



# Agilent Seahorse XF T Cell Metabolic Profiling Kit

## User Guide

### Kit 103772-100

For use with Agilent Seahorse XF Pro or XFe96 Extracellular Flux analyzers and T cells.

Not recommended to use with Agilent Seahorse XFe24 Extracellular Flux analyzers.

# Notices

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# Introduction

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## Assay Background

The Agilent Seahorse XF T Cell Metabolic Profiling kit is designed to enable the acquisition of robust bioenergetic measurements of both glycolytic and mitochondrial activity in T cell populations. These measurements can be associated with increased antitumor function of T cell therapy products. They are especially valuable in therapy development targeting to improve T cell persistence, or avoid exhaustion postactivation in a tumor microenvironment.<sup>1,2</sup> The new kit allows you to obtain more accurate measurements of the maximal respiratory capacity of T cells, by using the uncoupler BAM15. BAM15 is less cytotoxic than other protonophore uncouplers, such as FCCP, and is especially suitable for sensitive cell types (such as naïve T cells). BAM15 also surpasses FCCP in its exhibition of a wider range of concentrations that induce maximum respiration, minimizing the needs of uncoupler optimization.<sup>3</sup>

The kit supports two assay workflows.

### XF T Cell Persistence assay

The Agilent Seahorse XF T Cell Persistence assay is developed to assess the ability of T cell products (such as CAR-T) to develop durable immune response after infusion, and to generate memory-like T cells. Several publications indicate that T cells with a highly oxidative basal metabolic phenotype (mitoATP/glycoATP production rate) and high spare respiratory capacity (SRC) exhibit increased persistence after adoptive transfer.<sup>3</sup> This assay can be used to evaluate different construct designs, engineering strategies, selection of starting material, or metabolic conditioning during the manufacture expansion process, to drive a metabolic phenotype that correlates with persistent T cells. The typical assay profile and data output is shown in **Figure 1**.

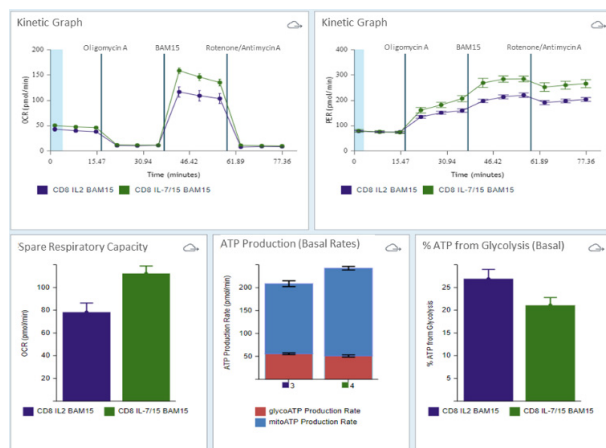


Figure 1. Typical Agilent Seahorse XF T Cell Persistence assay profile and data output.

## XF T Cell Fitness assay

The Agilent Seahorse XF T Cell Fitness assay is developed to evaluate if T cells can meet the metabolic demand under altered or restrictive nutrient conditions. In this way, it assesses the capacity of T cells to maintain metabolic fitness in a tumor microenvironment. The nutrient-restrictive conditions can be created by using substrate pathway inhibitors (such as etomoxir, UK5099, BPTES), replacing glucose by other carbon sources, or by directly altering levels of metabolic substrates in the assay medium. In this assay, the basal ATP production rates from both respiration and glycolysis (metabolic poise), as well as the maximal respiratory capacity, are reported. The typical assay profile and data output are shown in **Figure 2**.

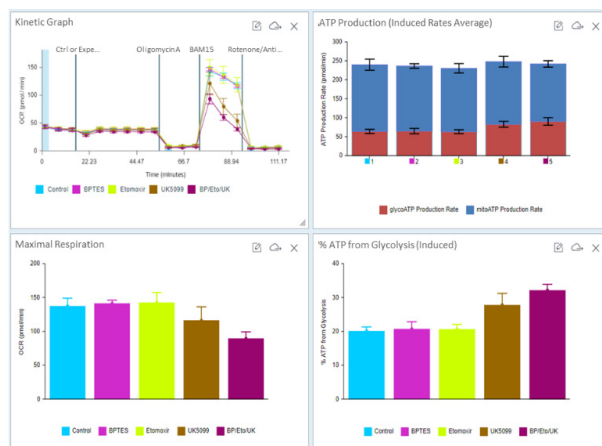
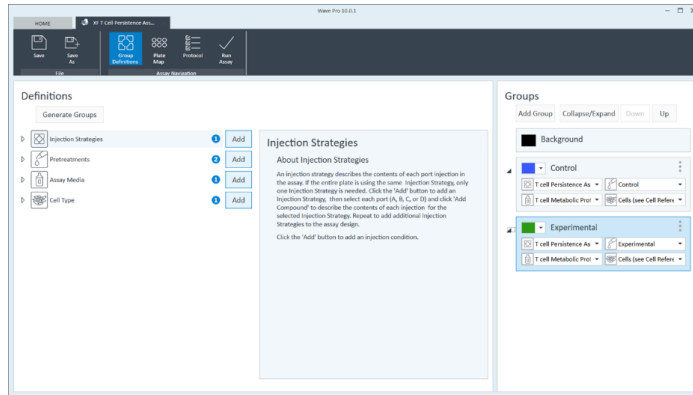


Figure 2. Typical Agilent Seahorse XF T Cell Fitness assay profiles and data output.

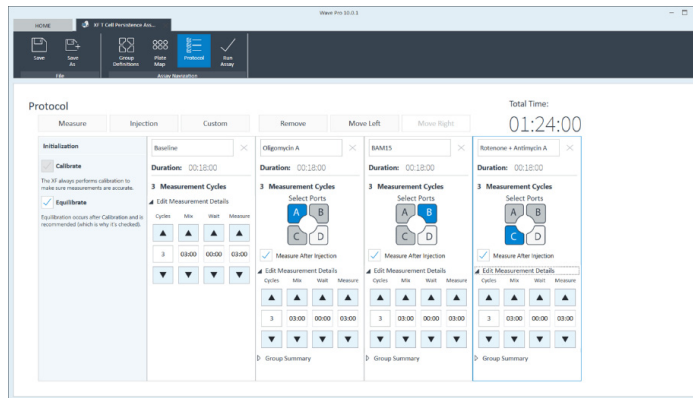
Templates for performing both XF T Cell Persistence and Fitness assays are provided in the Agilent Seahorse XF Pro Controller and Wave Pro software (compatible only with Agilent Seahorse XF Pro analyzers). If you use other XF analyzers (such as the Agilent Seahorse XFe96 or XF HS Mini analyzers), you can download templates from the [XF T Cell Metabolic Profiling kit](#) website. Examples of assay and controls groups, as well as instrument protocols, are shown in **Figure 3**.

# 1 Introduction

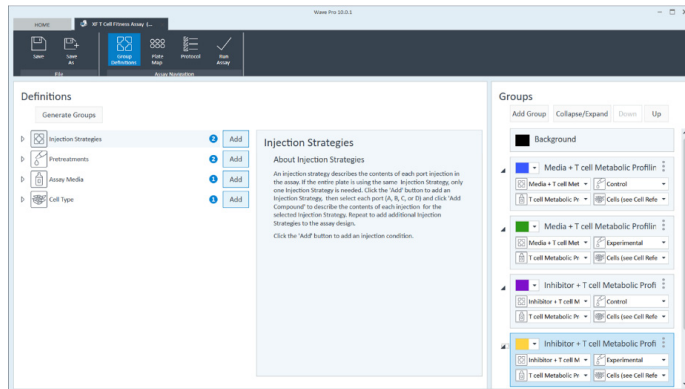
## XF T Cell Fitness assay



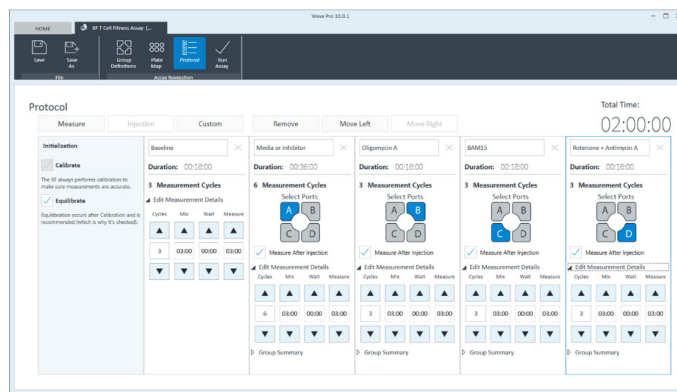
**3A**  
Starting group definitions in the XF T Cell Persistence assay or the standard T Cell Fitness assay templates for the XF Pro analyzer or XF96 analyzer. Here, users can define the type of cells or add more groups.



