



Error Introduced by:
Image Analysis Software
Camera & Part Holder

August 2008

“..any sufficiently advanced technology is indistinguishable from magic.” Arthur C. Clark

WORLD CLASS,

Background: Three different areas of error on the possible accuracy that can be obtained are explored:

- Image Analysis Software
- Camera and lens
- Placement of the sprinkler

Requirement: Confirm that image analysis software does not introduce additional errors into the measurements.

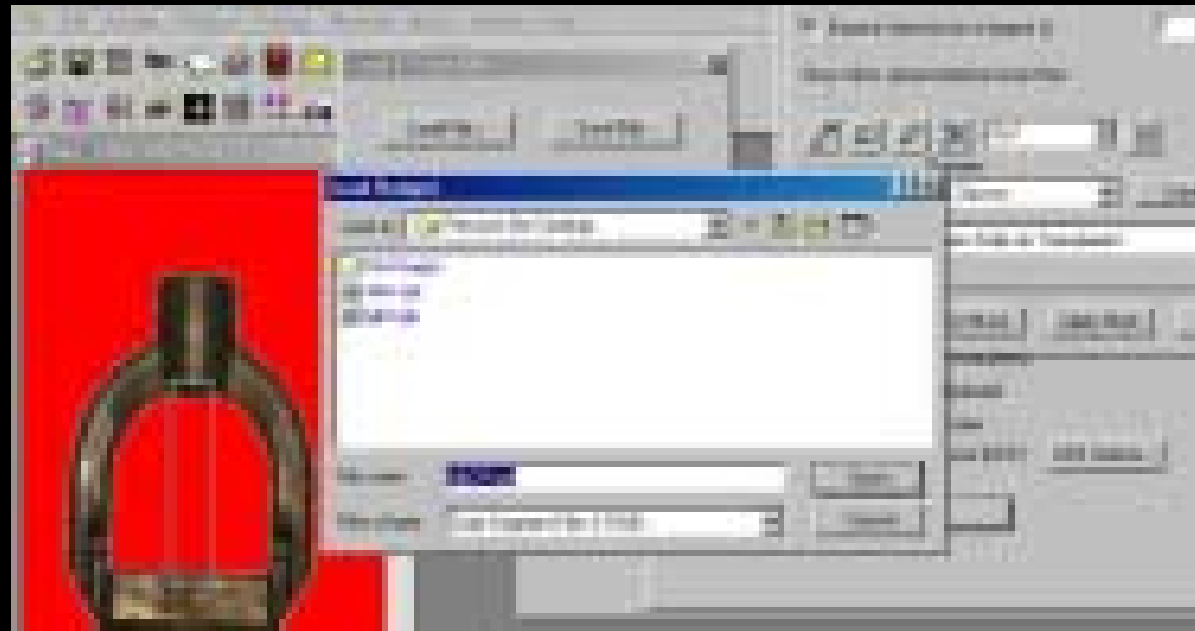


Image Analysis Software Results

- ◆ See the attached spreadsheet document
 - 26 Measurements performed 121 times

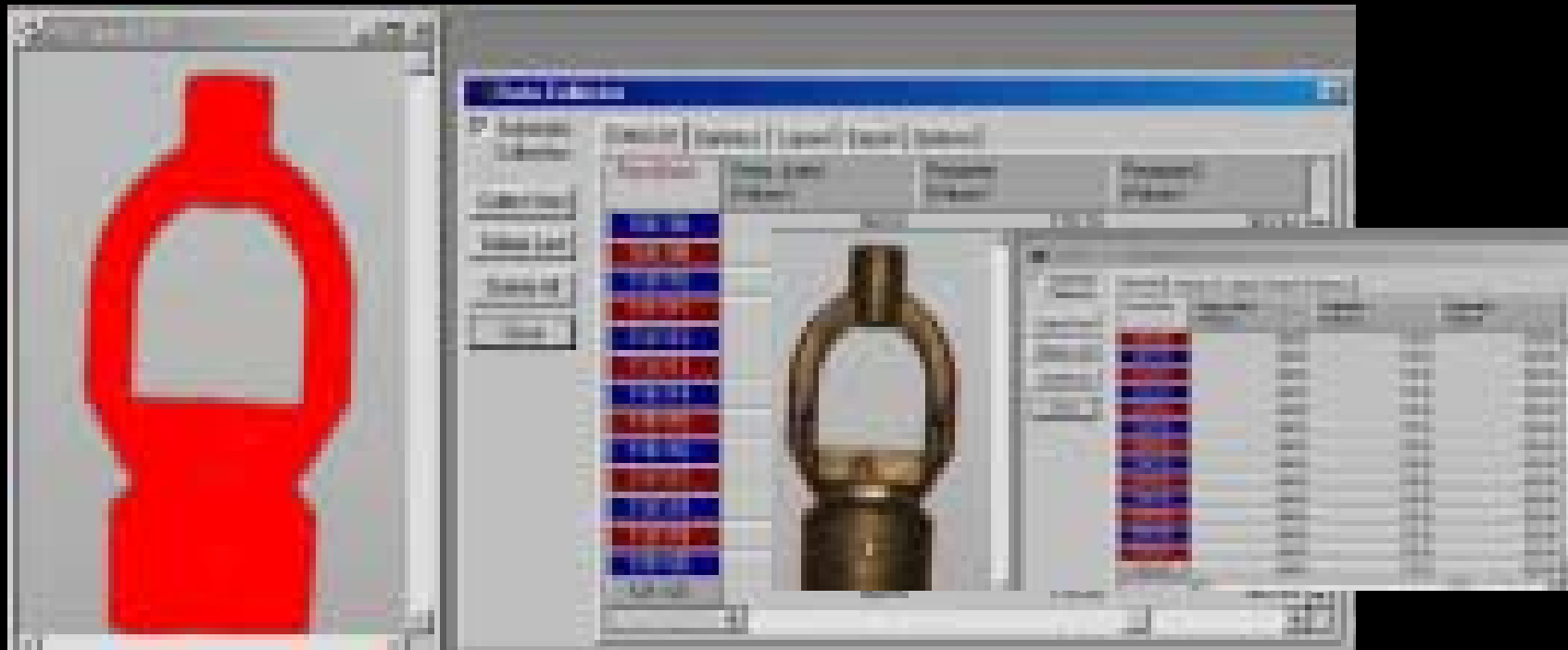


Image Analysis Software

