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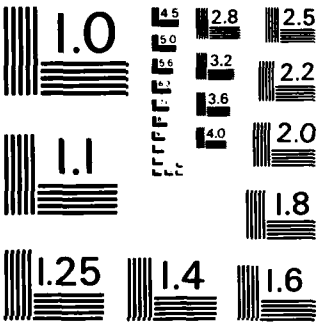

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EVALUATION OF VIKING PROTOTYPE
AND FIRST ARTICLE DIVING DRESSES
FOR USE WITH THE MK 12 SSDS

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PART 1.

Two prototype dry suits produced by Viking Technical Rubber, Inc. were evaluated for potential use with the MK 12 Surface-Supplied Diving System (SSDS). One dry suit was of lightweight configuration with integral soft boots, and the other was of heavier construction with hard, integrated boots.

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Studies of range of motion, buoyancy control, durability, comfort, ease of dressing, and leak integrity were conducted during 27 dives in a fresh water pool and 13 dives in a salt water channel to depths of 20 FSW. Deficiencies in the prototype suits were identified and included fit (cut) of the suits, foot support, cut of weight pockets, and seals at wrists and neck. The durability of both suits was satisfactory during this limited testing. Recommendations for suit alterations to enhance compatibility with the MK 12 SSDS are made.

PART 2.

The NEDU recommendations were incorporated into a First Article Suit by Viking Technical Rubber. This suit was tested and the results are presented in Part 2 of this report. The First Article Suit is considered suitable for use with the MK 12 SSDS.

ABSTRACT

PART 1.

Two prototype dry suits produced by Viking Technical Rubber, Inc. were evaluated for potential use with the MK 12 Surface-Supplied Diving System (SSDS). One dry suit was o lightweight configuration with integral soft boots, and the other was of heavier construction with hard, integrated boots. Studies of range of motion, buoyancy control, durability, comfort, ease of dressing, and leak integrity were conducted during 27 dives in a fresh water pool and 13 dives in a salt water channel to depths of 20 FSW. Deficiencies in the prototype suits were identified and included fit (cut) of the suits, foot support, cut of weight pockets, and seals at wrists and neck. The durability of both suits was satisfactory during this limited testing. Recommendations for suit alterations to enhance compatibility with the MK 12 SSDS were made.

PART 2.

The NEDU recommendations were incorporated into a First Article Suit by Viking Technical Rubber. This suit was tested and the results are presented in Part 2 of this report. The First Article Suit is considered suitable for use with the MK 12.

PART 1

INTRODUCTION

The Navy Experimental Diving Unit was tasked by the Naval Sea Systems Command (1,2) to evaluate two prototype dry diving dresses manufactured by Viking Technical Rubber, Inc., for use with the MK 12 Surface Supplied Diving System (SSDS). The manufacturer proposed the following advantages over the existing MK 12 diving dress (and we quote):

(1) Improved diver protection in contaminated water diving

(2) Ability to decontaminate after a dive mission

(3) Less weight required to obtain the same buoyancy mode because the suit material is non-compressible

(4) The suit would be versatile for cold and warm diving

(5) Suits are easily repaired

(6) Abrasion resistance is significantly improved

(7) Limited storage room is required as the suits can and should be stored rolled up

(8) Easier dressing and undressing

(9) The rubber outer coating can be blended of synthetic and natural rubber for improved resistance against certain hazardous materials

Some of the manufacturer's expectations were considered during testing.

In order to conduct a meaningful evaluation, the Viking dresses were subjected to a side-by-side comparison with the standard MK 12 dress. This side-by-side evaluation was done to ensure that all test team members were thoroughly familiar and current on both types of diving dresses. Further, the test was designed to place emphasis on the divers' ratings and comments which could be formulated on the basis of their test experience. Each of the three dresses (Viking heavy duty, Viking lightweight, and standard MK 12) was worn with woolen or Thinsulate undergarments by divers doing a wide variety of tasks. The primary purpose of this test and evaluation was to assess various human factors aspects of the Viking diving dresses, including but not limited to the fit, comfort, durability and interface with the standard MK 12 helmet. Testing of the suits in consideration for Approved for Navy Use designation was conducted in accordance with Test Plan No. 82-56 (3) at NEDU in the summer of 1983.

METHOD

SUBJECTS

Seven male U.S. Navy divers in good health volunteered to serve as Diver-Subjects. All subjects were experienced in diving the U.S. Navy's MK-12 Surface-Supplied Diving System. Table 1 presents relevant diver characteristics. Divers A, B, C, D served as test subjects throughout; Divers E, F, G served as subjects during the pier dives only. As can be seen in the table, the divers chosen displayed a wide range of physical measurements. However, relevant physical characteristics of the divers who served as test subjects were compared to U.S. Navy male diver norms published by Beatty and Berghage (4). All mean characteristics of the test subjects fell within the 35th to 90th percentiles of U.S. Navy divers with the exception of wrist circumference, which was at the 97th percentile. Thus, with the exception of larger wrists, these test divers were physically representative of the population which would be using the evaluated equipment.

