



NASA-STD-3000 Man-Systems Integration Standards

Volume I, Section 7

7 HEALTH MANAGEMENT

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This section contains the following topics:

- 7.1 [Introduction](#)
- 7.2 [Preventive Care](#)
- 7.3 [Medical Care](#)
- 7.4 [Crew Survival](#)

7.1 INTRODUCTION

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This section discusses the measures that must be taken to maintain the health of the crew. The following topics are covered:

- a. Preventive Care - Non-medical measures that must be taken to preserve crew health.
- b. Medical Care - Medical functions of prevention, diagnosis, and treatment.

This section discusses only functional considerations and requirements. Sections that discuss facilities and equipment required to implement these functions are referenced in applicable paragraphs.

7.2 PREVENTIVE CARE

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7.2.1 Introduction

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This section identifies and discusses the activities considered necessary for a crewmember to maintain good health in a reduced gravity environment. The subsections discuss the consideration and requirements for the following preventive care measures:

- a. Nutrition.
- b. Reduced gravity countermeasures.
- c. Health monitoring.
- d. Sleep.

e. Personal hygiene.

f. Pre- and post-mission health management.

Facilities and equipment for implementation of preventive care are discussed in [Section 10.0, Activities Centers](#).

7.2.2 Nutrition

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7.2.2.1 Introduction

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This section discusses the food and water intake requirements of the crewmembers. The information applies primarily to an IVA environment and reduced gravity conditions. The water requirements apply to potable water only.

(Refer to Paragraph 7.2.5.3.6, Personal Hygiene Water Requirements, for information on water for personal hygiene.)

(Refer to Paragraph 14.2.3.6, EVA Food and Drinking Water Design Requirements, for specific nutritional requirements when performing EVA activities.)

7.2.2.2 Nutrition Design Considerations

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7.2.2.2.1 Goal of Nutrition Program Design Considerations

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The goal of the nutrition program is to establish an Earth-normal pattern and quality of meals while meeting the physiological requirements of the crew.

7.2.2.2.2 Food Acceptability Design Considerations

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The following factors affect the acceptability of the food and the appetite of the crewmembers:

a. Past Experience And Personal Preference - Generally, a taste for new foods must be acquired. This will be an important consideration with international crews. Pre-mission crew selection of menus is desirable.

b. Variety - Food can lose its acceptance if eaten too frequently. A wide variety of foods is desirable. Food may also be varied by changing the form, texture, and flavor, without affecting nutritional content. The use of colors, shapes, garnishes, and portions in meal presentation, as well as packaging color, utensil shape and size, and visual display of trays may also enhance the eating experience.

c. Waste Management Facilities - In the past, inadequate body waste management facilities have discouraged food consumption.

(Refer to Paragraph 10.3, Body Waste Management, for design requirements of body waste management facilities.)

d. Space Adaptation Syndrome - Control of Space Adaptation Syndrome is essential for a better appetite.

(Refer to Paragraph 7.2.3.4.3, Nonexercise Countermeasures Design Requirements, for additional information.)

e. Atmospheric Contaminants - The buildup of background odors during missions may contribute subliminally to a decrease in appetite and consumption as a result of fatigue or adaptation.

(Refer to Paragraph 5.1, Atmospheric Control, for additional information.)

f. Availability - Snacks should be available with a minimum of preparation. This is particularly important for high energy output tasks such as EVA operations.

g. Food Form - The more Earth-normal quality of the food, the more acceptable it will be. This includes the desirability of fresh fruits and vegetables. Precooked frozen food has the highest overall acceptability of the current available methods of preservation.

h. Meal Scheduling - Lack of consistent meal periods in the crew schedule can lead to skipped meals and undernourishment.

i. Microgravity Environment - Some U.S. and Soviet space crews have reported that changes in taste and odor perception of foods occur during space flights. This may be due to body fluid shift and resulting head congestion.

(Refer to Paragraph 4.4, Olfaction and Taste, for additional information.)

7.2.2.2.3 Food and Water Quality and Quantity Design Considerations

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The type and quantity of food and liquid required by an individual is dependent on a number of factors. These factors must be considered when establishing an individual menu. These factors include:

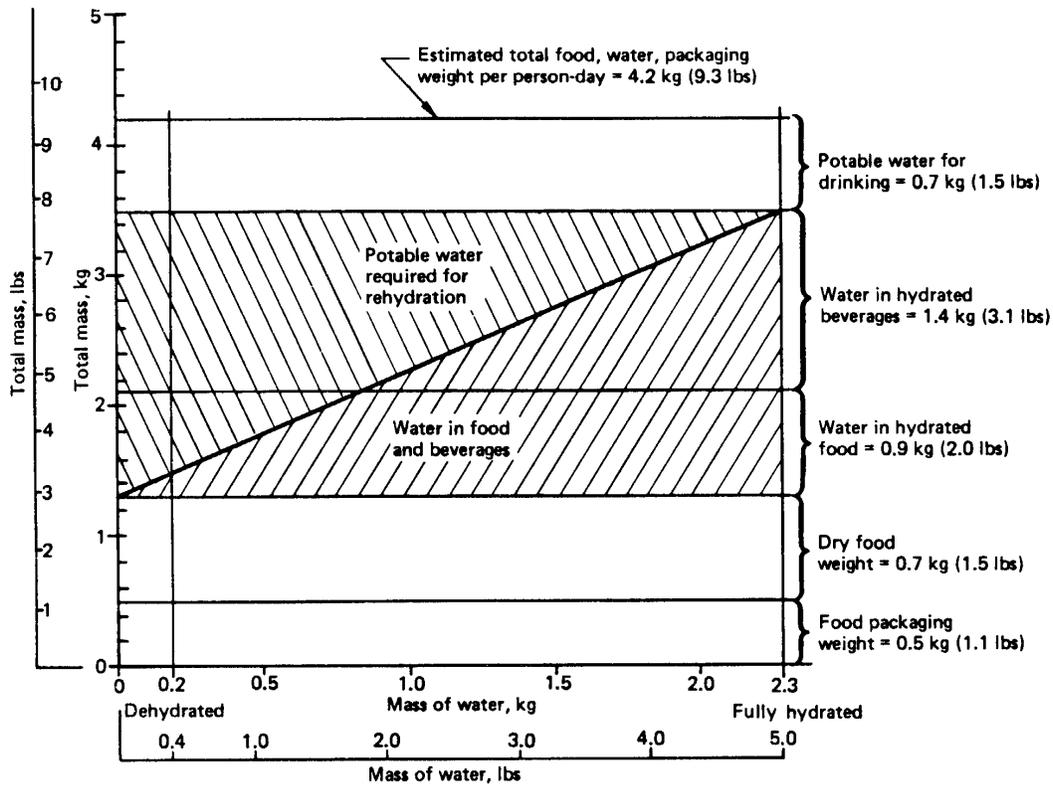
a. Crewmember Size and Activity Level - The level of activities and size of the crewmember influence the required calories and water intake. EVA activities, for instance, require a higher energy output.

b. Microgravity Effects - There are many unknown factors involved in the area of microgravity space nutrition and metabolism. The food provided must be varied and easily accessible such that a crewmember's individual needs and cravings can be satisfied. The food provided must be of sufficient quality, quantity, and nutrient content to meet the energy demands of various activities (e.g., EVA, countermeasure training, daily work activities), while accommodating each crew member's individual needs and desires.

c. Food Rehydration - The total amount of potable water required depends in part on the food rehydration requirements of the mission. This is illustrated in Figure 7.2.2.2.3-1, which shows food and water quantity requirements for varying levels of food hydration. The total water per person-day (rehydration water, drinking water, and water in food and beverages) is assumed to be 3 Kg (6.6 lbs). In the Figure, food packaging is assumed to be 0.5 Kg (1.1 lbs) and dry food weight 0.7 Kg (1.6 lbs).

d. Space Module Environment - Space module temperature and humidity impact the amount of water ingested.

Figure 7.2.2.2.3-1 Typical Mass of Food and Water per Person Day for Varying Levels of Food and Beverage Hydration



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Reference:: 107, pg. 410; NASA-STD-3000 185

7.2.2.3 Nutrition Design Requirements

{A}

7.2.2.3.1 Food Design Requirements

{A}

The food provided shall meet the following requirements:

a. Minimum Nutritional Requirements.

