PROJECT DOCUMENT COVER SHEET

INFLIGHT ASSESSMENT OF
CARDIOVASCULAR FUNCTION

M051

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REVISIONS					CHG. LETTER
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DB-53-M051
REPORT NUMBER

MSC FORM 151A (JUL 66)

EXPERIMENT IMPLEMENTATION PLAN
FOR
MANNED SPACE FLIGHT EXPERIMENT

1. Title of Experiment

INFLIGHT ASSESSMENT OF CARDIOVASCULAR FUNCTION

Experiment No. M-051

2. Sponsorship

Sponsoring Program Office (SPO)	OMSF, Space Medicine
Principal Investigator(s) (PI)	Approved _____ Date _____
PI Institutional Affiliation	NASA, MSC Biomedical Research Office, DB
SPO Manager	S. P. Vinograd, M.D.

3. Development

Experiment Development Center	Approved _____ Robert F. Thompson, MSC Date _____
Director of Medical Research and Operations	Approved _____ Charles A. Berry, M.D.
Center Experiments Manager Chief, Biomedical Research Office	Approved _____ Lawrence F. Dietlein, M.D. Date _____

4. Integration

OMSF Flight Program Office	ML
Payload Integration Center	Approved _____ Leland F. Belew, MFSC Date _____

5. Approval (Headquarters use only)

Sponsoring Program Office Approval _____ Date _____

Flight Program Office Approval _____ Date _____

Approved for Flight Assignment _____ Date _____

Program Office
Associate Administrator

Date _____

SECTION I - EXPERIMENT SUMMARY

1.0 TECHNICAL INFORMATION:

1.1 Purpose and Objective:

1.1.1 To provide evaluation of cardiovascular and hematologic systems pre- and postflight which will quantitate the changes in these systems resulting from prolonged space flight.

1.1.2 To provide information concerning the time course of cardiovascular deconditioning during flight and inflight data for predicting the degree of orthostatic intolerance and impairment of physical capacity to be expected following return to Earth's environment. The accomplishment of this objective is predicated upon the development and validation of the lower body negative pressure (LBNP) equipment (weightlessness tilt table analog) and the presence of a physician crewmember.

The detection of space flight cardiovascular deconditioning (degradations in cardiovascular function which may impair its performance during space flight or after return to Earth's environment) and the establishment of the time course of these changes constitute the purpose of this experiment.

Crewmen of Projects Mercury and Gemini, as well as subjects of recumbency and immersion studies, have exhibited a reduced orthostatic tolerance when exposed to the stress of passive tilt table studies during the postflight, postrecumbency, or postimmersion period. Characteristic features of this orthostatic response are cardioacceleration, lower extremity pooling of blood, and decreased pulse pressure. Severe orthostatism invariably results in syncope (loss of consciousness). Additionally, loss of body water (evidenced by weight loss), decrease in red blood cell mass, decrease in red blood cell survival time, and increase in red blood cell fragility have been demonstrated postflight in Gemini flight crews.

This investigation will provide insight into the following specific questions: Is there progressive cardiovascular deterioration in a weightless environment? If so, is it uniform or sporadic? At what level must it be checked in order to assure tolerance of reentry by the astronaut? How may such deterioration be checked? Can a preconditioning routine be developed to minimize inflight effects?

2.0 ENGINEERING INFORMATION:

2.1 Major Hardware Components:

2.1.1 VCG electrodes and harness (vest); present Apollo system or quick donning type, one set per astronaut with onboard readout of heart rate.

2.1.2 Signal conditioners, present Apollo type, one set.

2.1.3 Blood pressure cuff, improved Gemini type with onboard readout, one set.

2.1.4 Lower body negative pressure device (LBNP), in development, one set.

2.1.5 Vacuum source with suitable controls, safety devices, valves, and gauges for evaluation of LBNP.

2.1.6 Cage capacitance plethysmograph, or modified Mercury strain gauge, for measurement of leg volume, two units.

2.1.7 Ear canal temperature probe, stowage box 20" x 24" x 12".

2.1.8 Bicycle ergometer (from M050).

2.1.9 Experiment Data Acquisition System (EDS): Full data recording and dumping capability for biomedical data from M018, M050, M051, M053, M486, M488, M489 will be provided by either the OWS data system or by a separate piece of operating equipment.

2.2 Characteristics of Major Components:

	Size	Vol.C.F.	Wt. #	Power
(1) Vest & Signal Conditioners (3)	12"x12"x13"	0.9	5.1	*
(2) Blood Pressure Cuff	6" cyl, 6" lg	0.1	0.5	*
(3) LBNP (with vac. hose)	20"x15"x12"	2.1	20.0	*
(4) Gauges	3" dia x 2" lg	0.2	2.0	*
(5) Stowage box	20"x24"x12"	(3.34)	10.0	
(6) EDS (available from onboard operating equipment)				Rec. 10W TM 2W
(7) Ear Canal Temperature Probe	3/4"x3/8"x3/8"		.3	
Total:		3.3	37.9	12W

*Power for data handling included in EDS

3.0 OPERATIONS SUPPORT:

3.1 Preflight: Blood and LBNP studies will be done three times, at weekly intervals prior to flight. These sessions will last about 1 hour (one of them will take 1½ hours).

3.2 Inflight: LBNP testing will be performed on each crewmember every third day. A second crewmember will be present to assist in instrumentation, monitor, and operate the LBNP equipment. This observer will be the medical crewmember except when the medical crewmember is the subject. Time required for each run is about 70 minutes as detailed on the following time line.

3.3 Postflight: Three LBNP studies will be done on each crewmember within 48 hours after recovery, requiring about 1 hour each. Three blood samples will be taken within 90 minutes after recovery, requiring less than 5 minutes each. Seven more blood samples are proposed within 30 days after recovery. One of these is a 1½ hour procedure, the rest are 5 minute procedures.

