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SSEP
Student Spaceflight Experiments Program

A program of the
National Center for Earth and Space Science Education (NCESSE)
and the Arthur C. Clarke Institute for Space Education

SSEP Mission 9 to ISS: Mini-Laboratory Operation

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IMPORTANT NOTES
Information added or updated since this page went live on March 19, 2015, is in GREEN TEXT below.
Information still to be determined (if any) is in RED TEXT below.
Dates and times that are subject to change at NASA's discretion are in PURPLE TEXT below.

Last update of this page: September 30, 2015, 2:43 pm ET

This page provides all the information you need regarding the mini-laboratory used for experiments on SSEP Mission 10 to ISS — the NanoRacks **Fluids Mixing Enclosure (FME) Mark II Mini-Laboratory**, which NanoRacks has also referred to as a "Mixture Tube" or "MixStik". To minimize ambiguity, SSEP webpages and documents will refer to the device as a "**FME**" or "**Mini-lab**".

On this page you will find all the specifications for the mini-lab, a description of its straightforward operation, and all the constraints on your experimental design, including constraints due to the time it takes from shipping of your experiment to Houston, to arrival and operation on ISS, to return to Earth.

Before reading this page, be sure to read the Designing the Flight Experiment page. It will help you understand how to start thinking about a possible experiment.

1. Introduction to the FME Mini-Lab

The FME is a very simple mini-laboratory designed to carry small samples of fluids and solids—the **Experiment Samples**—and provides for the samples to be mixed at an appropriate time in orbit. This allows you to explore the effects of microgravity on a physical, chemical, or biological system contained in the mini-lab.

The FME consists of a single silicone tube that can contain one, two, or three separate volumes of fluids and/or solids. The tube is divided into sub-volumes using up to two tube clamps. You can think of the FME as one, two, or three small test tubes that can be mixed in orbit.

Each tube is 6.7 inches long (170 mm), with an outer diameter of 0.5 inches (13 mm) and an inner diameter of 3/8-inches (9.5 mm).

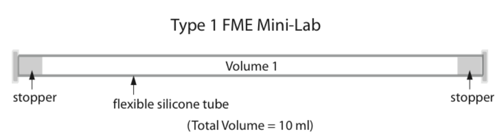

Figure 1: A Type 1 FME mini-lab containing 1 volume for fluids and solids. CLICK ON IMAGE ABOVE FOR ZOOM

Each flight experiment for SSEP Mission 9 to ISS **must be designed** for operation in a FME. The SSEP payload to the International Space Station will contain one FME for each flight experiment. The FMEs will be placed in a **Payload Box** which can contain up to 12 FMEs. SSEP flight experiments will share the Payload Box with flight experiments from professional researchers in academia, industry, and government. NanoRacks has the ability to fly multiple Payload Boxes to accommodate a payload of more than 12 FMEs. Once in orbit, the Payload Box is placed in a rack on Kibo—the Japanese Experiment module (JEM) on ISS.

2. Operating the FME Mini-Lab

The FME is a single silicone tube that can be divided into sub-volumes via clamps. At a prescribed time, an astronaut can release a clamp allowing the contents of the adjacent volumes to mix. Once a clamp is released, shaking the FME is strongly recommended to ensure mixing. Shaking the FME is a "Crew Interaction Request" that the student research team can request.

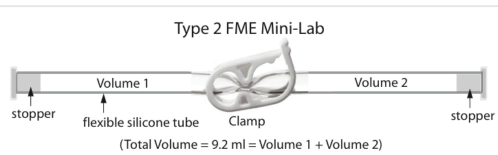

Figure 2: A Type 2 FME mini-lab containing 2 volumes for fluids and solids. CLICK ON IMAGE ABOVE FOR ZOOM

There are three types of FMEs depending on how many different 'test tubes' your experiment will need—

> **Type 1 FME**: contains only 1 experiment sample and no clamps. An experiment using a Type 1 FME by definition requires no mixing. Figure 1 provides a graphic of a Type 1 FME. Download Figure 1 as a pdf

Type 2 FME: contains 2 experiment samples, with the samples divided by 1 clamp. The samples do not need to be equal in volume. Figure 2 provides a graphic of a Type 2 FME. Download Figure 2 as a pdf