- ◆ Image analysis software was used to process the same image a number of times.
- ◆ 121 measurements were performed
- ◆ **Std.Dev. over all 26 measurements = 0**



Requirement: Confirm that image analysis software does not introduce additional errors into the measurements.

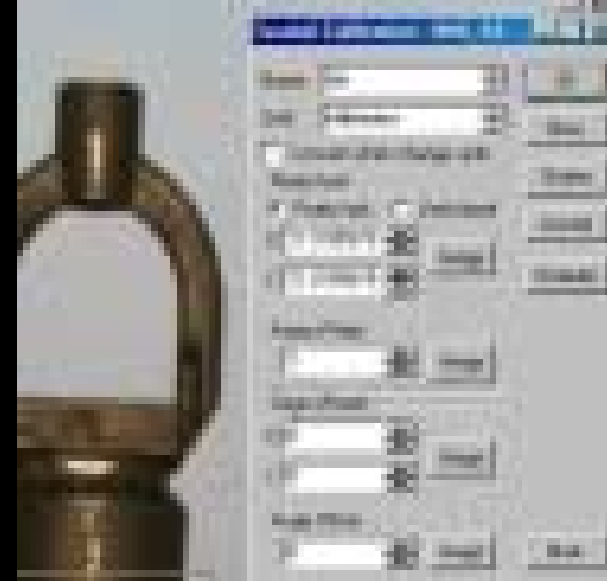
CONFIRMED: The image analysis software introduces zero error

Requirement: Calculate the error introduced by the current camera / lens configuration.



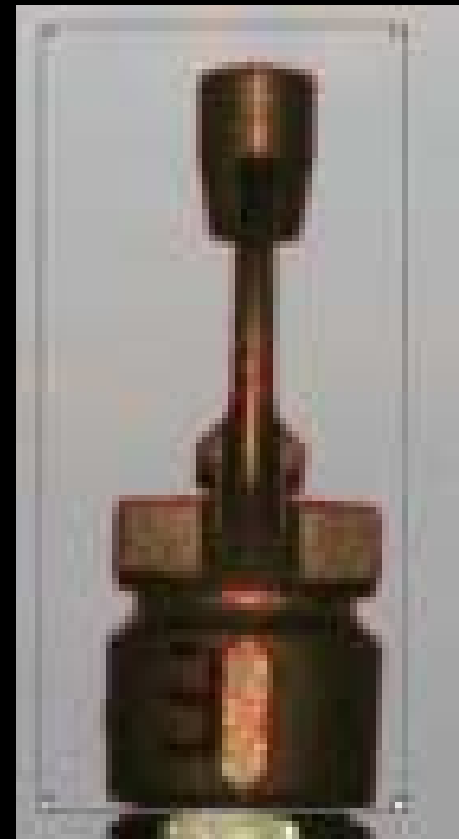
Camera / Lens Error

- ◆ Image analysis software was used to process different images of the same object, without moving the sprinkler
- ◆ All results are in MM
(7 pixels per MM)

