Navy Water Production and Treatment Needs

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ONR 332 Undersea Weapons and Naval Materials

Military Applications for Emerging Water Use Technologies

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Revolutionary Research . . . Relevant Results

Navy Water Production and Treatment Needs

1. Navy Research Structure
2. Current Navy Programs and Opportunities
3. Navy Shipboard Needs

Revolutionary Research . . . Relevant Results

Navy Water Production and Treatment Needs

Office of Naval Research (basic to applied research)

- 30 Marine Corps: Expeditionary Maneuver…
  - Individual water investment, systems command leverages Army
- 33 Sea Warfare and Weapons
  - 332 Undersea Weapons and Naval Materials
    - Environmental Quality Programs (water programs)

Applied Research and Development Centers

Naval Surface Warfare Center-Carderock

- Shipboard bilge, gray and blackwater treatment issues

Naval Surface Warfare Center-Carderock-Philadelphia

- Shipboard potable and high purity water issues, fleet engineering

Naval Facilities Command- Port Hueneme, CA

- Testing of Navy, Army, Marine desalination systems

Revolutionary Research . . . Relevant Results

Navy Water Production and Treatment Needs

2. Current ONR Programs and Opportunities

1992-2007 Program to develop better MF/UF membranes for wastewater treatment needs.

2002-2007 Expeditionary Unit Water Purification Program

- 5 year program to bring down costs of desalination (basic research) and built new technology demonstrators (applied research)

2010-2014 Program to build (R&D) next generation shipboard potable water systems (BAA Spring 2009)

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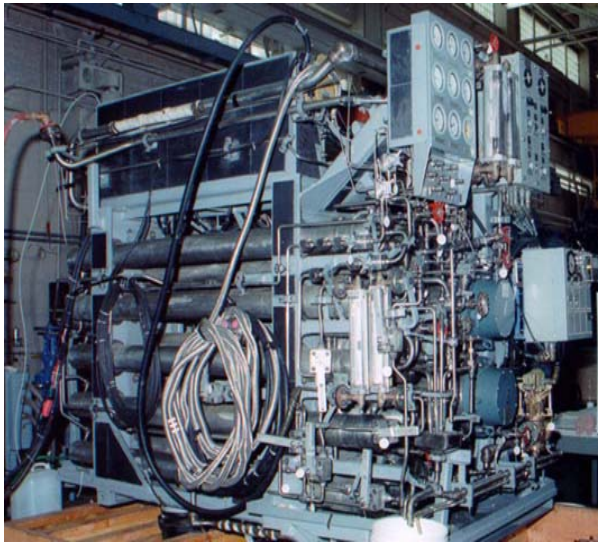
3. Navy Shipboard Needs

1. Potable water/ ultrapure water
   - 2010-2014 Program to build next generation shipboard potable water systems (BAA Spring 2009)
2. Bilge water
3. Graywater/ Blackwater

Present U.S. Navy Shipboard RO Systems

Single Pass RO Desalination Plant (1991)

