## 3.2 Medical Requirements Overview

**TABLE 3.2: MEDICAL REQUIREMENTS OVERVIEW**

| | |
|---|---|
| **MEDB# and Title:** | N3.07 Cycle Ergometer Test/Aerobic Functional Capacity |
| **Sponsor:** | Medical Operations |
| **Discipline:** | Cardiovascular, Exercise, Muscle |
| **Category:** | Medical Requirements (MR) |
| **References:** | SSP 50260, International Space Station Medical Operations Requirements Document (ISS MORD)<br>SSP 50667, Medical Evaluation Documents (MED) Volume B Section N3.07 and 4.3 |
| **Purpose/Objectives:** | This Medical Requirement Integration Document (MRID) encompasses both the annual assessment of cardiovascular status and the aerobic fitness testing performed before, during and following ISS flight.<br><br>The testing shall be performed on an annual basis for all astronauts on active flight status. The annual testing documents that the astronaut maintains an acceptable cardiovascular training status and has no clinically significant cardiac abnormalities.<br><br>Once a crewmember is assigned a specific mission, testing will be performed according to "crewmember assigned specific mission" schedule contained herein. The pre-, in- and postflight ISS testing provides data to document the cardiovascular training status of the astronaut. These data are used to set and adjust specific exercise prescriptions for each NASA crewmember prior to, during and following long-duration flight. The data from these assessments will also provide group data for analyzing countermeasure and rehabilitative program effectiveness. |
| **Measurement Parameters:** | ECG, heart rate, oxygen consumption to peak exercise levels ($VO_2$ peak, also referred to as aerobic capacity). Ratings of perceived exertion (RPE) are to be monitored during ground-based testing. Blood pressure measurements will be obtained pretest, at various points during exercise and throughout recovery. |
| **Deliverables:** | Assessment of aerobic capacity by Exercise Physiologists (EP). ECG interpretation by a cardiologist of ground tests. |
| **Flight Duration:** | ≥ 30 days for flight, annual requirement otherwise. |
| **Number of Flights:** | Every ISS Expedition |
| **Number and Type of Crew Members Required:** | All U.S. crewmembers. |
| **Other Flight Characteristics:** | None |

## 3.3 Preflight Training

**TABLE 3.3: PREFLIGHT TRAINING**

| | | | |
|---|---|---|---|
| **Preflight Training Activity Description:** | Countermeasures Systems CEVIS Operations (CMS OPS): This lesson introduces crewmembers to some of the Countermeasures Systems (CMS) hardware and software. It includes the Heart Rate Monitor (HRM), the Cycle Ergometer with Vibration Isolation System (CEVIS), and the Countermeasures Software (CMSS) located on Space Station Computers (SSC) which is used for data storage, data transmission and data retrieval. The lesson focuses on the purpose and operations of CMS hardware and software, incorporating procedure use throughout.<br><br>Portable Pulmonary Function System Operations (PPFS OPS): This training will be conducted during an assigned ISS crewmember's rotation to ESA prior to flight. The lesson introduces the crewmember to the Portable Pulmonary Function System (PPFS) hardware and software. The lesson includes how to set-up, calibrate, operate and stow the PPFS and its' associated consumables.<br><br>VO2 Training: The crewmember will use nominal PPFS procedures developed for VO2 measurements to connect session-unique hardware interfaces, perform a calibration, add files to the downlink list, shutdown, and stow. The crewmember may also choose to perform the sub-max portions of the exercise protocol.<br><br>VO2 Proficiency Training: This lesson provides refresher training on the test hardware, focusing on the test set-up, PPFS calibration procedures and troubleshooting. This lesson may be combined with a preflight data collection session, preferably the one scheduled for L-3 to L-1 month. | | |
| **Schedule:** | **Duration:** | **Schedule:** | **Personnel Required:** |
| | 60 minutes | L-1 year CMS Ops | Instructors/Crew |
| | 90 minutes | L-300 d PPFS Ops | Instructors/Crew |
| | 90 minutes | L-180 d VO2 Training | Instructors/Crew |
| | 60 minutes | L-90 to L-30 d VO2 Proficiency Training | Instructors/Crew/Exercise Physiologist (EP) |

