BalPure™

Electrolytic Ballast Water Treatment System

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Experience

- Installed Base of SANILEC systems producing over 1 million pounds per day of chlorine equivalent worldwide
- Severn Trent DeNora accounts for 65% of the worldwide operating on-site hypochlorite capacity
- Over 400 systems operating in 59 countries
- Offshore applications 21 different size systems capable of producing from 3 to 2400 pounds per day of hypochlorite
- Installations since 1974

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Electrolytic Ballast Water Treatment

Chemistry of electrolyzing sodium chloride

$$NaCl + H_2O + 2e^- \longrightarrow NaOCl + H_2$$

Salt+Water+Energy = Hypochlorite+Hydrogen

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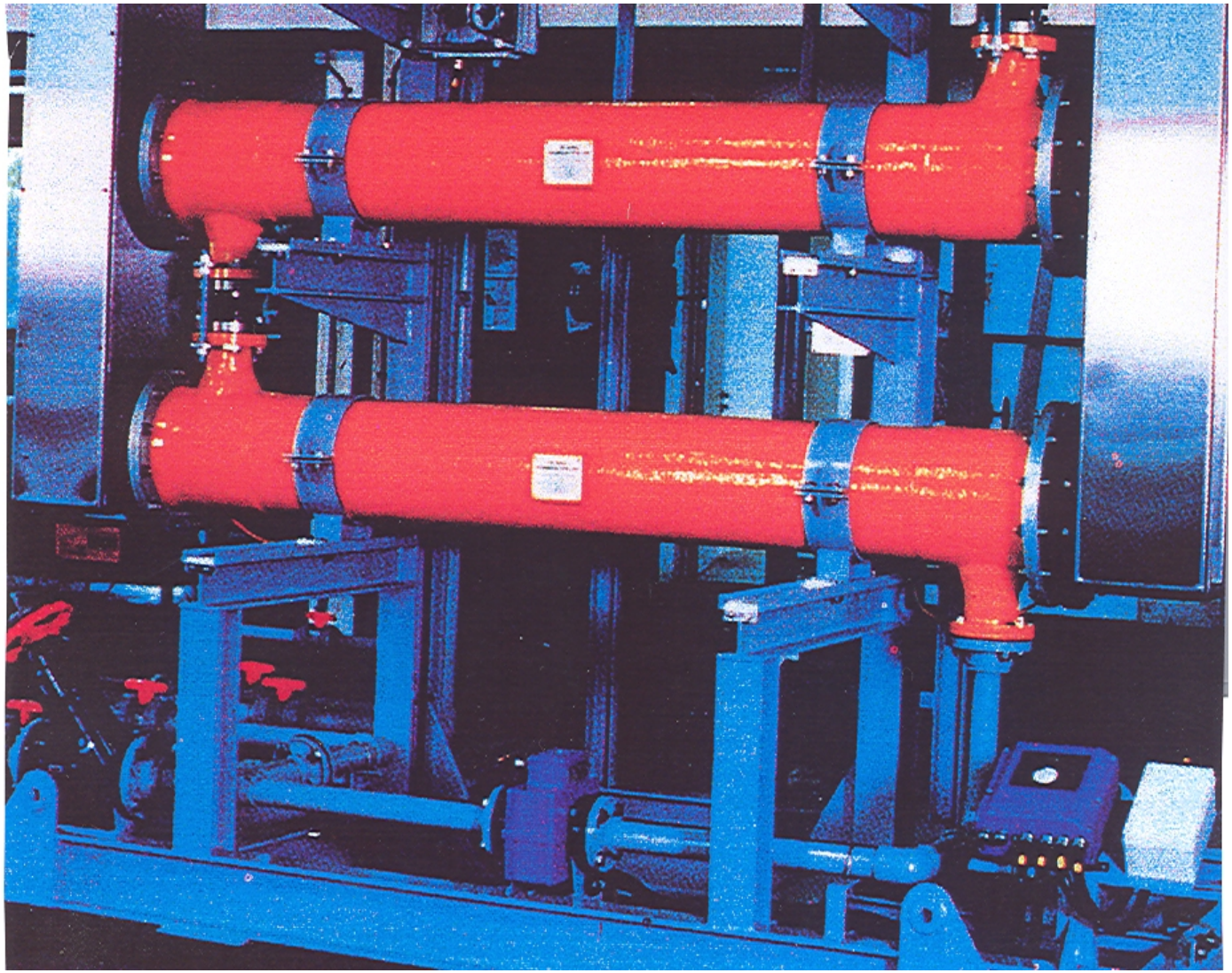
How Does It Work ?