**3B**  
Instrument protocol in the XF T Cell Persistence assay or the standard T Cell Fitness assay templates for XF Pro analyzer or XF96 analyzer. Parameters can be applied for other types of XF analyzers.



**3C**  
Starting group definitions in the induced XF T Cell Fitness assay template for XF Pro analyzer or XF96 analyzer. Here, users can define the type of cells or add more groups. A control group with medium injection must be included.



**3D**  
Instrument protocol in the induced XF T Cell Fitness assay template for XF Pro analyzer or XF96 analyzer. The Number of measurement cycles after the acute injection can be adjusted depending on kinetic response.

Figure 3. Template designs for assays using the Agilent Seahorse XF T Cell Metabolic Profiling kit.

Data analysis and reporting results of the XF T Cell Persistence and Fitness assays can easily be performed using Agilent XF Seahorse Analytics. An Agilent Seahorse XF Discovery software license (for XF Pro analyzers only), or a valid assay kit are required for use of these analysis views.

This user guide details how to use the XF T Cell Metabolic Profiling kit with T cells, analyze assay data, and generate result reports.

## Glossary

- **mitoATP production rate:** The rate of ATP production (expressed in pmol/min) associated with oxidative phosphorylation in the mitochondria. It is calculated by multiplying the oxygen consumption rate (OCR) signal between basal and oligomycin addition, with a P:O ratio. For details of the calculation, please refer to the [Agilent white paper](#) by Romero et al.
- **glycoATP production rate:** The rate of ATP production (expressed in pmol/min) associated with the conversion of glucose to lactate in the glycolytic pathway. For details of calculation, please refer to the [Agilent white paper](#) by Romero et al.
- **totalATP production rate:** The sum of mitochondrial and glycolytic ATP production rates in live cells under a specific assay condition. This parameter represents the energy demand or requirement for the cells under the conditions being tested.
- **Percent of ATP from glycolysis (basal):** The ratio of glycoATP and totalATP.
- **Spare respiratory capacity:** The difference between the maximal OCR signal (obtained after exposure to an uncoupler), and the basal OCR signal. This measurement indicates the potential (capacity) of a cell to respond to increased energetic demand, as well as how closely the cell is respiring at its theoretical maximum. This parameter can be an indicator of cell fitness or flexibility.
- **Spare respiratory capacity (%):** The ratio of the maximal respiration, obtained with the signal after exposure to an uncoupler and the signal after rotenone and antimycin A (Rot/AA) addition; and the basal respiration, obtained with the basal OCR signal and the signal after Rot/AA addition. The formula is:  $(OCR_{Max} - OCR_{Rot/AA}) \div (OCR_{Basal} - OCR_{Rot/AA})$ .
- **Maximal respiration:** The difference between the maximal OCR (obtained after exposure to an uncoupler) and the OCR signal after Rot/AA addition. The uncoupler mimics a physiological “energy demand” by stimulating the respiratory chain to operate at maximum capacity, which causes rapid oxidation of substrates (sugars, fats, and amino acids) to meet this metabolic challenge. It shows the maximum rate of respiration that the cell can achieve.

## References

- 1 Kawalekar, O. U. Distinct Signaling of Coreceptors Regulates Specific Metabolism Pathways and Impacts Memory Development in CAR T Cells. *Immunity* **2016**, *44*, 380–390.
- 2 Van Bruggen, J. A. C. et al. Chronic Lymphocytic Leukemia Cells Impair Mitochondrial Fitness in CD8<sup>+</sup> T Cells and Impede CAR T Cell Efficacy. *Blood* **2019**, *134*(1), 44–58.
- 3 Walls, J. et al. Assessing T Cell Bioenergetic Poise and Spare Respiratory Capacity Using Extracellular Flux Analysis. *Agilent Technologies application note*, publication number: 5994-4494EN.



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# Kit Information

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## Kit Contents

The Seahorse XF T Cell Metabolic Profiling kit includes six foil pouches, and each contains reagents sufficient for a full-plate assay in 96-well format. Every pouch includes one vial of the following compounds: oligomycin A, BAM15, and a mixture of rotenone/antimycin A (see **Table 1**).

**Table 1** Agilent Seahorse XF T Cell Metabolic Profiling kit contents.

Compound	Function	Cap Color	Quantity Per Vial
<b>Oligomycin A</b>	ATP synthase inhibitor	Blue	54 nmol
<b>BAM15</b>	Mitochondrial membrane uncoupler	White	100 nmol
<b>Rotenone/Antimycin A</b>	Complex I and III inhibitor (respectively)	Red	22 nmol each

## Kit Shipping and Storage

The XF T Cell Metabolic Profiling kit can be shipped at ambient temperature and stored at room temperature. The product is stable for one year from the date of manufacture. The actual expiration date is printed on the label of the assay kit box. Depending on the shipping date, the actual shelf life of the kit in the user's hand can vary between 3 to 12 months.

## Additional Required Items

The products in **Table 2** are also required for performing Seahorse XF T Cell Metabolic Profiling assays, but are not supplied with the kit.

**Table 2** Additional required items.

Item	Part number
Agilent Seahorse XF Pro analyzer or XFe96 analyzer	
Agilent Seahorse XFe96 PDL FluxPak*	103729-100
Agilent Seahorse XFe96 PDL Plates <sup>†</sup>	103730-100
Agilent Seahorse XF RPMI Medium, pH 7.4 <sup>‡</sup>	103576-100
Agilent Seahorse XF 1.0 M Glucose Solution	103577-100
Agilent Seahorse XF 100 mM Pyruvate Solution	103578-100
Agilent Seahorse XF 200 mM Glutamine Solution	103579-100
Agilent Reservoir, 12 column, polypropylene or Agilent Reservoir, 12 column, polypropylene, irradiated	201280-100 or 204365-100

\* Part number 103729-100 contains Agilent Seahorse XFe96 cartridges and XFe96 PDL plates required to perform XF assays.

<sup>†</sup> Part number 103730-100 does not contain XFe96 cartridges which are also required to perform XF assays. This part number is only needed when extra PDL plates are needed for optimizing seeding density.

<sup>‡</sup> XF RPMI medium can also be purchased together with the supplements listed in this table as bundled products (part number 103681-100). For a full list of all medium types and our recommendation for each assay kit, please refer to the **Agilent Seahorse XF Media Selection Guide**.

### 3

# Assay Workflow for XF Pro Analyzer

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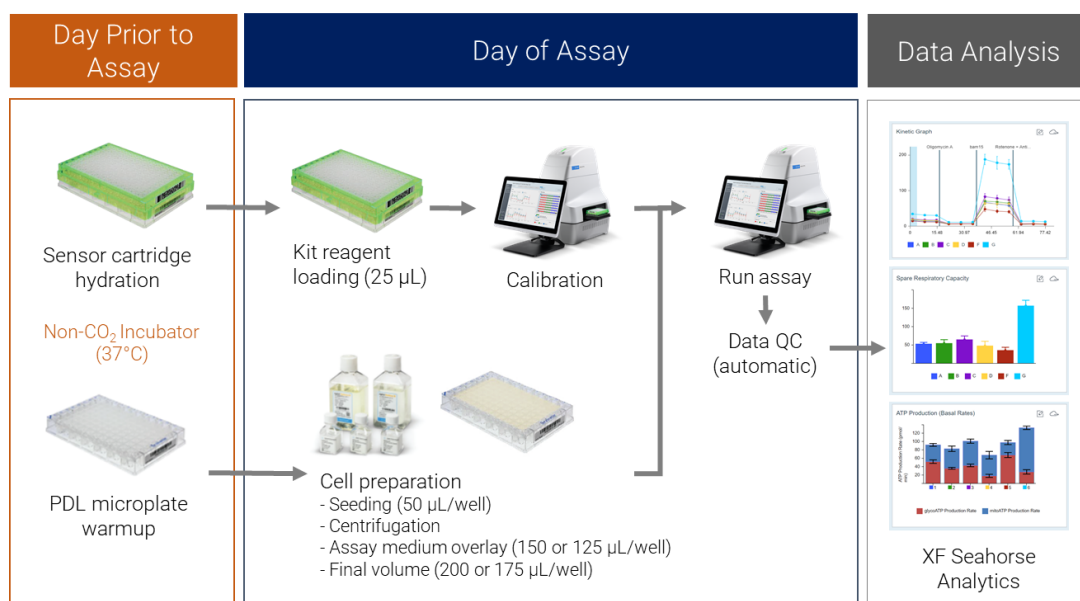


Figure 4. Agilent Seahorse XF T Cell Persistence and Fitness assay workflow with the Agilent Seahorse XF Pro Analyzer.

