Diving in Contaminated Water, 3rd Edition: Chemical and Biological Tests of Viking Dry Suits and Accessories

Trelleborg Viking , Inc.
170 West Rd., Suite 1
Portsmoutth, NH 03801
Toll Free: 800-344-4458
Tel. 603-436-1236
FAX 603-436-1392
email: tvi.usa@trelleborg.com
http://www.trelleborg.com/protective/

Boston Fire Department: Fighting a nine-alarm pier fire from below.

Rescue diver exiting the water in a PRO 1000 Turbo Dry Suit wearing a Divator Mask equipped with the Gill™ surface breathing valve.

New York Police Department dive team during the recovery of evidene from TWA Flight 800

Table of Contents

Glossary of Terms

Certain signal words are used in this booklet to alert you to potentially hazardous or life threatening risks you may encounter in conducting dives in contaminated water. These signal words are as follows:

⚠ CAUTION	**Identifies hazards or unsafe practices which could result in minor personal injury or property damage.**
⚠ WARNING	**Identifies hazards or unsafe practices which could result in severe personal injury or death.**
⚠ DANGER	**Identifies immediate hazards which will result in severe personal injury or death.**

In addition, you should be familiar with the following terms to properly interpret the data presented in this booklet:

IDLH: Immediately dangerous to life and health. Environments that pose an immediate threat to life or health.

PEL: Personal exposure limit.

TLV: Threshold limit value. Specifies the ceiling limit of a toxic substance an "average" person in reasonable health may be exposed to repeatedly on a daily basis with no ill effects.These benchmarks are set and revised on an annual basis by the American Conference of Governmental Industrial Hygienists.

Foreword

There is a definite need within the professional diving community to develop minimum performance requirements for equipment used to protect divers required to enter both chemically and biologically contaminated water.

Trelleborg Protective Products' diving department, Viking Diving, has undertaken an effort to develop a test matrix to quantify the performance of Viking dry diving suits for use in these environments. In lieu of defined acceptable standards within the diving community, we have taken the National Fire Protection Association (NFPA) standards for chemical protective clothing and modified it to test dry diving suits. The NFPA standard provides the benchmark performance criteria to approve suits for first responders entering unknown hazardous chemical environments.

Our goal in this report is to provide you with the information on Viking drysuits needed to make informed decisions to help ensure protection for the diver in contaminated water diving environments. In certain circumstances, your best decision may be not to dive.

⚠ WARNING	**When possible, diving in contaminated water should be avoided. If you are not trained for this type of diving operation, do not attempt it.**

The information in this report does not provide all the information or training needed to plan a dive operation. The diving supervisor and the diver must take responsibility for the safety of the diver based on a risk assessment of the actual conditions at the dive site.

The data contained in this report has been developed from tests conducted under controlled laboratory conditions, not under actual diving environments. The user must determine the applicability of these test results for the actual exposure anticipated.

These test results are specific only for Viking Diving materials and components. Comparisons to the performance of other manufacturers' diving equipment cannot be made.

Test Philosophy

The concept Trelleborg Viking used to develop this test format was modeled after the National Fire Protection Association (NFPA) 1991/2000 edition of the Standard for Vapor Protective Suits for Hazardous Chemical Emergencies. Some of the test methods and logic came from a study financed by the U.S. Fire Administration for Protective Clothing and Equipment Needs of Emergency Responders in Urban Search and Rescue Missions.

Testing was performed against new (unused) suit materials, gloves and critical interfaces: i.e. seams, latex, and zippers. If you are using equipment that is used or has been previously exposed to other chemicals, you cannot expect the same level of protection.

⚠ DANGER	**The test data in this booklet was based on new, unused equipment. Diving suits and equipment that have been abraded through use, or previously exposed to other chemicals or sunlight, may fail unexpectedly without warning, despite exposure that is less than or equal to those listed in this booklet. This may lead to severe personal injury or death.**

The chemicals chosen in the testing came from the American Society for Testing and Materials (ASTM) F1001, Standard Guide for the Selection of Chemicals to Evaluate Protective Clothing Materials, 1989. The ASTM list of chemicals may not include the hazardous chemicals you would expect to most frequently encounter, but rather the most aggressive chemicals within a given chemical class. From this database, you can assume a less aggressive chemical (i.e. for example, those with a larger molecular structure) will take a longer time to permeate the material.