1. The diet shall supply the nutritional quality required by JSC 32283 (Nutritional Requirements for Extended Duration Missions).
2. Additional nutritional requirements are required for EVA as per body size, EVA tasks, and duration of EVA. Foods and fluids shall be specifically allocated for this requirement per Paragraph 14.2.3.3.

b. Nutritional Program Monitoring - An automated nutrient monitoring process shall be provided that meets the nutrient monitoring requirements as specified in JSC 32283. Parameters required for medical or investigative purposes shall include documenting:

1. the crewmember that consumed the food.
2. amount of food consumed
3. time and date of consumption,
4. food item/lot number/serial number.

Data shall be downlinked periodically for analysis and must provide information in format acceptable for post flight analysis.

c. Microbiology - Microbiological acceptability limits shall be as given in Figure 7.2.2.3.1-1.

Figure 7.2.2.3.1-1 Microbiology Contamination Control Specification For Crew Food

AREA/ITEM	MICROORGANISM TOLERANCES	
1. Food Production Area	Samples Collected*	Limits (CFU**)
a. Surfaces	3 surfaces sampled per day	$\leq 3/\text{cm}^2$
b. Packaging Film	Before use	$\leq 3/\text{cm}^2$
c. Food Processing Equip.	2 pieces sampled per day	$\leq 3/\text{cm}^2$
d. Air	1 sample of 0.282 M ³ (10ft)	$\leq 13/320$ liters
1. Food Production Area	Samples Collected*	Limits (CFU**)
a. Nonthermostabilized	Total aerobic count	$\leq 10,000/\text{g}$
	Escherichia coli	$\leq 1/\text{g}$
	Coagulase positive Staphylococci	$\leq 1/5\text{g}$
	Salmonella	$\leq 1/25\text{g}$
	Clostridium Perfringens	$< 100/\text{g}$
	Yeast and molds	$< 100/\text{g}$

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* Sample collected only on days that food facility is in operation

** Total aerobic count

Reference:406

Figure 7.2.2.3.1-1 Microbiology Contamination Control Specification For Crew Food

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7.2.2.3.2 Potable Water Design Requirements

{A}

a. Quality - The potable water quality requirements are given in Figure 7.2.2.3.2-1

b. Quantity - The supply of available water for drinking and hydration of food dependent on degree of food hydration shall be given in Figure 7.2.2.3.2-2, the potable water quantity requirements. The supply of available water for drinking and rehydration of food is listed below:

1. Operational Mode - 2.84 to 5.16 Kg per person-day (6.26 to 11.35 lbs per person-day)
 2. Degraded and Emergency Mode - 2.84 Kg per person-day (6.26 lbs per person-day)
- c. Emergency - The supply of available water for drinking and rehydration of food shall be a minimum of 0.95 Kg (2.1 lbs) per person for each eight hours of anticipated emergency vehicle occupancy time, including orbital loiter time and time on the earth's surface without rescue services. An additional 1 Kg (2.2 lbs) of water and 8 one gram salt tablets shall be provided for each person for the purpose of supporting reentry fluid loss countermeasures.
- d. Temperature - Drinking water temperatures shall be as follows:
1. Cold Water - Cold water temperature shall be 1.6 degrees to 7.2 degrees C (35 degrees to 45 degrees F).
 2. Ambient Water - Ambient water temperature shall be 15.5 degrees to 26.7 degrees C (60 degrees to 80 degrees F).
 3. Hot Water - Means shall be provided for heating water up to 68 degrees +/- 2.8 degrees C (155 degrees +/- 5 degrees F).

Figure 7.2.2.3.2-1 Potable Water Quality Requirements (Maximum Contaminant Levels)

QUALITY PARAMETERS	LIMITS
PHYSICAL PARAMETERS	
Total solids (mg/l)	100
Color True (Pt/Co units)	15
Taste (TTN)	N/A
Odor (TON)	3
Particulates (max size - microns)	40
pH	6.0-8.5
Turbidity (NTU)	1
Dissolved Gas (free @ 37°C)	Note 1
Free Gas (@ STP)	Note 1
INORGANIC CONSTITUENTS (mg/l) (See Notes 2 and 5)	
Ammonia	0.5
Arsenic	0.01
Barium	1.0
Cadmium	0.005
Calcium	30
Chlorine (Total - Includes Chloride)	200
Chromium	0.05
Copper	1.0
Iodine (Total - Includes Organic Iodine)	15
Iron	0.3
Lead	0.05
Magnesium	50
Manganese	0.05
Mercury	0.002
Nickel	0.05
Nitrate (NO ₃ -N)	10
Potassium	340
Selenium	0.01
Silver	0.05
Sulfate	250
Sulfide	0.05
Zinc	5.0
BACTERICIDE (mg/l)	
Residual Iodine (minimum)	0.5
Residual Iodine (maximum)	4.0
AESTHETICS (mg/l)	
Cations	30
Anions	30
CO ₂	15

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*Figure 7.2.2.3.2-1 Potable Water Quality Requirements
(Maximum Contaminant Levels) (Continued)*

Figure 7.2.2.3.2-1 Potable Water Quality Requirements (Maximum Contaminant Levels) continued

QUALITY PARAMETERS	LIMITS
MICROBIAL	
Bacteria (CFU/100 ml)	
Total Count	1
Anaerobes	1
Coliform	1
Virus (PFU/100 ml)	1
Yeast & Mold (CFU/100 ml)	1
RADIOACTIVE CONSTITUENTS (pCi/l)	Note 3
ORGANIC PARAMETERS (ug/l) (See Note 2)	
Total Acids	500
Cyanide	200
Halogenated Hydrocarbons	10
Total Phenols	1
Total Alcohols	500
Total Organic Carbon (TOC)	500
Uncharacterized TOC (UTOC) (ug/l) (See Note 4)	100
ORGANIC CONSTITUENTS (mg/l) (See Notes 2 & 5)	

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Notes:

1. No detectable gas using a volumetric gas vs. fluid measurement system. Excludes CO2 used for aesthetic purpose.
2. Each parameter/constituent MCL must be considered individually and independency of others.
3. The maximum contaminant level for radioactive constituents in portable and personal hygiene water shall conform to Nuclear Regulatory Commission (NRC) regulations (10CFR20, et al.). These maximum contaminant levels are listed in the Federal Registry, Vol. 51, No. 6, 1986, Appendix B, as Table 2 (Reference Level Concentrations) Column 2 (Water). Control/containment/monitoring of radioactive constituents shall be the responsibility of the user. Prior to the introduction of any radioactive constituents shall be obtained from the Radiation Constraints Panel (RCP). The RCP will approve or disapprove proposed monitoring and decontamination procedures on a case-by-case basis.
4. UTOC equals TOC minus the sum of analyzed organic constituents, expressed in equivalent TOC.
5. In the event a quality parameter not listed in this table is projected, or found, to be present in the reclaimed water, the Water Quality Manager from NASA authorizing authority shall be contacted for a determination of the MCL for that parameter.

Figure 7.2.2.3.2-2 Potable Water Quantity Requirements

UNITS	MODE		
	Operational	90 Day Degraded ¹	Emergency ³

lb/person-day	6.26 ² - 11.35 ²	6.26 ²	6.26 ²
kg/person-day	2.84 - 5.16	2.84	2.84

Reference: 278 NASA-STD-3000 409, Rev. A With Updates

1 Degraded levels meet “fail operational criteria”.

2 Based on 2950 kcal/person-day IVA work rate. Actual amount depends on degree of hydration of the food.

3 Safe Haven conditions shall be maintainable for up to 45 days.NASA-STD-3000 409

1 Degraded levels meet fail operational criteria.

2 Based on 2950 kcal/person-day IVA work rate. Actual amount depends on degree of hydration of the food.

3 Safe Haven conditions shall be maintainable for up to45 days.

7.2.2.4 Example Nutritional Program

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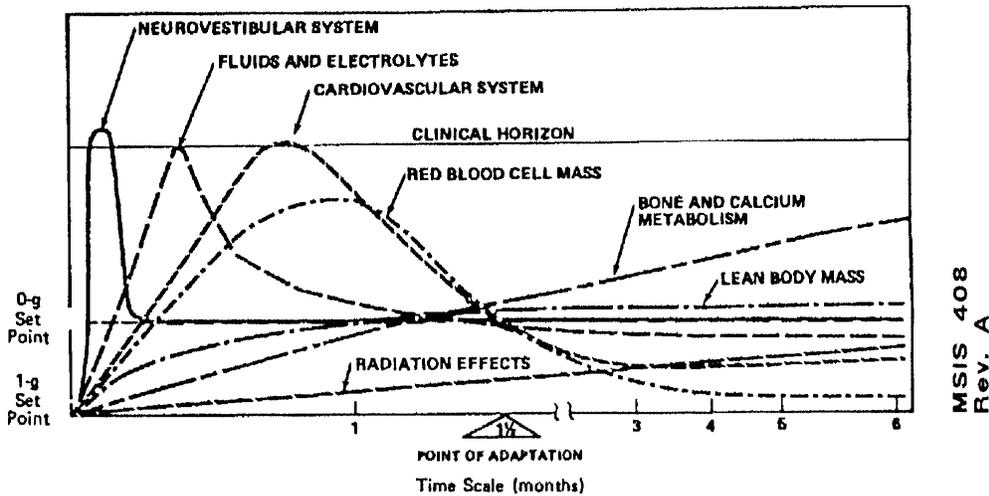
The menus on the Space Transportation System (Shuttle) are designed to provide the nutrients in Figure 7.2.2.4-1 in three meals per person per day.