Optimal cell seeding density should be empirically determined for your cell type prior to the assay. Please refer to the **“Frequently Asked Questions”** section for recommendations. Additional information can also be found on the [Agilent Cell Analysis Learning Center](#) website.

The [Agilent Life Science Publication Database](#) is an excellent resource for finding information published in peer-reviewed research articles.

## One Day Prior to Assay (Day 1)

Power up the XF Pro Analyzer to allow the temperature to stabilize overnight (minimum of two hours).

### Prepare the sensor cartridge and XF PDL cell culture plate

- 1 Open the Agilent Seahorse XFe96 Extracellular Flux Assay Kit and remove a sensor cartridge.
- 2 Place the sensor cartridge upside down next to the utility plate.
- 3 Follow one of the two options below depending on if an Agilent Seahorse XF Hydrobooster is provided with your cartridge:
  - a Option 1: If an XF Hydrobooster is included with the cartridge, fill each well of the utility plate with 200  $\mu$ L of calibrant solution and then place the XF Hydrobooster on top of the utility plate.
  - b Option 2: If an XF Hydrobooster is not included with the cartridge, fill each well of the utility plate with 200  $\mu$ L of sterile, tissue culture-grade water. Also, transfer approximately 20 mL of calibrant solution to a 50 mL conical tube. Place it in a 37 °C, non-CO<sub>2</sub> incubator overnight.
- 4 Lower the sensor cartridge onto the utility plate, submerging the sensors in the calibrant or water.
- 5 Verify that the calibrant or water level is high enough to keep the sensors submerged.
- 6 Place in a 37 °C, non-CO<sub>2</sub> incubator overnight.
- 7 Remove a precoated Agilent Seahorse XFe96 PDL cell culture plate from the box and place in a 37 °C, non-CO<sub>2</sub>, nonhumidified incubator overnight to warm up the plate.

### Design and upload the assay template to the XF Pro analyzer

Default assay templates are provided in the Seahorse XF Pro Controller software on the XF Pro Analyzer. You can modify instrument protocols and add or modify experimental groups using the default templates to create your custom template, if necessary.

If a custom assay template is created off the XF Pro Analyzer, for example using Seahorse Wave Pro software or Seahorse Analytics, follow the steps below to upload the custom assay template to the XF Pro Controller software.

- 1 Open the XF Pro Controller software on your XF Pro Analyzer.
- 2 Insert a USB drive (containing the custom assay template) in the front USB port or connect to a network drive containing the custom assay template.
- 3 Click **Import** (bottom of the New Assay view).
- 4 Locate the custom assay template file on the USB or network drive.
- 5 Click **Open** in the windows dialog box. The imported assay template will be available for selection from the **Templates** view on the XF Pro Analyzer.
- 6 Repeat for the next template, if applicable.
- 7 The imported **Assay Template(s)** will now be available for selection in the list of available templates.

## Day of Assay (Day 2)

### Prepare the cartridge

Complete hydration of the sensor cartridge by removing the water and adding 200  $\mu$ L of prewarmed calibrant to each well in the utility plate. Incubate in a 37 °C, non-CO<sub>2</sub> incubator for 60 minutes. If calibrant is already used for hydrating the sensor cartridge, simply remove the XF Hydrobooster prior to the start of the assay to complete the hydration of the sensor cartridge.

### Prepare the assay medium

- 1 Prepare standard Seahorse XF RPMI assay medium by supplementing 97 mL of Seahorse XF RPMI Medium, pH 7.4 with 1.0 mL each of Agilent Seahorse XF glucose, pyruvate, and glutamine solutions (10 mM, 1 mM, and 2 mM final concentrations in assay medium, respectively), as shown in **Table 3**. These are the recommended initial substrate conditions for all types of T cells. However, the desired assay medium composition can be modified depending on the user needs.

**Table 3** Agilent Seahorse XF RPMI assay medium.

Component	Volume (mL)	Final Concentration (mM)
Seahorse XF RPMI Medium, pH 7.4	97	–
XF 1.0 M Glucose Solution	1.0	10.0
XF 100 mM Pyruvate Solution	1.0	1.0
XF 200 mM Glutamine Solution	1.0	2.0

- 2 Warm up to 37 °C.

#### NOTE

No pH adjustment to the assay medium is necessary when nonsaturating concentrations of substrates, listed in **Table 3**, are used for XF assay medium.

## Prepare and seed T cells in the Seahorse XF PDL cell culture plate

**Important:** The procedure described below is also known as the Seahorse XF assay suspension cell protocol. Before starting any experiments, please read the information in the “**Frequently Asked Questions**” section, which contains information about the best practices for handling cells, as well as examples of calculations, to ensure that optimal results are achieved.

- 1 Take a small sample of cell suspension and count the cells.
- 2 Calculate the total number of cells needed (desired number of cells per well multiplied by the number of wells to be seeded).

For example: 100,000 cells per well × 100 wells =  $1.0 \times 10^7$  cells).

### NOTE

**It is recommended to allow at least 50% extra cells to account for the potential loss of cells during centrifugation and other steps.**

- 3 Transfer the appropriate volume of cell suspension from the culture vessel to a conical tube. Preferentially, use 15 mL conical tubes for best cell recovery. Use multiple tubes if needed, then pool the cells after resuspending them following centrifugation.
- 4 Centrifuge the cells at room temperature at 200 ×g for 10 minutes. Calculate the volume required to resuspend the cell pellet. We recommend using a volume 20% smaller than the calculated volume to avoid over-diluting the sample.
- 5 While the cells are being centrifuged, remove the warm XFe96 PDL microplate from the incubator and pipette 50 µL of assay medium into the background wells at the four corners.
- 6 Remove the supernatant carefully from the centrifuged conical tube using a pipette (do not aspirate, to minimize cell loss).
- 7 Resuspend the cells in warm assay medium. Take a small sample and perform the cell counting again. Adjust the volume to achieve the desired cell concentration (see [Table 4](#)).

### NOTE

**Table 4 lists the potential starting cell densities as tested in Agilent laboratories. It is recommended to perform density optimization when you start working with your cells to ensure optimal results (also see the “Frequently Asked Questions” section).**

**Table 4 Starting cell seeding conditions for the different types of T cells.**

Cell Type	Cell Suspension (Total Cells/mL)	Seeding Volume (µL/Well)	Final Cell Density (Total Cells/Well)
Naïve T Cell	$4.0 \times 10^6$	50	$2.0 \times 10^5$
Activated T Cell	$2.0 \times 10^6$	50	$1.0 \times 10^5$

- 8 Transfer 50 µL of the cell suspension to each well. **Do not** add cells to the four corner wells.

### NOTE

**Seeding volume is critical for achieving a uniform distribution of cells within a well. Do not seed cells in a volume higher than 50 µL (before the centrifugation step).**

- 9 Centrifuge gently (e.g., 200 ×g for 1 minute) to allow the cells to attach to the bottom of the wells. It is recommended to use a centrifuge break.
- 10 The final number of cells per well expected should be  $2.0 \times 10^5$  cells/well for naïve T cells, and  $1.0 \times 10^5$  cells/well for pre-activated (i.e., effector and memory) T cells.

### 3 Assay Workflow for XF Pro Analyzer

#### Prepare the compound solutions and load the injection ports

- 11 Gently add 150  $\mu\text{L}$ /well of warm XF assay medium for assays without an acute injection, or 125  $\mu\text{L}$ /well for assays with an acute injection, to achieve a resulting total volume of 200 or 175  $\mu\text{L}$ /well, respectively.
- 12 Incubate the plate at 37 °C in a non-CO<sub>2</sub> incubator for 45 to 60 minutes prior to the assay.

## Prepare the compound solutions and load the injection ports

**Important:** It is not necessary to perform titration experiments for the compounds provided in the kit when T cells are used. This is based on the results from the extensive tests performed with a wide panel of T cell types.<sup>3</sup> Check the “**Frequently Asked Questions**” section for more guidelines on working with other types of cells. Use the compounds on the same day that they are reconstituted. Discard any remaining compound solutions. **Do not** refreeze and reuse.