We also included Petroleum, Oil and Lubricants (POLs) in our testing.

The permeation tests were performed using the European Norm (EN) 369 and 374 but at the sensitivity level of 0.1µg/cm^2/min. According to ASTM F739, the test duration was until breakthrough, or a maximum of three hous.

- Chemicals not soluble in water were tested at 100% concentration.
- Water-soluble chemicals were diluted in water to a maximum 10% concentration.
- At a lower level of solubility the challenged chemical was saturated in water. *

To test against biological hazards, suit material, seams, and latex were tested to ASTM F1671 which is a viral penetration test.

Our published test results are only applicable to Trelleborg Viking manufactured rubber and latex. Chemical permeation tests and biological viral penetration tests were performed on seams against both chemical and biological virus. Zippers were penetration tested against the standard battery of chemicals.

This information is intended to provide chemical resistance data on Viking drysuits never before available. This data will improve your ability to plan successful diving operations.

The chemical permeation tests were performed at Trelleborg Industri AB chemical test facility, Sweden and Texas Research Institute (TRI), USA. The biological tests were performed by TRI. The zipper tests were conducted at the Force, Denmark.

*Carbon Disulfide and Dichloromethane are slightly soluble chemicals but were tested with 100% concentration.

Training exercise with Los Angeles Sheriff's Department Special Enforcement Bureau Dive Team. (Photo © S. Barsky. All rights reserved.)

Table #1: Chemical Guide

We have tested against the ASTM F1001 Standard Guide for Chemicals to Evaluate Protective Clothing Materials, 1989. The list of chemicals may not include the hazardous chemicals you would expect to most frequently encounter, but rather the most aggressive chemical within a given chemical class. Petroleum, Oil and Lubricants (POL's) were also tested.

Chemical	Chemical Class	Examples
Acetone	Ketones	Methyl isobutyl ketone
Acetonitrile	Nitriles Imides Amides	Acetamide Succinimide
Ammonia Solution	Ammonia dissolved in water at different concentrations.	
Carbon Disulfide	Sulfur Compound	
Dichloromethane	Chlorinated Hydrocarbons	Carbon Tetrachloride
Diethylamine	Amines	Ethyleneimine Trimethylamine
Dimethylformamide	Amides	Formamide Diethylformamide
Ethyl acetate	Esters	Butyl acetate Amyl acetate Methyl acetate
Hexane	Aliphatic	Heptane Octane
Methanol	Alcohols	Ethanol Propanol Butanol
Sulfuric Acid	Acids, Inorganic	Nitric Acid Hydrochloric Acid Phosphoric Acid
Tetrachloroethylene	Chlorinated Hydrocarbons	Trichloroethylene Perchloroethylene
Tetrahydrofuran	Ethers	Diethyl Ether "Ether"
Toluene	Aromatic Hydrocarbons	Benzene Xylene

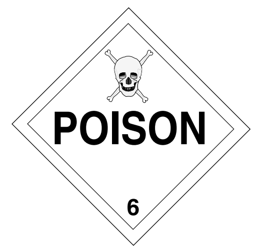
Description of Permeation Test Methods

(EN 369, EN 374, ASTM F739)

Testing was conducted on 1000g/m^2 Pro material, 1500g/m^2 Heavy Duty material, gloves, zippers, and latex.

A material sample disc is placed in a test cell dividing the cell into two separate chambers. The chemical is introduced into one chamber while nitrogen gas, air, or water in the other chamber collects the chemical permeating the material sample. The time at which the chemical is first detected and the rate at which chemical permeates is reported. The tests were conducted for all chemicals listed in ASTM F1001.

The table on the next page indicates the permeation through the material in minutes at a rate of 0.1µg/cm^2 /min.



