

MR087S EVA Exercise Prebreathe Protocol for Shuttle Crewmembers

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3.2 Medical Requirements Overview

TABLE 3.2: MEDICAL REQUIREMENTS OVERVIEW

MRID# and Title:	MR087S EVA Exercise Prebreathe Protocol for Shuttle Crewmembers
Sponsor:	Medical Operations
IPT:	EVA
Category:	Medical Requirements (MR)
References:	Medical Operations Requirements Document For Space Shuttle (MORD) Rev. G Section 4.7.1 EVA Prebreathe
Purpose/Objectives:	To mitigate the risk of Decompression Sickness (DCS) in crewmembers participating in EVA activities.
Measurement Parameters:	Heart rate, oxygen consumption, exercise workload
Deliverables:	An individualized exercise prebreathe prescription for the crewmember
Flight Duration:	< 30 days
Number of Flights:	Available for all flights with scheduled EVA's
Number and Type of Crew Members Required:	Shuttle crewmembers scheduled to participate in EVA's
Notes:	Additional References: MEDB 4.1 Cycle Ergometer Test/Aerobic Functional Capacity EVA Pre-Breathe Reduction Protocol Flight Rule B13.2.3-7.

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3.3 Preflight Training

TABLE 3.3: PREFLIGHT TRAINING

Preflight Training Activity	Description:	Training for the EVA Exercise Prebreathe Protocol will be conducted by CMS instructors, MOD/DX, EXL Personnel, and EVA trainers.			
	Schedule:	Duration:	Schedule:	Flexibility:	Personnel Required:
		CEVIS-HRM Ops 60 min. Prebreathe 120 min.	L-240 days L-240 days	N/A	CMS Instructor EXL Personnel, MOD/DX EVA trainers MOD/DX EVA trainers MOD/DX EVA trainers EXL Personnel MOD/DX EVA trainers, CMS Instructors
		EVA Prep and Post 1* 45 min. EVA Prep and Post 2 45 min.	L-230 days L-130 days		
		Submax Cycle Test 60 min. EVA Prep and Post 3 45 min.	L-30/45 days L-28 days		
Ground Support Requirements Hardware/Software	Preflight Hardware:	Preflight Software:		Test Location:	
	CEVIS Electronic Upright Cycle Ergometer (LODE) Theraband Tubing Heart Rate Monitor PCMCIA Card MEC	CEVIS software MEC Software		U.S.	
Training Facilities	Minimum Room Dimensions:	Number of Electrical Outlets:	Temperature Requirements:	Special Lighting:	
	8' x 10' room	2-110 Volt outlets	20-25 degrees C	N/A	
	Hot or Cold Running Water:	Privacy Requirements:	Other:		
	N/A	Controlled access	N/A		
Constraints/Special Requirements:	N/A				
Launch Delay Requirements:	If launch delay is greater than 90 days, the EVA crewmember will repeat L-30 submax cycle test.				
Notes:	<ul style="list-style-type: none"> ▪ The CEVIS-HRM Ops class is the ISS CMS OPS1 lesson that has been modified for Shuttle crewmembers. ▪ *The EVA Prep and Post lessons are taught by MOD/DX and are 8.0 hours, take place in building 9, and the Prebreathe portion of the lesson is approximately 45 minutes. 				

