Water treatment
AIR AND DIRT RELATED PROBLEMS

PRESENCE OF AIR

PRESENCE OF DIRT AND SLUDGE

CORROSION AND FOULING
PRESENCE OF AIR PROBLEMS

POOR HEAT TRANSFER FROM EMITTERS

NOISES IN THE EMITTERS AND PIPES

CAVITATION

CORROSION
PRESENCE OF AIR
Poor heat transfer by heat emitters

MUCH LOWER CONVECTIVE HEAT TRANSFER PROPERTIES

- SIGNIFICANT REDUCTION OF HEAT TRANSFER
- LOWER COMFORT LEVEL
- HIGHER OPERATING COSTS
PRESENCE OF AIR
Noises in piping and heat emitters

NOISE DUE TO AIR FLOW
- DURING NIGHT
- SYSTEM START-UP

NOISE IN SYSTEM COMPONENTS
- DUE TO MICRO-BUBBLE IN WATER FLOW
- RESULT: CAVITATION
PRESENCE OF AIR

Accelerated corrosion

Air contains oxygen $\rightarrow$ Oxygen + Ferrous metals $\rightarrow$ Corrosion

$$O_2 + 2Fe + 2H_2O \rightarrow 2Fe(OH)_2$$

Iron Hydroxide $Fe(OH)_2$

$$3Fe(OH)_2 \rightarrow Fe_3O_4 + H_2 + 2H_2O$$

The compound $Fe_3O_4$ is called magnetite, and appears as a dark gray sludge within the system.
PRESENCE OF AIR
Gaseous cavitation

1) RAPID CHANGES OF PRESSURE AND VELOCITY

2) AREA (CAVITY) WITH VERY LOW PRESSURE (HIGH VELOCITY)

3) LIQUID → VAPOUR

4) RAPID INCREASE OF PRESSURE

5) VAPOUR CAVITY IMPLOSION
PRESENCE OF AIR
Gaseous cavitation

OBTURATOR

CIRCULATOR
PRESENCE OF AIR
Circulation flow problems

INADEQUATE FLOW
- LOWER FLOW RATE THAN DESIGN ONE (WATER+AIR)
- LOWER ENERGY TRANSFER
- LOW COMFORT CONDITIONS

COMPLETE LOSS OF FLOW
- UNDERFLOOR HEATING SYSTEMS
- DUE TO AIR BUBBLE
Air separators
PRESENCE OF AIR
SITUATION 1

AIR NOT EXPELLED DURING SYSTEM FILLING

- AT THE UPPER PART OF HEAT EMITTERS
- AT THE TOP OF RISERS
- IN PIPING WITH IN-LINE OBSTACLES
AIR REMOVAL DEVICES

Automatic air vent – Application diagram
PRESENCE OF AIR
SITUATION 2

AIR DISSOLVED INSIDE WATER INTRODUCED DURING SYSTEM FILLING

AMOUNT OF DISSOLVED AIR

\[ f(\text{WATER PRESSURE}) \]

\[ f(\text{WATER TEMPERATURE}) \]

HENRY’S LAW

**Diagram:**

- Graph showing the amount of dissolved air as a function of water pressure and temperature.
- Key points and curves indicating different pressures (1 bar, 2 bar, 3 bar, 4 bar, 5 bar, 6 bar, 7 bar, 8 bar).
- Temperature range from 0°C to 180°C.

**Legend:**

- Pressione assoluta

**Units:**

- N° max di litri d’aria disolta per m³ d’acqua (L/m³)
PRESENCE OF AIR
SITUATION 2

AMOUNT OF DISSOLVED AIR

Filling with 1 m³ of water at:
- 20°C
- 2 bar

35 Nl of dissolved air

Heating of water at:
- 80°C
- 2 bar

17 Nl of dissolved air

18 Nl of air released
PRESENCE OF AIR
Boiler micro-bubbles

MICRO BUBBLES GENERATION

HOTTEST PART OF SYSTEMS
SURFACE OF COMBUSTION CHAMBER

Flame temperature 1000 °C
Wall temperature 160 °C
Combustion chamber wall
Boundary layer
Micro-bubbles
Water
Boundary layer temperature 156 °C
Average water temperature 70 °C
COMBINED ACTION OF DIFFERENT PHYSICAL PRINCIPLES

ENLARGMENT OF SECTION

FLOW VELOCITY REDUCTION

CREATION OF TURBULENCE

STICKING AGAINST MESH SURFACE

RELEASE OF MICROBUBBLES FROM FLOW

The bubbles fuse with each other. They increase in volume and rise towards the top.
DEAERATOR Sizing Criteria

**OPTIMAL WATER SPEED AT THE DEVICE CONNECTION (A1)**

\[ \approx 1,2 \text{ m/s} \]

**OPTIMAL DESIGN WATER FLOW-RATE**

<table>
<thead>
<tr>
<th>DN</th>
<th>Ø 22 - 3/4” - 1”</th>
<th>3/4”</th>
<th>1”</th>
<th>1 1/4”</th>
<th>1 1/2”</th>
<th>2”</th>
</tr>
</thead>
<tbody>
<tr>
<td>l/min</td>
<td>22,7</td>
<td>22,7</td>
<td>35,18</td>
<td>57,85</td>
<td>90,33</td>
<td>136,6</td>
</tr>
<tr>
<td>m³/h</td>
<td>1,36</td>
<td>1,36</td>
<td>2,11</td>
<td>3,47</td>
<td>5,42</td>
<td>8,20</td>
</tr>
</tbody>
</table>