Figure 7.2.2.4-1 Example Nutrition Program - Nutrient Requirements in Three Meals Per Person Per Day

Energy (kcal)	WHO equation	Vitamin B6 (mg)	2.0 men 1.6 women
Protein % of calories	12 - 15	Vitamin B12 (µg)	2.0
Vitamin A (RE)	1000 Ng/d men 800 Ng/d women	Calcium (mg)	800 - 1200
Vitamin D (Ug)	10	Phosphorus (mg)	800 - 1200
Vitamin E (TE)	10 men 8 women	Iodine (mg)	150
Ascorbic acid (mg)	100	Iron (mg)	10
Folate (µg)	200 men 180 women	Magnesium (mg)	350 men 280 women
Niacin (mg NE)	19 men 15 women	Zinc (mg)	15 men 12 women
Riboflavin (mg)	1.7 men 1.3 women	Potassium (mg)	3500
Thiamin	1.5 men 1.1 women	Sodium (mg)	1100 - 3300

Reference: 309, page 23 NASA-STD-3000 - 157, 406 With Updates

Figure 7.2.3.1-1 Time Course of Physiological Shifts Associated with Acclimation to the Micro-g Environment.



Reference: 208, Figure 1, page 134

With Updates

Figure 7.2.3.1-1 Time course of physiological shifts associated with acclimation to the micro-g environment

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7.2.3 Reduced Gravity Countermeasures

{OP}

7.2.3.1 Introduction

{OP}

The following section discusses the effects of gravitational changes on the human body and countermeasures that can be taken to maintain crew health. Space gravity environments can vary from multi-G (during launch) to microgravity in orbit. This section primarily deals with microgravity. The considerations and requirements apply to all reduced gravity conditions but proportionally less with increasing gravity. Specific countermeasure requirements for reduced gravity greater than microgravity must be established on an individual basis. Figure 7.2.3.1-1 illustrates the time course of shifts in various physiological parameters associated with acclimation to the micro-g environment.

7.2.3.2 Reduced Gravity Countermeasures Design Considerations

{OP}

Reduced gravity countermeasures fall into three general categories which are described below:

a. Countermeasures Against Initial Response to Reduced Gravity - There are several responses that begin within the first few hours of exposure to reduced gravity and continue for from one to five days depending on the individual. These responses are:

1. Vestibular side effects and space motion sickness.

2. Reduced motor skills due to unfamiliarity with reduced gravity.

3. Loss of Body Fluids - Body fluids shift headward in reduced gravity conditions, resulting in increased urination and fluid loss.

(Refer to Paragraph 7.2.3.4, Nonexercise Countermeasures, for information on countermeasures for the above effects.)

(Refer to Section 4.0, Human Performance Capabilities, for information on vestibular effects and motor performance in reduced gravity.)

b. Maintenance Of 1-G Conditioning - The body slowly loses conditioning with exposure to reduced gravity. Counter

measures should be considered against at least the following three deconditioning effects:

1. Loss of strength and muscle mass.

2. Loss of bone minerals.

3. Loss of cardiovascular conditioning.

Exercise is the primary countermeasure against these effects and is discussed in Paragraph 7.2.3.3.

c. Countermeasures Against Initial Response Upon Entry to 1-G - After exposure to reduced gravity, the human body makes several immediate adjustments when exposed to 1-G conditions.

The following are responses for which countermeasures should be considered:

1. Dehydration - This is due to the fluid losses during microgravity.

2. Rapid shift of fluids to the lower body due to re-exposure to the 1-G environment.

3. Reduced motor capabilities in 1-G.

Countermeasures against these effects are discussed in Paragraph 7.2.3.4.

7.2.3.3 Exercise Countermeasures

{OP}

7.2.3.3.1 Introduction

{OP}

This section discusses the exercise countermeasures against the deconditioning effects of reduced gravity that have resulted in loss of muscular strength and cardio-respiratory endurance.

(Refer to Paragraph 10.8, Microgravity Countermeasures, for information on the facility requirements for these exercise countermeasures.)

7.2.3.3.2 Exercise Countermeasures Design Considerations

{OP}

7.2.3.3.2.1 Deconditioning Effects Of Reduced G Design Considerations

{OP}

Two of the most immediate and significant effects of microgravity are the removal of weight forces from bone and muscle, and the headward shift of fluids. These changes lead to a progressive degradation of muscles, the skeletal system, and cardiovascular conditioning by Earth's standards. Musculoskeletal system changes, brought about by lack of exercise and the absence of gravitational forces, are mostly reversible, but they contribute to weakness and poor gravitational tolerance in the post-mission period. Cardiovascular deconditioning is manifested by a post-mission orthostatic intolerance, decreased cardiac output, and reduced exercise capacity. Both forms of deconditioning may impair the ability of an individual adapted to weightlessness to function and perform adequately during EVA or the critical phases during entry and landing.

7.2.3.3.2.2 Deconditioning Countermeasure Design Considerations

{OP}

Because the underlying factor producing the changes leading to both cardiovascular and musculoskeletal deconditioning in the absence of gravity, the effort to reduce these deconditioning effects has been primarily focused on restoring weight forces, stresses, and system interactions by simulating Earth-normal physical movements. The single approach which so far has received wide operational acceptance in the U.S. and USSR space programs is exercise. The following are considerations to be made when designing a reduced gravity exercise countermeasure program:

a. Type of Exercise - Exercises necessary to counteract the effects of reduced gravity are listed in Figure 7.2.3.3.2.2-1.

b. Mission Duration - For short-term missions (less than 10 days), pre-mission conditioning of crewmembers to elevated levels of fitness should compensate for the anticipated decrements in physiological function so that impairment during entry, landing and post-mission will be tolerable. Even for these short missions, however, in the interest of crew morale, some opportunity to exercise should be provided. For missions during which crewmembers will be exposed to microgravity for greater than 10 days, deconditioning countermeasures will be essential.

c. Limitations of Exercise Program - Until recently, it was believed that a proper exercise program could reverse the significant physiological/anatomical changes associated with the body's response to microgravity. However, studies of prolonged bed rest suggest that exercise, by itself, is insufficient to meet these ends. For instance, changes in endocrine and metabolic functions now are believed to result from changes in hydrostatic pressure and from lack of postural cues, rather than from a lack of activity. There is a possibility, however, that activities of higher intensity or longer duration could have countered these changes.

d. Motivational Factors - Motivation is an extremely important consideration. All of the planning and equipment can be wasted if the crewmembers are not motivated to participate in an exercise program. The following factors play an important role in the motivation of crewmembers:

1. Understanding - The crewmembers should be aware that the exercise program is providing positive benefits to their health and will benefit both in a reduced gravity environment and in their eventual return to Earth. For protracted durations in space, exercise countermeasures may be essential to mission fulfillment.

2. Feedback - Performance monitoring/display devices and record keeping to evaluate progress are known tools for enhancing motivation. Video displays and computerized programs are available for exercise equipment in a myriad of formats. This approach can be utilized to provide this feedback, as well as entertain the exercising crewmember.

3. Entertainment and Diversion - Video, music, reading materials, social interaction, Earth-viewing windows, etc., may act as a diversion to keep exercise from becoming monotonous for some crewmembers.

4. Games - Designing exercises that have an element of play can provide positive motivation. For instance, gravity forces less than 1-G constitute a new environment with a new set of physical challenges.

5. Facilities - Facilities that require little preparation prior to exercise and minimal stowage afterward are essential if crewmembers are to maintain motivation and adherence to the program.

(Refer to Paragraph 10.8, Microgravity Countermeasures, for information on exercise facility design.)

6. Support Facilities - Adequate facilities for washing and resting after exercise are necessary for motivation.

(Refer to Paragraph 10.2, Personal Hygiene, for information on body washing facility design and to Paragraph 10.4, Crew Quarters, for information on resting facility design.)

