PERFORMANCE EVALUATION
OF AN AIR PURIFICATION SYSTEM
IN AN ITALIAN “SAURO” CLASS SUBMARINE

Paolo ROTONDO
Italian Navy
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ITALIAN SUBMARINES

SAURO Class

Characteristics

Weight surface: 1476 tons
Weight dive: 1662 tons

Lenght: 64.36 m
Beam: 6.8 m

Propulsion: 3 diesel engine generators
1 propulsion electric engine
1 accumulator of 500 elements

Speed surface: 11 kn
Speed dive: 20 kn

Crew: 51
ITALIAN SUBMARINES
TODARO Class (U212A)

S. TODARO

SCIRE’
INTRODUCTION

POLLLUTION ON BOARD

- Gaseous
- Particulate (dust and particles)
  - Microbiologic
  - Electrical
- Electromagnetic waves
The importance of particulate size

The more common mechanical filters used in Conditioning & Ventilation systems are able to capture particulate pollutant greater then 5 µm.

The PM10 dusts, have to be considered indicative to evaluate the air pollution because they are captured by the cyliar membrane of the respiratory tree and could produce important breathing pathology,

The PM2 dusts instead are able to cross the respiratory tree and to be adsorbed by the blood;
**Sinergy between various state of pollution**

For example the dust sedimentation, facilitate micro-biologic and fungal transfer from the environment to the human body. The same kind of sub-micron dusts absorbs gases.
INTRODUCTION

Koala Sub – Application of clue

- Mechanical Filter (particulate > 200 µ)
- Special Activated Carbon Filter (VOC capturing)
- Ionic Filter (particulate >0.001 µ)
- Ionizator (low voltage)
- Germicide UV Lamp (low power – 8 w; no Ozone production)
INTRODUCTION

Koala Sub - Functional technical scheme

Purified air

- Mechanical filter
- Special Activated Carbon Filter
- Fans
- Ionic filter:
  - Polarized grid
  - Plate for capturing particulate
- Germicide UV lamp
- Polarization System

KOALA SYSTEM
INTRODUCTION

Ionic filter (non HEPA)

The system is formed by a stainless steel grid where the air is forced to go through and where it is charged with negative polarity. Following its way the air moves across electrically opposite-charged plate that capture all the polarized particulate. Its skill of capturing particulate arrives to the size of nanometer absolutely no-eliminable with traditional filtering.
External ionization system

There is a double ionizing points, positioned where the air flow came out; it’s capable to associate to this quantity of air (can be setted between 30÷60 m$^3$/h for each) a significant quantity of negative ions:

- avoid the fall of the remaining particulate
- force the particulate to remain in suspension in order to be captured in a further passage
- give to the outgoing air flow the special electric charge that seconds the natural exchange lungs
INTRODUCTION

Dimensions: 53 x 39 x 15 cm
INTRODUCTION
INTRODUCTION
SCENARIO

History of events on board

AM
  8.00 - Start mission - Boat departure
  8.55 - Doors Closed
  9:15 - Dive
  9.35 - Start baseline measures (Koala-Sub off)
  10.30 - Koala-Sub activated in sequence
  11.30 - Koala-Sub off in sequence
  11.55 - Start continuous monitoring (baseline)

PM
  01.05 - Koala Sub-activated
  01.35 - Periscope depth
  01.45 - Snorkel and engines on
  03.45 - Snorkel and engines off
  05.00 - Surface
  05.05 - Doors Open (Koala-Sub off)
  05.30 - End of the measures
  08.00 - End mission – Boat at the pier
MATERIALS AND METHODS

Parameters investigated

- Particulate fractions
- Volatile organic compounds (VOCs), as ppm of CH4
- Nitrogen oxides NOx
- Carbon monoxide CO
- Carbon dioxide CO2
- Volatile organic compounds containing the SO bond (SOx)
MATERIALS AND METHODS

Analysys Instruments:

(Bruel-Kjaer infrared analyzer)

VOCs, CO2, CO, NOx, SOx compounds
MATERIALS AND METHODS

Analysys Instruments:

- **Particulates**
  - (Bio-Test Diagnostic laser counter)

- **Microorganisms**
  - (Merck Rodac Culture plates)

- **Aquaria-Microflow sampler**
RESULTS

Particulate

Koala on
Snorkel on
Dive
Surface

Particles/ft³

0.3um
0.5um
1.0um
5.0um
RESULTS

V.O.C.s

Koala off (11.30) Koala on (13.05) Snorkel (13.45) Dive (15.45) surface 17,00

ppm CH4

0,00E+00
1,00E+02
2,00E+02
3,00E+02
4,00E+02
5,00E+02
6,00E+02
7,00E+02

time

11.57.32 12.06.51 12.15.51 12.25.27 12.34.33 12.43.38 12.53.07 13.02.21 13.11.19 13.20.42 13.29.59 13.38.58 13.47.48 13.57.32 14.06.48 14.15.53 14.25.19 14.34.31 14.43.36 14.53.02 15.02.12 15.11.17 15.20.41 15.29.53 15.38.51 15.47.46 16.06.48 16.15.53 16.25.19 16.34.31 16.43.36 16.53.02 17.02.12 17.11.17 17.20.41 17.29.53 17.38.51 17.47.46 18.06.48 18.15.53 18.25.19 18.34.31 18.43.36 18.53.02
RESULTS

Carbon dioxide

Koala off (11.30) Koala on (13.05) Snorkel (13.45) Dive (15.45) Surface 17,00
RESULTS

Carbon monoxide

Koala off (11.30) Koala on (13.05) Snorkel (13.45) Dive (15.45) Surface 17,00
RESULTS

Nox compounds

Koala off (11.30) Koala on (13.05) Snorkel (13.45) Dive (15.45) Surface 17,00

Time

Koala off (11.30) Koala on (13.05) Snorkel (13.45) Dive (15.45) Surface 17,00

ppm
RESULTS

Sox compounds

Koala off (11.30)  Koala on (13.05)  Snorkel (13.45)  Dive (15.45)  Surface 17.00

 ppm

0.00E+00  5.00E+01  1.00E+02  1.50E+02  2.00E+02  2.50E+02  3.00E+02  3.50E+02  4.00E+02

time
# RESULTS

## Microbiological

<table>
<thead>
<tr>
<th>Room</th>
<th>KOALA-SUB off</th>
<th>KOALA-SUB on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units for colony.</td>
<td>Units for colony</td>
</tr>
<tr>
<td></td>
<td>C.F.U.</td>
<td>C.F.U.</td>
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<tr>
<td>Torpedo room</td>
<td>800</td>
<td>300</td>
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<tr>
<td>CIC deck - A</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>CIC deck - B</td>
<td>110</td>
<td>42</td>
</tr>
<tr>
<td>Mess room</td>
<td>41</td>
<td>29</td>
</tr>
<tr>
<td>Electric board room</td>
<td>36</td>
<td>19</td>
</tr>
<tr>
<td>Engine room</td>
<td>220</td>
<td>105</td>
</tr>
<tr>
<td>Sleeping room</td>
<td>300</td>
<td>4</td>
</tr>
<tr>
<td>average</td>
<td>223.8</td>
<td>77</td>
</tr>
<tr>
<td>Percent Reduction average</td>
<td></td>
<td>-65%</td>
</tr>
</tbody>
</table>
Koala Sistem is good system to purify the air by particulate microrganism VOCs
Best result in closed environments. Close to the Koala there is an increase of air effective replacement.
CONCLUSIONS

Why Italian Navy chose it

Compact
Integrated
Easy manutenibile (and cheap)
Easy cleanable
Very low energy absorption
Submarine Air Monitoring
Air Purification Conference

Thanks for attention

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San Diego
USA