Type 3 FME: contains 3 experiment samples, with the samples divided by 2 clamps. The samples do not need to be equal in volume. Figure 3 provides a graphic of a Type 3 FME. Download Figure 3 as a pdf

Important notes:

- *Air Voids:* A volume containing a fluid does not need to be completely filled. Air voids are fine.
- *Sterilization of the FME Mini-lab:* The student flight team needs to assess if sterilization of the FME is needed prior to filling, based on the nature of their experiment. If heat sterilizing an FME, do not exceed 390 deg F for the silicone tube, or 200 deg F for clamps and end caps. Heat sterilization is not recommended for tubes partially filled with samples given it may damage those samples, or cause expansion of samples already loaded and possibly lead to failure of the tube or clamp. Alternatively, sterilization can be done by gas (*e.g.* ETO), radiation, or chemicals.
- *Sterilization of the Experiment Samples (Fluids and Solids):* It is particularly important for a student team flying a biological experiment to consider the need to sterilize not just the mini-lab but also sterilize, or obtain in a sterilized form, the biological material and any other fluids and solids used. Without the use of sterilized fluids and solids, other unwanted biologicals will surely be present, such as microbes and fungi (*e.g.,* yeasts and molds), and growth of these unwanted hitchhikers can easily cause failure of the experiment by killing the biologicals under study. This is one example of why it is vitally important for student researchers to work with professional researchers with expertise in the biological system to be studied. In addition, regarding more specific experiment samples, NanoRacks has made available protocols for sterilization of seeds and of fruit and vegetable samples. To obtain these protocols please Contact NCESSE.

3. Fluids Mixing Enclosure (FME) Kits – You Get the *Real* Flight Hardware and Load It for Flight to ISS

As part of the Baseline Program Cost, each participating community will receive a package of five **Fluids Mixing Enclosure (FME) Kits**, each Kit providing all the parts for the assembly and loading of a flight certified Type 1, Type 2, or Type 3 FME.

Each FME Kit provides the ACTUAL flight hardware. Each experiment selected for flight will be conducted in an FME that the student team assembles from one of their Kits, loads, seals, and ships or hand-carries to NanoRacks in Houston for flight on the ISS. When NanoRacks receives your FME, they will heat seal two polyethylene bags around it to serve as a second and third level of containment (see Section 6.1 below), load it in the Payload Box, and deliver the entire payload to NASA for integration into the launch vehicle.

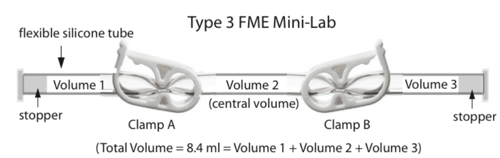

Figure 3: A Type 3 FME mini-lab containing 3 volumes for fluids and solids. CLICK ON IMAGE ABOVE FOR ZOOM

On return to Earth, the sealed FME will be shipped back to you, or provided to your team's representative in Houston. Once received, the student team conducts their own harvesting of the samples from the FME and analysis of the samples.

This approach allows students to get broad experience in all aspects of their experiment design and operation, and there is no third-party handling of the experiment samples before they are sealed in the FME destined for space. The other four FME Kits can be used by your community to demonstrate and assess the operation of the FME mini-lab, design and refine experiments, and conduct formal ground truth experiments (see Section 4 below) while the flight experiment is ongoing. The FME Kit is therefore also an exceptional experiment design tool, providing an understanding of precisely how the experiment can be conducted on ISS.

An important note on testing and refinement of proposed experiments: All experiments that are being proposed as part of the community-wide design competition should be tested using standard laboratory test tubes and mixing protocols in advance of writing any proposal in order to assess if the experiment is viable. The data from these tests should in fact be incorporated into the proposal. Once the flight experiment for the community is selected, the student flight team needs to assess and optimize the experiment using an actual FME before the final lock-in of the flight configuration of the experiment. The student team typically has at least 2 months (from selection to lock-in) to optimize their experiment in real flight hardware.

Figure 4: Photo of Type 3 FME with three separated fluids.

If a participating community would like more than 5 FME Kits, they are available as packages of five Kits for an additional cost.

Important note: NanoRacks has created videos with detailed instructions for assembling, loading, and sealing the FME. The videos are found in the Document Library.

