome Editing Buffer	100 mL (bottle) 100 mL (bag)
CTS™ Xenon™ Lower Conductivity Electroporation Buffer	100 mL (bottle) 100 mL (bag)

System components

CTS™ Xenon™ Electroporation Instrument

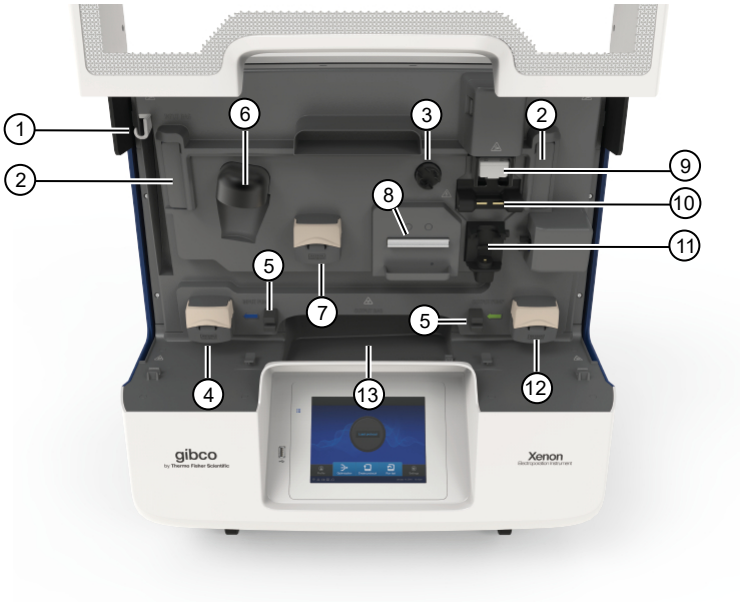
Front and rear view

① Door
② Touch screen
③ Castor with pad and wheel (× 4)
④ Grab rail (on left and right sides)



① USB wireless adaptor port
② USB 2.0 port
③ Power switch
④ Power cable inlet
⑤ Fuse compartment
⑥ Ethernet port
⑦ Peripheral interface port (RS-232)

Internal view



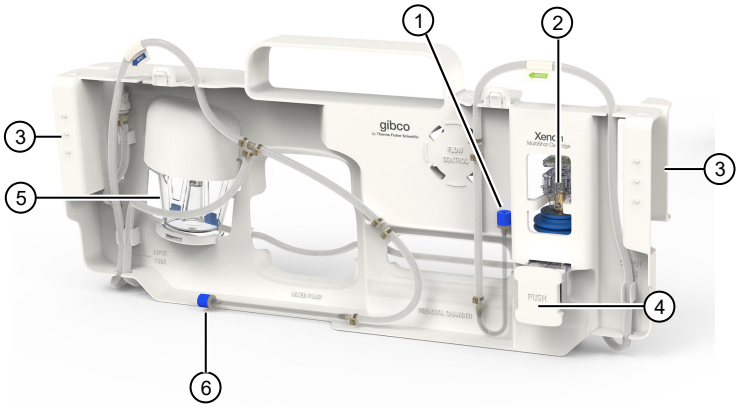
① Input bag hook
② Cartridge handle springboard
③ Stopcock driver
④ Input pump
⑤ Ultrasonic sensor
⑥ Mixing cup interface
⑦ Mixing cup output pump
⑧ Cooling block
⑨ Chip reader
⑩ Upper electrode mount
⑪ Electroporation chamber holder
⑫ Output pump
⑬ Output bag tray

SingleShot electroporation chamber

1. Top adaptor with authentication chip
2. Upper electrode housing
3. Upper electrode
4. Electroporation chamber
5. Lower electrode

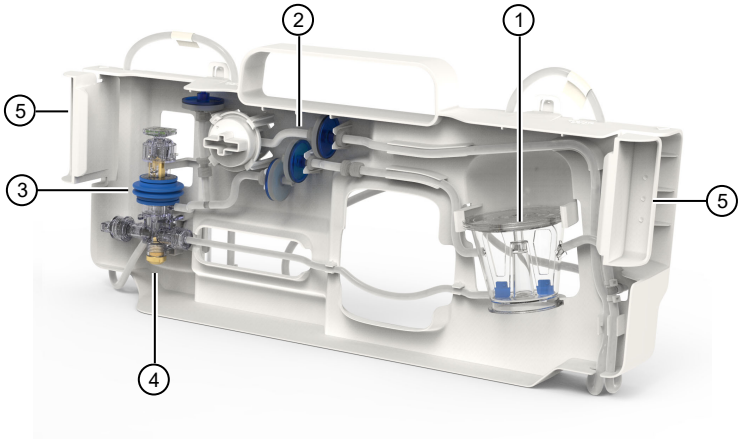
MultiShot electroporation cartridge

Front



1. Luer port for output bag
2. Electroporation chamber
3. Cartridge handle (on left and right sides)
4. Electroporation chamber push latch
5. Mixing cup (25 mL capacity)
6. Luer port for input bag

Rear



1. Mixing cup
2. Sterile filters
3. Electroporation chamber
4. Electrode
5. Cartridge handle (on left and right sides)

CTS™ Xenon™ buffer kits

There are three cell resuspension buffers available for use with the CTS™ Xenon™ Electroporation System.

- The CTS™ Xenon™ Electroporation Buffer is designed for use with various primary cell types when performing electroporation with standard DNA or RNA based payloads for gene expression or gene knockdown based applications.
- The CTS™ Xenon™ Genome Editing Buffer is designed to support cells through gene editing during and after electroporation. It is used with gene editing based payloads (Talen, Cas9) to enhance both knock-out and knock-in editing efficiencies.
- The CTS™ Xenon™ Lower Conductivity Electroporation Buffer is designed for use with cell types that require higher energy electroporation settings to achieve successful transfection. This formulation helps protect against excessive heat generation during the electroporation process.

Upon receiving the instrument

- Check the enclosed packing list against the order.
- Visually inspect the transport package, the instrument and the accessories for any damage incurred during transit.
- If the carton has been damaged in transit, it is particularly important that you retain it for inspection by the carrier in case there has also been damage to the instrument.
- Any damage claims must be filed with the carrier. Neither the manufacturer nor its agents can be held responsible for any damage incurred in transit, but the manufacturer will make every effort to help obtain restitution from the carrier. Upon receipt of the carrier's inspection report, arrangements will be made for repair or replacement.
- To register the instrument, activate your warranty, and be notified of important updates, go to **thermofisher.com**.

Guidelines for unpacking and set up of the instrument

- To prevent condensation, the instrument should be left in its protective, antistatic plastic wrapping until the ambient temperature has been reached.
- The instrument weighs 70 kg (154 lbs) and requires at least two people to lift. Use the proper precautions when lifting the instrument to avoid injury.
- Retain the original packaging and packing material for future transportation. The packaging is designed to assure safe transport and minimize transit damage. Use of alternative packaging materials may invalidate the warranty. Also retain all instrument-related documentation provided by the manufacturer for future use.
- Refer to the installation guide (Pub. No. 100107077) for detailed instructions on how to unpack the instrument.
- During instrument installation and maintenance, it is necessary to access the back of the instrument. If the back of the instrument faces a wall, ensure that there is sufficient clearance on the bench to rotate the instrument for access.

WARNING! Do not place the instrument adjacent to, or stack with other equipment to avoid improper operation. If this type of placement is necessary, all the instruments and equipment should be observed to ensure that they operate normally.

WARNING! Use of accessories, transducers, and cables other than those specified or provided by the manufacturer of the equipment can result in increased electromagnetic emissions, or decreased electromagnetic immunity of this equipment, and result in improper operation.

WARNING! Do not use portable RF communications equipment (including peripherals such as antenna cables and external antennas) within 30 cm (12 inches) of any part of the instrument (including cables specified by the manufacturer) to avoid degradation of equipment performance.

Required materials not provided

- *(Optional)* Electrical protective devices.
  The use of one or more of the following electrical protective devices is recommended.
  - Power line regulator (100–240 V)
  - Surge protector/line conditioner (10-kVA)
  - Uninterruptible power supply (1.5-kVA)
- USB-enabled Wi-Fi Module (for wireless connection)

User interface overview

Symbol	Function
Main dial	
	**Load protocol** Displays the instrument status when a protocol is run (see “Touchscreen status indicators”)
Optimization screen	
	Perform optimization for a new protocol (see “Optimization protocol” on page 61 for more details)
Create protocol screen	
	• Create a new SingleShot protocol (see page 29 for more details) • Create a new MultiShot protocol (see page 32 for more details) • Edit an existing SingleShot protocol (see page 30 for more details) • Edit an existing MultiShot protocol (see page 33 for more details)
Run previous screen	
	Select and run a protocol from the run history

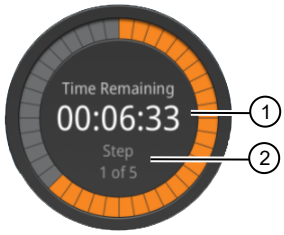
Touchscreen controls

Table 1 General touchscreen controls

Button	Function
	Returns to the previous screen.
	Go to **Home** screen.
	Go to **Sign in** screen.
	Go to **Settings** screen.
	Close the current modal window.

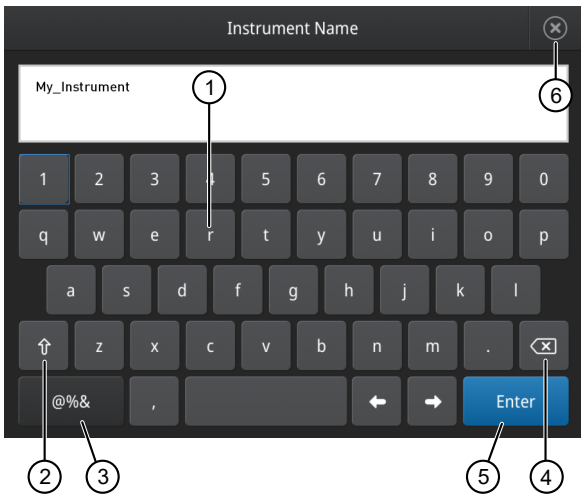
Touchscreen status indicators

Table 2 Status indicators

Button	Function
	View instrument status **1.** Time remaining **2.** Protocol status (step, paused, etc.)
	Indicates whether a USB device is inserted into the instrument.
	Indicates whether the Wi-Fi is on or off.
	Indicates whether the instrument is connected to wired network.
	Indicates whether the instrument is connected to the Thermo Fisher™ Connect.

Enter text

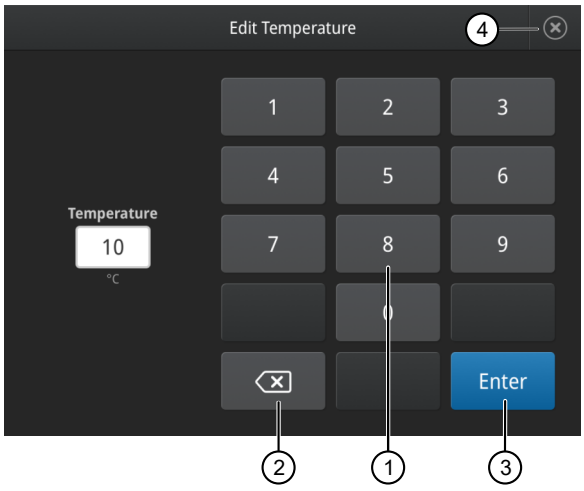
When you select a field that requires the input of text, the alphanumeric text editor, as seen in the following figure, opens.



① Enter a letter
② Change letter case
③ Enter punctuation or other symbols
④ Delete
⑤ Close and save
⑥ Close without saving

Enter numbers

When you select a field that requires a numerical input, the numeric editor, as seen in the following figure, opens.



① Enter a number
② Delete/backspace
③ Close and save
④ Close without saving

First time instrument setup

1. Place the instrument in a protected location with at least 10 cm of free space around the perimeter for ventilation.

2. Connect the power supply cable to the power inlet.

   The instrument operates at voltages of 100–240 VAC and the frequency range of 50/60 Hz. Ensure that the local supply voltage in the laboratory conforms to that specified on the type label on the back of the instrument

Connect the instrument to the Internet

The instrument can connect to the Internet by either wired or wireless methods.

To connect by wired method through the instrument Ethernet port using a cable, see “Set up a wired connection” on page 19.

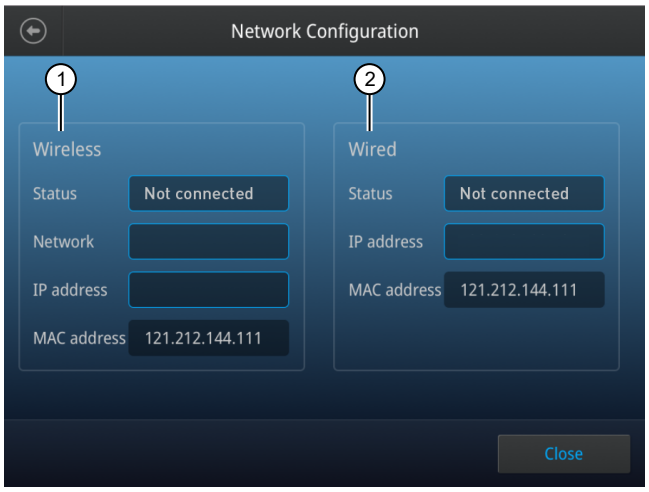
To connect by wireless method through the instrument USB wireless adapter port with a USB-enabled Wi-Fi card, see “Set up a wireless connection” on page 17.

Set up a wireless connection

Connect the High-Power USB Wi-Fi Module (Cat. No. A26774 to the USB wireless adapter port (see 8 for port location).

1. See “Set up a wired connection” on page 19 Steps 1 through 3 to find the **Network configuration** screen.

2. In the **Network configuration** screen, select a field in the **Wireless** panel.



① Wireless panel ② Wired panel

Note: During initial setup, if you selected the Wired option in the **Network Connection** screen, you will be required to enter the IP address if you selected the Static IP wired option. If you selected the Dynamic IP wired option, the IP address is automatically populated.

3. Once a wireless connection has been detected, a list of the available networks is displayed. Select the network name of your choice or select **Join others**.

   Note: If you choose **Join others**, the **Configure and Join Network** screen opens.

4. In the **Configure and Join Network** screen, select the **Network Name** field, then enter the name and security type of the network.

5. Select the security type from the **Security type** dropdown menu.

   Note: Contact your IT Systems Administrator for information on security type.

   Select from the following options:

   - Open
   - WEP
   - WPA Personal
   - WPA2 Personal
   - WPA Enterprise
   - WPA2 Enterprise

   Note: The above options are available only if **Join Other Network** was selected in Step 3. You cannot change the security type if you selected an existing network.

6. Select **Join** to continue or **Cancel** to exit from the **Find and Join a Network** screen.

7. Depending on the security type you have selected, enter the appropriate passwords and select **Join**.

8. If all the entered information is correct, the **Network Connection Complete** screen will appear. Select **OK** to continue.