3.4 Data Measurement Requirements:

3.4.1 Three ECG channels on onboard recorder.

3.4.2 Two channels, strain gauge or capacitance, readout, onboard recorder with onboard readout of heart rate.

3.4.3 One voice annotation channel on onboard recorder.

3.4.4 One time hack channel, onboard recorder.

3.4.5 Onboard readout of LBNP negative pressure gauge.

3.4.6 Written entries in onboard log.

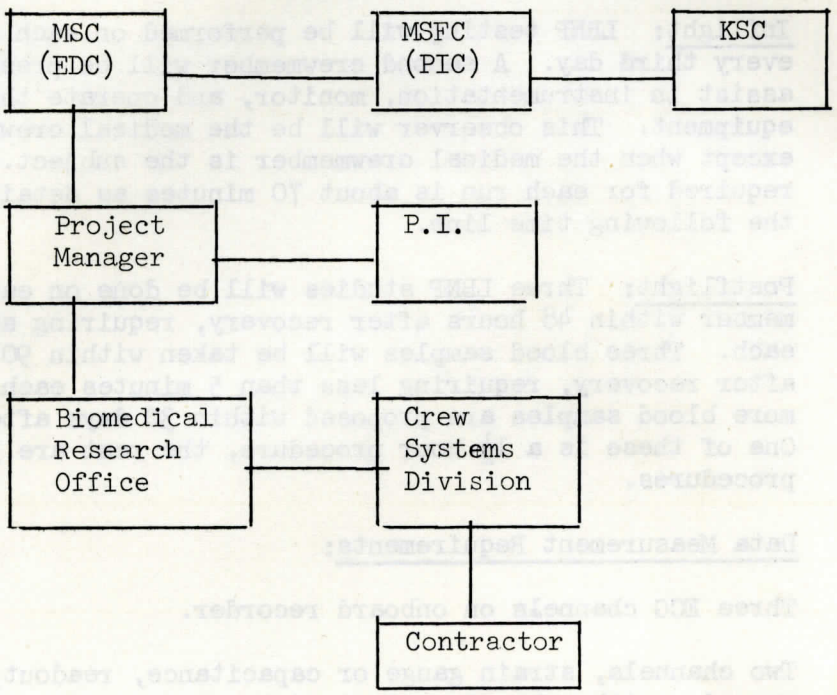
3.4.7 Onboard readout of blood pressure gauge.

3.4.8 Onboard readout of leg volume changes.

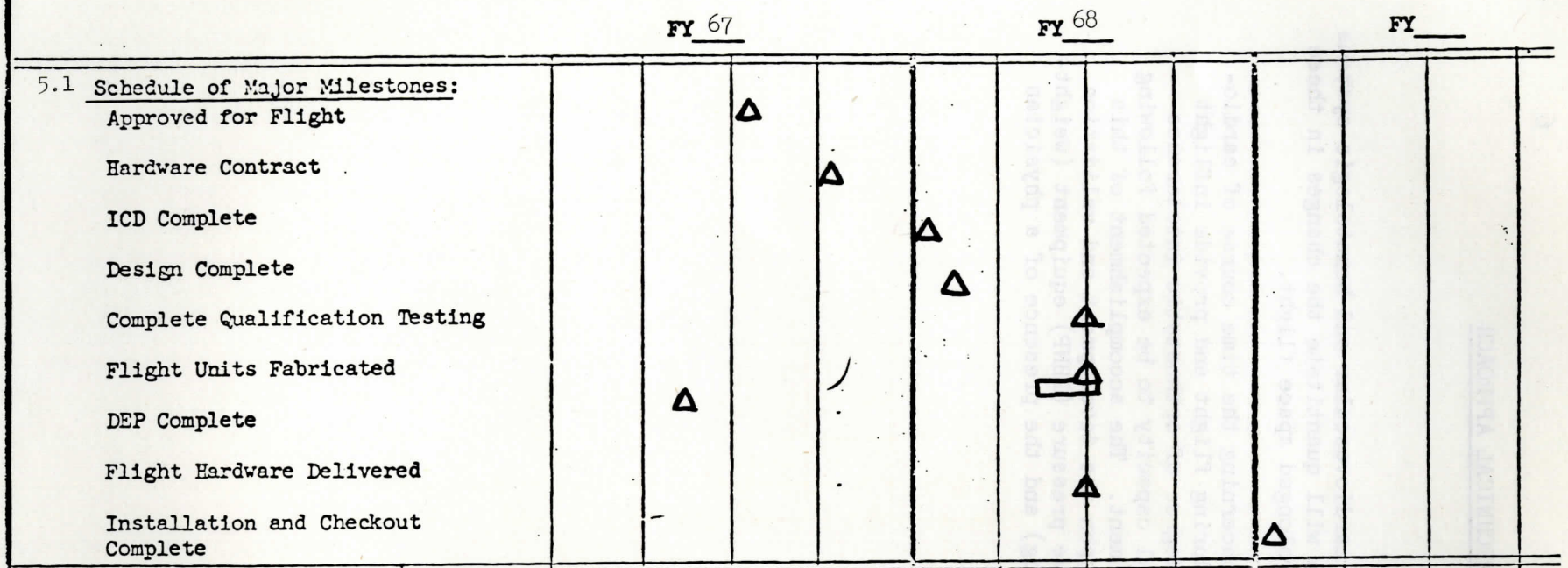
3.4.9 Onboard readout of ear canal temperature.

Data collection will be accomplished by both onboard tape recording with fast dump capabilities and onboard readout to permit both ground-based monitoring of flight crew status and onboard evaluation by the physician crewmember.

4.0 MANAGEMENT ARRANGEMENTS: The major organizational elements involved in implementation of the experiment and their relationship with the Principal Investigator, the equipment contractor, and the space vehicle contractor are as follows:



5.0 SCHEDULE AND RESOURCE REQUIREMENTS:



5.2 Funding Requirements	Funding Source											
Design, development, fabrication & testing (mock-up, prototype & support equipment)					200	200	100		200	100	100	
Supporting study effort	949-60				342	200	200	200	300	200	200	
Fabricate, test & deliver (flight hardware)					220				500	1000	500	500
Space vehicle installation & check-out												
Data analysis & publication												

SECTION II - TECHNICAL APPROACH

1.0 OBJECTIVES:

1.1 To provide evaluation of cardiovascular and hematologic systems pre- and postflight which will quantitate the changes in these systems resulting from prolonged space flight.

1.2 To provide information concerning the time course of cardiovascular deconditioning during flight and provide inflight data for predicting the degree of orthostatic intolerance and impariment of physical capacity to be expected following return to Earth's environment. The accomplishment of this objective is predicated upon the development and validation of the lower body negative pressure (LBNP) equipment (weightlessness tilt table analog) and the presence of a physician crewmember.

2.0 JUSTIFICATION: The detection of space flight cardiovascular deconditioning (degradations in cardiovascular function which may impair its performance during space flight or after return to Earth's environment) and the establishment of the time course of these changes constitute the purpose of this experiment.

Crewmen of Projects Mercury and Gemini, as well as subjects of recumbency and immersion studies, have exhibited a reduced orthostatic tolerance when exposed to the stress of passive tilt table studies during the postflight, postrecumbency, or postimmersion period. Characteristic features of this orthostatic response are cardioacceleration, lower extremity pooling of blood, and decreased pulse pressure. Severe orthostatism invariably results in syncope (loss of consciousness). Additionally, loss of body water (evidenced by weight loss), decrease in red blood cell mass, decrease in red blood cell survival time, and increase in red blood cell fragility have been demonstrated postflight in Gemini flight crews.