- 1 Remove one foil pouch from the Agilent Seahorse XF T Cell Metabolic Profiling kit box.
- 2 Open the pouch. Remove all three vials with a gloved hand.
- 3 Add 4 mL of assay medium to each vial to resuspend the content (see **Table 5**). Vortex for 30 seconds, if needed, to ensure that the content dissolves completely.

**Table 5** Compound solutions.

Compound	Cap Color	Volume to Add (mL)	Solution Concentration ( $\mu\text{M}$ )
Oligomycin A	Blue	4.0	13.5
Bam15	White	4.0	25
Rotenone/Antimycin A	Red	4.0	5.5

- 4 Load 25  $\mu\text{L}$  of compound to each injection port, according to **Table 6**. For the location of the ports, refer to **Figure 5**.

**Table 6** Assay type, injection port, and volume recommendations for 96-well cell plates.

Compound	Port Concentration	Assay Without Acute Injection		Assay With an Acute Injection		Final Concentration
		Port	Loading Volume	Port	Loading Volume	
Starting Volume	–	200 $\mu\text{L}$		175 $\mu\text{L}$		–
Test Compound	8 X	–	–	Port A	25 $\mu\text{L}$	1 X
Oligomycin A	9 X	Port A	25 $\mu\text{L}$	Port B	25 $\mu\text{L}$	1.5 $\mu\text{M}$
BAM15	10 X	Port B	25 $\mu\text{L}$	Port C	25 $\mu\text{L}$	2.5 $\mu\text{M}$
Rotenone/Antimycin A	11 X	Port C	25 $\mu\text{L}$	Port D	25 $\mu\text{L}$	0.5 $\mu\text{M}$ each

### 3 Assay Workflow for XF Pro Analyzer

#### Running the XF T Cell Persistence or Fitness assay on the XF Pro analyzer

##### NOTE

Proper port-loading techniques can be found in Basic Procedure “Loading the Sensor Cartridge with Compounds”, on the [Agilent Cell Analysis Learning Center](#) website. Please read the information prior to loading compounds. Ensure that the sensor cartridge is properly hydrated prior to use.

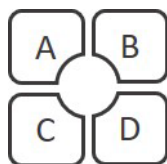


Figure 5. Location and numbering of injection ports on Agilent Seahorse XF sensor cartridges.

## Running the XF T Cell Persistence or Fitness assay on the XF Pro analyzer

##### NOTE

If your assay template is not uploaded to the XF Pro Analyzer, refer to section “[Design and upload the assay template to the XF Pro analyzer](#)” on page 12 to upload the assay template.

- 1 Select the assay template from the list of available templates. It can be a custom assay template, or an XF T Cell Persistence or T Cell Fitness assay template. Click **Open File** (or double-click the template).
- 2 Review the groups (cell types or conditions), plate layout map, and instrument protocol for your assay; modify if desired.
- 3 On the review and run display, click **Scan Assay Kit** to display the assay kit information dialog.
- 4 Use the external handheld barcode wand to scan the barcode on the kit box label (outside). This will automatically add the part number and lot number of the assay kit to this dialog.
- 5 In the **SW ID** field, manually type the SW code on the kit box label. Click **Apply**. The software will embed this information into your data file.
- 6 Click **Start Run** to start the assay.
- 7 When prompted, remove the cartridge lid and place the loaded sensor cartridge with the utility plate on the thermal tray of the Agilent Seahorse XF Pro Analyzer. Ensure correct plate orientation and that the cartridge lid has been removed. Then, click **I'm Ready**. Calibration takes approximately 15 to 30 minutes.
- 8 After completing calibration, the XF Pro Controller will display the Load Cell Plate dialog. Click **Open Tray** to eject the utility plate and load the cell plate. *Ensure that the lid is removed from the cell plate before loading.*
- 9 Click **Load Cell Plate** to run the assay.



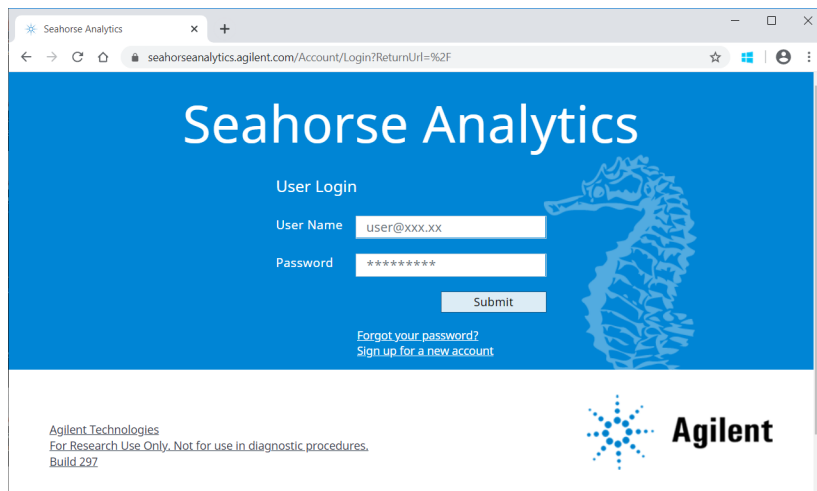
# Data Analysis

Seahorse Analytics is a web-based software platform that provides a simple, streamlined data analysis workflow for analyzing the XF T Cell Persistence and XF T Cell Fitness assay data.

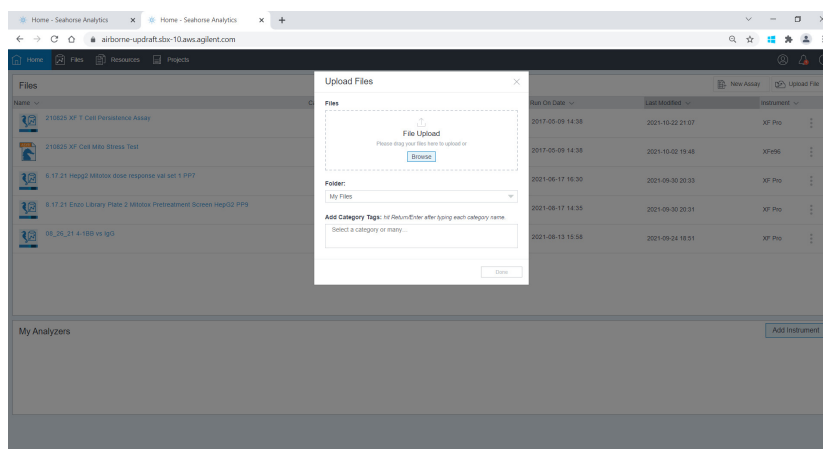
After obtaining assay result files, it is recommended to perform a data quality review before moving further to analyzing the data. With the XF Pro Analyzer, a data quality review is performed using the QC tool in Wave Pro software. By simply clicking the **Data Quality** function, the software will examine all the wells for outliers or unusual signals. A report is then generated, flagging wells with abnormal signals with explanations. Outliers, if any, can be excluded at this step.

Follow the steps below to use the relevant assay widgets in Seahorse Analytics:

- 1 After the assay is completed, transfer your assay result file to your office or personal computer using a USB drive or network drive.
- 2 To register or log in to your Seahorse Analytics account, visit: <https://seahorseanalytics.agilent.com>.



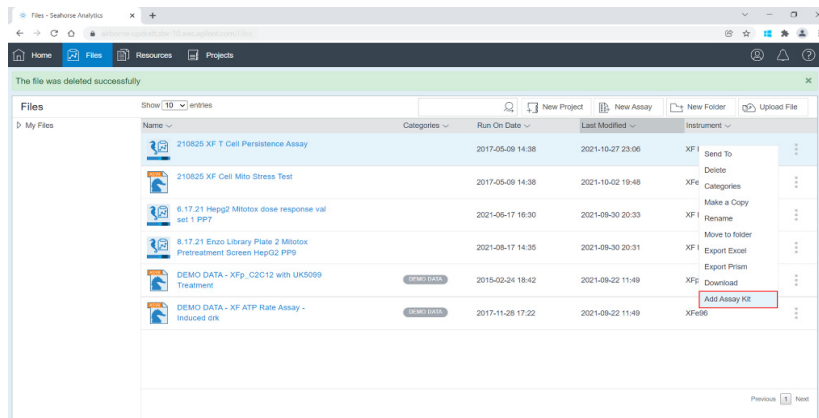
- 3 Import the assay result file to your account.