DIVING SUITS

Viking Lightweight Dry Diving Suit

This suit, pictured in Figure 1, will hereafter be referred to as the "Viking Red" suit because of its color. Designed to be used in conjunction with the present MK 12 outergarment, the suit was constructed of a lightweight rubber with an integral, soft, lightweight boot. The suit incorporated a yoke to mate with the MK 12 helmet breech ring and a shoulder zip entry. The cuffs were made of a thin latex rubber. Because of its intended use with the MK 12 outergarment, the suit did not have weight pockets or shoulder tabs. The manufacturer furnished suits in Viking sizes 1, 2 and 3 for testing.

Viking Heavyweight Dry Diving Suit

This suit, referred to as the "Viking blue" suit, is pictured in Figure 2 and was designed by the manufacturer to totally replace the MK 12 dry suit and outergarment. Thus, the suit incorporated calf, thigh and hip weight pockets, shoulder tabs and steel-toed integral boots. It was constructed of a heavy rubber with a yoke to mate with the MK 12 breech ring. A shoulder zip entry was provided. The cuffs of this suit were fabricated from a heavier latex rubber than used in the Viking red suit. The blue suits were provided in Viking sizes 1 and 3 for evaluation.

Standard MK 12 Dry Diving Suit

Standard suits of sizes 2, 3 and 4 were available for the test. This suit system is described in reference (5).

PROCEDURES

This testing was conducted in two phases. The first phase, consisting of range of motion studies, was conducted in the NEDU test pool in 55°F water.

TABLE 1. Relevant Diver Characteristics

Diver	Height (cm)	Weight (kg)	Body Surface (m^2)	Neck	Chest	Abdomen	Upper Arm	Forearm	Wrist	Calf	Ankle	Total Arm Length (cm)	Foot Length (cm)
				←circumference (cm)→									
A	201.5	91.4	2.4	40	104	91	32	29	19	38	24	79	28
B	180.3	83.9	2.0	40	109	95	35	30	19	37	24	73	28
C	172.7	72.6	1.9	37	100	83	30	29	19	39	23	74	26
D	172.7	82.6	2.0	41	103	83	37	30	19	39	24	70	26
E	182.9	88.5	2.1	40	112	95	34	31	19	40	23	75	28
F	177.8	85.0	2.0	39	103	94	33	29	20	40	26	73	26
G	175.3	70.3	1.8	37	102	86	28	27	17	33	21	73	25
$\bar{X}$	180.5	82.0	2.0	39.1	104.7	89.6	32.7	29.3	18.9	38.0	23.6	73.9	26.7
SD	10.0	7.8	.2	1.6	4.2	5.5	3.0	1.3	0.9	2.4	1.5	2.7	1.3

Lightweight (Red)
Coveralls.