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3.4 Preflight Activities

TABLE 3.4: PREFLIGHT ACTIVITIES

Preflight Activity	Description:	Preflight activities will include the Peak Cycle Test, Pre-breathe Class (protocol verification), and Submaximal Cycle Exercise Test.			
	Schedule:	Duration:	Schedule:	Flexibility:	Personnel Required:
		Peak Cycle Test: 60 min.*	L-270	30 days	EXL/Medical monitor (Level 1)
		Pre-breathe Class: 60 min.**	L-240	Within 30 days following cycle peak test	EXL/Medical monitor on-call (Level 3)
	Submaximal Cycle Exercise Test: 60 min.***	L-45-L-30	15 days	EXL/Medical monitor on-call (Level 3)	
Ground Support Requirements Hardware/Software	Preflight Hardware:	Preflight Software:		Test Location:	
	Electronic upright cycle ergometer (LODE), metabolic cart, theraband tubing, 3-lead EKG, blood pressure device, heart rate monitor	Software in the metabolic cart		U.S.	
Testing Facilities	Minimum Room Dimensions:	Number of Electrical Outlets:	Temperature Requirements:	Special Lighting:	
	Approximately 15' x 15'	4 -110 Volt outlets	20-25 degrees C	N/A	
	Hot or Cold Running Water:	Privacy Requirements:	Vibration/Acoustic Isolation:	Other:	
	Sink required Drinking water available	Controlled access	N/A	ACLS/MR080L	
Constraints/Special Requirements:	<ul style="list-style-type: none"> ▪ Wear workout clothing. ▪ No max exercise 24 hours prior to testing; no regular exercise 8 hrs prior to testing. ▪ No NBL training 48 hours (prefer 72 hours) prior to exercise testing and training. ▪ Limit food 2 hours prior to testing (light meal permitted up to 60 minutes before test). (Peak Cycle and Submaximal Cycle Tests) ▪ No alcohol, nicotine, or other vasoactive substances (e.g., cold medications) 8 hours prior to testing 				

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	<ul style="list-style-type: none"> limit caffeine 8 hours prior to testing (1 cup (8 oz or less of regular coffee or equivalent) permitted up to 60 minutes before test). (Peak Cycle and Submaximal Cycle Tests) See Appendix for additional restraints and special requirements for international crewmembers.
Launch Delay Requirements:	N/A
Notes:	See appendix
Data Delivery	<p>Data/Report to Designated Recipients (Nominal/Contingency):</p> <ul style="list-style-type: none"> The Exercise Pre-breathe Prescription will be incorporated into a report from the EXL to the crewmember’s flight surgeon within 48 hours of the Prebreathe Class. Upon acceptance of the protocol by the Crew Surgeon, the prescription will be delivered to the EVA trainer for Prep and Post Classes, to the crew Astronaut Strength, Conditioning, and Rehabilitation specialist for use in the gym, and to the crewmember. A second report will be delivered to the crew surgeon after the L-30/45 Submaximal Cycle Exercise Test to report changes in the physical fitness of the crewmember and/or any required changes to the EVA Pre-breathe Exercise Prescription.

3.5 In-Flight Activities

TABLE 3.5.1: IN-FLIGHT ACTIVITIES

In-Flight Activity	Description:	Prior to EVA, Shuttle or ISS designee will verify the calibration of the CEVIS and perform a practice run of the EVA Pre-breathe Exercise Protocol. Crewmembers also will perform the Pre-breathe Exercise Protocol as part of the nitrogen wash-out protocol prior to EVA.				
	Schedule:	Activity:	Duration:	Schedule:	Flexibility:	Personnel Required:
		Verify CEVIS calibration*	60 min.	Once per increment prior to any scheduled EVA’s	N/A	1 crewmember
		Practice run of EVA protocol**	60 min.	1 week before EVA		3 crewmembers (2 EVA, 1 IVA)
	EVA Pre-breathe Exercise Protocol	10 min./crewmember	Before EVA		3 crewmembers (2 EVA, 1 IVA)	
Procedures:	Located in the Med Ops book, EVA book, and Flight Data File.					
Constraints / Special Requirements:	<p>*If a CEVIS failure is detected, the Shuttle ergometer can be used instead of CEVIS during docked operations. Since workloads on the Shuttle ergometer increase in 25 watt increments, the workloads in the pre-breathe exercise prescription should be “rounded” to the nearest 25 watt setting.</p> <p>**A practice run of the EVA protocol may be scheduled at the discretion of the Crew Surgeon.</p> <p>Crewmembers are requested to report any medication usage in the 24 hours prior to any scheduled EVA activities.</p> <p>See Appendix for additional restraints and special requirements for international crewmembers.</p>					

