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DEVELOPMENT OF BREATHING DEVICE, EMERGENCY ESCAPE.(U)
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FINAL REPORT
DATA ITEM A00G
CONTRACT NO. N00024-74-C-5501
FOR THE DEVELOPMENT OF BREATHING DEVICE,
EMERGENCY ESCAPE.

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1.0 GENERAL

This report is issued in conclusion to an effort under Navy contract N00024-74-C-5501 for the development of a 15 minute life sustaining escape device from an irrespirable environment designated herein as Breathing Device, Emergency Escape (BDEE).

The development program consisted of the design, testing and manufacture of 50 preproduction prototypes to be delivered to the Navy for purposes of further testing.

The system developed incorporates a fire resistant hood with recirculation flow pumped through a "scrubber" by a venturi. The primary venturi flow is oxygen gas produced by a chemical oxygen generator.

2.0 DESCRIPTION OF DESIGN

The objective of the design as stated in paragraph 3.1 of SHIPS-B-5669 is to provide a device that can be made inexpensively in high volume, has maximum shelf life and reliability, is small, lightweight, and requires little or no maintenance.

The system that has been developed meets these criteria. In addition, the selected system has distinct advantages over stored gas systems in that no maintenance is required to assure a full gas supply. As compared to mask or mouthbit arrangements the powered recirculation and hood configuration leaves the user unencumbered, and permits him to communicate freely, wear glasses, and in general, operate in a normal manner.

2.1 Arrangement

The arrangment of the device as worn, is a life support pack attached to the back side of a hood. This arrangement was approved at the phase I design review. A schematic diagram shows the functions of the various elements within the life support pack and their general arrangement. See Figure 1

A primary objective of the design was to have a rugged unit. One that can take the abuse of being hit or dropped during a hurried exit without loss of function. All critical components are well protected within a box-like structure. There are no outboard tubes or projections which can be broken off or snag.

The housing structure and exterior features of the life support pack are all constructed of impact resistant polysufone plastic. The solvent bonded shear joints bonding the housing components together assure a rigid structure. Heavy wall reinforcement and generous fillets in stressed areas will assure that impact or abuse will not damage the structure or integrity of the seals.

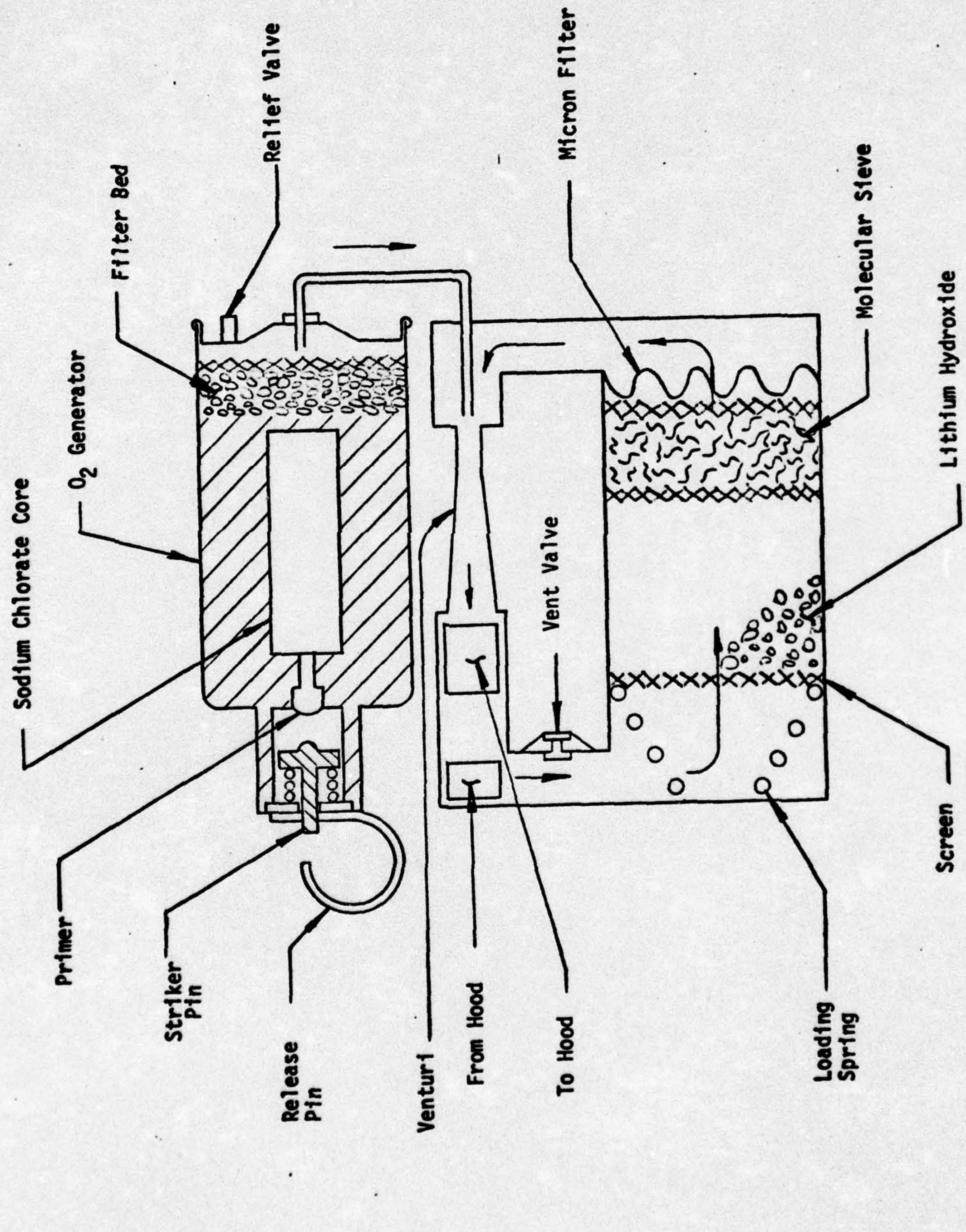
Relief Valve
Filter Bed
O_2 Generator
Sodium Chlorate Core
Micron Filter
Molecular Sieve
Lithium Hydroxide
Vent Valve
Primer
Striker Pin
Release Pin
Venturi
From Hood
To Hood
Loading Spring
Screen