Suit Material and Latex

Notes on Table #2, page 8:

Classification:
NT = Not Tested
Note:
Oil No. 1 (ASTM Oil No. 1) is a paraffinic oil. (lubrication oil)
Oil IRM 903 (ASTM Oil No. 3) is an aromatatic oil. (lubrication oil)
Liquid B is a liquid to simulate low octane gasoline. (70/30 isooctane/toluene)
Liquid C is a liquid to simulate high-octane gasoline. (50/50 isooctane/toluene)
Liquid F is a liquid to simulate diesel fuel and light heating oil. (80/20 paraffin oil/methylnaphalene)

The permeation tests were performed using the European Norm (EN) 369 and 374 but at the sensitivity level of 0.1 µg/cm^2/min. according to ASTM F739. The tests were conducted at ambient temperatures (77° +/- 2°F) for 8 hours. Tests were performed under laboratory conditions and do not represent actual usage conditions. The user should determine the applicability of these test conditions. The user should determine the applicability of these test conditions in assessing the suitability for the actual exposure anticipated.

*Ammonia is a gas. We have tested a solution of the gas. Very likely, this is what a diver will meet in some concentration.

**ISO 1817 Rubber, Vulcanized-Determination of the Effect of Liquids, was used as the basis to determine the composition of the Petroleum, Oils and Lubricants used in the permeation tests.

Table#2: Chemical Permeation Test Results on

Chemical	Concentration %	Solubility in Water	Specific Gravity	Breakthrough Time Minutes		
				PRO	HD	Latex
Acetone	10	100	0.79	50	60	90
Acetonitrile	10	100	0.78	>180	>180	40
Ammonia Solution	10	100	*	>180	>180	>180
Carbon Disulphide	100	0.2	1.26	1	1	8
Dichloromethane	100	1.3	1.34	5	5	17
Diethylamine	10	82	0.71	>180	>180	>180
Dimethylformamide	10	100	0.95	>180	>180	>180
Ethyl Acetate	8.7	8.7	0.9	20	52	65
Hexane	0.014	0.014	0.66	>180	>180	>180
Methanol	10	100	0.79	>180	>180	>180
Sodium Hydroxide	10	50	2.13	>180	>180	>180
Sulphuric Acid	10	100	1.83	>180	>180	>180
Tetrachloroethylene	0.015	0.015	1.62	>180	>180	40
Tetrahydrofuran	10	100	0.89	60	>180	80
Toluene	0.05	Not soluble	0.87	>180	>180	85
Oil No. 1 acc. to ISO 1817**	100	Not soluble	<1	>180	>180	>180
Oil IRM 903 acc. to ISO 1817**	100	Not soluble	<1	>180	>180	>180
Liquid B acc. to ISO 1817**	100	Not soluble	<1	12	40	40
Liquid C acc. to ISO 1817**	100	Not soluble	<1	10	24	28
Liquid F acc. to ISO 1817**	100	Not soluble	<1	150	>180	>180
JP4 (Jet fuel)	100	Not soluble	0.08	47	45	NT

Test Method and Results for Diffusion on Seams

Glued seams, and suit material-to-latex seams (cuff and neck seal), were tested against the standard chemical test battery. The tests were performed at room temperature in a standard two-chamber cell. Fifteen minutes after the challenge side of the test chamber was filled with the chemical, the complete assembly was weighed. Pristine material was also weighed separately. After one hour of chemical exposure, the material was weighed to determine the amount, if any of weight loss.

The column, DIFFUSION (Diff.) G/HR, shows the calculated diffusion for the whole suit. Diffusion means molecules passing through the material and seam (see table).

In the column INFLUENCE the amount and character of swell was recorded. There was no sign of glued or vulcanized seams coming loose except when it was noted “seams start to delaminate” (see table).

Notes on Table #3: Seam Diffusion Table, page 10:

Oil No. 1 (ASTM Oil No. 1) is a paraffin oil. (lubrication oil)
Oil IRM 903 (ASTM Oil No. 3) is an aromatic oil. (lubrication oil)
Liquid B is a liquid to simulate low octane gasoline. (70/30 isooctane/toluene)
Liquid C is a liquid to simulate high-octane gasoline. (50/50 isooctane/toluene)
Liquid F is a liquid to simulate diesel fuel and light heating oil. (80/20 paraffin oil/methylnaphalene)

The tests were performed under laboratory conditions and do not represent actual usage conditions. The user should determine the applicability of these test conditions in assessing the suitability for the actual exposure anticipated.

*Ammonia is a gas. We have tested a water solution of the gas. Very likely, this is what a diver will meet in some concentrations.
**The tests were performed to see the effect of 100% concentration.
***ISO 1817 Rubber, Vulcanized-Determination of the Effect of Liquids, was used as the basis to determine the composition of the Petroleum, Oils and Lubricants used in the permeation tests.