4. Ways to Think About Using the Different Types of FMEs—Some Examples

There are countless experiments that can be done in the FME mini-lab. To gain an understanding of the kinds of experiments possible in microgravity, first read the Designing the Flight Experiment page, and then the **Microgravity Science Background** and **Microgravity Experiment Case Studies** documents available for download at the Document Library. You can also read summaries of all SSEP experiments selected for flight to date.

Here are a few ways to think about using the different type FME mini-labs for microgravity experiments—

A Type 2 FME: is a good choice for experiments that need to be started with a single mix but do not need to be terminated. A dormant organism could be placed in one volume, and a suitable growth medium could be placed in the remaining volume. Once in orbit on ISS, the clamp between the two volumes is unlatched and the experiment is started. As one example, the Type 2 FME is well suited for an experiment exploring how a seed will germinate in microgravity. The dry seeds can be placed in one volume of the tube, and in cotton to wick the growth medium when the clamp is unlatched. But the timing is crucial – if the experiment is started on arrival at ISS, seedlings will be long dead by the time they arrive back on Earth. Once approach is to start the experiment closer to departure from ISS. Another approach might be to use a Type 3 FME (see below), to introduce a biological fixative to kill and preserve the seedlings for study when they arrive back on Earth.

A Type 3 FME: is good for any experiment that requires three separate samples to be brought together. A good example is an experiment that requires a first mix to activate the experiment, and a second mix to shut down the experiment. For example, a biological experiment where a first mix activates a freeze dried micro-organism by introducing a growth medium, and a second later mix introduces a biological fixative to kill and preserve the biology (or a growth inhibitor to greatly slow the biology) to terminate the experiment. Why might you want to do this? Imagine a biological experiment that explores whether generations of microorganisms produced entirely in microgravity have any observable differences relative to those cultured on Earth. But the lifetime for each generation can be very short. Even just the 2-4 days of re-exposure to gravity from the time the payload returns to Earth until the FME is received by the student team may result in a situation where the living generation was produced entirely in a gravity environment. Introducing a biological fixative or a growth inhibitor before the FME is brought back to Earth eliminates this problem. For more information, read the **Using Biologicals in SSEP Experiments: Dormant Forms, Fixatives and Growth Inhibitors** document downloadable at the Document Library.

A Type 1 FME: provides a self-contained microgravity environment for an experiment that is ‘pre-loaded’ before launch, and requires no mixing of sample materials once in orbit. It may be that just exposure to microgravity is the trigger for the experiment. As an example, a selected SSEP flight experiment was designed to test if synthetic blood has the same long shelf life in microgravity as here on Earth, which is an important question for addressing medical emergencies in space that require a transfusion (on long duration space flights, there will be no means to carry whole blood given its short shelf life.) The experiment required a Type 1 FME filled with synthetic blood sitting on ISS for many weeks, and on its return to Earth assessing if it degraded as compared to synthetic blood on Earth from the same manufacturing lot.

Note on the importance of Ground Truth Experiments: a ground truth experiment is one that is identical to the experiment in orbit, except it is conducted on the ground, and at the same time the experiment is conducted in orbit. The objective of a microgravity experiment is to assess the role of gravity in a physical, chemical, or biological system by taking the system to an environment where gravity is seemingly turned off, *e.g.*, taking it to a continuously freely falling laboratory like ISS. But to determine the role of gravity in a system, one needs to compare the flight experiment on its return to Earth to an identical experiment conducted at the same time on Earth – in the presence of gravity. A ground truth experiment is therefore always a vital element of microgravity experiment design. In addition, an experiment team should consider conducting multiple ground truth experiments, since this is straightforward to do, and provides more data that can be used to define an average behavior on the ground.

A ground truth is also vital in the case of an experiment that is not terminated on orbit using *e.g.*, a biological fixative or growth inhibitor. Such an experiment will likely continue after its return to Earth, and re-exposure to normal gravity can ‘contaminate’ the results. But the duration of the experiment on ISS may be substantially longer than the up to 4 days of exposure to gravity before you receive the FME (due to landing, transport back to Houston, and possible FedExing to you). The experiment will have been carried out mostly in microgravity, but also with a short exposure time to gravity. Comparison to a ground truth allows you to assess differences due to the microgravity exposure.

