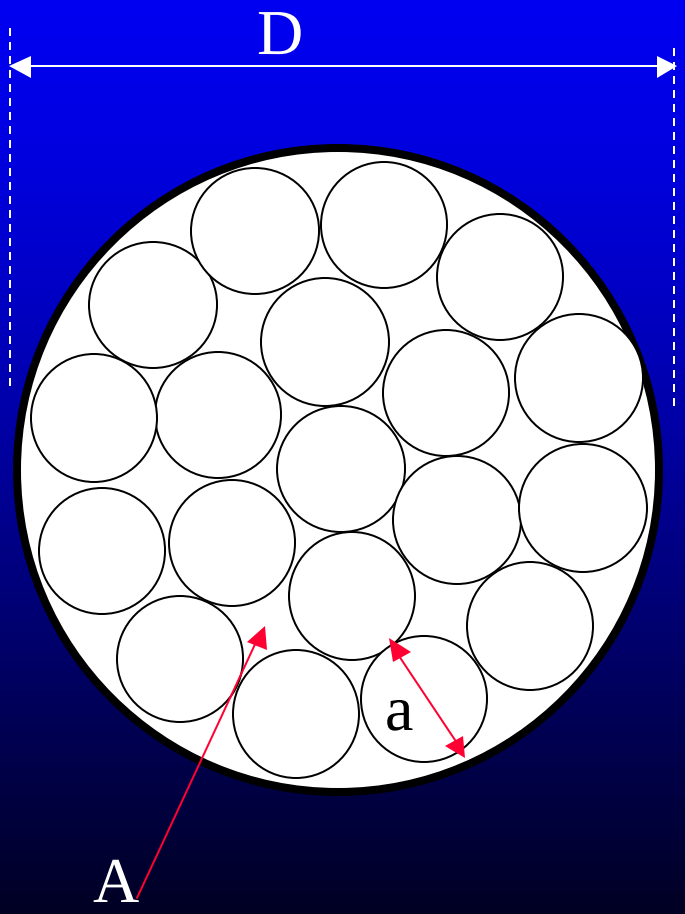
QUALIFICATION OF FLOW CONDTIONING DEVICES ACCORDING TO THE NEW API 14.3 PART 2 PROCEDURE.

Klaus J. Zanker and Dale Goodson

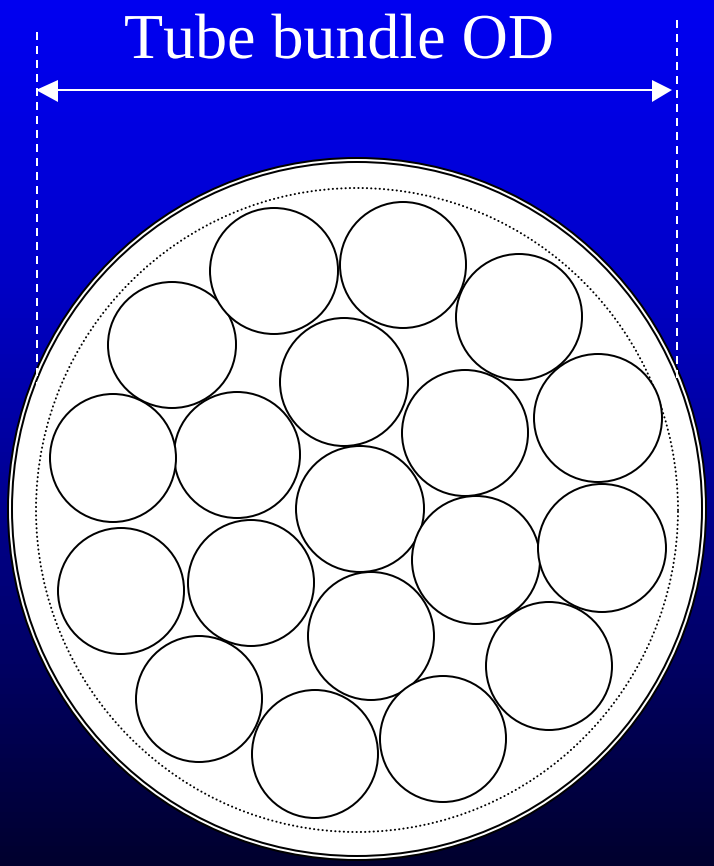
Daniel Industries, Inc.

Old Tube Bundle



1. a/D < 1/4
2. L/a > 10
3. A < 1/16(π D^2 /4)
4. Tubes any size - symmetrical
5. Tubes any shape
6. Tubes mounted into end rings
7. Tubes welded together
8. Tubes thin walled
9. All tubes mounted axially

New Tube Bundle



Tube wall thickness = t

Items 1, 2, 3, 4, 5, & 6 no longer apply, only 19 tube uniform concentric tube bundle allowed

- All tubes must touch one another
- Tubes must be welded together
- OD > 0.95 D
- t < 2.5 % of D

API Type Approval Requirements

- Baseline Calibration, evaluating performance of test facility
- To prove that the mechanical baseline configuration is valid, the baseline CD values should lie within the 95% confidence interval for the RG equation.
- Standard does not demand an “accredited facility”

Disturbance Tests

- **Good Flow Conditions** - test evaluating impact of flow conditioner on fully developed velocity profile.
- **Two 90^0 Elbows in Perpendicular Planes** - testing of flow conditioner performance in handling combination of a modest swirl and a non-symmetrical velocity profile.
- **Gate Valve 50% Closed** - test evaluating flow conditioner performance in strongly non-symmetrical velocity profile.
- **High Swirl** - test assessing flow conditioner performance in flows with high swirl angle (over 25^0).

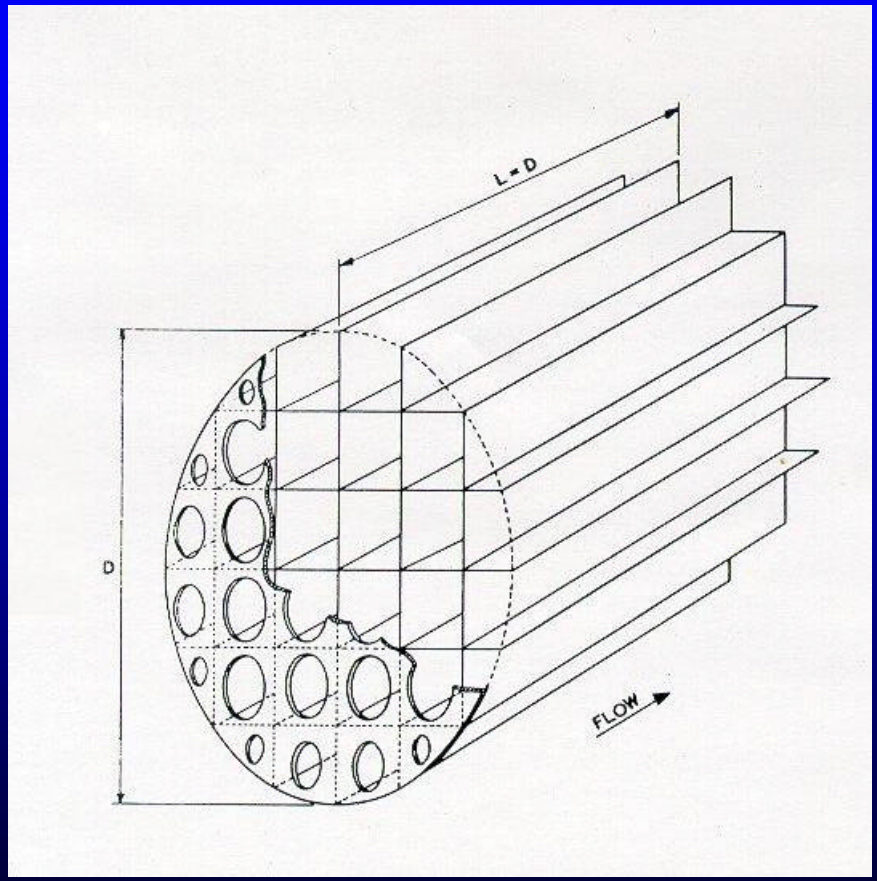
Additional Tests

- **Orifice ƀ ratio**: Check swirl test at β=0.40 and β=0.67
- **Reynolds Number Sensitivity:** Test at two ranges $10^4 < Re < 5 \times 10^5$ and $Re > 10^6$ with approximately a 7:1 ratio.
- **Scaling:** Test at two sizes selected from $D \leq 4$” and $D \geq 8$”

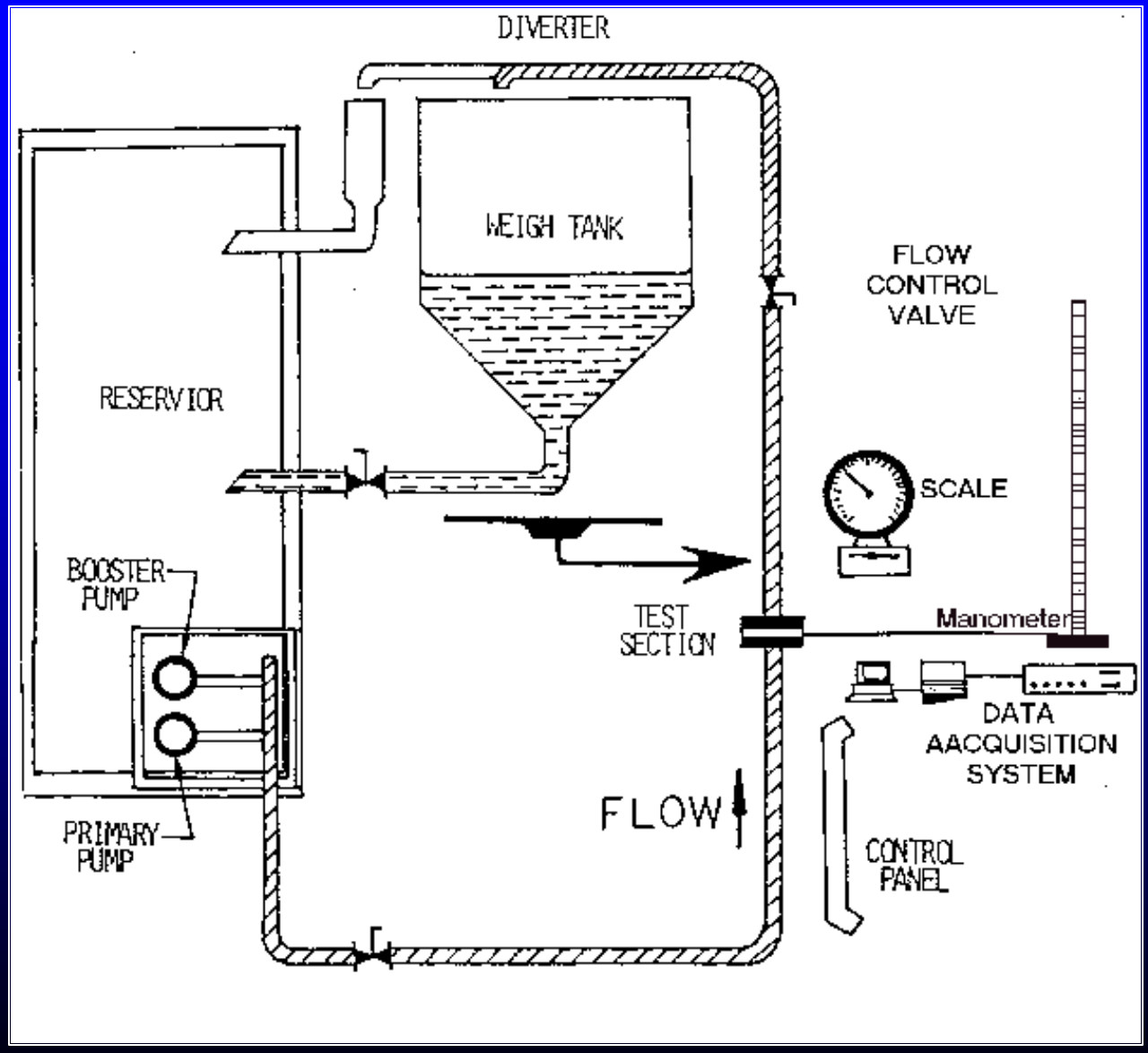
Zanker Plate Design

- **Zanker straightener** 1959 at BHRA, NEL conference in 1960, was included in ISO 5167 in 1980
- Mitsubishi in 1973 US patent 3840051
- Elizabeth Laws in 1992
- **Modified Zanker**: Thick plate, no honeycomb

Flow Straightener



Zanker Plate


DIVERTER
WEIGH TANK
FLOW
CONTROL
VALVE
RESERVIOR
SCALE
BOOSTER
PUMP
TEST
SECTION
Manometer
DATA
AACQUISITION
SYSTEM
FLOW
PRIMARY
PUMP
CONTROL
PANEL

DANIEL Flow Products Inc.

