Flow Measurement with FLOWave flowmeters in clean utility applications

Presentation - 2016 National GMP & Validation Forum
Introduction

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Background

QLD State Sales Manager at Bürkert
Sixty eight years young

fluid control components and systems
European manufacturing
present in 40+ countries
around 2,500 employees
highly skilled workforce
innovation as a core focus

about us
Low Conductivity Flow Measurement in clean utility applications

1 - The 5 Job’s of Flow Measurement in clean utilities applications

Velocities / Flow rates / Availability / Pressure / Process efficiencies

2 – Different Flow Measurement Technologies

3 – Our FLOWave Technology

4 – The FLOWave Program
1 - The Job of Flow Measurement in clean utilities applications

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What are Clean Utilities?

- **Clean utilities** refers to **fluids** and their **equipment** for applications in pharmaceutical & biotechnology production processes like -
  - Pharmaceutical Water production
  - WFI Storage and Distribution \((WFI = \text{Water for Injection})\)
  - WFI/PW Loop \((PW = \text{Pure Water})\)
  - Points of Use (POU)
  - Clean Steam, Pure Steam production

- Water for pharmaceutical in clean utility applications needs to be managed carefully for safety & security.

- Pharmaceutical water is regarded as being extremely critical, and there are very precise specifications in the pharmacopoeia monographs and GMP regulations.
Water for pharmaceutical uses is strongly regulated like everything else in our industry.

### Requirement examples

<table>
<thead>
<tr>
<th>Water Quality Parameter</th>
<th>Highly Purified Water (HPW)</th>
<th>Water for Injection (WFI)</th>
<th>Purified Water (PW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1.1 µS/cm (at 20 °C)</td>
<td>≤ 10 CFU/100ml</td>
<td>≤ 100 CFU/ml</td>
<td>≤ 500 ppb</td>
</tr>
<tr>
<td>≤ 10 CFU/100ml</td>
<td>≤ 500 ppb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 500 ppb</td>
<td>TOC</td>
<td></td>
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<tr>
<td></td>
<td>Electrical conductivity</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Microbiological monitoring</td>
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</table>

### Example uses

#### Distilled Water
Sterile & used for production of parenteral’s, serves as vehicle for injectable medicines and final rinsing of equipment.

#### DI Water
Manufacture of WFI, cleaning of facilities, pre-rinsing of equipment, autoclave cooling.
The Job of Flow Measurement in clean utilities applications
1. Confirm minimum velocity

- Maintain a certain minimum velocity of fluid flow through the entire distribution loop as demands increase at POU

- Minimum flow velocity according to ISPE: \( v \geq 0.9 \) m/s

- For cleaning: adequate flow velocity 1.5 - 2 m/s, Reynolds's number \( Re > 4,000 \)
2. Confirm continuous flow

- Since multiple users may draw at once, it is important to maintain flow in all parts of the water distribution loop.

- Locating the flowmeter at the return of the water loop ensures that you are measuring the lowest flow in the loop.

- The main reason for maintaining continuous flow through the entire water loop is to avoid the development of biofilms.
2. Confirm continuous flow

- Avoiding biofilms
  - “Grow” in water piping
  - Hard to suppress
  - Detach if certain volume is reached
  - Cause of microbiological incidents
3. Confirm water availability

- Many POUs are connected to different types of users:
  - Tank cleaning
  - Wash sink
  - Formulation
  - Sampling
  - ...

- Flowmeters calculate the loop consumption and determine to shut off users when peak load is reached
4. Confirm sufficient back pressure

- The flow sensor is connected to a control valve
- According to the measured flow rate, the control valve can decrease the flow back to the storage (or supply or distribution) tank to increase the pressure at the POUs
5. Optimize WFI usage

- Determining the daily, weekly and maximum WFI quantity
- Knowing the WFI usage will allow for optimization of the process for more efficient WFI usage
- Reduce consumption of expensive raw materials
Clean Utility Flow Measurement with FLOWave flowmeters in Pharma Industry

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Existing flow measurement technology for Clean Utilities (PW, WFI/UPW)

**Electromagnetic**
- Induced voltage by conductive medium through magnetic field

**Coriolis**
- Oscillating distortion of measuring tube by Coriolis force

**Ultrasonic**
- Transit time delay of ultrasonic sound waves
Main drawbacks on existing flow measurement technology for Clean Utilities (PW, WFI/UPW)

**Electromagnetic**
- Conductivity required – not suitable for WFI

**Coriolis**
- Limited drainability, tricky selection and design engineering, pressure drop

**Ultrasonic**
- Difficult, time-consuming installation, complicated validation
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How to overcome existing drawbacks in flow measurement of Clean Utilities like PW and WFI?