Figure 7.2.3.3.2.2-1 Exercise Countermeasure Design Considerations

Exercise Countermeasures		
Problem	Exercise	Comment
Bone mineral loss	Impact activities plus maximum isometric strength exercises	While evidence is mixed, these attempts should be continued; treadmill is suitable for impact activity
Muscular strength losses	Low frequency, high resistance exercises for all major muscle groups	Simulated one-g weight training program can be used, for instance, a rowing action ergometer.
Cardiovascular function (aerobic power) loss	Aerobic type exercise	Cycle and rowing type ergometer superior to treadmill for monitoring, quantifying, and ease of use.

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7.2.3.3.3 Exercise Countermeasure Design Requirements

{OP}

Exercise countermeasure requirements apply to space missions that expose crewmembers to microgravity conditions for longer than 10 days. For missions of 10 days or less, exercise countermeasures shall be available for crewmembers as necessary to maintain performance during the mission on entry to 1-G. The following are the exercise countermeasure design requirements:

a. Types of Exercise - The space module shall provide facilities for the following types of exercise:

1. Equipment for placing isokinetic, isotonic (concentric and eccentric), and isometric force upon the major muscle groups of the body shall be provided in order to counter disuse atrophy caused by microgravity.

2. Devices for exercising the cardiorespiratory system by engaging large skeletal muscle masses (i.e., aerobic exercises) as partial countermeasure to cardiovascular deconditioning shall be provided.

b. Duration of Exercise - Facilities and scheduling shall provide the capability for all crewmembers to exercise not less than 1 hour per day.

c. Exercise Regimens - Capability shall be provided for establishing and updating individualized exercise routines and goals for each crewmember.

d. Motivation and Training - Appropriate motivational devices and/or incentives shall be provided. Crewmembers shall be trained in the importance of exercise and how to use the equipment.

e. Data Monitoring of Exercise - There shall be the capability to monitor physiological parameters during exercise, store the data, and downlink this information to Earth. The following physiological parameters shall be monitored:

1. Routine Monitoring.

(a) Heart Rate.

(b) Duration of Exercise Period

(c) Power Output From Instrumented Exercise Device

2. Periodic Monitoring

(a) Electrocardiogram

(b) Blood Pressure

(c) Maximal and Submaximal Oxygen Uptake

(d) Muscle Performance

(e) Body Mass Measurement

7.2.3.4 Nonexercise Countermeasures

{OP}

7.2.3.4.1 Introduction

{OP}

This section discusses the nonexercise countermeasures for the deconditioning effects of reduced gravity. Nutrition, which plays a supportive role to other countermeasures, is discussed in Paragraph 7.2.2.

7.2.3.4.2 Nonexercise Countermeasures Design Considerations

{OP}

Exercise is the primary countermeasure against the body deconditioning effects of extended exposure to reduced gravity conditions. Other body effects appear more rapidly upon changes in the gravity environment. These effects should also be considered in mission planning and in providing countermeasures. The significant immediate effects due to changes in gravity conditions are as follows:

a. Vestibular side effects and space motion sickness in reduced gravity.

b. Loss of body fluids soon after exposure to reduced gravity (this results in dehydration when the fluids redistribute on exposure to 1-G conditions).

c. Reduced motor performance in a novel gravity environment (this requires training and adaptation and occurs both on entry to 1-G and microgravity conditions).

7.2.3.4.3 Nonexercise Countermeasures Design Requirements

{OP}

Nonexercise countermeasures shall be provided regardless of the duration of the mission. The following are required countermeasures:

a. Pressurized Countermeasures - Lower body positive pressure devices for gravity protection during 1-G entry and landing shall be provided.

b. Pharmacological Countermeasures - Pharmacological methods, including oral rehydration, shall be provided to increase the body's total fluid volume. These countermeasures shall be available for implementation just prior to entry into a 1-G environment.

c. Space Motion Sickness Countermeasures - Space motion sickness countermeasures shall be provided and shall include:

1. Prophylactic medication.

2. Scheduling so that activities which require head and body translation movements are minimized during the early days of the mission.

7.2.4 Sleep

{A}

7.2.4.1 Introduction

{A}

This section on sleep includes:

a. Effects of microgravity on sleep needs.

b. Scheduling.

c. Duration.

d. Sleep aids.

(Refer to Paragraph 10.4, Crew Quarters, for information on facilities to support sleep.)

7.2.4.2 Sleep Design Considerations

{A}

The following are considerations to be made when establishing a space module sleep schedule and facility in a microgravity environment.

a. Effects of Microgravity - The results of Skylab experiments do not show any major adverse changes in sleep as a result of prolonged space flight. Only during the 84 day flight did one subject experience any real difficulty in terms of sleep time. Even then, the problem diminished with time, although sleeping medication was required on occasion. The most significant changes occurred in the postflight period, with alterations more of sleep quality than quantity. It appears that readaptation to a 1-G environment is more disruptive to sleep than the adaptation to microgravity. In all, the Skylab investigators feel that adequate sleep can be obtained in a microgravity environment providing adequate sleeping areas are used, noise levels are minimized, and a familiar time reference for the sleep period is used.

b. Duration of Sleep - Satisfactory psychological performance is dependent upon an adequate sleep/wakefulness cycle, but few studies have been done to determine the optimum number of hours of sleep required per hours of waking time. The usual study has investigated the amount of sleep spontaneously taken per day without regard to performance. It has not been demonstrated at this point whether humans need 6 to 8 hours of sleep in every 24. On the short side, the quality of afternoon performance improves almost linearly as sleep duration is increased from 1 to 6 hours. Beyond a duration of 6 hours of sleep, improvement is less marked and is completely absent when sleep is lengthened from 8 to 10 hours in every 24.

c. Sleep/Work Cycle - The following factors must be considered about sleep/work cycles:

1. Personnel exposed to changes in environmental cues will show disrupted circadian rhythms.

2. Circadian rhythms significantly affect a wide variety of human functions in addition to sleep, including psychomotor and cognitive performance, mood, and social adaptability.

3. Careful planning of activity schedules, sleep/wake schedules, and artificial control of environmental cues may be necessary to offset the possible negative impact of circadian desynchronization on crew performance and adjustment.

4. Sleep periods should be preceded by at least 1 hour of nondemanding mental activity.

7.2.4.3 Sleep Design Requirements

{A}

The following are design requirements for crew sleep:

a. Facilities - Adequate sleep facilities shall be provided.

(Refer to Paragraph 10.4, Crew Quarters, for sleep facility design requirements.)

b. Duration - Scheduling should allow a minimum sleep period of 8 hours per day with minimum of 6 hours of uninterrupted sleep.

c. Pharmaceuticals - Appropriate sleep aid medication shall be made available to crewmembers via a controlled access system.

7.2.5 Personal Hygiene

{A}

7.2.5.1 Introduction

{A}

This section on personal hygiene includes the functional considerations and requirements for maintaining proper personal hygiene during a space mission.

(Refer to Paragraph 10.2, Personal Hygiene, for information on facilities supporting personal hygiene.)

7.2.5.2 Personal Hygiene Design Considerations

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Personal hygiene is important to both the psychological and physiological well being of the crew. The following are considerations for ensuring a proper personal hygiene program:

- a. Facilities - Facilities for performing personal hygiene functions must be properly sized and accessible.
- b. Equipment, Supplies, and Clothing - Personal hygiene equipment and supplies and crew clothing must accommodate the physiological differences in male and female crew members in the microgravity environment. The hardware should make this accommodation with as few interchangeable components as possible. The supplies and clothing should also be able to meet the personal tastes and needs of the crew members to the extent possible in the space module environment.
- c. Training - Crewmembers must be adequately trained and familiar with both personal hygiene equipment and procedures.
- d. Scheduling - Proper scheduling must be provided to allow adequate time for personal hygiene.
- e. Personal Hygiene Standards - Personal hygiene standards should be established prior to the start of the program.

7.2.5.3 Personal Hygiene Design Requirements

{A}

7.2.5.3.1 Body Grooming Design Requirements

{A}

The following body grooming measures shall be provided in the space modules.

- a. Skin Care - The capability shall be provided for crewmembers to condition their skin sufficiently to prevent drying and/or cracking.
- b. Shaving - Provisions shall be made for crewmembers to shave body hair.
- c. Hair Grooming - Provisions shall be made for crewmembers to cut hair to maintain the length within mission and/or personal requirements.
- d. Nail Care - Provisions shall be made for crew members to trim nails.
- e. Body Deodorant - The capability shall be provided for crewmembers to control body odor.
- f. Menstruation - Provisions shall be provided for the collection and disposal of menstrual discharge.

