



Dry Suit Diving

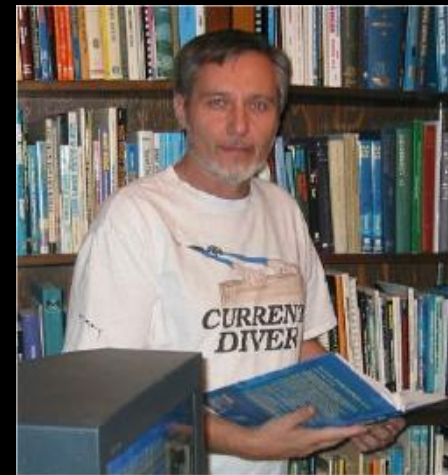
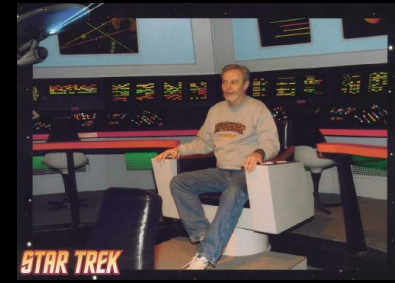
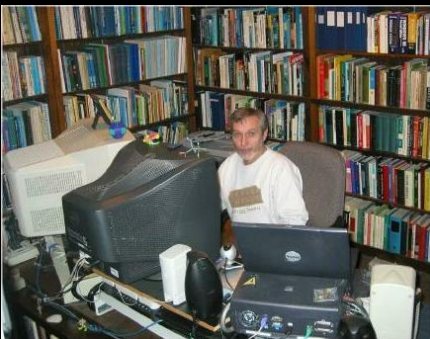
Larry “Harris” Taylor, Ph.D.

Diving Safety Coordinator, U of Michigan



Your Instructor

U of MI Diving Safety Coordinator
AAUS sanctioned Diving Safety Officer
Internationally rated 3 - star instructor (CMAS)
National Master Scuba Instructor (President's Council)
> 100 Diving Certifications
> 200 Diving Publications
> 1,200,000 visitors to "Diving Myths & Realities" web site
Library: one of the best resources in North America
Scuba Diver since 1977
Scuba Instructor since 1980
DAN Instructor since 1991
EAN_x Instructor since 1992
Ph.D. Biochemistry





Lecture is a Democracy!

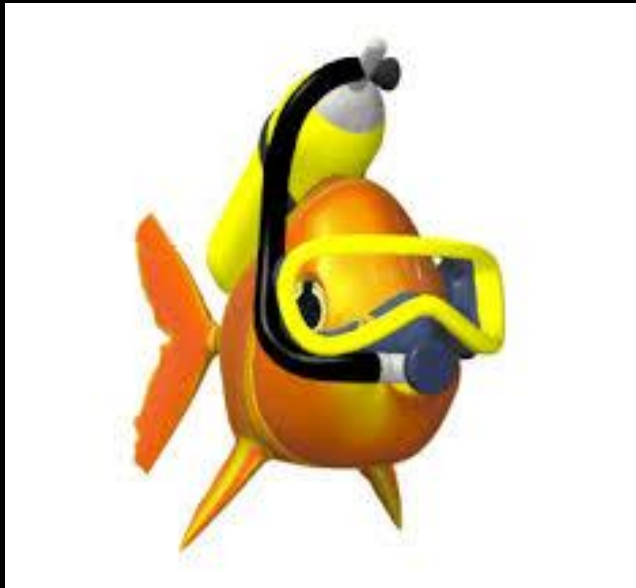
You control speed with your questions





The Water-work is Dictatorship!

Do as instructed or leave the water

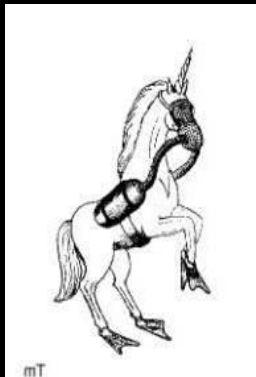


Knowledgeable, Physically Fit Divers

Gospel

According to “Harris”

Have More Fun!



Three Great Truths:



Diving Is Fun

Being Cold Is NOT Fun

Wet & cold divers subsidize those diving warm & dry

The Truth



Wet-suited divers:

Cold, On deck

Dry-suited divers:

Enjoying third dive

EFFICIENCY AND RELIABILITY

Temp	Wet Suit			Dry Suit		
	Dive Number			Dive Number		
	1st	2nd	3rd	1st	2nd	3rd
70°F	100%	100%	100%	100%	100%	100%
60°F	100%	90%	80%	100%	100%	100%
50°F	80%	70%	50%	100%	100%	100%
40°F	50%	25%	*	100%	85%	75%
32°F	*	*	*	100%	75%	55%

*Not Recommended

Table Based On 30 Minute Dives At Depth Of 50 Feet

Must Understand Heat Loss to Protect From the Cold



Ignoring (or Not Understanding) Heat Loss



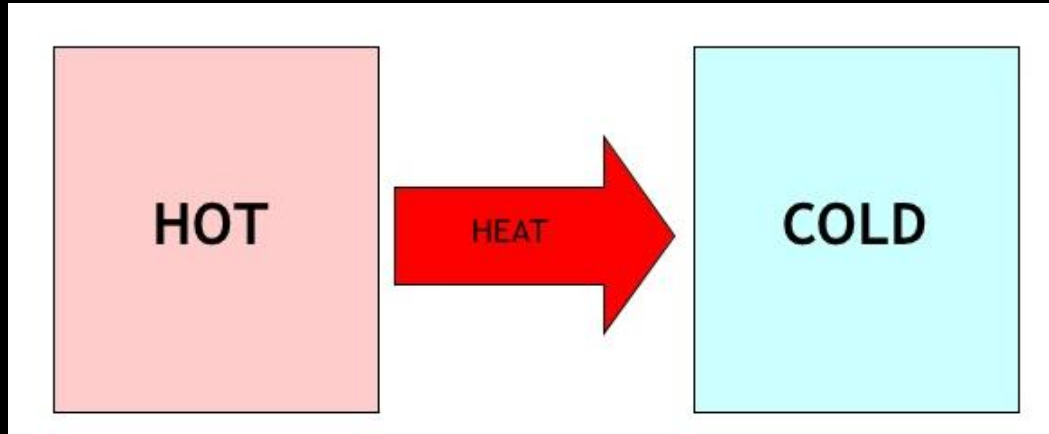
It is always the “not known” that poses the greatest risk



Heat



Heat is a Fluid



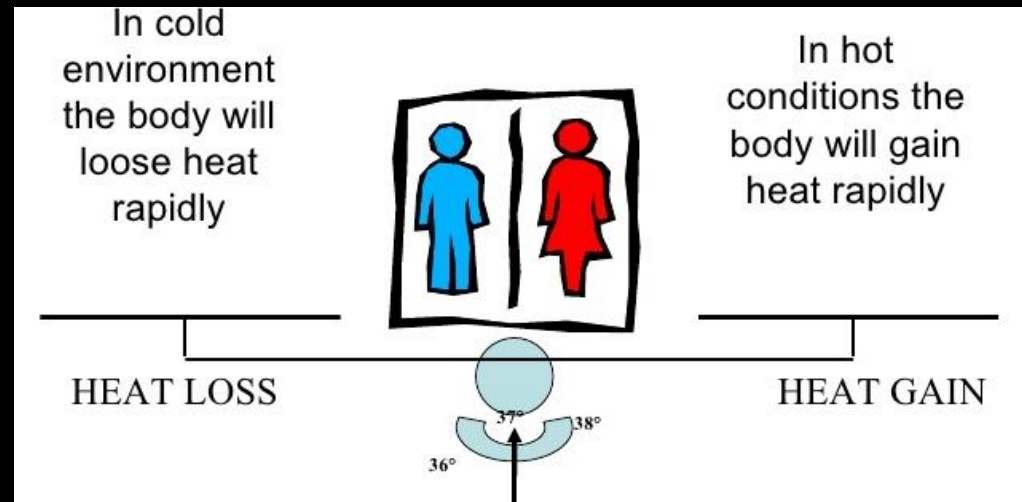
**Flows from hotter to colder
until
temperatures are equal**

Cannot stop movement

Protection comes from slowing process

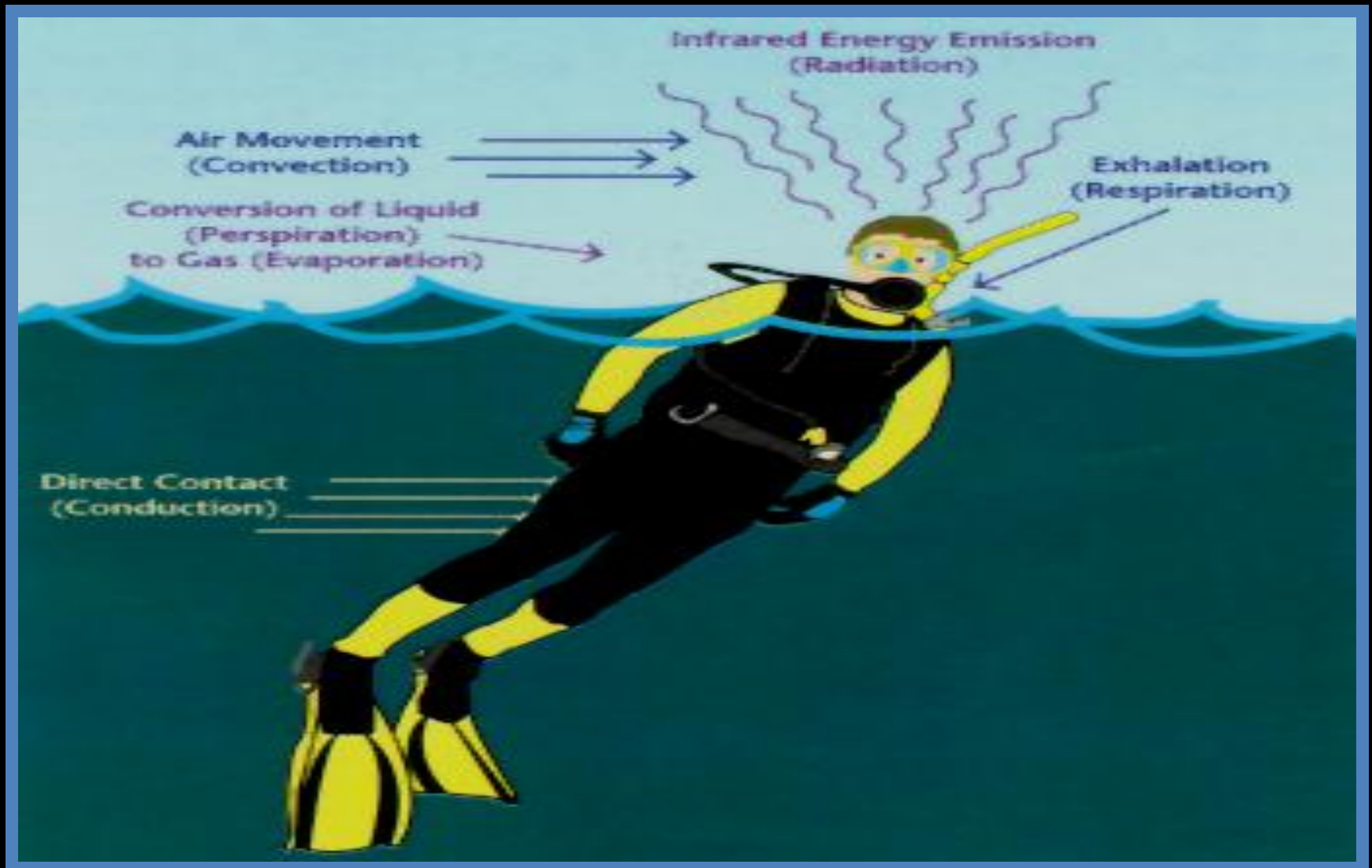
Thermal Balance

Heat Out:
Environment
Conduction
Convection
Radiation
Cooling
Respiration
Perspiration
Excretion
Disease

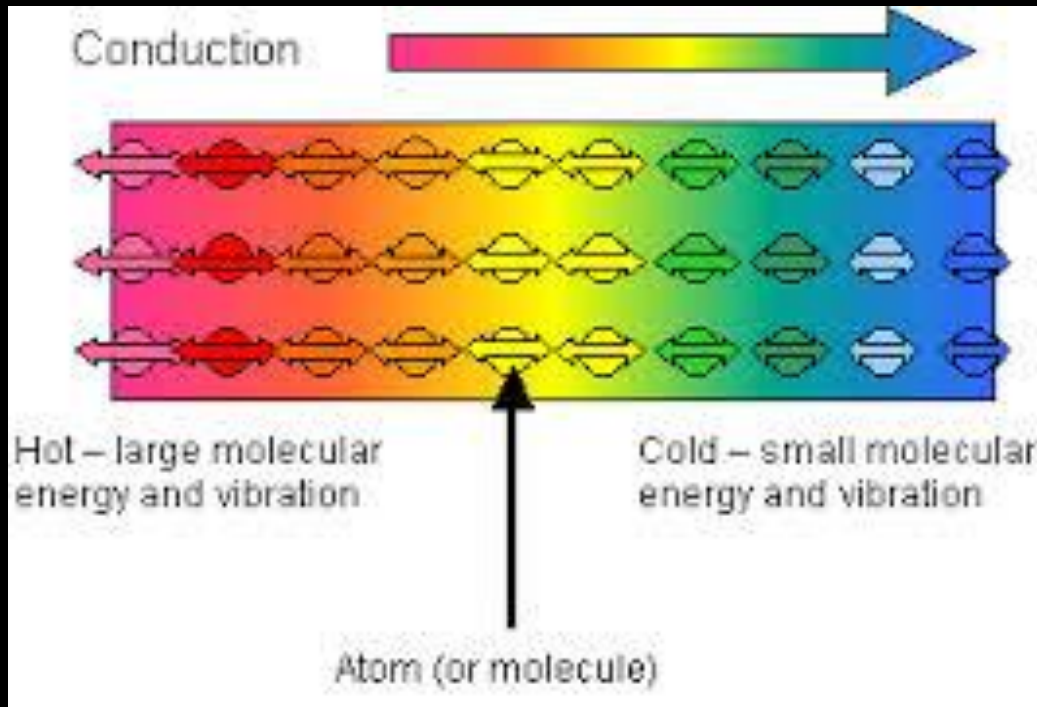


Heat In:
Metabolism
Muscle Movement
Environment
Conduction
Radiation

In-Water Heat Loss



Thermal Loss: Conduction



**Water removes heat
~ 25 x faster
than dry, still air
at same temperature**

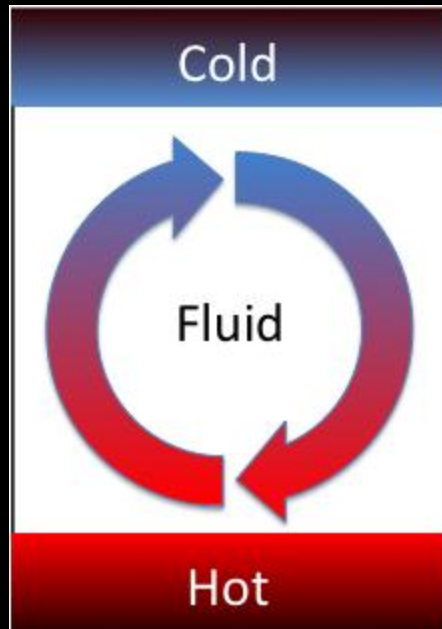
Direct transfer of energy at the molecular level