5. Mixing the Experiment Samples in the FME Once in Orbit: Available Crew Interaction Days and Allowed Crew Interactions

Specific astronauts on ISS will be assigned to oversee operation of the SSEP payload of experiments, and will receive training by NanoRacks on FME operation. Note, however, that to ensure SSEP operations fit within the overall schedule of crew activities, and to ensure astronaut training covers all possible FME interactions, NanoRacks in concert with NASA has defined–

Five Allowed Crew Interaction Days: there are only five specific days while the SSEP payload is aboard the space station when astronauts will be able to interact with the FMEs. These are designated the “Crew Interaction Days”, and are the only days that can be requested by student teams for crew interactions.

Allowed Crew Interactions: NASA has defined a list of likely the only specific crew interactions allowed with the FMEs. These are designated the “Allowed Crew Interactions”.

Important note: All student teams designing microgravity experiments must ensure that their experiment proposal only requests interactions on the allowed Crew Interaction Days, and only requests Allowed Crew Interactions. Any proposal submitted by a student team that does not adhere to these requirements should be rejected by the community and not forwarded to the community’s Step 1 Proposal Review Board.

5.1 Allowed Crew Interaction Days for Mission 9 to ISS
Student teams can only choose Crew Interaction Days from the Table below for the assigned astronaut to manipulate their FME – days which best fit their experiment design. For the days listed below, A=0 is the Day of Arrival, when the SSEP experiments payload is brought from the ferry vehicle through the hatch on ISS. U=0 is the Day of Undock, when the ferry vehicle with the SSEP experiments payload undocks from ISS for return to Earth.

Crew Interaction Day	Description	Day
1	on arrival at ISS	A=0
2	during first week	A+2
3	2 weeks prior to undock	U-14

4	in week prior to undock	U-5
5	in week prior to undock	U-2

Important note on adjustments to scheduled crew interaction days: ISS astronauts do not have tasks scheduled on weekends. The above schedule may require adjustment if any of the interaction days above fall on a weekend.

Important note on the duration of your experiment: the significant length of time from handover of your FME to NanoRacks in Houston through its arrival on ISS implies that most experiments will need to be in a dormant (inactive) state until arrival on ISS (see Section 6.3 below for constraints imposed by the timeline). If your experiment is inactive until initiated with a mix, then your experiment can be initiated (activated) on any Crew Interaction Day listed above with an astronaut unlatching a clamp. In addition, your might design an experiment that can also be terminated with a second mix, which is possible using a Type 3 FME. You then have the latitude to define how long your experiment should proceed in microgravity before de-orbiting and returning to Earth. But only the Crew Interaction Days in the Table above are allowed. For example, if you only want your experiment to run for two days on ISS, you can choose Crew Interaction Days that are two days apart (A=0 and A+2 above). If you want your experiment to run roughly two weeks, choose Crew Interaction Days that give you a roughly two-week run time for your experiment (U-14 and U-2 above). Also note that the crew interactions you define for your experiment are independent of any other FME experiment being performed.

For the five Crew Interaction Days in the Table above, an experiment can run for: 2 days, 3 days, 9 days, and 12 days. Also note that the time from Arrival to Departure is nominally 6 weeks, but can be significantly shorter or longer, *e.g.*, 4 to 14 weeks. Through choice of Crew Interaction Days, an experiment can also run for the entire time it is aboard ISS (from A=0 to U-2), as well as approximately 1 to 2 weeks less than the entire time (from A=0 to U-14).

5.2 Allowed Crew Interactions for Mission 9 to ISS

Each FME is self-contained, allowing each student flight experiment team to select appropriate Crew Interaction Days when mixing is to take place for their experiment. In the case of a Type 3 FME, mixing would require at least two crew interactions. To mix samples in the FME, the astronaut is instructed to “un-clamp” the appropriate clamp, and should also be instructed to “shake” the tube. Allowed crew interactions also include a request to “wait” a period of time between two interactions, and to “clamp” (which means re-clamp a particular clamp).

The only currently Allowed Crew Interactions are listed in the Table below, along with appropriate modifiers that can be used.

Allowed Crew Interactions That Can Be Requested	Allowed Modifiers
“Un-Clamp”	none
“Clamp” (means re-clamp)	none
“Shake”	type of shaking: “gently”, “vigorously” duration options in seconds: “5 sec”, “10 sec”, “20 sec”, “30 sec”, “60 sec”, “90 sec”
“Wait”	a team can request that the astronaut wait a specified number of seconds between two other requested interactions; wait duration: “xx sec”

Important note on the total time that can be requested per day: the maximum total time per FME on any one Crew Interaction Day is 120 seconds.