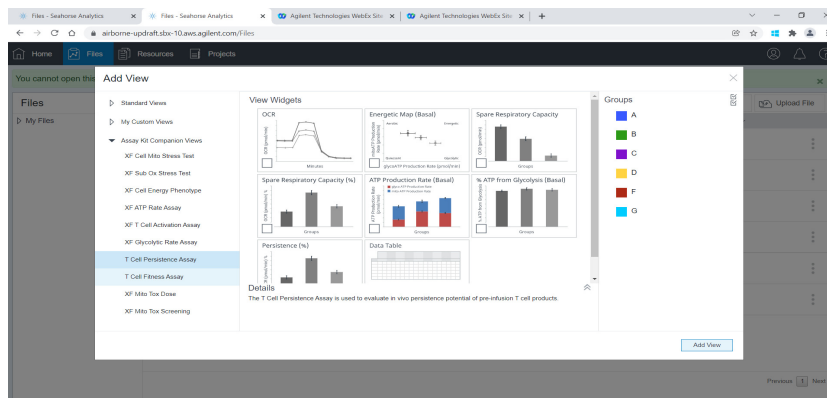
### 3 Assay Workflow for XF Pro Analyzer Data Analysis

- 4 Click the assay result file to open the **Add View** window. Click the **XF T Cell Persistence Assay** analysis view or the **XF T Cell Fitness Assay** analysis view found under the **Assay Kit Companion Views** menu.

If your result file does not contain the part number, lot number, and SW code information from your kit box label, the XF T Cell Persistence Assay analysis view and XF T Cell Fitness Assay analysis view will be locked. You can manually add the kit information to the file by clicking the three-dot menu to the right of the file on the Files view (only). This will unlock the XF T Cell Persistence and XF T Cell Fitness analysis views.



- 5 Select the desired analysis view(s) in the **View Widget** window, then click **Add View**.



For additional information about using Seahorse Analytics, visit [Agilent Cell Analysis Learning Center](#) website.

# 4

# Assay Workflow for XFe96 Analyzer

One Day Prior to Assay (Day 1) 20

Day of Assay (Day 2) 21

Data Analysis 25

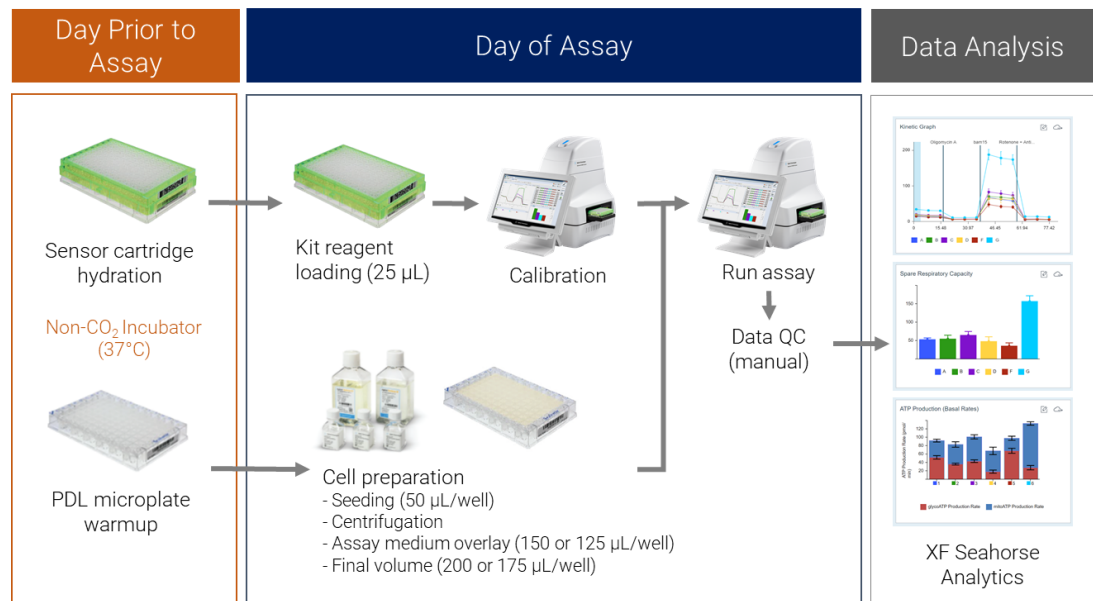


Figure 6. Agilent Seahorse XF T Cell Persistence and Fitness assay workflow with the Agilent Seahorse XFe96 Analyzer.

Optimal cell seeding density should be empirically determined for your cell type prior to the assay. Refer to the **“Frequently Asked Questions”** section for recommendations. Additional information can also be found on the **Agilent Cell Analysis Learning Center** website.

The **Agilent Life Science Publication Database** is an excellent resource for finding information published in peer-reviewed research articles.

## One Day Prior to Assay (Day 1)

Power up the XFe96 Analyzer to allow the temperature to stabilize overnight (minimum of 18 hours).

### Prepare the sensor cartridge and XF PDL cell culture plate

- 1 Open the Agilent Seahorse XFe96 Extracellular Flux Assay Kit and remove a sensor cartridge.
- 2 Place the sensor cartridge upside down next to the utility plate.
- 3 Follow one of the two options below depending on if an Agilent Seahorse XF Hydrobooster is provided with your cartridge:
  - a Option 1: If an XF Hydrobooster is included with the cartridge, fill each well of the utility plate with 200  $\mu$ L of calibrant solution and then place the XF Hydrobooster on top of the utility plate.
  - b Option 2: If an XF Hydrobooster is not included with the cartridge, fill each well of the utility plate with 200  $\mu$ L of sterile, tissue culture-grade water. Also, transfer approximately 20 mL of calibrant solution to a 50 mL conical tube. Place it in a 37 °C, non-CO<sub>2</sub> incubator overnight.
- 4 Lower the sensor cartridge onto the utility plate, submerging the sensors in the calibrant or water.
- 5 Verify that the calibrant or water level is high enough to keep the sensors submerged.
- 6 Place in a 37 °C, non-CO<sub>2</sub> incubator overnight.
- 7 Remove a precoated Agilent Seahorse XFe96 PDL cell culture plate from the box and place it in a 37 °C, non-CO<sub>2</sub>, nonhumidified incubator overnight to warm up the plate.

### Design and upload the assay template to the XFe96 analyzer

- 1 On your office or personal computer with internet access, download the default template(s) on the [XF T Cell Metabolic Profiling Kit](#) website.
- 2 Unzip the folder, then copy and paste the assay template files to a USB drive or network drive (if Seahorse XFe96 Analyzer is networked).
- 3 Open the Agilent Seahorse Wave software on the XFe96 Analyzer.
- 4 Insert a USB drive in the front USB port or connect to network drive.
- 5 Click **Import** (bottom of the New Assay view).
- 6 Locate the assay template file on the USB or network drive.
- 7 Click **Open** in the windows dialog box. The imported assay template will be available for selection from the **Templates** view on the XFe96 Analyzer.
- 8 Repeat for the next template, if applicable.
- 9 The imported **Assay Template(s)** will now be available for selection in the list of available templates.

## Day of Assay (Day 2)

### Prepare the cartridge

Complete hydration of the sensor cartridge by removing the water and adding 200  $\mu$ L of prewarmed calibrant to each well in the utility plate. Incubate in a 37 °C, non-CO<sub>2</sub> incubator for 60 minutes. If calibrant is already used for hydrating the sensor cartridge, simply remove the XF Hydrobooster prior to the start of the assay to complete the hydration of the sensor cartridge.

### Prepare the assay medium

- 1 Prepare standard Seahorse XF RPMI assay medium by supplementing 97 mL of Seahorse XF RPMI Medium, pH 7.4 with 1.0 mL each of Agilent Seahorse XF glucose, pyruvate, and glutamine solutions (10 mM, 1 mM, and 2 mM final concentrations in assay medium, respectively), as shown in **Table 7**. These are the recommended initial substrate conditions for all types of T cells. However, the desired assay medium composition can be modified depending on the user needs.

**Table 7** Agilent Seahorse XF RPMI assay medium.

Component	Volume (mL)	Final Concentration (mM)
Seahorse XF RPMI Medium, pH 7.4	97	–
XF 1.0 M Glucose Solution	1.0	10.0
XF 100 mM Pyruvate Solution	1.0	1.0
XF 200 mM Glutamine Solution	1.0	2.0

- 2 Warm up to 37 °C.

#### NOTE

No pH adjustment to the assay medium is necessary when nonsaturating concentrations of substrates, listed in **Table 7**, are used for XF assay medium.

## Prepare and seed T cells in the Seahorse XF PDL cell culture plate

**Important:** The procedure described below is also known as the Seahorse XF assay suspension cell protocol. Before starting any experiments, please read the information in the “**Frequently Asked Questions**” section, which contains information about the best practices for handling cells, as well as examples of calculations, to ensure that optimal results are achieved.