- Be innovative.
- Disruptive existing technologies
- – instead of improving 1,000 details.
- Develop a never seen before technology.
Solution: Surface Acoustic Waves

- SAW
- First explained in 1885 by Lord Rayleigh
- Seismic wave in earthquakes
- Radar, communications systems
- TV, pagers and mobile phones

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On Waves Propagated along the Plane Surface of an Elastic Solid. By Lord Rayleigh, D.C.L., F.R.S.

[Read November 12th, 1885.]

It is proposed to investigate the behaviour of waves upon the plane free surface of an infinite homogeneous isotropic elastic solid, their character being such that the disturbance is confined to a superficial region, of thickness comparable with the wave-length. The case is thus analogous to that of deep-water waves, only that the potential energy here depends upon elastic resilience instead of upon gravity.*

Denoting the displacements by \(\alpha, \beta, \gamma\), and the dilatation by \(\theta\), we have the usual equations

\[
\rho \frac{d^2\alpha}{dt^2} = (\lambda + \mu) \frac{d\theta}{dx} + \mu \nabla^2 \alpha, \text{ &c.} \quad \text{.........................(1),}
\]

in which

\[
\theta = \frac{d\alpha}{dx} + \frac{d\beta}{dy} + \frac{d\gamma}{dz} \quad \text{.................................(2).}
\]
SAW phenomenon
Wave propagation basics

Longitudinal waves
- Particle displacement parallel to the direction of wave propagation
- Particles do not move along with the wave, but oscillate

Transverse waves
- Perpendicular particle displacement

Surface Acoustic Waves (SAW)
- Rayleigh waves (and others)
- Particles in a **solid surface** move in elliptical paths
SAW phenomenon in thick and thin geometries

- On the surface of a solid, **thick body**: Rayleigh waves

- On the surface of a solid, **thin plate**: Rayleigh–Lamb waves “moving” on both sides:

- Rayleigh–Lamb waves couple into the liquid and form a compression wave in the liquid...
The “magic” of SAW
Waves coupling from solid into liquid

- SAW (Rayleigh–Lamb waves) couple into liquids and form a compression wave (so-called “mode conversion”)
- Rayleigh angle $\theta$ dependent on wave propagation velocities on the surface and in the liquid
Measurement principle
Propagation in tube walls and liquid

Propagation on solid surface: Rayleigh–Lamb wave (SAW)

Propagation in inside liquid: Compression wave with Rayleigh angle $\theta$

IDT (sender)  IDT (receiver 1)  IDT (receiver 2)
Measurement principle
Determining the flow rate

(1) and (4) sending in flow direction and receiving
(2) and (3) sending against flow direction and receiving

Excitation signal

Time differences between forward and backward propagation proportional to flow velocity

Received signals – Wave Groups

Lamb only
2 WG
4 WG
1 WG
3 WG
5 WG
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Eyes on FLOWave flowmeters
Options, variants, approvals

- Display mounting options and different sizes
- Compliance and approvals are part of the FLOWave package

<table>
<thead>
<tr>
<th>DIN</th>
<th>ASME BPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>DN 15</td>
<td>3/4”</td>
</tr>
<tr>
<td>DN 25</td>
<td>1”</td>
</tr>
<tr>
<td>DN 40</td>
<td>1½“</td>
</tr>
<tr>
<td>DN 50</td>
<td>2”</td>
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</table>
Clean Utility Flow Measurement with FLOWave

At a glance

- Superior drainability
- Less energy
  - No pressure drop
  - Lower power consumption (ca. 33% of Coriolis devices)
- Hygienic approvals without any restrictions or conditions
  - Same pharma tube in use
- Extremely light: easy handling and installation
- Straight-forward selection and specification
- Process diagnostics
- Customers approve
FLOWave flowmeters in application
FLOWave in application
Hot Water Loop

- FLOWave on hot water loop to control the **velocity** of the medium
- Just a tube, no cleanability issues
- Easy to commision
FLOWave in application
Cold Water Loop

- FLOWave on cold water loop to control the flow rate
- Just a tube, no cleanability issues
- Easy to commission
FLOWave in application
Barcelona Spain

• Pure water transfer from main tank to production area (clean room)

• Control the flow volume in the tank
Extremely compact
Thank you

Please visit table 10 for further information

Clean Utility Flow Measurement with FLOWave flowmeters in Pharma Industry. Presentation
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We make ideas flow.