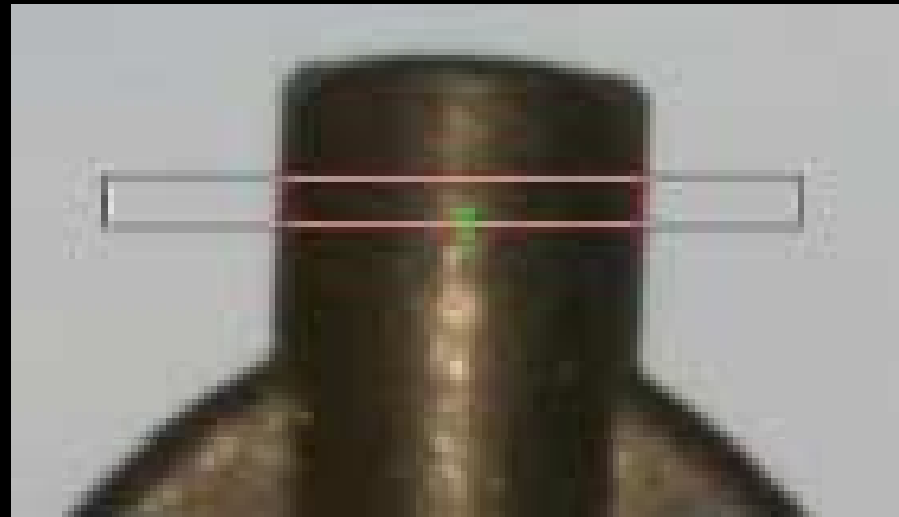


Camera / Lens Error

- ◆ The following measurements were performed:
- ◆ 1 Boss Width (D)
- ◆ 3 Spanner Flat (D)
- ◆ 4 NPT Boss Width (D)
- ◆ 5 Window Width (L)
- ◆ 11 Arm Angle (D)



1 Boss Width (D)



| | |
|--------------|----------|
| IMG_6385.JPG | 9.8033 |
| IMG_6386.JPG | 9.8017 |
| IMG_6387.JPG | 9.8038 |
| IMG_6388.JPG | 9.8029 |
| IMG_6389.JPG | 9.8033 |
| IMG_6390.JPG | 9.8045 |
| IMG_6391.JPG | 9.802 |
| IMG_6392.JPG | 9.801712 |
| IMG_6393.JPG | 9.802017 |
| IMG_6394.JPG | 9.801773 |
| IMG_6395.JPG | 9.802506 |