Major source of in-water heat loss

Heat loss to water

Heat loss warming breathing gas

Thermal Loss: Convection

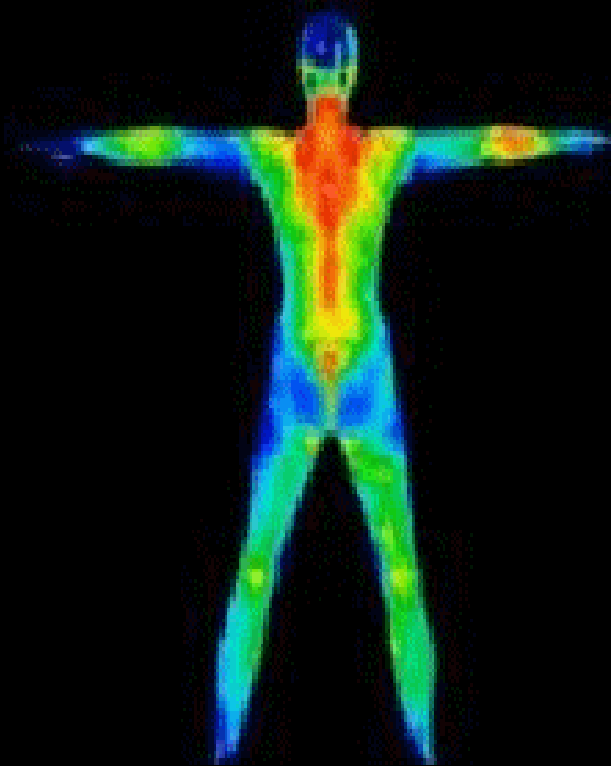


Moving liquid removes heat
Continual process

Wet suits restrict convective flow



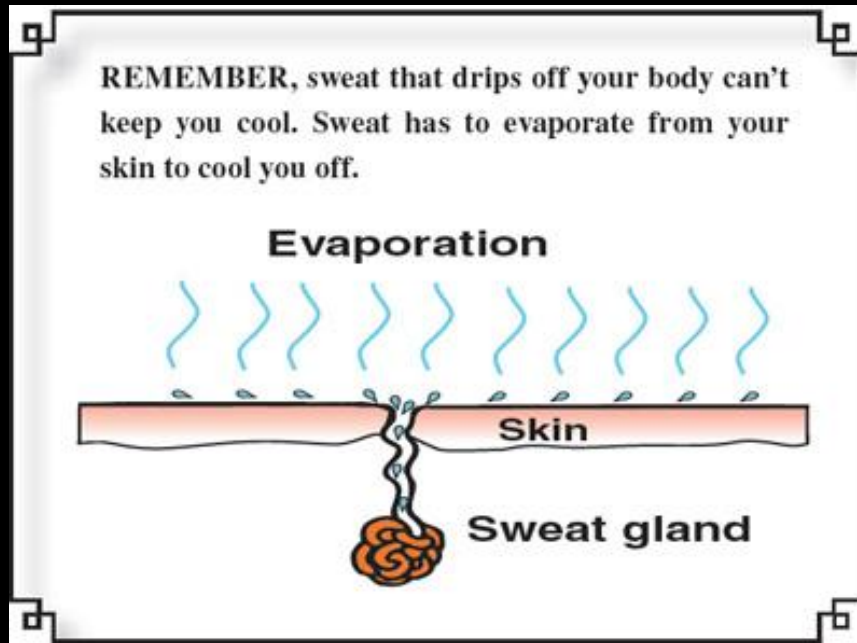
Thermal Loss: Radiation



Emission of infra red radiation

Minor problem in the water

Thermal Loss: Evaporation / Respiration



Change of state:
Liquid → gas
Requires energy

9.72 kcal / mole

Pre-dive sweating

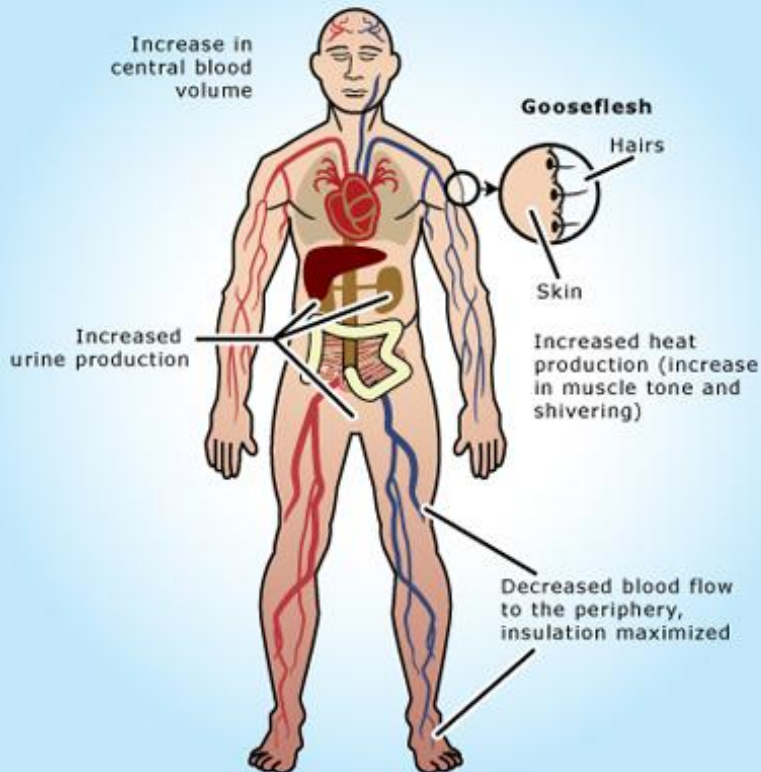
Insensible perspiration

Humidifying dry breathing gas

Humans are Tropical Critters

Better coping with heat than cold

How the body responds to cold



Hot	Cold
Vasodilation Arterioles dilate (enlarge) so more blood enters skin capillaries and heat is lost.	Vasoconstriction Arterioles get smaller to reduce blood going to skin: keeping core warm.
Sweating Sudorific glands secrete sweat which removes heat when water changes state.	Shivering Rapid contraction and relaxing of skeletal muscles. Heat produced by respiration.
Pilorelaxation This means the hairs flatten.	Piloerection Hairs on skin stand up.
Stretching Out By opening up, the body was a larger surface area.	Curling Up Making yourself smaller so smaller surface area.

Simplistic View of a Biochemist:

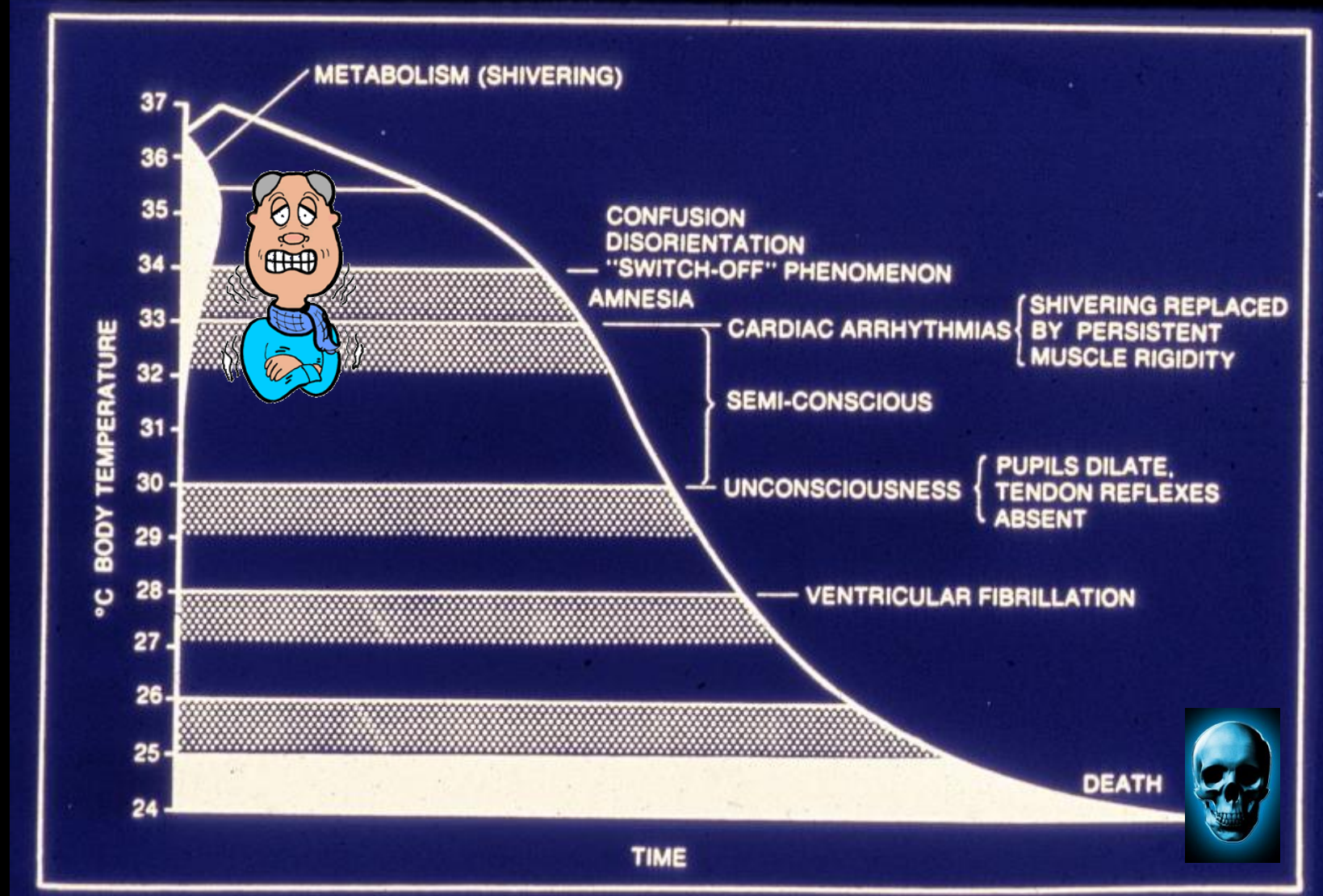
Heat = Life

Cold Robs Heat

No Heat = No Life

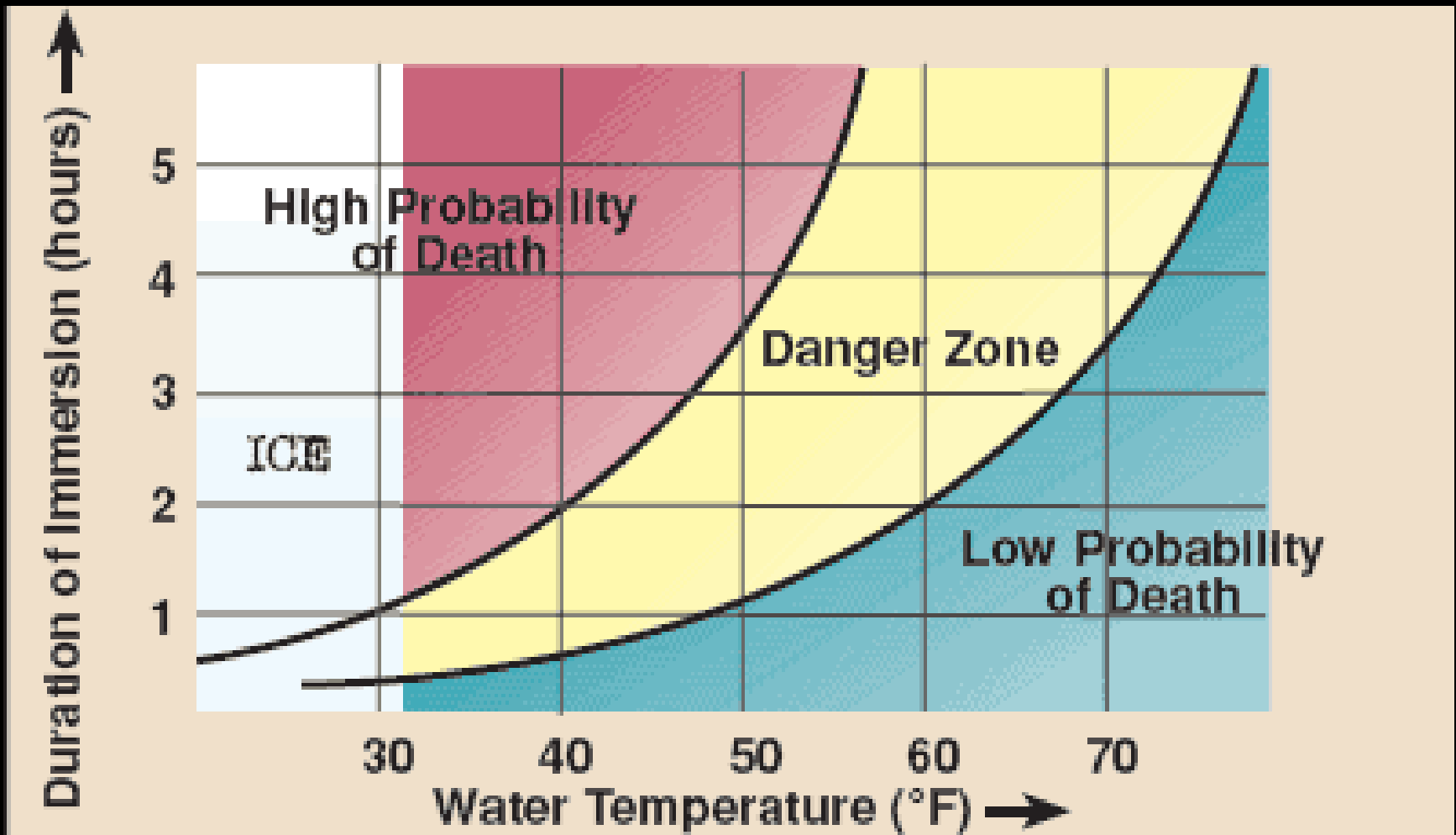


Body Response to Temperature Loss



First Shiver: Abort the dive!

Estimated Unprotected In-Water Survival Time






Wind Chill Can Lead to Substantial Heat Loss



Wind Chill Chart



		Temperature (°F)																		
		Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Wind (mph)	5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63	
	10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72	
	15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77	
	20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81	
	25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84	
	30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87	
	35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89	
	40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91	
	45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93	
	50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95	
	55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97	
	60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98	

Frostbite Times  30 minutes  10 minutes  5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

~~Cold~~



Cold:

Major physiological stressor

Major obstacle to diving participation

Major obstacle to limited bottom time

This is a course in NOT being cold



Not Being Cold



Commercial Divers Often Use Hot Water Suits



Surface supplied:

Tether

Breathing mix

Communications

Hot water



Historic Thermal Protection Schemes

Bel-Aqua FROG SUITS

A BEL-AQUA FROG SUIT FOR EVERY HEIGHT AND WEIGHT



Will keep you warm and dry even in 'the coldest water • Special durable rubber will last for years • Perfect freedom of movement, no binding or pulling • Front entry allows you to put on and take off the suit by yourself • Seams will not part, workmanship guaranteed.