FIGURE I

The life support pack assembly is non-rechargeable although the hood can be removed and reused. This is justified as follows:

A high percentage of the value of the device is in the expendable parts. After replacing the generator and scrubber bed only the value of the plastic housing would be retained. Since it is an emergency device with a low usage rate, the small savings to be realized by recharging used units would not justify the additional initial cost, complexity, training, inspection and facilities required to accomplish field recharging.

For purposes of training personnel in the use of the device, Scott can manufacture a limited production rechargeable device.

2.2 Life Support Pack

The life support pack contains an oxygen generator, a venturi aspirator, a Lithium Hydroxide CO_2 removal bed with a molecular sieve bed for moisture control, and a vent valve.

The oxygen generator was derived from a standard Scott portable unit used in an emergency aviation application and has been in service for the past five years. Canister hardware and manufacturing methods are the same.

The length is approximately 1½ in. less and it has an integral ignitor device. Oxygen is produced at a nominal rate of 5½ nlpm. The generator is fitted with a relief valve to preclude excessive pressure build-up in the canister.

The venturi and scrubber beds are integral with the housing. A short length of brass tubing conducts oxygen flow from the generator to the nozzle of the venturi. Here the 5½ lpm of oxygen powers the venturi to provide a total recirculation flow of approximately 60 lpm through the scrubber and hood loop.

The chemical scrubber is located in the tubular section below the oxygen generator. A bed of Lithium Hydroxide granules in the flow path removes metabolic CO_2 from the gas stream as it passes through. A bed of molecular sieve also contained within the cylinder and in series with the LiOH, acts to control moisture level and to absorb certain other odors and contaminants. A pleated paper micron filter at the cylinder outlet acts to filter out any Lithium Hydroxide dust or other particulate contaminant that may have entered the hood. This filter will remove smoke that may have entered the hood during the donning process.

Upstream of the chemical bed, a screen backed by a loading spring prevents the bed from loosening under vibration. Also, a light duty filter paper prevents Lithium Hydroxide dust from backflowing into the hood.

A simple silicone rubber flapper valve located between the hood outlet and filter bed inlet acts to maintain pressure within the hood at no more than .6 in. H_2O. The valve is located in a protected position behind the rear heat shield in order that the vented gas will be diluted before it emerges from the protection of the unit.

2.3 Hood

The hood provides the means of excluding the irrespirable atmosphere. This atmosphere could be oxygen deficient air, heavy smoke, or toxic gas; therefore, the hood has to be relatively leak tight. It must also be flexible, fit a wide range of subjects, should not hamper communication, and above all, it must not support combustion while containing an oxygen rich atmosphere (90% plus).

The hood provided meets these criteria.

The hood is constructed of fiberglas, coated with Teflon After a lengthy period of special coating, testing and evaluation, a 5 mil specially treated and coated material was selected. With this material the best combination of flexibility, minimum porosity and nonflammability properties were achieved. All seams are heat sealed for minimum porosity. A neck dam made of tough, elastic urethane seals tightly around the neck without the use of pull strings. The visor is clear teflon, 5 mil thick, which is heat sealed directly to the hood cloth.

The head harness within the hood supports the life support pack which hangs at the back. The head harness has been designed to accommodate all head sizes and provide a snug fit which prevents the unit from swinging forward with head motion.

The gas duct within the hood carries the scrubbed and dry flow from the venturi exit, at the back of the hood forward to the visor area where it serves to act as a defog wash. The duct is constructed from urethane coated nylon and presents minimum bulk as the hood is stowed. This duct, being adjacent to, and in front of the gas return port prevents hair from being sucked in and blocking that port.

The hood and life support pack are readily visible as white colored material is used throughout. Visibility is enhanced by two reflective strips on the cylinderical portion of the life support pack.

2.4 Carrying case

The case provided for the BDEE is a blow-molded polyethylene type designed specifically to contain the breathing device. The case functions only to protect the device from abuse and tampering. It is vented and does not seal the contents from the ambient. Protection of the unit is provided by a vacuum sealed heavy gauge composite film pouch.

The combination of wrap and box provides a very efficient and cost effective means of excluding any environmental contamination. A box alone, designed to both seal and protect, with the capability to withstand pressure cycling as experienced in air transport, is relatively complex, heavy, and costly.

The case is one-piece construction featuring an integral latch and hinge. A pocket formed in the base half prevents the breathing device from falling out when the box is opened in the vertical or normal carrying position.

Accessories for carrying the case are a wire formed belt clip and a shoulder strap. The belt clip snaps securely on the belt or folds into a recess on the case when not in use. The nylon shoulder strap is adjustable for user comfort.

Two means are provided to assure the readiness of the unit. A tamper indicator seal will be torn if the box is opened. If so indicated, the inner wrap should be checked to see that the vacuum seal is intact. A viewport in the case allows an inspector to view the color indicator of a packet of silica gel crystals within the wrap. Blue indicates good package integrity, clear or pink indicates that the vacuum seal may have been lost and inspection is necessary.

The cases provided for this contract are a fluorescent orange color, selected as a generally used color for safety equipment. Illustrated instructions fill one large panel of the case.