- Seawater slip stream enters one end of the electrolytic generator
- DC electric current is passed between electrodes through the Seawater to generate products
- Hydrogen removed while hypochlorite and seawater injected into main ballast line
- Br (Bromine) in Seawater reacts to form OBr^- (Hypobromite) and HOBr (hypobromous acid)
- HOBr acts as an aggressive disinfectant when injected back into the main ballast line

Electrolytic Ballast Water Treatment



Typical Severn Trent DeNora Double Cell Generating Skid

Competitive Advantages

- Efficacy of Halogens for disinfection is well established
- Electrochemical oxidation is a well proven technology with 30 years experience in the offshore industry, marine, and coastal power plants
- STDN BalPure™ units are modular in construction and can be backfitted into existing vessels without major modifications
- Biocide has significant half life, solution mixes extremely well with ballast water, efficacy is not dependent on seawater turbidity
- Electrochemical oxidation systems are low cost vs. the alternate proposed technologies
- The cost of EC is appx. $0.02 per M3 of ballast water treated ($0.15/KWH generation cost)

Key System Components

- Hypochlorite Generation
  + *Controlled Addition*
- Oxidant Monitoring
  + *Residual Maintained*
- Oxidant Neutralization
  + *Controlled Addition*
  + *Excess Sulfite Monitoring*
- Data Logger

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Oxidant Neutralization

- Use sodium sulfite
  - Also use as food, wine preservative
- $Na_2SO_3 + Br_2 + H_2O \rightarrow Na_2SO_4 + 2HBr$
- 4 gpl Na_2SO_4 already exists in seawater
- HBr will not decrease pH in highly buffered seawater

Univ. of Washington Study

Marrowstone Marine Field Station

- Located on Marrowstone Island at the northwest entrance to Puget Sound
- Typically used for marine fish diseases and aquatic toxicology research
- Previously conducted ballast water bench scale testing at this US Geological Survey Facility
  - Previously tested UV, Ozone, Chemicals
- Seawater can be pumped from the Sound at a rate of 1500 liters per min (90 M^3/hour)

Electrolytic Ballast Water Treatment

Marrowstone Marine Field Station

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Parameters Measured

- Total Residual Oxidant (TRO)
- Live organisms as Zooplankton
- Chlorophyll as a measure of Phytoplankton
- Bacteria
- Toxicity of the water
- Disinfection By-Products (DBP)

Test Results

- With or without Filtration: When initial hypo concentration is at least 3.0 ppm
  - *Culturable Bacteria reduced > 99.99%*
  - *Phytoplankton reduced > 99%*
  - *Mesozooplankton reduced > 99%*
- Filtration only impacts efficacy when hypo concentration is less than 1.5 ppm
- Bacteria grow back within 24 hours once residual oxidant is consumed