Refer to Paragraph 10.2.3.4, Hair Cutting Design Requirements, and Paragraph 10.2.3.5, Grooming & Shaving Design Requirements, for facility design requirements.)

7.2.5.3.2 Partial Body Cleansing Design Requirements

{A}

The capability shall be provided for crewmembers to perform selected body area cleansing as needed.

(Refer to Paragraph 10.2.3.1, Partial Body Cleansing Design Requirements, for facility design requirements.)

7.2.5.3.3 Oral Hygiene Design Requirements

{A}

The capability shall be provided for crewmembers to maintain proper oral hygiene. Proper oral hygiene includes tooth, mouth, and gum care.

Water for oral hygiene shall meet potable water quality standards defined in Paragraph 7.2.2.3.2.1.

(Refer to Paragraph 10.2.3.3, Oral Hygiene Design Requirements, for facility design requirements.)

7.2.5.3.4 Whole Body Cleansing Design Requirements

{A}

The capability shall be provided for crewmembers to perform whole body skin and hair cleansing.

(Refer to Paragraph 10.2.3.2, Whole Body Cleansing Design Requirements, for facility design requirements.)

7.2.5.3.5 Personal Clothing & Equipment Cleansing Design Requirements

{A}

The capability shall be provided to supply each crewmember with clean clothing and other washable items, including bedding and linens, over the duration of the mission.

(Refer to Paragraph 11.13.1.3, Clothing Design Requirements, and Paragraph 10.10.3, Laundry Facility - Design Requirements, for additional requirements.)

7.2.5.3.6 Personal Hygiene Water Design Requirements

{A}

Personal hygiene water is water that is used for external body cleansing. Personal hygiene water requirements are listed below:

- a. Quality - Minimum personal hygiene water quality requirements are given in Figure 7.2.5.3.6-1.
- b. Quantity - Personal hygiene water quantity requirements are given in Figure 7.2.5.3.6-2. This figure does not include requirements for laundry and dishwashing which are system dependent.
- c. Temperature - Temperature shall be adjustable from 21 +/- 4 oC (70 +/- 10 oF) to a maximum of 45oC (113oF).

Figure 7.2.5.3.6-1 Hygiene Water Quality Requirements (Maximum Contaminant Levels) (Continued)

QUALITY PARAMETERS	LIMITS
PHYSICAL PARAMETERS	
Total solids (mg/l)	500
Color True (Pt/Co units)	15
Taste (TTN)	N/A
Odor (TON)	3
Particulates (max size - microns)	40
pH	5.0-8.5
Turbidity (NTU)	1
Dissolved Gas (free @ 37°C)	N/A
Free Gas (@ STP)	Note 1
INORGANIC CONSTITUENTS (mg/l)	
(See Notes 2 and 5)	
Ammonia	0.5
Arsenic	0.01
Barium	1.0
Cadmium	0.005
Calcium	30
Chlorine (Total - Includes Chloride)	200
Chromium	0.05
Copper	1.0
Iodine (Total - Includes Organic Iodine)	15
Iron	0.3
Lead	0.05
Magnesium	50
Manganese	0.05
Mercury	0.002
Nickel	0.05
Nitrate (NO ₃ -N)	10
Potassium	340
Selenium	0.01
Silver	0.05
Sulfate	250
Sulfide	0.05
Zinc	5.0
BACTERICIDE (mg/l)	
Residual Iodine (minimum)	0.5
Residual Iodine (maximum)	6.0
AESTHETICS (mg/l)	
Cations	N/A
Anions	N/A
CO ₂	N/A

Figure 7.2.5.3.6-1 Hygiene Water Quality Requirements (Maximum Contaminant Levels) (Completed)

QUALITY PARAMETERS	LIMITS
MICROBIAL	
Bacteria (CFU/100 ml)	
Total Count	1
Anaerobes	1
Coliform	1
Virus (PFU/100 ml)	1
Yeast & Mold (CFU/100 ml)	1
RADIOACTIVE CONSTITUENTS (pCi/l)	Note 3
ORGANIC PARAMETERS (mg/l) (See Note 2)	
Total Acids	500
Cyanide	200
Halogenated Hydrocarbons	10
Total Phenols	1
Total Alcohols	500
Total Organic Carbon (TOC)	10,000
Uncharacterized TOC (UTOC) (mg/l) (see Note 4)	1,000
ORGANIC CONSTITUENTS (mg/l) (See Notes 2 & 5)	

Reference: 278 NASA-STD-3000 412b, Rev. A

With Updates

Notes:

1. No detectable gas using a volumetric gas vs. fluid measurement system. Excludes CO₂ used for aesthetic purposes.
2. Each parameter/constituent MCL must be considered individually and independently of others.
3. The maximum contaminant level for radioactive constituents in potable and personal hygiene water shall conform to Nuclear Regulatory Commission (NRC) regulations (10CFR20, et al.). These maximum contaminant levels are listed in the Federal Register, Vol. 51, No. 6, 1986, Appendix B, as Table 2 (Reference Level Concentrations) Column 2 (Water). Control/containment/monitoring of radioactive constituents used on SSF shall be the responsibility of the user. Prior to the introduction of any radioactive constituents on SSF, approval shall be obtained from the Radiation Constraints Panel (RCP). The RCP will approve or disapprove proposed monitoring and decontamination procedures on a case-by-case basis.
4. UTOC equals TOC minus the sum of analyzed organic constituents, expressed in equivalent TOC.
5. In the event a quality parameter not listed in this table is projected, or found, to be present in the reclaimed water, the Water Quality Manager from Man Systems shall be contacted for a determination of the MCL for that parameter.

Figure 7.2.5.3.6-2 Minimum Personal Hygiene Quantity Requirements

MODE			
UNITS	Operational	90 dAY Degraded ¹	Emergency ³
lb/ person-day	51.5 ²	16.0 ⁴	12.0 ⁵
kg/ person-day	23.4	8.18	5.45

Reference: 278
With Updates

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1. Degraded levels meet "fail operational criteria".
2. Based on 12-lb minimum capacity for hygiene and 25 lb used in a 90-day chamber test. Includes laundry (27.5 lb/person-day) and dishwashing (12 lb/person-day) quantities.
3. Based on 12 lb/person-day) capacity for hygiene and 4 lb/person-day for laundry.
4. Based on 12 lb/person-day minimum capacity for hygiene only.

Figure 7.2.5.3.6-2 Minimum Personal Hygiene Quantity Requirements

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1. Degraded levels meet fail operational criteria.
2. Based on 12 - lb minimum capacity for hygiene and 25 lb used in a 90-day chamber test.
Includes laundry (27.5 lb/person-day) and dishwashing (12 lb/person-day) quantities.
3. Based on 12 lb/person-day) capacity for hygiene and 4 lb/person-day for laundry.
4. Based on 12 lb/person-day minimum capacity for hygiene only.

Figure 7.2.5.3.6-2 Minimum Hygiene Quantity Requirements

7.2.6 Pre/Post-Mission Health Management

{A}

7.2.6.1 Introduction

{A}

This section specifically addresses the health management of the crewmembers before and after the mission. The other paragraphs of Sections 7.0, Health Management, deal primarily with health management during the mission.

