Fourth European Workshop on

Standardized Procedure for the Inspection of Sprayers in Europe

- SPISE 4 -

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Accuracy of nozzle flow rate measurement methods for the inspection of sprayers in use

Francesc Solanelles
Anna Tarrado
Ferran Camp
Felip Gracia

Centre de Mecanització Agrària
Departament d’Agricultura, Ramaderia, Pesca, Alimentació i Medi Natural
Rovira Roure 191
25198, Lleida, Spain
Nozzle flow rate measurement
Hose + stopwatch
Watertight adaptors
Watertight adaptors
### Flat fan standard nozzles

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Nozzle model and size</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albuz®</td>
<td>API 110 02, 03, 04</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>Teejet®</td>
<td>XR 110 02, 03, 04 VS</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>Hardi®</td>
<td>F 110 02, 03, 04</td>
<td>2, 3, 4</td>
</tr>
</tbody>
</table>

### Hollow cone standard nozzles

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Nozzle model and size</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albuz®</td>
<td>ATR yellow, orange, red</td>
<td>5, 8, 10</td>
</tr>
<tr>
<td>Teejet®</td>
<td>TXA 80 015 VK, TXB 80 02, 03 VK</td>
<td>5, 8, 10</td>
</tr>
<tr>
<td>Lechler®</td>
<td>TR 80 015, 02, 03</td>
<td>5, 8, 10</td>
</tr>
</tbody>
</table>
**Flat fan air injection nozzles**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Nozzle model and size</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albuz®</td>
<td>AVI 110 02, 03, 04</td>
<td>3, 5, 7</td>
</tr>
<tr>
<td>Hardi®</td>
<td>INJET 02, 03, 04</td>
<td>3, 6, 8</td>
</tr>
<tr>
<td>Lechler®</td>
<td>IDK 120 02, 03, 04</td>
<td>2, 4, 6</td>
</tr>
</tbody>
</table>

**Hollow cone air injection nozzles**

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<th>Nozzle model and size</th>
<th>Pressure (bar)</th>
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<tbody>
<tr>
<td>Albuz®</td>
<td>TVI 80 015, 02, 03</td>
<td>5, 8, 10</td>
</tr>
<tr>
<td>Lechler®</td>
<td>ITR 80 015, 02</td>
<td>5, 8, 10</td>
</tr>
</tbody>
</table>
Statistical analysis. Global

3 measurement methods (m)
2 nozzle types, standard and air injection (t)
3 sizes of each nozzle model (s)
4 nozzles for each size (n)
3 working pressures (p)
2 replicates for each measurement

Lineal model

\[ F_{ijkl} = \mu + m_i + t_j + s_k + p_l + (mt)_{ij} + \ldots + (tp)_{jl} + \ldots + \varepsilon_{ijkl} \]
Statistical analysis

No significant differences between the “hose + jar” and the nozzle bench measurements for flat fan nozzles

meas. method x nozzle type (NS)

meas. method x nozzle size (NS)

meas. method x pressure (NS)

Significant differences between the “hose + jar” and the watertight adaptors
Deviation of the flow rate measurements with the watertight adaptors. Albuz® API 110
Deviation of the flow rate measurements with the watertight adaptors. Lechler® IDK 120.
Deviation of the flow rate measurements with the watertight adaptors. Teejet® Conejet TX

Deviation from...
Deviation of the flow rate measurements with the watertight adaptors. Albuz® TVI

Deviation from: Hose + jar
Nominal flow rate
Hose + jar
Nominal flow rate
Hose + jar
Nominal flow rate
Summary. Deviation for flat fan nozzles

![Graph showing deviation for flat fan nozzles]
Summary. Deviation for hollow cone nozzles

-3
-1
1
3
5

5 bar
8 bar
10 bar

ATR
yellow
ATR
orange
Albuz

STANDARD
TXA 80
015 VK
TXB 80
02 VK
TXB 80
03 VK
TVI 80
015
TVI 80
02
TVI 80
03
ITR 80
015
ITR 80
02

Albuz
TeeJet
AIR INJECTION
Lechler

5 bar
8 bar
10 bar

Statistical analysis. Watertight adaptors

2 nozzle types, standard and air injection (t)
3 sizes of each nozzle model (s)
4 nozzles for each size (n)
3 working pressures (p)
2 replicates for each measurement