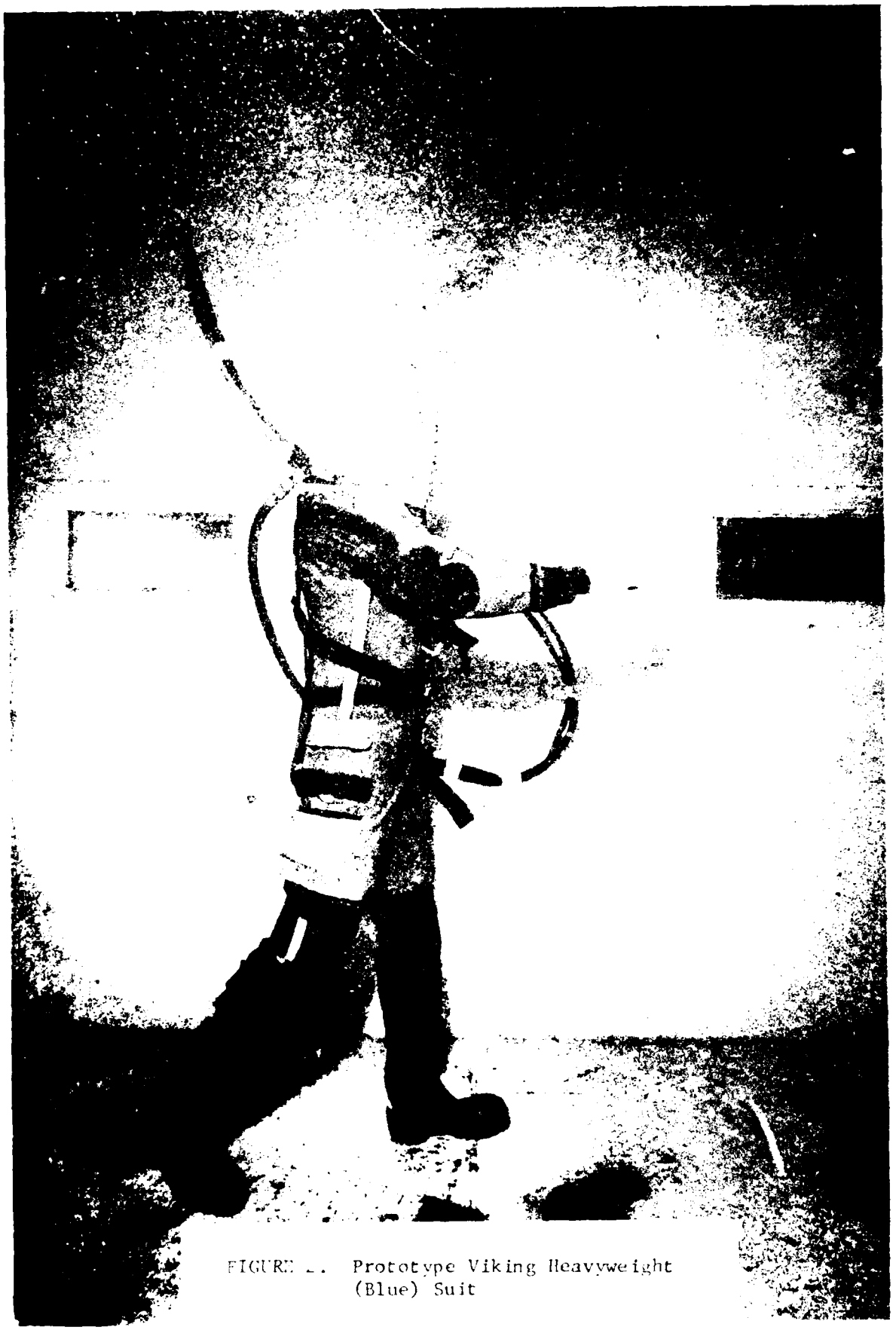


FIGURE . . Prototype Viking Heavyweight (Blue) Suit

The second phase addressed the suits' durability and maneuverability in different bottom types, and was conducted off of the pier in Alligator Bayou at NCSC, Panama City, FL. Before the dive series each volunteer received a thorough briefing on the study. All divers were trained in the Range of Motion Study (RMS) movements and each diver's anthropometric measurements recorded.

Test Pool Dives

The order of divers and the dry suit/undergarment combinations they used are presented in Table 2. Each diver dove the Mark 12 SSDS in each of the six possible combinations of underwear (woolen, Thinsulate) and dry suit (current Mark 12, Viking red suit, Viking blue suit). The woolen underwear was manufactured by Sears, Roebuck and Co.; the Thinsulate underwear was M-400 manufactured by Diving Unlimited International, Inc., San Diego, CA. Twenty-four formal data collection dives were accomplished. During this series of dives each diver was dressed fully in the designated suit, including all calf and thigh weights, harness, boots and umbilical. Before diving started, each subject was allowed to try on all sizes of suits and undergarments. Each diver selected a combination that was most comfortable to him. This fitting approach was used because it mimics the real world situation. The diver was hatted, given communication and leak checks, and proceeded down a ladder to the bottom of the pool. After assuming position on a spot marked on the pool bottom, four of the divers were photographed in all RMS movements. The nine RMS movements are illustrated in Figure 3. Each diver assumed the maximum range of motion in each movement, and held that position for one full second during which the photographer took his picture. The diver was allowed to grip a wall padeye for balance provided no leverage was exerted to influence the maximum range of motion. After completing the RMS, the diver's calf and thigh weights were removed individually by a standby diver until neutral buoyancy was achieved. The amount of weight removed was recorded. A controlled buoyant ascent to the surface was then conducted by having the diver close the helmet exhaust valve and pull on the helmet's chin button until he reached the surface. The diver then descended to the pool bottom, and used the helmet chin button to place himself in a feet-up position while grasping onto a deck payeye with his hands. The diver then let go and attempted to right himself and regain control of his buoyancy. The buoyancy exercise was conducted to determine whether the diver could (a) adjust and control his buoyancy as an aid in performing underwater work in a safe manner in a variety of conditions, and (b) regain and maintain buoyancy control in an emergency situation (e.g. "blowup"). After returning to the pool bottom each diver walked four lengths of the pool. He then inflated the suit, rose to the surface, and swam one and a half lengths of the pool on the surface. After this maneuver, the diver climbed the ladder, exited the pool, was undressed, and filled out a human factors questionnaire (Appendix 1).