The pouch used to protect the device from environmental contamination is a triple layer composite film of exceptionally low permeability. The material meets MIL-B-22191C, Type 1, requirements. A red tear strip located on one edge provides a readily apparent means of opening the pouch.

3.0 OPERATION OF THE DEVICE

Basic operating instructions are furnished herein. Refer to the appendix.

3.1 Technical description of operation

Initiation, accomplished by releasing the spring loaded plunger against the primer of the O_2 generator ignites a series of pyrotecnic mixes which establish a steady thermal decomposition of the main sodium chlorate generator core. The primary chemical reaction involved is:

$$NaClO_3 \longrightarrow NaCl + O_2$$

Heat is liberated

Oxygen released by the decomposition flows through a chemical filter and catalyst and is delivered essentially pure and odor free to the venturi nozzle. Flow restriction in the nozzle results in a nominal back pressure of 22 psi in the generator canister. Any over-pressure caused by momentarily high flows is vented through a relief valve installed directly on the canister.

The venturi ejector maintains the recirculation of gas within the hood by utilizing the energy in the 22 psi, 5.5 lpm flow from the generator. Approximately 60 lpm recirculation flow changes the air in the hood about twelve times per minute.

The venturi ejector is a very simple device, has no moving parts, and is therefore a reliable device. Proper operation is dependent only upon the geometry which is molded in. The operating principal of the venturi is based on an exchange of momentum between the rapidly flowing gas from the nozzle being ejected into the center of a stream of slower moving gas. The fast moving gas is slowed by contact with the slower gas. The slower gas is accelerated by this contact. High gas velocities within the venturi create a distinctive flow noise which the user can recognize as indication that the device is functioning normally.

From the venturi, gas is ducted into the hood through a channel or duct which directs the flow onto the visor. The warmer and drier gas maintains a fog free area of visor ahead of the eyes of the user. Gas exits from the hood at a port in the back, right behind the gas duct.

The outlet port has been carefully designed to insure that hair or other objects will not block the flow. The gas duct carrying the hood inlet flow forms a barrier which stands away from the port while the hood is in its inflated or operational position.

CO_2 and moisture from the users breath mix with the gas in the hood. Under design conditions, 1.7 lpm of metabolic CO_2 is produced. This results in a CO_2 concentration of 2.8% at the hood outlet with a nominal 60 lpm recirculation rate.

This percentage fluctuates (as indicated in the test results) due to the fluctuating output from the oxygen generator. Also, as CO_2 starts to break through the chemical bed, CO_2 concentration at the hood outlet gradually begins to rise as air entering the hood contains an increasing amount.

A vent valve positioned in the plenum area at the chemical bed inlet section controls the pressure in the hood and vents excess gas into a protected area behind the heat shield. Hood pressure is maintained below .6" wg. The valve vents momentarily, usually at each exhalation, to spill gas generated in excess of the metabolic requirements.

The scrubber canister contains Lithium Hydroxide granules which react with carbon dioxide. The main chemical reaction involved is: $2\ LiOH + CO_2 \longrightarrow Li_2CO_3 + H_2O$.

The excess water is formed as vapor and is picked up in the layer of molecular sieve at the outlet of the canister. The molecular sieve is chemically inert and adsorbs water and other gases by entrapment.

Before the gas leaves the scrubber canister it passes through a micron filter capable of removing any LiOH dust, smoke, or other particulate matter within the gas stream.

Lithium Hydroxide was chosen as the absorbent because of its highly reactive nature with CO_2. Other absorbents would have enough capacity for the bed size available but require longer dwell times than would be feasible in a device of this small size. On a weight basis, it is also favored. That is one reason the system weight has been held to a low 3½ lbs.

Heat is a by-product of both the CO_2 removal reaction and the moisture adsorption within the molecular sieve. Designing for the driest conditions at the bed outlet assures the least formation of fog on the visor. However, hood temperatures are highest under these conditions. There is a trade off to be made between hood temperature and visor fogging.

In designing the chemical beds for the units submitted under this contract it has been assumed that conditions during use will be indoors or in warm areas. Fog formation will be less likely than for outdoor use in cold weather. Therefore the moisture absorbent has been minimized to achieve cooler operation.

In the event visor fogging does become a problem to the user, he can wipe the visor against his face to clean off the fog. The visors, in addition, have been treated with an anti-fog coating.

The device while operating produces heat from both the generator reaction and the scrubber canister. Surfaces of the housing and heat shield are ribbed for handling. The ribbing is a means of providing a stand off to prevent body contact against broad surfaces. Temperatures are not hot enough to cause burns; however with the ribs one does not feel the heat and will not react to the temperature when touching it.

The device is designed to operate in its normal position with the slot in the heat shield upwards. This allows air flow to rapidly carry away the generator heat. If operated in other positions, the shield or housing surfaces on top of the generator canister will become hot to the touch.

4.0 DEVELOPMENT PROGRAM (CHRONOLOGICAL)

Work was accomplished in a 3 phase program of development plus an extension of time required to production tool the stowage case and heat shield and to refine the hood.

Reports were published at the conclusions of Phases I and II. A test report (ER 1081) was published at the conclusion of Phase III. Meetings were held with the congnizant Navy personnel after each phase.

4.1 Highlights of Phase I

Phase I was an experimental period during which specific requirements were investigated and designs formulated. Studies included scrubber bed sizing, venturi sizing, and package arrangement studies. The tasks included building two rechargeable prototype units (one for chest and one for rear mounting) and development of a test stand capable of furnishing simulated operating conditions.

Some preliminary hood material flammability tests were accomplished at this time.