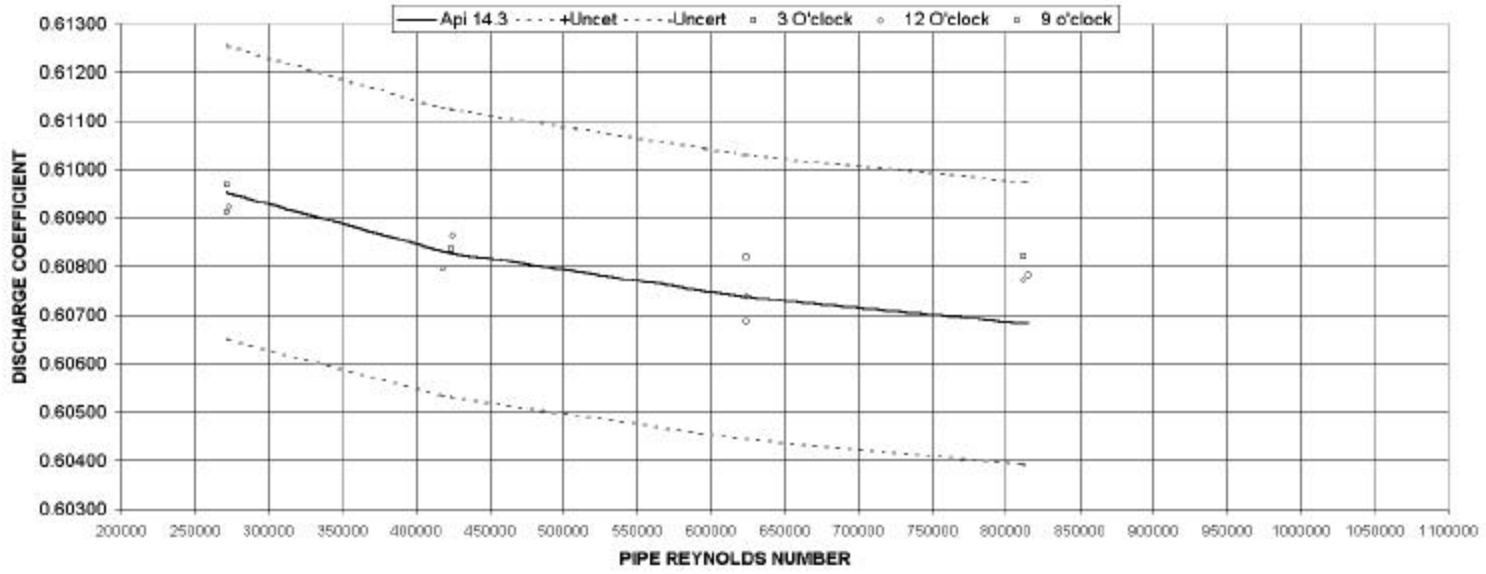
0.67 β : BASELINE SPRENKLE PLATE & 62.5 D UPSTREAM OF ORIFICE PLATE

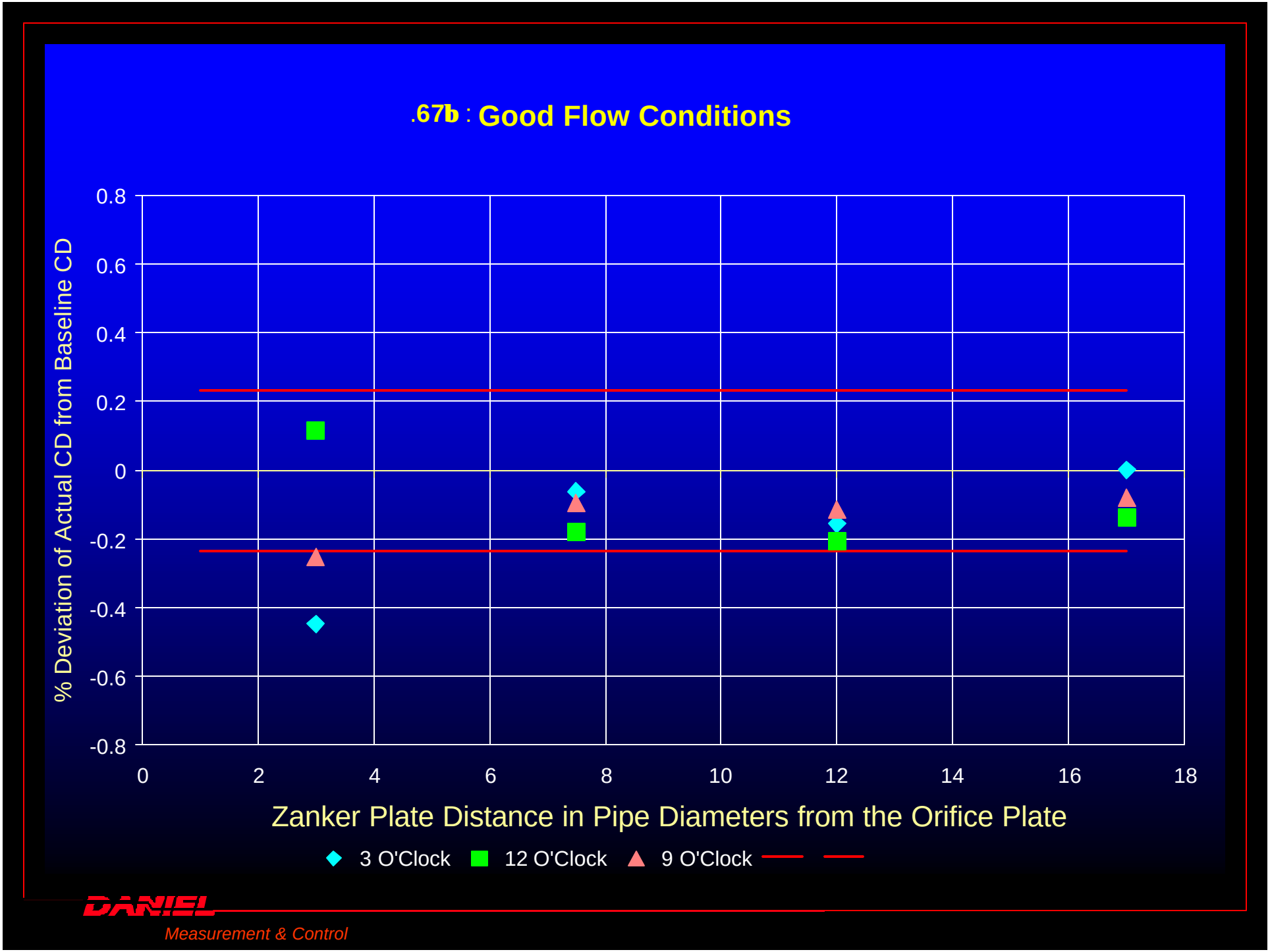
Tap No.	Date	β Ratio	d_bore in.	D_line in.	Weight Lbs.	Time sec.	P-Line psig	ρ lbs/ft³	FlowRate ft³/min	ΔP In.-Hg*	ΔP psi	T- Flow °F	T- Mano °F	Ambient Air Temp °F	R_D	C_D Actual	C_D API 14.3	$U_{(95)}$	UR_D
3 o'clock	05-Nov-98	0.67018	2.6968	4.024	14000	104.658	76.31	62.274	129.043	94.196	42.694	73.47	69.50	58.50	812245	0.60821	0.60683	0.46771	1.02551
3 o'clock	05-Nov-98	0.67018	2.6968	4.024	9000	87.818	78.73	62.272	98.866	55.294	25.062	73.64	69.50	58.70	623663	0.60819	0.60737	0.46771	1.03151
3 o'clock	05-Nov-98	0.67018	2.6968	4.024	9000	129.445	79.83	62.271	67.074	25.436	11.529	73.80	69.50	58.50	423985	0.60836	0.60827	0.46771	1.04290
3 o'clock	05-Nov-98	0.67018	2.6968	4.024	4000	90.043	80.09	62.269	42.857	10.339	4.686	74.08	69.50	58.60	271881	0.60969	0.60952	0.46771	1.06122

* Inches of Hg under H_2O

Tap No.	Date	β Ratio	d_bore in.	D_line in.	Weight Lbs.	Time sec.	P-Line psig	ρ lbs/ft³	FlowRate ft³/min	ΔP In.-Hg*	ΔP psi	T- Flow °F	T- Mano °F	Ambient Air Temp °F	R_D	C_D Actual	C_D API 14.3	$U_{(95)}$	UR_D
12 o'clock	05-Nov-98	0.67018	2.6968	4.024	14000	104.679	76.31	62.274	129.017	94.310	42.746	73.42	69.50	58.50	811554	0.60772	0.60683	0.46771	1.02552
12 o'clock	05-Nov-98	0.67018	2.6968	4.024	9000	87.769	78.73	62.272	98.922	55.503	25.157	73.65	69.50	58.90	624092	0.60739	0.60737	0.46771	1.03149
12 o'clock	05-Nov-98	0.67018	2.6968	4.024	9000	129.088	79.83	62.271	67.259	25.553	11.582	73.74	69.50	58.50	424827	0.60864	0.60827	0.46771	1.04284
12 o'clock	05-Nov-98	0.67018	2.6968	4.024	4000	89.723	80.01	62.269	43.010	10.428	4.726	74.08	69.50	58.70	272851	0.60924	0.60951	0.46771	1.06104

Tap No.	Date	β Ratio	d_bore in.	D_line in.	Weight Lbs.	Time sec.	P-Line psig	ρ lbs/ft³	FlowRate ft³/min	ΔP In.-Hg*	ΔP psi	T- Flow °F	T- Mano °F	Ambient Air Temp °F	R_D	C_D Actual	C_D API 14.3	$U_{(95)}$	UR_D
9 o'clock	05-Nov-98	0.67018	2.6968	4.024	14000	104.700	76.35	62.271	128.998	94.253	42.718	73.83	70.00	58.00	815726	0.60782	0.60682	0.46771	1.02542
9 o'clock	05-Nov-98	0.67018	2.6968	4.024	9000	88.080	78.43	62.270	98.576	55.212	25.023	73.87	70.00	58.10	623668	0.60686	0.60737	0.46771	1.03151
9 o'clock	05-Nov-98	0.67018	2.6968	4.024	9000	131.660	79.92	62.269	65.948	24.621	11.159	74.04	70.00	58.00	418152	0.60797	0.60831	0.46771	1.04338
9 o'clock	05-Nov-98	0.67018	2.6968	4.024	4000	90.284	80.09	62.267	42.744	10.304	4.670	74.25	70.00	57.80	271753	0.60911	0.60952	0.46771	1.06124