7.2.6.2 Pre/Post-Mission Health Management Design Considerations

{A}

Pre- and post-mission measures can be taken to promote the health of the crewmembers and to increase the chance of a successful mission. The measures are:

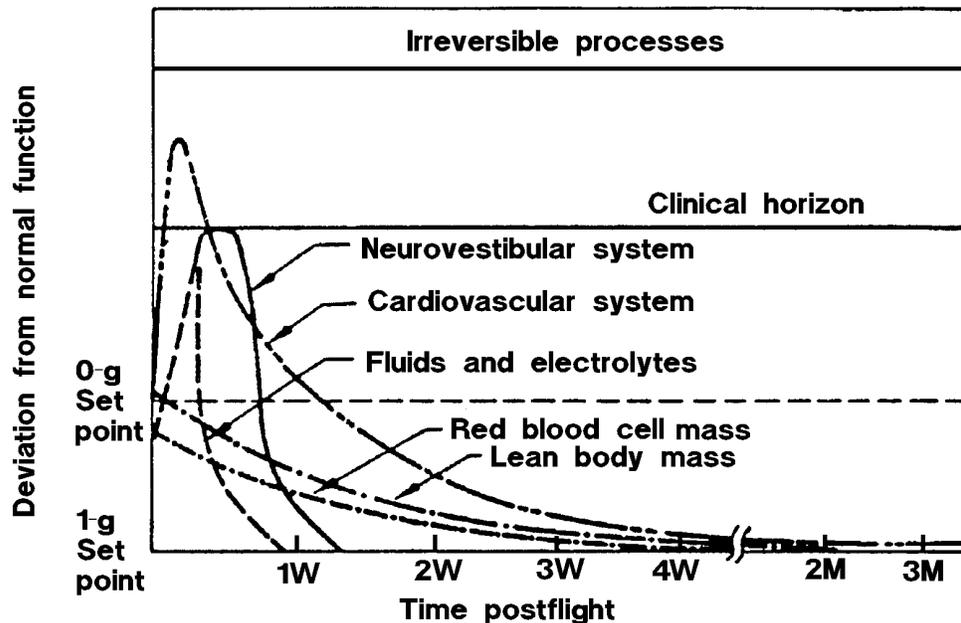
a. Crewmember Selection - Health criteria should be established to minimize the chances of illness and injury that would result in a loss of investment in training or a decrement in mission success. Required physical and psychological aptitudes and abilities of the crew can be established through careful analysis of the anticipated tasks to be performed during the mission.

b. Pre-Mission Health Stabilization - A health stabilization program that includes monitoring must be in place during the preparatory stages of the mission. Particularly important are immunization and exposure protection against those diseases that could become overt during the mission.

c. Pre-Mission Health Training - The goal of this training is to familiarize the crewmembers with the objectives and modalities of the health maintenance system including the methods of monitoring to be implemented.

d. Post-Mission Gravitational Readaptation - Readaptation to a 1-G environment varies by physiological system as shown in Figure 7.2.6.2-1. The health care, monitoring, and support for readaptation must consider these factors.

Figure 7.2.6.2-1 Time Course of Physiological Shifts During Readaptation to 1-G



Reference: 208, Fig 2, pg 135

Notes:

W - Week

M - Month

Figure 7.2.6.2-1 Time Course of Physiological Shifts During Readaptation to 1-G

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7.2.6.3 Pre/Post-Mission Health Management Design Requirements

{A}

The following pre and post-mission health care management programs shall be provided:

a. Pre-Mission Health Management - Crew selection and training, and health stabilization programs shall be conducted to:

1. Minimize the possibility of a health problem that would keep a trained crewmember from going on a mission.
2. Minimize the threat of mission decrement due to a health problem.

b. Post-Mission Health Management - Post-mission health care shall be provided to minimize the chance of illness or injury to the crewmember due to his or her deconditioned state.

7.2.7 Health Monitoring

{A}

7.2.7.1 Introduction

{A}

This section addresses the monitoring measures necessary to evaluate the health of the crewmembers and the health safety of the space module environment. This section discusses only monitoring of crew health and water quality. Other sections of this document monitoring requirements for the space module environment. These other sections are referenced in the appropriate paragraphs.

7.2.7.2 Routine Health Monitoring Design Considerations

{A}

7.2.7.2.1 Routine Crew Health Monitoring Design Considerations

{A}

The following are considerations for establishing a crew health monitoring program:

a. Record Keeping - The results of all crew health monitoring must be kept in a permanent and easily retrievable format for trend analysis. There must a simple and rapid way to communicate the data to the ground. The method for handling, storing, and transmission of crew members medicine health records must be totally secure.

b. Standards - Standards defining nominal limits of the monitored parameters and procedures for handling health problems (treatment, consultation, rescue, mission abort, etc.) must be clearly defined and available to responsible space module crewmembers.

c. Frequency of Monitoring - There should be an increased frequency of health monitoring at the beginning and the end of the mission compared with a baseline frequency during the middle of the mission. This is due to the effect of environmental changes on both the space module and the crew.

7.2.7.2.2 Water Quality Monitoring Design Considerations

{A}

The water supply characteristics, mission duration, anticipated hardware lifetime, and rescue opportunities for long-term space missions are unlike those encountered in any terrestrial application or previous manned space program. These characteristics introduce a variety of hazards which dictate the need for unique water quality requirements, monitoring, capabilities for quality maintenance and restoration, and novel technologies to enable these activities.

7.2.7.2.2.1 Toxicological Monitoring Design Considerations

{A}

The following are considerations for toxicological monitoring of the water supply:

- a. Water Recycling** - To avoid the severe launch or resupply penalties associated with ground-supplied water, long missions will incorporate a system to recycle water. Sources for the reclaimed water include cabin humidity condensate, spent wash water, and urine. Crewmembers will be exposed to reclaimed water in metabolic, personal hygiene, and housekeeping activities. Of particular impact will be the water-soluble volatile and nonvolatile contaminants from the waste, humidity, and condensate collection systems.
- b. Conventional Systems** - The maximum allowable concentration limits for many inorganic chemicals in potable water are below those which could be detected by conventional process control and screening analyses, such as conductivity and pH measurements.
- c. Chronic Exposure Considerations** - Water recycling introduces the potential for repeated exposure to metabolically active contaminants and increases the potential in reclamation and disinfection processes for chemical derivatization of innocuous constituents into toxic products, such as organohalides. Long missions and continuous habitation will necessitate that the effects of chronic exposure be considered along with acute toxicity.
- d. Prediction of Toxins** - Because toxicant incidence and abundance vary among different wastewater reclamation techniques, and since the composition of the source wastewater is highly variable, it is difficult to define the composition of product water. Of particular concern is the organic content of the reclaimed water.
- e. Total Organic Carbon** - Because of the variety and variability of organics reclaimed water, Total Organic Carbon (TOC) will be a critical surrogate measurement required for potability verification, process control, and hygiene quality determination.
- f. Exposure Limits** - The establishment of exposure limits for the wide variety of organics found in reclaimed water is a problem of enormous magnitude. Exposure limits, for the most part, do not exist for organics that have been identified in reclaimed water because these chemicals do not correspond to those (such as pesticides, petroleum products, industrial wastes, and urban and agricultural runoff) encountered in terrestrial water.
- g. System Breakdown** - The long system life inherent in long-term missions increases the potential for accumulation of toxic contaminants, for system failures and malfunctions, and for contributions to the overall contaminant burden by degradation of system materials.
- h. Stainless Steel** - Although stainless steel was successfully used to fabricate the STS water system, long-duration mission hardware life requirements may preclude its use.
- i. Impact of Experiments and Process** - Biological and industrial experiments and processes to be conducted on long-duration space missions constitute another potential and undefined source of contamination for the water system and increase the variability of the source water.

7.2.7.2.2.2 Microbiological Monitoring Design Considerations

{A}

Even in high quality water supplies protected by a residual bactericide, viable organisms can still persist. Therefore, the potential for microbial overgrowth is an ever-present hazard. The following are considerations for microbiological monitoring:

- a. Water Recycling** - In reclaimed systems, the potential exists for introduction of microorganisms into the system in greater numbers and variety than in conventional or previously used water systems.
- b. Use of Coliforms** - Coliforms, the conventional indicator organism group for terrestrial potable water, is not an adequate indicator of total microbial acceptability for aerospace water systems.
- c. Disinfectant-Resistant Forms** - Recycling of water introduces the potential for circulating pathogenic or opportunistic organisms, and increases the potential for selection of disinfectant-resistant microbiological species.
- d. Previous Systems** - Previous spacecraft water systems have been required to maintain throughout the potable water system and have successfully met this requirement.
- e. Time Considerations** - If any viable organisms are detected, one is immediately faced with the task of identification to assess the potential impact of the particular species. Since medical requirements preclude crew use of space module water until its quality has been verified, routine identification would impose additional delays before reclaimed water could be used.
- f. System Maintenance/Reliability** - Quality maintenance of the long-term mission water systems will require careful materials selection to preclude adverse deterioration over the expected operation of the system, the maintenance of a continuous residual bactericide downstream of the reclamation process(es), and a method of restoring system integrity in the event of system malfunction or contamination.
- g. Biofilm Potential** - The projected long term use of the water distribution system will favor the development of biofilms within the system. These films can harbor organisms and protect them from the residual bactericide. The resulting microbial contamination or microbial growth products in the water must be prevented.