Important note on the order of unlatching the two clamps for a Type 3 FME: to guard against human error in unlatching clamps for the Type 3 FME, Clamp A (located between Volumes 1 and 2) will be the first clamp unlatched by the astronaut, and will be color-coded as a GREEN clamp for the astronaut.

There are two possible configurations for unlatching Clamp B (located between Volumes 2 and 3):
i) Clamp B is unlatched at the same time as Clamp A. In this case Clamp B will also be color-coded as a GREEN clamp.
ii) Clamp B is unlatched on some later Crew Interaction Day. In this case, Clamp B will be color-coded as a BLUE clamp.

Important note on other possible crew interactions and interactions that are not allowed: If a student team wants NanoRacks to consider allowing an interaction other than what is provided in the Table above, please alert NCESSE as soon as possible. The likelihood of any other interactions is very low, but NCESSE is willing to assess the request with NanoRacks and NASA on a student team’s behalf. However, there can be no request for the astronaut to: observe what is happening in the FME; take notes; photograph the FME; or videotape the FME.

Why no photos or videos allowed?

6. Critical Experimental Design Constraints

Just like a professional researcher using a pre-existing laboratory or lab apparatus, you need to design your experiment to the constraints imposed by the equipment you are using and the environment in which it is to operate. Listed below are the critical design constraints you need to consider regarding: 1) the Experiment Samples (fluids and solids) that can be used; 2) the design of the FME and its operation on ISS; and 3) how long it will take: a) from receipt of your FME by NanoRacks in Houston to the time it arrives at ISS, and b) from your FME’s departure from ISS until it is received by you.

6.1 Experiment Samples—Restrictions on the Fluids and Solids That You Can Use in Your Experiment

Each SSEP experiment selected for flight must pass a NASA Flight Safety Review. The review is conducted by NASA Toxicology at Johnson Space Center, and is meant to ensure that the fluids and solid materials to be used in the experiment—the **Experiment Samples**—pose no risk to the astronaut crew, ferry vehicles, or ISS. The level of risk depends on the toxicity of the experiment samples AND how well they are contained in the mini-lab. The more “**levels of containment**” that are engineered into the mini-lab, the less the restrictions on the experiment samples. For each SSEP flight opportunity, NCESSE and NanoRacks work hard to ensure a high probability that each of the experiments passes Flight Safety Review. This is done by assessing the safety features engineered into the mini-lab to be used, and what restrictions this assessment imposes on allowable experiment samples.

As a benchmark of success, all of the 114 SSEP experiments selected for flight on the first 8 SSEP flight opportunities (SSEP on Shuttles Endeavour and Atlantis, and SSEP Missions 1 through 6 to ISS) passed Flight Safety Review. However, it is important to note that the final decision on whether an experiment passes the Review is NASA's and out of the control of NCESSE and NanoRacks.

For SSEP Mission 9 to ISS, the FME mini-lab has three nested and sealed enclosures surrounding the fluids and solids to guard against an accidental release into the crew cabin. This includes the main silicone tube, together with the two polyethylene bags NanoRacks will heat seal around the tube once the flight FME arrives in Houston (see Figure 5). The FME is said to have **three levels of containment,** and this provides so much redundancy against an accident that a very significant number of fluids and solids can be used by a student team. However, the following are restrictions and requirements regarding the fluids and solids that can be used in the FME mini-lab:

Figure 5: FME Mark II mini-labs in nested heat-sealed bags.
CLICK IMAGE ABOVE FOR ZOOM

a. *Prohibited Samples:* Student teams must **NOT** use any of the following fluids and solids.

radioactive fluids or solids
perfumes
hydrofluoric acid
magnets
cadmium
beryllium
acetone

A finalist proposal submitted to NCESSE that makes use of any of the substances listed above will be rejected automatically and will not move forward to the Step 2 Review Board for review.