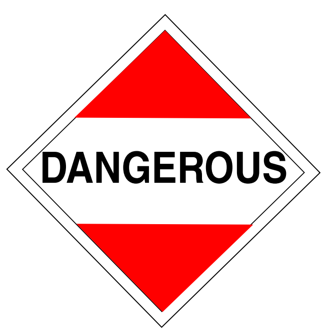


Table #3: Diffusion through Seams for Viking Suits

Chemical	Concentration	Solubility in Water	Specific Gravity	Diff G/HR	Effect
Acetone	10	100	0.79	4.8	No effect
Acetonitrile	10	100	0.78	0.02	No effect
Ammonia Solution	10	100	*	0.01	No effect
Dichloromethane	100	1.3	1.34	48	Reversible swell
Diethylamine	10	82	0.71	0.36	No effect
Dimethylformamide	10	100	0.95	0.02	No effect
Ethyl Acetate	8.7	8.7	0.9	0.01	No effect
Ethyl Acetate**	100	8.7	0.9	4.1	Low reversible swell
Hexane	0.014	0.014	0.66	0.03	No effect
Hexane**	100	0.014	0.66	29	Moderate reversible swell
Methanol	10	100	0.79	0.25	No effect
Sodium Hydroxide	10	50	2.13	0.01	No effect
Sulphuric Acid	10	100	1.83	0.02	No effect
Tetrachloroethylene	0.015	0.015	1.62	0.03	No effect
Tetrahydrofuran	10	100	0.89	0.05	Reversible swell
Tetrahydrofuran**	100	100	0.89	27.5	Seam starts to delaminate
Toluene	.05	.05	0.87	0.04	No effect
Toluene**	100	0.05	0.87	2.4	Seam starts to delaminate
Oil No. 1 acc. to ISO 1817***	100	Not soluble	$\leq$1	0	Minor swell
Oil IRM 903 acc. to ISO 1817***	100	Not soluble	$\leq$1	0.07	Moderate swell
Liquid B acc. to ISO 1817**	100	Not soluble	$\leq$1	7.3	Reversible swell
Liquid C acc. to ISO 1817**	100	Not soluble	$\leq$1	13.2	Reversible swell
Liquid F acc. to ISO	100	Not soluble	$\leq$1	12.6	Minor swell

Notes on Table #4: Risk Levels for Glued Seams and Materials, page 12

The effects were observed after the permeation tests.

Classification:

A = No effect
B = Minor effect
C = Moderate effect
NT = Not Tested

The tests were performed under laboratory conditions and do not represent actual usage conditions. The user should determine the applicability of these test conditions in assessing the suitability for the actual exposure anticipated.

*ISO 1817 Rubber, Vulcanized-Determination of the Effect of Liquids, was used as the basis to determine the composition of Petroleum, Oils and Lubricants used in the permeation tests.