7.2.7.2.3 Physical Monitoring Design Considerations

{A}

A variety of physical properties are readily measured in conventional laboratories to determine the quality of water supplies. These parameters include properties which have direct effects on water acceptability and those which are indicative of other undesirable conditions. The following are considerations for physical monitoring of the water supply:

- a. Color** - consumer rejection because of its effect on aesthetic quality and is indicative of contaminants.
- b. Taste and Odor** - evaluations that rely on the human sensory apparatus. Acceptability of the taste of potable water is important to both the psychological well-being and the physiological health of the crew. Potable water provided on previous U.S. manned space flights has been characterized as tasteless and undesirable. The flat taste of this water is probably a direct result of its high quality analogous to triple distilled water. In order to meet maximum concentration limits of potential toxicants, reclaimed water will have a similar tasteless quality unless additives are provided to enhance flavor. At times when bactericide overdosage has occurred, crews have indicated objectionable taste.
- c. Turbidity** - Turbidity is an indicator of particulate contamination which may be living or nonliving material. Excessive nonliving particulate material interferes with disinfection and can cause consumer rejection for aesthetic reasons. Large particles can harbor microorganisms in their interior.

d. Other Physical Parameters - Temperature, conductivity, and pH are other collective physical parameters which affect acceptability of water. These physical properties may be quite easy to measure and provide rapid, on-line information about the quality of the water.

7.2.7.3 Routine Health Monitoring Design Requirements

{A}

7.2.7.3.1 Routine Crew Health Monitoring Design Requirements

{A}

The space module shall have the following routine crew health monitoring capabilities:

a. Routine Diagnostic Physical Examination - The capability for conducting routine diagnostic physical examination of the crewmembers shall be provided on all long-term missions (in excess of two weeks).

(Refer to Paragraph 10.9.3.11.2, Routine Diagnostic Exam - Design Requirements, for equipment required for routine physical examination.)

b. Monitoring During Exercise - Requirements for physiological monitoring of the crew member during exercise are defined in Paragraph 7.2.3.3.3, Exercise Countermeasure Design Requirements.

(Refer to Paragraph 10.8.3.2, Countermeasure Monitoring Design Requirements, for facilities and equipment for monitoring during exercise.)

c. Pre- and Post-Mission Health Monitoring - Requirements for physiological monitoring before and after mission are defined in Paragraph 7.2.6.3, Pre- and Post-Mission Health Management - Design Requirements.

7.2.7.3.2 Water Quality Monitoring Design Requirements

{A}

The capability to detect, differentiate, and warn the crew as necessary to maintain crew health for selected contaminants in the space module water supply by real-time or near-real-time monitoring shall be provided.

The capability to disinfect/sanitize the water system shall be provided.

The following water quality monitoring requirements apply to all space module water that comes into direct contact with personnel (through ingestion, personal hygiene, housekeeping, etc.).

7.2.7.3.2.1 Water Quality Monitoring Schedule Design Requirements

{A}

Water quality shall be monitored according to the schedule shown in Figure 7.2.7.3.2.1-1.

Figure 7.2.7.3.2.1-1 Required Water Quality Monitoring Schedule For All Water Which Comes Into Contact With Personnel.

PARAMETER	ON-LINE ¹ POT HYG	OFF-LINE ² POT HYG
Physical		
Total Solids	- -	- -

Color	- -	+ +
Conductivity	X X	X X
Taste & Odor	- -	+ +
Particulates	- -	+ +
pH	X X	X X
Temperature	X X	X X
Turbidity	TBD TBD	+ +
Dissolved Gas	- -	+ -
Free Gas	- -	+ -
Inorganics		
Ammonia	- -	+ +
Iodine	X X	X X
Specific		
Inorganics ³	- -	+ +
Aesthetics		
Specific		
Contributors ⁴	- -	+ +
Microbial		
Bacteria		
Total Count	- -	X X
Anaerobes	- -	+ +
Coliform	- -	- -
Virus	- -	- -
Yeast & Mold	- -	- -
Microbe ID ⁵	- -	X X
Radionuclides ⁶	- -	X X
Organics		
TOC	X ⁷ X ⁷	X X
Specific		
Organics	- -	+ +

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Notes for Figure 7.2.7.3.2.1-1

X Denotes that monitoring is required.

- Denotes that monitoring is not required.

+ Denotes that this monitoring requirement will be waived if verification testing and analysis indicate that the respective quality parameter limit will be reliably met.

1 Analysis of these process stream samples will be performed to provide real time or near real time results for process control and presumptive water quality assessment. Requirements for on-line monitoring of additional parameters will be established if verification testing and analysis indicates that such monitoring is required for process control or water quality assessment.

2 Product water samples from the water systems will be analyzed off-line for confirmation of water quality. The continued operation of the ECLSS and the use of the water will not necessarily be contingent upon the availability of the analyses once the water systems are verified as being operational. In addition to the on-line and off-line analyses, grab samples from the water systems will be obtained for ground, post-mission analysis.

3 Specification of organic and inorganic elements and compounds to be monitored will be based on the potential for their being present in the product water and their toxicity. In the event a parameter not listed in this table is projected, or found, to be present in the reclaimed water, the Water Quality Manager, JSC will be contacted for a determination of the monitoring requirements.

4 Selection will be based on determination of critical aesthetic parameters.

5 This does not include identification of viruses.

6 Inflight monitoring capability will be provided by the specific experiment or procedure utilizing radionuclides.

7 Analytical procedure may provide an indirect equivalent of classical TOC.

7.2.7.3.2.2 Chemical Monitoring Design Requirements

{A}

The following requirements apply to monitoring of chemical contaminants in water:

a. Definition of Contaminants - A capability to monitor chemical contaminants in the space module reclaimed water shall be provided. Requirements for water quality monitoring of chemical contaminants are included in Figure 7.2.7.3.2.1-1.

b. Direct measurement - When necessary, organics and inorganics shall be monitored directly (not through a surrogate).

c. When required, exposure limits shall be established for organics and inorganics on an individual basis.

7.2.7.3.2.3 Microbiological Monitoring & Treatment Design Requirements

{A}

The following requirements apply to monitoring and treatment of microbiological qualities of water:

a. Determination of Potability - Capability shall be provided to support real-time decisions on water potability if organisms are detected.

b. Sampling Technique - Water sampling techniques shall preclude contamination by the operator during sampling.

c. Iodine - Iodine shall be used as the primary agent to maintain water microbiological quality

d. Alternative Microbial Control - On long-term missions when there is a potential for development of organisms resistant to iodine, an alternative microbial control technique shall be provided.

e. Recovery from Microbial Overgrowth - Provisions shall be made to recover potable and hygiene water microbial control in the event of overgrowth using processes that will not degrade the quality of water with respect to other parameters.

7.2.7.3.2.4 Physical Monitoring Design Requirements

{A}

Equipment shall be provided to meet the physical and aesthetic water quality monitoring requirements identified in Figure 7.2.7.3.2.1-1.

7.2.7.3.3 Environmental Monitoring Design Requirements

{A}

Environmental monitoring necessary to maintain crew health shall be provided as follows:

a. Particulate Monitoring - The capability to detect, differentiate, and warn the crew as necessary to maintain crew health for selected particulate contaminants in the space module by real-time or near-real-time monitoring shall be provided.

b. Microbial Contaminants Monitoring - The capability to monitor, detect, identify, quantitate, and warn the crew as necessary to maintain crew health for selected microbial contaminants in the space module by real-time or near-real-time monitoring, including selected internal surfaces, shall be provided.

(Refer to Paragraph 5.7.2.2.3, Ionizing Radiation Monitoring and Dosimetry Design Requirements, for ionizing radiation monitoring. Refer to Paragraph 5.7.3.2.2, Non-Ionizing Radiation Protection Design requirements, for non-ionizing radiation monitoring requirements.)

c. Chemical Contaminants Monitoring - The capability to detect, differentiate, and warn the crew as necessary to maintain crew health for specific chemical contaminants in the space module by real-time or near-real-time monitoring shall be provided.

d. Ionizing Radiation Monitoring - Refer to Paragraph 5.7.2.2.3, Ionizing Radiation Monitoring and Dosimetry Design Requirements for ionizing radiation monitoring.

e. Non-ionizing Radiation Monitoring - Refer to Paragraph 5.7.3.2.2, Non-ionizing Radiation Protection Design Requirements for non-ionizing radiation monitoring requirements.

f. Atmospheric Monitoring - Refer to Paragraph 5.1.3.4, Atmosphere Monitoring and Control Design Requirements, for atmosphere monitoring requirements.

The capability to decontaminate contaminated areas shall be provided. (See Section 5.1.3)

7.2.8 Biological Payloads

{A}

Biological payloads must meet the specific pathogen-free criteria as defined by the Human Research Policy and Procedures for Space Flight Investigations HRPPC) guidelines, JSC 20483. Basic environmental design requirements and acceptability limits shall minimize infectious agents, conditions, and cross contamination between the crew and biological payloads (animals, plants, etc.) that may impact crew health and mission requirements.