- 1 Take a small sample of cell suspension and count the cells.
- 2 Calculate the total number of cells needed (desired number of cells per well multiplied by the number of wells to be seeded).

For example: 100,000 cells per well × 100 wells =  $1.0 \times 10^7$  cells).

### NOTE

**It is recommended to allow at least 50% extra cells to account for the potential loss of cells during centrifugation and other steps.**

- 3 Transfer the appropriate volume of cell suspension from the culture vessel to a conical tube. Preferentially, use 15 mL conical tubes for best cell recovery. Use multiple tubes if needed, then pool the cells after resuspending them following centrifugation.
- 4 Centrifuge the cells at room temperature at 200 ×g for 10 minutes. Calculate the volume required to resuspend the cell pellet. We recommend using a volume 20% smaller than the calculated volume to avoid over-diluting the sample.
- 5 While the cells are being centrifuged, remove the warm XFe96 PDL microplate from the incubator and pipette 50 µL of assay medium into the background wells at the four corners.
- 6 Remove the supernatant carefully from the centrifuged conical tube using a pipette (do not aspirate, to minimize cell loss).
- 7 Resuspend the cells in warm assay medium. Take a small sample and perform the cell counting again. Adjust the volume to achieve the desired cell concentration (see **Table 8**).

### NOTE

**Table 8 lists the potential starting cell densities as tested in Agilent laboratories. It is recommended to perform density optimization when you start working with your cells to ensure optimal results (also see the “Frequently Asked Questions” section).**

**Table 8 Starting cell seeding conditions for the different types of T cells.**

Cell Type	Cell Suspension (Total Cells/mL)	Seeding Volume (µL/Well)	Final Cell Density (Total Cells/Well)
Naïve T Cell	$4.0 \times 10^6$	50	$2.0 \times 10^5$
Activated T Cell	$2.0 \times 10^6$	50	$1.0 \times 10^5$

- 8 Transfer 50 µL of the cell suspension to each well. **Do not** add cells to the four corner wells.

### NOTE

**Seeding volume is critical for achieving a uniform distribution of cells within a well. Do not seed cells in a volume higher than 50 µL (before the centrifugation step).**

- 9 Centrifuge gently (e.g., 200 ×g for 1 minute) to allow the cells to attach to the bottom of the wells. It is recommended to use a centrifuge break.
- 10 The final number of cells per well expected should be  $2.0 \times 10^5$  cells/well for naïve T cells, and  $1.0 \times 10^5$  cells/well for pre-activated (i.e., effector and memory) T cells.

## 4 Assay Workflow for XFe96 Analyzer

### Prepare the compound solutions and load the injection ports

- 11 Gently add 150  $\mu\text{L}$ /well of warm XF assay medium for assays without an acute injection, or 125  $\mu\text{L}$ /well for assays with an acute injection, to achieve a resulting total volume of 200 or 175  $\mu\text{L}$ /well, respectively.
- 12 Incubate the plate at 37 °C in a non-CO<sub>2</sub> incubator for 45 to 60 minutes prior to the assay.

## Prepare the compound solutions and load the injection ports

**Important:** It is not necessary to perform titration experiments for the compounds provided in the kit when T cells are used. This is based on the results from the extensive tests performed with a wide panel of T cell types.<sup>3</sup> Check the “**Frequently Asked Questions**” section for more guidelines on working with other types of cells. Use the compounds on the same day that they are reconstituted. Discard any remaining compound solutions. **Do not** refreeze and reuse.

- 1 Remove one foil pouch from the Agilent Seahorse XF T Cell Metabolic Profiling kit box.
- 2 Open the pouch. Remove all three vials with a gloved hand.
- 3 Add 4 mL of assay medium to each vial to resuspend the content (see **Table 9**). Vortex for 30 seconds, if needed, to ensure that the content dissolves completely.

**Table 9** Compound solutions.

Compound	Cap Color	Volume to Add (mL)	Solution Concentration ( $\mu\text{M}$ )
Oligomycin A	Blue	4.0	13.5
Bam15	White	4.0	25
Rotenone/Antimycin A	Red	4.0	5.5

- 4 Load 25  $\mu\text{L}$  of compound to each injection port, according to **Table 10**. For the location of the ports, refer to **Figure 7**.

**Table 10** Assay type, injection port, and volume recommendations for 96-well cell plates.

Compound	Port Concentration	Assay Without Acute Injection		Assay With an Acute Injection		Final Concentration
		Port	Loading Volume	Port	Loading Volume	
Starting Volume	–	200 $\mu\text{L}$		175 $\mu\text{L}$		–
Test Compound	8 X	–	–	Port A	25 $\mu\text{L}$	1 X
Oligomycin A	9 X	Port A	25 $\mu\text{L}$	Port B	25 $\mu\text{L}$	1.5 $\mu\text{M}$
BAM15	10 X	Port B	25 $\mu\text{L}$	Port C	25 $\mu\text{L}$	2.5 $\mu\text{M}$
Rotenone/Antimycin A	11 X	Port C	25 $\mu\text{L}$	Port D	25 $\mu\text{L}$	0.5 $\mu\text{M}$ each

## 4 Assay Workflow for XFe96 Analyzer

### Running the XF T Cell Persistence or Fitness assay on the XFe96 analyzer

#### NOTE

Proper port-loading techniques can be found in Basic Procedure “Loading the Sensor Cartridge with Compounds”, on the [Agilent Cell Analysis Learning Center](#) website. Please read the information prior to loading compounds. Ensure that the sensor cartridge is properly hydrated prior to use.

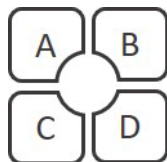


Figure 7. Location and numbering of injection ports on Agilent Seahorse XF sensor cartridges.

## Running the XF T Cell Persistence or Fitness assay on the XFe96 analyzer

#### NOTE

If your assay template is not uploaded to the XFe96 Analyzer, refer to section “[Design and upload the assay template to the XFe96 analyzer](#)” on page 20 to upload the assay template.

- 1 Select the assay template from the list of available templates. Click **Open File** (or double-click the template).
- 2 Review the groups (cell types or conditions), plate layout map, and instrument protocol for your assay; modify if desired.
- 3 Click **Start Run** to start the assay.
- 4 When prompted, remove the cartridge lid and place the loaded sensor cartridge with the utility plate on the thermal tray of the Agilent Seahorse XF Analyzer. Ensure correct plate orientation and that the cartridge lid has been removed. Then, click **I'm Ready**. Calibration takes approximately 15 to 30 minutes.
- 5 After completing calibration, the XF Controller will display the Load Cell Plate dialog. Click **Open Tray** to eject the utility plate and load the cell plate. *Ensure that the lid is removed from the cell plate before loading.*
- 6 Click **Load Cell Plate** to run the assay.



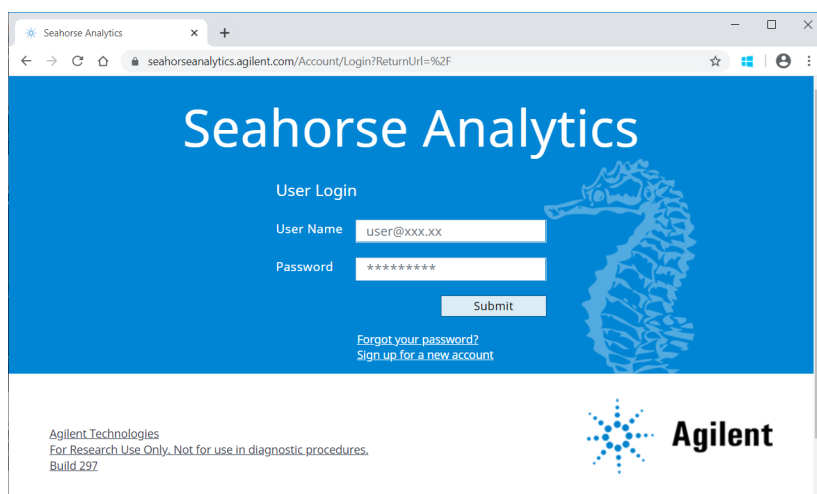
## Data Analysis

Seahorse Analytics is a web-based software platform that provides a simple, streamlined data analysis workflow for analyzing the XF T Cell Persistence and XF T Cell Fitness assay data.