3.0 EXPERIMENT APPROACH:

3.1 Procedure: Generally, it is anticipated that three preflight control data acquisition periods (T-21, T-10, and T-2) will be required. During these sessions, blood studies will be accomplished. These procedures are in essence the same as those performed during Project Gemini and are again essentially the same as those required for Project Apollo Experiment MOlla and M022.

The exercise testing and the baseline electrolytes will be accomplished within the context of the "Metabolic Cost of Inflight Tasks" (M050) and "Bone and Muscle Changes" (M052) experiments.

The postflight data acquisition periods should be accomplished as soon as possible, 24 hours and 48 hours after splashdown. The procedures will in essence be identical to the preflight periods. The LBNP procedure should be performed during the morning hours and each subject should have all LBNP tests at similar times of the test day. This test should be performed fasting or at least 3 hours after eating. It should not be preceded by vigorous exercise nor should it be performed while unduly fatigued or in high environmental temperatures. Inflight measurements during LBNP forcing will be made only if a physician is one of the crewmembers. Measurements should be obtained on each man every third day.

Lower body negative pressure procedures is as follows: After the proper bioinstrumentation has been placed on the subject, he will insert the legs and hips inside the LBNP device. The waist seal will then be adjusted and secured. Whether the cage capacitance plethysmographs can be placed in position most conveniently before or after getting into the LBNP device will be determined. The subject should be in such a position that he can rest comfortably without motion in an extended stance.

The baseline of each of the recording channels should be adjusted to the proper position on the strip chart and calibration signals recorded on all channels.

The procedure will consist of three phases. The first phase is a 5-minute control phase; the second, a 15-minute negative pressure phase; and the third, a 5-minute supine recovery phase. VCG, ear canal temperature, and leg plethysmograph recordings will be made continuously throughout the procedure. Blood pressure will be measured every 30 seconds. To insure a completely passive subject he should be requested to remain immobile during the 25 minutes that recordings are being made.

3.2 Parameters to be Measured: The broad experimental plan is depicted by Table 1. The major stress imposed upon the system under analysis is the space mission itself; the known load stresses imposed upon the system are exercise and lower body negative pressure.

TABLE 1

Preflight	Inflight	Postflight
Assessment of Baseline System Performance (Controls)	Time Course Assessment of Changes Caused by Major Stress	Time Course Assessments of Return to Control Values
a. Basic System Parameters b. Responses to Load Stresses	a. Basic Parameters b. Responses to Load Stresses	a. Basic System Parameters b. Responses to Load Stresses

Table 2 lists the parameters to be measured. The arrangement indicates the broad time relationship, the basic parameters for general system performance assessment and the specific parameters to be measured during stress loads. Expected values are indicated at the appropriate intersections of condition and parameter. Qualitative or interpretive parameters, for example, ECG and thoracic X-ray, will be evaluated by Normal (N) or Change (C).

TABLE 2

a. Preflight and Postflight Assessment of System Performance

	Rest	Load Stresses	
		Exercise	LBNP
Basic Parameters			
Thoracic X-ray	N		
Blood Volume	3.5-5.1		
RBC Mass	1500-2200 ml.		
Plasma Volume	2000-2800 ml.		
Electrolytes	N		
Forcing Parameters			
Electrocardiogram	N	N	N
Heart Rate	40-90		
Skin Temperature	87°-95° F.		
Blood Pressure	100/70	200/110	90/40
Leg Volume, % Change			4-5
LBNP			5 to -45

b. Inflight Assessment of System Performance

	Rest	Load Stresses	
		Exercise	LBNP
Basic Parameters			
Fluid Intake/Output	N		
Electrolytes	C		
Forcing Parameters			
Electrocardiogram	N	N	N
Heart Rate	40-90	70-180	70-180
Skin Temperature	60°-99° F.		
Blood Pressure	100/60 - 120/70	100/70 - 180/90	90/55 - 180/100

Research programs have established the required pressure gradient (LBNP) to simulate 1g tilt and the rates of "deconditioning" which might be expected during 30 days of weightlessness as simulated by bed rest or shorter periods of water immersion.

A research program would validate the experimental proceedings utilized for parameter measurements and attempt to isolate the effects of weightlessness from those of atmosphere differences.

4.0 DISCIPLINARY RELATIONSHIPS: Since the application of LBNP is not gravity dependent, it is possible to employ it in space flight as an "orthostatic" test to reveal the time course and magnitude of changes in circulatory regulation known to occur during adaptation to space flight.

Heart rate (HR) and electrocardiographic (VCG) data are to be acquired by means of slightly modified Apollo instrumentation. The major modification requirements are the incorporation of a means of calibrating the ECG (calibration to be applied across the input electrodes), a quick don, quick doff electrode and harness system, and a means of identifying the crewmemberf from which data is being collected.

Blood pressure data acquisition will require improvement. An acceptable technique which yields both onboard readout and a recordable output will be developed.

The electrolyte and fluid intake/output data for this study will be obtained from the experiment entitled "Bone and Muscle Changes During Prolonged Space Flight." No additional requirements are imposed.

The recording of heart rate, skin temperature, and the external workload constitute the requirement for evaluating the responses of the cardiovascular system to exercise. These requirements will be satisfied by the equipment involved in the experiment entitled "Metabolic Costs of Inflight Tasks."

The remaining studies are conducted pre- and postflight. These are standard Earth-based laboratory studies for which methodologies and instrumentation are developed and are in general use.

5.0 BASELINE OR CONTROL DATA: Laboratory equipment for the LBNP experiment is currently available and in use at USAF SAM, at Douglas Aircraft, Inc., and at Wilfort Hall USAF Hospital. Pre- and postflight uses of LBNP have been proposed by USAF as a Block I Apollo Experiment (M023). Baseline data proving the validity of the experiment are currently being collected at the Wilford Hall USAF Hospital. This background experimentation will subject test subjects to stresses similar to those to be encountered by the astronauts. Bed rest will be used to simulate weightlessness. Data collected to date indicate that LBNP results in the pooling of blood and shifts in position of viscera that are similar to the effects of being passively positioned with the long axis of the body parallel to the Earth's gravitational field (as in a tilt table test). The circulatory adjustments resulting from LBNP are strikingly similar to those resulting from tilt procedures. Furthermore, at a given pressure gradient, the response is more reproducible than the tilt response and is less subject to artifact. Serial steps of increasing differential pressure may be applied, with reproducible evidence of increasing circulatory stress. The tilt table procedure does not allow this flexibility in adjusting the degree of "orthostatic" stress.