<table>
<tr><td rowspan="2">Ground Support Requirements Hardware/Software</td><td colspan="2">Preflight Hardware:</td><td colspan="2">Preflight Software:</td><td>Test Location:</td></tr>
<tr><td colspan="2">CEVIS, Station Support Computer, PPFS, PPFS/PFE Consumables, HRM, USB</td><td colspan="2">CEVIS Control Panel w/Windows Operating System, PPFS Software (internal to the PPFS)</td><td>U.S. and ESA (Köln)</td></tr>
<tr><td rowspan="4">Training Facilities</td><td>Minimum Room Dimensions:</td><td>Number of Electrical Outlets:</td><td>Temperature Requirements:</td><td>Special Lighting:</td></tr>
<tr><td>Approximately 20 ft. x 20 ft.</td><td>Four 120 VAC (USA)<br>Four 220 VAC (ESA)</td><td>20 -25°C</td><td>N/A</td></tr>
<tr><td>Hot or Cold Running Water:</td><td>Privacy Requirements:</td><td colspan="2">Other:</td></tr>
<tr><td>Both</td><td>N/A</td><td colspan="2">N/A</td></tr>
<tr><td>Constraints/Special Requirements:</td><td colspan="5">Wear workout clothing (shorts, t-shirt, sneakers).</td></tr>
<tr><td>Launch Delay Requirements:</td><td colspan="5">Crewmembers will be required to participate in refresher training (VO2 Proficiency Training) if launch is delayed by more than 3 months.</td></tr>
<tr><td>Notes:</td><td colspan="5">[a] -60 minutes if done separately, 30 minutes if combined with a data collection session.</td></tr>
</table>

## 3.4 Preflight Activities (Includes Routine Annual Aerobic Capacity Test)

**TABLE 3.4: PREFLIGHT ACTIVITIES**

<table>
<tr><td rowspan="7">Preflight Activity Description:<br><br>Schedule:<br><br>Single Flow to Launch Schedule (Crewmember Assigned to Specific Mission):</td><td colspan="5"><u>Cycle Exercise Test:</u> Electrocardiogram and blood pressure measurements shall be performed at the end of 5 minutes of supine rest and three minutes of seated rest prior to the exercise portion of the test. ECG, ratings of perceived exertion (RPE), blood pressure measurements and metabolic gas analysis shall be obtained during the exercise portion of the testing. ECG and blood pressure shall also be recorded, at minimum, during the first 5 minutes of recovery and may be extended based upon clinical indications. One of two cycle exercise protocols will be used for testing (either a “light” or “nominal” protocol). The choice of protocol used is primarily dependent on the crewmember’s body weight (light protocol is designed for those weighing < 65 kg), but the nominal protocol also may be used for an individual weighing < 65 kg who regularly performs cycle exercise training. See “Cycle Exercise Test Protocols” Table below for further specifics.</td></tr>
<tr><td>Activity:</td><td>Duration:</td><td>Schedule:</td><td>Flexibility:</td><td>Personnel Required:</td></tr>
<tr><td>Annual Test</td><td>60 minutes</td><td>Annually</td><td>+/- 30 days</td><td>Lab Personnel<br>Crewmember, Physician (on call)</td></tr>
<tr><td>Upright Test</td><td>60 minutes</td><td>L-12 months[a]</td><td>+/- 30 days</td><td rowspan="3">Lab Personnel, Crewmember, Physician (on call)</td></tr>
<tr><td>Supine Measure</td><td>60 minutes</td><td>L-90/30 days*<br>*Ideally L-1 month, flexibility is given due to launches in Russia. The test should be scheduled during the last US rotation prior to launch</td><td rowspan="2">+/- 30 days<br>The L-90/30 days upright and supine tests should be performed within 14 days of each other</td></tr>
<tr><td>Upright Test</td><td>60 minutes</td><td>L-90/30 days</td></tr>
<tr><td rowspan="2">Ground Support Requirements Hardware/Software</td><td colspan="2">Preflight Hardware:</td><td colspan="2">Preflight Software:</td><td>Test Location:</td></tr>
<tr><td colspan="2">LODE Electronic Cycle Ergometer, Electrocardiographic System[b], Metabolic Gas Analyzer[c, d, e], Metabolic Gas Analyzer Accessories, Metabolic Gas Analyzer Consumables, Sphygmomanometer, RPE Chart, Supine Cycle Ergometer</td><td colspan="2">Electrocardiographic Software[b]<br>Metabolic Gas Analysis Software[c, d, e]</td><td>U.S.</td></tr>
</table>