On January 13th, 1975 a review meeting was held with the Navy to establish concurrence on test methods and design.

At this meeting, the Navy requested that development continue on the rear mounted unit rather than the chest mounted type. Also the hood material burn test was defined as a 6 second yellow flame exposure and a burning match laid in contact with the hood. It was also understood at the meeting that a fifteen minute rather than a ten minute unit would be preferred since there was no significant cost advantage.

Phase II (Design Phase)

During Phase II, considerable effort was spent in surveying candidate hood materials and evaluating burning characteristics of these materials.

A package arrangement was selected early in Phase II and a plastic model was constructed.

Several heat shielding arrangements for the oxygen generator were developed and evaluated during Phase II.

A complete set of drawings for hardware to be manufactured during Phase III were finished and submitted to the Navy at a meeting held on June 22, 1975. At that meeting, a report, ER 1066, was presented which outlined the status at the conclusion of phase II and summarized the results of research and testing of hood materials. At this meeting there was agreement that the teflon on glass fabric material should be the chosen hood material.

Also at the meeting, the stowage case concept of using a vented outer box along with a hermetically sealed wrap insert was approved.

Phase III

Phase III was the manufacturing and test phase. Upon acceptance of the design presented to the Navy materials were ordered and tooling started.

Temporary tooling for plastic injection molded parts was ordered. A preliminary quantity of hoods made from the Beta fiberglass impregnated with teflon was ordered.

Polysulfone plastic was selected as the housing material. It is a premium plastic, however its chemical inertness, low creep, high heat resistance, toughness and its ability to be solvent cemented made it the most suitable material.

Preliminary testing accomplished on the first prototypes indicated that porosity of the hood material was excessive. Time did not permit further development prior to the formal test program, therefore a urethane coated nylon inner hood was added to seal the hood. Effort to find a suitable single layer hood material continued.

A test procedure was written and submitted. Twenty-five test units were assembled for performance testing and tests were conducted with satisfactory results. Results of the tests were reported in Scott Report ER 1081 and presented to the Navy in a meeting held on May 11, 1976.

Fifty breathing devices were completed and readied for shipment to the Navy. The Navy elected not to receive these units as it was decided that extra time should be taken to refine the hood and heat shield and provide a carrying case. The shipment was then postponed and the contract extended.

<u>Extension period</u>

<u>Hood Development</u>

During the latter part of Phase III other sources of hood materials were located. The extra time available allowed the cloth manufacturers to develop variations to their process to improve the product with respect to leakage. Both materials and hood assemblies were evaluated.

Permeability tests were developed using different gases.

Helium, carbon dioxide, carbon monoxide, DOP smoke, freon, and isoamyl acetate were all investigated as a challenge atmosphere.

As a result of the investigation, another teflon coated glass fabric was selected. This fabric is a little thinner and stiffer than the original selection but it provides a satisfactory gas barrier and meets the stringent flammability requirements.

Considerable progress was made in developing the process for hood fabrication. Of particular concern was simplification of the attachment of the urethane neck seal to the hood body. That has now been accomplished with a heat sealing process. All the other hood seams are also heat sealed.

The hood design and pattern has now been developed for optimum fabrication efficiency in a production situation.

The head harness was revised to achieve simpler assembly. It also has been improved functionally to provide a tighter grip on the head for better stability.

Heat Shield

Production tooling was developed for an injection molded heat shield. Tooling for this item is quite complex and several design and molding problems had to be solved. The heat shield program was successfully concluded and production tools are now available to produce the shield at a fraction of the cost of the 2 piece painted metal shields originally used.

Stowage and Carrying Case

At the conclusion of Phase III a stowage case design had been completed. However the manufacture of such a case had not been initated. The reasons were that the 20 week lead time required to produce the tooling could not be fit into the Phase III schedule. Considering that possible performance test failures could result in last minute changes effecting the exterior size it did not seem advisable to commit to a 20 week tooling program. The extension period has provided the time needed to completely tool the case in its production configuration.

At the conclusion of the extension period formal tests were rerun to verify that the device with the changes made in the hood, heat shield and packaging would meet the requirements. In these tests the device exceeded the spec requirements.

5.0 TEST PROGRAM

The test program is summarized in Scott Report ER 1081 and a supplement to that report. The tests were accomplished in two time periods; one at the conclusion to Phase III, the other at the conclusion of the extension phase. (After the stowage case had been added and the hood and heat shield redesigned.)

The general test procedure is defined in Scott Report ER 1079, dated January 29, 1976. The test program followed is summarized in "Table I Test Program" taken from that report and included herein. A summary of the test results from ER 1081 is also included. See section 6.0 of this report. Also included in section 6 is a typical strip chart record showing % CO_2 vs. time.

The second series of tests run was limited to fewer test units and was designed to test hood characteristics and stowage case characteristics. Retests were run for test numbers 2, 6, 7, 9, 10, & 11. Results are reported in the supplement to ER 1081, dated December, 1976.