SECTION III - ENGINEERING INFORMATION

1.0 EQUIPMENT DESCRIPTION:

1.1 Heart Rate and VCG:

1.1.1 Sensors (Electrodes) and Harness: Apollo sensors can be used. Development of quick don and doff sensor and harness system would increase the operational efficiency of the experiment.

1.1.2 Signal Conditioners: Flight units are being developed by Spacelabs, Inc., and are scheduled for delivery by November 1967. A means of calibration and crewmember identification will be provided.

1.2 Blood Pressure Cuff: Modification of the present Gemini system to provide increased reliability and an onboard readout will be necessary.

1.3 Lower Body Negative Pressure Device (LBNP): A laboratory model has been developed by Lockheed for the USAF. Douglas Aircraft also has a laboratory model. The USAF is developing flight type equipment. A contract is being negotiated.

The device consists of a bag surrounding a framework which may be collapsed for storage, a sealing membrane to fit about the midsection of a man, an evacuation device (to create the required pressure gradient) with suitable controls, valves, and safety devices. A pressure sensor is incorporated to provide recording of tape and an onboard readout of the negative pressure.

1.4 Cage Capacitance Plethysmographs or Modified Mercury Strain Gauges: Two units, one for each leg, are required.

1.5 Ear Canal Temperature Probe.

1.6 Stowage Box Approximately 20" x 24" x 12".

1.7 Medical Data Acquisition System (Separate onboard operating equipment not a part of this experiment): A medical data acquisition system will be needed for this and other medical experiments proposed for this flight. The Gemini pulse code modulation system will satisfy part of the requirements for the medical data acquisition system but the frequency response (8 cps) is not adequate for ECG, EEG, and voice. Thus, an additional recorder and telemetry system is needed. For correlation purposes, mission elapsed time, and subject identity would also be necessary on the second recorder.

1.8 Characteristics of Major Components:

	Size	Vol. Ft.^{3}	Wt.#	Power
1. Vest & Signal Conditioners (3)	12"x12"x3"	0.9	5.1	*
2. Blood Pressure Cuff	6"cyl, 6" lg	0.1	0.5	*
3. LBNP (with vac. hose)	20"x15"x12"	2.1	20.0	*
4. Gauges	3" dia x 2" lg	0.2	2.0	*
5. Ear Canal Temperature Probe	3/4"x3/8"x3/8"	---	0.3	
6. Stowage Box	20"x24"x12"	(3.34)	10.0	
7. EDS (available from onboard operating equipment)				Rec. 10W TM 2W
Total:		3.3	37.9	12W

*Power for data handling included in EDS

1.9 Quantities Required:

	Vest & Signal Conditioners	BP Cuff	LBNP Vac. Source	EC Temp. Probe	Gauge Set
Mass Mockup	3	1	1	3	1
Training	3	1	1	3*	1
Qualification	1	1	1	1	1
Flight	6	2	1	3*	1
Backup	3	1	1	3*	1

*Ear Canal Temperature Probe will be molded to fit each individual crewmember.

1.10 Special GSE or Logistic Support: None.

1.11 Definition:

1.11.1 Mass Mockup: This unit is an exact model with correct external dimensional configuration and with weight, center-of-gravity, functional control, electrical connections, and mounting provisions of the flight hardware. This need not be a functional model.

1.11.2 Training Hardware: These units are of the flight configuration to provide realistic operation and manipulation characteristics and to determine compatibility with other crew equipment and activities. Training units must have operational characteristics identical to flight equipment.

1.11.3 Qualification Test Hardware: This is a flight qualifiable unit selected from the first production units. Qualification testing is performed on this unit.

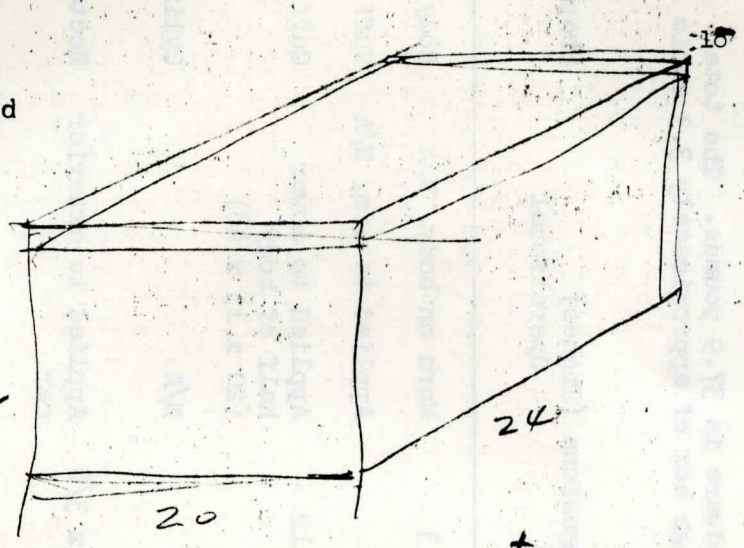
1.11.4 Flight and Backup Hardware: These units are flight items and must be identical in design, configuration, and production processing to the finally accepted qualification test unit. Any changes to the qualification test unit during qualification testing must be included in the flight and backup units prior to delivery to NASA MSC. These units must be manufactured using the same production techniques as the qualification test unit.

2.0 WEIGHT AND VOLUME: The total estimated weight of the experiment hardware is 37.9 pounds. The total estimated volume of the equipment is 3.3 cubic feet. A single stowage box of approximately 3.3 cubic feet is expected to be used for stowage.

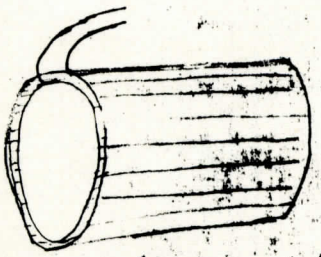
Equipment Item	Weight (Pounds)	Volume Stored (Cu. Ft.)	Operational (Cubic Feet)	Dimensions (Inches) Stored	Operational	Shape
Vests & Harness (3)	5.1	0.9	Worn on body, N/A	12 x 12 x 3	Worn on body, N/A	Body
Blood Pressure Cuff	0.5	0.1	Applied to arm, N/A	*	Applied to arm, N/A	Cuff
LBNP Device	20.0	2.1	Applied to lower half of body (3.3)	20 x 15 x 12	Applied to lower half of body (20 x 15 x 48)	Cuff
Gauges	2.0	0.2	N/A	*	N/A	Cylinder
Ear Canal Temperature Probe	0.3	< 0.0001	Applied to exterior ear	3/4 x 3/8 x 3/8	Applied to exterior ear	Rectangle
Stowage Box	10.0	(3.3)	N/A	20 x 24 x 12	N/A	Rectangle
EDS (not part of experiment)						
TOTALS	37.9	3.3				

*Fit common box shown.