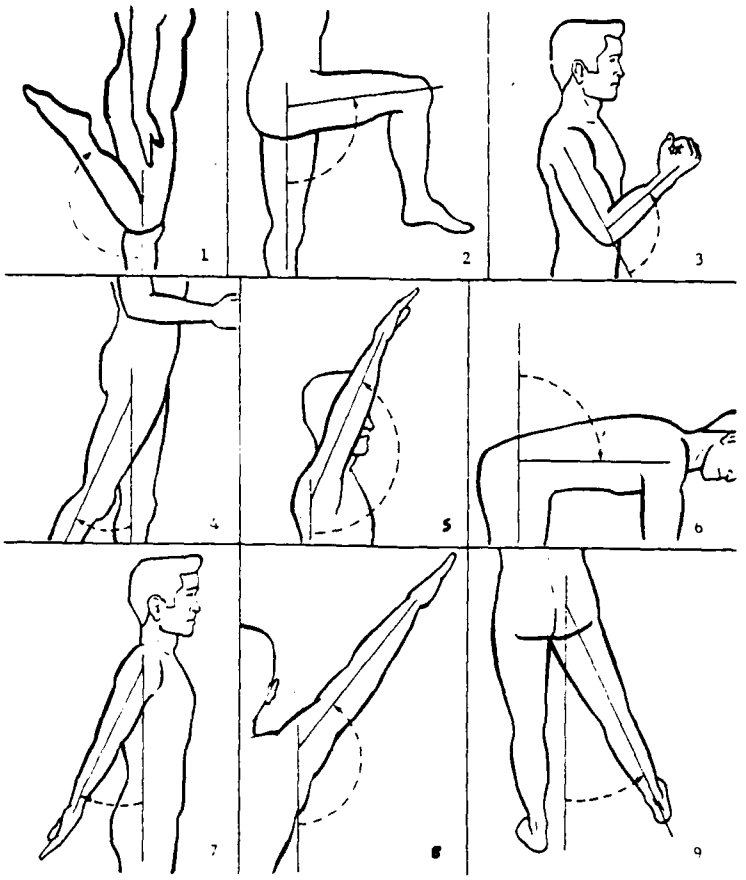
Pier Side Dives.

Pier-side dives were conducted from 23 to 25 August 1983 in Alligator Bayou, NCSC, Panama City, FL. Water depths ranged from 15 FSW to 25 FSW (7.6 meters) with water temperatures approximately 85°F (29.4°C). Air temperatures ranged from 82°F to 96°F (27.8°C to 35.6°C) and the duration of dives ranged between 8 and 15 minutes.

TABLE 2. Order of Divers and Their Dry Suit/Undergarment Configuration During Test Pool Evaluations.

DAY 1					DAY 2					DAY 3				
Dive	Diver	Suit Type	Suit Size	Under-Garment	Dive	Diver	Suit Type	Suit Size	Under-Garment	Dive	Diver	Suit Type	Suit Size	Under-Garment
1	C	MK-12	2	U	9	D	MK-12	2	U	17	D	VK-B	3	T
2	A	MK-12	3	U	10	C	MK-12	2	T	18	C	VK-B	1	T
3	B	MK-12	4	U	11	A	MK-12	3	T	19	A	VK-R	3	T
4	A	VK-R	3	U	12	D	VK-B	3	U	20	B	VK-R	3	T
5	C	VK-B	1	U	13	B	VK-B	3	U	21	D	VK-R	1	T
6	B	VK-R	2	U	14	D	VK-R	1	U	22	C	VK-R	1	T
7	A	VK-B	3	U	15	B	MK-12	3	T	23	A	VK-B	3	T
8	C	VK-R	1	U	16	D	MK-12	2	T	24	B	VK-B	3	T

KEY: Mark 12: MK-12
Viking Red: VK-R
Viking Blue: VK-B
Thermal Underwear: U
Thinsulate: T



1. Knee flexion: From an upright standing position, the knee is flexed fully so that it is drawn as close to the buttock as possible.

2. Hip flexion: The right knee is drawn toward the chest as far as possible.

3. Elbow flexion: The elbow is flexed, bringing the wrist toward the shoulder.

4. Hip flexion: The leg is kept straight and rotated to the rear as far as possible.

5. Shoulder joint flexion: With the elbow locked and palm down, the arm is raised as far as possible without rotating the shoulder joint.

6. Trunk flexion: From a standing position, the trunk is bent forward at the waist. The feet are together and the knees are locked.

7. Shoulder joint extension: While standing upright, the arm is raised to the rear with the elbow locked and palm facing back.

8. Shoulder joint abduction: The arm is raised out to the side. The palm is down and the elbow is locked. No rotation of the shoulder joint is allowed.

9. Hip abduction: The leg is abducted while standing in an upright position. The trunk is held vertical and the knee is locked.

Figure 3. Range-of-Motion Movements

All divers wore the woolen underwear under the Viking blue and Viking red suits during these dives. The Thinsulate undergarments were not worn due to the hot, humid testing conditions which were present. Air to the diver was supplied at 50 psig overbottom by a Quincy Model W5 20 compressor, Colt Industries, Quincy, Illinois. Thirteen dives by seven divers were completed during two days. The first day all divers wore the Viking blue suit, and the second day all divers wore the Viking red suit. Divers were dressed in a fashion similar to the test pool dives, with the exception that additional weights were inserted into the hip pockets. The time to dress a diver was determined by starting a stopwatch when the diver was clad in the undergarments and holding the dry suit in front of him. The watch was stopped when the diver was completely dressed by two tenders in the dry suit with coveralls and boots (if applicable), harness, and all weights inserted.

