



Daniel Orifice Plates

Calibration of Orifice Plates

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DANIEL®


EMERSON™
Process Management

Orifice Plates

- The most fundamental component for orifice flow measurement.
- Flat, circular, and held in line by a fitting or flanges.
- Universal (fitting) or Paddle type (flanges).

Orifice Plates

- ½ inch – 60 inch
- 304 and 316 Stainless Steel
- Monel
- Hastelloy
- Other materials on request
- AGA / ISO / API compliant

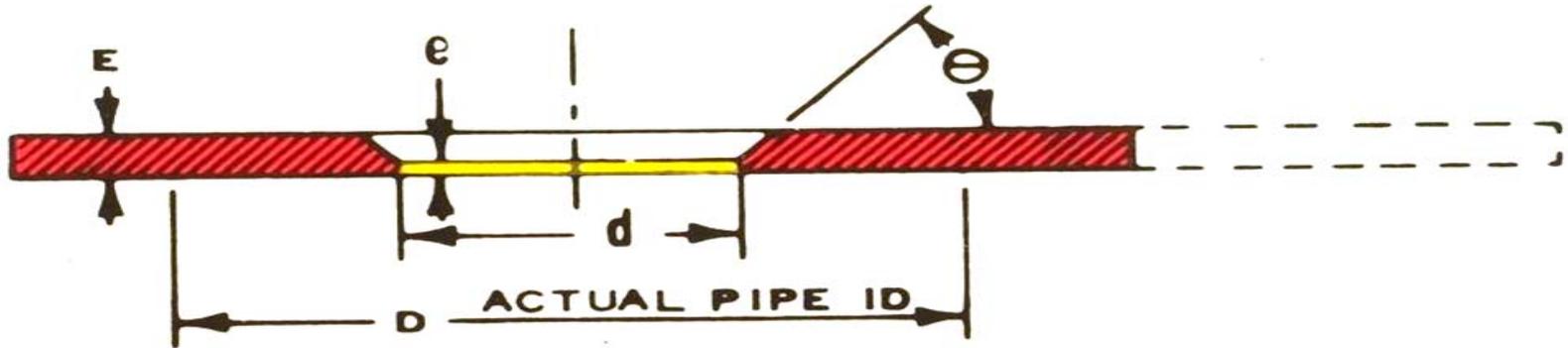


Orifice Plates

→ ISO 5167 & AGA Report No. 3 Requirements:

- Concentricity of the orifice bore
- Edge Thickness
- Plate Thickness
- Plate Flatness
- Plate Surface Finish
- Edge must be square and sharp, and **'will not'** reflect a beam of light

Orifice Plate Dimensions



e = Edge thickness

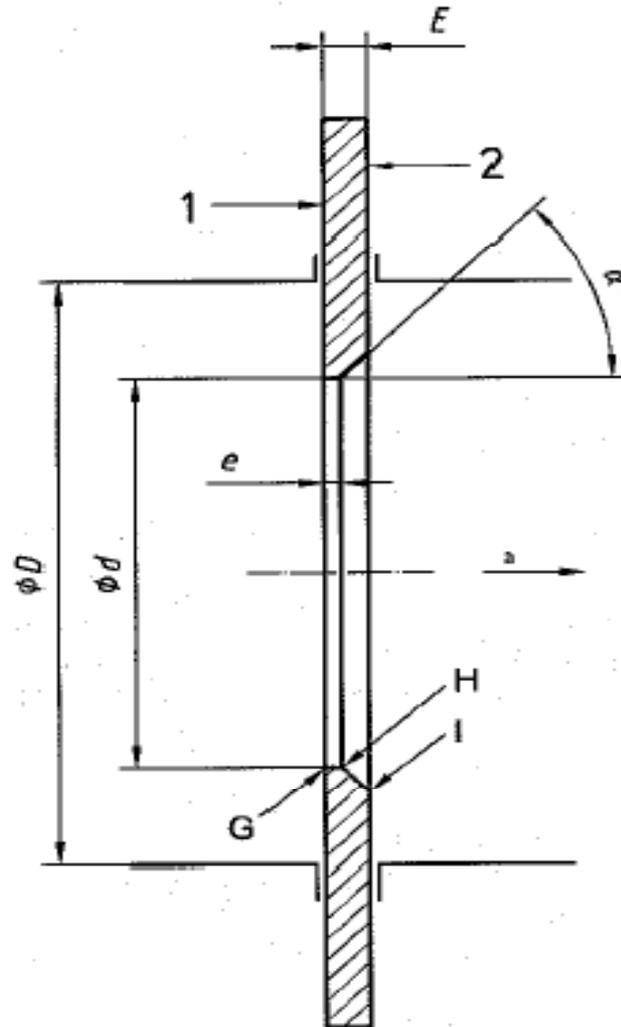
E = Plate thickness

Θ = Bevel requirements

d = Bore

D = Pipe I.D.