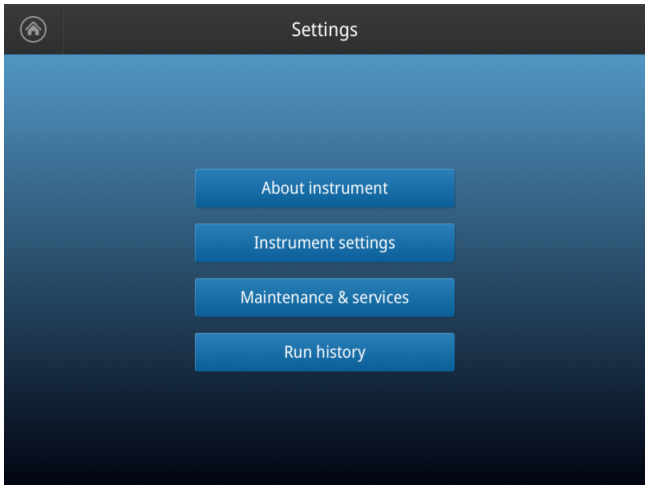
   Note: If incorrect information was entered the **Network Connection Failed** screen will open. Select **OK** to continue to the **Security type** screen.

Set up a wired connection

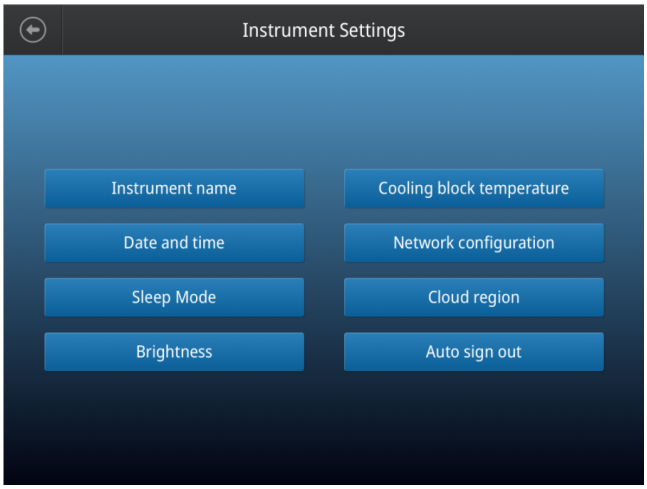
Connect one end of a Ethernet cable to the instrument Ethernet port, and the other end to an Ethernet port wall plug (see 8 for port location).

1. On the **Home** screen, select ⚙ **(Settings)**.

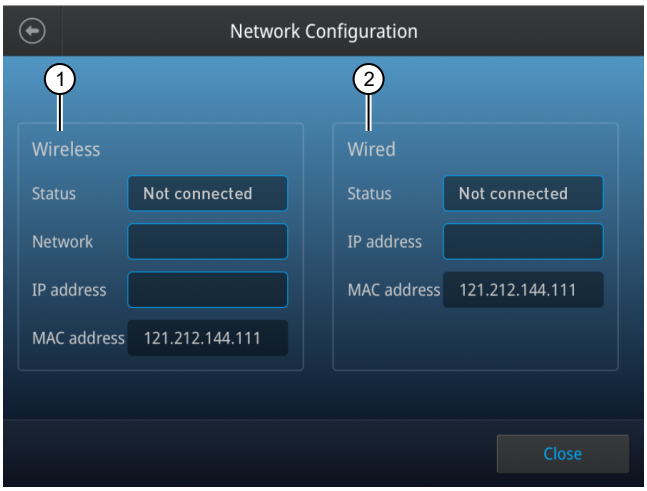
2. In the **Settings** screen, select **Instrument Settings**.



3. In the **Instrument Settings** screen, select **Network configuration**.



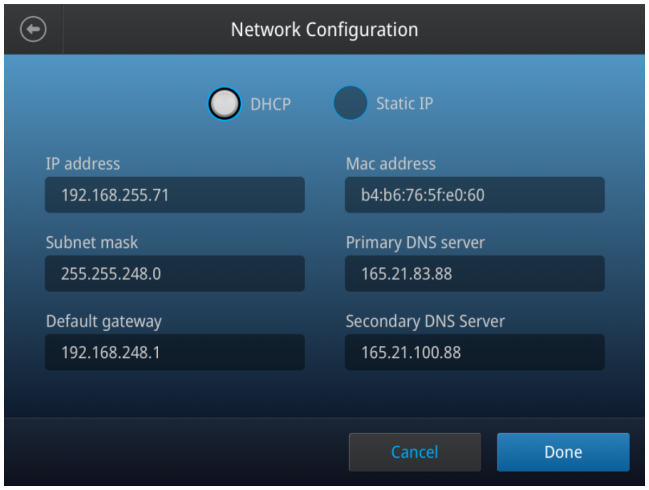
4. In the **Network Connection** screen, select a field in the **Wired** panel.



① Wireless panel ② Wired panel

5. Select a method to enter an IP address.
   a. Select **DHCP** to obtain an IP address automatically. A check mark appears when DHCP is selected.

b. Select **Static IP** to enter an IP address manually, then enter the appropriate IP addresses for the instrument, the Subnet Mask, and, optionally, the Default Gateway, the Primary DNS Server, and the Secondary DNS Server using the numeric editor. Addresses are in the form of X.X.X.X, where each X is a 3- digit number, from 001 to 255.



Note: If your instrument is not on a network, you do not need to set the IP address. Ask your system administrator if the IP address is assigned statically or dynamically. For static addresses, you need to know the IP address for the instrument, the subnet mask, and the default gateway.

6. Select **Done** to save the changes and go back to the **Instrument Settings** screen or select **Cancel** to exit the screen without saving the changes.

Create a user profile on the instrument

1. Select **(Sign In)** > **Get started** ▸ **Create profile**.
2. Fill in the required text fields and enter a four digit PIN to create your user profile.

   Note: The first profile created is automatically given an Administrator profile (indicated by an asterisk after the **Username**).

3. Select **Create**.

Manage user profiles

All users can manage their profiles to edit personal folder names, change PINs, and link to the cloud by selecting their **(Profile)** to enter their **My Profile** page.

Users with Administrator profiles (as indicated by an asterisk after their user name) are able to manage all user accounts by selecting **All accounts** after entering their **My Profile** page.

The following actions are available from the user profile screen:

- Change a PIN
- Create a new user profile
- Grant administrator rights to selected user profile (Administrator only)
- Delete a user profile (Administrator only)
- Delete a PIN (Administrator only)

Change a user PIN

1. Select **Edit**.
2. Enter the old PIN.
3. Enter a new four digit PIN.
4. Re-enter the new PIN, then select **Done**

Delete a user PIN

If a user PIN is forgotten, an administrator can delete the existing PIN to allow a new one to be created. This function resets a PIN, so the user with a deleted PIN is prompted to create a new PIN the next time they sign in)

1. Select **All accounts**.
2. Select the account with the forgotten PIN.
3. Select **Delete PIN**

Delete a user profile

1. Select **All accounts**.
2. Select the account to be deleted.
3. Select **Delete account**

Assign or remove administrator privileges

1. Select **All accounts**.
2. Select the account to be modified.
3. Switch the toggle to **Yes** to grant privileges, or **No** to remove privileges

An asterisk appears next to user profiles with administrator privileges.

About the Thermo Fisher™ Connect Platform

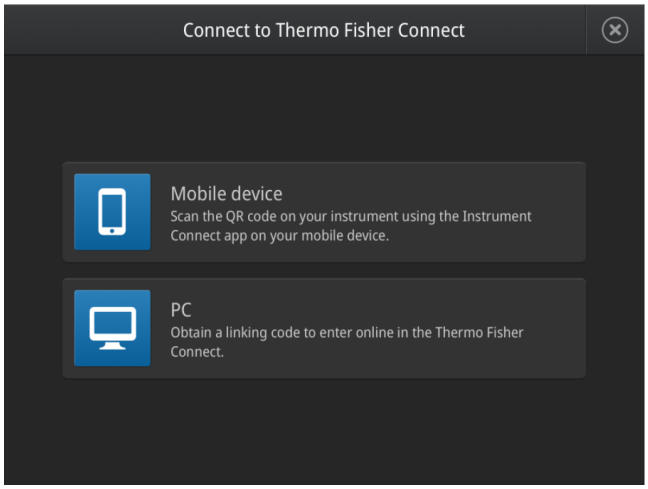
The Thermo Fisher™ Connect Platform enables access to the CTS™ Xenon™ instrument through InstrumentConnect by way of a web browser or mobile device. This cloud-based tool allows the user to perform the following functions when the instrument has Internet connectivity.

Create a Connect Platform account

1. Go to **thermofisher.com/connect** from your web browser.
2. Click **Sign up now** and follow the prompts to create an account.
   Your e-mail address is used as your username.
3. When signed in, click **Update PIN number**.
4. Enter a PIN number in the **new** and **confirm** fields.
   The PIN number is necessary to sign in to Connect Platform from the instrument.

Link the instrument to Connect (Administrator only)

1. Select **(Sign In) ▸ Link cloud**, then select the cloud region of the instrument.
2. Select the method for linking the instrument to Connect .



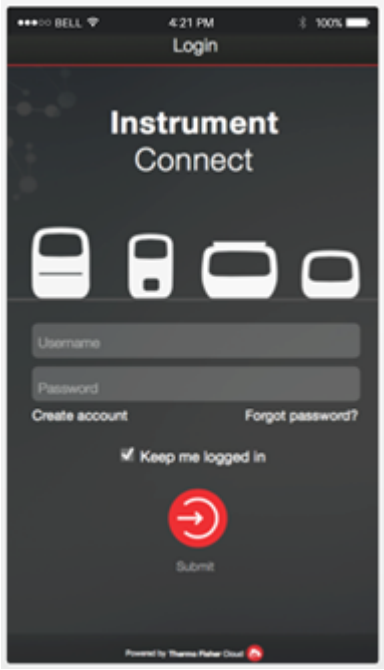
Connect by mobile device

Select **(Sign In)** ▸ **Get started** ▸ **Connect** ▸ **Mobile device** from the instrument to generate a QR code.

1. Download the "Instrument Connect Mobile Application" on your mobile device.
   a. For iPad™ or iPhone™ devices, download the application from the Apple™ App Store by searching for Instrument Connect by Thermo Fisher Scientific.

   b. For Android devices, download the application from Google™ Play by searching for Instrument Connect by Thermo Fisher Scientific.

2. Launch the Instrument Connect Mobile Application and log in using your Connect login and password.



3. Capture the QR code on the instrument screen.

Connect by PC

Select **(Sign In)** ▸ **Get started** ▸ **Connect** ▸ **PC** from the instrument to generate a linking code.

1. Log in to your Connect account using a web browser from a computer.
2. Select **(InstrumentConnect)** from the left navigation strip.
3. Select **(Add an Instrument)** from the top navigation strip.
4. Select **Xenon** from the drop down menu, then click **Next**.
5. Enter the linking code generated by the instrument in the text box, then click **Send**.
   Upon successful authentication, the instrument is linked to Connect.

Connect by instrument

1. Enter your Connect **Username** and **Password** from the instrument.
2. Click **Link account**.

   Note: If you do not have a PIN, you will be prompted to create one.

   Upon successful authentication, the instrument is linked to Connect.

Connect the instrument to the Internet

1. Connect your instrument to the Internet.
   - Connect through the instrument Ethernet port using a cable.
   - Connect via wireless connection with a USB-enabled Wi-Fi dongle.
2. Swipe down on the touchscreen to confirm that the instrument has an active network connection.

Create a PIN number

1. Log in to your Connect Platform account using a web browser.
2. Navigate to **(InstrumentConnect)**.
3. Select **Update PIN number**.
4. Confirm the PIN number.

Generate a link code from the instrument

1. Open the **Notifications** screen on the instrument.
2. Select **Connect** to generate a link code and QR code.
3. Copy down the link code generated by the instrument, or take a picture of the QR code with your mobile device if you have a QR code scanner app installed.

Set up a new administrator

1. To set up a new adminstrator, log in to current administrator Connect Platform account.
2. Select **Instruments**
3. Select the CTS™ Xenon™ instrument for the current administrator.
4. Select **Manage users**.
5. Assign the administrator role to another user linked to the same instrument.

Add an instrument to your Connect Platform account

The Connect Platform supports access to the CTS™ Xenon™ instrument with the InstrumentConnect application on your mobile device or from a web browser. When the instrument is connected, real-time instrument status can be viewed from the InstrumentConnect application.

IMPORTANT! The first Connect Platform account that links to the instrument becomes Administrator by default. If the first user needs to be unlinked from the instrument, a new user must be assigned the Administrator role beforehand. Failure to do so will result in the loss of instrument connectivity for all other linked users. For instructions on how to setup a new Administrator see “Set up a new administrator” on page 26.

Add an instrument to your Connect account (PC)

1. Log in to your Connect account using a web browser.
2. Select **(InstrumentConnect)** from the left navigation strip.
3. Select **(Add an Instrument)** from the top navigation strip.
4. Select **CTS™ Xenon™** from the **Instrument type** drop down menu, then click **Next**.
5. Enter the linking code generated by the instrument in the text box, then click **Send**.
   Upon successful authentication, the instrument is linked to Connect.

Add an instrument to your Connect account with linking code (mobile device)

1. Open the InstrumentConnect application on a mobile device.
2. Select **+**.
3. Select **Linking code**.
4. Enter the linking code obtained from the instrument.
5. Select **Send**.

Add an instrument to your Connect account with QR code (mobile device)

Install a QR code scanner app on your mobile device to connect to the instrument using the QR code.

1. Open the InstrumentConnect application on a mobile device.
2. Select **QR code**.
3. Take a picture of the QR code on the **Notifications** screen of the instrument with your mobile device.

Access your Connect account from an instrument

1. Swipe down to open the **Notifications** screen.
2. Select **Sign in**.

   Note: If another user account is displayed, select the **username** to sign out and connect a different user account.

3. Select your username from the list of linked accounts.
4. Enter your Connect PIN number.

   If you do not have a PIN number, set the PIN number in the dialog box.
5. Select **OK**.

2 Methods

Electroporation protocol options

There are three options available for selecting an electroporation protocol:

- If a protocol with the necessary electroporation parameters for your cell type already exists, the protocol can be chosen from a list of **User created** or **Template** protocols by selecting **Load protocol** on the main dial.
- A protocol that was previously run can be selected using **Run previous** if there is a run history for the protocol.
- If optimization is necessary for a new cell type without specific electroporation parameters, use **Optimization** to select an optimization protocol (see “Optimization protocol” on page 61).

If a new protocol is required, there are two methods for creating a new electroporation protocol:

- Use **Create protocol** to create a new protocol (see page 29 for details on SingleShot protocols, or page 32 for details on MultiShot protocols)
- Use **Open existing** to edit an existing protocol (see page 30 for details on SingleShot protocols, or page 33 for details on MultiShot protocols).

Select **Actions** to edit a protocol, import a protocol, or convert a SingleShot protocol into a MultiShot protocol.

- Select **Manage protocol** to edit a protocol.
- Select **Import** upload a protocol to the instrument.
- Select **Save SingleShot to MultiShot** to convert a SingleShot protocol into a MultiShot protocol.