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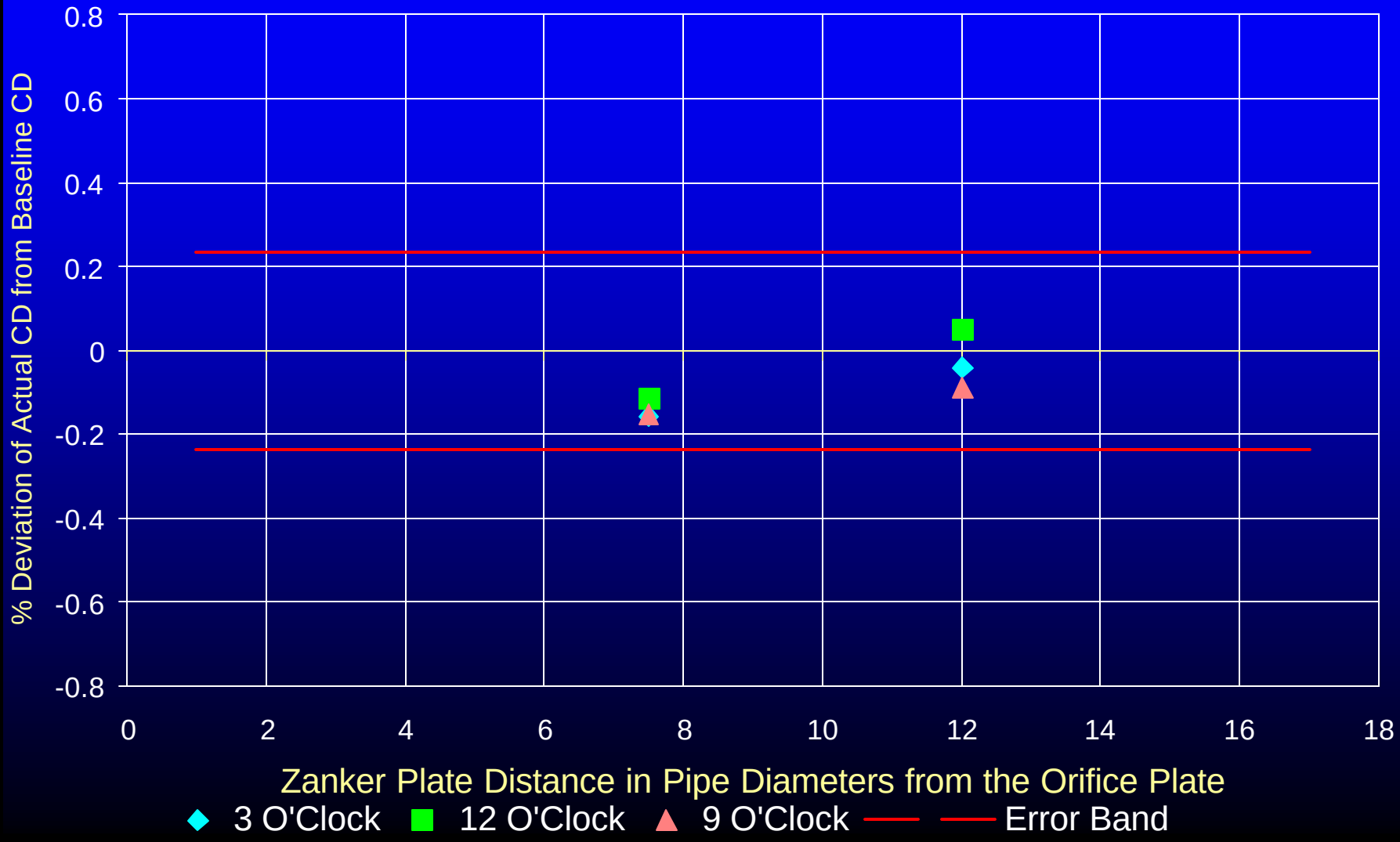
Measurement & Control

67b : Two 90° Elbows in Perpendicular Planes 17 D Meter Tube



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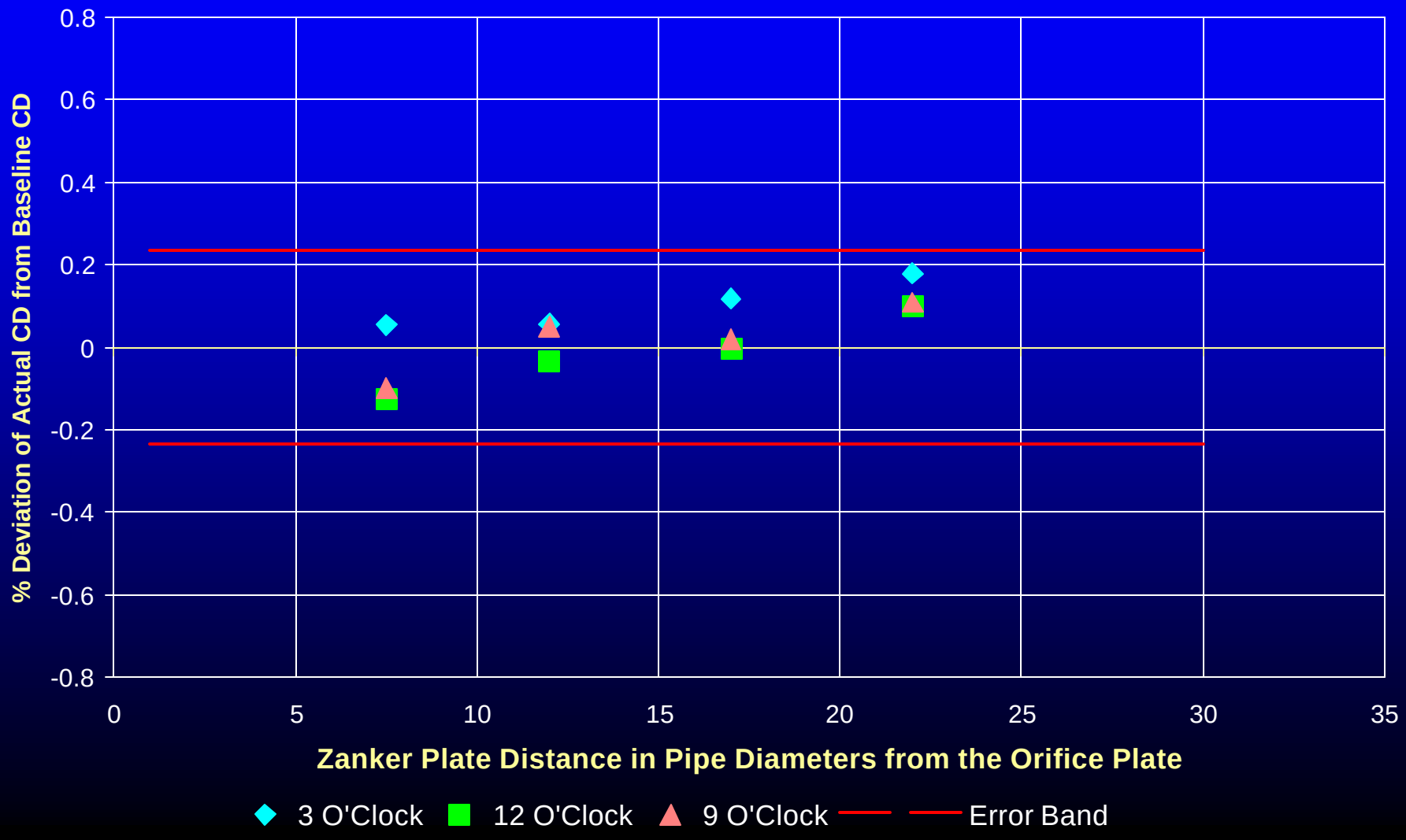
.67b : Two 90° Elbows in Perpendicular Planes 29D Meter Tube



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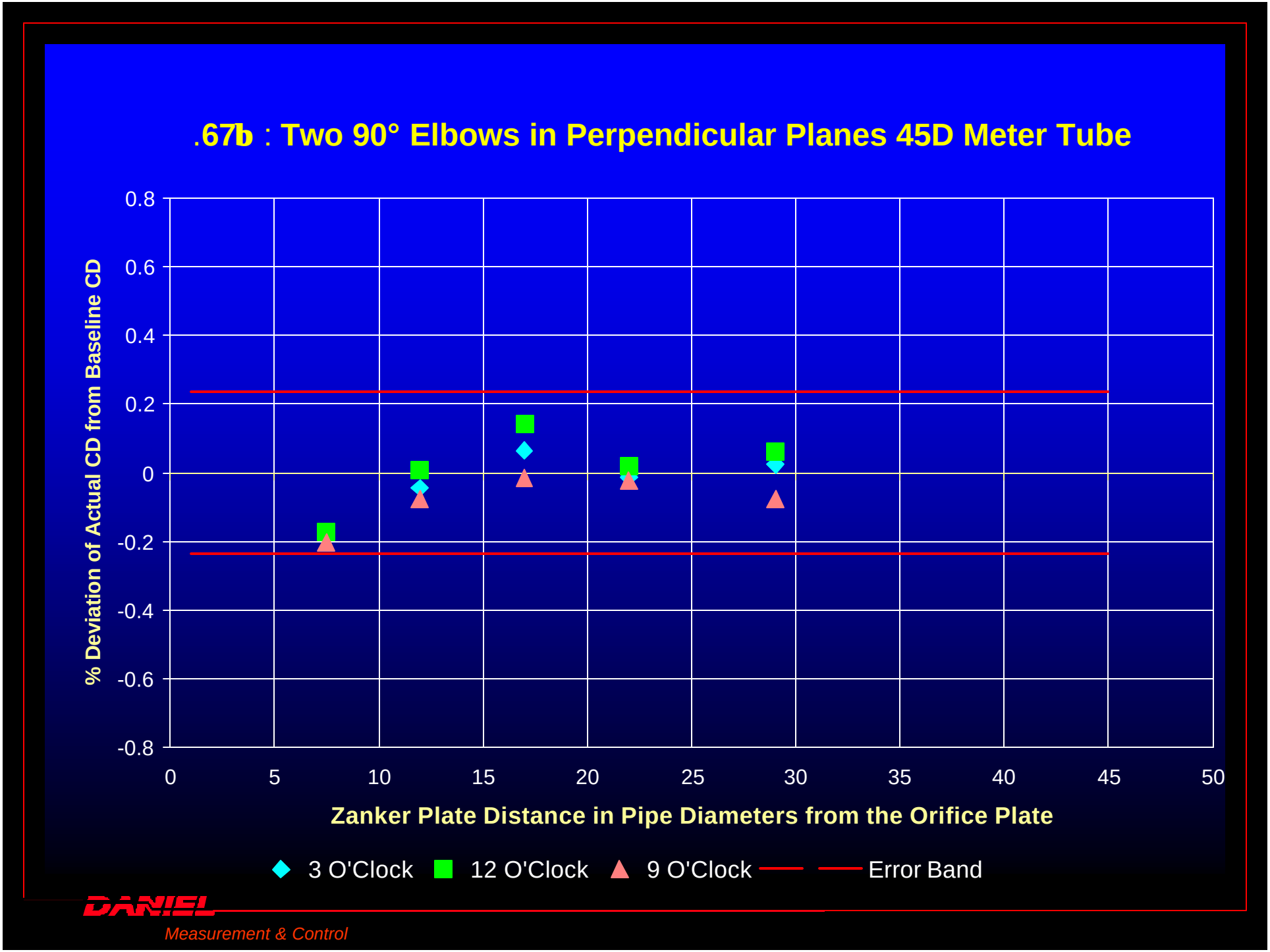
Measurement & Control