MAX 9.89679

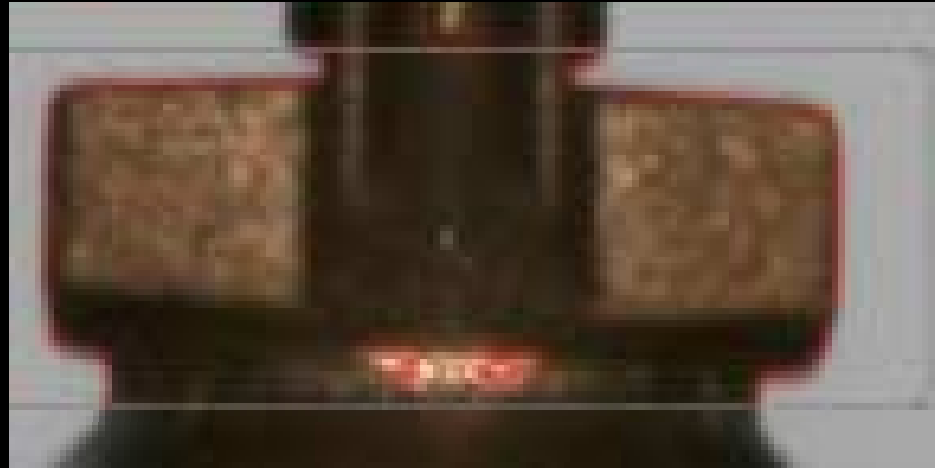
MIN 9.89234

AVG 9.893094

STD DEV 0.001316

3 Spanner Flat (D)

| | | |
|--------------|----------|----------|
| IMG_6550.JPG | 9.620819 | 22.96144 |
| IMG_6549.JPG | 9.620743 | 23.05205 |
| IMG_6448.JPG | 9.620148 | 23.14296 |
| IMG_6547.JPG | 9.620148 | 23.05209 |
| IMG_6546.JPG | 9.620178 | 23.05219 |
| IMG_6545.JPG | 9.6203 | 23.14311 |
| IMG_6544.JPG | 9.620163 | 23.05222 |
| IMG_6543.JPG | 9.620255 | 23.05217 |
| IMG_6542.JPG | 9.620773 | 23.05232 |

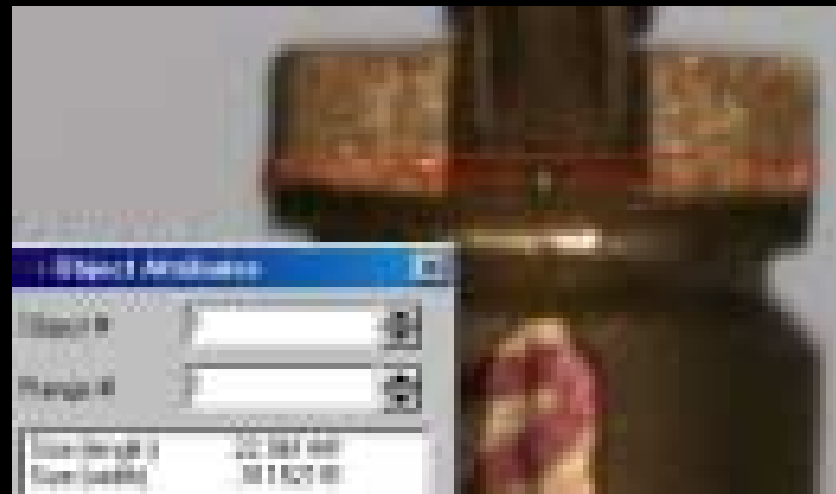


MAX 23.14311

MIN 22.96144

AVG 23.06228

STD DEV 0.054572



4 NPT Boss Width (D)

| | | |
|--------------|----------|-----------|
| IMG_6560.JPG | 9.89241 | 23.596603 |
| IMG_6559.JPG | 9.892853 | 23.596664 |
| IMG_6558.JPG | 9.892838 | 23.596741 |
| IMG_6557.JPG | 9.892868 | 23.596603 |
| IMG_6556.JPG | 9.892426 | 23.596664 |
| IMG_6555.JPG | 9.89234 | 23.596649 |
| IMG_6554.JPG | 9.892929 | 23.596603 |
| IMG_6553.JPG | 9.89679 | 23.59668 |
| IMG_6552.JPG | 9.892777 | 23.596649 |
| IMG_6551.JPG | 9.892716 | 23.596619 |