b. Hazardous Samples: NanoRacks and NASA reserve the right to refuse other fluids/solids not included in the list above based on hazard level. All student teams proposing experiments are therefore advised to consider carefully the level of hazard posed by the samples they are planning to use, even if they are not included in the list of prohibited samples above. **If your experiment is making use of something that is known to be hazardous, NCESSE advises you to alert us as soon as the potential hazard is identified as part of your experiment brainstorming. This approach will allow NanoRacks to assess the hazard and any potential impact on NASA Flight Safety Review before your team invests lots of time in experiment design and proposal writing.**

Examples of hazardous samples that require NCESSE to be contacted as soon as such a sample is being considered by a student team:

-fluids/solids that are hazardous enough that there is concern that the student team is handling these substances

-fluids/solids that when mixed can result in excess heat and/or pressure inside the tube, leading to loss of containment; fluids/solids can also be denied if there is evidence that excess heat – even chemically generated light – can adversely impact other FMEs that share the payload box on ISS

-biologicals with a designated BioSafety Level (BSL) of 2 or higher (see this CDC slideshow for more information)

c. *Problematic Samples*: there are a significant number of fluid/solid samples that can adversely interact with the mini-lab's silicone tube. These samples cannot be used in a 100% concentration; however, these materials may be used on a case-by case-basis depending on proposed concentrations, volumes, solutions, etc. NanoRacks therefore asks all student researchers to assess if any of their proposed fluids and solids are on the NanoRacks **List of Problematic Samples** document and if so, contact NCESSE as soon as such a substance is being considered for an experiment so that NanoRacks can review and rule on whether it can be used. The List of Problematic Samples document is located in the Document Library.

d. *Technology:* teams may not propose to fly technology in the FME. This includes batteries, lighting, and any device that is associated with electrical circuits and/or mechanical systems. Such technology is not covered by flight safety review. It requires a more detailed and lengthy process of flight certification. SSEP does not support flight certification of technology for placement inside the FME.

Additional requirements on experiment samples (fluids and solids) proposed for flight:

a. Human Samples: All human samples, such as blood, will need to be tested for Hepatitis B, Hepatitis C, HIV-1, HIV-2, HTLV-1, and HTLV-2. Before the selection of an experiment using human samples can be confirmed, the team must provide to NCESSE a certification letter from the sample vendor stating that tests for the presence of these viruses in the sample to be used for the flight experiment have been conducted, and the sample is free of the viruses listed above. If a vendor cannot provide the certification, the student team must arrange for these tests to be conducted in a medical laboratory, which can then provide the required certification letter. A certification letter should accompany any finalist proposal submitted to NCESSE if the use of human samples is proposed.

b. Material Safety Data Sheets: Each student team is required to provide a standard Material Safety Data Sheet (MSDS) for *each* of their experiment samples (fluids and/or solids). An MSDS is often available from the vendor from which you purchase the sample as a downloadable PDF file. For those samples where an MSDS is not typically provided by the vendor, *e.g.,* Tilapia fish eggs, NCESSE will provide the team the necessary guidance to submit the needed safety paperwork without undue burden. The MSDSs need not be provided when the proposals are sent for review, but they must be made available before the selection of an experiment for flight can be confirmed.

c. *Specificity of Samples:* Before the selection of an experiment for flight can be confirmed, each flight experiment team must provide a list of their samples with the level of specificity described in the document **Required Specificity for Description of Experiment Samples**, which is available for download in the Document Library. Required information includes precise sample names, volumes, concentrations, and pH.

6.2 FME Dimensions, and Volumes for Fluids and Solids

The FME is a mini-laboratory, which means the volumes for experimental samples **are small**. So be sure you design an experiment with the specifications below in mind.

Interesting Facts: flying crew and payload to Low Earth Orbit is exceedingly expensive, *e.g.,* the U.S. currently pays Russia $72,000,000 to fly a single astronaut to ISS. The volume and mass of payloads must therefore be kept low to keep costs manageable. That's why the FME as a professional microgravity mini-laboratory is small. But 'small' is relative – the volumes listed below are 50 times larger than those for the professional microgravity mini-labs used for cancer research – as well as SSEP – on the final two Space Shuttle flights.

Each FME tube is 6.7 inches long (170 mm), with an outer diameter of 0.5 inches (13 mm) and an inner diameter of 3/8-inches (9.5 mm).