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Photo / TV Requirements:	N/A
Cold Stowage Requirements:	N/A
Mission Extension Requirements:	N/A

Landing Wave-Off Requirements:	N/A
Data Delivery	Data/Report to Designated Recipients (Nominal/Contingency):
	<ul style="list-style-type: none"> ▪ CEVIS calibration verification results reported by crew to ground (Crew Surgeon/BME and then the EVA IPT Lead) prior to EVA. ▪ EVA exercise pre-breathe protocol are uplinked from the ground and stored on EVA PCMCIA cards stored in ISS Kit (nominal operations). ▪ Heart rates, perception of effort, and any deviation from protocol during practice run of EVA protocol reported by crew to ground (Crew Surgeon/BME, EVA IPT Lead, EXL representative, or designee) prior to EVA. ▪ Heart rates during Exercise Prebreathe Practice and Protocol are stored on PCMCIA cards and downlinked to the ground (Crew Surgeon/BME, EVA IPT Lead) prior to EVA. Practice Run Data are reported to the Crew Surgeon/BME and then the EVA IPT Lead, EXL representative, or designee within one week (nominal operations). ▪ If downlink not available, PCMCIA cards may be returned after flight, and data are sent to the EXL within 30 days of landing (contingency operations). ▪ If CEVIS fails and Shuttle ergometer must be used, crewmembers must wear the Shuttle-provided heart rate monitor watch and record heart rates during all EVA activities. Heart rate monitors to be downloaded after flight, and data will be delivered to the EXL within 30 days of landing (contingency operations).

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In-Flight Activities, (cont.)

TABLE 3.5.2: IN-FLIGHT HARDWARE

Hardware/Software Name	P/N	ISS Location	Vehicle (Up/Dn)	Category	Late Access / Early Destow/ Early Return	Docked Ops	Weights (kg)	Volume (cm ³)	Dimensions LxWxH (cm)	Power (watts)	Resupply	Download / Downlink
ISS Ergometer (CEVIS)	SEG46115811-301	U.S. lab	5A.1	CHeCS	N/A	N/A	36.9	803,793.8	109.7 x 51.6 x 142.0	120 or 28 VDC	N/A	N/A
Shuttle Ergometer	SDD46106864	Shuttle mid-deck	Shuttle	Shuttle	N/A	No	11.36	493,438.3	124.5 x 36.8 x 107.7		N/A	N/A
Heart Rate Monitor Kit	SED46115818-xxx	EVA or Cycle Ergometer Kit?	Shuttle	CHeCS	R+5 hr.	No	4.55	4719.5	30.5 x 15.2 x 10.2	Battery	Includes watches, transmitters and chest straps – 4 each and will be re-supplied with every crew rotation.	Yes
PCMCIA Cards for CEVIS (2)	SEG46116005-XXX	EVA Kit	Shuttle	CHeCS	No	No	0.41	283.2	N/A	N/A	For shuttle crew	N/A
Pistol Grip Tool (PGT)	GE1557000	A/L1D1	Shuttle	EVA	No	No	29.04	18,236.1	38.1 x 35.46 x 13.46	Battery	As needed	N/A
Prebreathe Hose Assy. Kits	SJG33112241-xxx	A/L1 Crewlock	Shuttle	EVA	No	No	N/A	N/A	N/A	N/A	As needed	N/A
Prebreathe Hose Spare Kit	SJG33112747-xxx	A/L1D0	Shuttle	EVA	No	No	N/A	N/A	N/A	N/A	As needed	N/A
Thera-band Tubing	SEZ33112286-301 HYG03318 (black)	Shuttle mid-deck	Shuttle	EVA	No	No	N/A	N/A	20 ft.	N/A	As needed	N/A
Ergometer Shoes	528-20627-1,2 528-43063 (no cleats)	Shuttle mid-deck	Shuttle	Shuttle	No	No	Varies	Varies	Varies	N/A	Every crew rotation	N/A

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3.6 Postflight Activities: N/A