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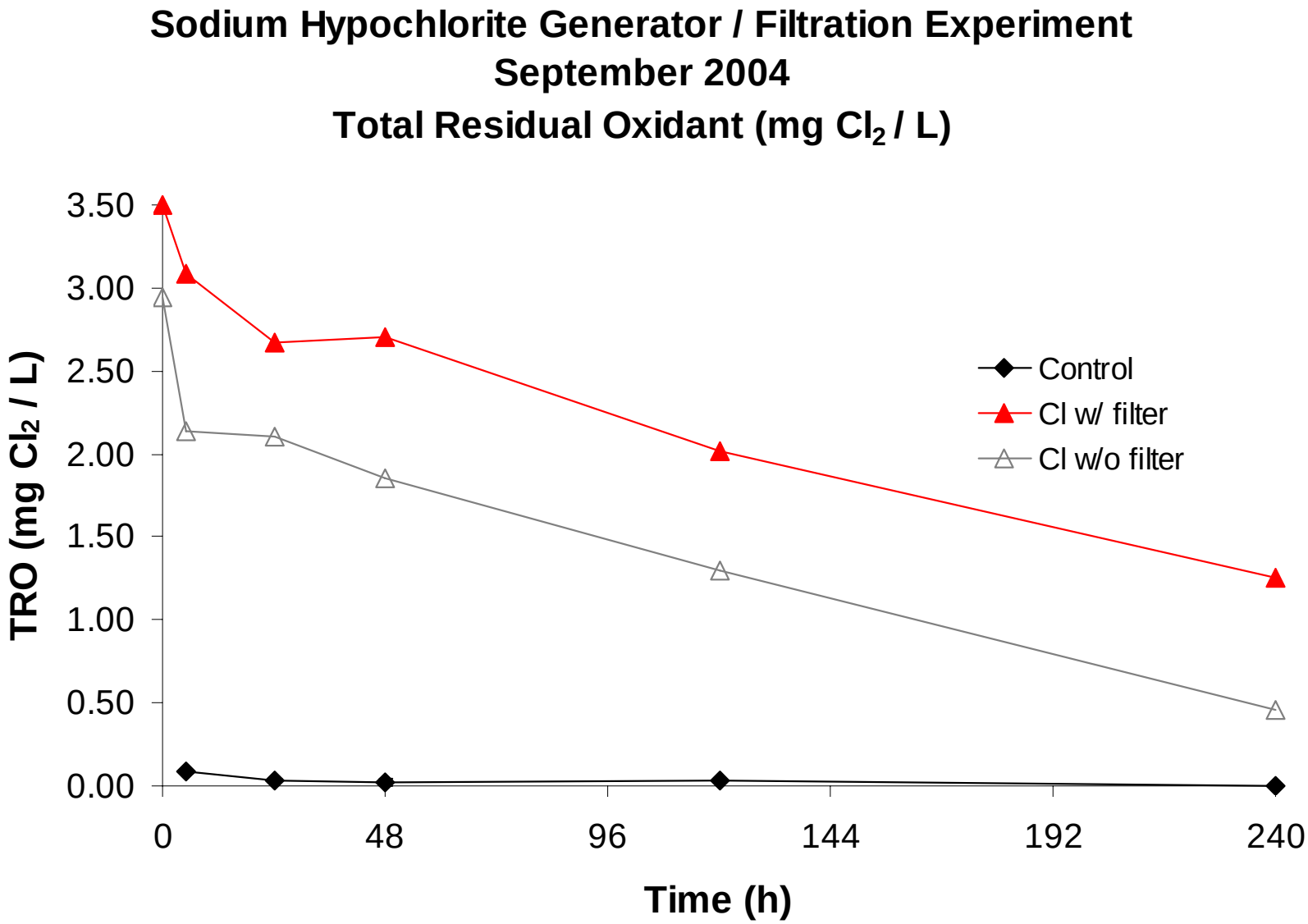