Orifice Plate Dimensions



Key

- 1 upstream face A
- 2 downstream face B
- ^a Direction of flow.

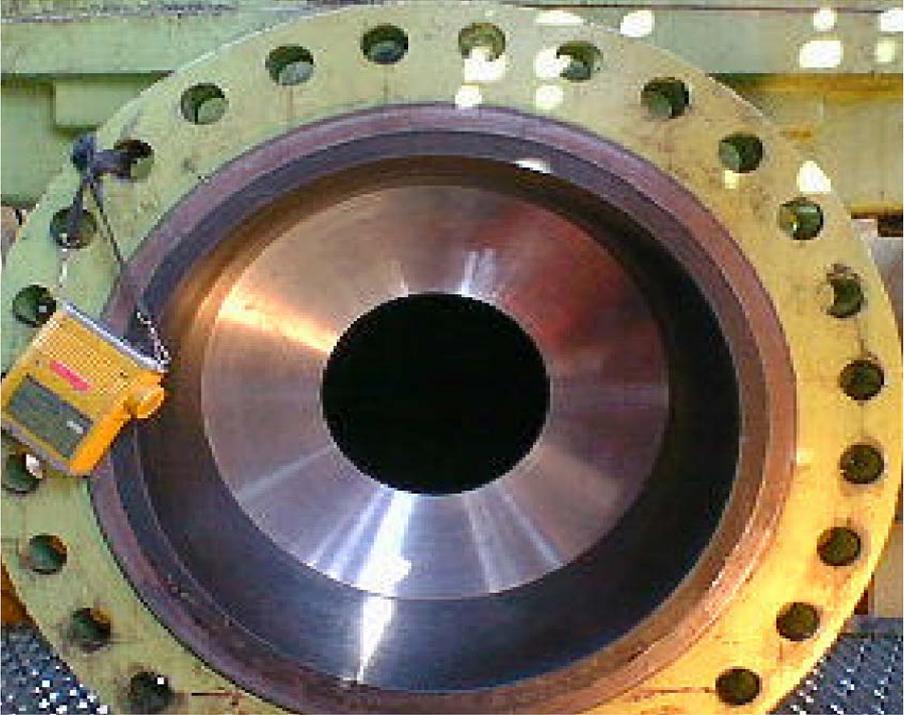
Orifice Plates



Orifice Plates – Universal Plate



Orifice Plates - Installed



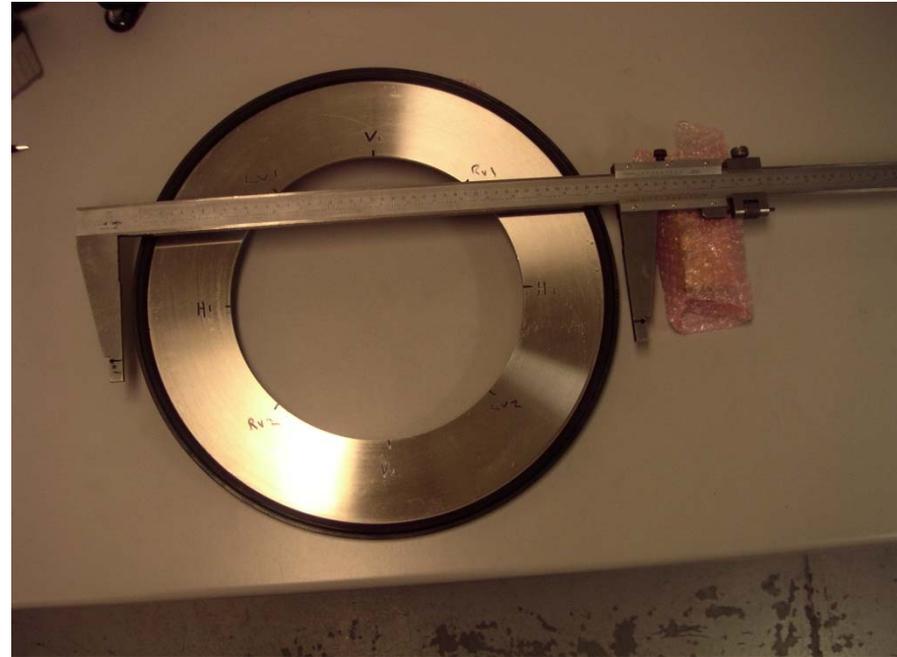
Orifice Plate Calibration

Options when ordering are:

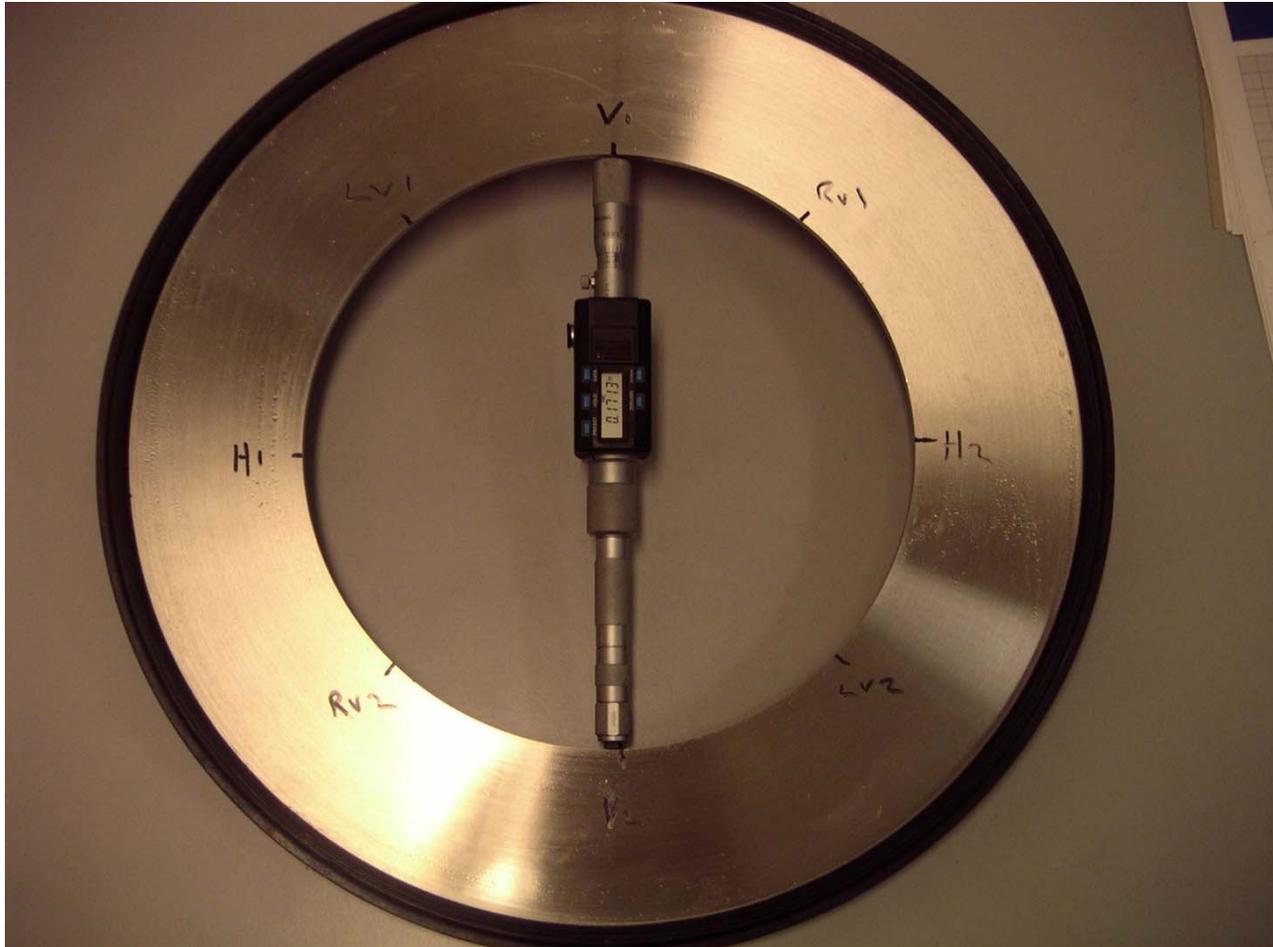
- **No Report** (Bore size is etched on plate)
- **CMM Report** (One page computer print out)
- **UKAS Report** (Report from an independent UKAS laboratory)
- **Full Edge Sharpness Report** (9 Page Report)

Orifice Plate Calibration – Outside Diameter

- The outside diameter of the plate is checked to ensure compliance with Daniel manufacturing procedures.