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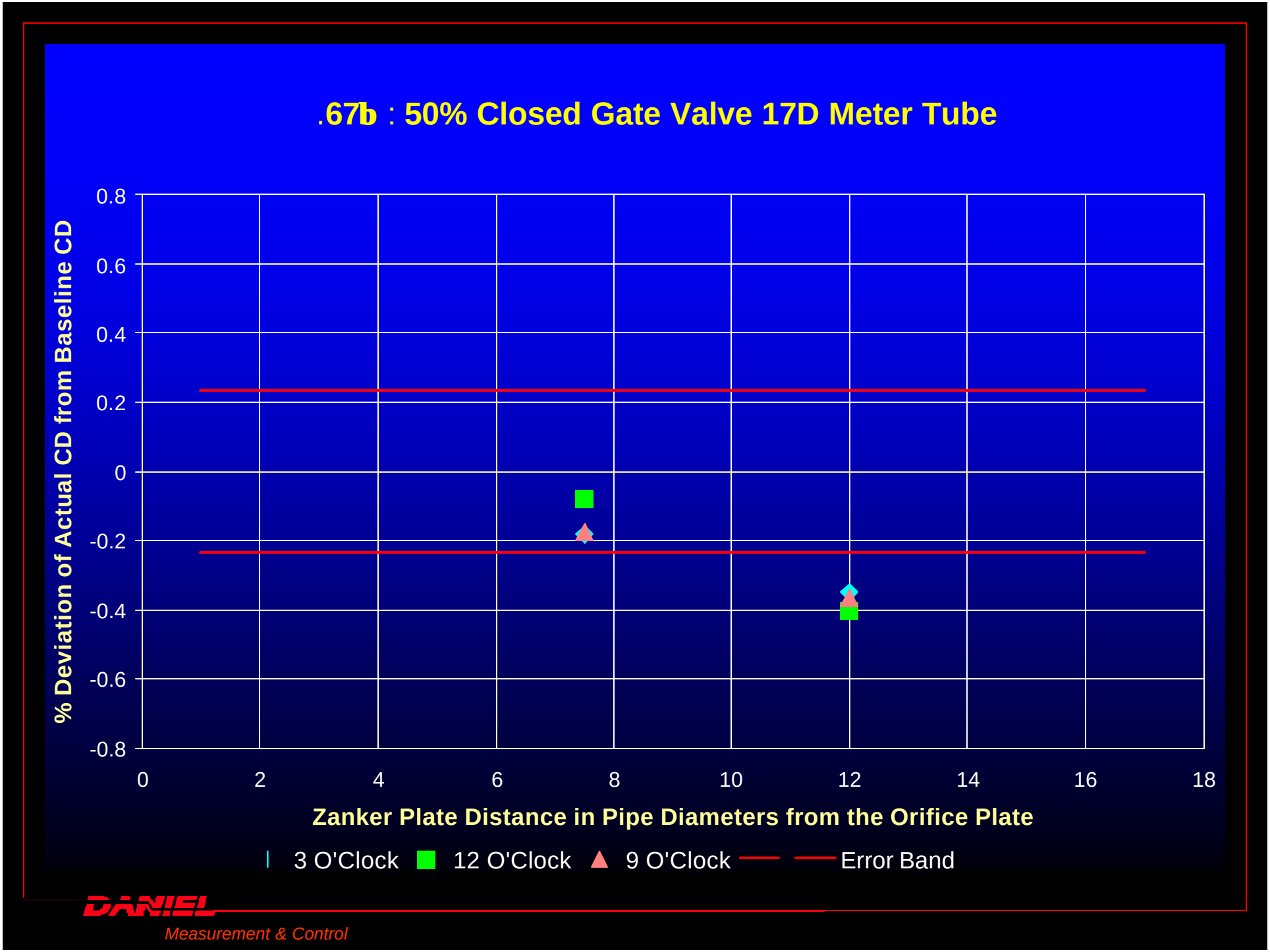
Measurement & Control



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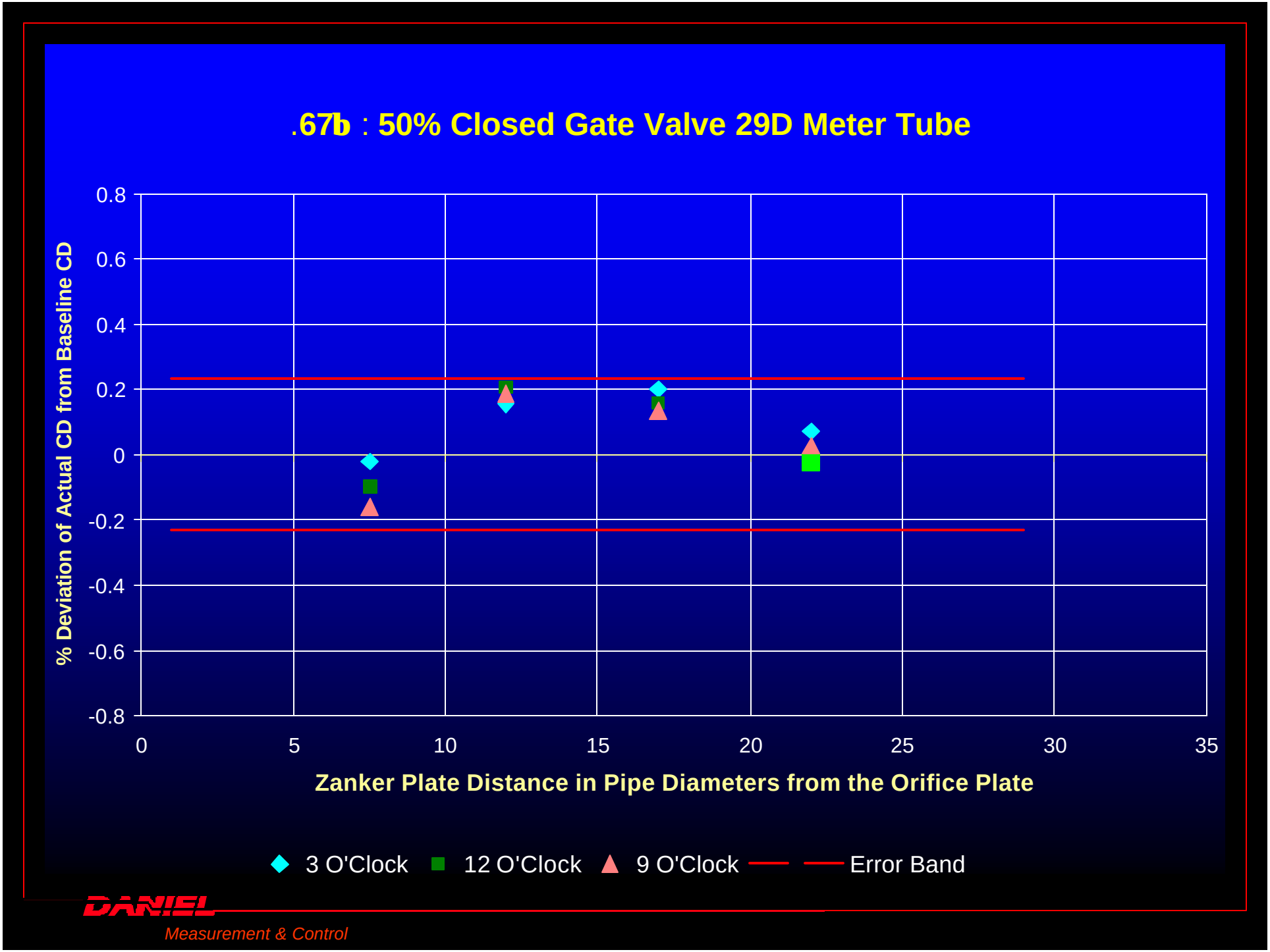

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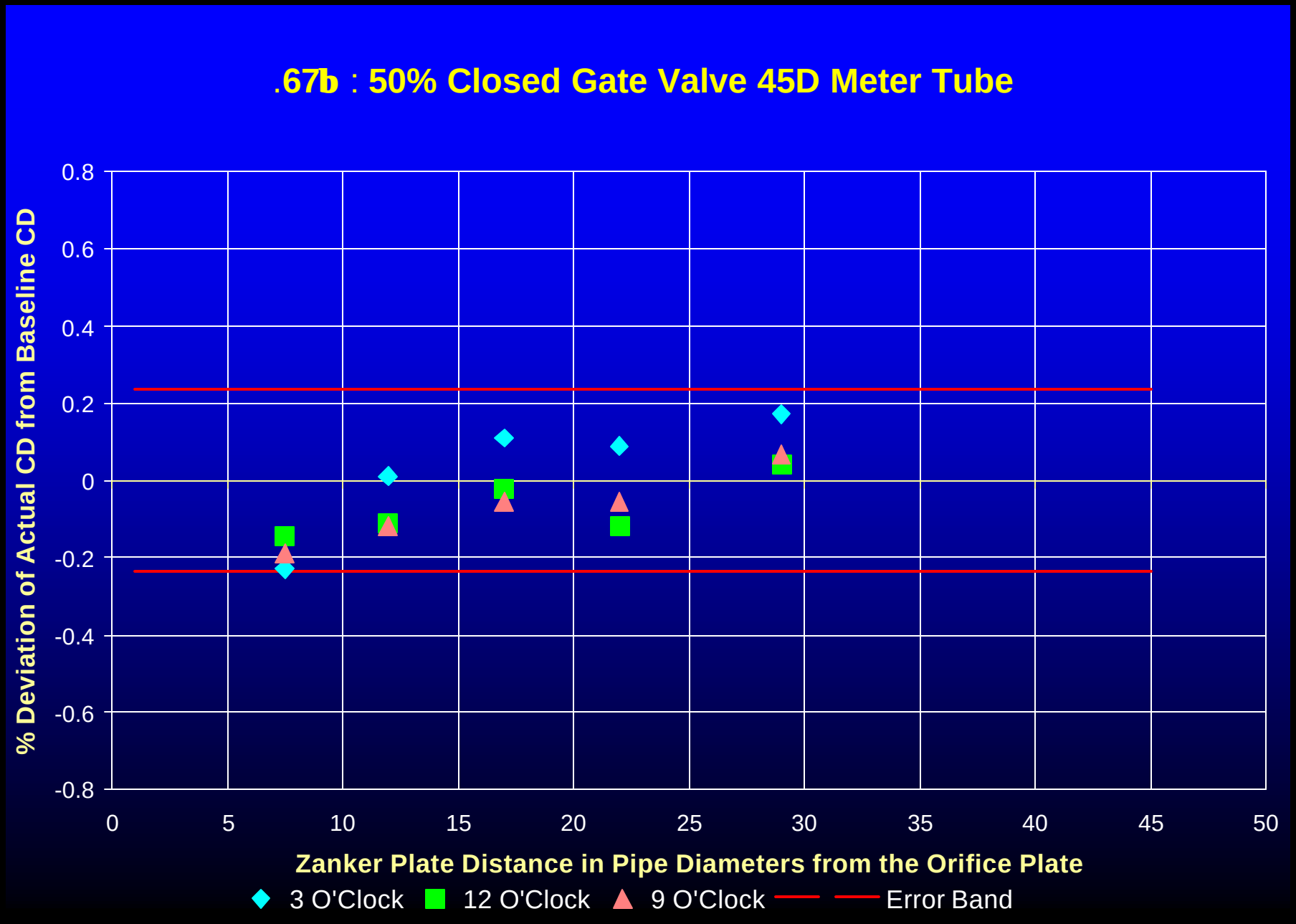