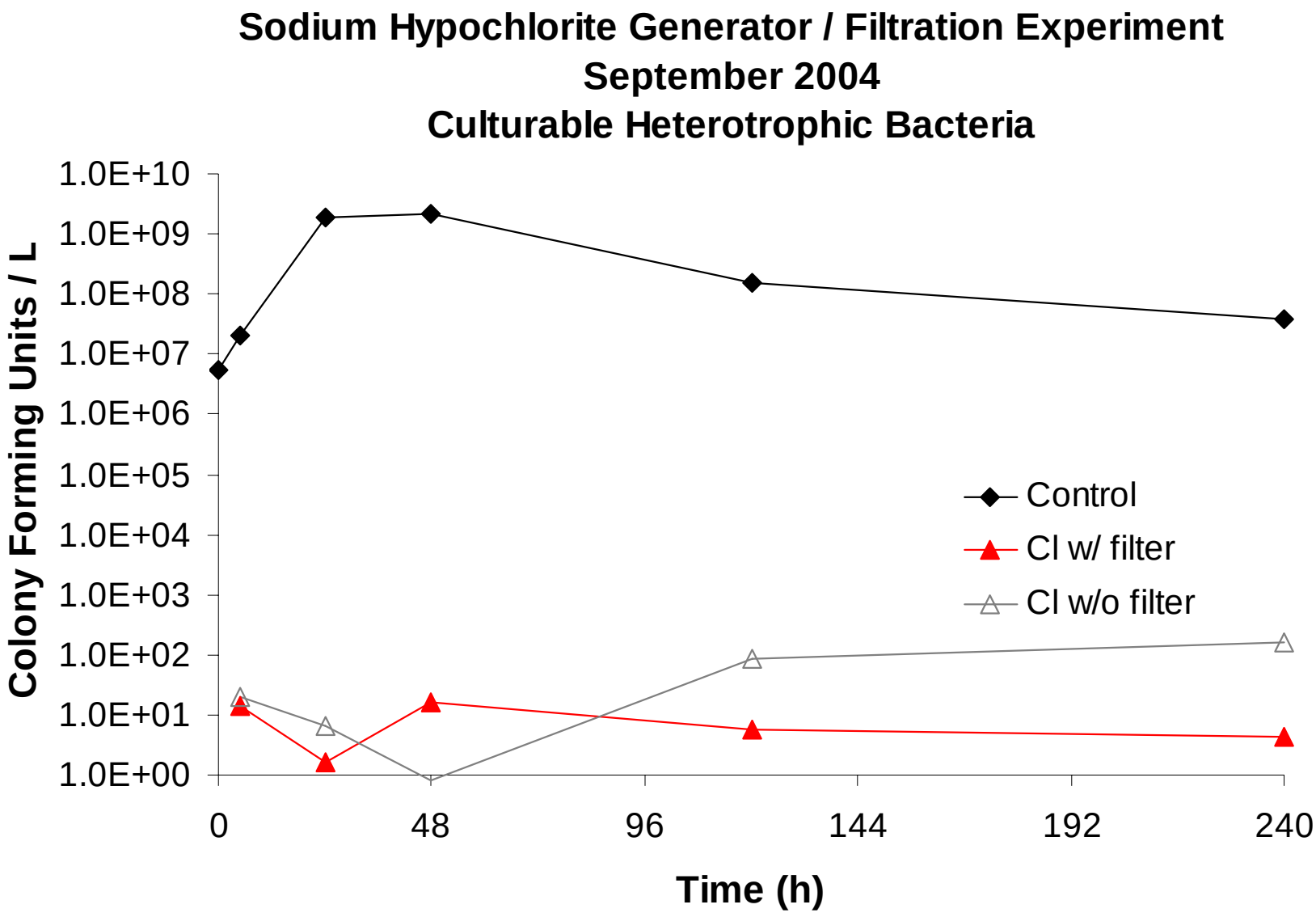
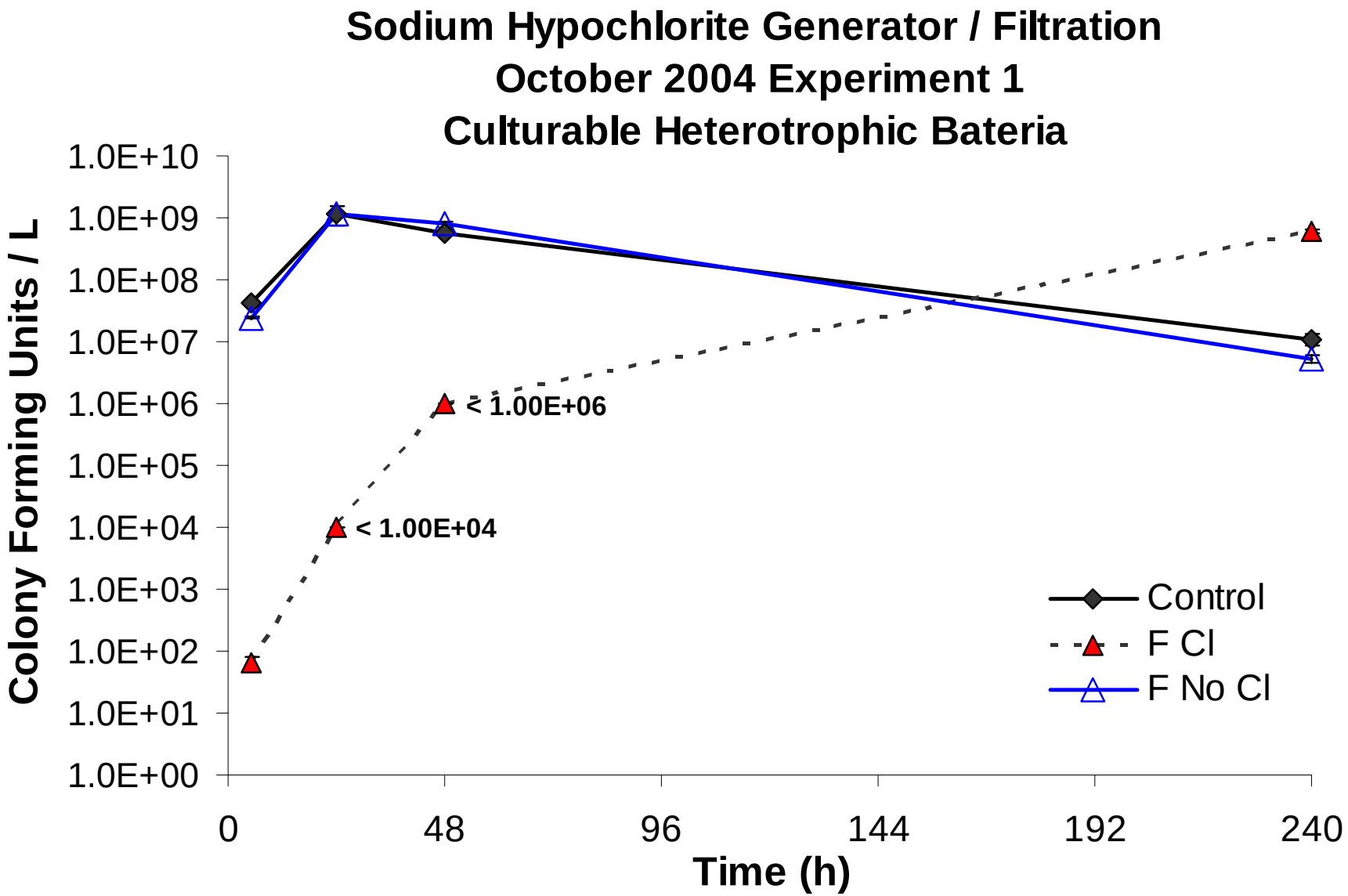
Test Results