MAX 23.596741

MIN 23.596603

AVG 23.596648

STD DEV 0.00004

11 Arm Angle (D)

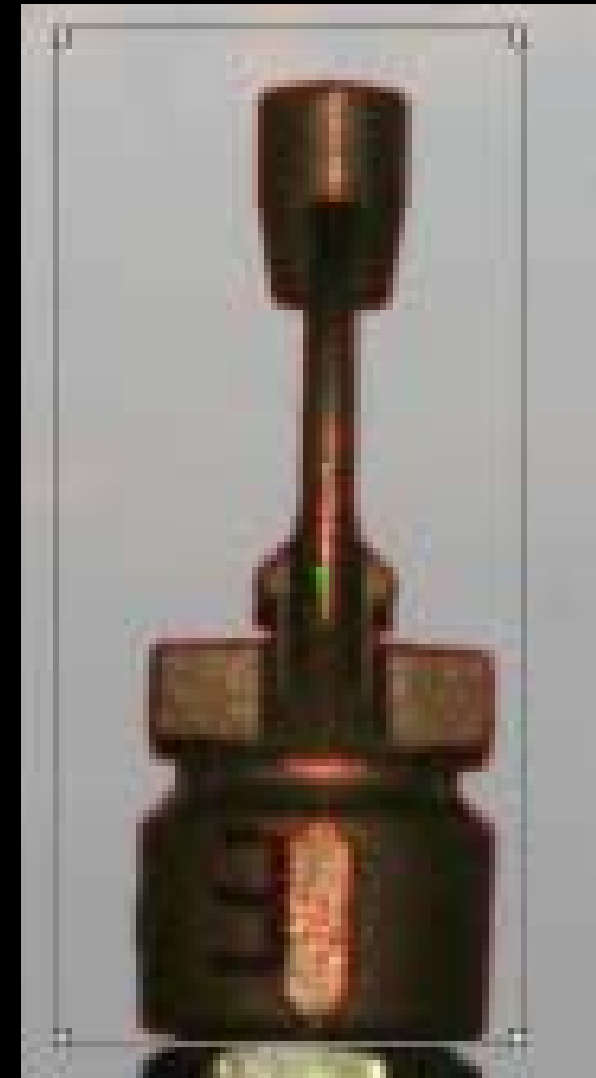
| | | | | | |
|------|--------------|----------|----------|-----------|---------|
| No 2 | IMG_6550.JPG | 9.620819 | 22.96144 | 23.687485 | 2.34871 |
| No 2 | IMG_6549.JPG | 9.620743 | 23.05205 | 23.687469 | 2.33359 |
| No 2 | IMG_6448.JPG | 9.620148 | 23.14296 | 23.688339 | 2.33551 |
| No 2 | IMG_6547.JPG | 9.620148 | 23.05209 | 23.596588 | 2.34681 |
| No 2 | IMG_6546.JPG | 9.620178 | 23.05219 | 23.687332 | 2.3543 |
| No 2 | IMG_6545.JPG | 9.6203 | 23.14311 | 23.596573 | 2.35617 |
| No 2 | IMG_6544.JPG | 9.620163 | 23.05222 | 23.687454 | 2.34642 |
| No 2 | IMG_6543.JPG | 9.620255 | 23.05217 | 23.596634 | 2.33547 |
| No 2 | IMG_6542.JPG | 9.620773 | 23.05232 | 23.59668 | 2.35782 |

MAX 2.35782

MIN 2.33359

AVG 2.34609

STD DEV 0.00932



Requirement: Error introduced by the current camera configuration:

The camera, under the current capture technique, introduces the following errors:

- ◆ 1 Boss Width = 0.001 mm (100X)
- ◆ 3 Spanner Flat = 0.05 mm (40 X)
- ◆ 4 NPT Boss Width = 0.00004 mm (1 000X)
- ◆ 11 Arm Angle = 0.009 degrees (50X)

Requirement: Calculate the error introduced by the current sprinkler holder configuration.



Sprinkler Holder Error

- ◆ Image analysis software was used to process different images of the same object, replacing the sprinkler in the same position on the holder each time

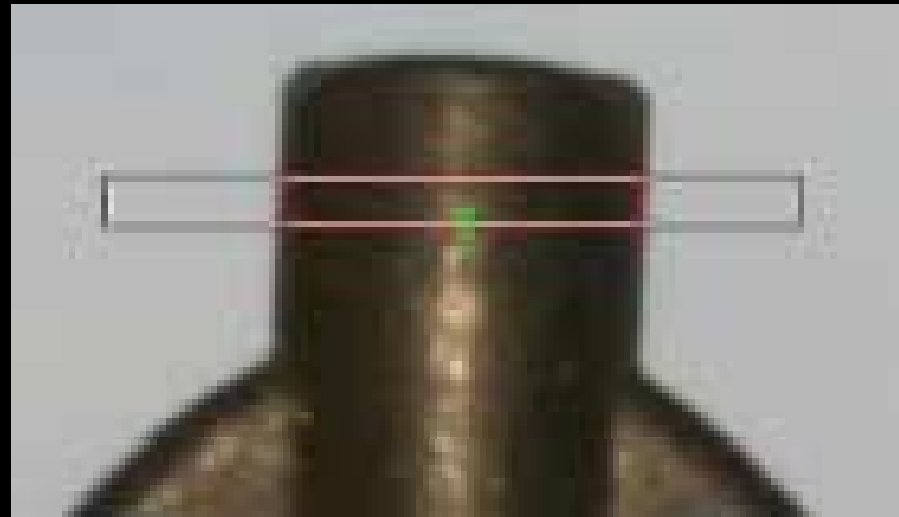


Sprinkler Holder Error

- ◆ The following measurements were performed:
- ◆ 1 Boss Width (D)
- ◆ 4 NPT Boss Width (D)
- ◆ 5 Window Width (L)
- ◆ 6 Window Height (L)
- ◆ 7 Deflector Boss Length (D)