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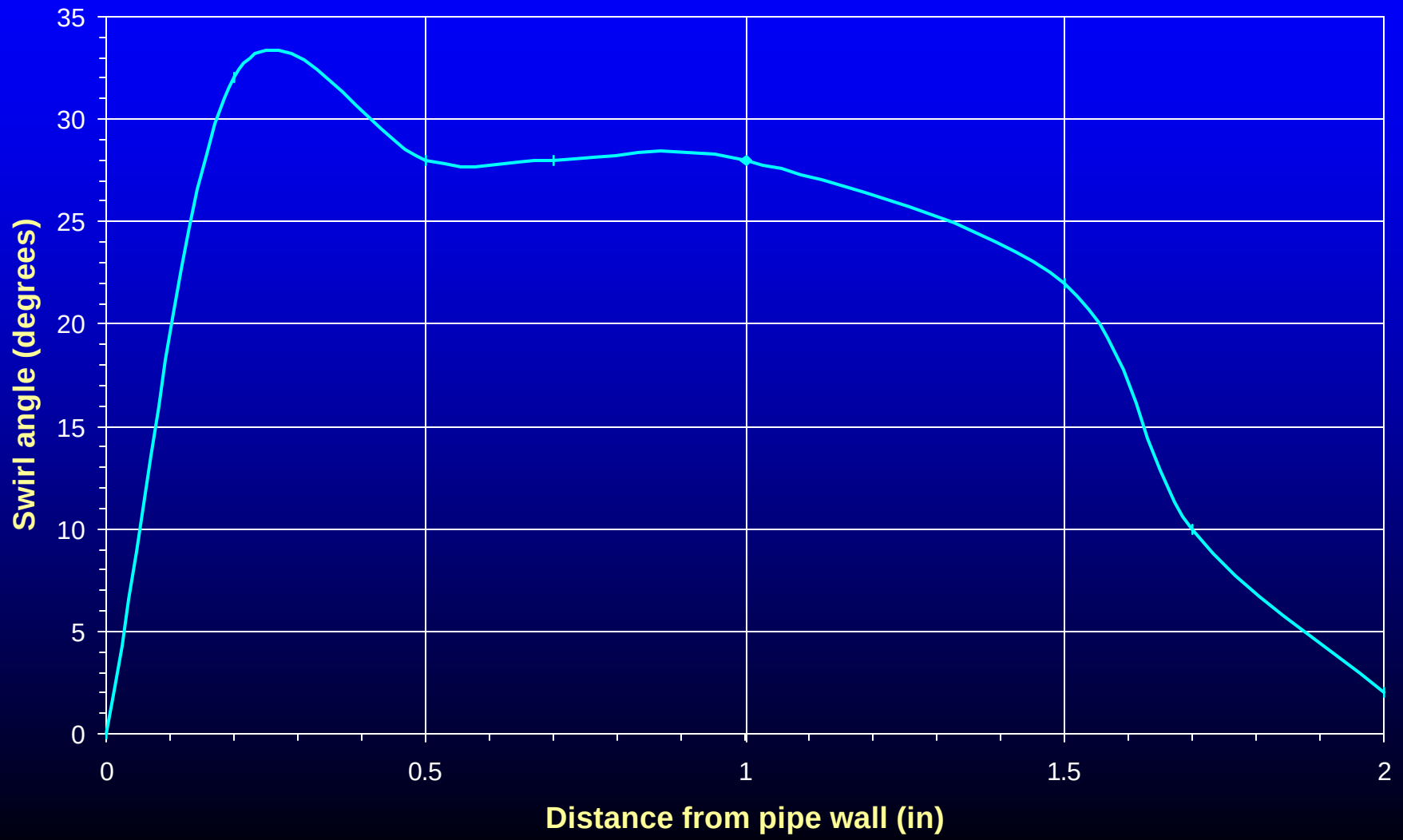
Swirl Producing Vane



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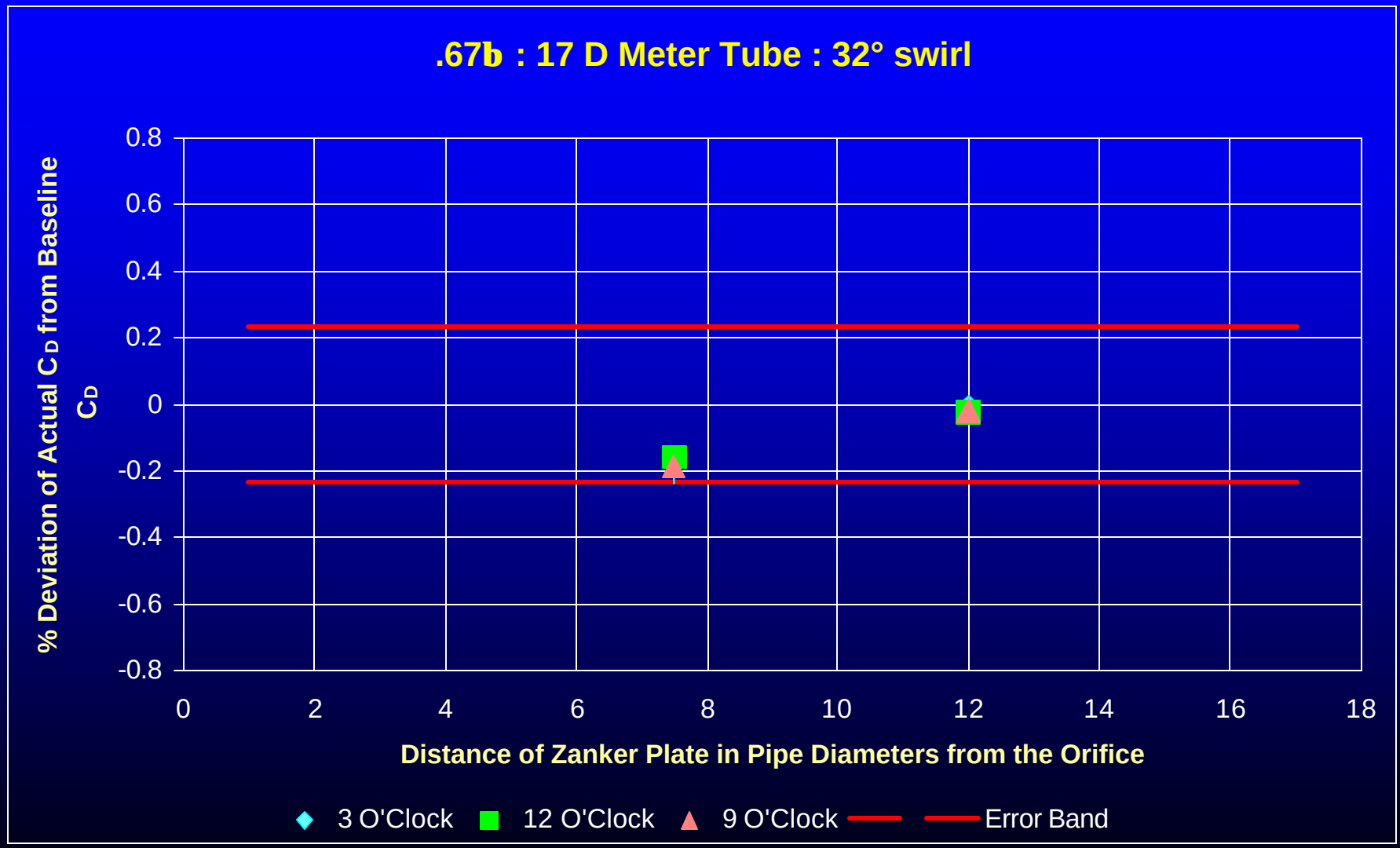

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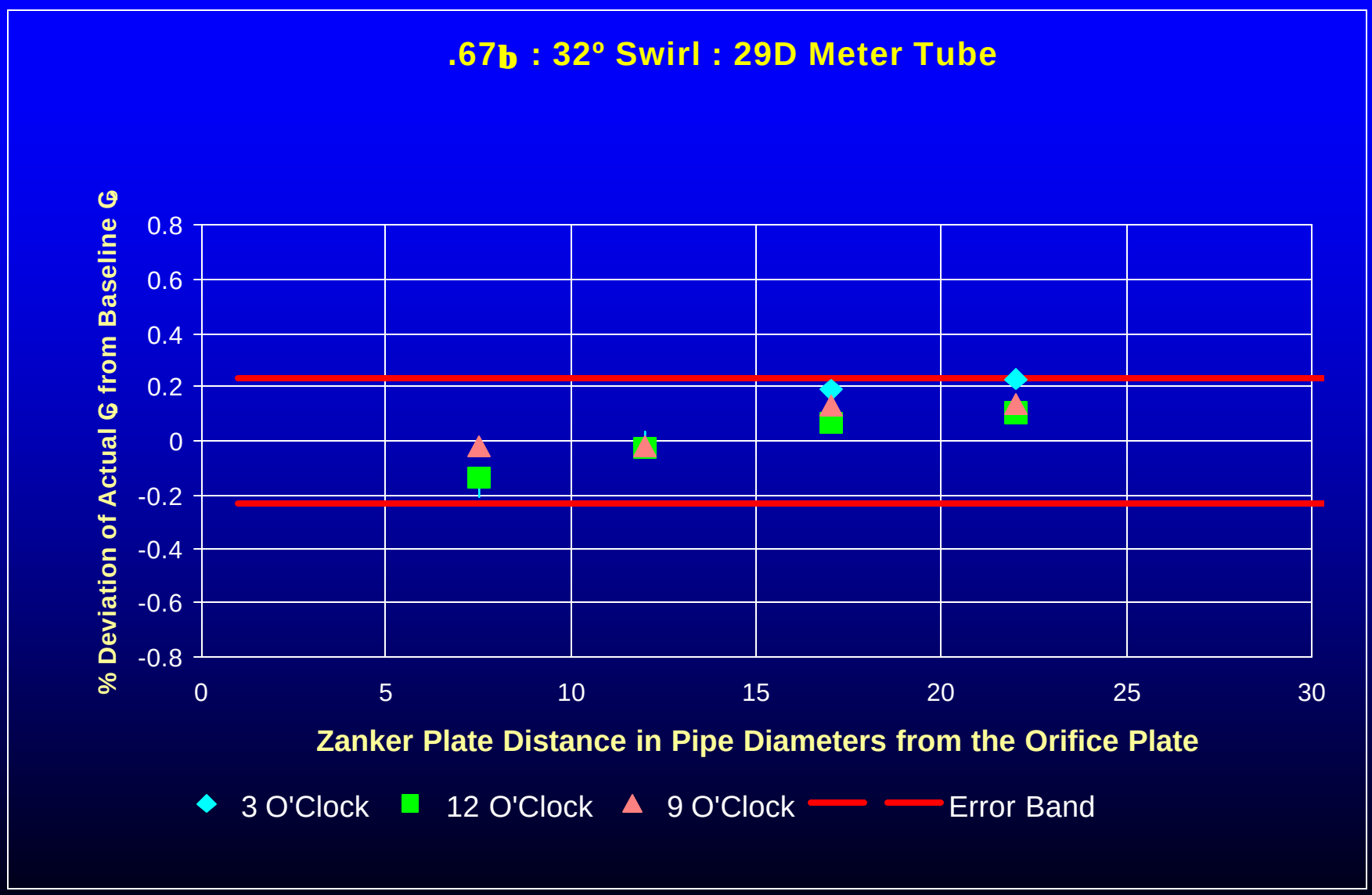