TABLE I TEST PROGRAM

SCOTT ER 1079 PARA. NO.	TEST	NO. OF UNITS / TEST NO.	3 / 1	3 / 2	2 / 3	2 / 4	2 / 5	3 / 6	1 / 7	1 / 8	1 / 9	1 / 10	1 / 11
4.2.1	GAS BUILD-UP		X										
4.2.2	MASK-IN LEAKAGE			X									
4.2.3	PROOF PRESSURE		X	X	X	X	X	X	X	X	X	X	X
4.2.4	HIGH TEMPERATURE OPER.					X							
4.2.5	LOW TEMPERATURE OPER.						X						
4.2.6	VIBRATION							X					
4.2.7	DROP								X				
4.2.8	WATER IMMERSION									X			
4.2.9	FLEXIBILITY										X		
4.2.10	SALT SPRAY											X	
4.2.11	FLAMMABILITY												X
	TEST TYPE												
4.1.1	MAN TEST A		X										
4.1.2	MAN TEST B			X									
4.1.3	MACHINE				X	X	X	X	X	X	X	X	X
	TEST PARAMETERS												
5.1	HOOD TEMP		X		X	X	X	X	X	X		X	
5.2	PURITY							X	X				
5.3	ACTIVATION				X	X	X			X	X	X	
5.4	VISOR FOGGING		X	X	X	X	X			X	X	X	
5.5	SURFACE TEMPERATURE		X		X	X	X	X	X	X		X	
5.6	PULL (HOOD, HOSES)										X		
5.7	RELIEF VALVE (GENERATOR)				X								
5.8	CO_2 LEVEL		X		X	X	X			X	X	X	
5.9	DURATION		X	X	X	X	X	X	X	X	X	X	

5.1 TEST FAILURES

There were no test failures during the final test period.

A minor problem was identified during the first test period and corrected as verified by the 2nd tests.

A punctured pouch occurred during the water immersion test, vibration test, and drop tests. It was caused by sharp corners on the heat shield and projecting screw heads.

5.2 Corrective Action

The heat shield has been replaced with one in which the screw heads are depressed below the surface. A protective layer is used between the pouch and body of the device, and the carrying case has been added. These actions have all been verified as effective by the supplemental test program concluded in October - November 1976.

6.0 PERFORMANCE

Performance is summarized in Table II (following).

Figure 2 is a reproduction of a test strip chart record of CO_2 concentration at the hood outlet during operation at design conditions.

Table III is taken from ER 1081 and a summary of several test parameters for the individual tests as monitored during the test program.

TABLE II

PERFORMANCE SUMMARY & PHYSICAL SPECIFICATIONS

PERFORMANCE	TYPICAL VALUES AT NORMAL ROOM AMBIENT OPERATING CONDITIONS	REQUIREMENT PER SHIPS-B-5669
CO_2 (1.7 lpm input)		
at hood outlet	2.8%	4%
at 15 mins.	3.5%	4%
Duration	16.5 mins.	15 mins.
Hood Temp.	100-120^{o}F	160^{o}
Shield Temperature	110-120^{o}F	175^{o}F
Smoke Leakage	.05%	.1%
Hood Gas Permeation	4%	Not Specified
Weight of Device	3.6 lb.	
Weight of Device & Case	5.0 lb.	
Oxygen Output	5.5 lpm	
Total Oxygen	120 gms.	
Recirculation Rate	60 lpm	