7.3 MEDICAL CARE

{A}

7.3.1 Introduction

{A}

This section presents the minimum functional requirements for a space medical care facility.

(The equipment and facilities for implementing these medical care requirements are discussed in Section 10.9, Space Medical Facility.)

7.3.2 Medical Care Design Considerations

{A}

7.3.2.1 Objectives of Medical Care Design Considerations

{A}

A space medical care facility should meet the following objectives:

- a. Ensure health and safety (ensure crew safety and optimal health during routine operations).
- b. Prevent excess mortality and morbidity.
- c. Prevent mission termination (prevent early mission termination due to medical contingency).
- d. Prevent an unnecessary rescue (provided rescue is a possibility).
- e. Increase the probability of success of a necessary rescue (provided rescue is a possibility).

7.3.2.2 Anticipated Illness and Injuries Design Considerations

{A}

The exact nature of the required medical care depends on the space mission (the mission duration and goal) and the illness and injuries that are expected to occur in that mission. The characteristics of the illness and injuries that are particularly important for design consideration are listed below:

- a. **Probability of Disease or Injury Occurrence** - This can be determined through historical data and analysis of the nature of the mission tasks (some tasks are more likely to cause specific injuries). It must be remembered that selection and pre-mission monitoring can screen out many potential illness.
- b. **Time for a Disease to Become Overt** - If a disease has a long incubation or development period relative to the space mission, then diagnosis and treatment during the mission becomes less important. However, should the disease have a short incubation, then diagnosis and treatment become very important. Therefore, it is imperative that means be available to determine the presence of these diseases and treat them.
- c. **Disability Level of the Ill or Injured Crewmember** - Should a crewmember become ill or injured, the seriousness of the illness or injury must be determined in order to make adjustments in workload schedules, etc. The space module must have effective diagnostic and preventive measures against diseases and injuries that would seriously disable the crew member.
- d. **Recuperation Period** - The medical facility must have effective diagnostic and preventive measures against diseases and injuries that would disable the crewmember for an extended period. Should a crewmember require a lengthy recuperation period, particularly if isolation is necessary, mission planning would require modification to accommodate the situation. In addition, provision for recuperation in the medical facility must be provided.

e. Probable Results of Partial or No Treatment - The medical facility must primarily be prepared to handle those illness and injuries which would heal more rapidly with treatment or which would become serious without treatment.

7.3.2.3 Earth - versus Space-Based Medical Care Design Considerations

{A}

The administration of medical care requires a combination of ground support and the skills and facilities of the crewmembers. Longer space missions and longer rescue delays require more reliance on the skills and resources of the crewmembers themselves. The following are considerations which effect the medical facility design and the training of the crew:

a. Earth-Based Medical Care - Past space missions have been monitored continuously by an Earth-based Flight Control Team, which includes medical personnel as team members. With this system, the medical team obtains health-related information via spacecraft telemetry. This is supplemented through use of a private medical conference, as necessary, with the crew. The information obtained during monitoring is intended to deal with direct medical problems and also to evaluate circumstances that appear to be leading toward such problems. This information includes data concerning status of environmental control systems, radiation exposure, food supply, water condition, and personal hygiene.

b. Space-Based Medical Care - Medical support of future space operations will require new philosophies and new technologies. The epicenter of medical care will shift from ground-based Mission Control Centers to a space-based medical unit. The minimum projected time for arrival of a rescue vehicle is mission dependent; in fact, rescue may be unavailable altogether (such as on a Mars mission). In addition to the delay factor, there also is the issue of establishing medical criteria for committing a patient to entry into a 1-G environment, following extended exposure to microgravity, without endangering his or her condition. These considerations mean that future space modules must have the personnel, facilities, and technologies to provide adequate medical care and health maintenance services, including provision for such microgravity or partial gravity countermeasures as specially tailored exercise programs.

c. Human Engineering of Medical Facility - Proper human engineering of the space medical facility can increase the effectiveness of the medical system and decrease the requirement for extensive crew training. Information in the remainder of this document (particularly Section 10.9 Space Medical Facility, and Section 9.0, Workstations) should be used as the basis for the design of all medical facilities.

7.3.3 Medical Care Design Requirements

{A}

7.3.3.1 General Design Requirements

{A}

A space module shall have a medical facility which can effectively provide preventive, diagnostic, and therapeutic medical capabilities in accordance with U.S. clinically acceptable current and anticipated medical practice standards.

(Refer to Section 10.9, Space Medical Facility, for information about the design of the medical facility.)

7.3.3.2 Prevention Design Requirements

{A}

The space medical facility shall be capable of supporting the administration of preventive medical care as defined in Paragraph 7.2, Preventive Care.

7.3.3.3 Diagnostic System Design Requirements

{A}

The space medical facility shall be capable of supporting diagnosis of anticipated illness and injuries, assessment of their degree and severity, and the tracking of the overall health status of ill or injured crewmembers.

7.3.3.4 Treatment (Therapeutics) Design Requirements

{A}

The space medical facility shall be capable of supporting various therapeutic measures:

- a. Treatment - The capability shall exist to treat a crewmember for anticipated diseases and injuries.
- b. Stabilization - The capability shall exist to stabilize a critically ill crewmember until transportation to an appropriate facility is available. In the event an illness or injury is not treatable at the module.
- c. Handling of Deceased Crewmember - The capability shall exist to handle a deceased crewmember in an efficient, safe, and acceptable manner.

7.4 CREW SURVIVAL

{A}

7.4.1 Introduction

{A}

7.4.2 Crew Survival Design Considerations

{A}

7.4.3 Crew Survival Design Requirements

{A}

- a. The emergency vehicle shall be designed to preclude hazard to the crew and to allow egress from the crashed vehicle in the event of off nominal landing loads specified below in Figure 7.4.3-1.
- b. Equipment and attachment structures inside the crew compartment (including fittings and fasteners) shall be designed for off nominal landing loads specified below in Figure 7.4.3-1.

Figure 7.4.3-1 Ultimate Inertia Load Factors

Nx	Ny	Nz
20.0	3.3	10.0
-3.3	-3.3	-4.4

Note: These load factors shall act independently and the longitudinal load factor shall be directed within 20_ of the longitudinal axis. Figure 7.4.3-1 Ultimate Inertia Load Factors

7.4.3.1 Medical Kit Design Requirements

{A}

The emergency vehicle shall provide an emergency medical kit listed in Figure 7.4.3.1-1.

Figure 7.4.3.1-1 Emergency Vehicle Medical Kit

Airway	
Oral airway	Min. of 4
Tracheal tube w/atylet	Min. of 2
Laryngoscope	1
Pertrach Kit	1
Comox resuscitator	1
Ambu Bag	
Antiseptics	
Alcohol wipes	
Bandages	
Ace Bandage	
Band-Aids	
Kling	
Sponges	
Telfa pads (4 x 4s)	
Wound pack	
Burns	
Silvadene cream (silver sulfadiazine)	
Decongestants	
Afrin nasal spray	(1 bottle)
Diagnostic Equipment	
Blood Pressure cuff	
Stethoscope	
Eye Treatment	
Tearisol eye drops (artificial tears)	
Motion Sickness	
Phenergan, oral	
Scop/Dex	
Pain Medications	
Ascriptin (aspirin)	
Tylenol (acetaminophen w/codeine)	
Miscellaneous	
Scissors	
Tweezers	
Tape (generic adhesive - medical)	

Steri-Strip skin closure	
Penlight	

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7.4.3.2 Crew Survival Kit Design Requirements

{A}

The emergency vehicle shall provide survival equipment listed in Figure 7.4.3.2-1.

Figure 7.4.3.2-1 Emergency Vehicle Proposed 24 Hour survival Kit (Post-landing).

ITEM	BOTH	LAND ONLY	WATER ONLY
Water (2 liter/person)	2 liter/person		
Day/night flare	2		
Thermal blanket (large)	2		
Chem Lights	10		
Strobe light	1		
Pen gun flares	1 gun, 14 flares		
First aid kit	1		
PRC-112 radio (kit)	1		
Signal mirror	1		
Knife	1		
Sunscreen	1		
Compass	1		
Whistle	1		
Penlight	2		
SARSAT Beacon	1		
Motion sickness pills			In first aid kit
Sea dye marker			4
Life raft			crew raft
Matches		10	
Fire starter kit		2	

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