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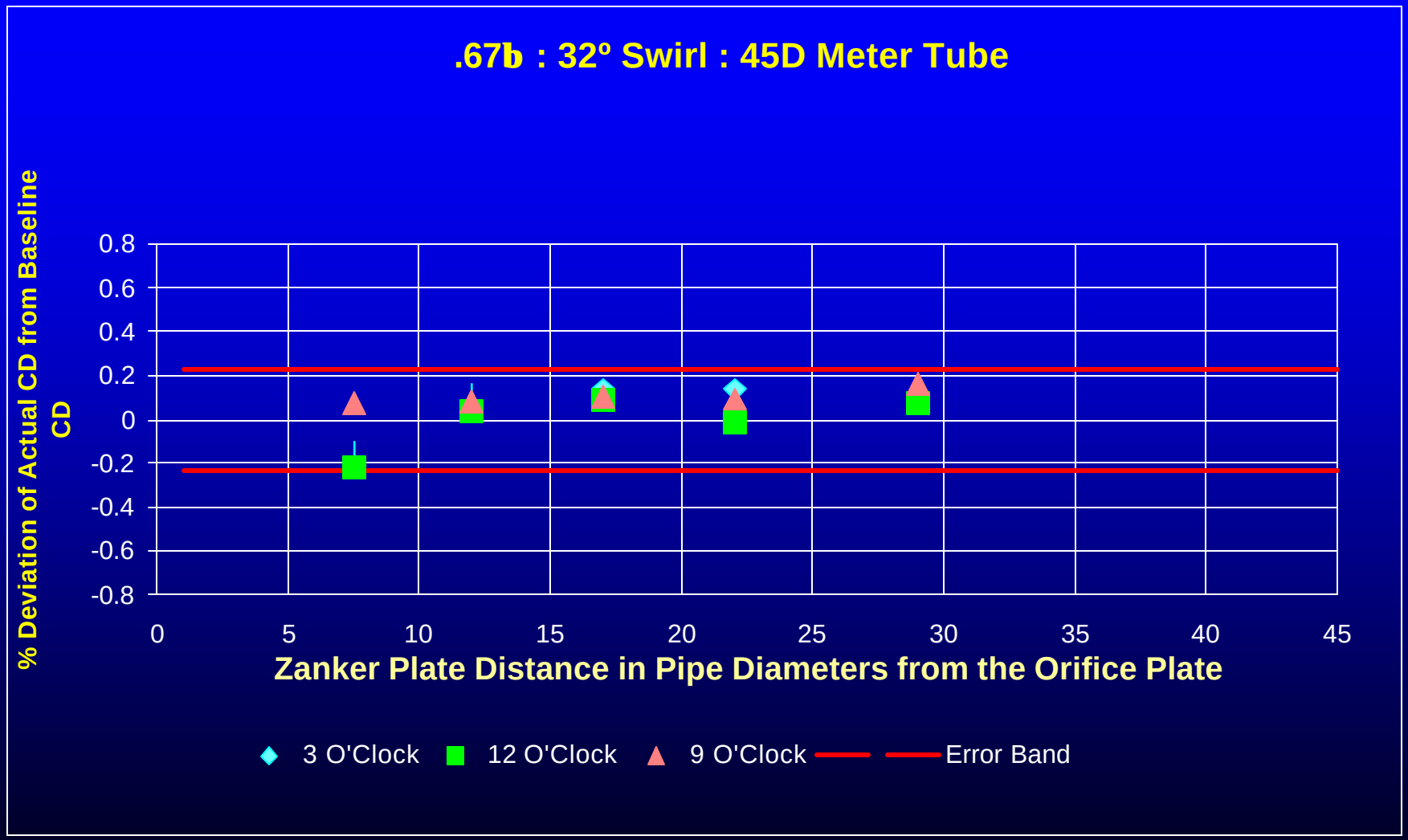

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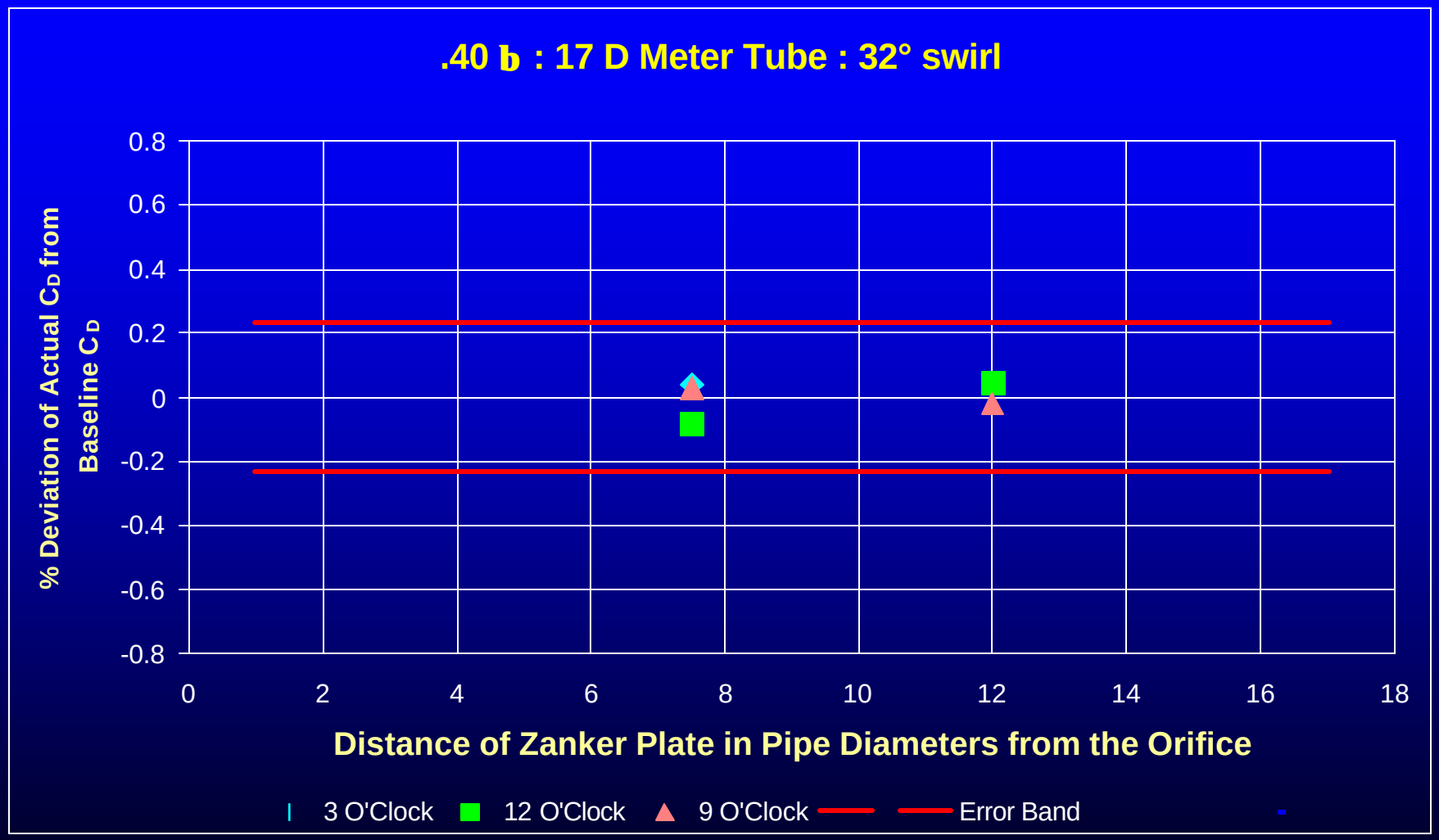

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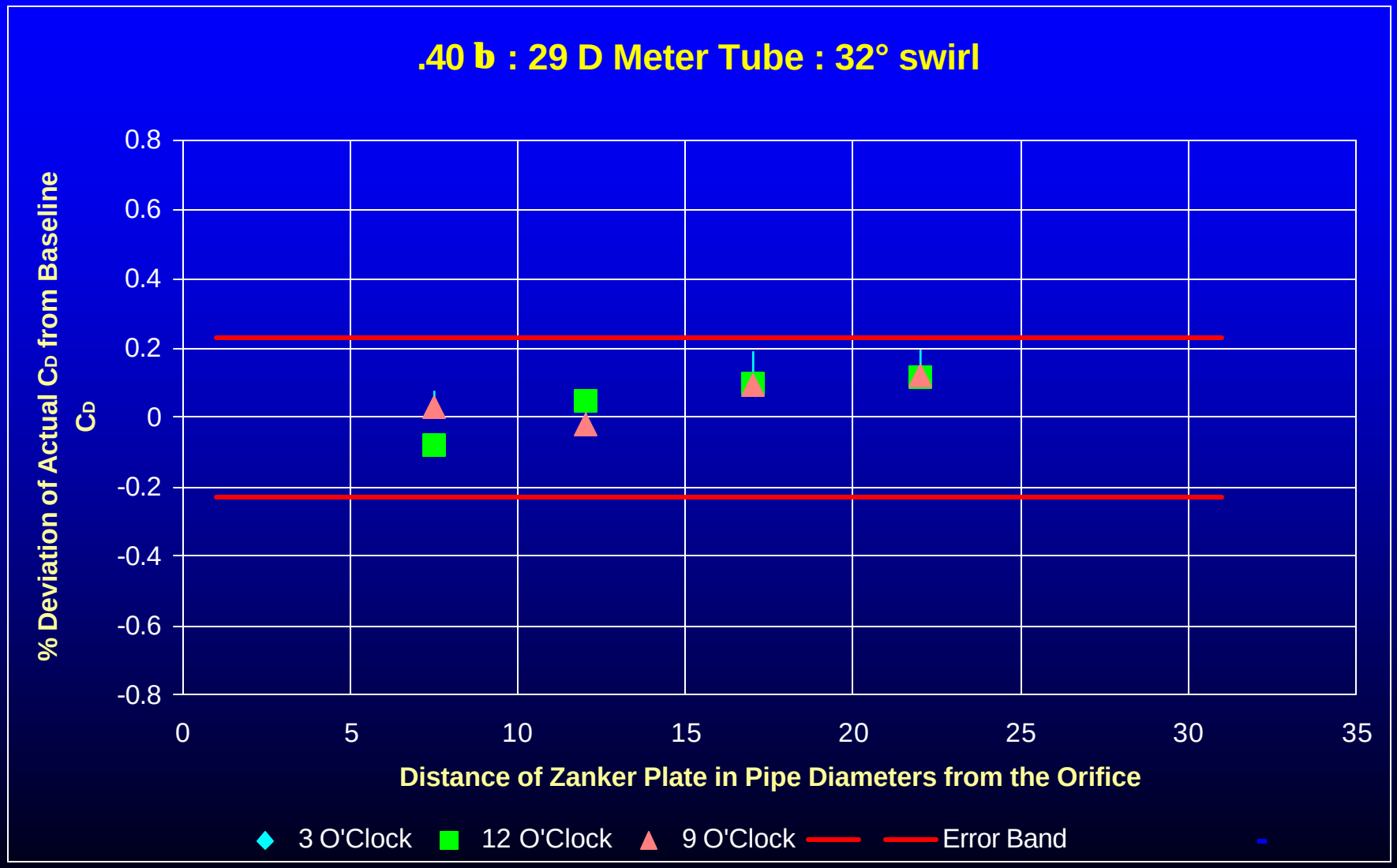