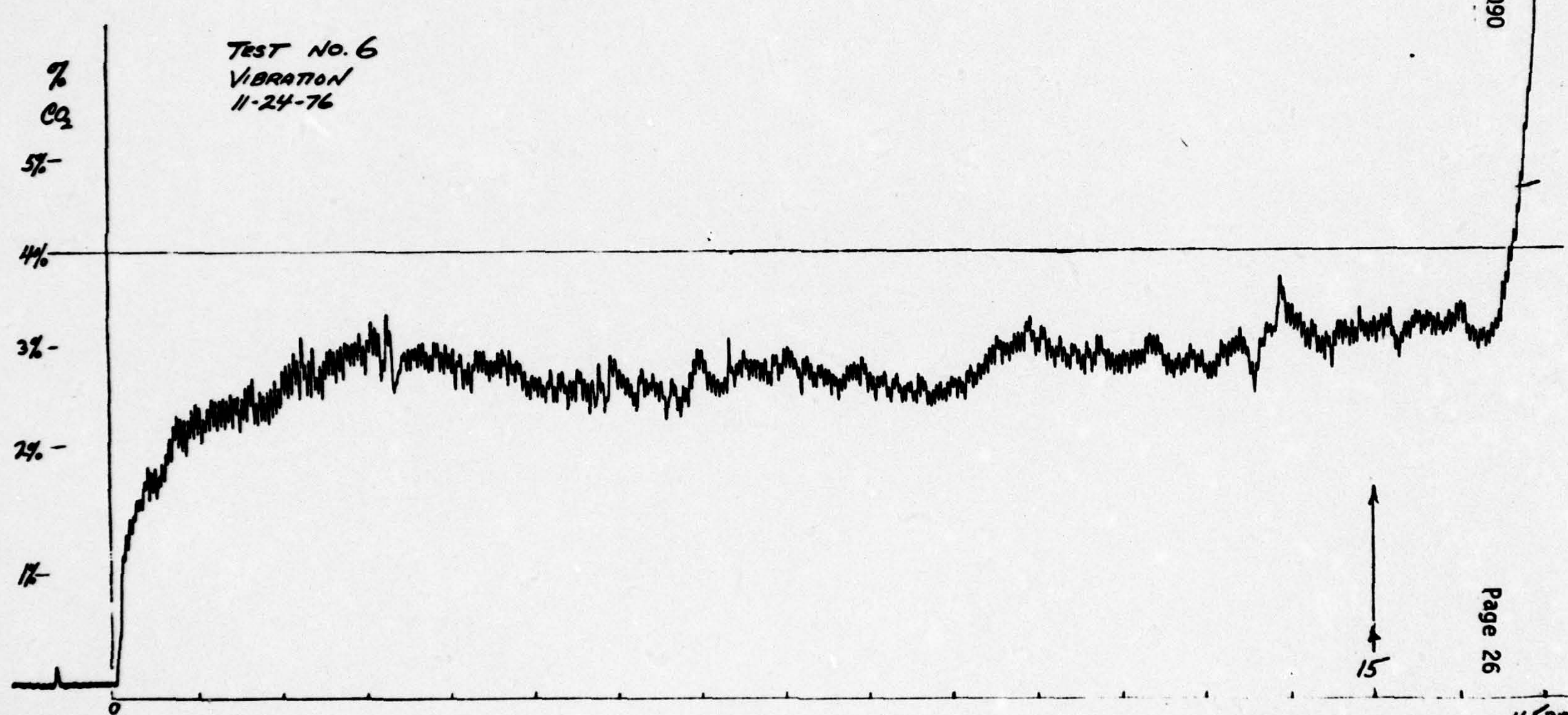

FIGURE 2

Typical Test Results: CO_2% at hood outlet vs. time in minutes

TABLE III

TEST NO.	TITLE	SERIAL NO.	CORE LOT	DURATION	ACTUATOR PULL FORCE	% CO_2 @ 15 MIN.	INDICATED VENTILATION RATE (LPM)	MAXIMUM TEMPERATURES HOOD	SHIELD A	SHIELD B
1	Gas	8	357	17.4	---	2.3	---	92	98	99
1	Build	11	361	15.5	---	2.2	---	107	99	112
1	Up	18	357	17.9	---	2.5	---	105	112	110
2	Hood	19	357	19.0	---	---	---	---	---	---
2	Inward	22	357	17.9	---	---	---	---	---	---
2	Leakage	13	361	15.5	---	---	---	---	---	---
3	Machine	6	357	17.4	14	3.3	58	98	107	112
3	Test	16	361	15.3	17	3.3	70	112	115	113
4	High	12	361	14.4	13	2.7 @ 14.4	70	126	121	125
4	Temperature	9	357	15.7	12	3.4	63	123	124	121
5	Low	14	361	18.3	11	3.5	53	119	102	107
5	Temperature	21	357	21.3	11	4.1	46	107	99	106
6	Vibration	7	357	18.4	---	---	---	95	108	113
6		17	357	16.8	---	3.5	63	115	110	112
6		24	361	15.2	---	---	---	110	117	117
7	Drop	25	357	17.8	---	---	---	105	113	115
8	Water Immersion	23	357	18.8	16	3.3	58	110	105	112
9	Flexability	5	361	14.8	14	3.6	65	---	---	---
10	Salt Spray	10	357	17.1	15	3.2	57	115	110	115
11	Flammability	15	361	---	---	---	---	---	---	---

STATUS OF THE DESIGN

1) The design is complete and performance demonstration testing has been satisfactorily accomplished.
2) Production tooling of all plastic components is essentially complete. In some instances cavities may be remounted with automated core pulls, etc. to improve production efficiency.
3) Production heat sealing equipment for assembly of the hood will need to be built. No change in design or method is anticipated.
4) Production of the oxygen generator is being accomplished on present adequate Scott equipment.
5) The case is fully tooled.
6) There is no area which currently could not be in production within normal lead times.

APPENDIX

(PRELIMINARY)

INFORMATION FOR PROPER INSPECTION, STORAGE AND USER OPERATION OF EMERGENCY ESCAPE BREATHING DEVICE (BDEE), SCOTT P/N 802300 SERIES

(PRELIMINARY)

INFORMATION FOR PROPER INSPECTION, STORAGE AND USER OPERATION OF EMERGENCY ESCAPE BREATHING DEVICE (BDEE), SCOTT P/N 802300 SERIES

A. GENERAL

1. Stowage Case

a. Keep the BDEE in its stowage case for protection until removed for emergency use.

b. The stowage case cannot be opened without tearing the tamper seal. If the seal is torn, inspect the inner bag for integrity. If it shows no signs of damage, affix a new seal.

c. The case may be belt-mounted, using the wire-formed belt clip nested in the latch recess, or carried by its shoulder strap.

2. Inner Bag

a. A three layer laminated inner bag is vacuum sealed over the device. It prevents exposure to atmosphere which could cause loss of efficiency in the chemical beds.

b. If the bag has lost its vacuum seal, repackage the device in a new bag.

c. The device may be stowed up to two months in a leaky bag without changing its operating characteristics, provided the device is kept in its original bag and has not been subjected to frequent changes in altitude.

d. A view port, provided in the stowage case, facilitates observation of the humidity sensitive indicator for detection of a failed bag.

e. The indicator, in the form of a stripe, is dark blue when the bag seal is normal. A clear-to-light pink color indicates that the bag requires inspection.

f. A torn Tamper Seal also indicates that the bag should be inspected.

g. Abuse, or a drop violent enough to tear the Tamper Seal, may damage the bag.

B. USE OF THE DEVICE

1. Training

a. Even though brief instructions appear on the stowage box, it is important that adequate instruction and training be given to all potential users to assure proper use in an emergency.