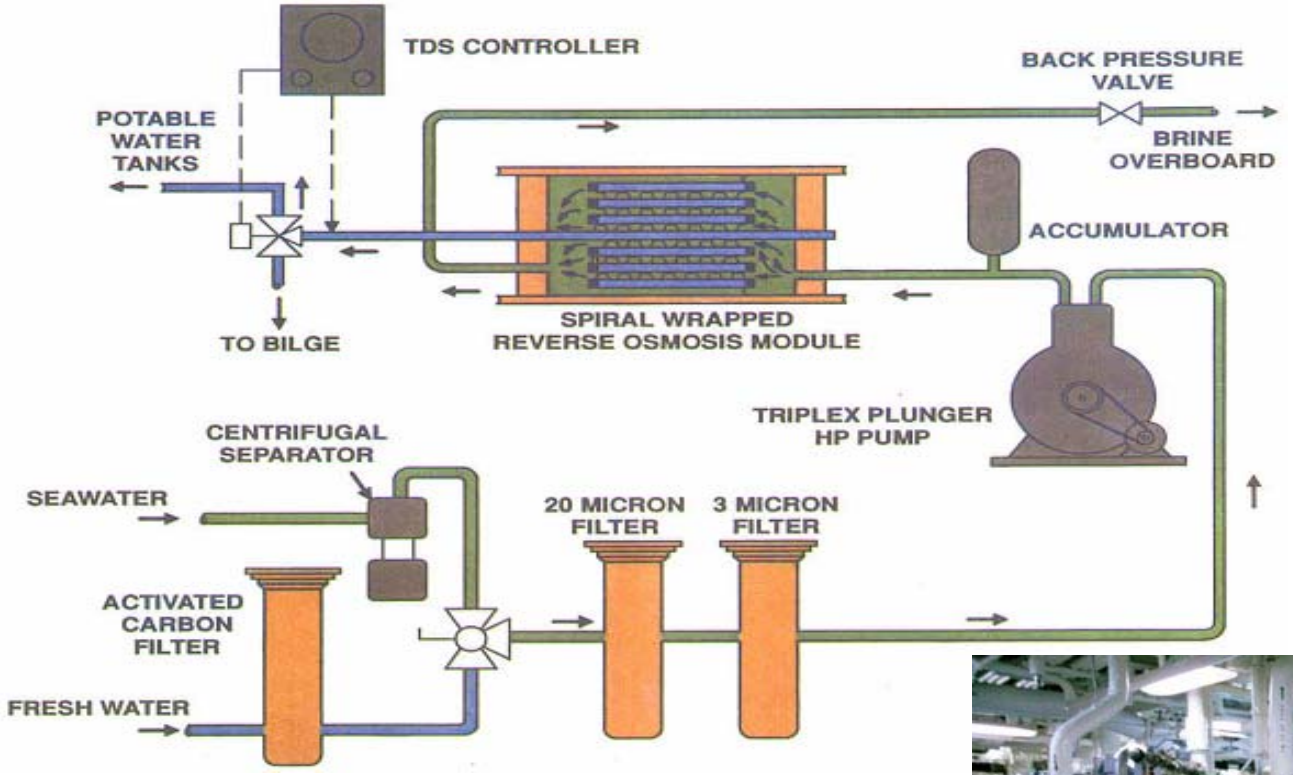


Multi-Pass RO Desalination Plant (1995)

Manual RO Desalinator
for Life Raft Survival Packages
(1991)

