

**Navy Experimental Diving Unit**

"We are the diving technical experts for the U.S. Armed Forces"



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**The Role of Supercritical Cryogenic Air in Diving in Warm, Chem/Bio Polluted Water**

John R. Clarke



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- Chemical protective garments greatly exacerbate heat stress, especially in warm environments.
- In a perfect world, a user's breathing gas would serve as an internal and external body coolant.



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**Cryogenic breathing sources make that ideal solution a reality.**

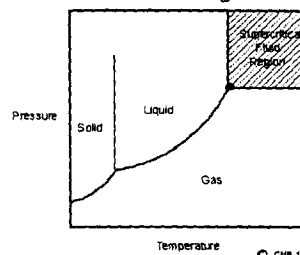
Farenheit	Celcius	Kelvin	comments
212	100	373.15	water boils
32	0	273.15	water freezes
-40	-40	233.15	
-297	-183		liquid oxygen boils
-300.42	-195.79	77.36	liquid nitrogen boils
-452.11	-268.95	4.2	liquid helium boils
-459.67	-273.15	0	absolute zero



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- Liquid air and oxygen have a number of safety issues associated with them.
- Those safety issues are eliminated by the use of supercritical air.

Phase Diagram



Supercritical fluids are produced by heating a gas above its critical temperature or compressing a liquid above its critical pressure.

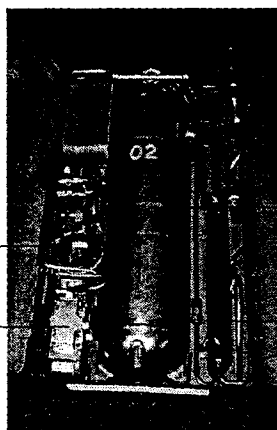


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- Supercritical air has a temperature of -320° F at ~ 900 psi.
- It is a single phase fluid with the same density as liquid air.
- If pressure is reduced below about 550 psi, the supercritical fluid converts back to liquid air.



SCAMP -  
Supercritical  
Air Mobility  
Pack



Antifreeze  
reservoir

coolant  
pump

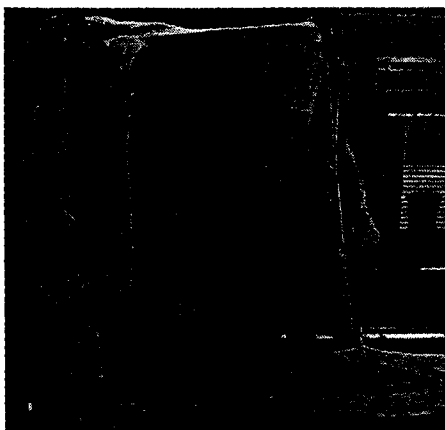
dewar

heat  
exchanger



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As breathing gas is consumed, body heat picked up by a tube suit is transported back to the cryogenic dewar to keep the fluid at the pressure needed to keep it supercritical.



DeltaTemax  
tubesuit







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- NEDU is engaged in a MOU with NASA's KSC to:
- help them convert the open-circuit SCAMP into a closed-circuit unit, thereby extending duration.



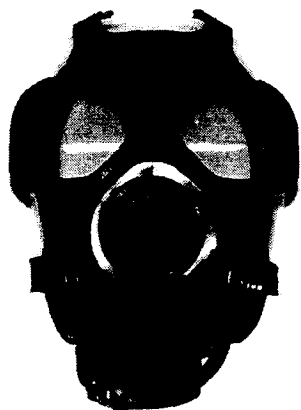
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- NEDU has a SCAMP system on loan from Tyndall Air Force Base.
- The Air Force was evaluating the SCAMP for use in fire fighting.
- The Air Force effort is on hold pending ORs.

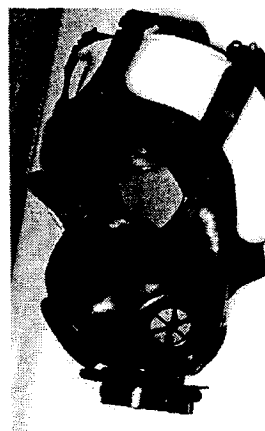


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- NEDU is exploring the use of the SCAMP for chem/bio protection on dry land, and
- in contaminated or warm water.



M45 gas mask



Informal demo



115° F,  
partial  
chemical  
protective  
garments



hose to ISI  
regulator

hoses to and  
from tube suit



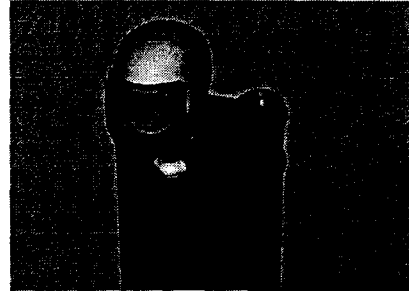
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**SUMMARY**

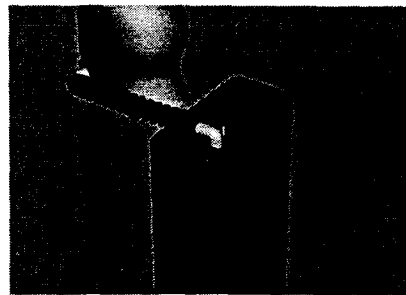
- Wearer was comfortable wearing chem/bio protective garments while conducting moderately heavy work in 110 - 120° F ambient temps.
- There was no fogging of the gas mask, a serious limitation with existing SCBA.



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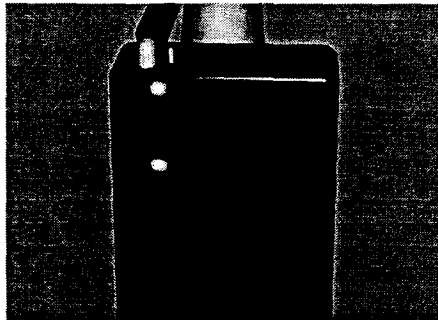


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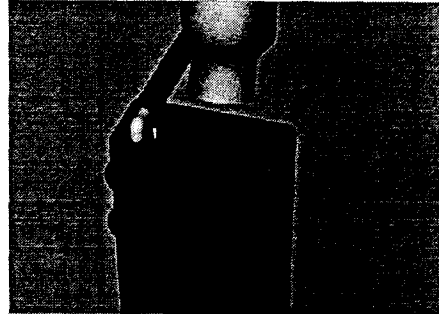




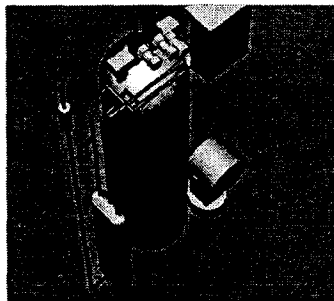
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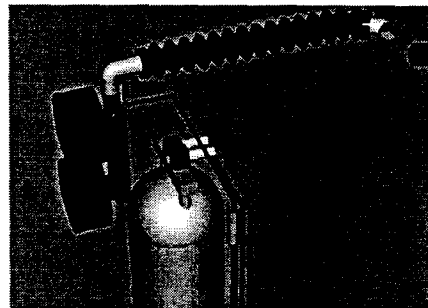
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#### SUMMARY

- The SCAMP is quickly moving from a developmental item to a fleet useful product.
- The SCAMP has been dived, and in principle, needs only changes in material to be certifiable for diving in warm, contaminated water.