Type 1 FME:
Total Sealed Volume: 10.00 ml (this is volume after the two barbed stoppers are inserted in each end of the tube)

Type 2 FME:
Total Sealed Volume = Volume 1 + Volume 2: 9.2 ml (this is volume after the two barbed stoppers are inserted in each end of the tube)
Note: compared to a Type 1 FME, introduction of one clamp in the Type 2 reduces total volume by 0.8 ml
Note: minimum volume for Volume 1 or Volume 2 (achieved when a clamp is placed as close to the end of the tube as possible): 1.2 ml

Type 3 FME:
Total Sealed Volume = Volume 1 + Volume 2 + Volume 3: 8.4 ml (this is volume after the two barbed stoppers are inserted in each end of the tube)
Note: compared to a Type 1 FME, introduction of two clamps in the Type 3 reduces total volume by 2 x 0.8 = 1.6 ml
Note: minimum volume for Volume 1 or Volume 3 (achieved when a clamp is placed as close to the end of the tube as possible): 1.2 ml
Note: minimum for Volume 2 (achieved when both clamps placed as close to one another as possible): 1.9 ml

6.3 Constraints Due to the Flight Timeline for SSEP Mission 9 to ISS

Important constraints on the design of your experiment are associated with the timeline from turnover of your flight FME to NanoRacks in Houston, to when it arrives back in Houston after its flight in space. While the milestones listed below remain tentative until NASA sets precise launch and landing dates for the ferry vehicles to and from the ISS, the milestones make it possible for the student proposing teams to design their experiment with the mission timeline in mind.

The relevant critical milestones for the mission timeline for **SSEP Mission 9 to ISS**—

- Deadline for NanoRacks in Houston to receive your flight FME: **Launch minus 2.5 weeks**
- Handover of the SSEP Payload to NASA: **Launch minus 1 week**
- SSEP payload is placed aboard the ferry vehicle: **Launch minus 2 days**
- Target launch date for SSEP Payload to ISS: **Current target: Spring 2016**
- Payload transferred to ISS: **Launch plus approximately 2-3 days**
- Payload transferred from ISS to ferry vehicle; spacecraft undocking and landing: **Aim is for Launch plus approximately 4-6 weeks, but can be significantly longer, *e.g.*, 14 weeks**
- Your FME is ready for pickup in Houston or for domestic FedExing to you overnight: **Landing +(24 to 60) hours**

These dates lead to the following conclusions:

a. it will take about **3 weeks** from the time you give your flight FME to NanoRacks to the time it arrives at ISS

b. it will be on ISS for approximately **4-6 weeks or longer** before being transferred to the return vehicle, and the vehicle undocks for return to Earth

c. it will be **24 to 60 hours** from the time the ferry vehicle undocks from ISS to when your FME is ready for pick up in Houston (or domestic FedExing to you)

d. it will be **7.5 weeks or longer** from the time you give your FME to NanoRacks in Houston to it being ready for pickup in Houston (or FedExing to you) after its return from space

These conclusions likely lead to the following constraints on your experiment design:

a. Your experiment likely needs to be in stasis (in a dormant or inactive state) until it arrives on ISS. For example, if you are using biological samples, they need to be dormant until the experiment is initiated on ISS. Some examples of dormant biological samples include: seeds; dehydrated macroscopic organisms and eggs such as brine shrimp eggs; and hundreds of freeze-dried microscopic organisms like bacteria—all of which are commercially available. If the dormant biological sample is placed in one volume of the FME, the experiment can be initiated by an astronaut on ISS by unlatching the clamp and mixing the sample with a rehydration or nutrient fluid contained in the adjacent volume.

b. Dormant samples may benefit from refrigeration during transport of your flight FME from you to Houston and on to ISS. **NanoRacks is arranging refrigeration for transportation of the FMEs from the moment your flight-ready FME arrives at NanoRacks to when it reaches the ISS** (see Section 6.4 below).

Important note: refrigeration of FMEs aboard the ISS is not available.

c. Prior to the transfer of your FME to the ferry vehicle for return to Earth, you might want to terminate a biological experiment by introducing either a "fixative" which kills and preserves the biology, or by introducing a growth inhibitor which dramatically slows biological activity. This allows you to 'shut-down' the biology before it is re-exposed to a gravity environment for up to 2.5 days before you receive it in Houston (four days if FedEx overnight shipping is required from Houston to you). Terminating a biological experiment can be done in a Type 3 FME with a fixative or inhibitor in the third volume, where the appropriate clamp can be unlatched before the FME leaves ISS. For more information, read the document **Using Biologicals in SSEP Experiments: Dormant Forms, Fixatives and Growth Inhibitors** in the Document Library.