<table>
<tr><td rowspan="4">Testing Facilities</td><td>Minimum Room Dimensions:</td><td>Number of Electrical Outlets:</td><td>Temperature Requirements:</td><td>Special Lighting:</td></tr>
<tr><td>Approximately 20 ft. x 20 ft.</td><td>Four 120 VAC</td><td>20 -25°C</td><td>NA</td></tr>
<tr><td>Hot or Cold Running Water:</td><td>Privacy Requirements:</td><td colspan="2">Other:</td></tr>
<tr><td>Access to hot and cold running water is necessary.</td><td>Access to room must be controlled during testing.</td><td colspan="2">All monitoring personnel will be AED qualified and an AED will be present within the test facility. The EP monitoring the ECG shall be certified as a BLS provider by the AHA and is trained in the interpretation of graded exercise results.</td></tr>
<tr><td>Constraints/Special Requirements:</td><td colspan="4">• Testing to be performed during normal clinic hours.<br>• Physician On call is within 15 minutes of facility.<br>• If cardiac dysrhythmia causing symptoms or hemodynamic compromise is noted pretest, the medical monitor will be notified and the test postponed until medical monitor approval to proceed.<br>• No max exercise 24 hours prior to testing; no exercise 8 hours prior to testing.<br>• Wear workout clothing (shorts, t-shirt, sneakers).<br>• No large meals 2 hours prior to test. A light meal permitted up to 60 minutes before test.<br>• Limit caffeine intake 8 hours prior to test. One cup (8 oz.) of regular coffee or equivalent permitted up to 60 minutes before test.<br>• No alcohol or nicotine 8 hours prior to test.<br>• Do not apply lotion to the torso on the day of testing (pretest).<br>• Contraindications: previous musculoskeletal injury which would prevent cycle exercise to maximal levels.<br>• No Neutral Buoyancy training 48 hours prior to test; prefer 72 hours.<br>• This test will not be conducted with the crewmembers within 72 hours of returning to Houston from overseas travel or within 48 hours of domestic travel unless approved by the Crew Surgeon.<br>• Test Termination Criteria: See page 8.</td></tr>
<tr><td>Launch Delay Requirements:</td><td colspan="4">L-3 to L-1 data collection will be repeated if launch is delayed by more than 3 months.</td></tr>
<tr><td>Notes:</td><td colspan="4">a) A peak cycle exercise test performed within one year of the launch date may be substituted for the L-12 mo. test upon crew surgeon approval.<br>b) A 12-lead ECG is required for all annual and astronaut assigned pre- and postflight testing. The system currently required is the GE CASE system which allows direct transmission of electrocardiographic data to a cardiologist for interpretation.<br>c) For annual testing, the preferred metabolic gas analysis system is the Parvo Medics TrueOne 2400 system; however, the PPFS is acceptable.<br>d) For astronaut assigned mission testing at L-12 months, the preferred metabolic gas analysis system is the PPFS; however, the Parvo Medics TrueOne 2400 system is acceptable. The intent of using the PPFS for crew members assigned to a specific mission is that the data will be optimally comparable to that collected during the ISS mission (the PPFS is the inflight metabolic gas analysis device).</td></tr>
</table>

| | |
|---|---|
| | e) For astronauts assigned mission testing at L-3 to L-1 months, the PPFS metabolic gas analysis system is required for upright peak cycle testing unless there is a hardware failure that prevents use. For the L-3/1 months supine peak cycle testing the PPFS is the preferred method, but the Parvo Medics TrueOne System is acceptable.<br>• If review of test data indicates that the crew member did not give a maximal effort, a test session shall be rescheduled as soon as practical.<br>• After the L-1 month testing session, a set of cycle exercise protocols for on-orbit use shall be transmitted to Astronaut Strength Conditioning and Rehabilitation personnel.<br>• RPE data is collected as a subjective measure used to aid the technicians conducting the test.<br>• For astronauts assigned a specific mission, it is preferred that the assigned crew surgeon attends, but this is not a requirement. |
| **Data Delivery** | • Following ground testing, the 12-Lead ECG test data shall be transmitted to a cardiologist and the Picture Archive and Communication System (PACS) within 48 hours of testing (prefer immediately following). The PACS/Electronic Medical Record (EMR) will serve as the archive of final reports delivered to the flight surgeon. Raw ECG data will be archived in the GE CASE system. A preliminary report of test findings may be viewed directly by the crew surgeon via the PACS. Final reports with cardiologist interpretation will be posted to the EMR from PACS within 14 days following the test session.<br>• Cycle exercise test data including the metabolic gas analysis data, will be analyzed by the discipline experts and a final report shall be posted to the Mission Medical Repository (MMR) and Electronic Medical Record (EMR) within 14 days following the test session. The EMR will serve as the archive of the exercise test data. A preliminary report of test findings may be directly shared with the crew surgeon and ASCR personnel.<br>• If the EVA pre-breathe reduction exercise protocol is being considered for the mission, the cycle test data will be shared with EVA experts to develop the pre-flight training protocols. |