ASK THE MAN WHO OWNS ONE, HE IS OUR BEST ADVERTISEMENT

BEL-AQUA SHORTY — Rubber swim suit with arms and legs exposed.
 BEL-AQUA SWIM SHIRT — Rubber shirt to hold body heat in the upper body.
 BEL-AQUA SNORKEL — Flexible rubber snorkel with special mouthpiece.
 BEL-AQUA NIGHT LIGHT — Rubber flashlight holder will waterproof a five cell flashlight. It floats!
 BEL-AQUA SPEAR SLINGS — "The most powerful propellant possible in rubber. Lasting.

LOOK FOR THE WATER GREEN COLOR — GET THE BEST FOR YOUR MONEY

BEL-AQUA WATER SPORTS CO.
 3720 WEST 54th STREET LOS ANGELES 43, CALIFORNIA AX 3-7124



To lengthen the season . . .
 . . . To keep warmer longer


The EDCO SUB-MARINER

A WET TYPE SUIT OF SOFT NEOPRENE FOAM RUBBER

**WARMTH
COMFORT
DURABILITY**

The Sportsman Shorty . . . \$45
 The Sportsman Full Suit . . . \$75

AVAILABLE AT YOUR DEALERS
 . . . or write . . .



Easy to put on . . . Like a pull-over sweater

E D C O **ENGINEERING DEVELOPMENT CORPORATION**

305 american trust company building berkeley 4 california

WARMER

— GUARANTEED!

totes WORLD'S Largest Selling Dry Suit

100% PURE GUM RUBBER—No seams to leak! Now EASIER to put on—no talc needed. LIGHT STRETCHY! Amazingly TOUGH! Used and recommended by commercial divers for working at greatest depths . . . in coldest waters.

Why feel around with patchwork, cement and weak, foam material. Here's a complete professional suit . . . ready to dive and at a price that defies even the do-it-yourself kits. Compare with suits at twice the price.

See your dealer or write for free catalog, stretchy sample and size chart. **\$22.95** IN SAFETY YELLOW



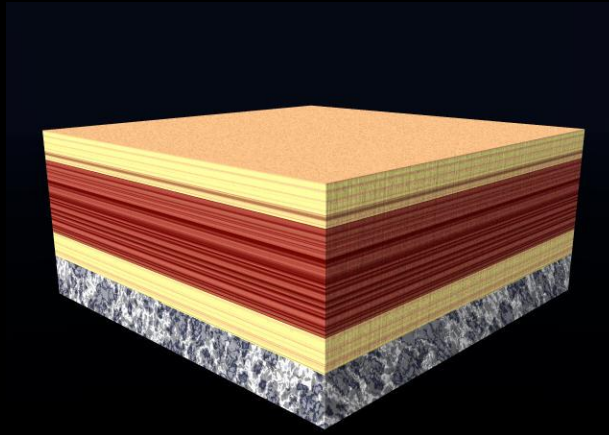
So-Le MARX RUBBER CO., Dept. SD-11, Loveland, Ohio. Dealers Write!

RUB-COTE



Make your own rubberized diving suit in half an hour. A new specially scientific compounded liquid latex now enables anyone to coat sweat shirts, long johns, or similar articles of clothing. Just paint it on and let it dry and "presto"! you'll have a rubber coated suit that is completely elastic and form fitting. Send \$3.00 M.O. for 1 quart to:

RUB-COTE
 3037 SPAULDING STREET
 LONG BEACH, CALIFORNIA



The Layer Concept



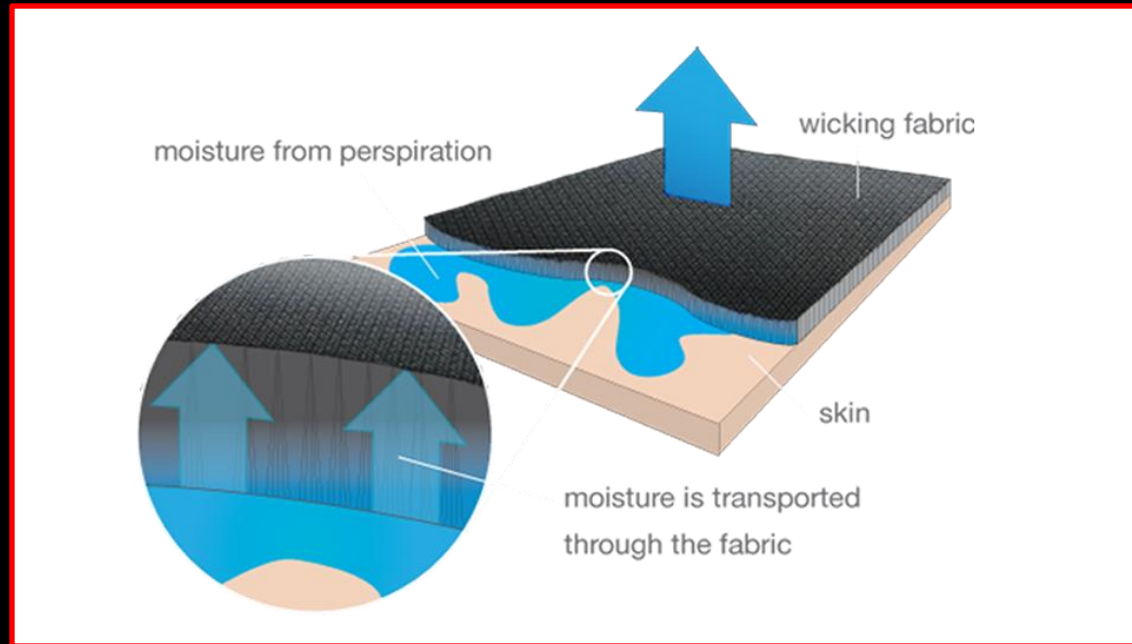
Three Layers of Thermal Protection



Layers varied depending on
Environmental conditions
Workload
Personal Comfort

First Layer: Next to Skin

Purpose: Keep Skin Dry



Hydrophobic microfiber wicks water away from skin
Dry skin loses heat much slower than moist skin

First Layer: Next to Skin

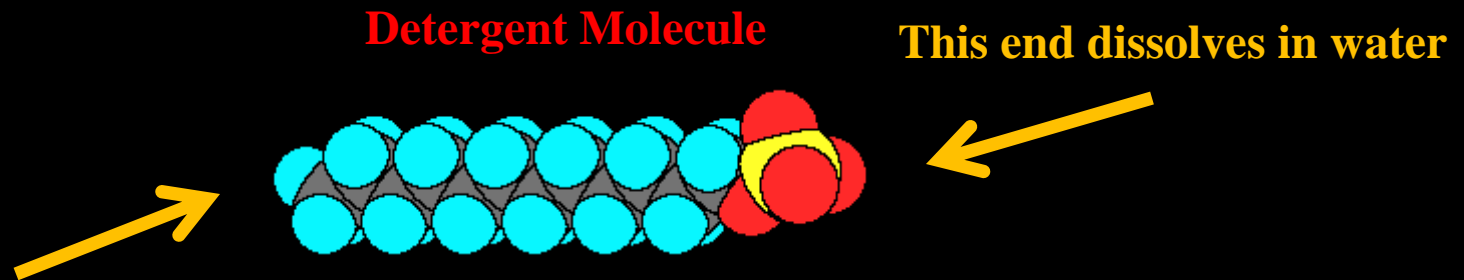


Polypropylene
Capilene
Dry Base
Dry Max (Socks)

Must be synthetic material (all natural fibers absorb water)
Different weights available (dependent on temperatures/workload)

**Hydrophobic Materials Soon Acquire a Foul Body Smell
(Body oils stick to hydrophobic material and turn rancid)**

**Wash with breathable fabric detergent,
(tiny amount of detergent) in cold water
then smell the garment**



This end sticks to grease/hydrophobic material

If detergent odor present:

(This “stuck” detergent can absorb water / lessen insulation)

Wash with only cold water until detergent smell is gone

On trips, best to have multiple sets of first layer garment

Second Layer: Insulation

Primary resistance to heat loss

Fabric is matrix to hold trapped gas (the insulator)

Insulation value = $\frac{\Delta T \cdot A \cdot t}{\text{heat loss}}$

ΔT : temperature difference

A : cross-sectional area

t: time

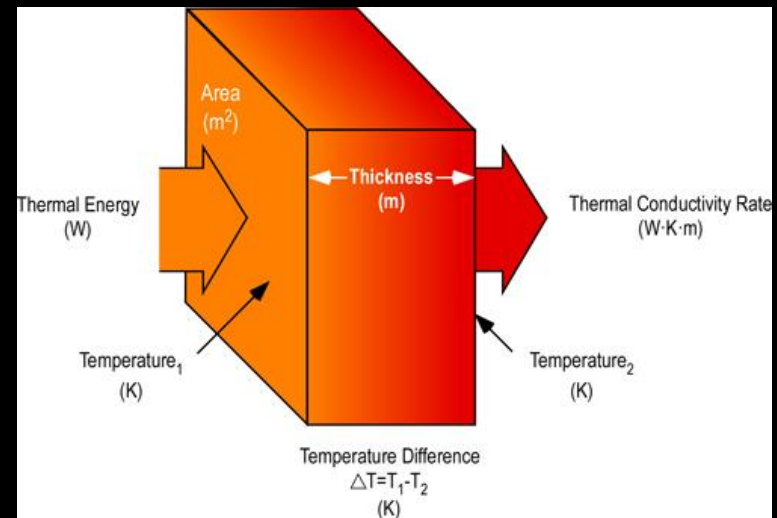
Heat loss depends on:

Temperature difference across barrier

Thickness & area of insulation

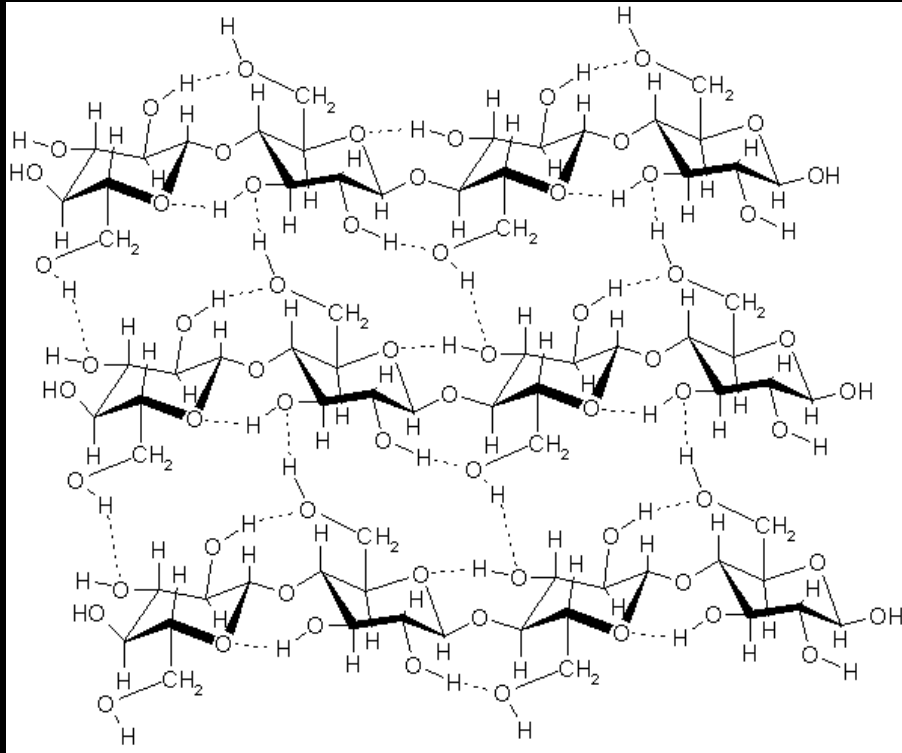
Thermal resistance of insulator

Time



Second Layer: Insulation

Cotton (cellulose) is a No! No!



Cotton is a poly-sugar

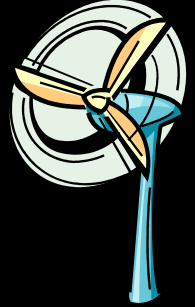
Every $-OH$ can grab water

All natural fibers absorb water

Water decreases insulation

Cellulose (Cotton)

Ability to hold water makes cotton a “great” summer fabric
perspiration “grabbed” by cotton fibers
water evaporates
evaporation takes heat
result is a cooling effect



Ability to hold water makes cotton an undesirable in-water fabric
evaporative cooling promotes heat loss & hypothermia

water removes heat ~ 25 x faster than dry still air of same temperature

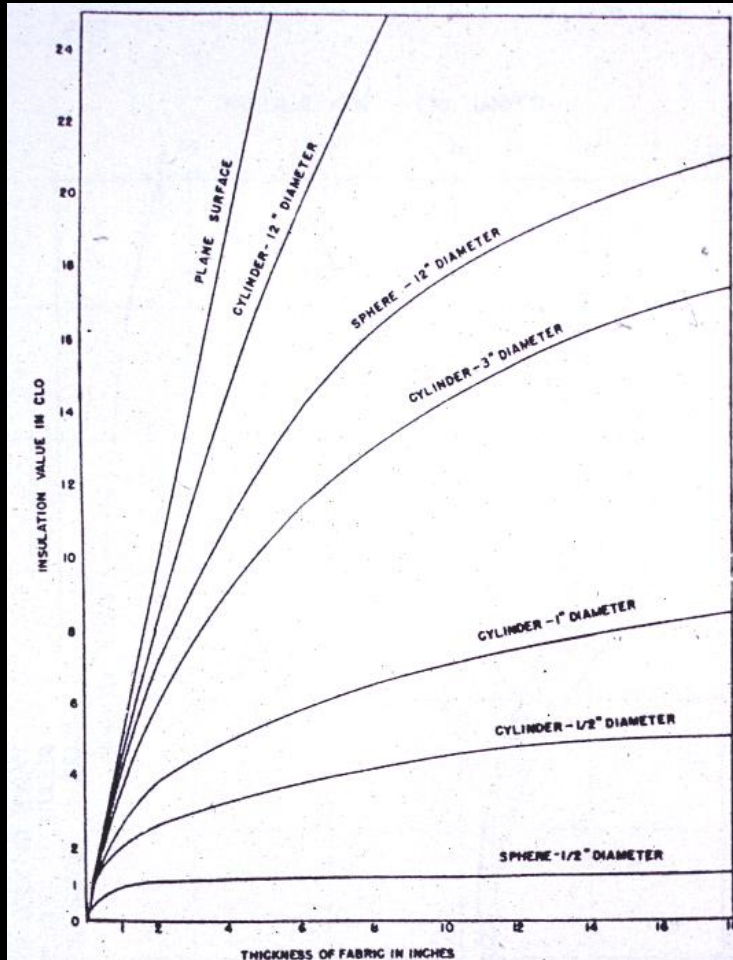
Fogery : > 50% wilderness deaths a result of wearing cotton jeans

Yosemite Rangers: wearing cotton in winter → “death-seeking behavior”



Second Layer: Insulation

Shape of insulator affects heat loss



**Best Resistance : planar surface
(at right angles to heat flow)**

In general:

Planar > cylindrical > spherical

Second Layer: “Wooly Bears”

Wool or synthetic “pile”