Test Results



Test Results



Test Results

- Ballast water has no toxicity once neutralized with sodium sulfite up to 22 ppm or ten times required
  + Discharge Toxicology Studies Show No Effect On
    - *Herring Embryo*
    - *Mysid Shrimp*
    - *Bivalve Larval*
    - *Kelp*
    - *Diatoms*
- Disinfection By Products in effluent meet U.S. drinking water standards
  + THM 68 ppb (80 ppb)
  + HAA5 9 ppb (60 ppb)
  + Bromate < 1 ppb (10 ppb)

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Commercial Testing

- 1,000 M^3 per hour system being tested by United States Coast Guard at the Naval Research Labs in Key West Florida
  - Test protocol is based on IMO G-8 standards for Ballast Water Treatment testing.
- STDN has received a grant from the National Oceanic and Atmospheric Administration (NOAA)
  - Conduct a shipboard demonstration test of the STDN Ballast Water Treatment System

Commercial Testing

- Partnership formed with a major US vessel owner to install a BalPure unit on one of their vessels
  - Vessel route is between US cities on the Gulf Coast
  - System sized for 2,000 M^3 per hour ballast flow
  - Treatment System will be installed in six major components
    - Electrolyzers
    - Control Panel and transformer / rectifier
    - Hydrogen separation
    - Booster pumps
    - In line analyzers
    - sulfite addition
- Installation to occur at end of second quarter 2007

Commercial Certification

- Vessel owner and STDN will apply to the United States Coast Guard (USCG) Shipboard Technology Evaluation Program (STEP)
  - Pilot testing data completed
  - Environmental impact data developed
- BalPure™ Ballast Water Treatment System is patent pending