**Peak Cycle Exercise Test Protocol**

| Nominal (Watts) | Light (Watts) | Stage Time (min) | Elapsed Time (min) |
|---|---|---|---|
| Seated Rest | Seated Rest | 3:00 | 3:00 |
| 50 | 45 | 3:00 | 6:00 |
| 75 | 60 | 1:00 | 7:00 |
| 100 | 75 | 1:00 | 8:00 |
| 125 | 90 | 1:00 | 9:00 |
| 150 | 105 | 1:00 | 10:00 |
| 175 | 120 | 1:00 | 11:00 |
| 200 | 135 | 1:00 | 12:00 |
| 225 | 150 | 1:00 | 13:00 |
| 250 | 165 | 1:00 | 14:00 |
| 275 | 180 | 1:00 | 15:00 |
| 300 | 195 | 1:00 | 16:00 |
| 325 | 210 | 1:00 | 17:00 |
| 350 | 225 | 1:00 | 18:00 |
| 375 | 240 | 1:00 | 19:00 |
| 400 | 255 | 1:00 | 20:00 |
| 425 | 270 | 1:00 | 21:00 |
| 450 | 285 | 1:00 | 22:00 |
| 475 | 300 | 1:00 | 23:00 |
| 50 W (Cool Down) | 45 W (Cool Down) | 3:00 | ET + 3 min |

Note 1: Nominal Protocol is to be used for subjects weighing >65 kg. However, clinical discretion may be used in the assignment of protocols. For example, the Nominal Protocol would also be appropriate for <65 kg individual who regularly performs cycle exercise. The pedaling speed for use during these tests is 75 rpm.

Note 2: The CEVIS is limited to 350 Watts maximum. If an astronaut attains 350 Watts during flight, the 350 Watt stage shall be extended to a maximum of 3 minutes before the crew member proceeds to cool down. Therefore, the maximum testing time on ISS, including rest and cool down, is 21 minutes. [It is highly unlikely that an individual performing the light protocol would reach 350 Watts].

**Cycle Exercise Test Termination Criteria**

1. Onset of symptoms consistent with angina pectoris
2. Sustained ventricular tachycardia (defined as 7 or more sequential complexes)
3. Cardiac dysrhythmia not observed preflight that is accompanied with unusual symptoms of exertional intolerance
4. Technical difficulties monitoring the ECG
5. Unusual or severe shortness of breath (inconsistent with level of effort)
6. Signs of poor perfusion, including pallor, cyanosis, or cold and clammy skin
7. Volitional fatigue (as noted above, if the test results are deemed a submaximal effort the test will be repeated).

## 3.5 In-Flight Activities

**TABLE 3.5.1: IN-FLIGHT ACTIVITIES**

| In-Flight Activity | | | | | |
|---|---|---|---|---|---|
| **Description:** | Cycle ErgometryTest:<br>A cycle ergometry test will be performed on the inflight cycle ergometer according to the schedule below. The protocol used is identical to that conducted preflight. The test may be requested prior to a crewmember performing an EMU EVA or at any point during the mission as indicated. | | | | |
| **Schedule:** | **Duration:** | | **Schedule:** | **Flexibility:** | **Personnel Required:** |
| | **If First Performance** | | FD 14<br>FD75<br>R-14 days<br>As Clinically Indicated | +/- 2 days<br>+/- 7 days<br>+/- 5 days | ISS Crewmember<br>Ground Monitoring Personnel[a] |
| | Set Up (Partial; Single/1st Crew): | 45 minutes | | | |
| | Set Up (Partial; Middle/Last Crew): | 25 minutes | | | |
| | Set Up (Full; Single/1st Crew): | 90 minutes | | | |
| | Set Up (Full; Middle/Last Crew): | 25 minutes | | | |
| | Max PFE Subject test: | 85 minutes (Med Ops: 60 minutes, Exercise: 25 minutes) | | | |
| | Stow (Partial Single/Last Crew): | 30 minutes | | | |
| | Stow (Partial; 1st /Middle Crew): | 15 minutes | | | |
| | Stow[e] (Full; Single/Last Crew): | 95 minutes | | | |
| | Stow (Full; 1st /Middle Crew): | 15 minutes | | | |
| | **If Subsequent Performance** | | | | |
| | Set Up (Partial; Single/1st Crew): | 20 minutes | | | |
| | Set Up (Partial; Middle/Last Crew): | 15 minutes | | | |
| | Set Up (Full; Single/1st Crew): | 60 minutes | | | |
| | Set Up (Full; Middle/Last Crew): | 15 minutes | | | |
| | Max PFE Subject test: | 70 minutes (Med ops: 45 minutes, Exercise: 25 minutes) | | | |
| | Stow (Partial Single/Last Crew): | 30 minutes | | | |
| | Stow (Partial; 1st /Middle Crew): | 15 minutes | | | |
| | Stow[e] (Full; Single/Last Crew): | 80 minutes | | | |
| | Stow (Full; 1st /Middle Crew): | 15 minutes | | | |
| | PPFS Power-up: | 10 minutes | | | |
| | PPFS Conclude: | 5 minutes | | | |
| | Max CEVIS Kit Consolidate | 20 minutes | 6 months after first use | | ISS Crewmember |