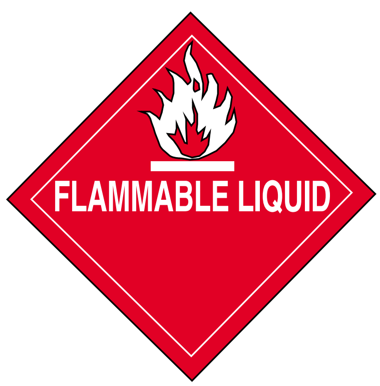


Table #4: Risk Levels for Glued Seams and Suit Materials

Chemical	Conc. Mat.	PRO	HD	Latex	Glued Seam	Conc. Zipper	Zipper
Acetone	10	B	B	B	A	100	B
Acetonitrile	10	A	A	A	A	100	B
Ammonia Solution	10	A	A	A	A	Gas	A
Carbon Disulphide	100	B	B	B	B	NT	C
Dichloromethane	100	B	B	B	B	100	C
Diethylamine	10	A	A	A	A	100	B
Dimethylformamide	10	A	A	A	A	NT	NT
Ethyl Acetate	8.7	A	A	A	A	100	B
Hexane	0.014	A	A	A	A	100	A
Methanol	10	A	A	A	A	100	A
Sodium Hydroxide	10	A	A	A	A	NT	NT
Sulphuric Acid	10	A	A	A	A	100	B
Tetrachloroethylene	0.015	A	A	A	A	NT	NT
Tetrahydrofuran	10	A	A	A	B	100	B
Toluene	0.05	A	A	A	A	100	B
Oil No. 1 acc. to ISO 1817*	100	A	A	A	B	NT	NT
Oil IRM 903 acc. to ISO 1817*	100	B	B	B	C	NT	NT
Liquid B acc. to ISO 1817*	100	B	B	B	C	NT	NT
Liquid C acc. to ISO 1817*	100	C	C	C	C	NT	NT
Liquid F acc. to ISO 1817*	100	B	B	B	B	NT	NT
JP4 (Jet fuel)	100	B	B	B	C	NT	NT

Test Method and Results for Zippers

Penetration resistance testing of the dry suit zipper was conducted in accordance with ASTM F903, Standard Test Method For Resistance of Protective Clothing Materials to Penetration by Liquids. A minimum of three suit zippers were tested for each liquid in the ASTM F1001, Standard Guide for Chemicals to Evaluate Protective Clothing Materials. Prior to the test each zipper was conditioned by 50 cycles of completely opening and completely closing the zipper.

The tests were conducted on Dynat zippers that have a Neoprene coating. The BDM zipper, which we use in our diving suits, has a coating of neoprene with 5% Butyl rubber added. Technically there is a difference. Butyl is a better chemical barrier against some chemicals than neoprene. Theoretically, test results with Viking suits should be better, but these tests were incomplete at this time.

The pass/fail criteria is no breakthrough after one hour.
Chemical tested at Reagent (NEAT) 100% concentration.

⚠ WARNING	**The tests listed in this booklet were performed on Dynat zippers. Viking uses BDM zippers in the diving suits they manufacture.**

Table #5: Chemical Penetration Resistance for Zippers (ASTM F903)

Chemical	Requirement	Result
Acetone	BT≥1 Hour	Pass
Acetonitrile	BT≥ 1 Hour	Pass
Ammonia Solution	BT≥ 1Hour	Pass
Carbon Disulphide	BT≥1 Hour	Pass
Dichloromethane	BT≥1 Hour	Pass
Diethylamine	BT≥1 Hour	Pass
Dimethylformamide	BT≥1 Hour	Pass
Ethyl Acetate	BT≥1 Hour	Pass
Hexane	BT≥1 Hour	Pass
Methanol	BT≥1 Hour	Pass
Nitrobenzene	BT≥1 Hour	Pass
Sodium Hydroxide	BT≥1 Hour	Pass
Sulphuric Acid	BT≥1 Hour	Pass
Tetrachloroethylene	BT≥1 Hour	Pass
Tetrhydrofuran	BT≥1 Hour	Pass
Toluene	BT≥1 Hour	Pass

All tests were performed according to ASTM F903.

The tests were performed under laboratory conditions and do not represent actual usage conditions. The user should determine the applicability of these test conditions. The user should determine the applicability of these test conditions in assessing the suitability for the actual exposure anticipated.

Test Method and Results of Viral Penetration (ASTM F1671)

This test evaluates a material's ability to resist the penetration of a viral simulate. The simulate is a bacterial phage called PhiX-174. This virus kills certain bacteria but is not harmful to humans.

The phage is grown in a sterile broth to a concentration greater than 1 X 108 pfu/ml. A pfu is a plaque forming unit and is the basic measuring unit of phage. The broth containing the phage is placed on the outside surface of the barrier in a special test cell. After five minutes, the cell is pressurized for 1 min. at 2 p.s.i., then allowed to sit for 54 minutes.

At the end of the exposure time, the side not exposed is rinsed with fresh sterile broth. If any phage is passed through the barrier, it will contaminate the rinse broth. This broth is then mixed with bacteria E-coli, and a culture is grown. After 24 hours in an incubator, the bacteria culture is examined. The presence of bacterial phage is detected by spots of dead bacteria called "plaques." If no plaques are formed then no bacterial phage was present. The absent of plaques results in the barrier passing the test.

Table #6: Biological Penetration Test Results

Material	Results
PRO	Pass
HD	Pass

The tests were performed under laboratory conditions and do not represent actual usage conditions. The user should determine the applicability of these test conditions in assessing the suitability for the actual exposure anticipated.