Orifice Plate Calibration – Bore Diameter



Orifice Plate Calibration – Bore Diameter

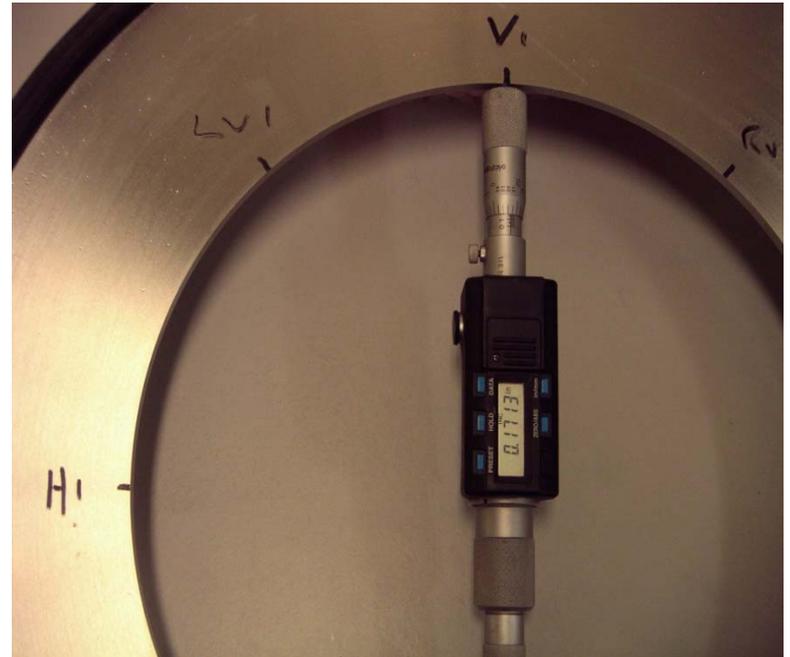
ISO 5167-2:2003 Section 5.1.8.1

- Diameter of the orifice d
- The diameter d shall in all cases be greater than or equal to 12.5 mm.
- The Diameter ratio (beta ratio), $\beta=d/D$ shall always be greater than or equal to 0.10 and less than or equal to 0.75
- The orifice bore shall be cylindrical

Orifice Plate Calibration – Bore Diameter

ISO 5167-2:2003 Section 5.1.8.2. & 3

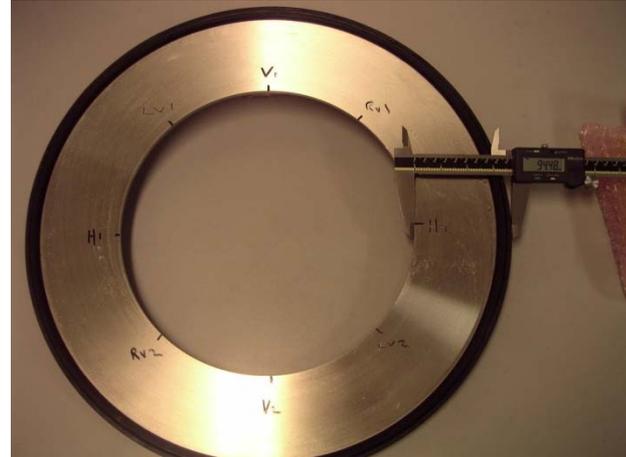
- The value d of the diameter shall be taken as the mean as the mean of the measurements of at least four diameters at approximately equal angles to each other.
- No diameter shall differ by more than 0.05% from the mean diameter



Orifice Plate Calibration – Concentricity

ISO 5167-2:2003 Section 6.5.3

- The part of the plate within the pipe shall be circular and concentric with the centre line.
- This inspection determines concentricity between the inside and outside diameters of the plate.