| | | | | |
|---|---|---|---|---|
| | | of Limited Life Items | | |
| **Procedures:** | In-flight procedures can be found within the SODF: ISS Med (Medical Checklist) | | | |
| **Constraints / Special Requirements:** | • If cardiac dysrhythmia causing symptoms or hemodynamic compromise is noted, the crew surgeon will be notified and the test postponed until approval to proceed is obtained.<br>• Wear workout clothing (shorts, t-shirts, sneakers).<br>• No max exercise 24 hours prior to testing; no exercise 8 hours prior to testing.<br>• Limit caffeine intake 8 hours prior to test. One cup (8 oz.) of regular coffee or equivalent permitted up to 60 minutes before test.<br>• No large meals 2 hours prior to test. A light meal is permitted up to 60 minutes before test.<br>• No alcohol, or nicotine 8 hours prior to test.<br>• Do not apply lotion to the torso on the day of testing (pretest).<br>• Each crewmember uses the PPFS to measure metabolic oxygen consumption and heart rate via ECG. As a redundancy, the crewmember will also don a Heart Rate Monitor.<br>• Contraindications: Musculoskeletal injury that precludes crew member from performing a maximal cycle ergometer effort.<br>• **Test Termination Criteria: See page 8.** | | | |
| **Photo / TV Requirements:** | Privatized video during PPFS set-up and during exercise testing, Ku-band for data transmission[b]. No Ku LOS can occur during the exercise portion of the test (maximum 21 minute window)[c]. | | | |
| **Cold Stowage Requirements:** | NA | | | |
| **Mission Extension Requirements:** | R-14 day test shall be repeated if mission is extended by > 16 days. | | | |
| **Landing Wave-Off Requirements:** | NA | | | |
| **Notes:** | [a]– Ground monitoring personnel consists of a BLS certified EP trained in the interpretation of graded exercise test results. and a hardware specialist (expert on PPFS use and troubleshooting). Crew surgeon attendance is optional; however, the crew surgeon or his designated back-up shall be available by phone for consultation if required.<br>[b] – The Ku requirement is established so that ground personnel can assist in the PPFS set-up and troubleshooting any hardware anomalies that occur. The Ku requirement during the exercise portion of the test is established for both hardware and medical monitoring purposes.<br>[c] – The actual window protected for each test is dependent on the fitness level of the crewmember.<br>[d] – The current route of data transmission is dual (to MCC Houston and to DAC Odense). DAC Odense verifies hardware functionality and data quality.<br>[e] – Full set up and stow are as needed, the expected nominal configuration is partial set up and stow. | | | |
| **Data Delivery** | CEVIS and HR monitor data is sent to the PPFS and included with the PPFS data. The PPFS data is downlinked to DAC. DAC provides the raw data via encrypted server to the BME Data Manager to store on the Countermeasures SharePoint site for the Exercise Physiology and Countermeasures Laboratory (ExPC) for analysis. The ExPC will deliver test results and final recommendations to the crew surgeon and ASCR via the MMR within 5 working days of receiving initial cycle exercise data. A preliminary interpretation of the test can be provided, via encrypted means, to the crew surgeon and ASCR within 2 working days, if requested. The raw data is archived on the ExPC's encrypted PGP server. | | | |

## In-Flight Activities, (cont.)

### TABLE 3.5.2: IN-FLIGHT HARDWARE

| Hardware/Software Name |
|---|
| ISS Ergometer |
| CEVIS Accessory Bag |
| Isolator Kit Assembly |
| On-Orbit Mounting Frame |
| IVIS Box, Blue |
| IVIS Box, Red |
| Station Support Computer Kit 1 USB |
| Heart Rate Monitor Kit |
| PPFS and accessories |
| 3 Liter calibration syringe/HRF PFM/PAM Calibration Syringe Tube |
| PPFS accessories kit |
| Calibration gases |