After the diver was hatted and a communication check conducted, the diver descended a ladder to the bottom of the pier. He then performed the RMS as outlined previously. The diver then proceeded down an incline to a set of horizontally and vertically aligned pilings. These pilings were encrusted with barnacles and shells. When wearing the Viking blue suit the diver rubbed various aspects of the suit against the pilings to determine abrasion resistance, and shimmied up and down a twelve-foot (3.7 meter) piling using his arms and legs. Divers wearing either suit then proceeded up and over the horizontal pilings and did an umbilical stretch for another 80 ft (approximately 25m). The divers noted traction and support provided by the boots as the channel bottom changed from sand to mud. Various positions and body attitudes were assumed by the divers to determine flexibility, fit and protection. Divers then returned to the pier, climbed the ladder, and were undressed. Following each dive the diver filled out a human factors questionnaire (Appendix II).

RESULTS AND DISCUSSION

DESIGN OF SUITS

The design of the Viking red (lightweight) suit was less than adequate in several areas. The soft, integral lightweight boots did not provide sufficient firmness in the boot sole to support the diver's weight. This was particularly noticeable when the diver ascended and descended the pier ladder. The resultant pressure on the diver's foot became uncomfortable to painful as the sole of the boot did not support the foot. Thus, the diver's toes and heel sagged over the rungs which concentrated the weight of the diver in one small area. It was possible to wear a MK 12 boot over the lightweight integral booties, but the MK 12 boot needed to be at least 2 sizes larger than the Viking red suit size. This combination did provide adequate foot support. There was also some concern by the divers over the lack of toe protection afforded by the soft boots.

The light latex rubber cuffs on the red suit ballooned to a diameter greater than 16 inches during controlled ascents with two divers, indicating the cuff had insufficient thickness and strength to support the internal pressures generated in the suit. In addition, at a depth of 15 feet in the

Test Pool, several divers experienced leg and foot squeezes causing discomfort when wearing this lightweight suit with woolen underwear. This problem was offset when the divers wore Thinsulate undergarments with the suit.

An examination of the Viking blue (heavyweight suit) revealed that the velcro tabs provided on the shoulder were positioned too far forward to accommodate the buckles on the MK 12 mixed gas harness. The tabs should be repositioned 30-50 centimeters towards the rear on the shoulder. The tabs also need to be more securely fastened to the suit. All of the shoulder tabs had been torn from the suits by the end of the evaluation; however, no leaks at these points were noticed. All of the weight pockets on the Viking blue suit were too narrow to accommodate the standard MK 12 weights. During this evaluation the pockets were modified by removing one row of stitching to allow the use of weights. The problem was of such magnitude that pliers and vise-grips were used to remove weights from pockets after a dive. The boots integrated with the blue suit provided good support on the ladder and the hard toe allowed sufficient foot protection. When the suit was subjected to rough use against pilings and other underwater hazards, it resisted abrasions and tearing admirably. No tears or rips were noted in any suits except for ballooning around the Red suit cuffs. All zippers worked well.

FIT OF SUITS

Both the Viking red and Viking blue suits were sized much larger than the corresponding size of current MK 12 dry suits. A Viking suit size #1 corresponded to a MK 12 suit size #2, a Viking #2 was comparable to a MK 12 #3, and a Viking #3 was cut larger than a MK 12 #4. In general, the trunk portion (i.e. crotch to neck) of the Viking suits fit relatively well, but the arms and legs were consistently cut too long for the diver-subjects. Further, the Viking blue suits used in the test appeared to have different sized suit torsos (e.g. size "2") matched to suit boots (e.g. size "1"). This of course resulted in cramped foot space for some of the divers. The Viking red suit slid easily when worn over Thinsulate underwear, easily fit under the standard MK 12 coveralls, and was perceived by the divers to allow optimum flexibility.

DRESSING/UNDRESSING

The Viking red suit was easy to put on and take off due to the lightweight, flexible rubber used in construction. However, when assisted by tenders, there was no significant difference in the average time it took to fully dress a Viking blue-suited diver ($\bar{X}$ = 4:45 min) or a Viking red-suited diver ($\bar{X}$ = 4:35 min) over a period of 12 dives.