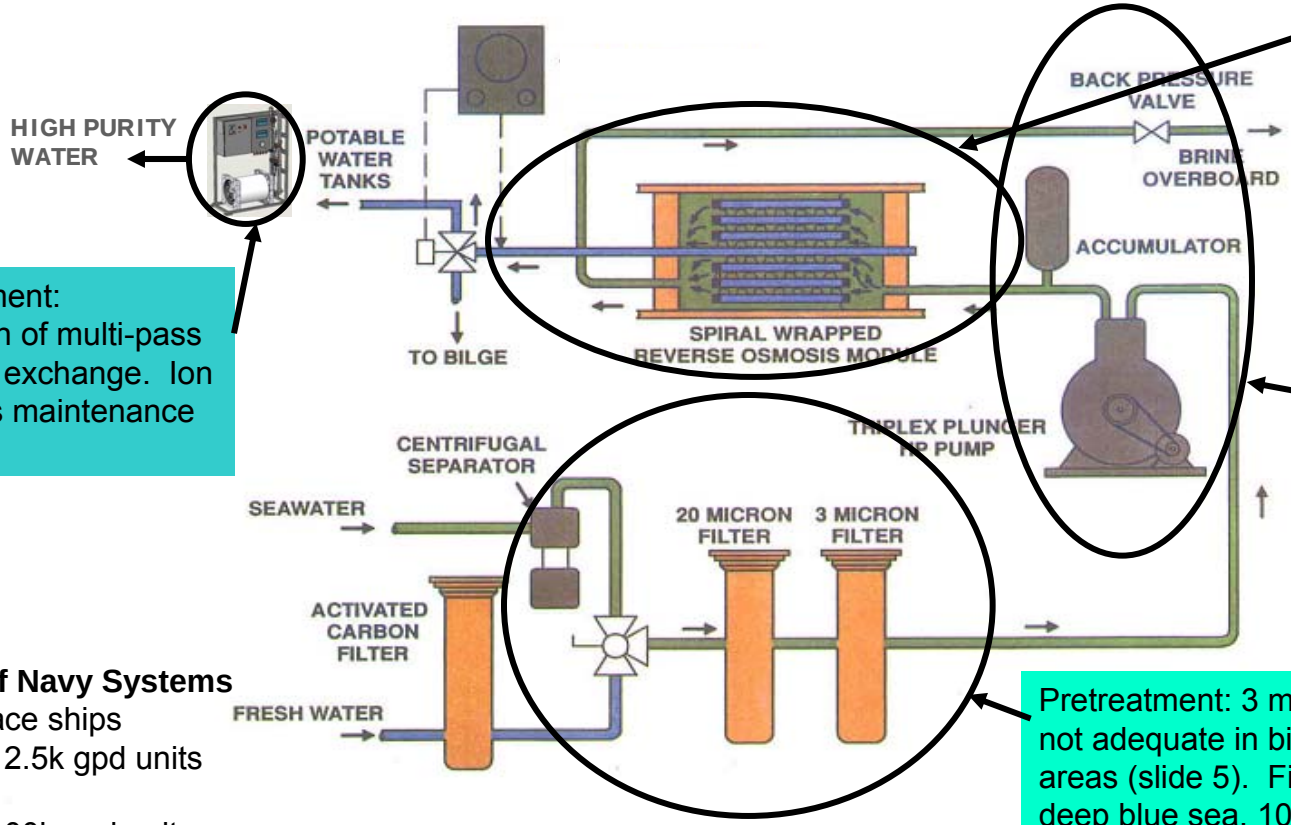
Current Capability

Navy Standard Reverse Osmosis (NSRO) Plant



Shortfalls in current capability

Desalination System Areas that need Improvement



Advanced Desalination: 20% recovery is for long membrane life, but results in pumping 100 gal to get 20 gal. Pumps and prefiltration must be oversized. Membranes are low flux and chlorine liable.

Post Treatment: Combination of multi-pass RO and ion exchange. Ion exchange is maintenance intensive.

Energy Reduction: NSRO has 80/20 split between brine and potable stream. 80% of water does not pass thru RO filter and leaves system at 1000 psi. Need to recover this energy.

Capacity of Navy Systems

- most surface ships
  - 2-6 12.5k gpd units
- carriers
  - 3-5 100k gpd units
- metrics:
  - gpd per cubic foot
  - gpd per kilowatt-hr
  - total ownership costs

Pretreatment: 3 micron particle size is not adequate in biologically active areas (slide 5). Filters last 1000 hrs in deep blue sea, 10's hrs in littorals. Creates a storage problem brings operational availability down greatly.

Objectives of EC

- Develop an advanced shipboard desalination system that costs the same or less than NSRO, that occupies 40% less volume, has 40% less weight, uses 65% less energy, and has 50% lower total ownership costs.
- The desalination system will be able to operate in littoral environments at >95% operational availability, eliminating the need for costly and risky water barging and enabling in port humanitarian missions.

15 S&T Efforts in 2003 BAA, 21 S&T efforts in 2005 BAA

What can transition into Advanced Shipboard Desalination ?