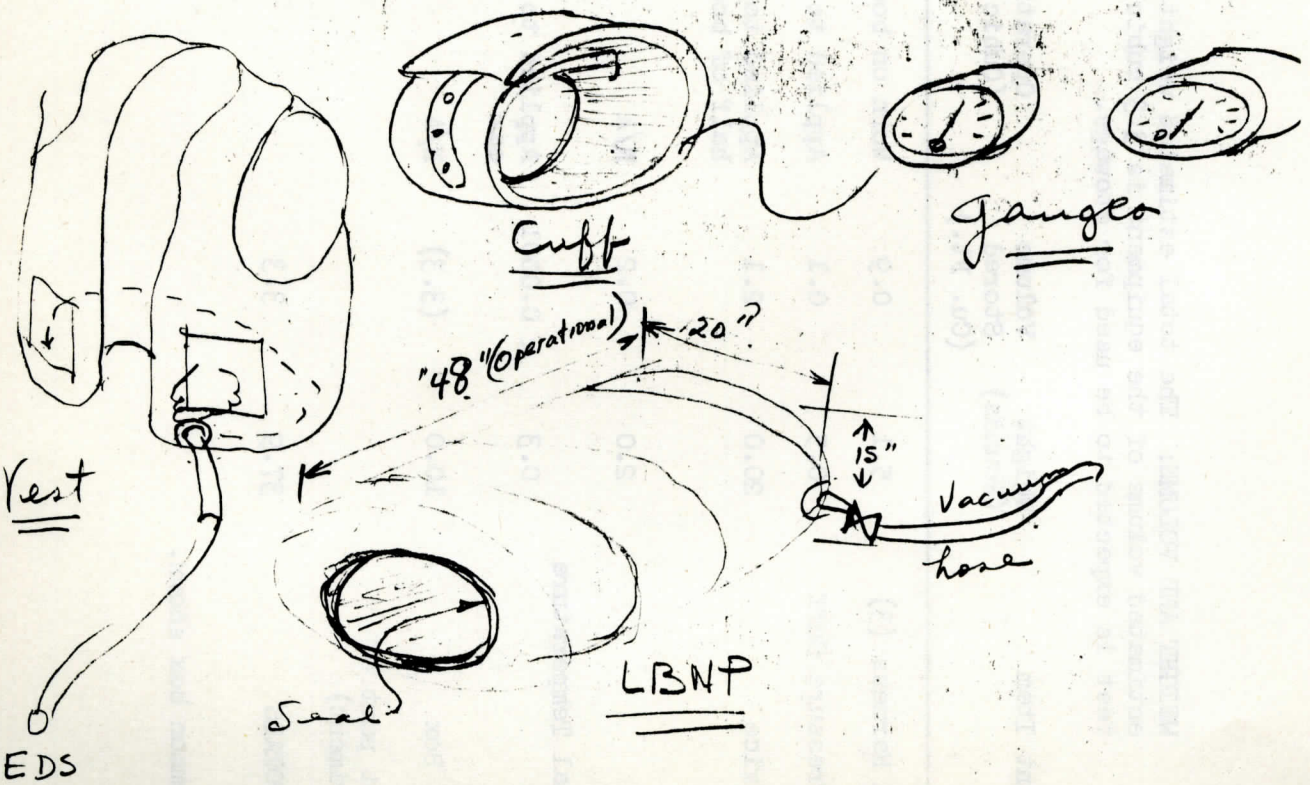
3.0 ENVELOPE: Stowed



Common stowage box



Cage Capacitance Unit (2)
for Leg Volume



4.0 SPACECRAFT INTERFACE REQUIREMENTS:

4.1 Stowage for launch should be in the Multiple Docking Adapter (MDA). In any case, EVA should not be necessary to retrieve equipment. The universal racks planned for the MDA and OWS will provide adequate stowage mounting.

4.2 Electrical power will not be required except for data system shown below. Data monitoring and connection power will come from separate data system.

4.3 Plumbing modifications are required for vacuum line to LBNP.

4.4 Life support services are not required.

4.5 Biomedical and systems data will be provided through the umbilical to the Airlock Module.

5.0 POWER: Recorder 10W
TM 2W

6.0 ENVIRONMENTAL CONSTRAINTS:

Constraint	Range	
Thermal ° C.		
Stored	-51 to +70	
Operational	-51 to +70	
Tolerance Levels		
Pressure	25 psia to 1 x 10^{-6} mm Hg	
Relative Humidity	15% to 100%	
Atmospheric Composition	20% to 100% O_2	
Contaminants		
Acceleration (Storage)	0 to 7g	
Positive		
Negative		
Transverse		
Acceleration (Operation)	0 to 0.1g	
Positive		
Negative		
Transverse		
Vibration (Storage)		
Random	20 to 100 cps	linear increase (log by $\log_2$ plot) from 0.001g^2/cps to 0.075g^2/cps
	100 to 500 cps	constant at 0.075g^2/cps
	500 to 1000 cps	linear decrease (log by log plot) from 0.075g^2/cps to 0.015g^2/cps
	1000 to 2000 cps	Constant at 0.015g^2/cps
Shock	30g	

7.0 DATA MEASUREMENT REQUIREMENTS: The following table presents data handling requirements

Test Time Span	Parameter	Band Width (Hz)	Range	Accuracy
25 min.	VCG	0-100	0-5VDC	±3%
	VCG	0-100	0-5VDC	±3%
	VCG	0-100	0-5VDC	±3%
	Blood Pressure	0-50	0-20MC differential	±3%
	LBNP	0-0.25	0-5VDC	±3%
	Leg Volume	0-0.25	0-5VDC	±3%
	Leg Volume	0-0.25	0-5VDC	±3%
	Body Temp.	0-0.25	0-5VDC	±3%
	Timing			±0.1 sec.
	Voice			

SECTION IV - RELIABILITY AND QUALIFICATION REQUIREMENTS

The experiment equipment and associated hardware will be controlled and measured against acceptable standards of workmanship and design to assure system operational integrity and minimum degradation of experiment objectives. Such standards and measurements will be verified by implementing in-process inspection techniques and Government monitoring of qualification tests, including certification histories, as required.

Preparation of the final R and QA program will be closely coordinated with the payload integration center to insure adequate provisions for flight safety and experiment success.