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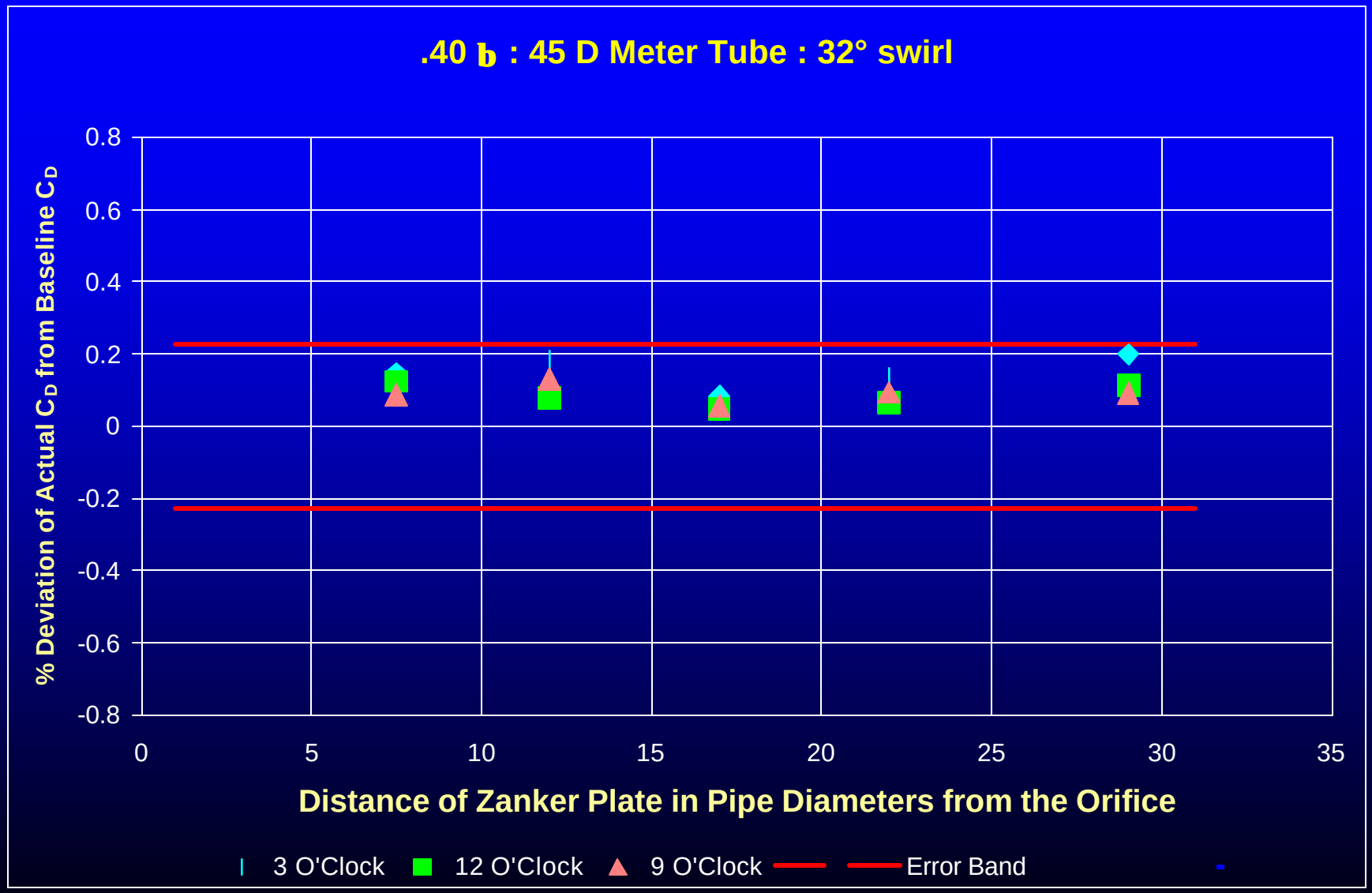

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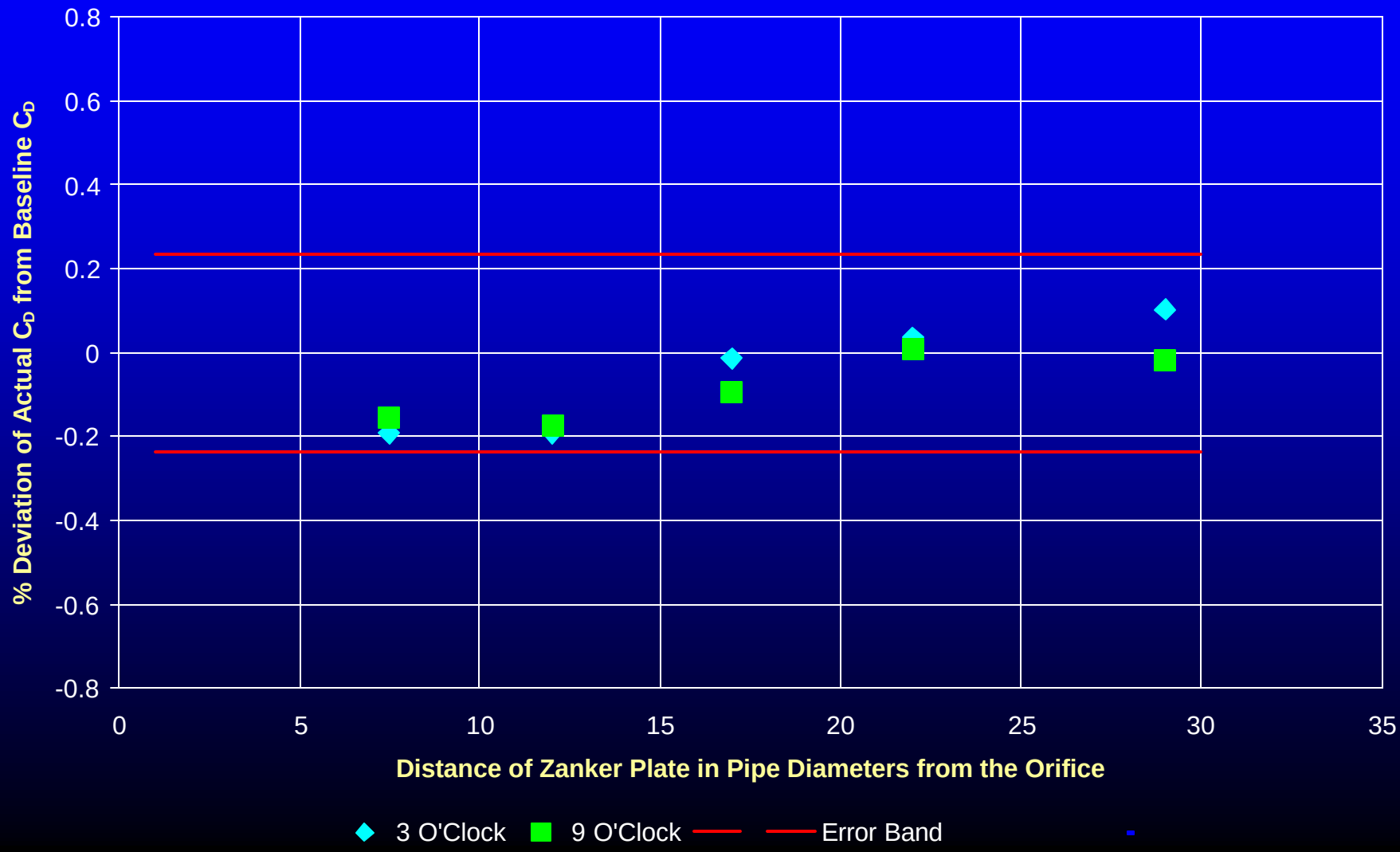

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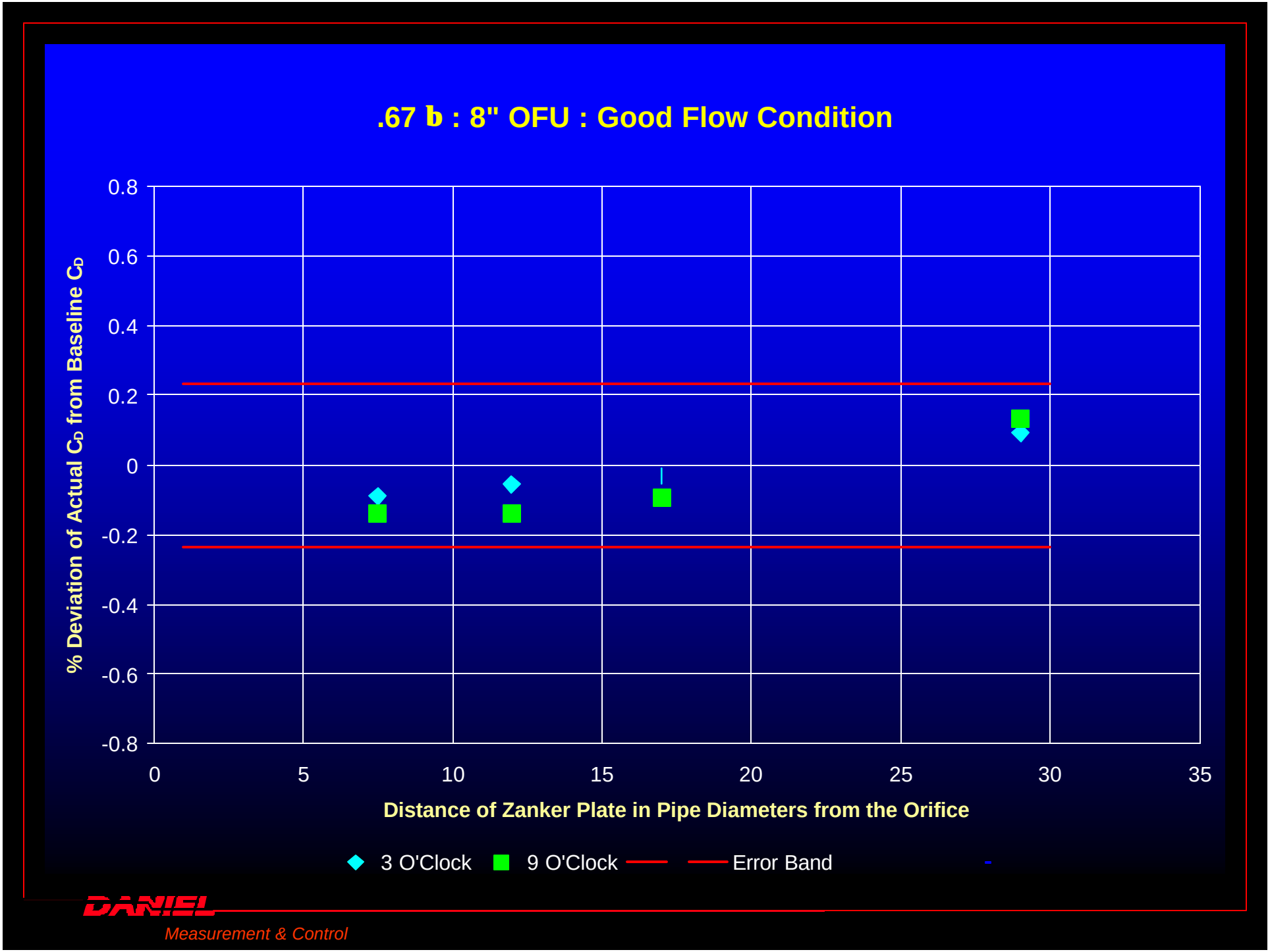