Electroporation parameters

The CTS™ Xenon™ Electroporation Instrument is designed to operate within specific parameters. The values and limits for each parameter are listed below. If your input value exceeds the maximum value, an error is displayed.

Parameters that can be modified include:

- **Pulse voltage** (range: 500–2,500 V)
- **Pulse width** (range: 1–30 ms)
- **Number of Pulses** (range: 1–10 pulses)
- **Pulse interval** (range: 500 ms–1 second [in 100 ms intervals])
- **Cell Type**
- **Buffer Type** (CTS™ Xenon™ Genome Editing Buffer, CTS™ Xenon™ Electroporation Buffer , CTS™ Xenon™ Lower Conductivity Electroporation Buffer)
- **Pulse Type** (Conventional, Reverse polarity)

The individual parameters (voltage, pulse width, pulse number, pulse interval) have their own independent upper limits. However, certain combinations of these variables will exceed the energy limit of the system even when still within the individual limit. For example, a protocol of 2300 V/30 ms/3-pulses can be entered but not run as it exceeds the energy limit of the system despite each variable being within its limits.

A graphical representation of the electroporation parameters can be viewed by selecting **Pulse profile** when viewing the protocol parameters screen.

Create/Edit SingleShot protocols

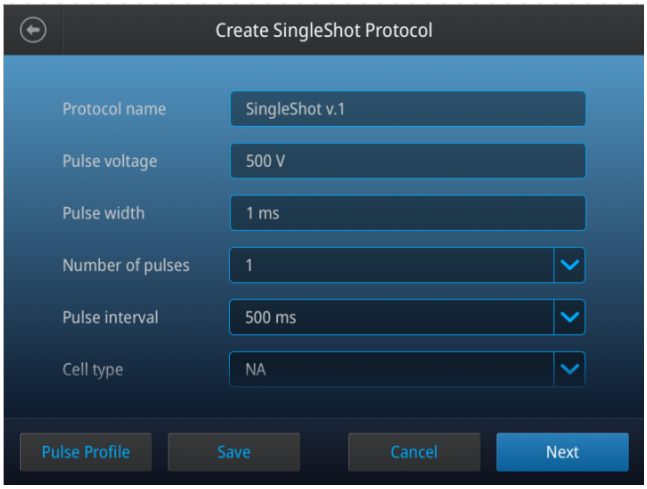
SingleShot protocols are used to process 2 × 10^7 to 1 × 10^8 cells in a 1 mL sample volume.

Create SingleShot Protocol

1. In the **Home** screen, select **Create protocol**.

2. Select **SingleShot** ▸ **Create new**.

3. Select a text field or open a dropdown menu to set the electroporation parameters for the protocol.



Note: Swipe the screen to scroll up or down.

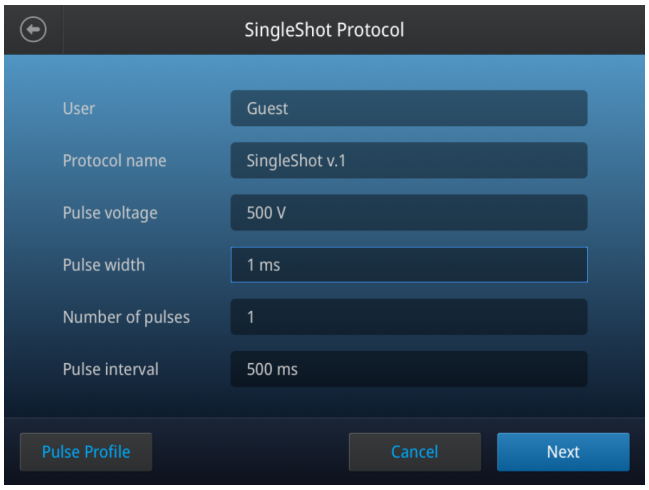
4. Select **Save** (see “Save a Protocol” on page 34), **Next** to run the protocol, or **Cancel**.

Edit SingleShot Protocol

1. In the **Home** screen, select **Create protocol**.

2. Select ↻ **SingleShot** ▸ **Open existing**.

3. Select a text field or open a dropdown menu to set the electroporation parameters for the protocol.



Note: Swipe the screen to scroll up or down.

4. Select **Save as** to save the edited protocol (see “Save a Protocol” on page 34).

Create/Edit MultiShot protocols

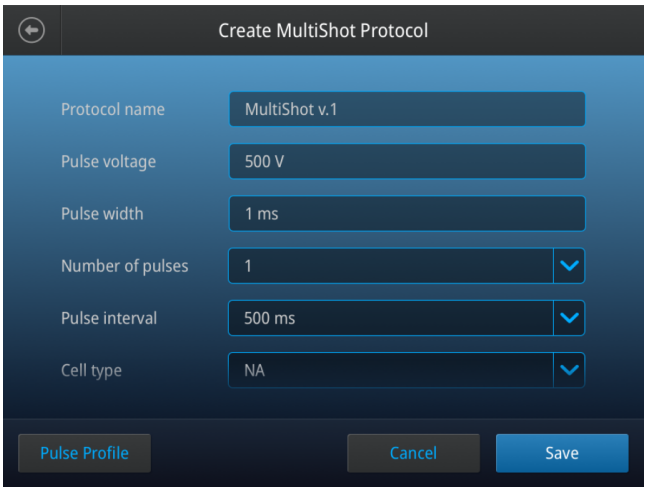
MultiShot protocols are used to process 1 × 10^8 to 2.5 × 10^9 cells in a 5–25 mL sample volume.

Create MultiShot Protocol

1. In the **Home** screen, select **Create protocol**.

2. Select **MultiShot** ▸ **Create new**.

3. Select a text field or open a dropdown menu to set the electroporation parameters for the protocol.



Note: Swipe the screen to scroll up or down.

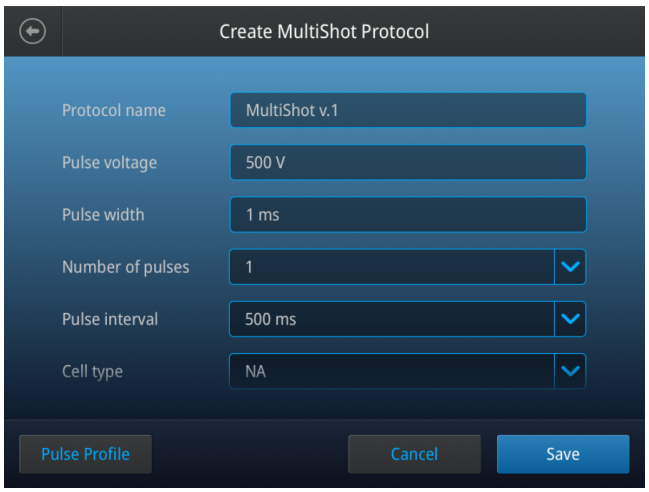
4. Select **Save** to save the protocol (see “Save a Protocol” on page 34), **Next** to run the protocol, or **Cancel**.

Edit MultiShot Protocol

1. In the **Home** screen, select **Create protocol**.

2. Select **MultiShot** ▸ **Open existing**.

3. Select a text field or open a dropdown menu to set the electroporation parameters for the protocol.



Note: Swipe the screen to scroll up or down.

4. Select **Save as** to save the edited protocol (see “Save a Protocol” on page 34).

Convert a SingleShot protocol to a MultiShot protocol

1. Load the SingleShot protocol to be converted from the protocol list.

2. Select **Action** ▸ **Save SingleShot to MultiShot**.

3. Select **Save** (see “Save a Protocol” on page 34).

Save a Protocol

1. Once edits to a protocol are complete, select **Save** to save the protocol.
2. In the **Save** screen, enter a name for the edited protocol.

Characters allowed	Characters not allowed
<100 characters	>100 characters
Letters, numbers, spaces, underscores, and dashes	% * ? | ; : , ! @ # $. ( ) < > / \ " ' ` ~ { } [ ] = + & ^ (tab)

3. Select **Save**.

Import protocols

Import protocols from SingleShot or MultiShot protocol selection pages by selecting **Actions ▸ Import**.

Protocols can be imported from the following locations:

- Thermo Fisher™ Connect Platform (see “Access your Connect account from an instrument” on page 27 for details).
- USB memory device
- Network drive

Manage protocols

Manage protocols from SingleShot or MultiShot protocol selection pages by selecting **Actions ▸ Manage Protocol**.

From the Manage Protocol page, the following features are available:

- Examine protocol details
- Delete protocols
- Export protocols
- Filter protocols by name, user, cell type, or date

General guidelines

- To obtain the highest transfection efficiency optimize transfection conditions by using the pre-programmed optimization protocols (see "Optimization protocol" on page 61).
- Because cell culture conditions vary from user to user, be sure to use low passage number, actively dividing cells (for dividing cells).
- If optimization is required for a new cell model or payload type, optimization can be performed using the Neon™ Transfection System. To ensure scalability between Neon™, Neon™ NxT, and Xenon™ systems, use the 100 µL Neon™ or Neon™ NxT Tip during optimization (see the *Neon™ Transfection System User Guide* Pub. No. MAN0001557 and *Neon™ NxT Electroporation System User Guide* Pub. No. MAN0026677).
- Culture conditions (media, supplements, culture vessel, seeding density, media depth, etc.) both pre and post electroporation can affect transfection efficiency, cell health, growth and expansion.
- Prepare an additional 20–30% extra volume of sample to account for volume loss during handling. For example, if a 1 mL electroporation volume is required, prepare 1.2 mL (ensure cell numbers are adjusted accordingly).

Guidelines for using CTS™ Xenon™ buffer kits

- CTS™ Xenon™ buffer kits are designed specifically for use with the CTS™ Xenon™ Electroporation System, the Neon™ NxT Electroporation System, and the Neon™ Transfection System. Performance with alternate buffers cannot be guaranteed and may be detrimental to cells even when using the same electroporation protocols, cell concentrations, and payload amounts.
- Store buffers at 2–8°C. Avoid temperature fluctuations because they can increase the risk of precipitation.
- Use buffers at room temperature (18–22°C) for electroporation. Remove the required amount of buffer to perform the experiment and allow it to reach room temperature in a sterile vessel. Immediately return the remaining buffer to storage at 2–8°C.
- Do not allow cells to be suspended in undiluted buffer for >30 minutes before electroporation.
- Optimize the amount of time cells remain suspended in buffer post-electroporation prior to adding media (0–15 minutes) because it can impact the health of the cells and transfection performance.
- Use the CTS™ Xenon™ Electroporation Buffer for non- gene editing based payloads such as RNA and DNA.
- Use the CTS™ Xenon™ Genome Editing Buffer with gene editing based payloads (Talen, Cas9, ZNFs). See page 47 for post-electroporation dilution guidelines.
- Use the CTS™ Xenon™ Lower Conductivity Electroporation Buffer for applications which require higher energy electroporation settings or if lower cell densities are preferred.

Guidelines for electroporation payloads

- The total payload volume should not exceed 20% of reaction volume (e.g., 200 µL for the 1 mL SingleShot format).
- When performing CRISPR/gRNA based gene editing, use a 1:1 molar ratio of gRNA to Cas9 protein as a starting point.

- The quality and concentration of DNA and RNA is important for achieving high transfection efficiency. Use high quality purification kits to prepare nucleic acids (see page 71).
  - Use the PureLink™ HiPure Plasmid DNA Purification Kit to purify plasmid DNA.
  - Use TrueTag™ Donor DNA Kits to prepare and purify high purity donor DNA.
- Resuspend the purified DNA in deionized water or TE buffer (10 mM Tris-HCl, 1 mM EDTA, pH 8.0) at a concentration between 1–5 µg/µL. Concentrations may vary depending on cell type.
- Check the purity of the purified DNA preparation by measurement of the $A_{260/280}$ ratio. The ratio should be at least 1.8 for electroporation.
- The instrument has been routinely tested with 4–7 kb plasmids and plasmids up to approximately 12 kb should not be a problem. Using plasmids larger than 12 kb can lower transfection efficiency.

IMPORTANT! Do not precipitate DNA with ethanol to concentrate DNA. Concentrated DNA by ethanol precipitation shows poor transfection efficiency and cell viability due to salt contamination.

Controls

High-quality controls play an integral role in the successful optimization of gene editing conditions in your cell type of choice. To assess transfection efficiency for your cell type, it is recommended to use a plasmid encoding GFP (green fluorescent protein) or any colored variant of GFP (Clontech™ or equivalent). For best results, the vector encoding the GFP should have the following features:

- Strong promoter active in a variety of mammalian cells such as the immediate early CMV (cytomegalovirus) promoter
- SV40 polyadenylation signals downstream of the GFP gene for proper processing of the 3’ end of the GFP mRNA.
- Antibiotic selection marker
- pUC origin of replication for propagation in *E. coli*

Required materials

See page 71 for ordering information.

- Primary immune cells, stem cells, or immortalized mammalian cells
- CTS™ Xenon™ buffers
- Payload for electroporation (High quality DNA at a concentration of 1–5 µg/µL in deionized water, Cas9 protein and gRNA, etc. (see “Guidelines for electroporation payloads” on page 35)
- Cell culture vessels containing the appropriate complete growth medium
- D-PBS or Phosphate buffered saline (PBS) without Ca^{2+} and Mg^{2+} (see “Accessory products” on page 71)
- Centrifuge (for manual cell preparation)
- Rotea™ Counterflow Centrifugation System (for automated cell preparation)
- Countess™ Automated Cell Counter or equivalent

- Bioprocessing bags (see “Accessory products” on page 71)
- Luer-lock syringe with sufficient capacity for the sample and an additional 10–20 mL of air (for filling the input bag)

Note: Review the protocol before you start using the system with your samples if you are a first time user of the CTS™ Xenon™ Electroporation System.

Prepare cells

Prepare cell suspensions for electroporation either manually, or using an automated system such as the CTS™ Rotea™ Counterflow Centrifugation System.

A protocol for preparation of activated T cells is provided as an example of preparation of cells for electroporation, but conditions will vary depending upon cell type and the downstream experimental procedure to be performed.

Due to variations in levels of activation, growth of the cells, and losses that can occur during sample preparation, it is recommended that cells are prepared in excess. A standard practice is to prepare 20–30% addiitonal cells to account for variation when working with primary T cells.

If performing automated preparation of cells, refer to the manual of the specific instrument (e.g., the *CTS™ Rotea™ Counterflow Centrifugation System User Guide* MAN0018908) for instructions on how to prepare the cells.

Activate T cells

See the instructions for the *CTS™ Dynabeads™ CD3/CD28 User Guide* for complete protocol details.

1. Cultivate the required number of cells (cell density ~1 × 10^6 cells/mL) by seeding a flask containing complete growth medium supplemented with fresh IL-2.
2. Add CTS™ Dynabeads™ CD3/CD28 Dynabeads™ magnetic beads at the following ratios:
   - 3:1 bead:cell ratio (if starting from PBMCs)
   - 1:1 bead:cell ratio (if starting from purified T cells)
3. Incubate the cells at 37°C in a humidified incubator with 5% CO_2.
   If using a static flask, place the flask horizontally to maximize gas exchange.

Prepare cells for electroporation

Prepare the activated T cells for electroporation three days after activation.