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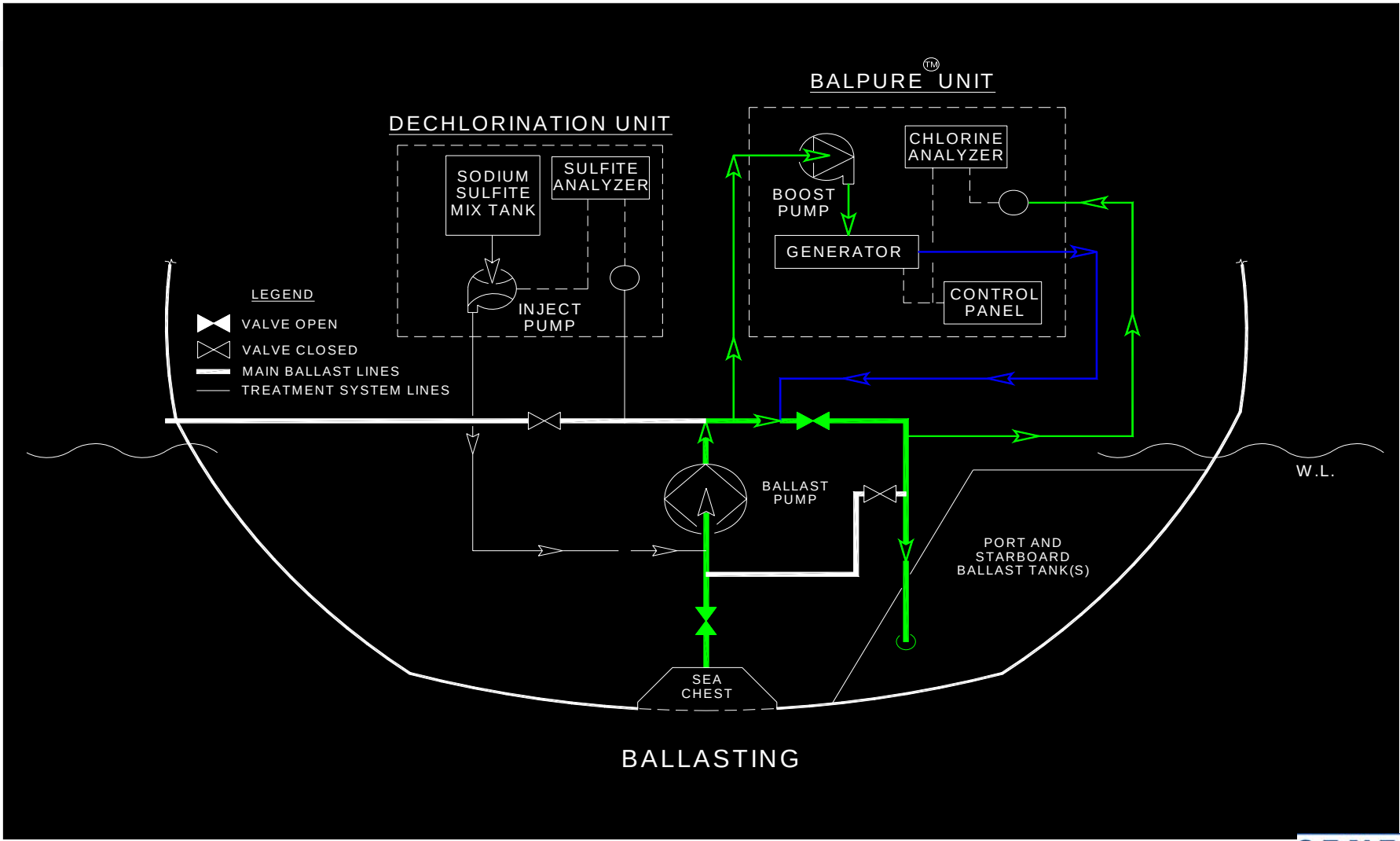