1 Boss Width (D)

| | | |
|----|--------------|----------|
| 1 | IMG_6398.JPG | 9.900665 |
| 2 | IMG_6399.JPG | 9.90979 |
| 3 | IMG_6400.JPG | 9.902832 |
| 4 | IMG_6401.JPG | 9.892059 |
| 5 | IMG_6402.JPG | 9.898117 |
| 6 | IMG_6403.JPG | 9.896362 |
| 7 | IMG_6404.JPG | 9.898239 |
| 8 | IMG_6405.JPG | 9.907791 |
| 9 | IMG_6406.JPG | 9.895783 |
| 10 | IMG_6407.JPG | 9.898514 |



MAX 9.909 MIN 9.892 AVG 9.90001

STD DEV 0.0054

◆ Less 0.001 mm camera error = 0.004 mm

4 NPT Boss Width (D)

| | | | |
|----|--------------|----------|-----------|
| 1 | IMG_6398.JPG | 9.900665 | 23.50592 |
| 2 | IMG_6399.JPG | 9.90979 | 23.505966 |
| 3 | IMG_6400.JPG | 9.902832 | 23.506348 |
| 4 | IMG_6401.JPG | 9.892059 | 23.505814 |
| 5 | IMG_6402.JPG | 9.898117 | 23.506317 |
| 6 | IMG_6403.JPG | 9.896362 | 23.505829 |
| 7 | IMG_6404.JPG | 9.898239 | 23.507782 |
| 8 | IMG_6405.JPG | 9.907791 | 23.505997 |
| 9 | IMG_6406.JPG | 9.895783 | 23.506439 |
| 10 | IMG_6407.JPG | 9.898514 | 23.506424 |



MAX 23.5077 MIN 23.5058 AVG 23.5062
STD DEV 0.00058

◆ Less 0.00004 mm camera error = 0.00054 mm

5 Window Width (L)

| | | | | |
|----|--------------|----------|-----------|----------|
| 1 | IMG_6398.JPG | 9.900665 | 23.50592 | 19.15367 |
| 2 | IMG_6399.JPG | 9.90979 | 23.505966 | 19.15457 |
| 3 | IMG_6400.JPG | 9.902832 | 23.506348 | 19.1501 |
| 4 | IMG_6401.JPG | 9.892059 | 23.505814 | 19.14993 |
| 5 | IMG_6402.JPG | 9.898117 | 23.506317 | 19.14958 |
| 6 | IMG_6403.JPG | 9.896362 | 23.505829 | 19.14973 |
| 7 | IMG_6404.JPG | 9.898239 | 23.507782 | 19.14954 |
| 8 | IMG_6405.JPG | 9.907791 | 23.505997 | 19.15273 |
| 9 | IMG_6406.JPG | 9.895783 | 23.506439 | 19.1553 |
| 10 | IMG_6407.JPG | 9.898514 | 23.506424 | 19.15002 |

MAX 19.1553

MIN 19.14954

AVG 19.15152

STD DEV 0.002



6 Window Height (L)

| | | | | | |
|----|--------------|----------|-----------|----------|-----------|
| 1 | IMG_6398.JPG | 9.900665 | 23.50592 | 19.15367 | 21.634216 |
| 2 | IMG_6399.JPG | 9.90979 | 23.505966 | 19.15457 | 21.615906 |
| 3 | IMG_6400.JPG | 9.902832 | 23.506348 | 19.1501 | 21.650757 |
| 4 | IMG_6401.JPG | 9.892059 | 23.505814 | 19.14993 | 21.651489 |
| 5 | IMG_6402.JPG | 9.898117 | 23.506317 | 19.14958 | 21.634888 |
| 6 | IMG_6403.JPG | 9.896362 | 23.505829 | 19.14973 | 21.612305 |
| 7 | IMG_6404.JPG | 9.898239 | 23.507782 | 19.14954 | 21.62146 |
| 8 | IMG_6405.JPG | 9.907791 | 23.505997 | 19.15273 | 21.634888 |
| 9 | IMG_6406.JPG | 9.895783 | 23.506439 | 19.1553 | 21.609192 |
| 10 | IMG_6407.JPG | 9.898514 | 23.506424 | 19.15002 | 21.612915 |