SECTION V - OPERATIONS SUPPORT

1.0 SPACECRAFT ORIENTATION REQUIREMENTS: None.

2.0 ASTRONAUT TRAINING: Each astronaut will be trained in procedures and techniques while baseline control data is being obtained. Total training required is as follows:

	During Baseline Testing	Other Training	Total Per Man
Astronaut 1	3 Hrs.	2 Hrs.	5 Hrs.
Astronaut 2	3 Hrs.	2 Hrs.	5 Hrs.
Physician/Astronaut	3 Hrs.	10 Hrs.	13 Hrs.

3.0 ASTRONAUT TRAINING SYNOPSIS:

3.1 Training in proper application of electrodes .

3.2 Donning and fastening vest.

3.3 Operation of signal conditioners.

3.4 Method of calibrating equipment.

3.5 EDS interfaces.

3.6 Application of capacitance plethysmograph.

3.7 Application of ear canal temperature probe.

3.8 Application of LBNP device and body seals.

3.9 Watching BP and HR responses to gain experience in evaluating responses.

3.10 Timeline table follows:

TIMELINE TABLE

Time (Min.) Cum. Time/ Unit Time	Observer	Time (Min.) Cum. Time Unit Time	Subject
0:00/5:00	Obtains from storage compartment: a. Blood Pressure Apparatus b. Harness and Vest c. Electrode Application Kit d. Ear Canal Temperature Probe e. Biomedical Cable f. 2 Cage Capacitance Plethyomographs	0:00/5:00	Removes outer garments
5:00/0:30	Connects Biomedical Cable to EDS.	5:00/0:30	Extends Lower Body Negative Pressure Device and secures to working area.
5:30/0:30	Turns knobs and switches on EDS to activate Tape Recorder, Display System, and Vacuum Source.	5:30/4:00	Removes 8 electrodes from Electrode Application Kit and connects each electrode to appropriate outlets in Vest.
6:00/1:00	Assembles units of Temperature Recording Device.		
7:00/1:00	Assembles units of Blood Pressure Apparatus.		
8:00/3:00	Prepares skin sites for electrode application on back, one leg, and axillae of subject.	9:30/2:00	Prepares skin sites for electrode application over anterior chest.
11:00/3:00	Applies electrodes to skin		
		11:30/0:30	Dons Vest and Harness.
		12:00/2:00	Assists in electrode application.

Time (Min.) Cum. Time/ Unit Time	Observer	Time (Min.) Cum. Time/ Unit Time	Subject
14:00/0:30	Adjusts and tightens Vest and Harness.	14:00/0:30	Assists in adjusting Vest and Harness.
14:30/0:30	Connects Biomedical Cable to Signal Conditioners in Vest and activates Signal Conditioners.	14:30/0:30	Assembles Strain Gage Unit for left leg.
15:00/1:00	Checks each VCG channel to ascertain proper function by transmitting to display system.	15:00/0:30	Assembles Strain Gage Unit for right leg.
		15:30/0:30	Steps into LBNP enclosure and assumes comfortable position with legs extended and waist seal loose about waist.
16:00/2:00	Applies Plethysmograph Unit to left leg.	16:00/2:00	Stands or reclines quietly.
18:00/2:00	Applies Plethysmograph Unit to right leg.	18:00/2:00	Connects outlet from left Strain Gage to Biomedical Cable.
20:00/2:00	Calibrates each Plethysmograph after securing gages with adhesive. Observes display to calibrate.	20:00/1:00	Connects outlet from right Strain Gage to Biomedical Cable.
		21:00/1:00	Avoids leg movement during and after calibration.
22:00/1:00	Attached temperature sensing device and connects to Biomedical Cable.	22:00/1:00	Applies Blood Pressure Apparatus to left arm.
23:00/0:30	Connects output from Blood Pressure device to Biomedical Cable.	23:00/3:00	Remains motionless except for upper extremities while assisting in securing waist seal and compressing safety release device during check of waist seal.

Time (Min.) Cum. Time/ Unit Time		Time (Min.) Cum. Time/ Unit Time	
23:30/1:30	Checks signals from Temperature Sensing Device and Blood Pressure Apparatus to ascertain proper function.		
25:00/3:00	Secures waist seal.		
28:00/1:00	Sets LBNP regulator to -10mm Hg, activates vacuum source, and checks seal and pressure gage. Releases vacuum.		
29:00/2:00	Checks each channel and records calibration signals for each.		
31:00/5:00	Records all channels continuously throughout 5 minutes.	31:00/5:00	Remains motionless during 5 minutes of control data acquisition.
36:00/0:30	Calibrates all channels (1 button). Sets vacuum regulator to -40 (?50) mm Hg and opens vacuum system to evaluate LBNP enclosure to -40 mm Hg pressure.	36:00	Compresses safety release device and maintains this compression throughout application of negative pressure. Remains motionless during 15 minutes.
36:30/15:00	Observes Blood Pressure (2x/min.), heart rate (continuously with 10 second means) on display system and appearance of subject. Comments as indicated into voice channel. Calibrates system every 2 minutes.		
51:30/5:00	Open LBNP system and closes vacuum source. Continues recording for 5 minutes after release of LBNP. Calibrates at 2 and 4 minutes.	51:30/5:00	Releases safety device. Remains motionless during 5 minutes recovery period.

Time (Min.) Cum. Time/ Unit Time	Observer	Time (Min.) Cum. Time/ Unit Time	Subject
56:30/1:00	Turns off recording system and disconnects Biomedical Cable at EDS	56:30/1:00	Loosens waist seal and Blood Pressure Apparatus.
57:30/1:00	Completes removal of waste seal. Disconnects Blood Pressure output from Cable and removes apparatus from subject's arm. Stows in container.	57:30/1:00	Disconnects Temperature Sensing Device from ear.
58:30/1:30	Removes both Plethysmograph elements from subject's legs. Disconnects from Biomedical Cable. Stows in container.	58:30/1:30	Begins removal of chest electrodes.
60:00/1:00	Disconnects Temperature Sensing Device from Biomedical Cable. Removes and stows in container.	60:00/1:00	Steps out of LBNP enclosure. Continues removal of chest electrodes.
61:00/1:00	Removes remaining electrodes from back, leg, and axillae.	61:00/2:00	Cleans electrodes and returns them to Electrode Application Kit.
62:00/1:00	Returns LBNP device to folded-up mode and secures.		
		63:00/2:00	Removes Vest and Harness. Cleanses skin sites and discards disposable material in waste container.
63:00/3:00	Stows Cable, Electrode Application Kit, and Vest-Harness in container and places in storage.		
		65:00/1:00	Dons outer garments.
66 minutes		66 minutes	

3.11 Summary of Astronaut Activities:

	Preflight	Inflight		Postflight
		Subject	Observer	
Astronaut #1	5	4.8	4.8	3
Astronaut #2	5	4.8	4.8	3
Physician/Astronaut	13	4.8	4.8	3
	23	14.4	14.4	9

The experiment is to be performed using each of the astronauts (3) as subject for 1.2 hours per occurrence. One astronaut will be required simultaneously as observer. Frequency of experiment is once per day per astronaut at equal intervals throughout the mission. Total manhours: 1.2 hours x 2 men x 3 occurrences per day x 4 days = 28.8 hours.