1. Add complete growth medium into the final culture vessel for every sample to be electroporated.
2. Pre-warm the culture vessel(s) at 37°C in a humidified incubator with 5% CO_2 for 30 minutes.
3. Allow electroporation buffer to equilibriate to room temperature.

   Note: Do not allow the electroporation buffer to undergo repeated temperature changes (from 4°C to room temperature). Instead, prepare a small aliquot quickly and aseptically, then allow the aliqot to warm to room temperature.
4. Calculate the required amount of Cas9 and gRNA to prepare the RNP complex.
   - Use 120 µg Cas9 and 30 µg gRNA (per 1 mL) for 5 × 10^7 cells
   - Use 80 µg Cas9 and 20 µg gRNA (per 1 mL) for 2 × 10^7 cells

   Note: The total payload volume should not exceed 20% of the total sample volume.

5. If cells are grown in static flasks, gently mix the cells with a serological pipette to dislodge the cells from the magnetic beads.

6. Transfer the cells and beads into an appropriate vessel for removal of magetic beads with either the CTS™ DynaMag™ Magnet or other magnetic separator.

7. Perform bead removal procedure according to the protocol specific for the type of magnet being used.

8. Centrifuge the tubes at 400 × *g* for 7 minutes.

9. Aspirate the supernatant in each tube and resuspend the cell pellets in 10 mL of PBS (without Ca^{2+} and Mg^{2+}). Gently pipette the cells to obtain a single cell suspension.

10. Centrifuge the tubes at 400 × *g* for 7 minutes.

11. Aspirate the supernatant in each tube and resuspend the cell pellets in half the estimated volume of CTS™ Xenon™ Electroporation Buffer , CTS™ Xenon™ Genome Editing Buffer or CTS™ Xenon™ Lower Conductivity Electroporation Buffer.

    For example, if an estimated volume of 5 mL is required, add 2.5 mL.

12. Perform a cell density count.

13. For genome editing samples, adjust the cell volume with additional buffer based on cell count, then subtract the volume required for the RNP complex and donor DNA.

14. Add the required volume of RNP complex. Mix gently and incubate the cells for 5 minutes at room temperature.

15. Add the required volume of donor DNA.

16. Proceed to “Perform electroporation” on page 40.

Perform electroporation

Run SingleShot protocol

SingleShot protocols are used to process 2 × 10^7 to 1 × 10^8 cells in a 1 mL sample volume.

To avoid contamination, prepare the SingleShot Chamber in a cell culture hood using sterile procedure.

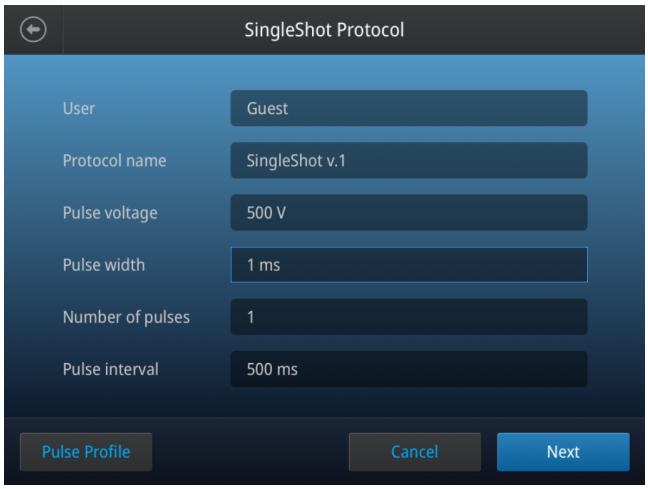
Note: SingleShot chambers are single-use consumables, and should be disposed of properly after performing electroporation.

Load a SingleShot Protocol

1. Select **Load Protocol**.

2. Select the **SingleShot** option for your electroporation procedure.
3. Select the **Template** or **User created** option and navigate to the protocol that you want to use.

4. Confirm that the protocol parameters are suitable for your procedure.



5. Select **Step by step** or **Quick start** to load the SingleShot chamber into the instrument (see “Prepare SingleShot chamber” on page 41).

Prepare SingleShot chamber

1. Fill the SingleShot chamber with ~1 mL of cell suspension using a P1000 micropipette.

   Place the tip of the pipette at the bottom of the chamber and fill from the bottom up to avoid bubble formation.

   It is important that the liquid forms a convex meniscus at the lip of the chamber to prevent bubbles from being trapped inside when the chamber is sealed. If additional volume is required, use a P20 micropipette or smaller to add additional liquid.

2. Attach the cap to the SingleShot chamber.

   Invert the electroporation chamber to ensure that there are no bubbles inside. The presence of bubbles can negatively impact performance by causing electrical arcing.

If bubbles are observed, remove the liquid from the chamber using a P1000 micropipette, then refilll the chamber (avoid introducing any bubbles while pipetting). Top off the chamber by 10 µL increments until a convex meniscus forms.

3. Using the hand holds, insert the SingleShot chamber into the electroporation chamber holder so that the upper and lower electrodes meet the electrical contacts.

Run SingleShot Protocol

1. Close the instument door.

2. Select **Run single shot**/**Electroporate** to start the electroporation process.

Run MultiShot protocol

MultiShot protocols are used to process 1 × 10^8 to 2.5 × 10^9 cells in a 5–25 mL sample volume.

To avoid contamination, bring all of the required consumables to a cell culture hood to prepare the MultiShot cartridge using sterile procedure.

Note: MultiShot chambers are single-use consumables, and should be disposed of properly after performing electroporation.

Load a MultiShot Protocol

1. Select **Load Protocol**.

2. Select the **MultiShot** option for your electroporation procedure.
3. Select the **Template** or **User created** option and navigate to the protocol that you want to use.
4. Select **Step by step** or **Quick start** to load the MultiShot cartridge into the instrument (see “Prepare MultiShot cartridge” on page 43).

Prepare MultiShot cartridge

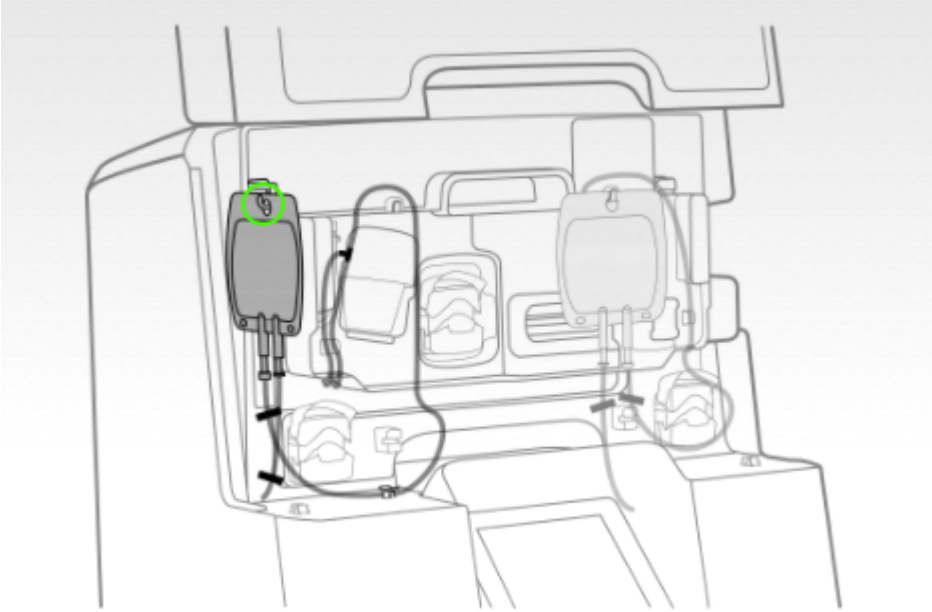
1. Fill the input bag with up to 30 mL of cell suspension.
2. Introduce 10–20 mL of air drawn from within a sterile cell culture hood into the bag through the input line.

   The air can be injected into the input bag using a syringe, and is used to reduce sample loss in the lines and reduce the possibility of foaming in the suspension.
3. Attach the input and output bags to their fluid lines.

   Make sure that the pinch clamps are attached to the tubes to prevent leakage.
4. Pull the cartridge handles outward and insert the MultiShot cartridge into the instrument. Release the handles to allow the cartridge to lock in place with the cartridge handle springboards.

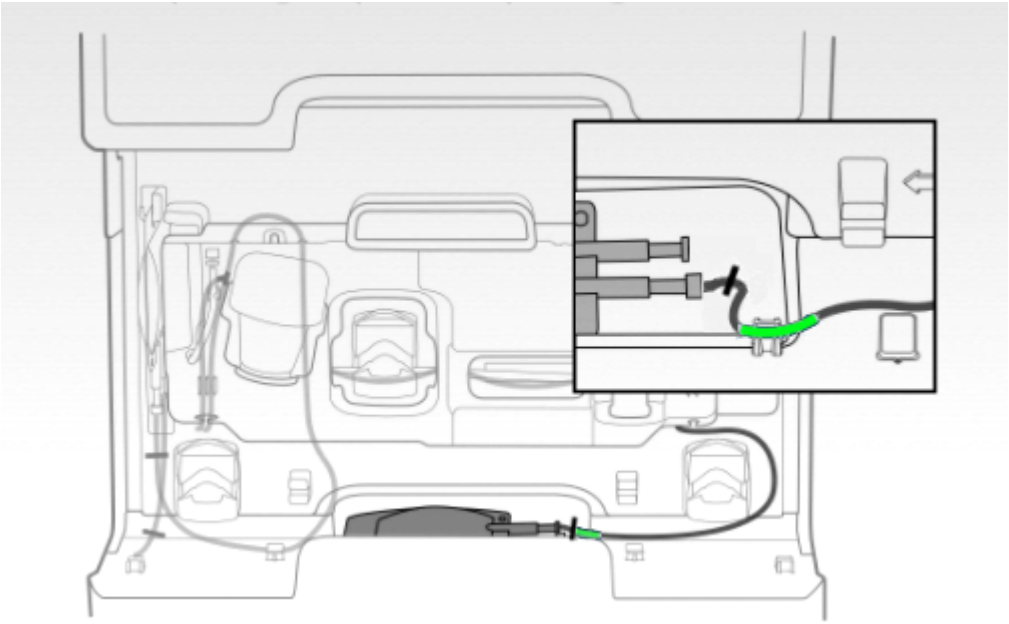
5. Push the electroporation chamber push latch forward to engage the electroporation chamber with the electrical contacts of the instrument.

6. Attach the input bag to the holder hook and make sure the tubes are secure.

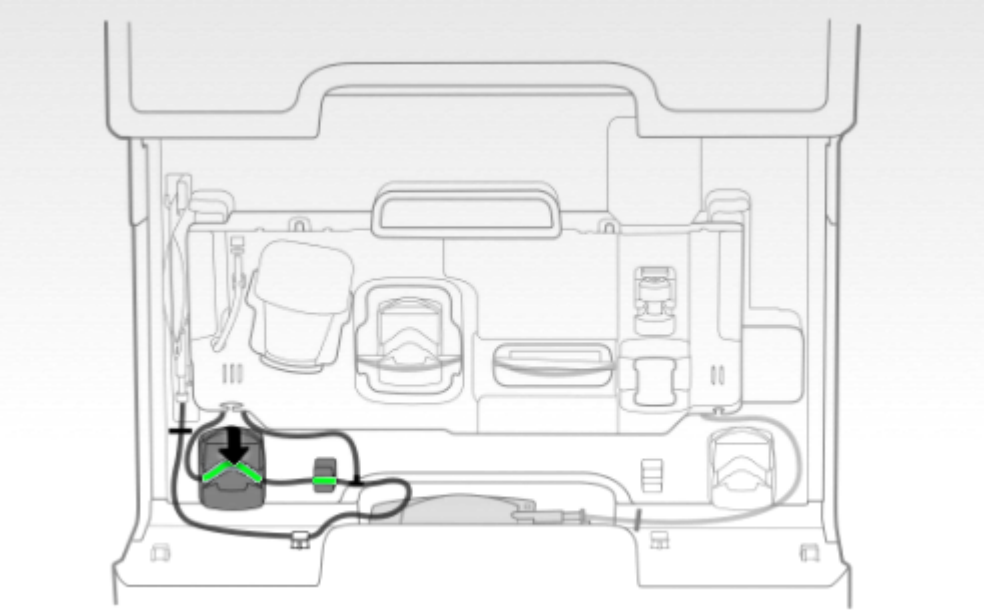


7. Place the output bag in the output bag tray and make sure the tube is secure.

Note: The tube leading to the output bag should be positioned so that it faces the opening of the instrument to minimize bubble formation.

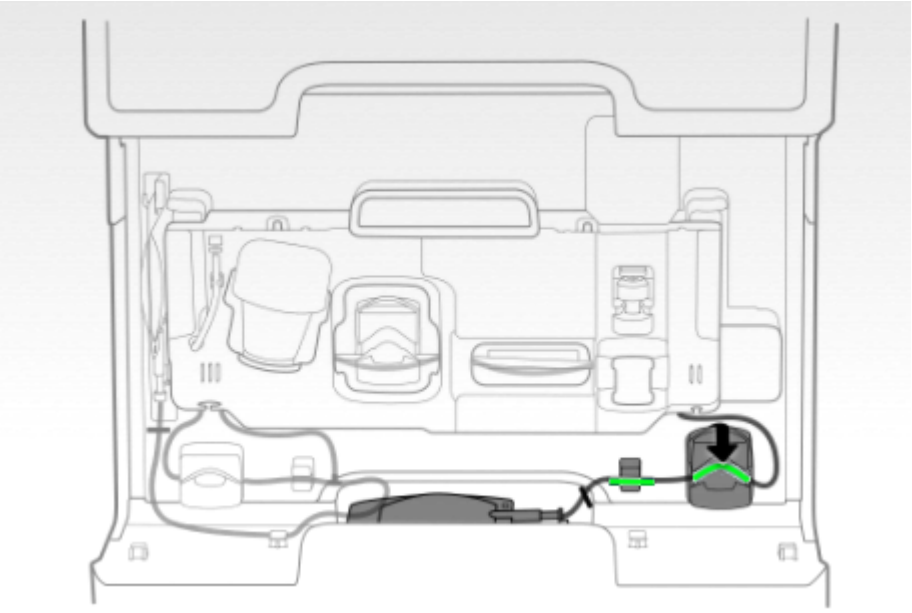


8. Route the tube that runs from the input bag to the mixing cup through the input pump and ultrasonic sensor, then close the pump.