MAX 21.651489

MIN 21.609192

AVG 21.627802

STD DEV 0.015



7 Deflector Boss Length (D)

Sprinkler No 2

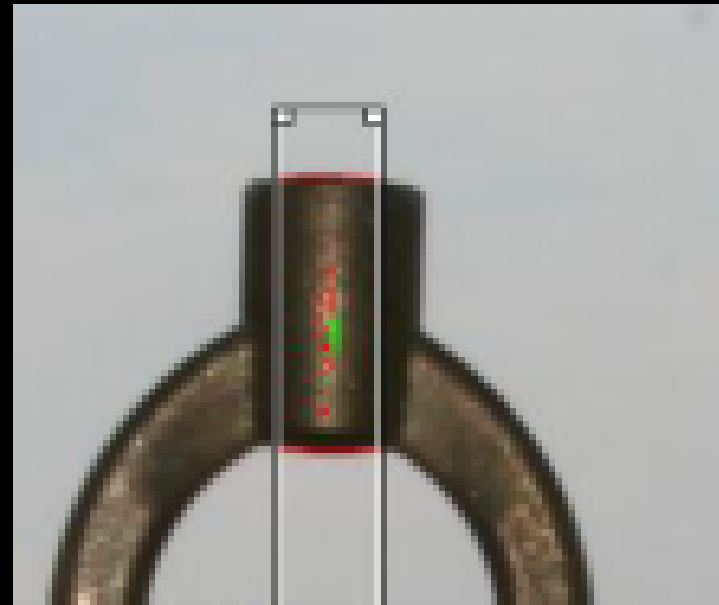
| | | | | | | |
|----|--------------|----------|-----------|----------|-----------|-----------|
| 1 | IMG_6398.JPG | 9.900665 | 23.50592 | 19.15367 | 21.634216 | 15.247559 |
| 2 | IMG_6399.JPG | 9.90979 | 23.505966 | 19.15457 | 21.615906 | 15.222656 |
| 3 | IMG_6400.JPG | 9.902832 | 23.506348 | 19.1501 | 21.650757 | 15.276001 |
| 4 | IMG_6401.JPG | 9.892059 | 23.505814 | 19.14993 | 21.651489 | 15.20105 |
| 5 | IMG_6402.JPG | 9.898117 | 23.506317 | 19.14958 | 21.634888 | 15.202026 |
| 6 | IMG_6403.JPG | 9.896362 | 23.505829 | 19.14973 | 21.612305 | 15.247314 |
| 7 | IMG_6404.JPG | 9.898239 | 23.507782 | 19.14954 | 21.62146 | 15.251221 |
| 8 | IMG_6405.JPG | 9.907791 | 23.505997 | 19.15273 | 21.634888 | 15.24707 |
| 9 | IMG_6406.JPG | 9.895783 | 23.506439 | 19.1553 | 21.609192 | 15.262085 |
| 10 | IMG_6407.JPG | 9.898514 | 23.506424 | 19.15002 | 21.612915 | 15.247803 |

MAX 15.276001

MIN 15.20105

AVG 15.240479

STD DEV 0.02



Requirement: Error introduced by the sprinkler holder:

The sprinkler holder introduces the following errors:

- ◆ **1 Boss Width = 0.004 mm (100X)**
- ◆ **4 NPT Boss Width = 0.00054 mm (1 000X)**
- ◆ **5 Window Width = 0.002 mm (500X)**
- ◆ **6 Window Height = 0.015 mm (150X)**
- ◆ **7 Deflector Boss Length = 0.02 mm (50X)**

The measurements not performed require a suitable sprinkler holder in order to obtain measurements of:

- ◆ **2 Arms**
- ◆ **12 Concentricity**
- ◆ **9 Arm Widths**
- ◆ **13 /14 Porosity**

Further manual measurements will produce similar excellent results. A repeatable sprinkler holder which can do thousands of measurements is required.

IN SUMMARY: Three different areas of accuracy were explored:

- Image Analysis Software introduces no error;

- The camera / lens introduces a small error and largest error is the sprinkler holder

IN SUMMARY:

With careful placement of the sprinkler, an accuracy between 50 – 1 000 X that required can be obtained.