FIGURE 1

FIGURE 2

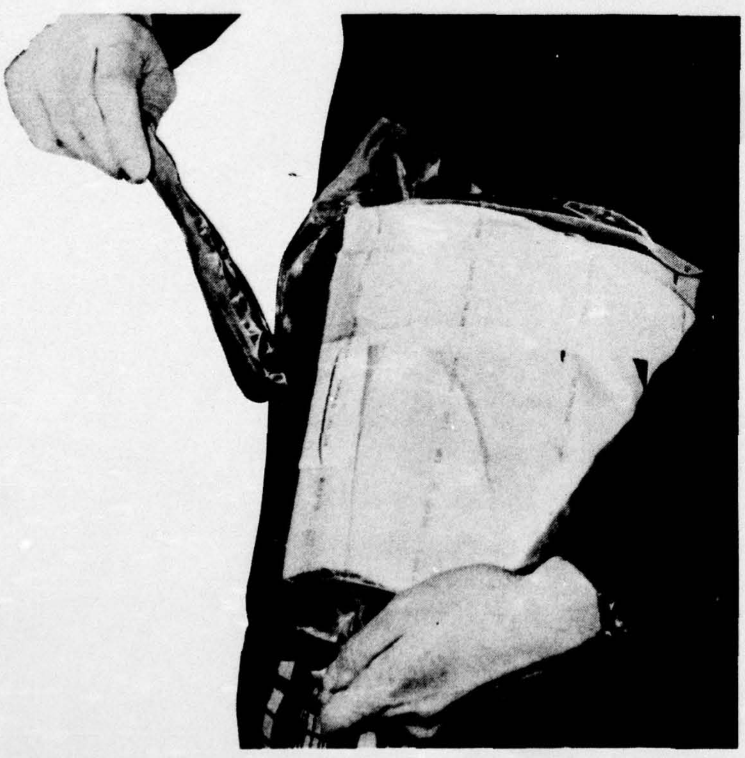

FIGURE 3

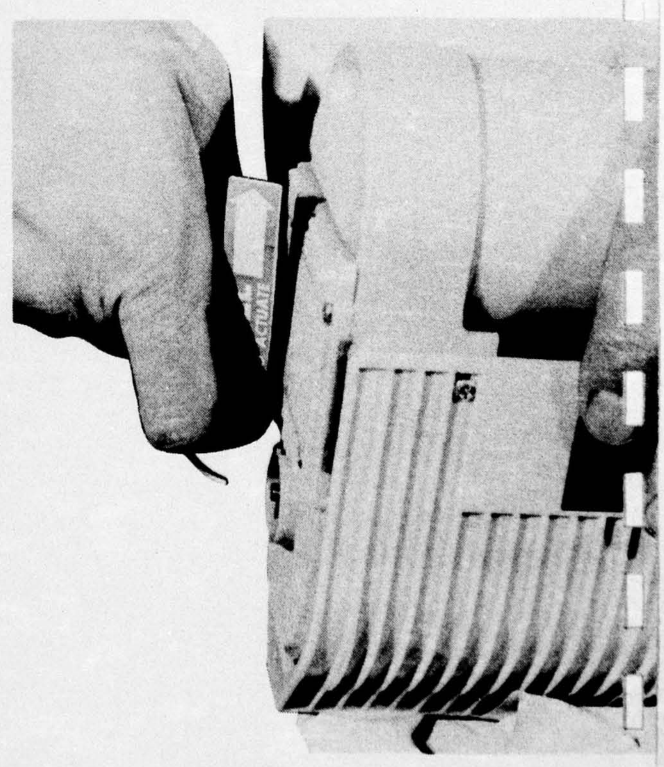

FIGURE 4

C. DONNING

Step 1. Removal of the device from the stowage case.

a. A single latch, labled "LIFT", is provided at the top edge of the case. Lift the latch to open the case as shown in figure 1.

CAUTION: DO NOT CONFUSE THE LATCH WITH THE WIRE-FORMED BELT CLIP.

b. Some initial resistance to opening, caused during seal fracturing, may be noted after lifting the latch. Continue to open.

c. Grasp either end of the bag projecting from the corners of the case and pull the device out of the case as shown in figure 2.

Step 2. Opening Inner Bag. (See figure 3)

a. Identify the edge with the Red Tear Strip.

b. Grasp as shown in figure 3 to initiate the tear.

NOTE: Pre-cut notches and the stiff tear strip facilitate removal of the end.

c. In the event identity of the strip is lost, a little extra effort on any edge of the bag will start a tear.

d. Remove the device from the bag.

Step 3. Initiating Oxygen Flow (See figure 4)

a. Pull the release pin clearly marked "PULL TO ACTUATE" on the red tag as shown in figure 4. Pull in the direction indicated; parallel with the housing surface. Actuation has been accomplished.

CAUTION: DO NOT ATTEMPT TO PULL THE PIN OUTWARD.

(Removal of the release pin allows a spring loaded plunger to strike a primer cap on the oxygen generator initiating gas flow which will be audibly noted by the user.)

Step 4. Donning the Device. (See figure 5)

a. Hold the device by the open end of the hood, with the recirculating unit away from the user.

b. Identify the elastic neck seal and the approximate 3-1/2" diameter hole into which the head will be inserted.

c. Bend forward from the waist as shown in figure 6 and force the head into the hole while grasping the edges of the hood on each side. Use the thumbs to assist in pulling the seal over the face.

NOTE: Users with glasses may find it easier to don the device while remaining in an upright position (see figure 7). Start by placing the chin in the hole and stretching the hole up over the top of the head.

d. While standing upright, pull down on the front of the hood until the head harness is felt to be tight over the forehead (see figure 8). This will insure maximum stability while being worn.

CAUTION: MAKE SURE THERE IS GOOD CONTACT AT THE NECK SEAL WITH THE NECK. MAKE SURE NO CLOTHING IS TRAPPED IN THE SEAL AND HAIR DOES NOT PROTRUDE BETWEEN THE SEAL AND THE NECK.

D. NORMAL OPERATION

1. It is normal to hear the sound of rushing air in the hood, indicating the oxygen generator is delivering oxygen to the hood.

   NOTE: Normal operational duration is 15 minutes.

2. When the noise stops, the device should be removed from the head within a short period of time.

3. Heat build-up within the hood is also a normal condition. Temperatures may reach 110°F inside the hood, depending on the user's activity. This condition may cause some discomfort, but it does not indicate a malfunction.

4. External areas of the housing, particularly in the area of the heat shield, may become hot to the touch.

   CAUTION: EXERCISE CARE WHEN TOUCHING THE HOUSING.