Very comfortable next to skin

Warm, as long as dry

Loses insulation rapidly when wet

Loses insulation when compressed

Decent insulation at reasonable price

Least expensive protection



Pile may clog valves

Value based on # fibers / area; not weight

Second Layer: Open Cell Foam



Synthetic foam open cell structure

First compression resistant underwear

Warm when dry

Holds insulation at depth

Rapidly loses insulation when wet

Foam structure a bit non-flexible

Second Layer: Type b Marine Thinsulate



Synthetic microfilament polypropylene

Compression resistant

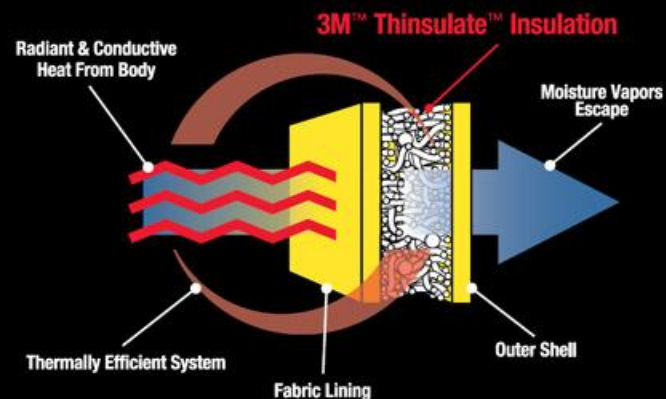
Warm when dry

Holds insulation at depth

Holds insulation (~85 %) when wet

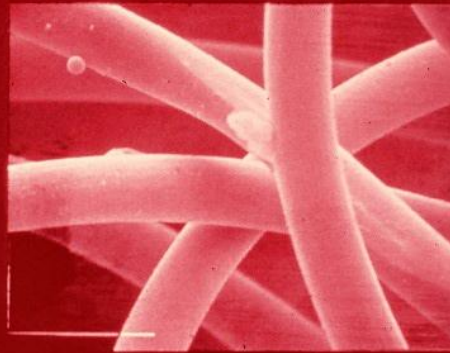
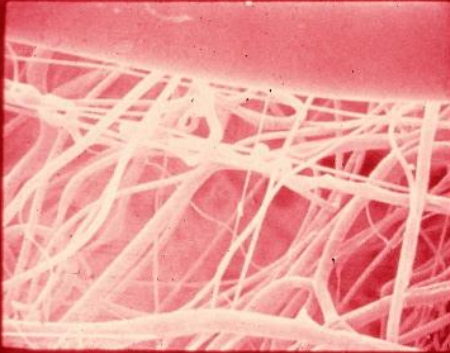
Expensive

Best insulation for wet environments



Second Layer: Type b Marine Thinsulate

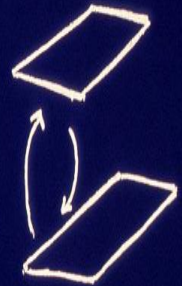
750x



Thinsulate®
INSULATION

Polyester

CONVECTION



Smaller cell size traps more air (insulator)

Requires more convective / conduction steps to transverse garment

Second Layer: Polartec

Polartec: series of > 300 synthetic hydrophobic fabrics

Polyester: polyethylene terephthalate (PET)

Napped (fuzzy) insulator

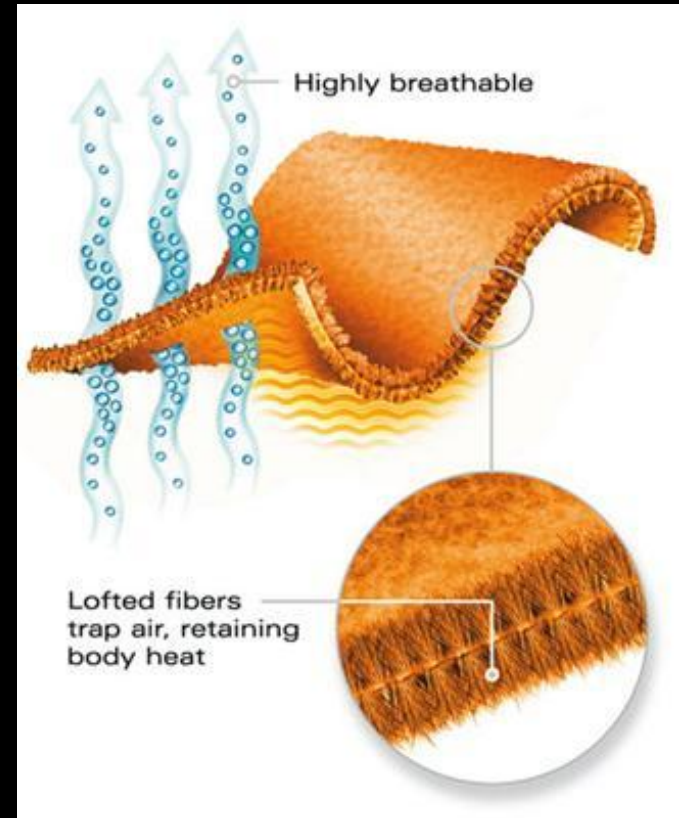
Can serve as

Layer 1

Layer 1 & 2 combined

Layer 1, 2 , & 3 (with waterproof shell)

Depends on weight and design of fabric



Second Layer: Radiant Barrier

Metallic heat reflective coat underneath cloth layer

Radiant barriers work extremely well in a vacuum

Reasonable in sealed, dry, surface garments

Not effective underwater

Experimental in the 1980's

Sold under brand name Underwave

Did not stay long on the market

Occasionally surfaces on e-bay



Second Layer: Blue Heat

Active electrical heating system

Boots, gloves, and full torso sold separately

Lasts about 2 hours on 100% power

Designed to supplement, not replace, thermal undergarments

Very expensive

Concern that heating may increase DCI risk

Use on lowest power

Best used on final ascent



Second Layer: Insulating Gas

Primary insulation:
thermal resistance of gas in the suit

Thermal conductivity: the quantity of heat transmitted through a unit thickness of a material - in a direction normal to a surface of unit area - due to a unit temperature gradient under steady state conditions (measured in watts per meter Kelvin, $W/(m \cdot K)$).

Examples:

Air, atmosphere	(gas)	0.024
Argon	(gas)	0.016
Carbon dioxide	(gas)	0.0146
Helium	(gas)	0.142
Nitrogen	(gas)	0.024
Water	(liquid)	0.58

The lower the value,
The better the insulation



Second Layer: Insulating Gas

Carbon Dioxide (CO₂)

Tried because of thermal conductivity

Readily available and inexpensive

$\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3$ (carbonic acid)

Carbonic acid creates itching and rashes

Argon (Ar)

Studies show little value (as practiced) when used with air diving
(Effective with 6 fill/empty cycles to provide all Argon insulation)

Valuable when diving tri-mix (N₂, He, O₂; heli-air) or heliox

(Can't use breathing gas 'cause of heat loss with helium)



Second Layer: Argon Inflation System



KIT INCLUDES: HL413

- Aluminum 8 cu ft cylinder
- XS Scuba PRO valve
- Highland pony mount
- Highland compact first stage
- Mini tech pressure gauge
- Highland DIN cap
- Standard over pressure valve
- 22" Miflex quick-disconnect hose
- Argon sticker

MiFlex MQD22-BK

Low pressure quick-disconnect hose
Length: 22"
Color: black

Argon First Stage HL405

DIN 300 bar inlet
Factory set at 120 psi IP
Compact low profile size
Simple flow-by piston design

DIN Cap HL401

Machined Delrin construction
Seal the first stage from moisture
Protect threads on first stage
Attached nylon cord lanyard



**Valve on Bottom
Easier to control**

Connects to Suit Inflator

**May need 2 cylinders:
One to fill/flush 6 times
One for dive**

Second Layer: Aerogel ?

Low density, open-cell nanopore structure

~ 20 nm cells approximate air molecule movement in vacuum

Structure is ~ 95% air

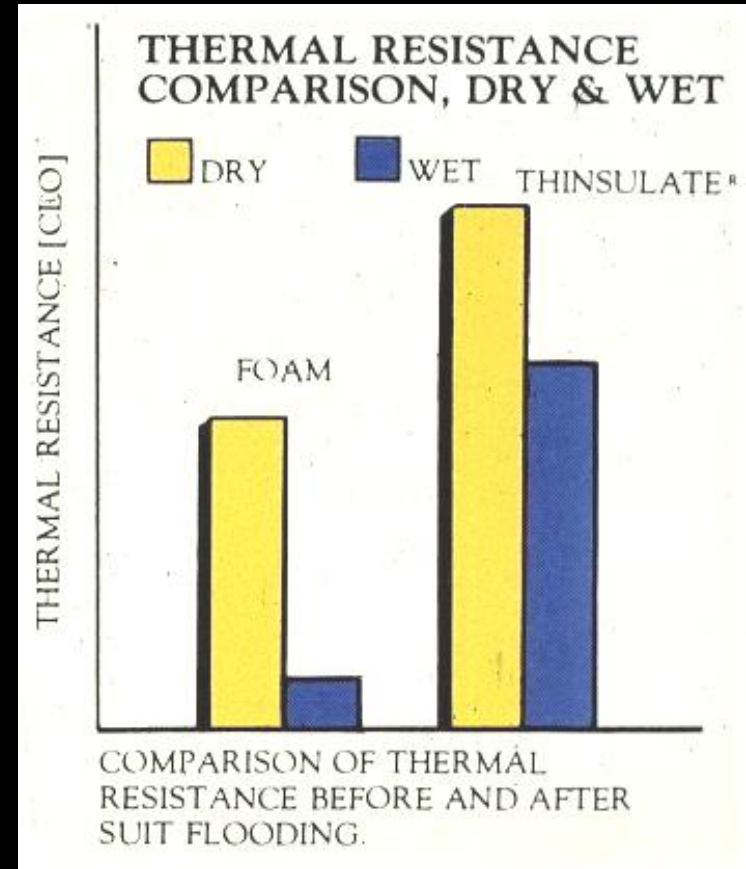
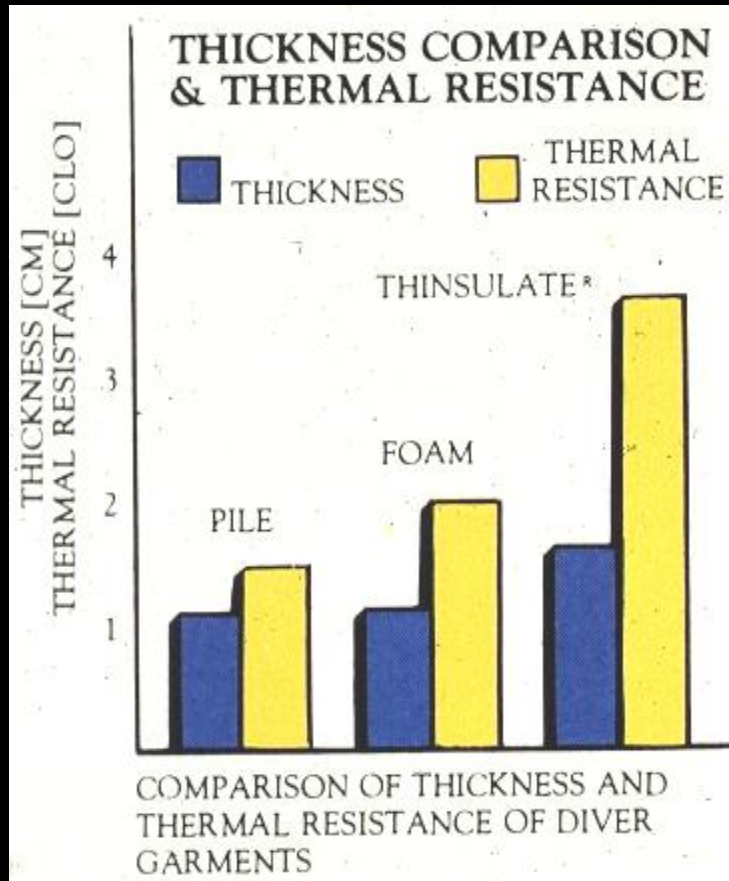
Extremely low thermal conductivity

Expensive: US Navy experimental dive suit; \$ 5,200,000

Underwear was 1,200,000

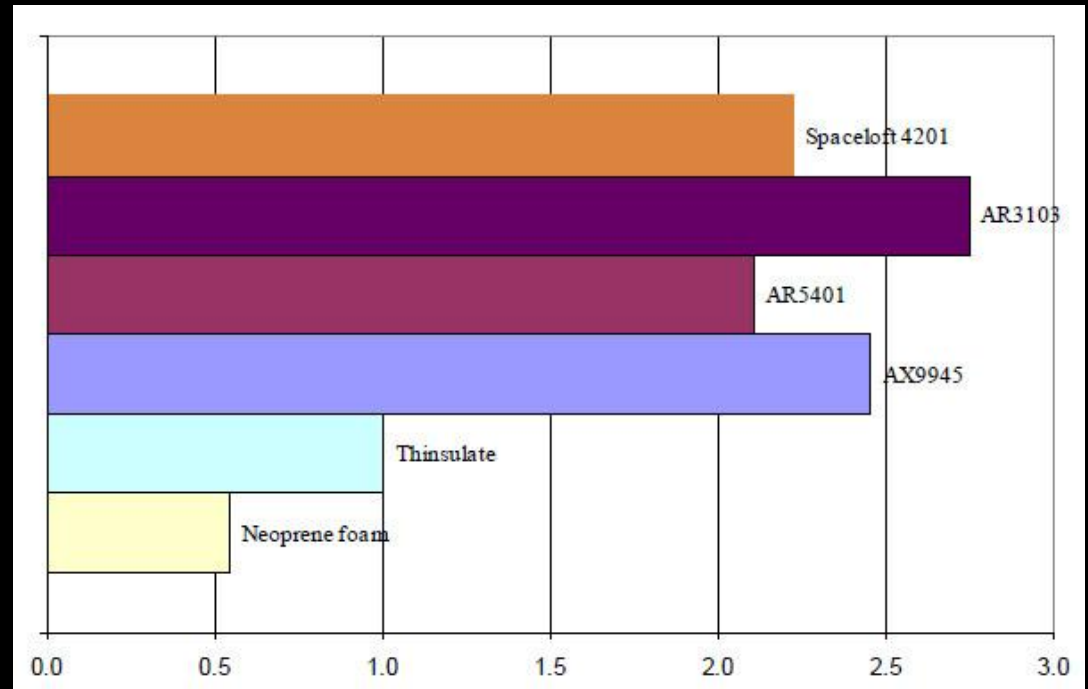


Insulation Value Comparisons



Thinsulate holds thermal protection even when submerged

Insulation Dry Value Comparisons



Top four are aerogels

Diver Ratings Of Underwear

Insulation
Value

Comfort

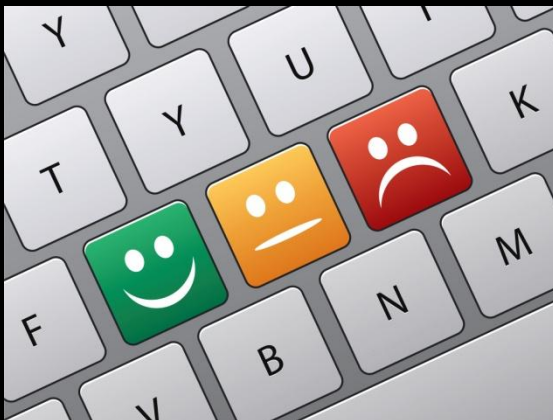
Insulation
When Wet

Thinsulate
Foam
Pile

Pile
Thinsulate
Foam

Thinsulate
Pile
Foam

Overall: Thinsulate Preferred



From 1982: Personal Test of Diving Underwear



THERMAL EVALUATIONS: TESTS

3/16" DUI "CAT" SUIT
1/4" COLD WATER HOOD
3-FINGERED MITTENS

FIRST LAYER: POLYPROPYLENE

50 F FRESH WATER
LITTLE MOVEMENT

UNDERWEAR

TIME TO FIRST SHIVER

BUNTING/ RADIANT BARRIER

28 MINUTES

ACRYLIC PILE

68 MINUTES

OPEN-CELLED FOAM

88 MINUTES

THINSULATE (C2)