## 3.6 Postflight Activities

**TABLE 3.6: POSTFLIGHT ACTIVITIES**

| | | | | |
|---|---|---|---|---|
| **Postflight Activity** | Cycle Exercise Test: Crewmembers will perform the same cycle exercise test protocol postflight as performed preflight. | | | |
| **Description:** | **Duration:** | **Schedule:** | **Flexibility:** | **Personnel Required:** |
| **Schedule:** | 60 minutes<br>60 minutes | R+ 5 days[a]<br>R+ 30 days[b] | +/- 2 days<br>+/- 4 days | Lab Personnel<br>Crewmember<br>Physician(On Call) |
| **Ground Support Requirements Hardware/Software** | **Postflight Hardware:** | | **Postflight Software:** | **Test Location:** |
| | LODE Electronic Cycle Ergometer, Electrocardiographic System[c], PPFS, PPFS Accessories, PPFS Consumables, Sphygmomanometer, RPE Chart | | PPFS software<br>ECG system software | U.S. |
| **Testing Facilities** | **Minimum Room Dimensions:** | **Number of Electrical Outlets:** | **Temperature Requirements:** | **Special Lighting:** |
| | Approximately 20 ft. x 20 ft. | Four 110 V | 20 -25°C | NA |
| | **Hot or Cold Running Water:** | **Privacy Requirements:** | **Other:** | |
| | Access to hot and cold running water is necessary | Access to room must be controlled during testing. | All monitoring personnel will be AED-qualified and an AED will be present within the test facility. The EP monitoring the ECG shall be certified as a BLS provider by the AHA and is trained in the interpretation of graded exercise results. | |

| | |
|---|---|
| **Constraints/Special Requirements:** | • Testing to be performed during normal clinic hours.<br>• Physician On call is within 15 minutes of facility.<br>• If cardiac dysrhythmia causing symptoms or hemodynamic compromise is noted pretest, the medical monitor will be notified and the test postponed until medical monitor approval to proceed.<br>• No max exercise 24 hours prior to testing; no exercise 8 hours prior to testing.<br>• Wear workout clothing (shorts, t-shirt, sneakers).<br>• No large meals 2 hours prior to test. A light meal permitted up to 60 minutes before test.<br>• Limit caffeine intake 8 hours prior to test. One cup (8 oz.) of regular coffee or equivalent permitted up to 60 minutes before test.<br>• No alcohol or nicotine 8 hours prior to test.<br>• Do not apply lotion to the torso on the day of testing (pretest).<br>• Contraindications: previous musculoskeletal injury which would prevent cycle exercise to maximal levels.<br>• No Neutral Buoyancy training 48 hours prior to test; prefer 72 hours.<br>• This test will not be conducted with the crewmembers within 72 hours of returning to Houston from overseas travel or within 48 hours of domestic travel unless approved by the Crew Surgeon.<br>• It is recommended that the crew surgeon be physically present to monitor the R+5 test; however, an alternative medical monitor is acceptable. Note that the NASA IRB may require medical monitoring for crew members participating in experiments that require testing earlier than R+5.<br>• The after-travel constraint may be waived to allow data sharing between experiments that require cycle testing earlier than R+5.<br>• **Test Termination Criteria: See page 8.** |
| **Early Destow / Early Return:** | NA |
| **Notes:** | [a]— It is recommended that the crew surgeon monitor this test; however, an alternative medical monitor is acceptable.<br>[b] — Physician “on call” and within 15 minutes of facility (test to be performed during normal clinic hours).<br>[c] — The ECG system currently required is the GE CASE system. |
| **Data Delivery** | • Following ground testing, the 12-Lead ECG test data shall be transmitted to the cardiologist and the Picture Archive and Communication System (PACS) within 48 hours of testing (prefer immediately following). The PACS/Electronic Medical Record (EMR) will serve as the archive of final reports delivered to the flight surgeon. Raw ECG data will be archived in the GE CASE system. A preliminary report of test findings may be viewed directly by the crew surgeon via the PACS. Final reports with cardiologist interpretation will be posted to the EMR from PACS within 14 days following the test session.<br>• Cycle exercise test data including the metabolic gas analysis data, will be analyzed by the discipline experts and a final report shall be posted to the Mission Medical Repository (MMR) and Electronic Medical Record (EMR) within 14 days following the test session. The EMR will serve as the archive of the exercise test data. A preliminary report of test findings may be directly sent to the crew surgeon and ASCR personnel via encrypted means. |