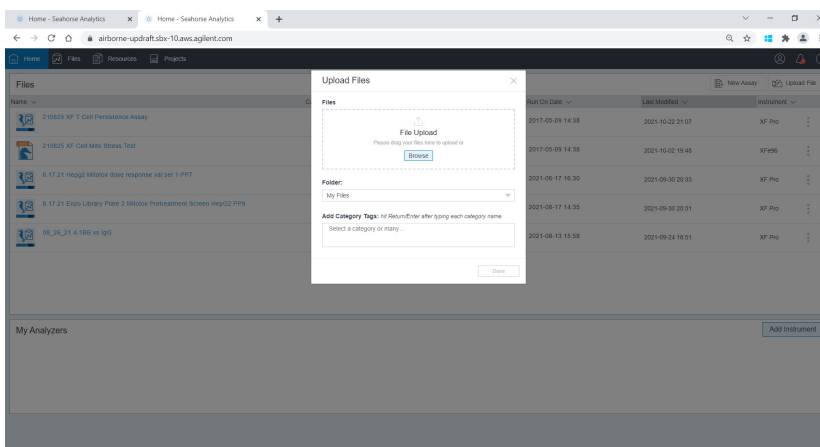
After obtaining assay result files, it is recommended to perform a data quality review with either Wave Desktop software or in Seahorse Analytics, before moving further to analyzing the data. A data quality review is performed by manually examining the O<sub>2</sub> and pH level data for each well. Outliers, if any, can be excluded at this step.

Follow the steps below to use the relevant assay widgets in Seahorse Analytics:

- 1 After the assay is completed, transfer your assay result file to your office or personal computer using a USB drive or network drive.
- 2 To register or log in to your Seahorse Analytics account, visit: <https://seahorseanalytics.agilent.com>.

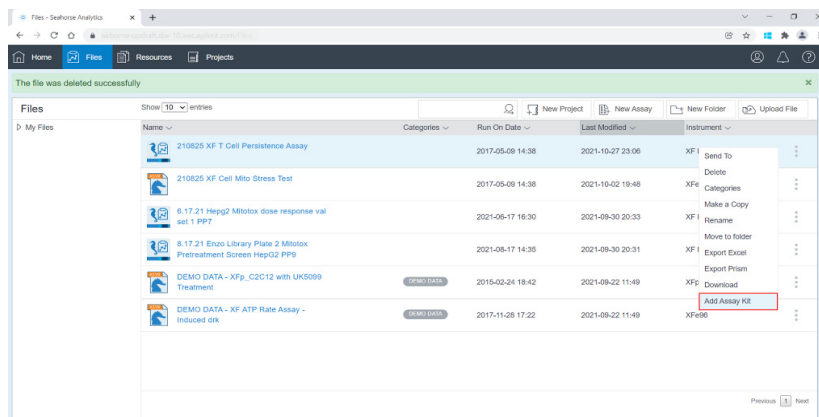


- 3 Import the assay result file to your account.

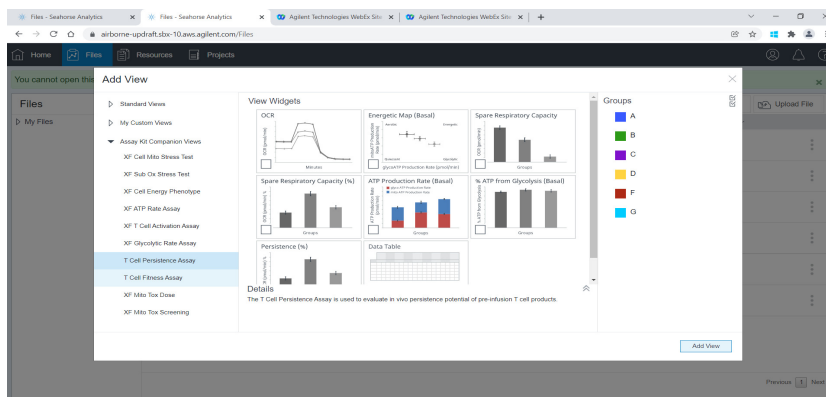


- 4 Click the three-dot menu to the right of the file on the **Files** view (only). Click **Add Assay Kit**.

## 4 Assay Workflow for XFe96 Analyzer Data Analysis



- 5 In the pop-up dialog box, enter the assay kit information (kit part number, lot number and SW ID). Click **Validate**. This unlocks the XF T Cell Persistence Assay and XF T Cell Fitness Assay analysis views.
- 6 Click the result file to display the **Add View** window. If a data quality review has not been performed, it can be done by using the **Standard Graph** widgets. Outliers, if any, can be excluded at this step using the **Modify** function. For more information about this function, please visit the [Agilent Cell Analysis Learning Center](#).
- 7 After the data quality review, open the **Add View** window again. Click the **XF T Cell Persistence Assay** analysis view or the **XF T Cell Fitness Assay** analysis view found under the **Assay Kit Companion Views** menu.
- 8 Select the desired analysis view(s) in the **View Widget** window, then click **Add View**.



For additional information about using Seahorse Analytics, visit [Agilent Cell Analysis Learning Center](#) website.

## 5

# Frequently Asked Questions

## How should T cells be handled to maximize the chance of a successful assay?

Cell preparation is one of the most critical steps to ensure consistent and robust response. Here are some tips for you to consider:

- Never put your cells on ice and never spin cells in a cold centrifugation chamber. Metabolism is strongly affected by temperature changes. In general, lowered temperature will slow or alter metabolism and exert stress on cells, leading to reduced metabolic rates and higher assay variation.
- Warm up the PDL cell culture plate overnight prior to use. Plastic plates can absorb O<sub>2</sub> from the air. When the temperature increases, the O<sub>2</sub> absorbed in the plates is slowly released into the wells. This process can take hours to reach equilibrium. If cells are plated onto a cold PDL plate, the O<sub>2</sub> in the plate is then slowly released into the assay medium during the assay. This can interfere with assay signals, especially in the case when the OCR signal is in the low detection range.
- Ensure consistent cell counting by counting both total cells and viable cells. This is critical for achieving consistent assay results. Ensure that you obtain both the total cell number, as well as the viable cell number (or a percentage). A cell-counting protocol using the Agilent NovoCyte Quanteon flow cytometer has been developed. For more information, please contact the Agilent technical support team at: [cellanalysis.support@agilent.com](mailto:cellanalysis.support@agilent.com).
- Count cells twice: before centrifugation, and after resuspending cells in assay medium. The second counting in step 5 in **Figure 8** is especially important to ensure accurate seeding density, and should not be omitted because some cells can be lost when discarding spent medium.

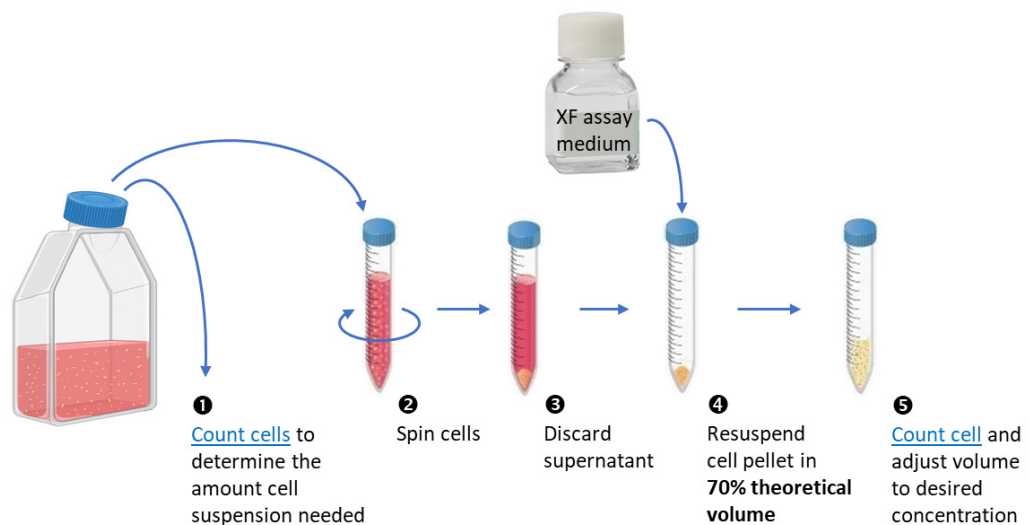


Figure 8. Suggested cell-preparation steps for cell seeding with T cells.

- Use total cell number (live + dead cells) to calculate the number of cells needed for each well. Both live and dead cells occupy space at the bottom of wells. Therefore, you should use total cell count to calculate medium volume and dilution factor for cell seeding, not using viable cell count. This is especially important when you have a sample with less than 90% viable cells. In this case, if you only consider viable cells, you may end up seeding too many cells per well, leading to high assay variability. Viable cell count is only useful in performing normalization of signals.