128 MINUTES

From 1982: Personal Test of Diving Underwear

THERMAL EVALUATIONS : CONTROL



1/8" HOODED "CHICKEN VEST"
1/4" FARMER JOHN WET SUIT
1/4" COLD WATER HOOD
1/4" 3-FINGERED MITTENS

50 F FRESH WATER
LITTLE MOVEMENT

TIME TO FIRST SHIVER = 55 MINUTES

The bottom line in underwear selection

No single underwear package will

Work in all combinations of water temperature and workload

Divers need multiple packages

Experience needed to match package with diving conditions

Multiple divers on the same site may have different packages

But, each will have individually correct system for their needs





DUI'S

Thermal Guidelines

THERMAL STRESS IS

**The Greatest Limiting Factor
In Diving Today**

THERMAL STRESS IS

**Tolerated In Most Diving Operations
Which Is A Mistake**

THERMAL STRESS IS

A Factor In Most Diving Accidents

THERMAL STRESS IS

Predictable And Preventable

People Produce **HEAT** At Different Rates
People Lose **BODY TEMPERATURE**
At Different Rates

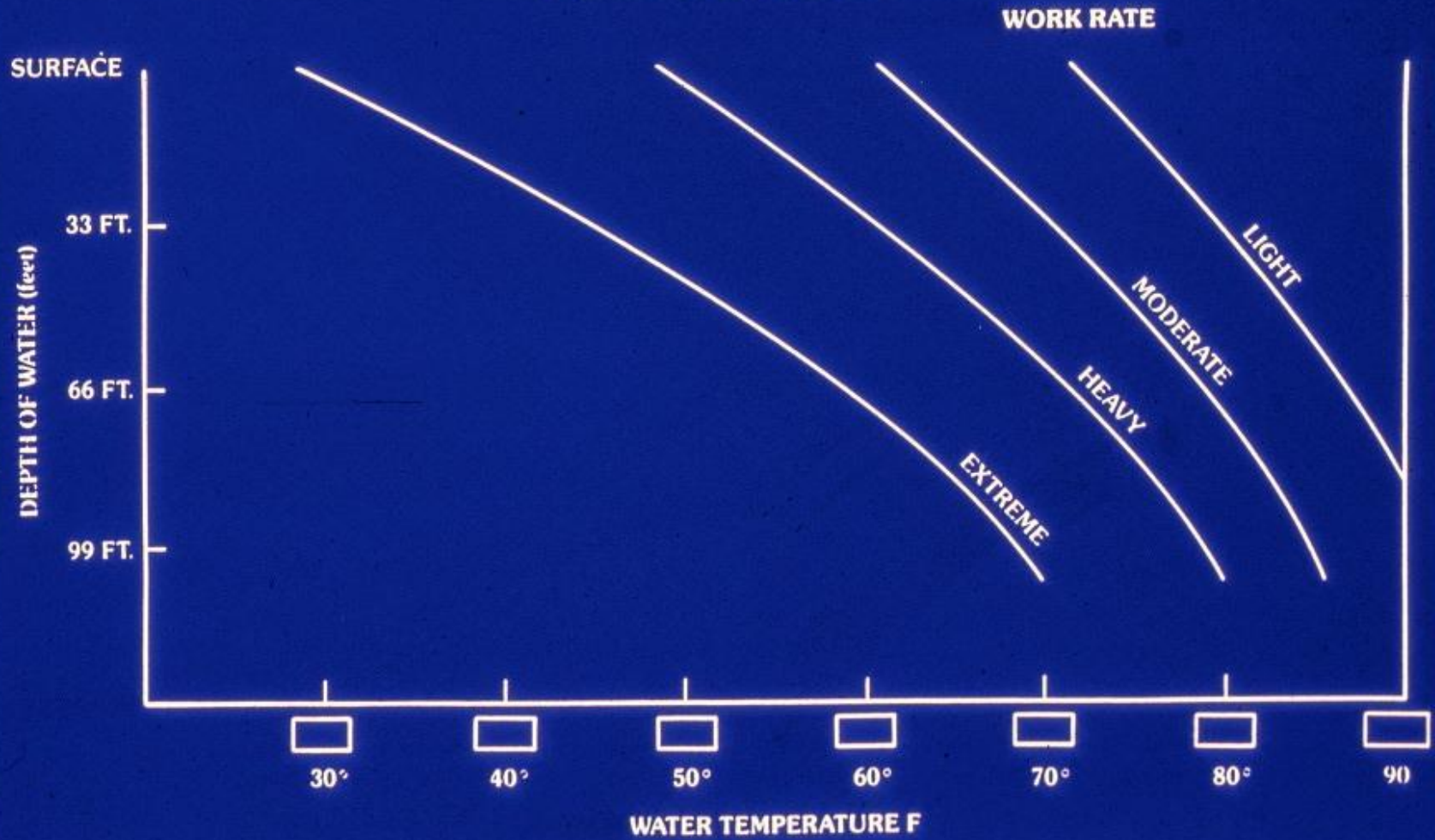
OUR GOAL:

**Each Diver Performing At 100%
Efficiency And Reliability**

EXERCISE RATE

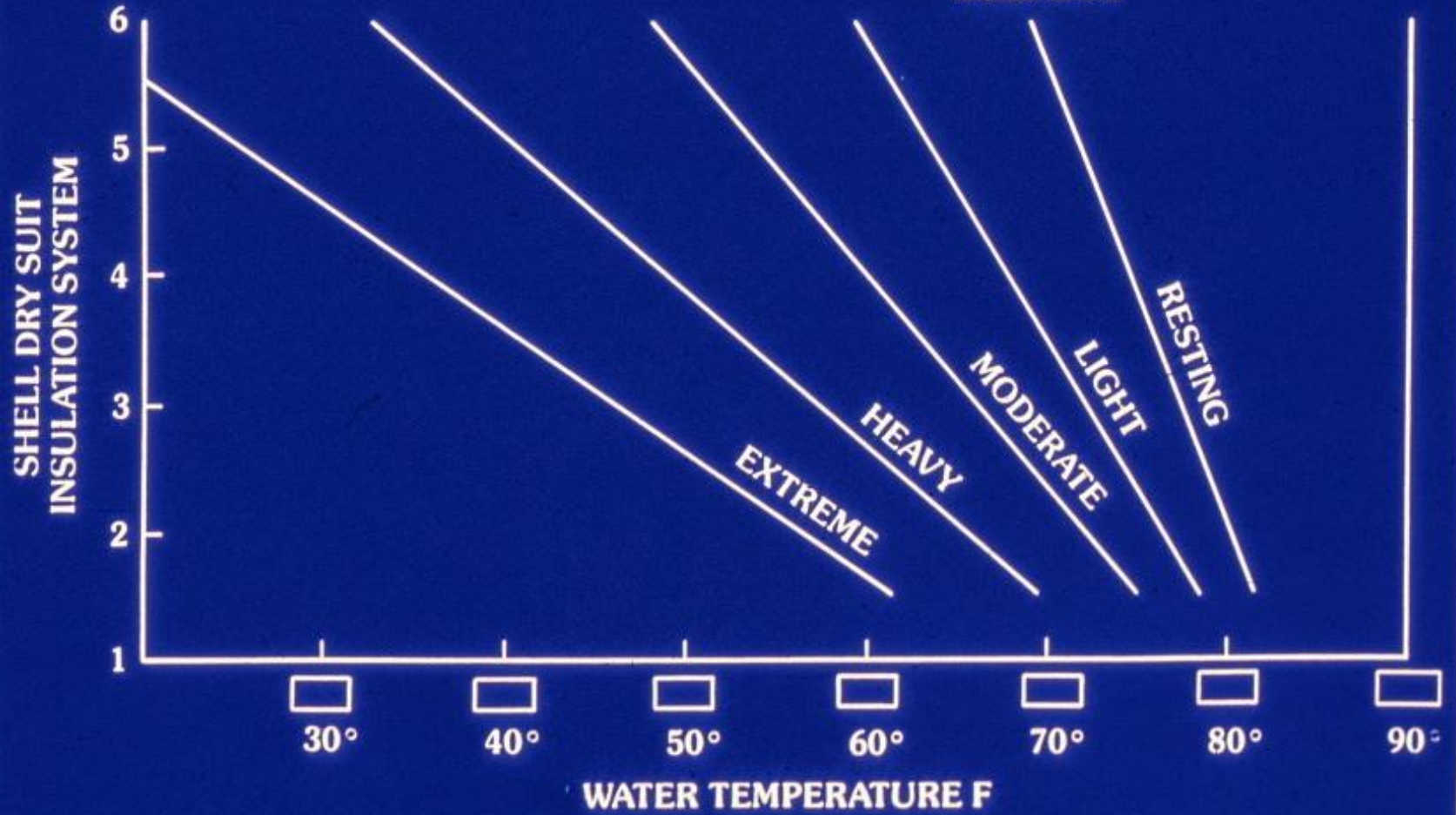
- Light** - Taking Photographs Or Observing
- Moderate** - Normal Swimming
- Heavy** - Strong Swimming Or Dragging An
Object Across The Bottom

WET SUIT PERFORMANCE PREDICTION CHART



DRY SHELL SYSTEM PERFORMANCE PREDICTION CHART

WORK RATE



PLUS RATING TABLE

Your Body Weight

		90	105	120	135	150	165	180	195	210	225	245
-4	-2	0	+2	+4	+6	+8	+10	+12	+14	+16	+18	+20

Degrees

**Find Your Plus Rating As Listed
Below Your Body Weight**

IF COMFORTABLE

✦ No Modifications

Example: 165 Lb. Person Is a + 10

IF TOO WARM

- Open Collar Shirt
- Loose Clothing

✦ Move Up 2°

Example: + 10° To + 12°

IF YOU PERSPIRE

✦ Move Up 4°

Example: + 10° To 14°

IF TOO COLD

- Button Up
- Wear Long Sleeves

✦ Move Down 2°

Example: + 10° To + 8°

NEED A SWEATER

✦ Move Down 4°

Example: + 10° To + 6°

IF YOU USE

A DUI CF 200 Dry Suit

✦ Move Up 4°

Example: + 10° To + 14°

DIVER

DRY SUIT + 10 DIVER

ACTIVITY			Insulation Level	Weight Added	
Heavy	Moderate	Light		Salt	Fresh
Water Temp °F					
74	78	82	A Expeditionary weight polypropylene underwear	_____	_____
64	72	76	B Single layer bunting or lightweight pile*	_____	_____
54	63	70	C 50°-65° DUI Thinsulate divewear*	_____	_____
47	58	66	D Double weight bunting* DUI pile plush, heavy-weight high quality pile* or V. foam	_____	_____
34	48	60	E 35°-50° DUI Thinsulate divewear*	_____	_____

Note: Includes appropriately matched boots and gloves.

*Also includes medium weight polypropylene underwear.

WET SUIT + 10 DIVER

WATER Depth Feet	Heavy	ACTIVITY	Light
		Moderate Water Temp °F	
0'	48	62	72
33'	60	70	80
66'	72	78	88
99'	78	84	

Temperature in order to be at thermal equilibrium

AUXILIARY INSULATION

Degrees F	Insulation	Weight Added	
		Salt	Fresh
+5° to +10°	Back-packing bunting or pile suit top and bottom	_____	_____
+10°	Heavy polyester or poly-nylon sweat pants and shirt	_____	_____
+5° to +7°	Heavy jogging suit	_____	_____
+5°	Mountaineering expedition weight or wool polypropylene top and bottom	_____	_____
+5° to +7°	Heavy wool/acrylic sweater	_____	_____
+5°	DUI plus 5 vest	_____	_____

EFFICIENCY AND RELIABILITY

TEMP	WET SUIT			DRY SUIT		
	DIVE NUMBER			DIVE NUMBER		
	1st	2nd	3rd	1st	2nd	3rd
70°F	100%	100%	100%	100%	100%	100%
60°F	100%	90%	80%	100%	100%	100%
50°F	80%	70%	50%	100%	100%	100%
40°F	50%	25%	*	100%	85%	75%
32°F	*	*		100%	75%	55%

*Not recommended unless involved in a life saving rescue.

Table based on 30 minute dives at depth of 50 feet.

MISERY INDEX

TEMPERATURE DIFFERENCE FROM THERMAL COMFORT °F	FOR DIVES LONGER THAN 20 MINUTES BUT LESS THAN 60 MINUTES RESULT
-5°	Diver will rewarm between dives.
-10°	Outer body shell will accumulate thermal debt, but can be tolerated.
15°	Degrade diver in water performance and accumulate body shell thermal debt.
20°	Significant performance degradation, poor efficiency.
-25°	Reduce diver to shivering and misery.
-30°	Should not be attempted.
+5°	Can be tolerated, take off glove or ventilate water through hood.
+10°	Must be careful, watch for signs of heat prostration. If occurring, terminate dive.
+15°	Substantial heat build-up, can lead to disastrous results.



Diving Unlimited International • 1-800 327-8439
1148 Delvan Drive, San Diego, CA 92102-2499

A DUI dry suit is thermal insurance where the dividend is always more than the premium.

WET SUIT + 10 DIVER

WATER Depth Feet	ACTIVITY		
	Heavy	Moderate	Light
Water Temp °F			
0	48	62	72
33	60	70	80
66	72	78	88
99	78	84	

Temperature In Order To Be At Thermal Equilibrium

MISERY INDEX

**Dives Longer Than 20 Mins. But
Less Than 60 Mins.**

TEMPERATURE DIFFERENCE

- 5° Diver Will Rewarm Between Dives**
- 10° Outer Body Shell Will Accumulate Thermal Debt, But Can Be Tolerated**
- 15° Degrade Diver In Water Performance And Accumulate Body Shell Thermal Debt**

TEMPERATURE DIFFERENCE

- 20° Significant Performance Degradation, Poor Efficiency**
- 25° Reduce Diver To Shivering And Misery**
- 30° Should Not Be Attempted**

TEMPERATURE DIFFERENCE

- +5° Can Be Tolerated, Take Off Glove Or Ventilate Water Through Hood**
- +10° Must Be Careful, Watch For Signs Of Heat Prostration. If Occurring, Terminate Dive**
- +15° Substantial Heat Build-Up, Can Lead To Disastrous Results**

COLD HURTS

HEAT KILLS

DRY SUIT + 10 DIVER

Activity			Insulation Level	Weight Added	
Heavy	Moderate	Light		Salt	Fresh
Water Temp °F					
34	48	60	E 35°-50° DUI Thinsulate Divewear*	—	—

Note: Includes Appropriately Matched Boots And Gloves. *Also Includes Medium Weight Polypropylene Underwear

DIVER _____

DRY SUIT + 10 DIVER

ACTIVITY			Insulation Level	Weight Added	
Heavy	Moderate	Light		Salt	Fresh
Water Temp °F					
74	78	82	A Expeditionary weight polypropylene underwear	—	—
64	72	76	B Single layer bunting or lightweight pile*	—	—
54	63	70	C 50°-65° DUI Thinsulate divewear*	—	—
47	58	66	D Double weight bunting* DUI pile plush, heavy-weight high quality pile* or V. foam	—	—
34	48	60	E 35°-50° DUI Thinsulate divewear*	—	—

Note: Includes appropriately matched boots and gloves.
*Also includes medium weight polypropylene underwear.