4.0 **PRELAUNCH SUPPORT:** Operation and calibration of data sensors and gauges must be checked and recorded.

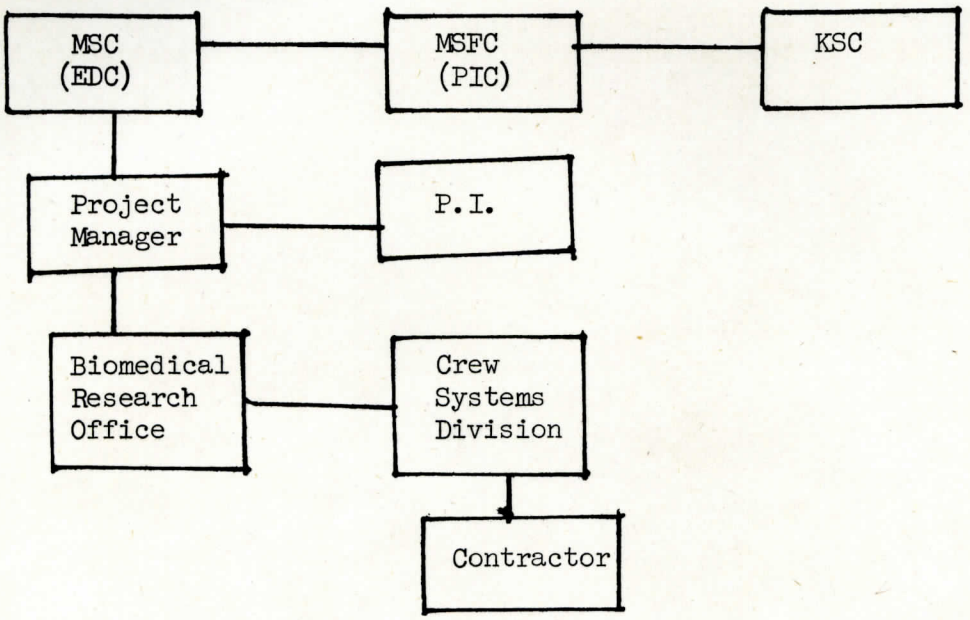
5.0 FLIGHT OPERATIONAL REQUIREMENTS: None anticipated

6.0 **RECOVERY REQUIREMENTS:** Experiment equipment will not be recovered. The data will be returned in the form of tape to confirm TM data. Weight = 2.5 lbs., Volume = 8.25 cu. ft.

7.0 **DATA SUPPORT REQUIREMENTS:** There are no special data support requirements.

SECTION VI - MANAGEMENT ARRANGEMENTS

The following diagram depicts the elements of the Experiment Development Center (EDC) and other organizations that interface with it.



1.0 RESPONSIBILITY ASSIGNMENTS: The Principal Investigator/Program Manager will have overall responsibility for integration control of the various elements of the experiments. The Project Managers will assume responsibility for acceptable hardware development and testing. Monitoring of activities will be performed at MSC by the Biomedical Research Office. Preflight studies and the integration of findings into a final report will be the responsibility of the Principal Investigator (PI).

2.0 ORGANIZATION DESCRIPTIONS: The sponsoring program office is NASA Headquarters, OMSF, with E. McLaughlin, M.D., as the supporting office sponsor. Marshall Space Flight Center is the Experiment Integration Center. The Payload Integration Center will perform all technical and administrative tasks required to assure overall mission coordination between the Experiment Development Center or Principal Investigator and all other NASA organizations. The PIC will provide the resources for experiment receipt and storage, bench testing, installation in carrier, and integrated experiment/carrier testing; experiment development and compatibility checks with carrier and subsystem mockups; experiment operational procedures development; and experiment logistics supporing planning. This group will direct the Kennedy Space Center in installation and spacecraft modifications for the experimental hardware, as well as in retrieval of the tape recordings.

At the Manned Spacecraft Center, supervision of experiment development will be by the Biomedical Research Office. The experiment PI is R. L. Johnson, M.D., for the entire flight portion and C. L. Fischer, M.D., for the pre- and postflight hematology portion.

SECTION VII - MANAGEMENT REPORTING

Financial, schedule, and technical information will be furnished to the appropriate Headquarters program office as required.

Reporting documentation to be used for managing the program are as follows:

a. Monthly Progress Report

b. Monthly Financial Reports (inhouse and contractor)

c. Final Report

SECTION VIII - PROCUREMENT ARRANGEMENTS

All hardware will be developed by MSC. Contractors have not been selected.

SECTION IX

SCHEDULE AND RESOURCES REQUIREMENTS

SECTION IX - SCHEDULE AND RESOURCE REQUIREMENTS
1.0 DEVELOPMENT SCHEDULE

Indicate the planned development schedule for the major milestones outlined below:

Major Milestones	Planned Development Schedule FY 67	FY 68	FY 69
Experiment Approval	△		
RFP Release	△		
Hardware Contract Awarded	△		
Integration Specification Issued			
Interface Control Document. Complete		△	
Revise E I P		△	
Design Complete		△	
Prototype Delivered		△	
Quality Testing Complete		△	
Flight Units Fabricated			
Flight Units Assembled			
Acceptance Test Complete		△	
Flight Hardware Delivered			
Ground Support Equipment Delivered			
Installation Complete			
Checkout Complete			
Shipped to Launch Site			
Flight Analysis Complete			
Final Report			

QUARTERLY FUNDING REQUIREMENTS (Dollars in Thousands)

	Source of Funding	FY				FY				FY				TOTALS
DESIGN														
Exp. Hardware														
Trai ning Equip.														
Checkout Equip.														
SUPPORT STUDIES														
SUPPORT FACILITIES AND SERVICES														
SUPPORT EQUIPMENT														
Mockup														
Engineering test units														
Fabrication														
Assembly														
Test														
Prototype														
Fabrication														
Assembly														
Test														
Training Units														
Fabrication														
Assembly														
Test														
Checkout Equipment														
Fabrication														
Assembly														
Test														

QUARTERLY FUNDING REQUIREMENTS (Dollars in Thousands)

	Source of Funding	FY				FY				FY				TOTALS
FLIGHT EQUIPMENT														
Flight Unit														
Fabrication														
Assembly														
Testing														
Spares														
Fabrication														
Assembly														
Testing														
DOCUMENTATION														
Major Documentation														
Def. Exp. Plan														
Rel. Predictions														
Qual. Test Rept.														
Failure Analysis														
etc.														
Periodic Reports														
Briefings & Reviews														
TRAVEL														
VEHICLE INTEGRATION														
Vehicle Modif.														
Installation														
Checkout														