Orifice Plate Calibration – Concentricity

ISO 5167-2:2003 Section 6.5.3

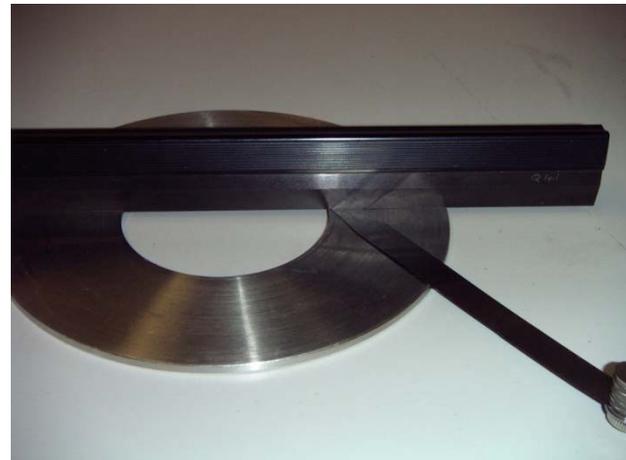
→ Further inspection is required to ensure conformance when the plate is inserted in the orifice fitting.

$$e_d \leq \frac{0,0025D}{0,1+23\beta^4}$$

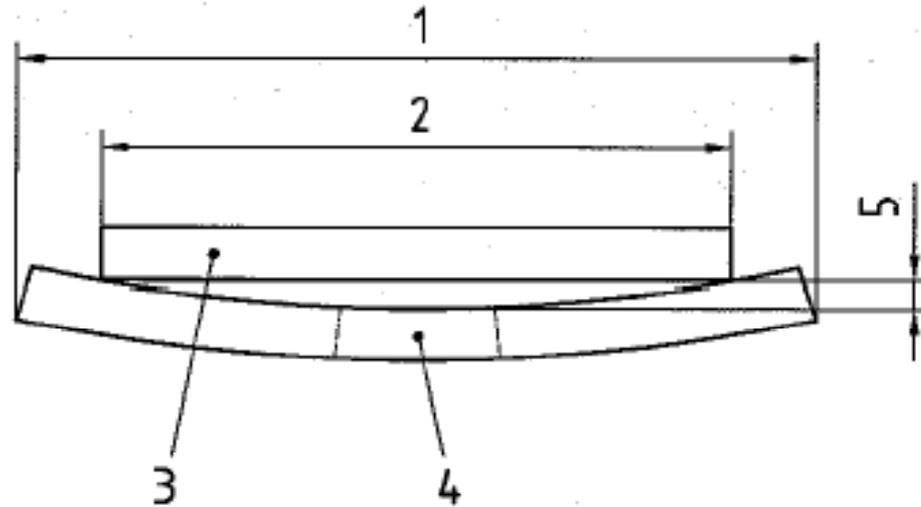
Orifice Plate Calibration – Plate Flatness

ISO 5167-2:2003 Section 5.1.3.1

- The upstream face shall be flat.
- It will be considered flat when the maximum gap between the plate and a straight edge of length D laid across any diameter is less than $0.0005(D-d)/2$



Orifice Plate Calibration – Plate Flatness



Key

- 1 orifice plate outside diameter
- 2 pipe inside diameter (D)
- 3 straight edge
- 4 orifice
- 5 departure from flatness (measured at edge of orifice)

Orifice Plate Calibration – Thickness e

ISO 5167-2:2003 Section 5.1.5.1

- The thickness ' e ' of the orifice shall be between $0.005D$ and $0.02D$



Orifice Plate Calibration – Thickness E

ISO 5167-2:2003 Section 5.1.5.3

→ The Thickness of 'E' shall be between 'e' and $0.05D$



Orifice Plate Calibration – Bevel Angle

ISO 5167-2:2003 Section 5.1.6.1 & 2

- If the thickness E of the plate exceeds the thickness e of the orifice, the plate shall be bevelled on the downstream side.
- The bevelled surface shall be well finished.
- The angle of the Bevel shall be $45^\circ \pm 15^\circ$