Cuff Ring System and Dry Gloves

The hands are one of the areas of the body often neglected in contaminated water diving. It is very important to protect the hand to prevent contaminants from being absorbed through the skin.

When attached directly to the dry suit, the Viking cuff ring system not only allows for direct mating of a dry glove, but also field changing of the latex cuff seals if damaged.

Currently the most common dry glove used with the Viking cuff ring system is a latex dry glove. The chemical protection afforded by these gloves has never been tested.

To be used in conjunction with our line of Level A chemical suits, Trelleborg Viking stocks 2 other types of gloves. The chemical testing available on these gloves is extensive. Both have been used with our cuff ring system and have been found to work very well.

To make sure the glove does not become detached from the ring we suggest the use of a rubber elastic seal, this is used to keep it on the chemical suit.

The following table lists two gloves, Neoprene rubber and Butyl rubber. Both offer varying protection levels. It is the responsibility of the diving supervisor and diver to assess the suitability of the glove you plan to use.

⚠ **CAUTION**	**The neoprene glove listed in these tests is molded. It is not a foam neoprene glove as is commonly used for sport diving. Foam neoprene is the same material used to manufacture wetsuits. Foam neoprene gloves do not provide the same protection as molded neoprene gloves.**

Viking cuff ring installed on suit.

Permeation Test Results for Gloves (ASTM F739)

Chemical	Neoprene Breakthrough Time (min.)	Neoprene Permeation rate ug/cm_/mi.	Butyl Breakthrough Time (min.)	Butyl Permeation rate ug/cm_/mi.
Acetone	49	>500	ND	NA
Acetonitrile	120	9.53	ND	NA
Ammonia Solution	ND	NA	ND	NA
Carbon Disulphide	4	>500	<4	>500
Dichloromethane	NT	NT	23	>100
Diethylamine	15	>500	27	>500
Dimethylformamide	96	>500	ND	NA
Ethyl Acetate	24	>500	253	>500
Gasoline	148	32	NT	NT
Hexane	57	>500	4	>500
Hydrochloric Acid	ND	NA	ND	NA
Hydrofluoric Acid	ND	NA	ND	NA
Hydrogen Chloride	ND	NA	ND	NA
Hydrogen Fluoride	300	4.4	15	>100
Methanol	239	72	ND	NA
Muriatic Acid	ND	NA	ND	NA
Nitrobenzene	84	>500	ND	NA
Oleum	170	>500	270	>500
Sodium Hydroxide	ND	NA	ND	NA
Sulphuric Acid	ND	NA	ND	NA
Tetrachloroethylene	48	>500	<4	>500
Toluene	20	>500	28	>500

All glove permeation tests were performed according to ASTM F739 with a minimum detectable permeation rate of less than or equal to 0.1µg/cm^2/min. Tests were performed under laboratory conditions and do not represent actual usage conditions. **The user should determine applicability of conditions when assessing suitability of the actual anticipated exposures.**

Classification:

ND = No Breakthrough in 8 hours
NA = Not Applicable
NT = Not Tested

Suggested Diving Systems

The following diving systems offer varying amounts of protection. There are uses, environments, and chemicals for which these systems are unsuitable. It is the responsibility of the diving supervisor and the diver to review the available data and verify that the system is appropriate for the intended use.

Pro 1000 Dry suit

Attached Vulcanized rubber dry hood
Attached cuff ring system
Attached dry gloves*
Full-face mask with positive pressure system

Heavy Duty Suit with attached Helmet Yoke and Valves

Attached cuff ring system
Attached dry gloves*
Demand helmet with double exhaust valves

Heavy Duty Suit with attached Helmet Yoke (no neck seal or valves)

Attached cuff ring system
Attached dry gloves*
Free Flow Helmet (air hat) with double exhaust valves

* See section on Dry Gloves.

Decontamination Recommendations and Considerations

Decontamination shall be performed on the scene when a dry suit has been exposed to, or has been potentially exposed to, hazardous materials. On scene decontamination shall be performed while the suit is still being worn to minimize potential contamination of the wearer during removal.