BUOYANCY CHARACTERISTICS

The buoyant characteristics of each suit when worn by a diver in a normal configuration (i.e. with helmet, harness, etc.) were inferred from the amount of weight required for removal to reach a neutrally buoyant state (i.e. diver could be lifted gently off of test pool bottom at 15 feet and would remain motionless). This data is presented in Table 3 for each of the suit-underwear combinations. The most buoyant combinations involved the wearing of the

Thinsulate underwear, regardless of the outer suit. However, the Viking blue and the MK 12 suits exhibited similar buoyancy characteristics with the Thinsulate undergarments. With the wearing of standard U.S. Navy underwear, the Viking blue suit was the most buoyant, the MK 12 suit the least buoyant.

The various suits sans outergarments were also weighed, dry, without weights. The Viking red suit (size #2) weighed ~9.5 lbs; the Viking blue suit (size #3) weighed about 17 lbs; and the MK 12 suit weighed ~11.5 lbs. The outer garment used with the Viking red suit and the MK 12 suit weighed ~4 lbs, and the jocking harness weighed ~3 lbs.

All divers were able to perform controlled ascents, descents, and inflated suit surface swims in each suit/underwear combination. Further, each diver was able to right himself and regain neutral buoyancy after letting go of the padeye and before reaching the surface of the pool. No significant differences in buoyancy control during these exercises were noted as a function of suit type.

RANGE OF MOTION

The results of the scoring of 216 photographs (6 suit combinations x 9 positions x 4 subjects) are presented in Table 4 in the form of average degrees of movement for each position and suit/undergarment combination.

When wearing Thinsulate undergarments, the greatest range of motion was documented in the Viking red and blue suits, which overall were similar to each other in the range of motion permitted the divers. The MK 12/Thinsulate combination was more restrictive than the Viking suits worn with Thinsulate. Similar range of motion movements were found for the Viking blue and MK 12 suits when worn over the standard woolen underwear; the Viking red suit was the most restrictive suit when worn with woolen underwear. Only in the hip abduction movement did both Viking suits permit greater range of motion than the MK 12 suit; however, these suits were substantially (16-17°) more restrictive than the MK 12 in the hip extension movement. The Viking blue suit allowed marginally (2-6°) greater range of motion in 5 of 9 movements compared to the MK 12 suit.

In summary, the greatest range of motion was exhibited by divers in the MK 12/woolen and Viking blue/Thinsulate combinations; the most restrictive were the MK 12/Thinsulate and Viking red/woolen combinations.

DIVER RESPONSE TO QUESTIONNAIRES

The responses of the divers to the post-dive questionnaires were tabulated and are presented in Table 5. Both of the prototype Viking suits were rated as "average" to "easy" in putting on and taking off regardless of whether Thinsulate or woolen underwear was worn. In this category the prototype suits were rated better than the MK 12 suit, which was rated "marginal" to "average" when worn with Thinsulate.

TABLE 3. Amount of Weight in lbs (kg) Removed From Each Diver/Suit/Undergarment Configuation to Reach a Neutrally Buoyant State.

Diver	MK 12-U	MK 12-T	Viking B-U	Viking B-T	Viking R-U	Viking R-T
A	60 (27)	12 (5)	36 (16)	16 (7)	24 (11)	24 (11)
B	52 (24)	20 (9)	16 (7)	12 (5)	44 (20)	20 (9)
C	60 (27)	20 (9)	32 (15)	16 (7)	36 (16)	12 (5)
D	32 (15)	24 (11)	36 (16)	30 (14)	60 (27)	38 (17)
$\bar{X}$	51 (23)	19 (9)	30 (14)	18 (8)	41 (19)	24 (11)
SD	13 (6)	5 (2)	10 (5)	8 (4)	15 (7)	11 (5)

TABLE 4. Average range of motion movements (in degrees) from four divers in each of the nine positions for each outer suit/undergarment combination. (VB: Viking blue suit; VR: Viking red suit, MK 12).

		THINSULATE			WOOLEN		
	Movement	MK 12	VR	VB	MK 12	VR	VB
1.	Knee flexion	96	100	90	94	96	96
2.	Hip flexion	60	70	70	73	68	78
3.	Elbow flexion	106	112	113	114	112	112
4.	Hip extension	28	34	27	40	24	23
5.	Shoulder joint extension	148	149	155	153	149	155
6.	Trunk flexion	77	86	85	87	81	90
7.	Shoulder joint exteension	35	33	47	51	48	46
8.	Shoulder joint abduction	133	134	140	144	139	144
9.	Hip abduction	25	29	31	27	34	33
		708	747	758	783	751	777

TABLE 5. Responses of divers to questionnaire completed post-dive. (U=Woolen underwear; T=Thinsulate).