## 3.7 Summary Schedule

**TABLE 3.7: SUMMARY SCHEDULE**

| ACTIVITY | DURATION | SCHEDULE | FLEXIBILITY | PERSONNEL REQUIRED | CONSTRAINTS |
|---|---|---|---|---|---|
| **Preflight Training** | | | | | |
| CMS CEVIS Ops | 60 minutes | L-1 year | +/- 30 days | Instructors/Crew | |
| PPFS Ops | 90 minutes | L-300 days | +/- 30 days | Instructors/Crew | |
| VO2 Training | 90 minutes | L-6 months | +/- 30 days | Instructors/Crew | Optional, wear workout clothing |
| VO2 Proficiency Training | 60 minutes | L-60 days | +/- 30 days | Instructors/Crew | Optional, wear workout clothing |
| **Preflight** | | | | | |
| Annual Cycle Test – Non Assigned Astronaut | 60 minutes | Annually | +/- 30 days | Lab Personnel/ Crewmember | See Note 1 below |
| Upright Test | 60 minutes | L-12 months | +/- 30 days | Lab personnel, Crewmember, Physician (On Call) | See Note 1 below |
| Supine Measure | 60 minutes | L-90/30 days | +/- 30 days | | |
| Upright Test | 60 minutes | | L-3 to L-1 month supine and upright test need to be performed within 14 days of each other. | | |

| ACTIVITY | DURATION | SCHEDULE | FLEXIBILITY | PERSONNEL REQUIRED | CONSTRAINTS |
|---|---|---|---|---|---|
| **In-Flight** | | | | | |
| Cycle Ergometry Tests | **If First Performance**<br>**Set Up**<br>Partial; Single/1st Crew: 45 minutes<br>Partial; Middle/Last Crew: 25 minutes<br>Full; Single/1st Crew: 90 minutes<br>Full; Middle/Last Crew: 25 minutes<br>**Max PFE subject test**: 85 minutes<br>(Med Ops: 60 minutes, Exercise: 25 minutes)<br>**Stow**<br>Partial Single/Last Crew: 30 minutes<br>Partial; 1st /Middle Crew: 15 minutes<br>Full; Single/Last Crew: 95 minutes<br>Full; 1st /Middle Crew): 15 minutes<br>**If Subsequent Performance**<br>**Set Up**<br>Partial; Single/1st Crew: 20 minutes<br>Partial; Middle/Last Crew: 15 minutes<br>Full; Single/1st Crew: 60 minutes<br>Full; Middle/Last Crew: 15 minutes<br>**Max PFE subject test**: 70 minutes<br>(Med ops: 45 minutes, Exercise: 25 minutes)<br>**Stow**<br>Partial Single/Last Crew: 30 minutes<br>Partial; 1st /Middle Crew: 15 minutes<br>Full; Single/Last Crew: 80 minutes<br>Full; 1st /Middle Crew: 15 minutes<br>PPFS Power-up: 10 minutes<br>PPFS Conclude: 5 minutes | FD 14<br>FD 75<br>R-14 days<br>As Clinically Indicated | +/- 2 days<br>+/- 7 days<br>+/- 5 days | ISS Crewmember<br>Ground Monitoring Personnel | See Note 2 below |
| | Max CEVIS Kit Consolidate 20 minutes | 6 months after first use of Limited Life Items | | ISS Crewmember | |
| **Postflight** | | | | | |
| Cycle Ergometry Tests | 60 minutes<br>60 minutes | R+ 5 days<br>R+ 30 days | +/- 2 days<br>+/- 4 days | Lab Personnel<br>Crewmember<br>Physician (On Call) | See Note 3 below |
| **Postflight Debrief** | | | | | |
| No extra time | ~R+30 d | As scheduled | N/A | ASCR/ Crewmember/Lab Personnel/Crew surgeon | Included as part of the Med Ops overall debrief |

**Note 1 (Annual/Preflight):**

- Testing to be performed during normal clinic hours.
- Physician On call is within 15 minutes of facility.
- If cardiac dysrhythmia causing symptoms or hemodynamic compromise is noted pretest, the medical monitor will be notified and the test postponed until medical monitor approval to proceed.
- No max exercise 24 hours prior to testing; no exercise 8 hours prior to testing.
- Wear workout clothing (shorts, t-shirt, sneakers).
- No large meals 2 hours prior to test. A light meal permitted up to 60 minutes before test.
- Limit caffeine intake 8 hours prior to test. One cup (8 oz) of regular coffee or equivalent permitted up to 60 minutes before test.
- No alcohol or nicotine 8 hours prior to test.
- Do not apply lotion to the torso on the day of testing (pretest).
- Contraindications: previous musculoskeletal injury which would prevent cycle exercise to maximal levels.
- No Neutral Buoyancy training 48 hours prior to test; prefer 72 hours.
- This test will not be conducted with the crewmembers within 72 hours of returning to Houston from overseas travel or within 48 hours of domestic travel unless approved by the Crew Surgeon.