E. DOFFING

1. Grasp the hood at the back lower edge and pull forward over the head.

F. DISPOSAL

1. The device cannot be recharged; discard after using.

   NOTE: Allow the generator to completely expend before discarding.

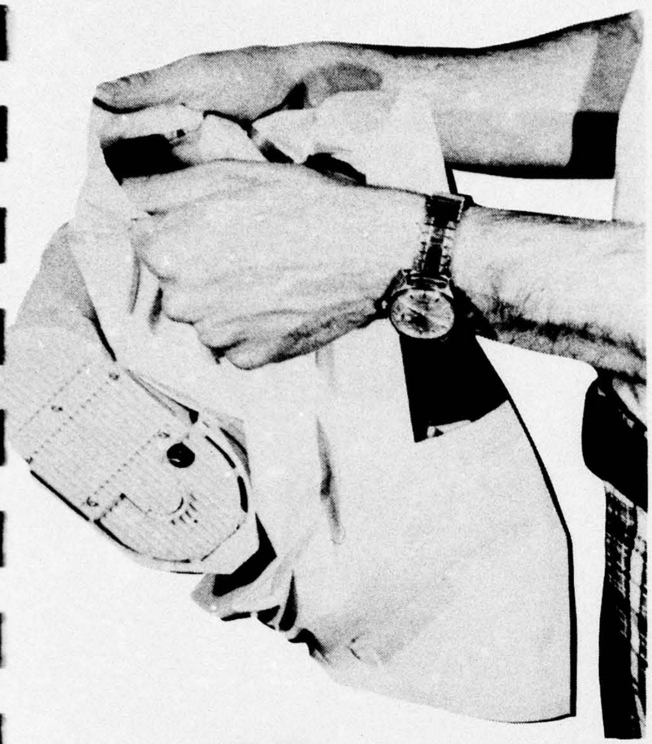

FIGURE 5

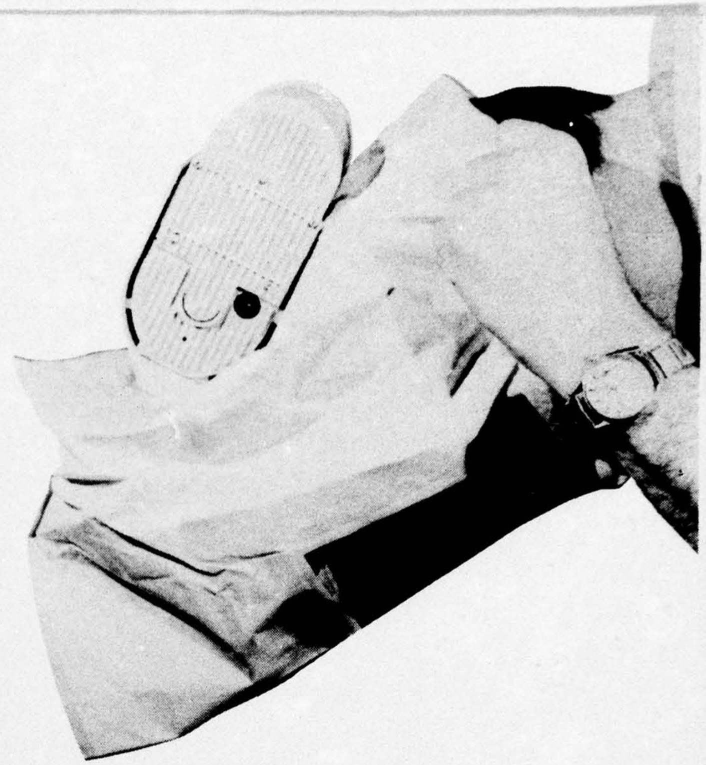

FIGURE 6

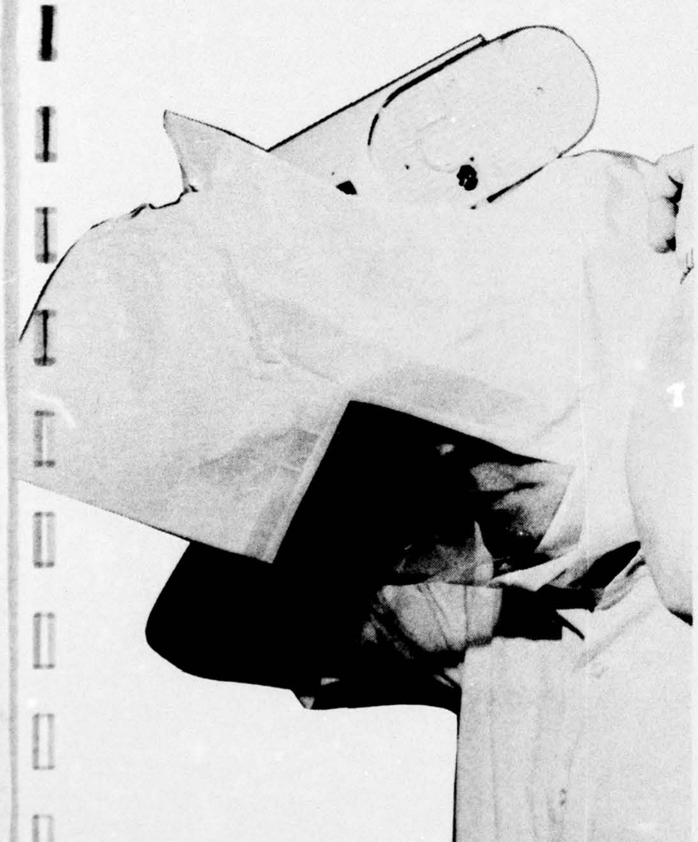

FIGURE 7

FIGURE 8