3.7 Summary Schedule

TABLE 3.7: SUMMARY SCHEDULE

ACTIVITY	DURATION	SCHEDULE	FLEXIBILITY	BLOOD VOLUME	PERSONNEL REQUIRED	CONSTRAINTS
Preflight Training						
CEVIS-HRM Ops Prebreathe	45 min. 120 min.	L-240 days L-240 days	N/A	N/A	CMS Instructor EXL personnel, MOD/DX, EVA trainers	N/A
EVA Prep and Post 1	45 min.	L-230 days			MOD/DX, EVA trainers	
EVA Prep and Post 2	45 min.	L-130 days			MOD/DX	
Submax Cycle Test	60 min.	L-30/45 days			EXL Personnel	
EVA Prep and Post 3	45 min.	L-28 days			EVA trainers/CMS Instructors	

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Preflight						
Peak Cycle Test	60 min.	L-270	30 days	N/A	EXL/medical monitor	<ul style="list-style-type: none"> ▪ Wear workout clothing. ▪ No max exercise 24 hours prior to exercise testing; no regular exercise 8 hrs prior to testing. ▪ No NBL training 48 hours (prefer 72 hours) prior to exercise testing. ▪ Limit food 2 hours prior to testing (light meal permitted up to 60 minutes before test). (Peak Cycle and Submaximal Cycle Tests) ▪ No alcohol, nicotine, or other vasoactive substances (e.g., cold medications) 8 hours prior to testing. ▪ limit caffeine 8 hours prior to testing (1 cup (8 oz or less of regular coffee or equivalent) permitted 60 minutes before test. (Peak Cycle Test and Submaximal Tests)
Pre-breathe Class	60 min.	L-240	Within 30 days following cycle peak test		EXL	
Submaximal Cycle Exercise Test	60 min.	L-45 to L-30	15 days		EXL	

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Activity	Duration	Schedule	Flexibility	Blood Volume	Personnel Required	Constraints
In-Flight						
Verify CEVIS calibration	60 min.	Once per increment prior to any scheduled EVA's		N/A	1 crewmember	If a CEVIS failure is detected, the Shuttle ergometer can be used instead during docked operations. Since workloads on the Shuttle ergometer increase in 25 watt increments, the workloads during the prebreathe prescription should be "rounded" to the nearest 25 watt setting. Also, crewmembers must wear heart rate monitor watch when using Shuttle ergometer. *A Practice Run of the EVA protocol may be scheduled at the discretion of the Crew Surgeon.
Dry run of EVA protocol*	60 min.	1 week before EVA			3 crewmembers (2 EVA, 1 EVA)	
CEVIS Pre-breathe Protocol Prescription	10 min./per crewmember	Before EVA			3 crewmembers (2 EVA, 1 IVA)	
Wheels-Stop: N/A						
Postflight: N/A						
Postflight Debrief						
EVA Debrief (Med Ops or EVA Office) in which specific questions with regard to the EVA PRP are addressed.						

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APPENDIX

L-270 Peak Cycle Test performed in JSC Exercise Physiology Lab (EXL).

Crewmembers will be scheduled for the peak cycle test when they are scheduled for the EVA skills class. The test will be scheduled at L-270 for assigned EVA crewmembers that have already completed the EVA skills class. If an assigned EVA crewmember has completed the peak cycle test within three years of scheduled launch date, a Submax Exercise Test will be scheduled at L-270 instead. ***

The pre-flight EVA peak cycle test uses the same protocol documented for ISS crewmembers to assess physical fitness at L-270 (MR080L). The protocol consists of three sub-maximal exercise stages of 3-minutes duration each. Sub-maximal exercise stages are 50, 100 and 150 watts for average-sized individuals and 50,75,100 watts for smaller individuals. Upon completing the sub-maximal stages, the workload increases incrementally by 25 watts in one-minute increments until volitional fatigue is reached, or the subject cannot maintain the prescribed pedal cadence of 75-80 rpm at the current workload.