**Note 2 (In-flight):**

- If cardiac dysrhythmia causing symptoms or hemodynamic compromise is noted, the crew surgeon will be notified and the test postponed until approval to proceed.
- Wear workout clothing (shorts, t-shirts, sneakers).
- No max exercise 24 hours prior to testing; no exercise 8 hours prior to testing.
- Limit caffeine intake 8 hours prior to test. One cup (8 oz) of regular coffee or equivalent permitted up to 60 minutes before test.
- No large meals 2 hours prior to test. A light meal is permitted up to 60 minutes before test.
- No alcohol, or nicotine 8 hours prior to test.
- Do not apply lotion to the torso on the day of testing (pretest).
- Each crewmember uses the PPFS to measure metabolic oxygen consumption and heart rate via ECG. As a redundancy, the crewmember will also don a Heart Rate Monitor.
- Contraindications: Musculoskeletal injury that precludes crew member from performing a maximal cycle ergometer effort.

**Note 3 (Postflight):**

- Same constraints as preflight.
- It is recommended that the crew surgeon be physically present to monitor the R+5 test; however, an alternative medical monitor is acceptable. Note that the NASA IRB may require medical monitoring for crew members participating in experiments that require testing earlier than R+5.
- The after-travel constraint may be waived to allow data sharing between experiments that require cycle testing earlier than R+5.

**Background Addendum**

***VO2max and Ventilatory Threshold Defined***

- **VO2max** = the maximum amount of oxygen the body can use during maximal exercise and reflects aerobic fitness.
- **Ventilatory Threshold (VT**) = the intensity at which you switch from using predominately aerobic to anaerobic energy pathways. Exercise intensity cannot be maintained for more than a couple of minutes at intensities above VT. This metric is determined using the gas analysis collected during the VO2max test.
    - Using ISS as a test bed to understand changes in VT during spaceflight will likely be very informative for understanding exploration mission task capabilities.

- It has been shown that the submaximal PFE has up to 60% error in estimation of $VO_2$max. A maximal test without gas analysis provides a peak workload metric only. This metric does not provide information needed to answer questions related to exploration tasks or ISS or exploration exercise requirements. **Accurate determination of VO2max and VT requires continuous metabolic gas analysis.**

***Why Measure VO2max during ISS missions? (Rationale and Future Needs)***

**Historical data base**: Crew return from ISS missions with gains, losses, and maintenance in $VO_2$max. We do not have the data to explain these changes with respect to in-flight exercise intensity and when during the mission these changes occur. Over time we will develop a data base of aerobic fitness metrics ($VO_2$max, VT, peak workload) to answer:

1) *What is the minimum aerobic fitness standard for duty?*
2) *Do VT and VO2max change similarly during flight and what is the time course?*
3) *How can we optimize exercise prescriptions given the future increase in number of crew on ISS and exercise hardware limitations on exploration vehicles?*
4) *What exercise intensity and volume is needed to improve or maintain VO2max and VT during long duration flight?*

**Immediately improved exercise prescriptions**: Measuring $VO_2$max during flight will enable ASCR's to adjust workloads based on in-flight changes in $VO_2$max, prescribe workloads to more accurately to elicit specific metabolic intensities, and potentially save crew time and hardware "wear and tear" by reducing exercise volume and increasing exercise intensity.

**Immediately improved medical preparedness**: Significant declines in $VO_2$max negatively effects neuro-vestibular function and the ability to participate in post-flight data testing. Measuring $VO_2$max during flight will help inform crew surgeons of potential difficulties their crewmember may have with landing activities and post-flight testing.

**Future Exploration**: The historical data base that will be developed from measuring $VO_2$max on ISS will inform future exploration exercise hardware requirements, define exploration mission tasks, and landing scenarios.

***Implementation & Contingency***

- Stop submax PFE testing
- Start $VO_2$max testing with the PPFS when agreements are in place.
- If the PPFS goes down the test session will be cancelled or rescheduled when the PPFS is operable again.

- In the event of long-term PPFS failure, the crew will perform max testing without the PPFS as described in the “Interim Plan” below.

***Interim Plan***

- A maximal test without gas analysis will be performed until agreements are in place with DAC/ESA and crew members are trained on the ground to perform maximal testing with the PPFS.
- Variables measured: Max workload (Watts), Max heart rate using a heart rate monitor, and exercise test duration.
- Equipment: CEVIS & Heart rate monitor
- Schedule: No deviation from nominal schedule
- Rationale: A maximal test without gas can be used as a benchmarking tool to trend changes in aerobic fitness using heart rate, peak work load and test time during the mission. This data can be used to make minor adjustments to the *individual crewmembers’* exercise prescriptions, but is not sufficient to inform global changes in exercise prescriptions for ISS crew.

**Note: The data from this non gas max test is different from data collected from the PPFS and cannot replace PPFS data. The data collected in the interim plan will not provide the information stated in the section: “*Why Measure VO2max during ISS missions? (Rationale and Future Needs)”*.**