**MAXIMUM WATER SPEED AT THE DEVICE CONNECTION (A1)**

\[ \approx 1,5 \text{ m/s} \]
DEAERATOR
Installation
Impurities inside systems
PRESENCE OF DIRT
Reduced heat transfer in heat exchangers

- SIGNIFICANT REDUCTION OF HEAT TRANSFER
- HEAT EXCHANGER BREAKING POSSIBILITY
- HIGHER OPERATING COSTS AND ENERGY CONSUMPTION
PRESENCE OF DIRT
Problems related to mechanical components

DAMAGES TO ROTATING COMPONENTS IN CIRCULATORS

VALVES IRREGULAR WORKING
PRESENCE OF DIRT AND SLUDGE

Corrosion

BASIC MATERIAL (STEEL) + DIRT + OXYGEN → CORROSION
DIRT REMOVAL DEVICES
Strainers vs Dirt Separators

BASED ON MESH SIZE

BASED ON DROPPING BY GRAVITY
DIET RMOVAL DEVICES
Filtration

MESH SIZE
MINIMUM IMPURITY DIAMETER TRAPPED [µm]

<table>
<thead>
<tr>
<th>Size</th>
<th>½&quot;</th>
<th>¾&quot;</th>
<th>1&quot;</th>
<th>1 ¼&quot;</th>
<th>1 ½&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesh size [µm]</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>470</td>
<td>470</td>
<td>530</td>
</tr>
</tbody>
</table>

Kvs
THE Kvs VALUE IS CALCULATED WITH CLEAN MESH

<table>
<thead>
<tr>
<th>Size</th>
<th>½&quot;</th>
<th>¾&quot;</th>
<th>1&quot;</th>
<th>1 ¼&quot;</th>
<th>1 ½&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kvs</td>
<td>4,1</td>
<td>7,3</td>
<td>11,0</td>
<td>17,4</td>
<td>25,0</td>
<td>37,0</td>
</tr>
</tbody>
</table>
DIRT REMOVAL DEVICES
Filtration

STRAINER INSTALLATION
DIRT REMOVAL DEVICES
Filtration: example

Y-STRAINER: 1” size (mesh 0.4 mm)

Design flow: 1500 l/h

ΔP STRAINER = 180 mm w.c. (1.8 kPa)
(no obstruction)
DIRT REMOVAL DEVICES

Filtration: example

INSUFFICIENT FILTER MAINTENANCE

70% OBSTRUCTION

STRAINER PRESSURE LOSS INCREASED BY 4.5 TIMES
(experimental data)
DIRT REMOVAL DEVICES
Filtration: example

Y-STRAINER: 1” size (mesh 0,4 mm)

ΔP STRAINER = 780 mm w.g. (7,8 kPa)
(70% obstruction)
DIRT REMOVAL DEVICES
Dirt separator: example

DIRT SEPARATOR INSTALLATION
DIRT REMOVAL DEVICES

Operating principle

- **Enlargement of section**
- **Flow velocity reduction**
- **Impurities collision against mesh**
- **Dirt separation**
- **Dropping by gravity**

Combined action of different physical principles.
DIRT REMOVAL DEVICES
Dirt separator: example

DESIGN FLOW
1500 l/h

ΔP DIRT SEPARATOR
28 mm w.g.
(0,28 kPa)

NO MAINTENANCE

DESIGN FLOW
1500 l/h

ΔP DIRT SEPARATOR
28 mm w.g.
(0,28 kPa)
Magnetic Effect
DIRT REMOVAL DEVICES

Operating principle

ENLARGEMENT OF SECTION

IMPURITIES COLLISION AGAINST MESH

FLOW VELOCITY REDUCTION

DIRT SEPARATION

DROPPING BY GRAVITY + MAGNETIC ATTRACTION
DI RT SEPARATOR
Sizing Criteria

OPTIMAL WATER SPEED AT THE DEVICE CONNECTION (A1) ≈ 1,2 m/s

MAXIMUM WATER SPEED AT THE DEVICE CONNECTION (A1) ≈ 1,5 m/s

OPTIMAL DESIGN WATER FLOW-RATE

<table>
<thead>
<tr>
<th>DN</th>
<th>Ø 22 - 3/4&quot; - 1&quot;</th>
<th>3/4&quot;</th>
<th>1&quot;</th>
<th>1 1/4&quot;</th>
<th>1 1/2&quot;</th>
<th>2&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>l/min</td>
<td>22,7</td>
<td>22,7</td>
<td>35,18</td>
<td>57,85</td>
<td>90,33</td>
<td>136,6</td>
</tr>
<tr>
<td>m³/h</td>
<td>1,36</td>
<td>1,36</td>
<td>2,11</td>
<td>3,47</td>
<td>5,42</td>
<td>8,20</td>
</tr>
</tbody>
</table>
DIRT SEPARATOR
Installation
Multifunctional Components
AIR AND DIRT SEPARATOR

Combined Functions

AIR SEPARATOR

DIRT SEPARATOR

COMBINED COMPONENT
AIR AND DIRT SEPARATOR

Installation
MULTIFUNCTIONAL HYDRAULIC SEPARATOR
Combined Functions

HYDRAULIC SEPARATOR + AIR SEPARATOR + DIRT SEPARATOR + MAGNETIC EFFECT
MULTIFUNCTIONAL HYDRAULIC SEPARATOR
Multifunctional Device
MULTIFUNCTIONAL HYDRAULIC SEPARATOR

Installation
MULTIFUNCTIONAL HYDRAULIC SEPARATOR

Scheme of application
Thank you.