## 5 Frequently Asked Questions

- Minimize the number of centrifugation steps during cell preparation. We recommend spinning cells only once during cell preparation. This means performing cell counting first to obtain the total number of cells you have, before spinning the cells. This will give you an idea about the volume of assay medium you will need to resuspend the pellet without over-diluting your cell suspension; avoiding spinning the cells again.

### Can I thaw frozen T cells and seed directly to XF PDL culture plates to perform XF assays on the same day?

When working with frozen T cells, it is recommended to thaw the cells in T cell maintenance medium overnight before using the cells to perform XF assays. This is because cellular metabolism takes time to recover. The overall signal can be low if overnight recovery is not implemented. If it is desired to obtain data from the cells right after thawing, it is recommended to perform a second assay with the same batch of cells after recovering in T cell maintenance medium overnight.

### Do you provide a tool for calculating the cells required at each of the cell-preparation steps?

We do not provide a tool for this purpose. However, you can use **Table 11** as an example of how to calculate the number of cells you will need for your assay.

**Table 11** Example calculations for preparing a cell suspension to seed 30 wells in 96-well format.

Desired seeding density and volume per well	$1.0 \times 10^5$ cells in 50 $\mu$ L
Total number of cells needed for an experiment with 30 wells plus 50% extra	$(1.0 \times 10^5 \text{ cells} \times 30 \text{ wells}) \times 1.5 = 4.5 \times 10^6$ cells
Target cell density for the final cell suspension in assay medium (to be used in seeding plate)	$1.0 \times 10^5 \text{ cells} / 50 \mu\text{L} = 2.0 \times 10^6$ cells/mL
Cell count for cell suspension in growth medium (total cells)	
	$1.5 \times 10^6$ cells/mL
Amount of cell suspension needed	
	$4.5 \times 10^6 \text{ cells} / 1.5 \times 10^6 \text{ cells/mL} = 3 \text{ mL}$
Spin and carefully remove cell culture medium	
Recommended assay medium volume to resuspend cell pellet (= 70% of the theoretical volume assuming there is no loss of cells)	
	$(4.5 \times 10^6 \text{ cells}) / 2.0 \times 10^6 \text{ cells/mL} \times 70\% = 1.575 \text{ mL}$ (Round up to <b>1.6 mL</b> )
Cell count for cell suspension in assay medium (use 100 $\mu$ L aliquot, dilute if needed)	
	$2.5 \times 10^6$ cells/mL
Cell viability	
	93%
Total cells (live + dead) in 1.5 mL cell suspension (amount left after 100 $\mu$ L is used for cell counting)	
	$(1.5 \times 10^6 \text{ cells/mL}) \times 1.5 \text{ mL} = 3.75 \times 10^6$ cells
Additional assay medium needed to achieve target cell density for the final cell suspension	
	$(3.75 \times 10^6 \text{ cells} / 2.0 \times 10^6 \text{ cells}) - 1.5 \text{ mL} = 0.375 \text{ mL}$
Transfer 50 $\mu$ L to each well	
Total cells per well (live + dead)	
	$1.0 \times 10^5$ cells
Cell number to use for normalization	
	$(1.0 \times 10^5 \text{ cells}) \times 0.93 = 9.3 \times 10^4$ cells/well

### Do I need to perform a cell density optimization experiment, and how?

Yes. We recommend a test, such as microscopic evaluation of the monolayer, to optimize cell-plating density when you first start performing XF assays. The seeding densities recommended in **Table 4** or **Table 11** serve only as a reference point, and you should plan testing with a couple of seeding densities above and below the recommended numbers. This is because

different cell-counting methods used by different users or in different labs may yield different counting results, which could lead to suboptimal seeding density on the XF cell culture microplates. If cell density is below optimal, it may yield reduced signal level. In contrast, if a well is overloaded with cells, some of the cells cannot attach to the bottom of the well and can be pushed aside during the assay when compounds are injected. This can result in high well-to-well variation in assay results. In general, cells should be distributed evenly as a monolayer at the bottom of the plate after the centrifugation step, with some space between the cells (see [Figure 9](#)). The optimal cell density after the centrifugation step should show a cell distribution similar to [Figure 9A](#), or slightly higher, and should never be more than 100% confluent (not denser than what is shown in [Figure 9B](#)).

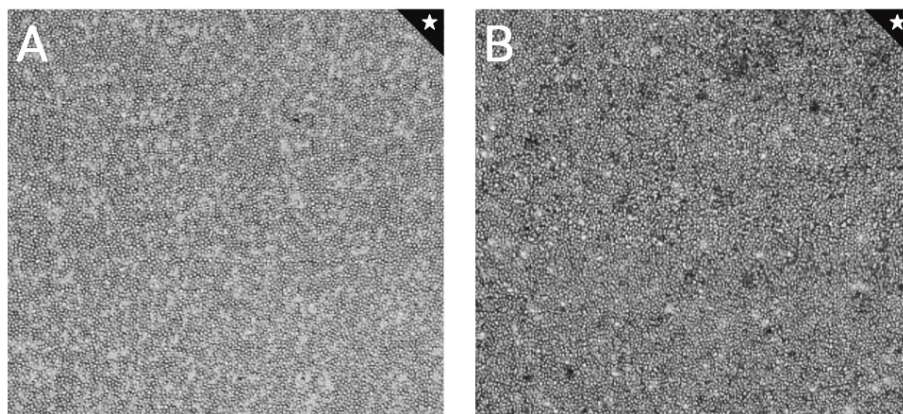


Figure 9. Microscopic view of optimal cell seeding densities: (A) Low end of optimal cell density. (B) High end of optimal seeding density.

### **Do I need to perform experiments to optimize the concentrations of injection compounds for different types of T cells?**

Extensive tests have been performed with different types of human T cells (such as  $T_{naive}$ ,  $T_{effector}$ ,  $T_{memory}$ ) from separate donors, as well as mouse T cells. The results show that the recommended compound concentrations work well for all T cell types. Therefore, it is not necessary to perform concentration optimization experiments when working with T cells.

### **Can I use the XF T Cell Metabolic Profiling kit for other types of cells (non T cells)?**

In theory, the kit should work for all types of cells. However, verification and optimization experiments (such as seeding density and modulator concentration) are required to use the kit with non T cells. [Table 12](#) shows a suggested concentration range for preparing reagents, to perform a concentration optimization experiment. For information on how to optimize seeding density, refer to the [Agilent Seahorse XF Learning Center](#).

Table 12 Recommended concentration range for injection compound optimization experiments.

Compounds	Assay Medium per Vial (mL)	Stock Concentration ( $\mu\text{M}$ )	Loading Solution			Fold in Port	Final Concentration ( $\mu\text{M}$ )
			Stock Solution ( $\mu\text{L}$ )	Assay Medium ( $\mu\text{L}$ )	Concentration ( $\mu\text{M}$ )		
Oligomycin A	2.0	27	200	400	4.5	9x	1.0
			300	300	13.5		1.5
			400	200	18.0		2.0
BAM15	3.3	30	200	400	10.0	10x	1.0
			300	300	15.0		1.5
			400	200	20.0		2.0
			500	100	25.0		2.5
			600	0	30.0		3.0
Rotenone/ Antimycin A	2.0	11	150	450	2.75	11x	0.25
			300	300	5.5		0.5
			450	150	8.25		0.75

### I cannot access Seahorse Analytics. What should I do?

If you experience any issues using Seahorse Analytics, please contact the Agilent Cell Analysis Support team, at: [cellanalysis.support@agilent.com](mailto:cellanalysis.support@agilent.com), to report your issue. You should also double-check your internet connection and/or web browser. Seahorse Analytics works best with Google Chrome, Safari (Apple), Mozilla Firefox, and Microsoft Edge. For any other issues preventing you from using Seahorse Analytics for data analysis, you can export your data to Microsoft Excel and GraphPad Prism to quantify and plot maximum responses and area under the curve data. For more information on how assay parameters are calculated, refer to the Agilent application note, 5994-4494EN.<sup>3</sup>

### Can I use the kit to run assays with my Agilent Seahorse XFe24 Analyzer?

The Seahorse XF T Cell Metabolic Profiling kit (part number 103772-100) has not been validated for use with the XFe24 Analyzer. If using the kit with an XFe24 Analyzer is desired, please contact Agilent technical support at: [cellanalysis.support@agilent.com](mailto:cellanalysis.support@agilent.com).

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