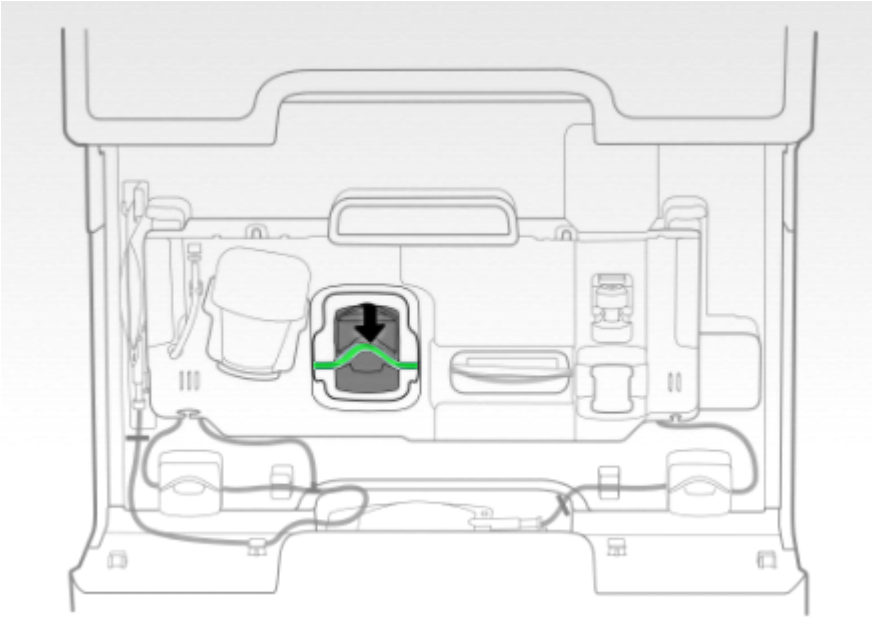


Note: Since the path of the tubing is not visible once the cartridge is locked in place, the tube that runs to the mixing cup is identifiable by the tag marked "input" attached to it.

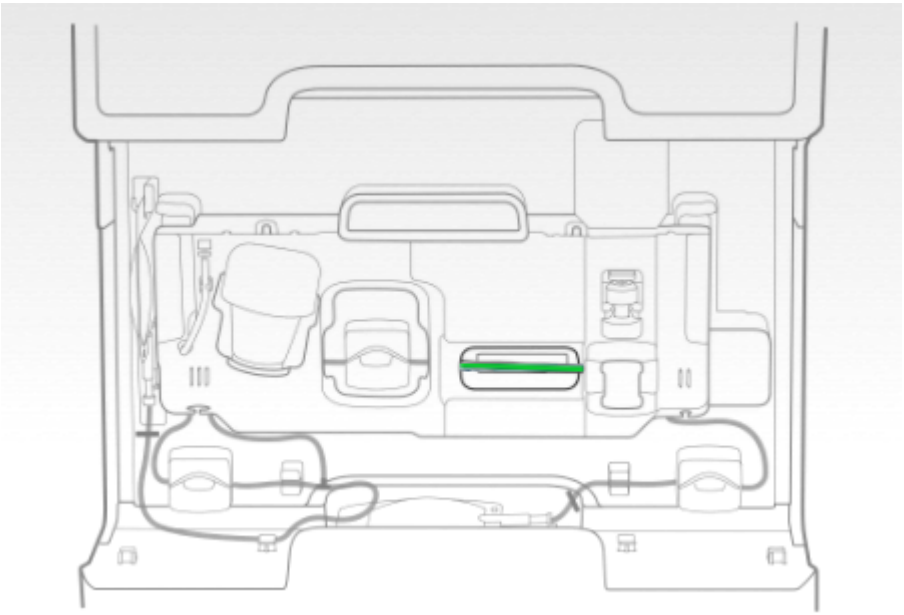
9. Route the tubing leading to the output bag into the output pump and sensor, then close the pump.



10. Route the tubing from the input bag into the mixer pump, then close the pump.



11. Route the tubing from the mixer pump across the entire length of the pre-cooling block.



12. Release the pinch clamps on the input and output bags.

Note: Ensure that the tubes are not crimped to allow unimpeded flow of liquid.

Run MultiShot Protocol

1. Enter the MultiShot volume, then select **Next**.
2. Select **Transfer** to move cells from the input bag to the mixer.
3. Close the instument door.
4. Select **Electroporate** to start the electroporation process.
5. After electroporation is complete, secure the pinch clamps on the output bag to prevent loss of the sample.

Post-electroporation procedure

- Transfer the entire sample to an appropriately sized culture vessel containing the appropriate volume of pre-warmed complete media to allow the cells to recover. See “Considerations for handling cells post-electroporation”.
- Analysis of gene modification can be performed 48–72 hours post-electroporation. Each system could have a unique optimal analysis timepoint dependent upon project goals.
- If the cells are to be maintained further, it may be necessary to perform media changes or add more complete media. Alternate culture maintenance procedures can also be utilized and optimized to produce desired results.

Considerations for handling cells post-electroporation

- Some cell and payload types/sizes will benefit from a recovery period post-electroporation. This period allows the cells to recover and seal the cellular membrane prior to adding media to the electroporation reaction. It has been shown that larger payloads benefit from a recovery period of up to 60 minutes. [1]
- Seeding density post-electroporation has been demonstrated to affect transfection performance. The optimal conditions will depend on cell type, culture vessel, and experimental goals such as phenotype and desired end point.
- The CTS™ Xenon™ Genome Editing Buffer functions best when diluted 20–50 fold with complete media and used to maintain cells for at least 24 hours post-electroporation.

  If dilution >50-fold is required, increase the volume with CTS™ Xenon™ Genome Editing Buffer before adding complete media to achieve a final 20–50 fold dilution.

  For example, if 1 mL of electroporation reaction is to be cultured in 100 mL of media, the CTS™ Xenon™ Genome Editing Buffer will be diluted 100-fold (1:100) which is >50-fold, and can negatively impact performance.

  If the final target reaction/buffer dilution is 40-fold (1:40), use the following equation to determine the initial amount of buffer for the first dilution.

[1] Lesueur, L. L., Mir, L. M. & André, F. M. (2016) Overcoming the specific toxicity of large plasmids electrotransfer in primary cells *in vitro*. *Molecular Therapy - Nucleic Acids* **5**.

$$\frac{x}{y} = \frac{1}{z}$$

x = total volume of electroporation reaction to be diluted into media (mL)

y = total volume of post-electroporation culture (mL)

z = target buffer dilution (20–50 fold)

$$\frac{x}{100} = \frac{1}{40}$$

x = total volume of electroporation reaction to be diluted into media (mL)

y = 100 mL

z = 40 (dilution factor)

Solving the equation produces the result of x = 2.5 mL total electroporation reaction.

To determine the required amount of additional buffer, subtract the initial volume of electroporation reaction from the calculated value x (2.5 mL – 1 mL = 1.5 mL), then add 97.5 mL of complete media to bring the total volume to 100 mL, in order to produce a 40-fold dilution.

Note: This dilution recommendation was developed for activated primary human T-cells. Other cell types may require further optimization.

Maintenance

Cleaning and maintenance

CAUTION! Cleaning and decontamination. Use only the cleaning and decontamination methods specified in the user documentation. It is the responsibility of the operator (or other responsible person) to ensure the following requirements are met:

- No decontamination or cleaning agents are used that can cause a HAZARD as a result of a reaction with parts of the equipment or with material contained in the equipment.
- The instrument is properly decontaminated a) if hazardous material is spilled onto or into the equipment, and/or b) prior to having the instrument serviced at your facility or sending the instrument for repair, maintenance, trade-in, disposal, or termination of a loan (decontamination forms may be required from customer service).
- Before using any cleaning or decontamination methods (except those recommended by the manufacturer), users should confirm with the manufacturer that the proposed method will not damage the equipment.

Clean the surface of the CTS™ Xenon™ Electroporation Instrument with a damp cloth. **Do not** use harsh detergents or organic solvents to clean the unit.

The instrument (chassis, electrodes and screen) shall be resistant to the following chemicals:

- Cleaning agents containing 70% ethanol, 70% isopropanol, 0.6% sodium hypochlorite.
- Cleaning solutions containing DMSO.

In case liquids (e.g., buffer, water, coffee) are accidentally spilled inside the instrument, wipe the spill using dry laboratory paper.

For any other repairs and service, contact Technical Support. **Do not** perform any repairs or service by yourself to avoid damage to the instrument or voiding the warranty.

Replace the fuses

Required materials

- Two UL listed fuses, rated 10 A, type T (time-lag), 5 × 20 mm, 250 VAC
- Small flat-tip screwdriver

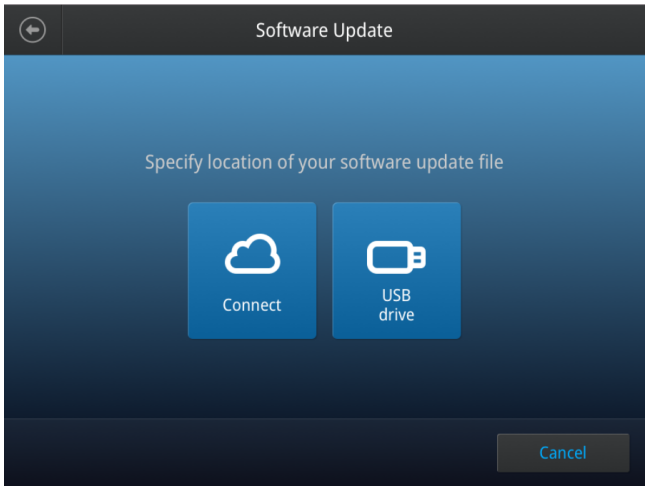
Replace fuses

DANGER! ELECTRICAL SHOCK HAZARD. Severe electrical shock, which could cause physical injury or death, can result from working on an instrument when the high voltage power supply is operating. To avoid electrical shock, disconnect the power supply to the instrument, unplug the power cord, and wait at least 1 minute before working on the instrument.

1. Power off the instrument by disconnecting the power.
2. Use a flat-tip screwdriver to remove the fuse compartment from the instrument.
3. Remove the fuse from the fuse compartment for inspection.
4. Replace blown fuse(s) with new IEC/UL listed fuses, rated 10A, 250VAC, size: 5 x 20 mm.
5. Replace the fuse compartment in the instrument.
6. Connect the instrument power cord.

Upgrade the system firmware

Update software directly through Connect or using an USB drive with updated software downloaded from **thermofisher.com/connect**.



Determine firmware version on instrument

When a new firmware version is released, you may be required to load the new firmware on the instrument.

You will need a USB memory device, and the login details if your instrument requires login, to upgrade the firmware.

1. Select **(Settings)** > **About Instrument**.
2. View current firmware version.

Upgrade the instrument firmware (Cloud)

IMPORTANT! You cannot upgrade the firmware while a run is in progress.

1. Select **(Settings)** ▸ **Maintenance & Services** ▸ **Software Update** ▸ **ThermoFisher Connect**.
2. Select **Yes** to start the upgrade.

   IMPORTANT! To prevent instrument malfunction and required service, do not power off the instrument during the upgrade.

   When the upgrade process is complete, the instrument will automatically restart.

Download new firmware

1. Go to **thermofisher.com** from your web browser.
2. Click **Product Support** ▸ **Technical Resources** ▸ **Product Support** ▸ **Software, Patches & Updates**.
3. Select CTS™ Xenon™ Electroporation Instrument in the list, then click **Updates & Patches**.
4. Find the appropriate file. If the version number is:
   - The same as the current version on the instrument, you do not need to upgrade the firmware.
   - Different from the current version on the instrument, download the new firmware.
5. Insert a USB memory device into the USB port on the computer.
6. Click the link in the Software column, then select the USB memory device as the location for the saved file.

   Note: The file must be downloaded to the root directory of the USB memory device and not into a folder.

7. Remove the USB memory device from the computer when the download is complete.

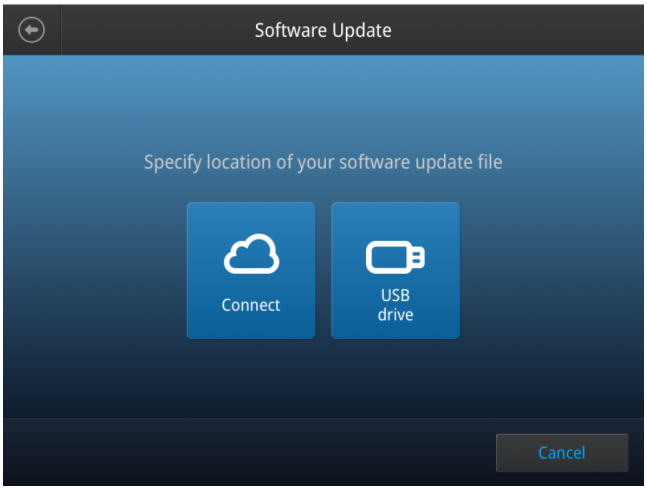
Upgrade the instrument firmware (USB drive)

IMPORTANT! You cannot upgrade the firmware while a run is in progress.

1. Insert the USB memory device (FAT32 format file system) with the new firmware in the USB port of your instrument.

   Note: For instruments with the USB shortcuts feature enabled, you will be directed to the **USB shortcuts** screen. Select **Update Software** to proceed to the **Software Update** screen.

2. Select **(Settings)** ▸ **Maintenance & Services** ▸ **Update Software** ▸ **USB drive**.
   The Software Update screen opens:



3. Select the row with the new firmware file from the USB memory device, then **Select**.

4. Select **Yes** to start the upgrade.

   IMPORTANT! To prevent instrument malfunction and required service, do not power off the instrument during the upgrade.

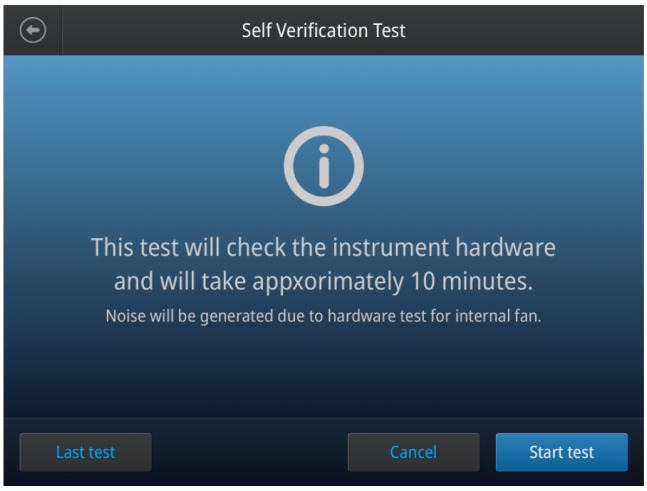
   When the upgrade process is complete, the instrument will automatically restart.

Self Verification test

Use the **Self Verification Test** feature to check the instrument hardware. The check includes testing the cooling block, pumps, and other components.

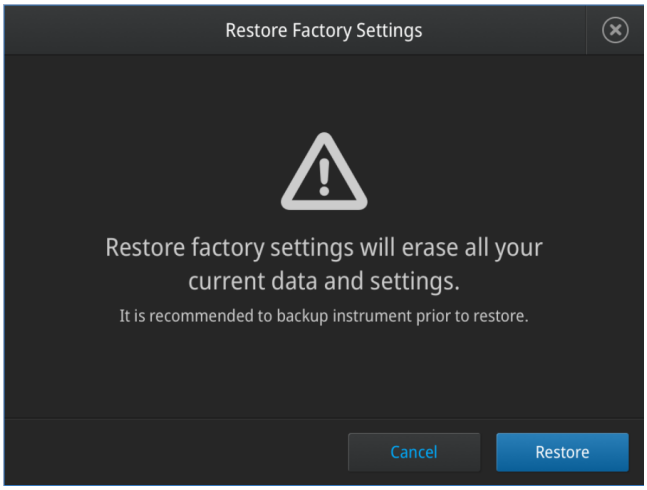
Select **Last Test** to view the results of the last **Self Verification Test**.