1. **Ceramic MF membranes TRL 4** 30 year membrane
2. **Chlorine Resistant RO membranes TRL 3** current weakness
3. **Membrane Distillation TRL 4** low pressure, reduced weight, waste heat, low noise
4. **Forward Osmosis- magnetic draw solute TRL 3** low pressure
5. **Forward Osmosis- membrane development TRL 3** higher fluxes
6. **Hybrid Energy Recovery Device TRL 4** 90% recovery, reliability
7. **Electrocoagulation for MF/RO pretreatment TRL 5** no chem storage
8. **Increased flux Reverse Osmosis membranes TRL 4** reduced energy

Remaining S&T efforts are still at lower TRL levels.

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2. Navy Shipboard Needs
   - Potable water/ultrapure water
   - Bilge water
     - Must treat to below 15 ppm oil to release
     - Gravity separators on ships
     - Newer ships—dryer bilges--- oil emulsified by cleansers
     - Navy is adding membrane polishers
     - Navy is interested in novel emulsion breaking technologies
   - Graywater/ blackwater

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Navy Water Production and Treatment Needs

2. Navy Shipboard Needs
    - Potable water/ultrapure water
    - Bilge water
    - Graywater/ Blackwater
        - From about 1992-2004 Navy developed membrane bioreactor technology, with Xenon and zeeweed membranes and now broadened to other membranes
        - Went from benchtop to pilot plant to a prototype tested on an aircraft carrier (gray water only).
        - Such technology may be implemented to meet tightening environmental requirements
        - Navy is now monitoring new commercial technologies/ developing better bugs.