Metered Disinfection While Ballasting

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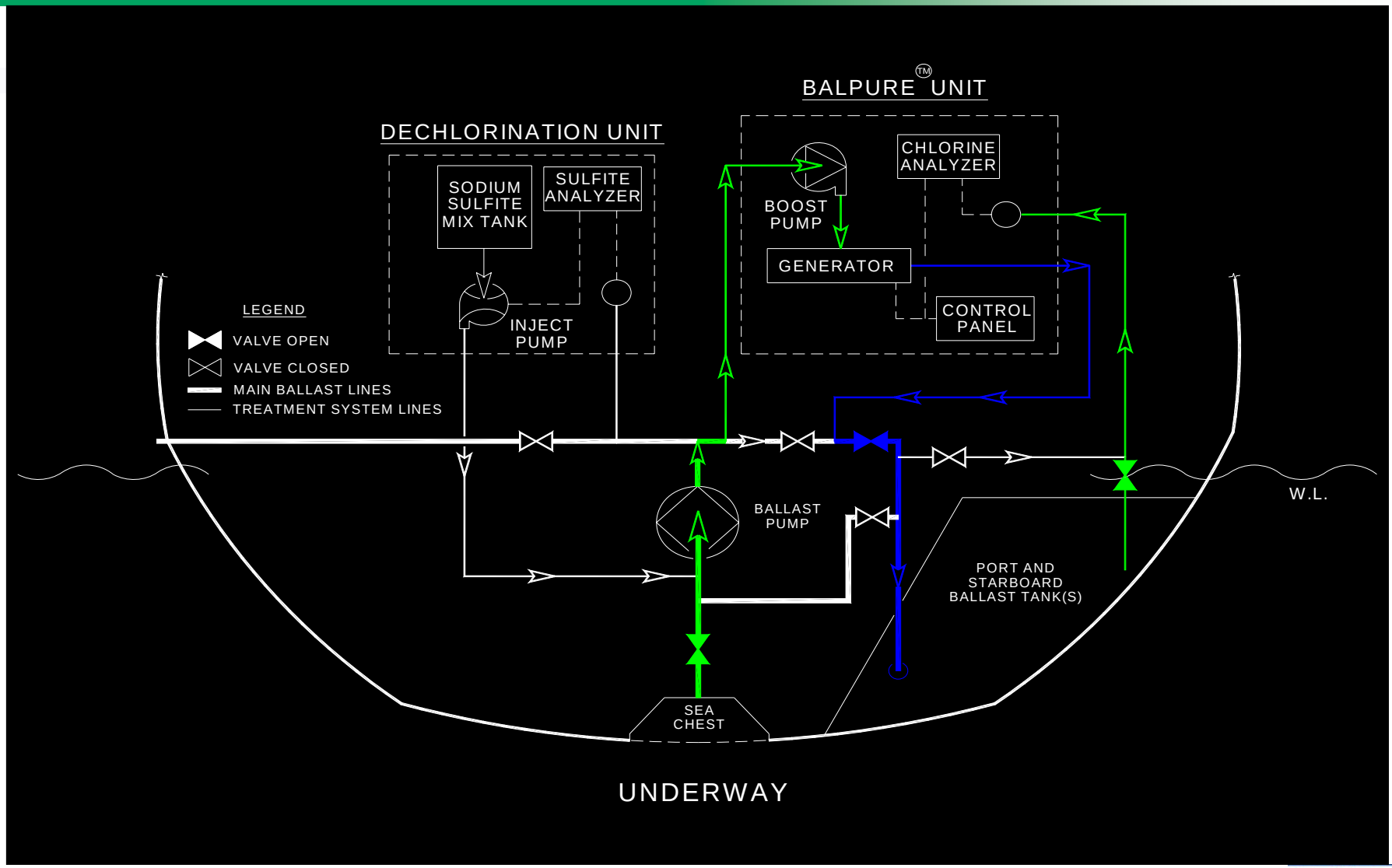