6.4 Thermal (Temperature) Control

There is no active thermal (temperature) control within the FME. You should therefore expect the FME to be subjected to whatever the temperature conditions might be along its route from handover of your FME to NanoRacks in Houston to return of your FME after its flight in space. So, as an example, if you ship via FedEx to Houston without any added thermal control, *i.e.*, cold packs, depending on time of year, the FedEx truck can be exceedingly hot.

Provided for you below are the options and expectations for thermal control for different legs along the route.

SSEP is meant to offer real experiment opportunities on ISS that are interdisciplinary, and at the grade 5-12 level, intersect the science curriculum across the physical science, earth/space science, and biological science strands. That said, SSEP experiments are exceptionally well suited to biology, as long as biological samples can be maintained in a relatively dormant state until reaching ISS. While many biologicals can be kept in a dormant state at room temperature, some of them require refrigeration at a temperature of 2-8ºC. We therefore work with NanoRacks to arrange refrigeration of the SSEP payload over much of your FME's journey, including the following legs (unless otherwise noted):

Figure 6: SSEP Payload Box containing FME Mark 2 mini-labs. CLICK ON IMAGE ABOVE FOR ZOOM

a. shipping of your FME from you to NanoRacks in Houston: you can ship with cold packs (there are real constraints provided by NanoRacks for how to do this successfully)

b. NanoRacks storage of your FME until handover to NASA: teams can request their FMEs to be refrigerated (at approximately 2-4ºC)

c. from NanoRacks handover to NASA, through loading aboard the ferry vehicle, launch, and transfer to ISS: NanoRacks has made arrangements for refrigeration on this leg.

> **IMPORTANT NOTE: during transport of the payload to the launch site, loading aboard the ferry vehicle, launch, and through arrival at the ISS, if any FME mini-lab requires refrigeration then the entire SSEP payload of mini-labs will be refrigerated. Based on prior SSEP missions, all teams should expect their FME to be refrigerated.**

d. aboard ISS, over the 6 weeks or more that your FME will be aboard ISS, there will be no refrigeration. During this time, you should expect the ambient conditions of the crew cabin, with a temperature of 21-24ºC (70-75°F) – a shirtsleeve environment.

e. from loading aboard the return ferry vehicle, to undocking, to landing, and transport to Houston (expected duration: 24-60 hours): no refrigeration is available for this leg

f. shipping from NanoRacks in Houston to you: you can request your package be shipped with the same cold packs used when you sent the FME to Houston

As a result of these considerations, each experiment should be designed assuming it will be refrigerated en route to ISS. Additionally, teams requesting refrigeration during transportation to ISS, may want to have their experiment initiated shortly after arrival at ISS, given that the FMEs will be brought to room temperature on arrival, and remain at room temperature for the remainder of their stay aboard ISS.

Note that for Mission 9 to ISS, the thermal controls described above are the only ones available. For example, there will be no access to an incubator aboard ISS, nor can any of the samples be kept frozen during transportation or aboard ISS.

6.5 Other FME Constraints

The FME:

- has no means of active data acquisition on orbit
- has no onboard light source, and the FMEs must be stowed in an opaque payload box.
- has no provided power

7. Very Important Information for the Experimenter

Make sure to read the Designing the Flight Experiment page for how to think about framing an experiment, and an overview of the science that might be explored in microgravity. Make sure to read about the suite of Teacher and Student Resources. Make sure to get **very** familiar with the SSEP Mission 9 to ISS: Critical Timeline, and information on the student team proposal process on the Flight Experiment Design Competition page.

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The Student Spaceflight Experiments Program (SSEP) is a program of the National Center for Earth and Space Science Education (NCESSE) in the U.S., and the Arthur C. Clarke Institute for Space Education internationally. It is enabled through a strategic partnership with NanoRacks LLC, working with NASA under a Space Act Agreement as part of the utilization of the International Space Station as a National Laboratory. SSEP is the first pre-college STEM education program that is both a U.S. national initiative and implemented as an on-orbit commercial space venture.