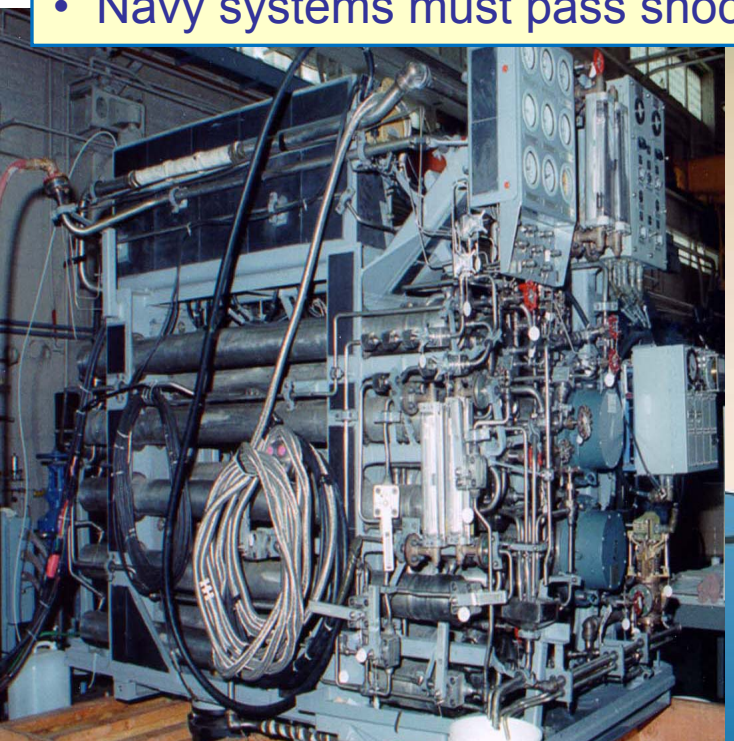
Shipboard Design Considerations

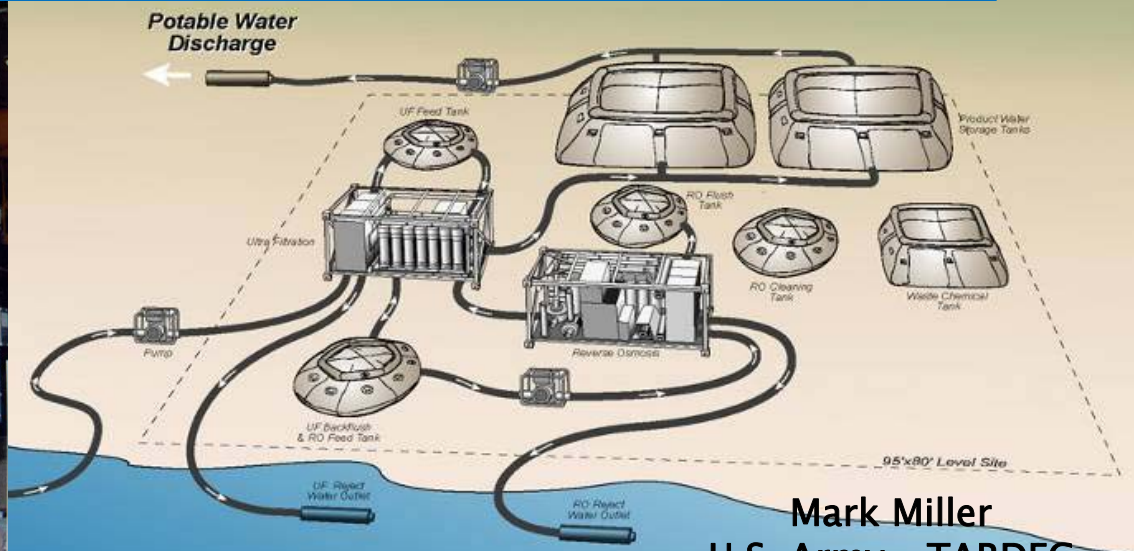
Army Operations versus Navy Operations

- Unit is compact for shipping but occupies large real estate in operation

  Real estate is an overriding concern on Navy vessels

- Operations are outdoors, open air. Below deck operation
- Army is resupplied daily. Navy is not, must carry for entire deployment
- Hazmats are bigger issue for Navy (store large quantities/ use below deck)
- Navy systems must pass shock and vibration test, be built for ship lifetime





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Shipboard Design Considerations

- **Ships are floating communities** ⇒ water is not a weapons system. The Navy will pay a premium only for corrosion resistant materials, otherwise we are like your local utility

- **Shipboard space restrictions** ⇒ Real estate is very important on a ship but gains in production per cubic foot cannot come with greater capital expense. Also, there are height limitations, limit use of **feed tanks**, installed as ship is built- all parts must fit through hatches, weight not a factor for Navy

- **Simplified piping design with few control valves** ⇒ simplified feed water and filtrate headers, unattended operation, low maintenance

- **Shipboard HAZMAT storage, handling and disposal restrictions**

⇨ *Minimize or eliminate use of coagulants and <u>NO</u> in-situ acid cleanings*

  - ► Typical “clean in place” techniques (500 ppm chlorine, 1% to 2% acid) unacceptable
    - “Chemically enhanced flushes” that utilize generation and injection of lower concentration disinfectant on feed side of pretreatment membrane

- **Submarines** may have further unique needs such as reduced noise and vibration, pressurized brine discharge, more strict ventilation requirements.

Questions ?

GEN 2 Technology Demonstration Unit is an evolution of the ONR EUWP Program

SCIENCE & TECHNOLOGY

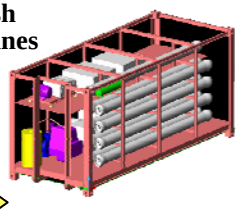
Basic and exploratory research and development of water treatment and desalination technologies

Ceramic MF Membranes

Chlorine Resistant RO Membrane

Non-chemical anti-scaling treatment

High Capacity Brackish Water RO Membranes



100,000 gal/day GEN 1 Expeditionary RO System

EUWP Generation I Demonstration

TWPS

Energy Recovery

Quintaplex HP Pumps

High Recovery Membrane Filtration

High Capacity Seawater RO Membranes

Component Demonstrations

300,000 gal/day GEN 2 Technology Demonstration Unit for Potential Fleet Application

Navy RO Systems (NSRO, SSN, CVN 78)

Development of Navy-Qualified Equipment

Shipboard In-Service Experiences

Higher Purity Water Generation