	MK 12		V-B		V-R	
	U	T	U	T	U	T
Ease of donning:						
Easy	1	-	4	1	6	2
Average	3	2	5	3	3	2
Marginal	-	2	1	-	1	-
Difficult	-	-	-	-	-	-
Ease of doffing:						
Easy	1	-	4	1	6	2
Average	3	1	6	3	3	2
Marginal	-	3	-	-	1	-
Difficult	-	-	-	-	-	-
Ability to dress						
Unassisted?						
YES	-	1	1	1	1	1
NO	4	3	4	3	2	3
Design of suit:						
Too long	1	1	7	2	3	2
Too short	1	1	-	-	-	-
Just right	2	2	3	2	7	2

	MK 12	V-B	V-R
Boot soles thick enough?			
YES	8	14	11
NO	0	0	3

All suits were judged to be difficult to don without assistance. As can be seen from Table 5, the design of the Viking blue suit was judged to be too long by the majority of divers who wore this prototype with woolen underwear. While most divers rated the Viking red suit as "just right", there were several divers who also judged the cut of this suit as "too long".

Both the MK 12 boots and the Viking blue stiff boot provide adequate boot support; the soft boot with the Viking red suit was judged indequate by three of the divers. Most divers felt the prototype suits provided good traction. Only one toe injury (Viking red suit) was reported; however half of the divers reported apprehension concerning the lack of protection afforded by the integral boot with the Viking red suit. The use of a molded, semi-firm integrated boot such as found in the Viking red suits places artificial restrictions on the comfort and use of the suit by divers with various foot sizes. A soft, flexible, molded integrated boot used in conjunction with a hard-soled overboot (e.g. present MK 12 system) provides superior comfort, support, traction and flexibility in sizing.

Finally, both of the prototype suits were relatively free of leaks compared to the MK 12 suit. Buoyancy control problems with the Viking suits centered on the divers being too buoyant with the Viking blue (n=4); that is, there was not enough weight available using all the weights in the suit to keep the diver on the bottom when using this suit. This can be corrected by adding additional weight.

Within the limited parameters of this testing, both of the prototype Viking suits performed well enough to warrant further, more extensive testing. After correcting the discrepancies previously noted, additional studies on durability, thermal protection, leak integrity in contaminated water, and fit would be appropriate. Due to its integrated design (i.e. no outergarment required), the Viking blue suit was judged to possess the most merit for additional testing.

VIKING REPORT

PART 2

1. INTRODUCTION

Following the completion of testing of the two prototype Viking lightweight (red) and heavywe ght (blue) suits the deficiencies identified in those suits were discussed with Viking Technical Rubber, Inc. A revised, first article suit, constructed of the same heavy duty material as the Viking Blue Suit, was purchased by NEDU. This suit incorporated changes recommended by NEDU with the exception of fit which had been previously described by some subjects as too long in the body, arms and legs. The fit of the suits was discussed with Mr. Jorn Stubal, president of Viking Technical Rubber. He advised that since suit material is not elastic the cut of the suit has to be generous to allow the diver a good range of motion. The extra slack in the crotch is taken up when the diver enters the water and when he adjusts his jocking strap. This explanation was accepted. The sizing of the boots integrated with the blue suit was felt to be adequate; i.e. the boots fitted to each suit size were large enough to accommodate all but unusually large-footed divers of a certain physique. For these rare individuals the manufacturer can produce special suits.

The primary purpose of the testing for Part 2 of this report was to determine if the changes made by Viking were acceptable and if this first article suit could be recommended for the designation Approved for Navy Use (ANU).

2. THE FIRST ARTICLE SUIT

The first article suit is constructed of the same 1500 gram per square meter heavy duty material as the Viking Blue prototype. The cuffs are heavy duty latex to prevent ballooning and the integral boots are of robust construction with heavy duty soles and steel toe protection. In common with both Blue and Red suits and indeed the existing MK 12 suit, thermal protection of the diver depends upon the type of underwear worn. The suit is shown in Figure 4.

The following changes to the prototypes, recommended by NEDU, were incorporated:

a. Enlarged weight pouches to accept standard MK 12 hip, thigh and calf weights.

b. The weight pockets are laced to eyes on the suits for easy removal to allow decontamination of the suit after diving in contaminated water.

c. The shoulder tabs are repositioned 50 centimeters to the rear, reinforced and reversed so that the hinge rather than the opening of the tab will take the weight of the harness.

[illegible] Dry Suit
[illegible]

3. PROCEDURE

The suit was visually inspected to confirm that the recommended changes had been made.

Six male U.S. Navy divers and one male Royal Navy diver, all in good health and experienced in MK 12 diving procedures were then dressed in the first article suit and carried out a dive in the NEDU test pool. During his dive, each subject carried out the same range of motion studies detailed in Part 1 to confirm that the new shoulder tabs were effective and that the weight pouch arrangement did not restrict him.

4. RESULTS

All the NEDU recommended modifications were satisfactorily incorporated in the first article suit. The standard MK 12 weights were easy to insert and remove from the weight pouches. The weight pouches were fitted in the correct positions and did not restrict the divers' movements. They were simple to remove for decontamination.

The shoulder tabs were correctly positioned and functioned satisfactorily.