Lineal model

\[ D_{ijk} = \mu + t_i + s_j + p_k + (tp)_{ik} + (sp)_{jk} + \ldots + \varepsilon_{ijk} \]
## Deviation values (%) (nozzle type x pressure)

<table>
<thead>
<tr>
<th>Flat fan nozzle type</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Standard</td>
<td>4.55 a</td>
</tr>
<tr>
<td>Air injection</td>
<td>11.55 a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hollow cone nozzle type</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Standard</td>
<td>-3.50a</td>
</tr>
<tr>
<td>Air injection</td>
<td>4.70a</td>
</tr>
</tbody>
</table>
Deviation values (%) (nozzle type x pressure)
## Deviation values (%) (nozzle type x size)

<table>
<thead>
<tr>
<th>Flat fan nozzle type</th>
<th>Size</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>02</td>
<td>03</td>
<td>04</td>
</tr>
<tr>
<td>Standard</td>
<td>4.60 a</td>
<td>3.22 b</td>
<td>2.12 b</td>
</tr>
<tr>
<td>Air injection</td>
<td>5.18 a</td>
<td>6.89 b</td>
<td>6.52 b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hollow cone nozzle type</th>
<th>Size</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>015</td>
<td>02</td>
<td>03</td>
</tr>
<tr>
<td>Standard</td>
<td>-3.30 a</td>
<td>-3.52 a</td>
<td>-3.17 a</td>
</tr>
<tr>
<td>Air injection</td>
<td>1.99 a</td>
<td>1.66 a</td>
<td>1.98 a</td>
</tr>
</tbody>
</table>
Deviation values (%) (nozzle type x size)

![Graph showing deviation values for different nozzle types and sizes.]
## Special nozzles

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<thead>
<tr>
<th>Manufacturer</th>
<th>Nozzle model and size</th>
<th>Pressure (bar)</th>
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<tbody>
<tr>
<td>Teejet®</td>
<td>TJ60 110 02, 03, 04</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td>Teejet®</td>
<td>TT 110 02, 03, 04</td>
<td>2, 3, 4</td>
</tr>
</tbody>
</table>

**Wide flat spray**

**Twin flat fan**
Summary. Deviation for special nozzles

![Graph showing deviation for special nozzles with pressure levels 2 bar, 3 bar, and 4 bar.](image-url)
Special nozzles. Significant differences between “hose + jar” and nozzle bench measurements.
## Special nozzles

### Deviation values (%) (nozzle type x pressure)

<table>
<thead>
<tr>
<th>Nozzle type</th>
<th>Pressure (bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Twin flat fan</td>
<td>2.23 a</td>
</tr>
<tr>
<td>Wide flat spray</td>
<td>-5.45 a</td>
</tr>
</tbody>
</table>

### Deviation values (%) (nozzle type x size)

<table>
<thead>
<tr>
<th>Nozzle type</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>02</td>
</tr>
<tr>
<td>Twin flat fan</td>
<td>1.92 ab</td>
</tr>
<tr>
<td>Wide flat spray</td>
<td>-3.92 a</td>
</tr>
</tbody>
</table>
Conclusions

No significant differences between “hose + jar” and nozzle bench measurements. Only small differences in the case of special nozzles.
Conclusions

Measurement deviations between the flow rate measured with the watertight adaptors and the “hose + jar”
Conclusions

Measurement deviations between the flow rate measured with the watertight adaptors and the “hose + jar”

Deviation is always higher when all the nozzles are measured at lower pressure

Some nozzle measurements show a positive deviation, whereas others show a negative deviation

The trend is not clear: e.g. positive deviations for flat fan nozzles but negative for twin jet flat fan nozzles.

Nozzle size has an effect on the deviation of some kind of nozzles, but there is not a clear pattern
Conclusions

Measurement deviations between the flow rate measured with the watertight adaptors and the “hose + jar”

Deviation is always higher when all the nozzles are measured at lower pressure

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Nozzle size has an effect on the deviation of some kind of nozzles, but there is not a clear pattern

The measurement error of the nozzle adaptors should be taken into account in sprayer inspections.