QUARTERLY FUNDING REQUIREMENTS (Dollars in Thousands)

	Source of Funding	FY				FY				FY				TOTALS
PUBLICATION														
Data reduction														
Analysis														
Reporting														
GRAND TOTAL														

2.0

3.0 MANPOWER:

3.1 Inhouse (man-months):

	FY67	FY68	FY69	Total
Contract Technician	-	48	48	96

3.2 Contractor: To be determined during contract negotiations.

4.0 FACILITIES: The following major facilities will be used for conducting the experiment hardware development testing, qualification tests, and astronaut training:

NASA Manned Spacecraft Center (inhouse)

SECTION X - EXPERIMENT RESULTS

1.0 DATA HANDLING: Operational biomedical data and voice communications recorded on the ground during this experiment should be provided to Biomedical Research Office, Manned Spacecraft Center. Tapes received from the spacecraft should be returned to the Biomedical Research Office, Manned Spacecraft Center for processing.

2.0 TECHNICAL REPORTS:

2.1 "Quick Look" reports 1 month after flight by PI.

2.2 Data reports 3 months after flight by PI.

2.3 Preliminary analysis 4 months after flight by PI.

2.4 Technical notes/memorandum (NASA and contractor) 8 months after flight by PI.

3.0 PUBLIC INFORMATION: As applicable.

ATTACHMENT 2

Alterations in erythrocyte and leukocyte kinetics can be expected from intervals of prolonged space flight. Observations already made on Gemini missions show a time related, hemolytic process manifested by a decreased red cell mass, shortened $^{51}CrT_{\frac{1}{2}}$, and an increased spleen/liver ratio. It is, therefore, of considerable interest to monitor the hematologic parameters on any future long duration mission.

Any pre- and postmission program designed to investigate the hematology of manned space flight must take into account the spacecraft atmosphere, crew activity levels, and diet. Therefore, this information should be made available to the personnel interpreting the hematologic results. Furthermore, the formed elements of the blood cannot be separated from the plasma milieu in which they circulate. Thus, a complete chemical and physical profile of plasma must accompany the hematologic effort.

Basically, the hematology effort is designed to investigate the following fundamental aspects of the erythron: red cell production, release, and destruction. Production release information is best obtained by isotope methods, specifically Fe^{59} plasma clearance and reappearance times. Aspects of red cell destruction include quantitation and determination of etiology. The former aspect is best "looked at" by isotope techniques including ^{51}Cr red cell mass determinations and I^{125} RISA measurements. This combination yields a directly measured total blood volume. The $^{51}CrT_{\frac{1}{2}}$ values are also obtained from the red cell mass measurement, supplying an indication of red cell longevity. The etiologic determination of any hemolytic process is rather detailed. Loss of red cell integrity, with early demise, may be the result of an altered plasma membrane, reduced available energy stores, and/or altered internal osmotic properties. Various specific enzyme systems contribute to various aspects of these vital red cell parameters and, therefore, must be assayed. Various physical measurements of the erythrocyte population; e.g., counts, differentials, osmotic fragilities, etc., are also essential for they supply information needed to integrate the more detailed biochemical analyses. Based on the reasoning used in this text, the appended test protocol is suggested.

ADDENDUM 1

Suggested Hematology Testing

Test	Responsible Agency	Method
Erythrocyte Count	NASA-MSC	Coulter Counter
Hct	" "	Micro Hematocrit
Hgb	" "	Cyanomethemaglobin
Osmotic Fragility	" "	Fragiligraph
Reticulocyte Count	" "	Wet Method
Platelet Count	" "	Phase Microcopy
WBC	" "	Routine
Differential	" "	Routine
Hgb Electrophoresis	" "	Cellulous Acetate
Plasma Immunoelectrophoresis	" "	Strips
Erythrocyte Electrolytes	" "	MgCl Rinse and Analysis
Plasma Osmolality	" "	Routine
Plasma Electrolytes	" "	Routine
Erythrocyte Phosphates	University of Texas	To be stipulated
Organic		
Inorganic		
Red Cell Mass	Baylor University	Cr^{51} in Vitro Tag
Plasma Volume	" "	RI5A - 125
Iron Kinetics	" "	Fe59
Red Cell Lipids	University of Toronto	Gas Chromatography
Plasma Lipids	" " "	" "
Fecal Urobilingen	" " "	" "
Erythrocyte Enzymes	Ohio State University	
and Associated Studies		
Methemoglobin	" " "	Spectrophotometry
Autohemolysis	" " "	24 and 48 Hours
Hemolytic Sensitivity to	" " "	
Complement Lysis		
Acidified Serum		
Erythrocyte Catalase	" " "	Titrametric Method of Feinstein

Test	Responsible Agency	Method
Reduced Glutathione	Ohio State University	Spectrophotometric Method for SH Grays
Specific Glycolytic Enzyme Systems	" " "	
Glucose 6-PO_4		
Pyruvate Kinase		
Phosphoglyceraldehyde Dehydrogenase		
Phosphofructokinase	" " "	
Red Cell Cholinesterase	" " "	Acetylthicholine Spectrophotometric Method
H_2O_2 Lysis Test	" " "	Method of Mengel
"Lipid Peroxids" Assay in vivo and in vitro	" " "	
Glutathione Peroxidase	" " "	H_2O_2 Diffusion Technique

ADDENDUM II

Day	Enzyme Assay	Plasma Membrane Assay	Red Cell Mass	Plasma Volume Test	Red Cell Survival	Fe^{59} Kinetics	Special Hematology	Blood Requirements		Radiation Dose	
								Number of Venopunctures	Volume in cc's		
F-10	X	X	X	X			X	3	50	88 m rem	
F-9					X				10		
F-8					X		X		10		
F-7											
F-6	X	X			X		X	1	17		
F-5											
F-4											
F-3											
F-2	X	X			X		X	1	17		
F-1											
F											
R(ASAP)	X	X	X	X		X	X	3	5	268 m rem	
R+30 min						X		1	2		
R+60 min						X		1	2		
R+90 min						X		1	2		
R+1 day	X	X			X	X	X	1	25		
R+3 days					X	X	X	1	10		
R+5 days					X	X	X	1	10		
R+7 days	X	X			X	X	X	1	25		
R+14 days					X		X	1	7		
R+21 days					X		X	1	7		
R+30 days	X	X	X	X	X		X	3	50	88 m rem	
TOTALS								20	249	444 m rem	

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