Carry out the **Self Verification Test** periodically or whenever there is an intermittent instrument error. Contact your service representative in case of block failure.



Restore factory settings screen (*Administrator profile only*)

Select **Restore factory settings** to remove all the data and customized settings and revert to factory settings. All data and settings will be erased once factory settings are restored. At the end of the restoration process, the message, "Your instrument has been restored." is displayed and the instrument automatically reboots after 30 seconds.



Repackaging the instrument

If you need to send the instrument to Thermo Fisher Scientific for warranty issues, or you wish to transport the instrument to another location, repackage the unit as follows.

Note: Prior to sending the instrument, ensure the instrument is properly decontaminated if the instrument is exposed to any viable biological agents, radioactive materials, or hazardous chemicals (toxic, carcinogenic, mutagenic, toxic for reproduction, sensitizing, and/or have not been fully tested). Contact Technical Support for a decontamination protocol and to obtain a Returns Goods Authorization (RGA) number and return shipping instructions.

Repackaging and storage instructions

1. Turn off the main power switch at the rear of the instrument and detach the power cord from the rear of instrument.
2. Place the instrument in the original box including the original packing foam.
3. Tape the box securely and place appropriate shipping labels for shipping the instrument to Thermo Fisher Scientific. Always transport the box with the unit in the **upright** position.
4. If the instrument is not to be used for extended periods of time, store the repackaged instrument in an upright position at 4°C to 40°C.

A

Troubleshooting

Troubleshooting

Problem	Cause	Solution
No power (the display remains blank when the power is turned on)	AC power cord is not connected	Check AC power cord connections at both ends. Use the correct cords.
Consumable error	Authenticator chip missing or detection failure	Check if the authenticator chip is in the consumable. Change to another consumable if chip is present. Contact field service if the error is persistent.
	Contact issue or chip damaged	Change to another consumable. Contact field service if the error is persistent.
	Consumable has been previously used	Consumables are single-use products. Change to a new consumable.
Electroporation fault	Incorrect buffer used	Check to make sure that the proper buffers have been used to resuspend the cells.
	Incorrect buffer selected	Check to make sure that the proper buffers have been used to resuspend the cells.
	Consumable fault	Remove consumable and perform a self-diagnostics test if error is persistent. Contact field service if the error is persistent.
	Faulty electrode pin	Remove consumable and perform a self-diagnostics test. Contact field service if an error is reported in the self-diagnostics test.

(continued)

Problem	Cause	Solution
Arcing (sparks)	Air bubbles in the electroporation chamber	Check to see if there are bubbles in the SingleShot Chamber. Perform a self-diagnostics test if the error is persistent. Contact field service if the error is persistent.
	Incorrect buffer used	Check to make sure that the proper buffers have been used to resuspend the cells.
Low cell survival rate	Poor DNA quality	Use high quality plasmid DNA for transfection (see page 35 for guidelines and recommendations on DNA quality).
	Cells are stressed or damaged	Avoid severe conditions during cell harvesting especially high speed centrifugation, vigorous pipetting, or vortexing. Avoid using over confluent cells or cells at high densities as this may affect the cell survival after electroporation. After electroporation, immediately plate the cells into prewarmed culture medium **without antibiotics**.
Low transfection efficiency	Poor optimization of electrical parameters	Perform optimization for your cell type.
	Poor plasmid DNA quality or the plasmid DNA concentration is too low	Use high quality plasmid DNA for transfection (see page 35 for guidelines and recommendations on DNA quality). The ideal cell density is 2×10^7–1×10^8 cells/mL.
	Incorrect cell density	Cell densities less than 1×10^7 cells/mL or greater than 3×10^8 cells/mL require performing optimization. The ideal cell density is 2×10^7– 1×10^8 cells/mL.

(continued)

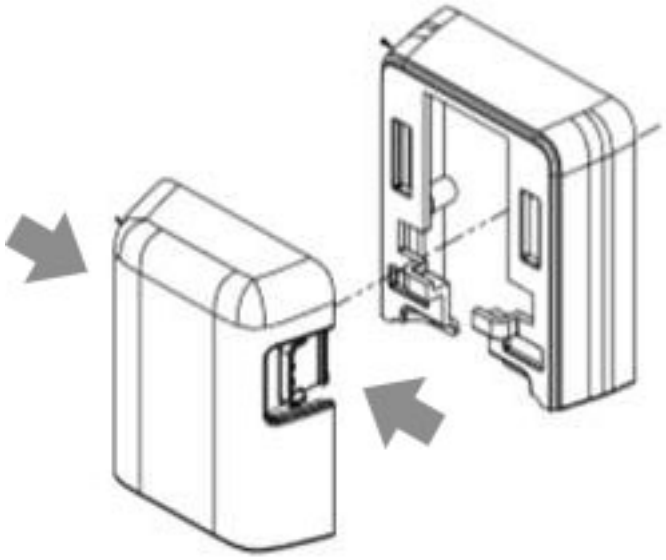
Problem	Cause	Solution
Low transfection efficiency	*Mycoplasma* contaminated cells	Test cells for *Mycoplasma* contamination. Start a new culture from a fresh stock.
Non-reproducible transfection efficiency	Inconsistent cell confluency or passage number	Always use cells with low passage number and harvest cells with comparable confluency levels.
	Difference between primary cell donor sources	Perform process controls to account for variability across primary cell donor sources.

Remove jammed electroporation chamber

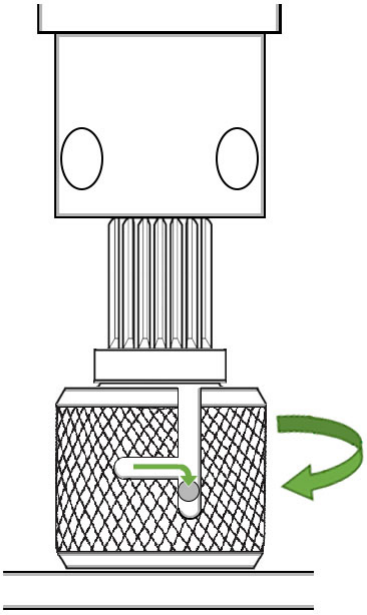
In the event that a SingleShot electroporation chamber becomes jammed in the chamber holder, the plastic cover over the holder needs to be manually disassembled to remove the SingleShot chamber.

Remove the plastic cover

1. Remove the top plastic capper cover lid by depressing the tabs at the sides.

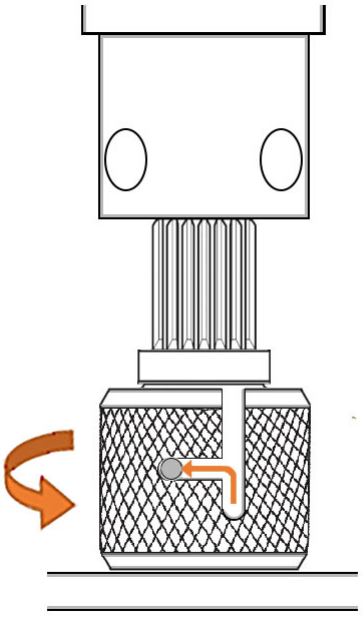


2. Twist the knurled knob clockwise until the pin rests in the vertical slot to release the top electrode holder.



3. Remove the electroporation chamber.

4. Twist the knurled knob counter-clockwise and ensure that the pin is fully engaged in the horizontal slot of the knob.



5. 2. Snap back the top plastic capper cover lid to the capper cover base.

Error codes

This section describes the error messages displayed by the instrument. Contact Technical Support if the instrument needs to be sent for servicing.

Error code	Meaning
0x8851	Subsystem firmware corrupted. Please update firmware.
0x8852	Subsystem firmware version mismatch. Please update firmware.
0x8860	Package is not suitable for this instrument.
0x8861	Instrument class is not supported by this upgrade package.
0x8862	Unable to verify upgrade package signature.
0x8863	Unable to extract upgrade files.
0x8864	Unable to locate upgrade package.
0x8867	Unable to recover from upgrade failure.
0x8870	Unable to save more data, instrument file system is full.
0x2001	Unable to detect presence of consumable.
0x2002	Consumable has not been commissioned.
0x2004	Wrong consumable type has been loaded.
0x2005	Consumable has been used.
0x1100	Unable to start fluid extraction. Liquid sensor active.
0x1101	Unable to detect fluid during extraction.
0x1102	Unable to move purger during fluid extraction.
0x1200	Unable to home cell mixer cup.
0x1301	Unable to fill chamber from mixer.
0x1302	Unable to fill chamber.
0x1303	Unable to move filler pump to target position.
0x1401	Unable to open stop cock.
0x1402	Unable to close stop cock.
0x1500	Tube is not present at extraction pump. (Extractor tube is not inserted in properly).

(continued)

Error code	Meaning
0x1601	Extractor pump lid is not closed.
0x1701	Filler pump lid is not closed.
0x0101	Unable to move capper to home position
0x0102	Unable to move capper to uncap position.
0x0200	Unable to start draining.
0x0201	Unable to drain sample out.
0x02FF	Unable to move drainer pump to target position.
0x0301	Unable to move valve to closed position.
0x0302	Unable to move valve to open position.
0x0401	Unable to move electrode pin to closed position.
0x0402	Unable to move electrode pin to open position.
0x0500	Tube is not present at drainer pump. (Drainer tube is not inserted in properly).
0x0600	Drainer pump lid is not closed.
0x8013	High voltage chamber current exceeded upper limits.
0x8016	Conductivity exceeded threshold before pulsing.
0x8019	Door opened while zone running.
0x8047	Electroporation fault.
0x8048	Electroporation fault.
0x8049	Electroporation fault.
0x8054	Consumable error.
0x8057	Consumable error.
0x805A	Consumable error.
0x805B	Consumable error.
0x805F	Consumable error.

B

Optimization

Optimization protocol

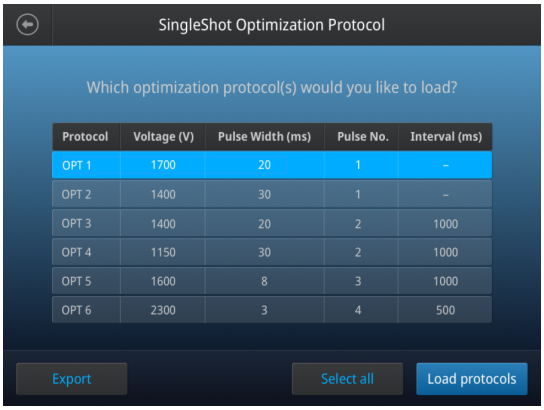
Electroporation is mainly dependent on the combination of three electric parameters such as the electric field, pulse width, pulse interval, and pulse number. Based on your initial results, you may need to optimize the electroporation parameters for your cell type and payload.

The process involves applying electrical energy to cells to achieve temporary pores that allow for the transfer of genetic material across the cell membrane. If properly optimized, the delivery efficiency of electroporation can ensure successful genetic manipulation of various cell types for many applications. In order to properly optimize electroporation parameters, it is important to understand how they influence the cell. The parameters (voltage, pulse width, pulse interval, and pulse number) are optimized to overcome the transmembrane potential of the cellular lipid bilayer.

- The voltage is the strength or intensity of the electrical energy and is the most critical factor influencing transfection efficiency and viability.
- Pulse width, or duration of how long the voltage is applied to the cell, correlates with the size of the pore created in the cell membrane.
- Pulse number, or multiple pulses can be used to create more pores on the membrane as well as drive charged payloads (DNA or RNA) into the cell cytosol.
- Pulse interval is the distance (or time) between pulses in a multi-pulse profile.

The CTS™ Xenon™ Electroporation Instrument is pre-programmed with six optimization protocols that have been found to provide a successful starting point for electroporation parameter optimization. Alternatively, the Neon™ Transfection System, our benchtop RUO electroporation platform can also be used for electroporation optimization. The Xenon™ electroporation consumables and instrument have been designed to directly scale from the Neon™ 100 µL tip.

Perform optimization using the CTS™ Xenon™ Electroporation Instrument by preparing cells for six SingleShot reactions. Use one chamber for each of the six protocols, and use the protocol that gives the best result for subsequent experiments, or for further optimization.

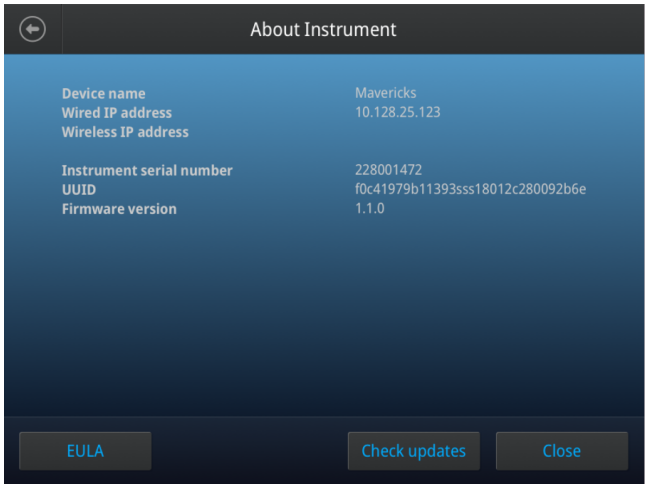


C Recommended instrument settings

About Instrument screen

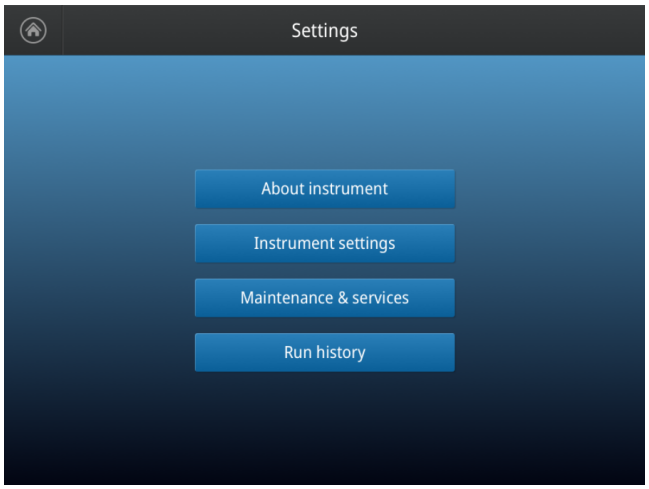
Select **Settings** ▸ **About Instrument** to find out more information about the instrument (e.g., firmware version and instrument statistics).

- Select **EULA** to view the End User License Agreement, or download it to a USB drive.
- Select **Check updates** to find out if updates are available for the instrument .