5. CONCLUSIONS

The first article Viking heavy duty MK 12 diving dress is comfortable, robust, easy to don and dress, and would satisfactorily meet the requirements of a MK 12 diver providing suitable insulating clothes are worn underneath. The integral boots were comfortable and appear to give good protection to a working diver. There is no provision for heating a diver breathing oxygen/helium mixtures, but nor is there with the current MK 12 dress.

REFERENCES

1. Naval Sea Systems Command ltr 00C/WRB 13485 Serial 285 to Viking Technical Rubber, Inc. Subject: Evaluation of Viking Prototype Diving Dresses, 11 March 1982.

2. Naval Sea Systems Command message NAVSEA 00C-3 to Commanding Officer, Navy Experimental Diving Unit. Subject: Request for T&E of Viking Prototype Diving Dresses For Use With MK 12 SSDS, 11 March 1982.

3. Navy Experimental Diving Unit Test Plan No. 82-56. Evaluation of Viking Dry Suit For Suitability of Use With MK 12 SSDS. AUTHOR: E. H. Pahl, April 1983.

4. Navy Experimental Diving Unit Report 10-72, Diver Anthropometrics, by H. T. Beatty and T. E. Berghage, 1 June 1972.

5. U.S. Navy Diving Manual, NAVSEA 0994-LP-001-9010, Vol. 1, Change 2, 1978, Navy Department, Washington, D.C.

APPENDIX I

NEDU TEST PLAN NO. 82-56
Evaluation of Viking MK 12 SSDS Diving Dress

Test Pool Dives

1. Name: _____

   Date: _____

2. Suit Worn: (circle) Mark 12 Viking Red Viking Blue

3. Underwear Worn: (circle) Woolen Thinsulate Other

4. Rate ease of donning the suit: (circle)

   Easy Average Marginal Difficult

5. Rate ease of removing the suit: (circle)

   Easy Average Marginal Difficult

6. Can you dress yourself in this suit? YES___ NO___

   If NO, why not? _____

   _____

7. Rate the fit of the suit around the:

	Too loose	Just right	Too tight
Feet	_____	_____	_____
Calfs	_____	_____	_____
Thighs	_____	_____	_____
Hips	_____	_____	_____
Waist	_____	_____	_____
Chest	_____	_____	_____
Arms	_____	_____	_____
Wrists	_____	_____	_____

8. Is the present design of the suit:

   a. Too long ____
   b. Too short ____
   c. Just right ____

   Explain a. or b. _____

   _____

   _____

9. Were soles of boots thick enough to enable you to walk on the bottom comfortably? YES___ NO___

If NO, explain:_____

_____

10. Was there enough support around the boot to easily enter and exit the water? YES___ NO___

If NO, explain:_____

_____

11. While wearing this suit/boot configuration, did you:

a. have good traction while walking? YES___ NO___
b. injure your toes? YES___ NO___
c. feel any apprehension about wearing a boot with no toe protection? YES___ NO___
d. start to get cold? YES___ NO___
If YES, in what area of body?_____
e. notice any leaks? YES___ NO___
If YES, where?_____
f. have any problems with buoyancy control? YES___ NO___
If YES, explain:_____

_____

12. Your comments, suggestions, and observations:

_____

_____

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APPENDIX II

NEDU TEST PLAN NO. 82-56
Evaluation of Viking MK 12 SSDS Diving Dress

Pier Dives

1. Name: _____ Suit #_____

   Date: _____

2. Suit Worn: (circle) Mark 12 Viking Red Viking Blue

3. Underwear Worn: (circle) Woolen Thinsulate Other_____ (Specify)

4. Rate ease of donning the suit: (circle)

   Easy Average Marginal Difficult

5. Rate ease of removing the suit: (circle)

   Easy Average Marginal Difficult

6. Did you incur suit squeeze on the bottom? YES ____ NO ____

7. Rate the fit of the suit in the water around the:

	Too loose	Just right	Too tight
Feet	_____	_____	_____
Calfs	_____	_____	_____
Thighs	_____	_____	_____
Hips	_____	_____	_____
Waist	_____	_____	_____
Chest	_____	_____	_____
Arms	_____	_____	_____
Wrists	_____	_____	_____

8. Is the present design of the suit:

   a. Too long ____
   b. Too short ____
   c. Just right ____
   Explain a. or b._____

9. Were soles of boots thick enough to enable you to walk on the bottom comfortably? YES___ NO___

If NO, explain:_____

_____

10. Was there enough support around the boot to easily enter and exit the water? YES___ NO___

If NO, explain:_____

_____

11. While wearing this suit/boot configuration, did you:

a. have good traction while walking? YES___ NO___
b. injure your toes? YES___ NO___
c. feel any apprehension about wearing a boot with no toe protection? YES___ NO___
d. notice any leaks? YES___ NO___
If YES, where?_____
e. have any problems with buoyancy control? YES___ NO___
If YES, explain:_____

_____

12. Your comments, suggestions, and observations:

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