DIVER _____

DRY SUIT + 10 DIVER

ACTIVITY			Insulation Level	Weight Added	
Heavy	Moderate	Light		Salt	Fresh
Water Temp °F					
74	78	82	A Expeditionary weight polypropylene underwear	—	—
64	72	76	B Single layer bunting or lightweight pile*	—	—
54	63	70	C 50°-65° DUI Thinsulate divewear*	—	—
47	58	66	D Double weight bunting* DUI pile plush, heavy-weight high quality pile* or V. foam	—	—
34	48	60	E 35°-50° DUI Thinsulate divewear*	—	—

Note: Includes appropriately matched boots and gloves.
*Also includes medium weight polypropylene underwear.

DRY SUIT + 10 DIVER

Heavy	Activity		Insulation Level	Weight Added	
	Moderate	Light		Salt	Fresh
	Water Temp °F				
34	48	60	E 35°-50° DUI Thinsulate Divewear*	—	—

Note: Includes Appropriately Matched Boots And Gloves. *Also Includes Medium Weight Polypropylene Underwear

AUXILIARY INSULATION

Degrees F	Insulation	Weight Added Salt	Fresh
+5° To +10°	Back-Packing Bunting Or Pile Suit Top And Bottom	—	—
+10°	Heavy Polyester Or Poly Nylon Sweat Pants And Shirt	—	—
+5° To +7°	Heavy Jogging Suit	—	—
+5°	Mountaineering Expedition Weight Or Wool Polypropylene Top And Bottom	—	—
+5° To +7°	Heavy Wool/Acrylic Sweater	—	—
+5°	DUI Plus 5 Vest	—	—

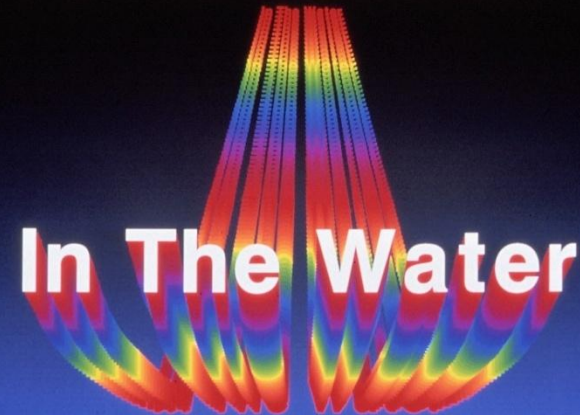
EFFICIENCY AND RELIABILITY

Temp	Wet Suit			Dry Suit		
	Dive Number			Dive Number		
	1st	2nd	3rd	1st	2nd	3rd
70°F	100%	100%	100%	100%	100%	100%
60°F	100%	90%	80%	100%	100%	100%
50°F	80%	70%	50%	100%	100%	100%
40°F	50%	25%	*	100%	85%	75%
32°F	*	*	*	100%	75%	55%

*Not Recommended

Table Based On 30 Minute Dives At Depth Of 50 Feet

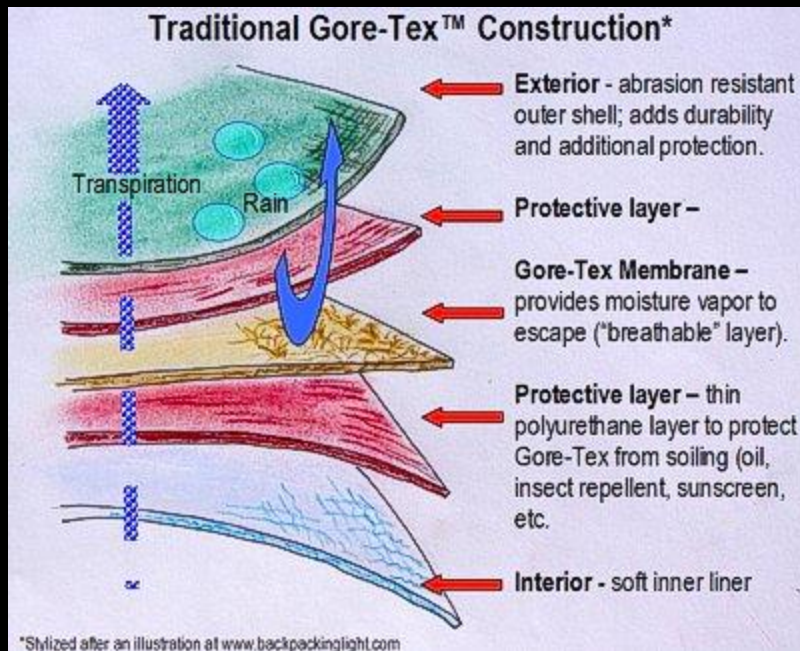
TOTAL COMFORT



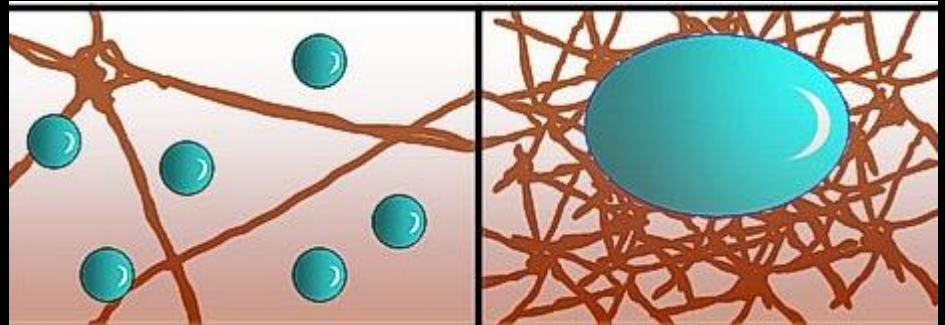
Third Layer: Gore Tex

Short for Gore's textile fabric

Used for outdoor wear; not intended for in-water use



Gore Tex membrane:
Excludes water droplets
Passes water vapor



9 billion pores per square inch
Each pore 20,000 x smaller than water droplet

Wash with warm water & breathable fabric detergent; no fabric softener or bleach

Third Layer: Dry Suits

Keeps the insulation dry

Protects insulation from abrasion

Allows efficient, reliable cold water diving





Wet vs. Dry Suits



Summary of Wet Suit Properties

Insulation: gas trapped in neoprene material
tight fit restricts water flow (conductive / convective heat loss)

Advantages: inexpensive
reasonable protection in temperate water environments
rapid deployment

Disadvantages: insulation (gas bubbles) decreases with depth
insulation decreases with age (gas bubble cells rupture)
buoyancy decreases with depth
ineffective in water below 60 °F
wind-chill on the surface
needs close fit
rush of cold water on entry
repair only when dry
chill increases air consumption



Summary of Dry Suit Properties

Insulation: separate from outer shell

variable to match diver to water temp, work load and comfort

Advantages: constant insulation thermal protection

constant insulation buoyancy

don't need perfect fit

easy field repairs

no cold water rush on entry

consistent air consumption

longer “dive season”

Reasonable post-dive thermal protection

Disadvantages: expensive

requires multiple undergarment packages

specialized training to use efficiently

longer deployment time

can overheat on surface

require more weight than weight suit



General Guidelines for Personal Thermal Protection

WATER TEMPERATURE (°F)											
Wetsuit Thickness	35	40	45	50	55	60	65	70	75	80	85
1-2 mm								← OK →			
3 mm							← OK →				
4-5 mm						← OK →					
6-7 mm					← OK →						
Over 7 mm				← OK →							
Drysuit	← OK →										

Cold Water is defined as $< 70^{\circ}\text{F}$

Suit Thickness



mm	inches
2	0.089
3	0.118
4	0.157
5	0.197
6	0.236
7	0.276
8	0.315
10	0.394
12	0.472
14	0.551

Can be listed in
either
Metric or English Units

Fraction	Decimal
1/8	0.125
1/4	0.250
1/2	0.500





Wet vs Dry Suits



WETSUITS

- Warmth from water trapped close to skin
- Wet = Warm
- Neoprene insulation
- Inexpensive option
- Multiple styles
- Multiple thicknesses



DRYSUITS

- Warmth from full body protection
- Wrist and neck seals
- Integrated booties
- Fully waterproof
- Loose fitting
- Expensive



Dry Suits: Styles



Style: Canvas and Latex



Historically, first in common use
Mainstay of commercial & military salvage
Used with “hard hat”
Required heavy weights to offset buoyancy
Required surface support crew
Out-dated (except for Hollywood)



Style: Uni-Suit

Thick (6.5 mm) foam neoprene
(wet suit with wrist & neck seals)
Extremely buoyant
Required ~40 pounds weight
Valve placement awkward to vent
Designed to use without BCD
Very rugged
Not designed for swimming;
For commercial / military salvage divers



Out dated technology

Style: Vinyl



Inexpensive

Non-breathable

Stiff

Not very rugged

Very little use in diving

Commonly used in rain and sauna suits

Outdated dry suit technology

Style: “Pack Cloth”



Polyurethane laminate: urethane coating on nylon

Nylon weight/thickness described as denier

Higher the denier value, the thicker the fabric

Inexpensive, introduced dry diving to many

Not compression at depth

More reliable than foam

No inherent thermal protection

Easily repaired

Not too flexible; like “diving in a garbage bag”

Some movement of air with position change

1980’s technology

Style: Tri-laminate (TLM)

Three layers: polyester, butyl rubber, and polyester

Butyl rubber layer increases flexibility

Material originally developed for NATO chemical warfare

Combines light weight with excellent abrasion resistance

Resistant to chemicals, ozone , and smog

Quick and easy to repair

With telescoping zipper, can obtain a more snug fit

Responsible for increased popularity of dry suit diving

May de-laminate with time



Style: Vulcanized Rubber



Commercial, military, high end recreational
No seams ... suit is vulcanized to single unit
Waterproofing on outside
Generally loose fit
Durable
Easily repaired
Usually zipper across the back
Expensive (but, cost effective for avid diver)



Used in Hazmat diving
rubberized exterior easily decontaminated

Style: Crushed Neoprene



Crushed neoprene (DUI's CLS 200)

CF 200 between layers of nylon

True 4-way stretch

Extremely rugged (most durable suit made)

Can be tailored (many options) to individual needs

Some inherent thermal protection

Telescoping torso

Self-don zipper

Must be dry to repair

Very little internal volume (less air movement)

Expensive (but , cost effective for avid diver)

My CF 200x suit (purchased 1984) still viable.



Style: Mixed CF 200 & TLM

Crushed neoprene bottom for strength and durability
Top portion TLM for lightness and comfort
Less expensive than full CF 200 suit





Haz-Mat Suits

Totally Encapsulated
Dual Seal Valves
Extremely Rugged
Require mated helmet



DUI CXO



AquaLung HazMat



Viking HD



Newt



Exo



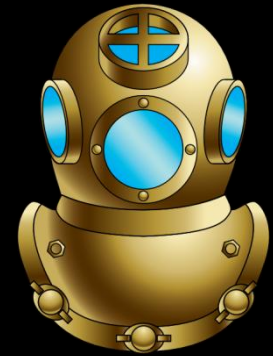
Jim



Sea Wasp

Hard Shells

1 Atmosphere Systems
Very expensive



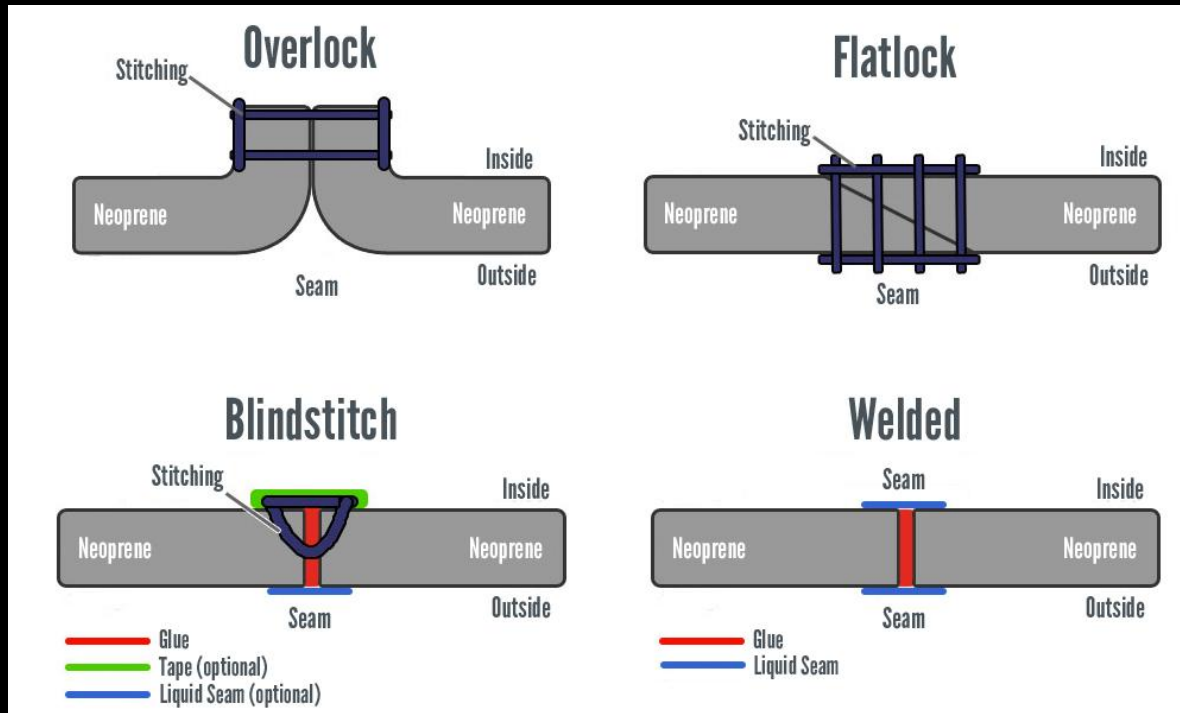


Seam Construction



Seam Construction: Foam Neoprene

Like a wet suit: Glued and Sewn



The more steps, the better the seal, the greater the cost

Seam Construction: Vulcanized Rubber

No seams

Suit assembled with uncured rubber

Entire outer shell vulcanized

Provides single continuous coating

Difficult to alter

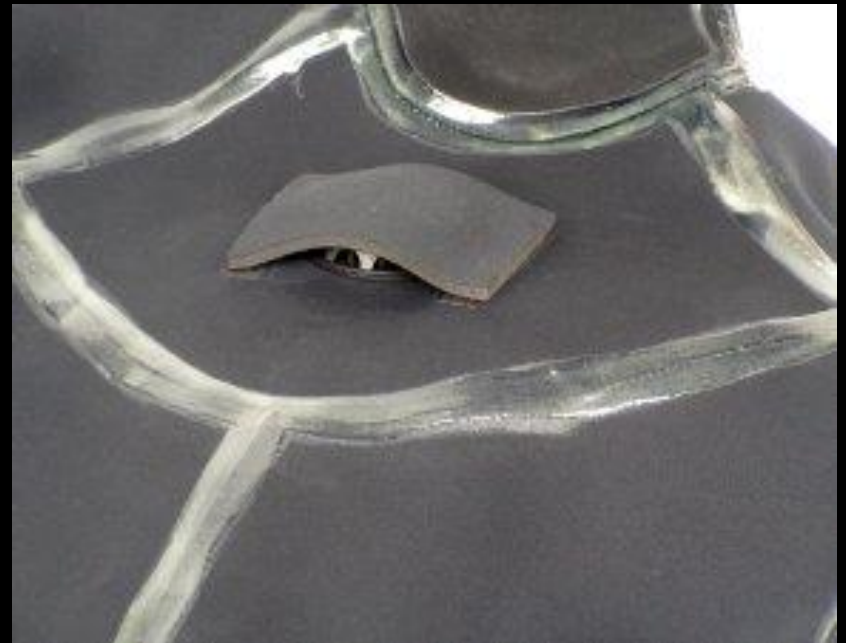
Difficult to tailor to individuals



Seam Construction: TLM & CF 200

Material sewn (typically 7 threads) , then glued
Nylon inner coating removed at seam
Elastomer coating applied
Seams taped