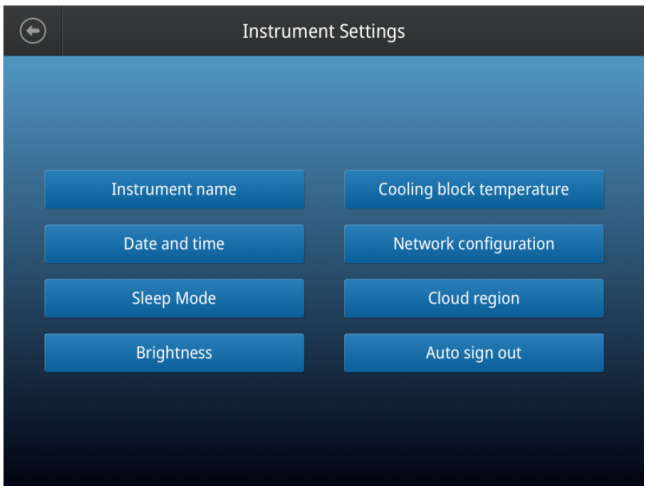
Recommended instrument settings

Select **(Settings)** and access the **Settings** screen to configure the instrument.



Instrument settings (Administrator only)

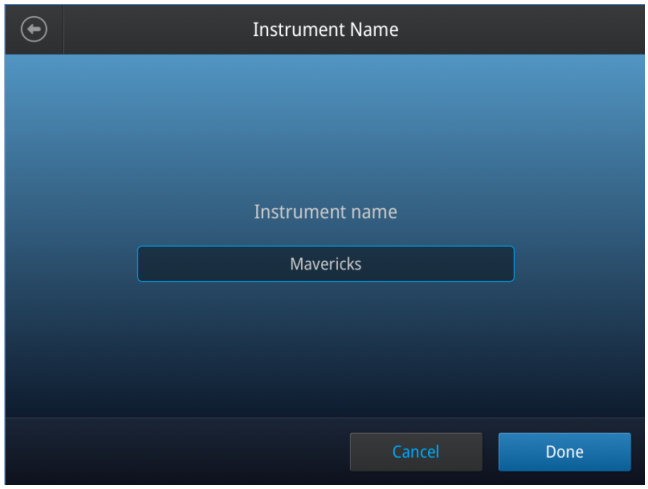
Select **Instrument Settings** to set the following instrument parameters.



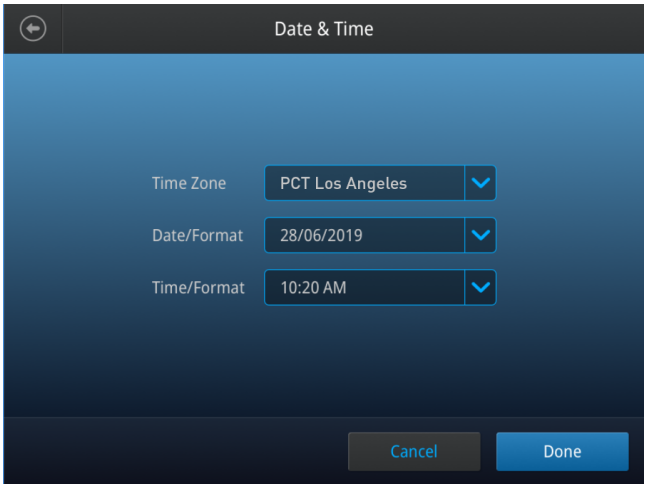
- **Instrument name**

  Select the **Instrument name** field to activate the text editor. Enter up to 25 alphanumeric characters to identify the instrument.

  Note: The instrument name cannot have spaces. Separate consecutive characters with a hyphen or underscore; for example, *My_Instrument*.

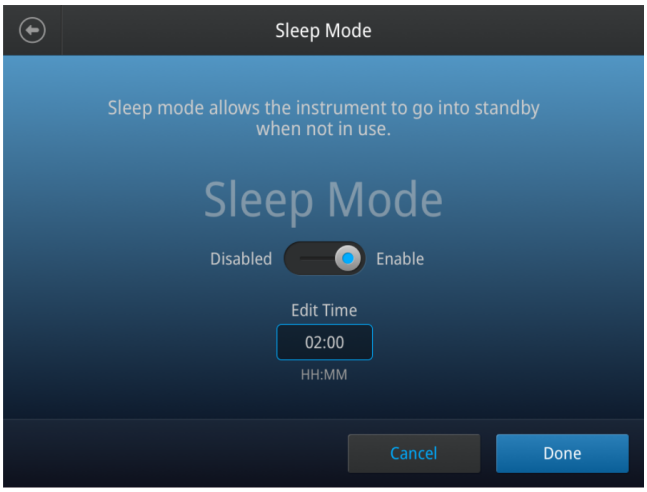


- **Date and time**
  - Select the **Time Zone** field to set the time zone.
  - Select the **Date/Format** field to choose the date format and set the date.
  - Select the **Time/Format** field to activate the numeric editor to set the time.

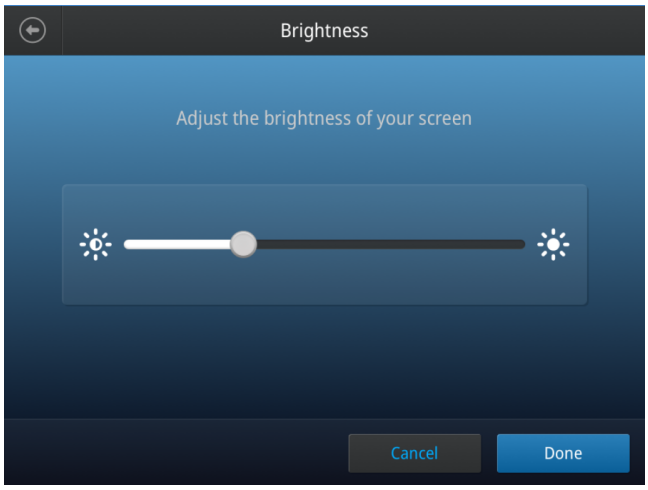


- **Sleep mode**

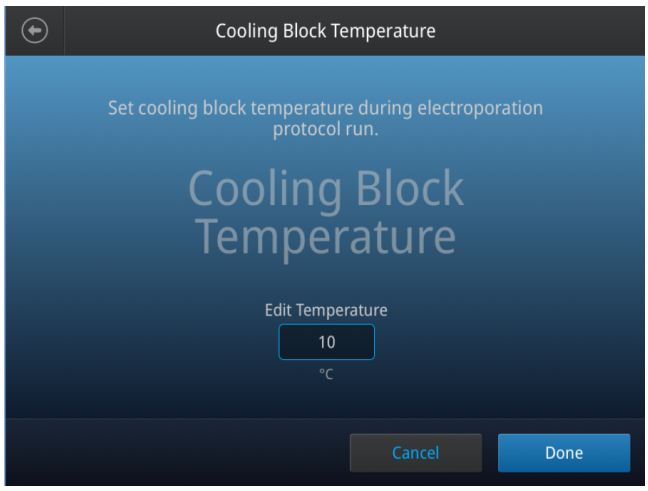
  Use the **Off** and **On** toggle to disable or enable sleep mode. In the 'On' mode, select the **Edit Time** field to activate the numeric editor to set the time after which the instrument will go from idle mode to standby mode.



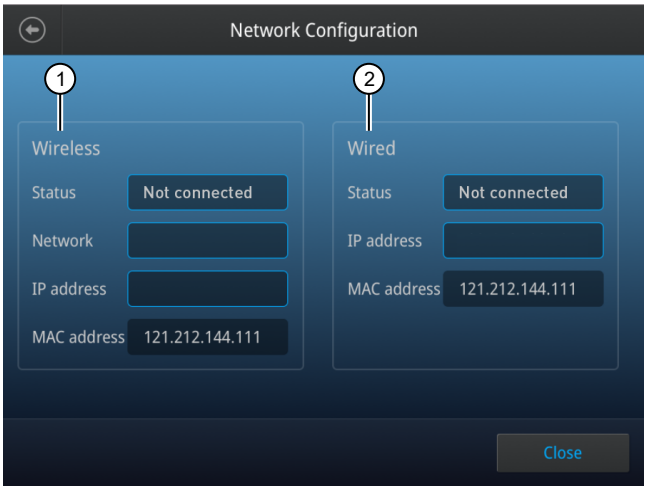
- **Brightness**
  Use the slider to adjust the brightness of the touch screen.



- **Cooling block temperature**
  Select the **Edit temperature** field to activate the number pad. Enter the desired value, then select **Done**.



- **Network configuration**
  Select the type of network connection that will be used to connect the instrument to the Internet. For details on using the Wireless and Ethernet options, see “Connect the instrument to the Internet” on page 17.

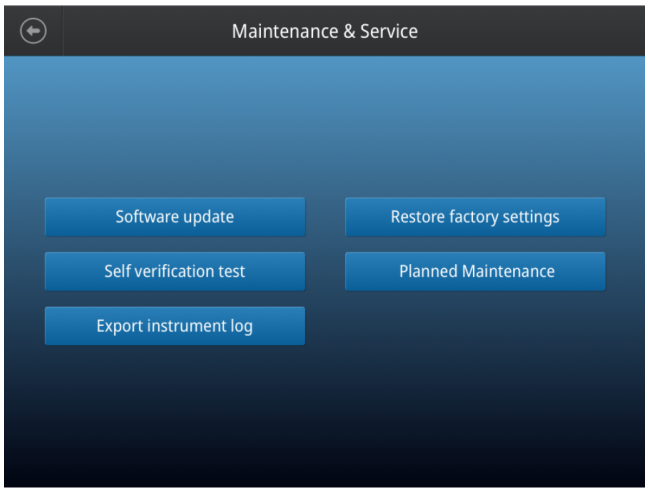


① Wireless panel
② Wired panel

- **Cloud region (*Administrator profile only*)**
  Select the appropriate field to set the cloud region for the instrument.
- **Auto sign out (*Administrator profile only*)**
  Use the toggle to enable/disable automatic sign out of a user when no activity is detected on the instrument for a selected period of time.

Maintenance & services

Select **Maintenance & Services** to set the following instrument parameters.

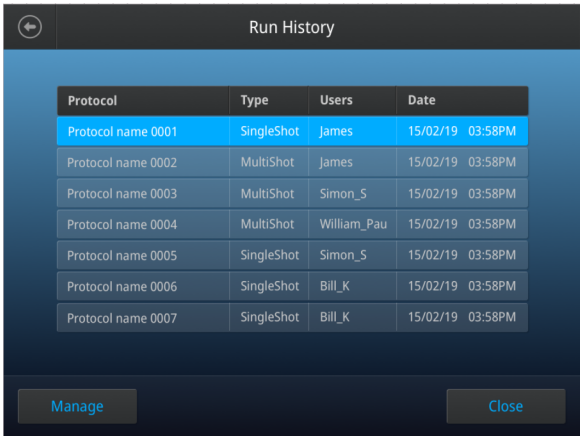


- (Administrator only) Select **Software Update** to update the System firmware. See “Upgrade the system firmware” on page 50 for instructions on updating the firmware.
- Select **Self Verification Test** to conduct a check on the instrument hardware. The check includes testing the pumps, motors, and other components. See “Maintenance” on page 49 for instructions on conducting the self-verification test.
- Select **Export Instrument Log** to export the instrument logs to a USB memory device. Insert the USB memory device into the USB port before using this feature.
- (Administrator only) Select **Restore factory settings** is used to reset the instrument to the original factory settings See “Restore factory settings screen (Administrator profile only)” on page 53.
- Select **Planned maintenance** to enable reminders for service 45 days before the anniversary of the previous service date.

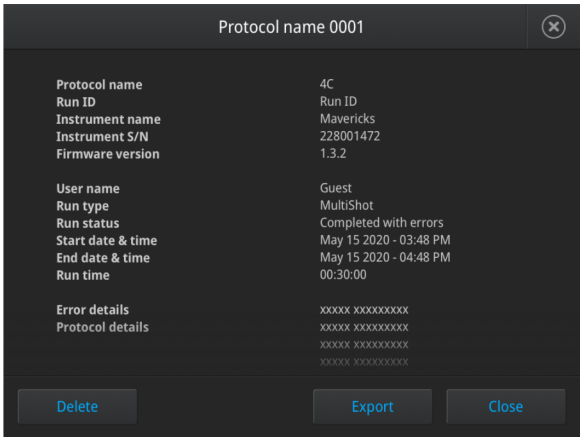
Run History

Select **Run History** to display the entire list of runs performed by the instrument.

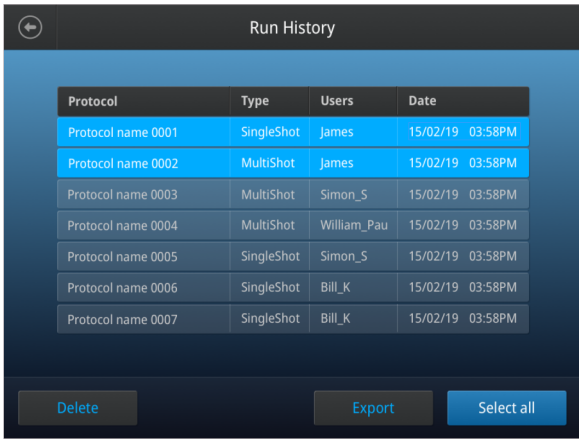
- Select a particular file to view the details of that run.



- Select **Export** to save the run details to a USB memory device, or **Delete** to delete the the run history file.



- Select **Manage** to perform the following functions:



- Delete a run report
- Select all run reports
- Export a run report

D

Specifications

Product specifications

Electrical rating	100–240 ±10% VAC, 1200 VA
Electroporation pulse voltage range	500–2500 V
Electroporation pulse width range	1–30 ms
Electroporation pulse interval range	500–1000 ms
Number of electroporation pulses	1–10 pulses
Cell mixer stirrer rotating speed	60 rpm
Pre-cooling technology	Peltier
Pre-cooling temperature setting range	10–30°C
Electroporation chamber volume	1 mL
Operating Temperature	15℃ to 30℃
Maximum Relative Humidity	Up to 80%
Degree of Protection	IPX0
Protective Earthing	Class I (earthed)
Installation category	II
Instrument type	Benchtop unit
Instrument dimensions (door fully open)	674 mm (w) × 539 mm (l) × 1095 mm (h)
Instrument weight	70 kg (154 pounds)
Built-in features	8 inch touch screen digital display (capacitive)
Transportation conditions	–40°C to +70°C, packed in transport packaging
Storage conditions	–25°C to +50°C, packed in transport packaging

E Related products

Accessory products

Additional products

The following products are for use with the Xenon™ Electroporation System and are available separately.

For more information, go to **thermofisher.com** or contact Technical Support.