A monitoring physician shall be present during the peak cycle test. When a crewmember is scheduled for the peak cycle test, the monitoring physician shall contact a flight surgeon (the crew surgeon for flight-assigned crewmembers or the Flight Medicine Clinic for unassigned crewmembers). The flight surgeon will review the crewmember's medical record, and will discuss any potential medical issues or concerns with the crewmember. The flight surgeon will then communicate with the monitoring physician regarding any potential medical contraindications to the crewmember's performance of the peak test. The flight surgeon and the monitoring physician will also specifically review cardiac rhythm anomalies that have been previously observed and should determine how similar anomalies will be managed should they be noted during the peak test. The peak test shall not be performed if the medical monitor has not communicated with the subject's Flight Surgeon about the individual's medical readiness for the test.

Physiologic parameters recorded during the peak cycle test will include 3-lead ECG, blood pressure, and oxygen consumption measurements. Pre-cordial ECG leads are not required. Paper data strips using the 3-lead ECG are recorded for 5 seconds of each minute of the test, and are used to calculate the heart rate for each interval. These interval data strips are destroyed once an accurate heart rate has been determined. The ECG is worn throughout the event to provide immediate rhythm assessment, should an adverse medical event occur during testing. Should an adverse medical event occur during the peak cycle test, the monitoring physician shall immediately notify the Flight Medicine Clinic. The Flight Medicine Clinic will provide any additional medical evaluation that may be required. If a crewmember cannot perform this test for non-cardiovascular medical reasons (e.g. orthopedic problems), the test may be postponed with concurrence of the flight surgeon.

The peak cycle test data will be analyzed by the EXL to determine whether the test can be considered a "peak exertional effort". The test will be considered valid based on the individual's heart rate, respiratory exchange ratio, oxygen consumption and ventilation responses to the exercise. If the results are determined to be unacceptably below peak exertion, the subject will be asked to repeat the test on a subsequent day.

Prebreathe Class (Protocol Verification): This session should occur about 1 month following the peak cycle test (above). The crewmember will perform according to the exercise prebreathe prescription, with measurements of oxygen consumption and heart rate (heart watch). The protocol consists of exercise for one minute at 37.5%, one minute at 50%, one minute at 62.5%, and seven minutes at 75% $\text{VO}_{2\text{pk}}$ as predicted by the results of the peak cycle test. The crewmember will perform 88% of each target workload with the legs on the upright electronic ergometer and approximately 12% of the work with the arms using elastic tubing. For the prebreathe exercise prescription to be "verified", the oxygen consumption measured during the final 2 minutes of the 75% workload should be within 10% of the targeted VO_2 value. If the measured VO_2 is not within 10% of the expected value, the prebreathe exercise prescription is revised, and the crewmember will be asked to complete another verification session.

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Submaximal Cycle Exercise Test: This protocol is the same as the Physical Fitness Evaluation (PFE) Tests performed by ISS crewmembers before, during and after flight. The protocol consists of three 5-minute exercise stages at 25%, 50%, and 75% of their preflight peak exercise capacity. During each test, measurements of heart rate (heart watch or 3-lead ECG), oxygen consumption, and blood pressure are obtained at each exercise stage. The data from this test can be used to determine if the fitness level of the crewmember has changed since the most recent peak cycle test, and to insure that their individual exercise prebreathe prescription is commensurate with their level of fitness.

PEAK CYCLE TEST TERMINATION CRITERIA

1. Crewmember fatigue or crewmember request for any reason.
2. Inability to maintain the prescribed cadence (75-80 rpm) at the current workload.
3. Onset of chest pain or equivalent angina symptoms, such as unusual or extreme shortness of breath, or signs of poor perfusion, as noted by the subject or determined by the monitoring physician.
4. Progressive decrease in heart rate or systolic blood pressure during increasing exercise intensity, accompanied by clinically significant signs or symptoms.
5. Clinically significant cardiac dysrhythmias (e.g., second or third degree atrioventricular block, new onset left bundle branch block, sustained ventricular or supra-ventricular arrhythmias). (See AMERD for details)
6. Systolic blood pressure > 260 mmHg, or diastolic blood pressure > 115.