Sampling while Underway

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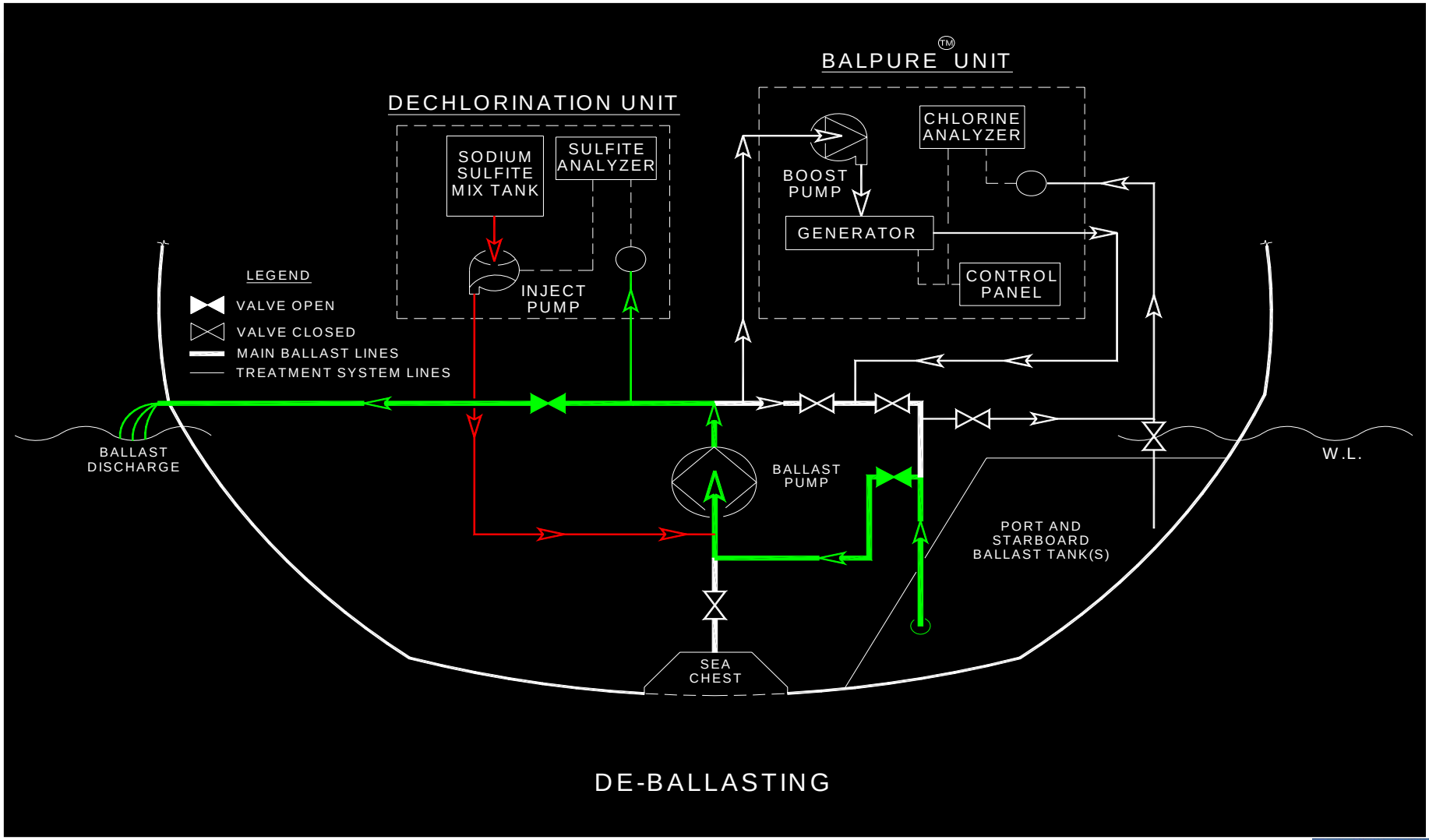

Metered Dechlorination while Deballasting

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NRL Unit 1000 M3/Hr @ 5 ppm

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Electrolytic Ballast Water Treatment

Estimates for 1000 M^3 / Hr BWT Unit

- Power
  - 52 AC KVA
- Process Water
  - None required
- Instrument Air
  - None required
- Sulfite for dechlorination
  - 2 Kg (7.7L) per 1,000M^3 ballast
- Maintenance
  - 4 hours per month
- Base Unit Cost
  - $440K

2000 M^3 / Hr System Dimensions

ITEM	DIMENSIONS (M) **Length X Width X Height**	WEIGHT (Kg)
Generator	2.3 X 0.6 X 2.2	260
Transformer/Rectifier & Control Panel	2.4 X 0.6 X 2.0 (1.1 X 1.3 X 2.0)	820 (400)
Degas	1.6 X 0.6 X 1.7	91
Booster Pumps	1.2 X 1.2 X 1.6	136
Analyzers	1.4 X 0.4 X 1.5	105
Sulfite Addition	0.4 X 0.3 X 1.1	68
Overall	3.7 X 1.8 X 3.1	3,325

Electrolytic Ballast Water Treatment

Conclusions

- Meets IMO standards for Ballast Water Management
  - Destruction of living organisms
  - Bacteria inactivated
- De-chlorinated Effluent is not Toxic
- DBPs can be below drinking water standards
- Filtration is not required to meet IMO standards
- Operating cost is less than $0.02 / M3 of ballast water

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