Product	Quantity	Catalog no.
CTS™ Dynabeads™ CD3/CD28	10 mL	40203D
CTS™ DynaMag™ Magnet	1 magnet	12102
CTS™ Xenon™ Genome Editing Buffer	100 mL bottle 100 mL bag	A4998001 A4998002
CTS™ Xenon™ Electroporation Buffer	100 mL bottle 100 mL bag	A4997901 A4997902
CTS™ Xenon™ Lower Conductivity Electroporation Buffer	100 mL bottle 100 mL bag	A5788001 A5788002
CTS™ Xenon™ SingleShot Electroporation Chamber	pack of 6	A50305
CTS™ Xenon™ MultiShot Electroporation Cartridge	1 unit	A50306
Labtainer™ BioProcess Container (BPC)Labtainer™	pack of 10	SH30658.13
VueLife® FEP Bag	pack of 10	Saint-Gobain 32-C
DPBS, no calcium, no magnesium	500 mL	14190144
CTS™ OpTmizer™ T-Cell Expansion SFM (including supplement)	1000 mL	A1048501
Human IL-2 Recombinant Protein	100 µg	PHC0021
CTS™ Immune Cell SR	50 mL	A2596101
CTS™ Rotea™ Counterflow Centrifugation System	1 unit	A44769
Countess™ Automated Cell Counter	1 unit	C10227
PureLink™ HiPure Plasmid Maxiprep Kit	25 preps	K210007
PureLink™ HiPure Plasmid Filter Maxiprep Kit	25 preps	K210017

(continued)

Product	Quantity	Catalog no.
TrueGuide™ gRNA	—	**thermofisher.com/trueguide**
TrueCut™ Cas9 Protein v2	10 µg	A36496
TrueCut™ Cas9 Protein	2.5 µg	A45220P
TrueTag™ Donor DNA Kit, GFP	10 reactions	A42992
TrueTag™ Donor DNA Kit, RFP	10 reactions	A42993

F

Safety

Safety information

Follow the instructions in this section to ensure safe operation of the CTS™ Xenon™ Electroporation Instrument. The CTS™ Xenon™ Electroporation System is designed to meet EN61010-1 Safety Standards. To ensure safe, reliable operation, always operate the CTS™ Xenon™ Electroporation Instrument according to the instructions in this manual. Failure to comply with the instructions in this manual may create a potential safety hazard, and will void the manufacturer's warranty and void the EN61010-1 safety standard certification. Thermo Fisher Scientific is not responsible for any injury or damage caused by use of this instrument when operated for purposes which it is not intended. All repairs and service should be performed by Thermo Fisher Scientific.

- When setting up the instrument, ensure that it is resting on the flat rubber foot of each castor, and not the wheel.
- Always ensure that the power supply input voltage matches the voltage available in your location.
- For operating environment, see "Product specifications" on page 70.
- This instrument is air-cooled so its surfaces become hot during operation. When installing the instrument, leave a space of at least 10 cm (4 inches) to the rear for proper operation of the inlet and exhaust fans..
- Never insert metallic objects into the air vents of the instrument as this could result in electrical shock, personal injury and equipment damage.
- Always set the main switch on the power supply unit to OFF before connecting the power cord to the wall outlet.
- Always ensure that the grounding terminal of the instrument and that of the wall outlet are properly connected. Connect the power cord to a grounded, 3-conductor power outlet.
- To avoid potential shock hazard, make sure that the power cord is properly grounded.
- Be sure to position the instrument such that it is easy to disconnect the unit.
- Be sure to set the main switch to OFF and unplug the power cord before moving the instrument.

Safety compliance

The instrument design and manufacture complies with the following standards and requirements for safety, electromagnetic compatibility, and Environmental WEEE.

Reference	Description
EU Directive 2014/35/EU	European Union “Low Voltage Directive”
IEC 61010-1 EN 61010-1 UL 61010-1 CAN/CSA C22.2 No. 61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements
IEC 61010-2-081 EN 61010-2-081	Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-081: Particular requirements for automatic and semi-automatic laboratory equipment for analysis and other purposes

Informational symbols

Symbol and description	
 **CAUTION!** Risk of danger. Consult the manual for further safety information.	
 **CAUTION!** Risk of electrical shock.	
	WEEE (Waste Electrical and Electronic Equipment) symbol indicates that this product should not be disposed of in unsorted municipal waste. Follow local municipal waste ordinances for proper disposal provisions to reduce the environmental impact of WEEE. This instrument meets European requirement WEEE Directive 2012/19/EU.
	**ON** (power)
	OFF (power)
	Protective earth (ground)
	The CE mark symbolizes that the product conforms to all applicable European Community provisions for which this marking is required. Operation of the CTS™ Xenon™ Electroporation Instrument is subject to the conditions described in this manual. The protection provided by the device may be impaired if the instrument is used in a manner not specified by the manufacturer.

(continued)

Symbol and description	
c UL us	This product conforms to UL 61010-1, CAN/CSA C22.2 No.61010-1 "Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part I: General Requirements." Instruments bearing the UL symbol are certified by Underwriters Laboratories to be in conformance with the applicable safety standard for the US and Canada.
UK CA	The UKCA mark symbolizes that the product conforms to all applicable provisions in Great Briitain (England, Wales, and Scotland) for which this marking is required. Operation of the CTS™ Xenon™ Electroporation Instrument is subject to the conditions described in this manual. The protection provided by the device may be impaired if the instrument is used in a manner not specified by the manufacturer.
	Regulatory Compliance Mark indicates conformity with Australian standards for electromagnetic compatibility.
25	China RoHS EFUP 25

Symboles d'information

Symbol and description	
	MISE EN GARDE ! Risque de danger. Consulter le manuel pour d'autres renseignements de sécurité.
	MISE EN GARDE ! Risque de choc électrique.
	Le symbole **DEEE** (Déchets d'équipements électriques et électroniques) indique que ce produit ne doit pas être mis au rebut avec des déchets ménagers non triés. Suivez la réglementation locale relative à l'élimination des déchets usuels pour réduire l'impact environnemental des DEEE. Rendez-vous sur **www.invitrogen.com/weee** pour prendre connaissance des options de collecte et de recyclage..
	ON (MARCHE) (alimentation)
	OFF (ARRÊT) (alimentation)
	Protection par la mise à la terre (masse)
CE	La marque CE est un symbole indiquant que le produit est conforme à toutes les dispositions applicables de la Communauté européenne pour lesquelles ce marquage est obligatoire. L'utilisation du CTS™ Xenon™ Electroporation Instrument est soumise aux conditions décrites dans ce manuel. Si vous utilisez l'instrument d'une manière non spécifiée par le fabricant, la protection offerte par l'appareil pourrait s'en trouver détériorée.

(continued)

Symbol and description	
c UL us	Ce produit est conforme à UL 61010-1, CAN/CSA C22.2 No.61010-1 «Exigences de sécurité pour l'équipement électrique pour la mesure, le contrôle et l'utilisation en laboratoire, Partie I : Généralité Les exigences.» Les instruments portant le symbole UL sont certifiés par Underwriters Laboratories conforme à la norme de sécurité applicable aux États-Unis et au Canada.
UK CA	La marque UKCA est un symbole indiquant que le produit est conforme à toutes les dispositions applicables en Grande-Bretagne (Angleterre, Pays de Galles et Écosse) pour lesquelles ce marquage est obligatoire. L'utilisation du CTS™ Xenon™ Electroporation Instrument est soumise aux conditions décrites dans ce manuel. Si vous utilisez l'instrument d'une manière non spécifiée par le fabricant, la protection offerte par l'appareil pourrait s'en trouver détériorée.
	La marque de conformité réglementaire indique qu'elle est conforme aux normes australiennes compatibilité électromagnétique
25	Chine RoHS EFUP 25

Environmental requirements

WARNING! The emissions characteristics of this equipment make it suitable for use in industrial areas and hospitals (CISPR 22 class A). If it is used in a residential environment (for which CISPR 11 class B is normally required) this equipment may not offer adequate protection to radio-frequency communication services. It may be necessary for the user to take mitigation measures, such as relocating or re-orienting the equipment.

Condition	Acceptable range
Installation site	Indoor use only
Electromagnetic interference	Do not use this instrument in close proximity to sources of strong electromagnetic radiation (for example, unshielded intentional RF sources). Strong electromagnetic radiation may interfere with the proper operation of the instrument.
Pollution degree	The instrument has a Pollution Degree rating of II. The instrument may only be installed in an environment that has non-conductive pollutants such as dust particles or wood chips. Typical environments with a Pollution Degree II rating are laboratories and sales and commercial areas.

Electromagnetic compatibility (EMC) standards

Class A notice

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules; and CISPR 11 Class A. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area or domestic environment is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense. Do not use this device in close proximity to sources of strong electromagnetic radiation (e.g. unshielded intentional RF sources), as these can interfere with the proper operation.

EMC compliance

Reference	Description
IEC 60601-1-2	Medical electrical equipment - Part 1-2: General requirements for basic safety and essential performance - Collateral Standard: Electromagnetic disturbances
IEC 61000-3-2	Harmonic current Emissions
IEC 61000-3-3	Voltage changes, voltage fluctuations and flocker emissions
IEC 61000-4-2	Electrostatic Discharge Immunity
IEC 61000-4-3	Radiated RF Electromagnetic Field Immunity Immunity to proximity fields from RF wireless communications equipment
IEC 61000-4-4	Electrical Fast Transient/Burst Immunity
IEC 61000-4-5	Surge Immunity
IEC 61000-4-6	Immunity to conducted disturbances induced by RF fiedls
IEC 61000-4-8	Power-frequency Magnetic Field Immunity
IEC 61000-4-11	Voltage Dips, short Interruptions and Voltage Variation Immunity

(continued)

Reference	Description
IEC 61326-1 Class A EN 61326-1 Class A **The equipment is intended for use in a basic electromagnetic environment.** Conducted emission: CISPR 11 Class A Radiated emission: CISPR 11 Class A	Electrical Equipment for Measurement, Control and Laboratory Use – EMC Requirements – Part 1: General Requirements
FCC Part 15 Subpart B (47 CFR)	U.S. Standard Radio Frequency Devices

Electrical safety

The following information on electrical safety must be observed, failing to follow these instruction may result in electric shock, fire and/or serious personal injury or death.

In the event of an equipment malfunction, it is the responsibility of the customer to report the need for service to Thermo Fisher Scientific or to one of the authorized agents. For service information, contact Technical Support (page 81).

Servicing of this device is to be performed by trained service personnel only.

- Plug the system into a properly grounded receptacle with adequate current capacity.
- Prior to switching on the product, ensure that the nominal voltage setting on the product matches the nominal voltage of the AC supply network.
- This product should be connected to the power mains using a 3-wire (two conductors and ground) power cable and plug. Use this power cable with a properly grounded electrical outlet to avoid electrical shock.
- Never operate the instrument with the ground disconnected. Grounding continuity is required for safe operation of the instrument.
- If extension cords or connector strips are implemented, they must be checked on a regular basis to ensure that they are safe to use.
- Never use the product if the power cable is damaged. Check the power cable on a regular basis to ensure that it is in proper operating condition. By taking appropriate safety measures and carefully laying the power cable, you can ensure that the cable will not be damaged and that no one can be hurt by, for example, tripping over the cable or suffering an electric shock.
- Do not insert the plug into sockets that are dusty or dirty. Insert the plug firmly and all the way into the socket. Otherwise, sparks that result in fire and/or injuries may occur.
- Do not overload any sockets, extension cords or connector strips; doing so can cause fire or electric shocks.
- To fully disconnect power either detach or unplug the power cord, positioning the instrument such that the power cord is accessible.
- Ensure that the connections with information technology equipment, e.g., PCs or other industrial computers, comply with the IEC60950-1/EN60950-1 or IEC61010-1/EN 61010-1 standards that apply in each case.

- Use suitable overvoltage protection to ensure that no overvoltage (such as that caused by a bolt of lightning) can reach the product. Otherwise, the person operating the product will be exposed to the danger of an electric shock.
- The overvoltage protection should limit the magnitude of the overvoltage surge to 1 kV between the any of the power line and ground.
- Unless expressly permitted, never remove the cover or any part of the housing while the product is in operation. Doing so will expose circuits and components and can lead to injuries, fire or damage to the product.
- Any object that is not designed to be placed in the openings of the housing must not be used for this purpose. Doing so can cause short circuits inside the product and/or electric shocks, fire or injuries.

Chemical safety

WARNING! GENERAL CHEMICAL HANDLING. To minimize hazards, ensure laboratory personnel read and practice the general safety guidelines for chemical usage, storage, and waste provided below. Consult the relevant SDS for specific precautions and instructions:

- Read and understand the Safety Data Sheets (SDSs) provided by the chemical manufacturer before you store, handle, or work with any chemicals or hazardous materials. To obtain SDSs, see the "Documentation and Support" section in this document.
- Minimize contact with chemicals. Wear appropriate personal protective equipment when handling chemicals (for example, safety glasses, gloves, or protective clothing).
- Minimize the inhalation of chemicals. Do not leave chemical containers open. Use only with sufficient ventilation (for example, fume hood).
- Check regularly for chemical leaks or spills. If a leak or spill occurs, follow the manufacturer cleanup procedures as recommended in the SDS.
- Handle chemical wastes in a fume hood.
- Ensure use of primary and secondary waste containers. (A primary waste container holds the immediate waste. A secondary container contains spills or leaks from the primary container. Both containers must be compatible with the waste material and meet federal, state, and local requirements for container storage.)
- After emptying a waste container, seal it with the cap provided.
- Characterize (by analysis if needed) the waste generated by the particular applications, reagents, and substrates used in your laboratory.
- Ensure that the waste is stored, transferred, transported, and disposed of according to all local, state/provincial, and/or national regulations.
- **IMPORTANT!** Radioactive or biohazardous materials may require special handling, and disposal limitations may apply.

WARNING! HAZARDOUS WASTE (from instruments). Waste produced by the instrument is potentially hazardous. Follow the guidelines noted in the preceding General Chemical Handling warning.

Biological hazard safety

WARNING! Potential Biohazard. Depending on the samples used on this instrument, the surface may be considered a biohazard. Use appropriate decontamination methods when working with biohazards.

WARNING! BIOHAZARD. Biological samples such as tissues, body fluids, infectious agents, and blood of humans and other animals have the potential to transmit infectious diseases. Conduct all work in properly equipped facilities with the appropriate safety equipment (for example, physical containment devices). Safety equipment can also include items for personal protection, such as gloves, coats, gowns, shoe covers, boots, respirators, face shields, safety glasses, or goggles. Individuals should be trained according to applicable regulatory and company/ institution requirements before working with potentially biohazardous materials. Follow all applicable local, state/provincial, and/or national regulations. The following references provide general guidelines when handling biological samples in laboratory environment.

- U.S. Department of Health and Human Services, *Biosafety in Microbiological and Biomedical Laboratories (BMBL)*, 6th Edition, HHS Publication No. (CDC) 300859, Revised June 2020
  www.cdc.gov/labs/pdf/CDC-BiosafetymicrobiologicalBiomedicalLaboratories-2020-P.pdf
- Laboratory biosafety manual, fourth edition. Geneva: World Health Organization; 2020 (Laboratory biosafety manual, fourth edition and associated monographs)
  www.who.int/publications/i/item/9789240011311

Documentation and support

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  - Certificates of Analysis
  - Safety Data Sheets (SDSs; also known as MSDSs)

  Note: For SDSs for reagents and chemicals from other manufacturers, contact the manufacturer.

Limited product warranty

Life Technologies Corporation and/or its affiliate(s) warrant their products as set forth in the Life Technologies' General Terms and Conditions of Sale at **www.thermofisher.com/us/en/home/global/terms-and-conditions.html**. If you have any questions, please contact Life Technologies at **www.thermofisher.com/support**.