Very durable
Commercial grade suits:
Heavier seal (worth the price)





Neck Seals



Neck Seals: Neoprene

1/8" neoprene “fold-under”

Strong

Little stretch

Some thermal protection

Most popular neck seal

Longer life than latex

After dive: dry, rub with unscented talc

Measure and trim carefully ... too tight can restrict breathing



Neck Seals: Latex

Thin latex cone

Comfortable

Somewhat fragile

Enormous stretch

No thermal protection

Must trim latex cone to neck size

After dive: dry, rub with unscented talc

Measure and trim carefully ... too tight can restrict breathing



Neck Seals: “Bellows-Style” Latex

Thin latex cone with bellows

Comfortable

Somewhat fragile

Enormous stretch

No thermal protection

Must trim latex cone to neck size

Designed for very large or very small necks

After dive: dry, rub with unscented talc



Neck Seals: Latex (Viking)

A more robust “bellows” seal



Neck Seals: SI Tech Quick Neck



SI-Tech Latex Quick Neck
Glue ring to neck area of suit
Use tool to attach latex neck seal

Neck Seals: ZIP (DUI)

Latex or Silicone

Allows rapid replacement

Groove on neck seal fits into slot on suit



Neck Seals: Apollo Bio-Seal



 bio-neck seal

Cosmo gel (1500 % stretch)
Adds additional sealing surface
Extremely rugged





Wrist Seals



Wrist Seals Neoprene

Neoprene core

Two types: cone (most common) & fold under (warmest)

Lycra (for strength) outer covering

Only expands 106 % (slows entry and exit)

Warmer than latex

Problem: small leaks along “wrist channels” (from flexing)



Store in bag containing unscented talc

Wrist Seals Latex

Driest Seal

Latex expands 400% (easy entry and exit)

Expansion useful for a variety of glove systems

Short life-time (gets gummy with time)

Typically sold very long; need to trim to size

Two major styles: bottle or cone

Fit critical with bottle seal



Store in bag containing unscented talc

Wrist Seals ZIP (DUI)

Latex or silicone

Designed for easy replacement of old/broken seals

Suit has fitting on wrist

ZIP cone is inserted into wrist ridge and cut to aize

Zip can be added (send dry suit to DUI) to any suit



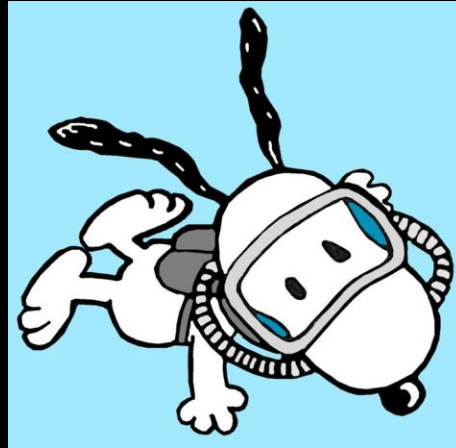
Wrist Seals: Apollo Bio-Seal



 bio-wrist seal

Cosmo gel (1500 % stretch)
Adds additional sealing surface
Extremely rugged





Valves



Valves: Inflation

Chest Mounted

Press to inflate suit

Allows suit inflation to offset suit squeeze

Two connector styles:

DIN /QD (Like BCD fitting)) and CEJN (easier release)

Proper hose comes with the valve



Valves: Inflation

Desirable features:

Easy to operate with thick gloves/mittens

Easy to connect / disconnect with gloves/mittens

No sharp edges

Sharp edges on valves major source of dry suit punctures

Always store inflator valves with protective cap

Self-don zippers: arrange hose parallel to zipper



Cover Guard

// to zipper



Valves: Inflation

Can open valve to examine seals

Do not use silicone oil or grease on seals

Cement inflator assembly to suit with aquarium cement

Do not use aqua seal



Valves: Haz Mat Inflation

Has more chemically resistant seals

Two different seals

On-Off switch at the inlet valve

Easy to operate with thick gloves/mittens



Valves: Deflation (Exhaust)

Usually shoulder mounted

Sometimes on wrist or lower leg

Allows release of air on ascent

Two types:

Push to deflate

Push to deflate with auto-dump



Valves: Deflation (Exhaust)

Desirable features:

Easy to reach / operate with gloves /mittens

Auto-dump:

Can adjust release pressure

Close on descent

Open on ascent

Raise shoulder to level and valve auto-vents



Set release pressure (1-10" water) by rotating ring
Requires experience to use effectively



Zippers



Zippers

Provides water proof seal of entry/exit point

Early seals same zipper as NASA space suits

Modern suits a bit cheaper

Two common placements: torso (self-don) & across shoulders



**Zipper teeth hold
rubber sealing surfaces together**



Zippers: Between the Legs



Developed for Norwegian military
Crawl through seal to enter exit suit

Advantages:

Allows excretion without removing suit

Disadvantages:

Cumbersome entry

Requires assistance to open / close zipper

Requires careful aim

Zippers: Across the Back

Runs from one shoulder to the other across the back

Advantages:

Least expensive seal

Easy entry / exit

Disadvantages:

Tend to swim with bent arms

Extended crotch: extra air volume

Zipper vulnerable to back pack abrasion

Typically requires assistance to open / close zipper



Zippers: Torso or Self-Don

Runs diagonally across front

Extended (telescoping) torso

Enter suit, fold down torso

Advantages:

Self-donning

Snug fit with good flexibility

Minimum extra air volume

Can use as relief zipper

Can use to ventilate between dives

Disadvantages:

Expensive

Possible wear on zipper



Zippers: Torso or Self-Don

Some suits include a cover to protect the self-don zipper



Zippers: Front



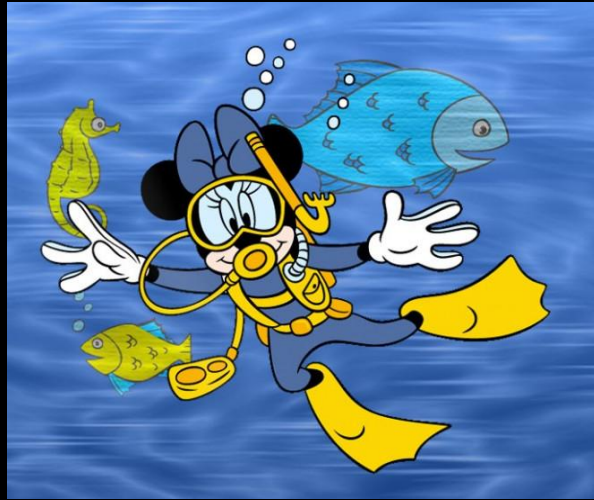
Zippers: Relief

More common on sailing & kayaking suits

Offers another failure point

Redundant with self-don





Hoods



Hoods

Purpose: restrict heat loss from the head

This loss is not trivial

Need to protect head and neck



Hoods: Wet Suit

Commonly used

Must use hoods with little neck protection

Cold water designed to be under wet suit jacket

Not possible with dry suit neck seal



Hoods: Dry Suit

Thicker neck

Especially important for latex neck seals

DUI has insulated vented hood

Allows air bubbles to self-vent



“No-Nose” Hoods



**Mask seals on outside
Slit for regulator**

Unwise for full face masks

Hoods: Attached



Considered warmer

Viking has totally dry hood

Cumbersome to set up

Typically a commercial suit

Requires tender to assist

Hoods: Full Face Mask

Have soft rubber area for mask seal
Mask seals on outside of hood



Exo-26



Guardian



Aga

Surface Head Covering

Significant heat loss on surface :

IR radiation from head

Evaporative energy from hair and suit

Wind chill

Best to keep head covered



Boots

Cheaper suits have socks: Require over-boot

Need room for insulation

Attached boots preferred

Can get variety of soles to suit diving sites



Over-Boots

For extreme needs of protection or traction

worn over attached boot

Worn over suits with socks



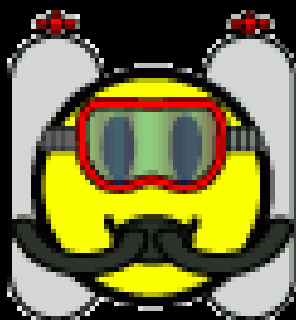
Commercial Thor Overboots

These overboots are designed to be worn on top of the standard fitted boots and are intended to offer extra protection and also allow the diver to place LEAD INSOLES for extra weight and buoyancy control





Gloves



Gloves

No single glove or glove system perfect for all scenarios

Multiple diving profiles require different glove set up

Hands (especially fingers) easily chilled

Thermograph of hand area

Fingers → major source of heat loss



Gloves

5-finger wet suit gloves are inadequate
3-finger and mittens sometimes used
wet fingers rapidly lose heat



Gloves: Dry Gloves With Wrist Seal

Wrist seal on glove over lays wrist seal on suit



Putting on second glove cumbersome

Gloves: DUI Dry Gauntlet

Kevlar palm & fingers

Liner for warmth

Extra thickness on back of hand

Seals over wrist seal on suit



Putting on second glove cumbersome

Gloves: Rigid Wrist Rings

Rigid rings on glove and suit mate together
Keeps latex wrist seal intact
Room for multiple different thermal linings
Started “dry hands” technology



Gloves: DUI Dry ZIP Glove

Requires mating surface on dry suit wrist
Wrist seal replaced with the glove



Gloves: Viking Dry Glove

Requires mating surface on dry suit wrist
Keeps latex wrist seal intact





Weights



Standard Weight Belt



Can be harsh on zipper

Difficult to vary weights

Difficult to manage with heavy weights

Without “contraction mechanism” can slip at depth

Best used with plastic coated weights

Lead is neurotoxin

Sharp edges can abrade suit

Weight Belt With Pockets



Pockets filled with lead shot
Easy to vary weights
Limited capacity
Usually no “contraction mechanism”

Standard Weight Belt - Modifications



Double Buckle

Introduced for river diving
More secure than single buckle
Both open same way



Homemade Suspenders

Puts weight on shoulder

Unwise:

Difficult to ditch (3 buckles)

DUI Weight and Trim System



Weight supported by shoulders
Pull cord weight release
Worn under most BCD's
Holds maximum 40 pounds



SeaSoft Weight and Trim System



Commercial grade harness
Weight supported by shoulders
Pull cord weight release
Worn under most BCD's
Holds maximum 60 pounds

BCD– Integrated Weight System



Every vendor has different design
Need to try several
Pull-down dump desirable

Integrates buoyancy compensator and weights
Requires familiarization

Practice dropping weights on surface at end of dive

Ankle Weights

Keep feet down

Restrict air flow into feet

Generally not used by experienced dry suit divers

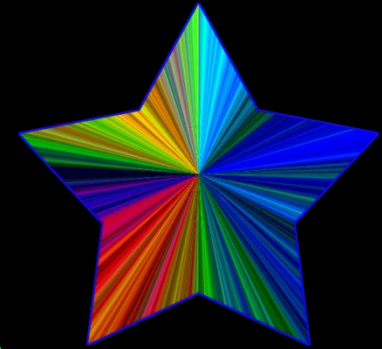




Options



Colors



NYLON COLORS INCLUDE:

AQUA	
BLACK	
BLUEJAY	
FUCHSIA	
GRAY	
NAVY BLUE	
NEON PINK	
NEON YELLOW	
NEON GREEN	
ORANGE	
PURPLE	
RED	
ROYAL BLUE	
SILVER	
YELLOW	

**Originally Only Two Colors
Black:**

**Warmer (absorbs more radiation)
“Look like seal” or “look like predator”**

Orange:

Bright color, easily visible

Now, multiple color options available



Fins

Insulation increases foot size

Fin pocket needs to be larger than for wet suit

Need larger, stiffer fin to overcome suit drag

Need strong strap to securely hold fin

Fins with holes not preferred (impalement risk)

Fin keepers: firmly secure fins in place

Concern that inversion will “blow away” fins



Fin Keepers



Suspenders

Secures crotch for tight fit

Holds dry suit bottoms when suit opened for surface interval

Suits manufactured after 2008 have replaceable suspenders



No suspenders sometimes awkward during surface interval

Pads & Protection

Used to reinforce (prevent abrasion)

Knee pads standard

Larger, thicker knee pads additional

Elbows typically additional



Gaitors



Chaps



Kevlar

Pockets

Variety of sizes and colors to suit needs

Knife pocket essential

Key pocket (inside suit) a good idea



Dry Suit Hangar

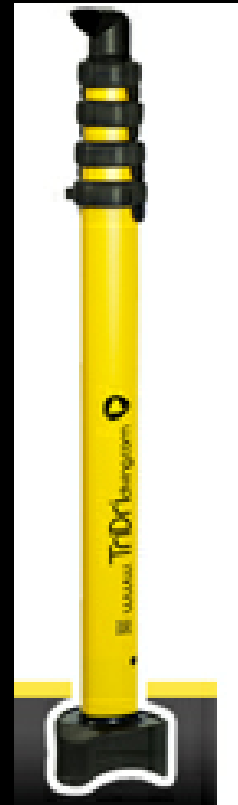
Hang suit by feet to facilitate drying



Dry Suit Dryer

Commercial systems

Home-made (PVC pipe and hair dryer)



Repair Kit

General: for leaks and tears

Manufacturer Specific: neck and wrist seals; zipper



Carrying Case / Bag

Want undergarments separate from suit
Typically, manufacturer dependent





At Depth Urination



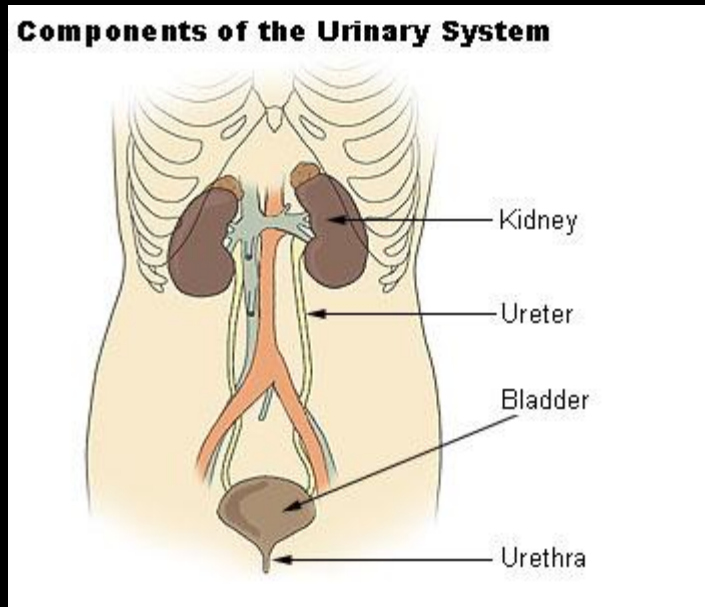
Immersion Diuresis

Combination of cold water and pressure

Moves fluid from periphery to central core

Excess Fluid in circulation removed by kidneys

Fluid moved to the bladder



Simplest Solution: Depend

Simple inexpensive urine collection



P-Valves

Diving Condom

Tube carries urine to dump valve

1-way valve dumps urine to outside environment
(failure can cause severe barotraumas)

Condom is a vasoconstrictor

Penile DCS has been reported



Needs disinfection after use
To prevent infections



She P-Valves

Allows females to plug into the P-valve

Not anatomically correct for all



for women costs £71. For
further details visit
www.dirdirect.com

Dry Suit Urine Collection Device (DUCD)

Urine collected during dive and dumped post dive





Choosing A Suit



Choices



Consider:

- Environment
- Surface Exposure
- Personal Comfort
- Frequency of Use
- Other Uses
- Maintenance
- Fit
- Cost

Choose for your needs

General Considerations



No manufacturer has “Best Suit”

For every diver, in every diving scenario

Dive shops are “franchise operations”

So, visit many shops

Examine many manufacturers

Talk to Divers

Check reviews on internet (Carefully)

If possible, dive the suit

Choose Best FOR YOU!