Due to the vast number of chemicals and their different properties, no guaranteed decontamination procedure exists. The best way to decontaminate must be decided for the specific chemical encountered. This decision may only be made by people educated for this task and with a good working knowledge of chemistry.

In the absence of such knowledge, the minimum decontamination shall consist of rinsing or spraying the garment with water and scrubbing lightly with a soft bristled brush using Decon-Check™ (see following page), then thoroughly rinse with plain water. This process shall be repeated at least twice.

The health and safety of the diver, both during and after the decontamination process, and the health and safety of the personnel applying the decontamination agent, must be taken into consideration.

After removal, the dry suit must be placed in a suitable container for subsequent cleaning, additional decontamination, inspection, or disposal.

Inspection

An assessment of the need for additional decontamination shall be made if the dry suit is to be reused after it has been exposed to hazardous materials and initially decontaminated. A close visual inspection of any diving equipment used in contaminated water is essential once the gear has been decontaminated.

During the inspection, the diver should be looking for any of the following:

- Brittleness of the material
- Color changes in the material
- Swollen material

Any of the above conditions should make you immediately suspect the equipment may have been damaged and should not be used again without further examination by Trelleborg-Viking. However, just because a piece of equipment visually appears to be in good condition is no guarantee of performance.

The assessment shall consider the severity of the chemical exposure including such factors as:

⚠ WARNING	Diving equipment that has been damaged due to exposure to contaminants cannot always be identified by visual inspection. Caution must always be followed in reusing equipment that has been previously exposed to chemical environments.

The duration of the exposure occurred;
The concentration of the hazardous materials;
The toxicity of the hazardous materials;
IDLH, PEL, TLV* recommendations;
Skin absorption and cancer notations;
Acute and systemic toxicity (poison, suspect carcinogen, carcinogen, teratogen).

The assessment shall consider the chemical affinity between the hazardous material and the dry suit including:
Breakthrough times;
Permeation rates;
Discoloration or other manifestations of the contamination;
Degradation.

If there is any question if the dry suit can continue to be used, it should be returned to Trelleborg Viking, Inc. for inspection. Before returning any suit to Viking you must call to obtain an authorization first.

Data contained in this report has been developed from tests conducted under controlled laboratory con-

⚠WARNING	When possible, diving in contaminated water should be avoided. If you are not trained for this type of diving operation, do not attempt it.

ditions, not under actual diving environments. The user must determine the applicability of these tests results for the actual exposure anticipated.

The test results contained in this report are specific only for Viking Diving materials and components. Comparisons to the performance of other manufacturers diving equipment cannot be made.

There are uses, environments and chemicals for which these systems are unsuitable. It is the responsibility of the user to review available data and verify the system for the intended use.

Additional Information

In this report we have concentrated our efforts to provide you with concise technical information on Viking drysuits. In order to plan an effective dive operation there are many other factors to consider. The below publications are excellent reference material on diving in contaminated water environments.

American Society for Testing Materials. *Standard Guide for Selection of Chemicals to Evaluate Protective Clothing Materials.* ASTM. West Conshohocken, PA. 2001

Barsky, Steven M. *Contaminated and Potable Water Diver Training Program*. Trelleborg-Viking, Inc. Portsmouth, NH. 1999 – CD-ROM

Barsky, Steven M. *Diving in High-Risk Environments, 3rd Edition*. Hammerhead Press, Santa Barbara, CA. 1999, 197 pages

Code of Federal Regulations (CFR) 1910.120 – Hazardous Waste Operations and Emergency Response. OSHA Regulations, Subpart H, Subpart Title: Hazardous Materials.

Maryland Sea Grant. *The Hazards of Diving in Polluted Water: Procedings of an International Symposium.* UM- SG-TS-92-02. Maryland Sea Grant College, College Park, Maryland, 1992.

Traver, Richard P. *Manual of Practice for Marine Safety Officers and On Scene Coordinators Involved in Chemically and/or Biologically Contaminated Underwater Operations (NTIS) – Publication PB-86-128022.* Hazardous Waste Engineering Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH 45268, 1984.

U.S. Department of Health and Human Services. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities.* Cincinnati, Ohio, 1985.

U.S. Fire Administration. *Protective Clothing and Equipment Needs of Emergency Responders in Urban Search and Rescue Missions – CLIN 004.* FA-136. Emmitsburg, MD. 1993