Orifice Plate Calibration – Edge Sharpness

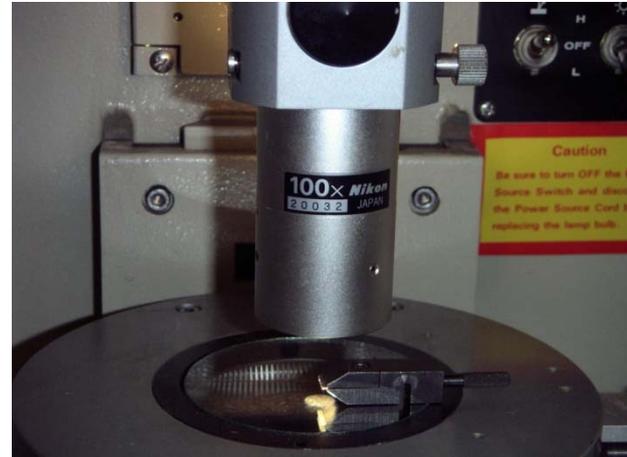
ISO 5167-2:2003 Section 5.1.7.2

- The upstream edge shall be sharp. It is considered so if the edge radius is not greater than $0.000d$
- If $d \geq 25\text{mm}$ this requirement may be considered as satisfied by visual inspection.
- Checking that the edge does not reflect a beam of light when viewed with the naked eye.



Orifice Plate Calibration – Edge Sharpness

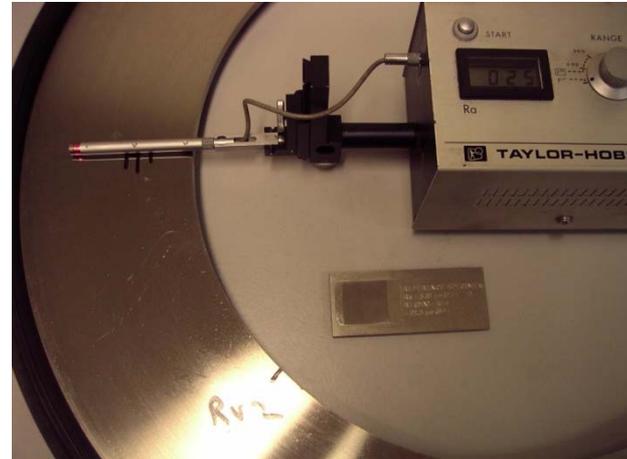
- An impression of the leading edge G is taken using lead foil and magnified 100x on a shadowgraph machine.
- The radius of the upstream edge is measured by comparing the magnified image with radius graphs.
- Downstream edges H & I are within a separated flow region hence quality requirements are less stringent



Orifice Plate Calibration – Surface Finish

ISO 5167-2:2003 Section 5.1.3.2

- The upstream face of the orifice plate shall have a roughness criterion $R_a \leq 10^{-4}d$ within a circle whose diameter is not less than D and which is concentric with the orifice
- The flatness and surface condition of the downstream face may be judged by visual inspection



Orifice Plate Calibration – CMM

- Most of Daniel orifice plates are manufactured in Houston where they are checked by a CMM



Orifice Plate Calibration – CMM



Orifice Plate Calibration – CMM

FLATNESS OF PLATE						
			+ TOL	- TOL	DEV	OUT-TOL
FM			0.0150		0.0070	++
DIAMETER & ROUNDNESS OF THE O/D						
	ACTUAL	NOMINAL	+ TOL	- TOL	DEV	OUT-TOL
DI	18.5924	18.6100	0.0000	0.0200	-0.0176	----
EM			0.0200		0.0024	+
DIAMETER & ROUNDNESS OF THE BORE						
	ACTUAL	NOMINAL	+ TOL	- TOL	DEV	OUT-TOL
DI	12.8793	12.8838	0.0054	0.0064	-0.0045	----
EM			0.0054		0.0003	+
CONCENTRICITY OF THE BORE TO THE O/D						
PS			0.0200		0.0021	+
THICKNESS OF PLATE						
	ACTUAL	NOMINAL	+ TOL	- TOL	DEV	OUT-TOL
Z	0.3769	0.3750	0.0100	0.0100	0.0019	+
THE 45 DEG. BEVEL						
	ACTUAL	NOMINAL	+ TOL	- TOL	DEV	OUT-TOL
AN	45 21'11"	45 00'00"	15 00'00"	15 00'00"	0 21'11"	+
LENGTH OF ORIFICE BORE						
	ACTUAL	NOMINAL	+ TOL	- TOL	DEV	OUT-TOL
Z	0.2390	0.2500	0.0000	0.0200	-0.0110	----

END OF PRESENTATION

Thank you for your attention

Any Questions?