Whenever possible, support a local dive shop

Use Internet as “last resort”

General Considerations

For each manufacturer:

Reputation

Length of time in business

Warranty

Access to Repairs

Are commercial grades available

Best for avid diver because of rugged reliability

Instructional materials

Repair kits

Accessories/upgrades





Final Decision

**Choose best fit and comfort
For
Your diving needs
And
Your diving budget**





Leaks



Small Amounts of Water are Common Post-dive

All suits eventually leak a bit

(Damp, OK, as long as warmth maintained)

Sealed Suit

100% humidity leads to condensation

Condensation + perspiration:

can add ~1 cup moisture into suit during dive



Leaks: Zipper

Most common problem: failure to completely close

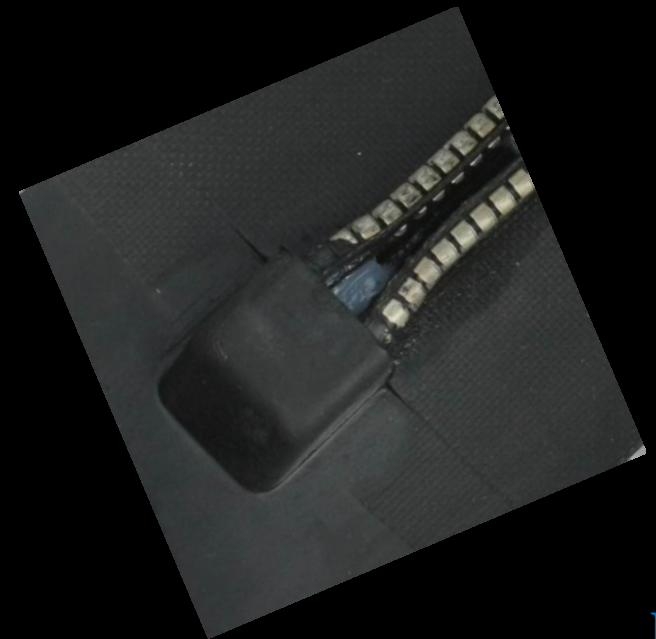
Also, dirt / debris in zipper seal area

Closely with a snug pull

Clean zipper before and after every dive

Lubricate only with paraffin wax or Zip Tech

Never use silicone



Leaks: Seals

Pay particular attention to neck seal
(Want a totally smooth surface)

Rubber deteriorates with age

Latex will get gummy

Replace when gummy or torn

Lubricate with dry, unscented talc

Never use silicone

Look for:

Hair under seals

Protruding underwear

Tears and stretches



Leaks: Valve Stem

~ 75 % dry suit leaks from sharp burs on the inlet valve stem

Sharp edge cuts fabric during storage

Always store with stem covered & valve on outside of folded suit



Leaks: Outlet Valves

Improper adjustment

Dirt / sand in mechanism

Open in strong current

Worn components (seals and spring)

Rinse thoroughly after every dive

Never use silicone

Attach with aquarium cement, not aquaseal



Leaks: Suit Fabric

Most common problem:

De-lamination of polyurethane coating

De-lamination of layers in trilaminate (TLS) suits

Weeping (gas cell rupture) in neoprene based suit

Or

Suit puncture, rip, or tear





Care & Maintenance



Seals

Occasionally wash with mild soap and water
Removes body oils and environmental grime

Treat with dry, unscented talc

No silicone



Talc Bag

Dry Suit

After every day of diving:

Rinse suit (water pic) in shower

Run water through exhaust valves

Rinse closed zipper teeth with water pic

Hang by heels to dry



Avoid:

Sunlight, volatile organics, electrical motors (ozone)

Store:

Rolled or folded

Guard on inflator valve stem

Inflator valve & closed zipper on outside

Zipper

Clean with soapy water & tooth brush (Vertical strokes)

Lubricate (on outside of zipper)

pure paraffin wax, Zip Tech, or DUI Zip lube

Store unzipped

No silicone



Silicone Spray

Do not use any silicone product!

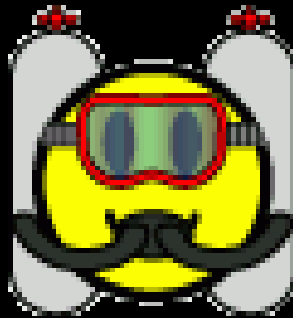
Loosens / degrades seals

Makes repairs impossible





Repairs



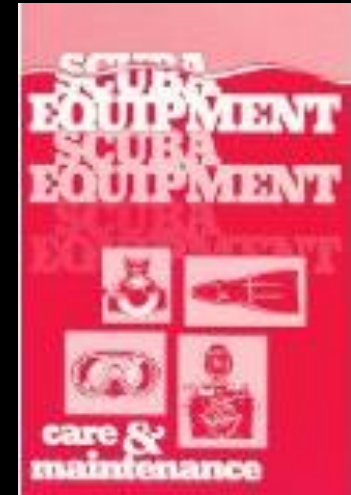
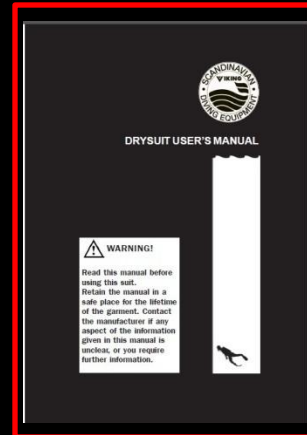
Dry Suit Repairs

Expensive, so more you can do, the less costly the diving
Info Sources:

Manufacturer's Manual

Manufacturer's Web site

U – tube videos



Finding Leaks

1. Post-dive: feel suit for localized wet spots

Use soccer ball or balloon to fill neck; plastic cups for wrists

Inflate

Spray with soap solution

Leaking air will provide bubble source

2. Wear suit, overinflate, have someone spray suit with soap

3. Place a strong white light inside the suit in a dark room

Look for escaping light



Repairing Leaks

Use Aquaseal (1:1 with cotol) on inside of suit

Well ventilated room

Let dry for ~30 minutes, then reapply

Let dry 24 hours

**Cotol
Speeds
Drying**



Major Repairs

Zipper, neck seal and wrist alterations (installing ZIP)

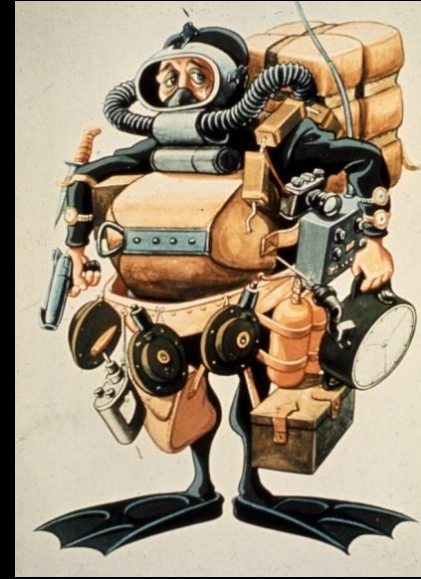
Best done by professional

Commercial quality repair

Warranty

Some (DUI) test suit integrity





Equipment Concerns



Weighting

Each equipment configuration/underwear: different weights

Standard weight belts chafe zipper

Integrated weight systems preferred

Ankle weights:

“training wheels” for fearful diver

offset center of buoyancy

increase leg work



Setting buoyancy:

~ 500 psig in cylinder

BCD and Dry Suit empty

Adjust weight to float at eye level

Inhale: rise

Exhale: sink

Buoyancy Compensator (BCD)

Always worn

Used only on the surface or emergency

Need access to inflation valve

Buoyancy at-depth controlled with suit



Hose Length

Long enough to reach BCD and Dry Suit inflators

Without strain on hose or valve

Best not to cross zipper

Short enough to avoid entanglement loops

Often requires custom length hoses



See anything that needs improvement?



See anything that needs improvement?



Mask on forehead

easily lost

picks up body oil; promotes fogging

some consider it sign of stress

Dry suit hose crosses zipper

potential premature wearing

Weight belt not trimmed

potential loss of weights from snag

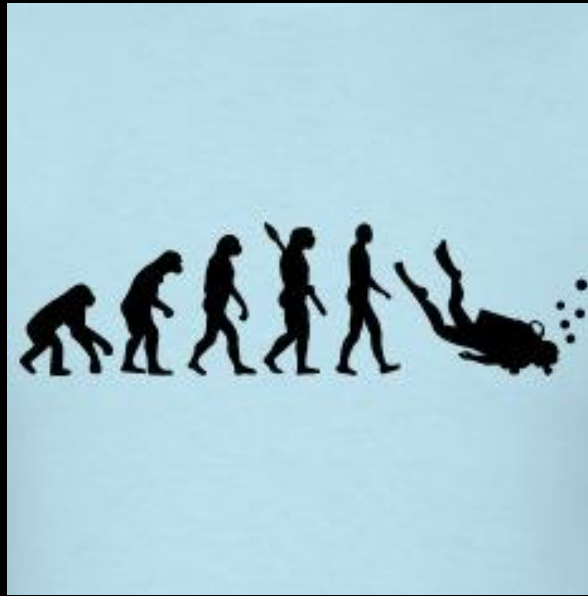
Weight belt crosses zipper

potential premature wearing

Probably should be wearing gloves

2nd regulator may not be secured

(Not in “golden triangle”)



Diving Techniques



Pre-Dive Check

Assemble all gear before putting on dry suit

(Limit overheating)

Lubricate zipper

Check suit for integrity



Donning Underwear

Best done in a seated position

Should be on dry ground to protect booties

Needs to be free of seals and zipper



Donning Dry Suit

Follow manufacturer's recommendation for your style zipper



Remember to fully close zipper

Closing zipper

Back Zipper: Best to have another close



Remember to fully close zipper

Check Seals Before Entering Water

Look for anything (usually underwear) that interferes with seal
Seals should be smooth with no folds



Pre-Dive Buddy Check

S = Signals

E = Emergency procedures (air sharing)

A = Activity of dive

B = Buoyancy Control check

A = Air On

G= GO Diving!



Entering Water

Dry Suit: deflated as much as possible
BCD inflated to maintain flotation
Final check with buddy
To descend: vent BCD



Entering Water

Without BCD

Must overinflate suit (stresses seals and zipper)

Difficult to maintain vertical orientation for descent



Many Michigan deaths have been attributed to diving a dry suit without BCD
Diving a dry suit without BCD is considered “death seeking behavior”

Descent

Control descent with small bursts of gas to Inflate dry suit

Only enough to offset squeeze

should feel compression on legs in vertical position

want to minimize amount of air (moving center of buoyancy)

Close (or ½ max) auto exhaust



Descend in feet first vertical position
best visibility of site and buddy
best position to equalize ear pressure
“clear” with Frenzel

At Depth

Should feel suit hugging the body ... no moving gas pockets

Common Error: adding too much gas to suit



Ascent

Manual: lift arm; press vent as needed to release expanding gas

Auto: lift arm; open valve; hold arm level with shoulder



Manual



Auto

Post-Dive

Remove dive gear
Immediately cap inlet valves
Brush away dirt
Store





Potential Problems



Potential Problems

Problems should be mere inconveniences, not life threats



Practice Prevents Piss-Poor Performance

Flooded Suit

Can be from rip, tear or exhaust valve failure

Typically, little water entry 'cause suit is sealed system

Immediate problem is hypothermia

Can easily ascend to surface

Problem is exiting the water with excess weight

Non-synthetic undergarments absorb water weight

Additional mass from water in suit



Inverted Position

“Finger walking” Desirable low impact technique
creates little silt
saves air



Recovery:
Push forward with hands
Creates horizontal swimming position

Air inside lower leg makes this technique easy

Inverted Position – At Depth

Very rare in properly weighted/diver

Drive hard downward ... then arch back as much as possible

This will change orientation to vertical position

Vent air

Or

Drive hard downward

Tuck and roll forward into vertical position

Vent excess air



Inverted Position – On Surface



Can be lethal, especially if regulator has been lost

Problem: feet out of water ... no downward driving force

Solution:

First, try to tuck and roll

once head above feet, air moves to shoulders

Over inflate suit (while exhaling) ... drives shoulders to surface

Last resort, drop weights, add air to bcd

Once feet in water, you have propulsion to move forward

If face down, can try crossing legs and rolling hard



**Mi divers have been found in the St. Clair River
drifting inverted, regulator dangling, air in cylinders**

Stuck Inflator Valve

Classic solution:

Unhook inflator hose; vent air from dump valve

Problem: maynot work ... on surface before you have time to un-hook

Runaway valve generates rush of air ... sounds like a freight train

Lay on back (create more drag) with arms and legs spread

Relax, breathe normally and enjoy the ride

Once in position, try to remove inflator hose with dominant hand





Open Water Exercises



Open Water Skills

Dive 1

Establish Correct Buoyancy

With all air removed from BC and suit, should float at eye level

Rise and fall with inhalation

Redo at end of dive

Practice ascent and descent along vertical ascent lines

While remaining stationary in mid water, assemble H shaped puzzle

Swim across variable terrain to practice buoyancy controls



Dive 2

Practice finger walking

Practice recovery from inverted (at depth and on surface)

Practice flare and dump for free for simulation

Dive 3

Practice flooded suit

(Simulate with added weight)

Remove and replace DCD /scuba

Dive 4

Connect & disconnect inflator hose

Just swim over terrain



**Dive Long
And
Prosper!**