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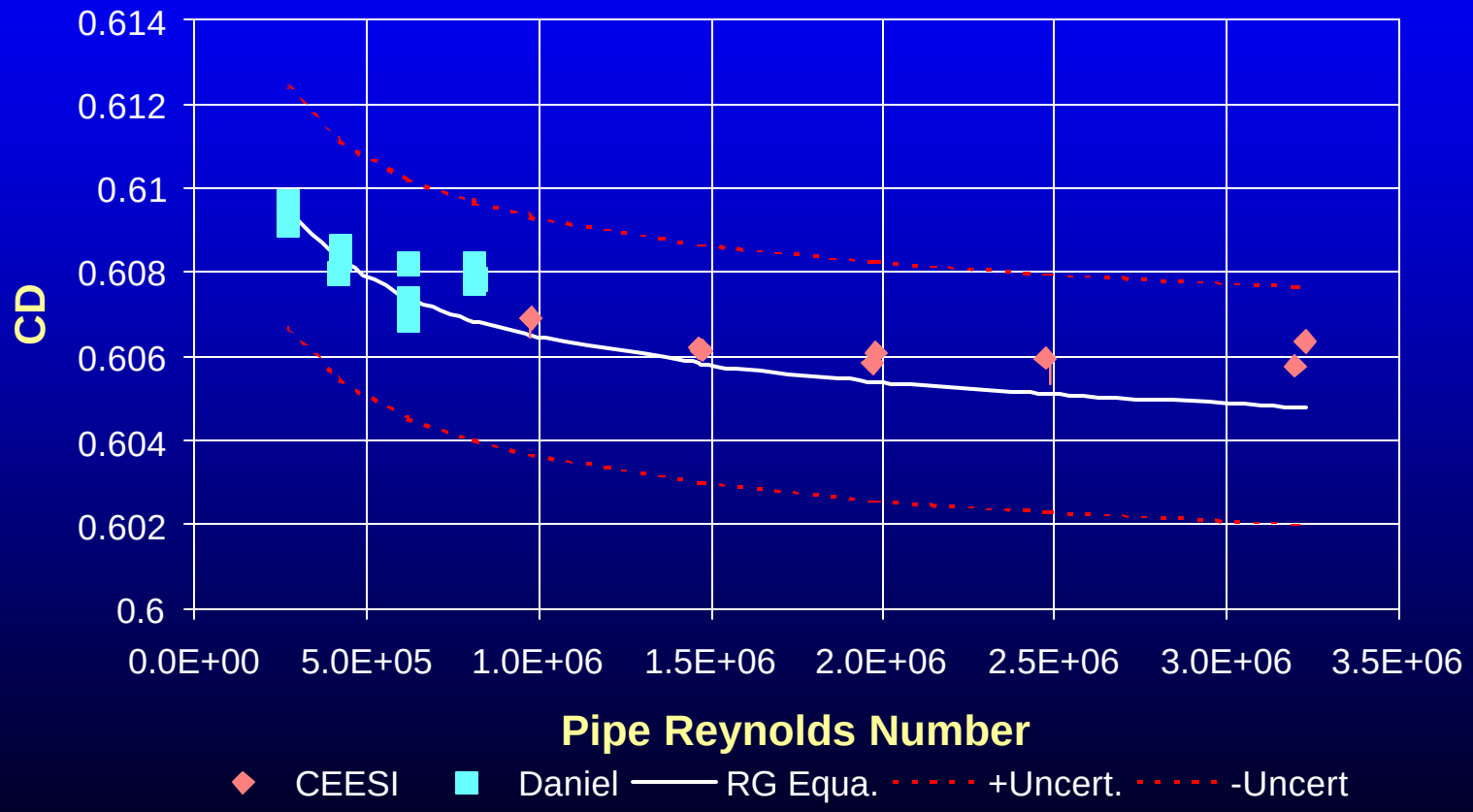
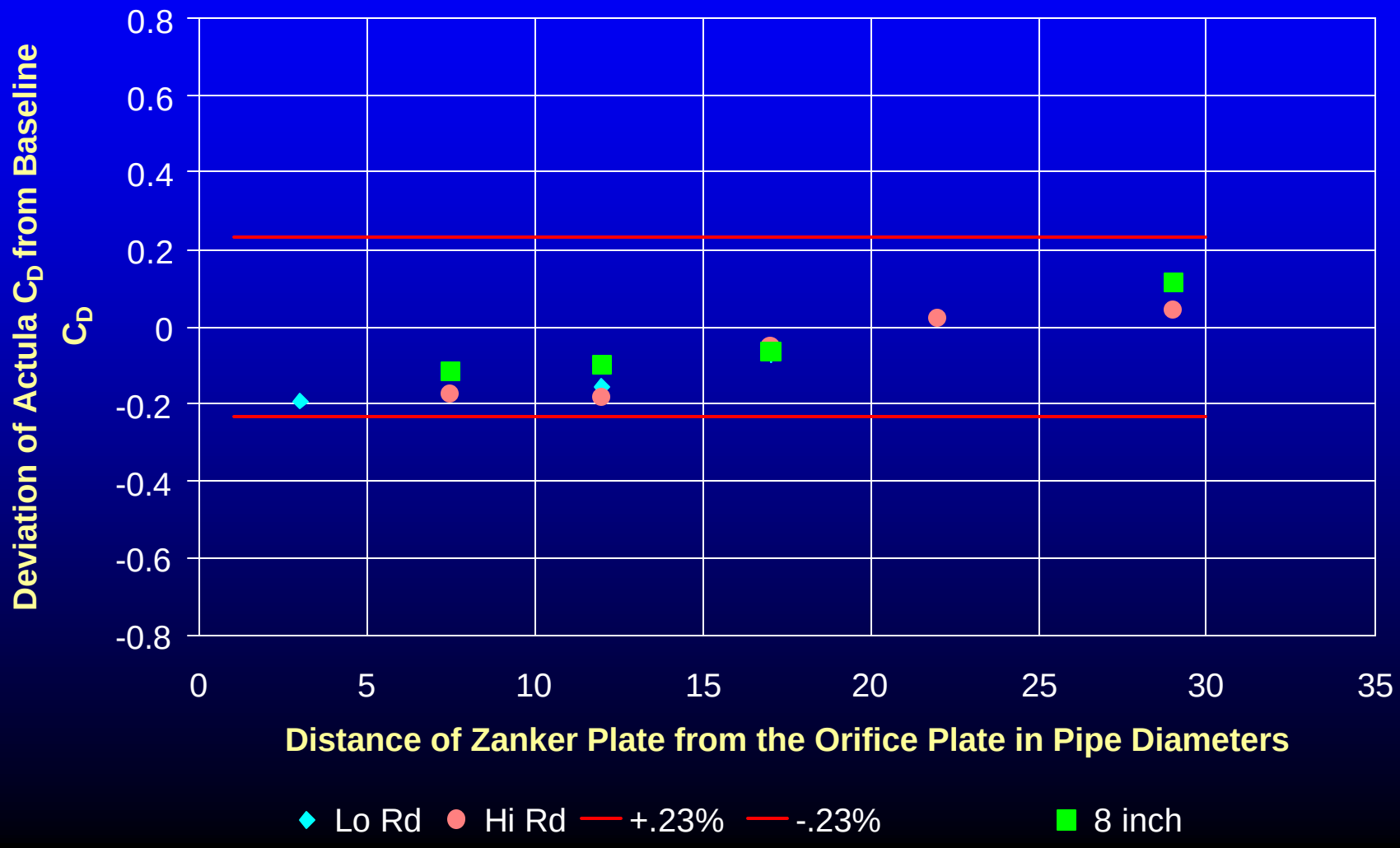
4' OFU : .67b :Ceesi & Daniel Baselines



Good Flow Conditions : 4" Hi R_D & Low R_D : 8 inch



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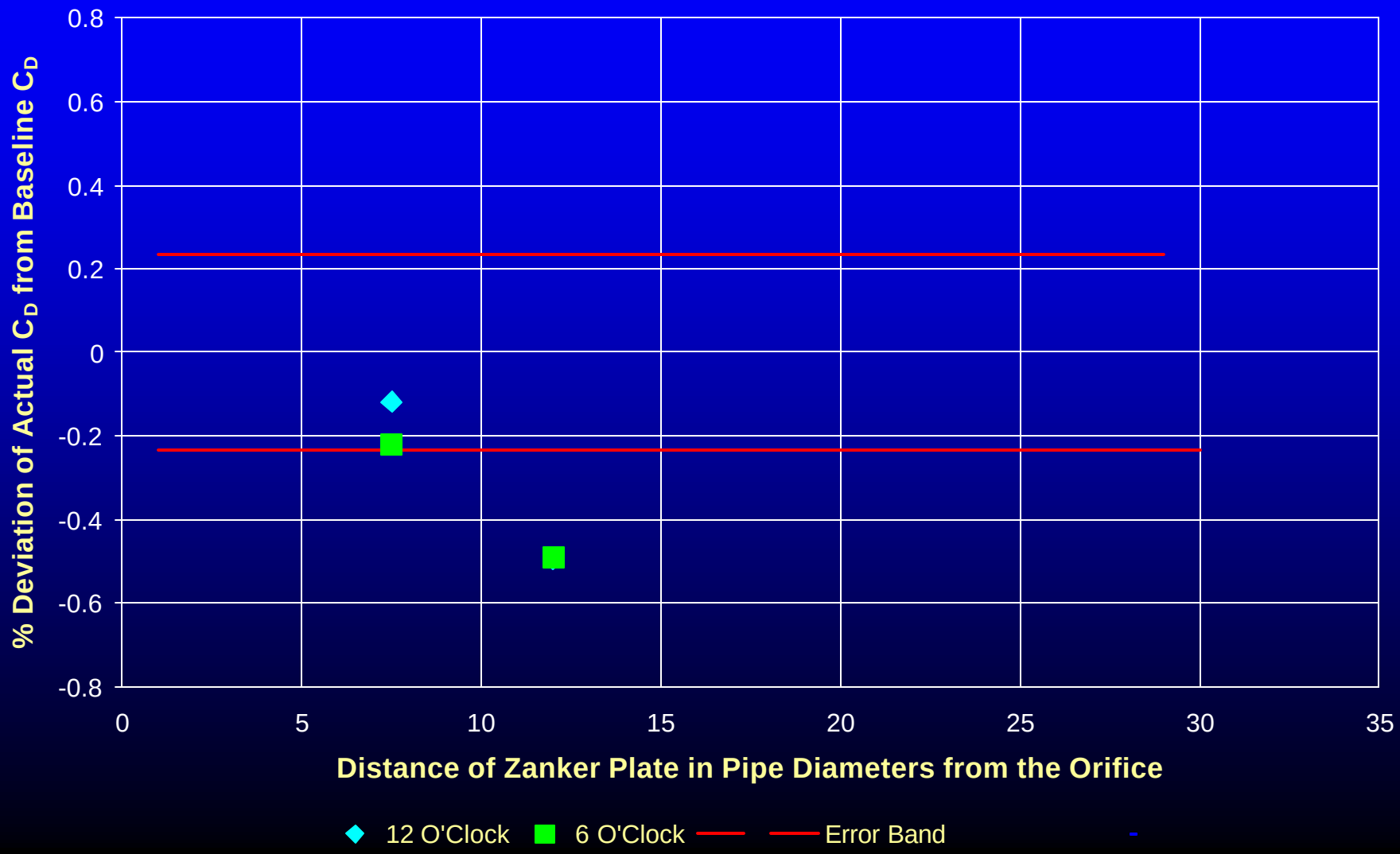

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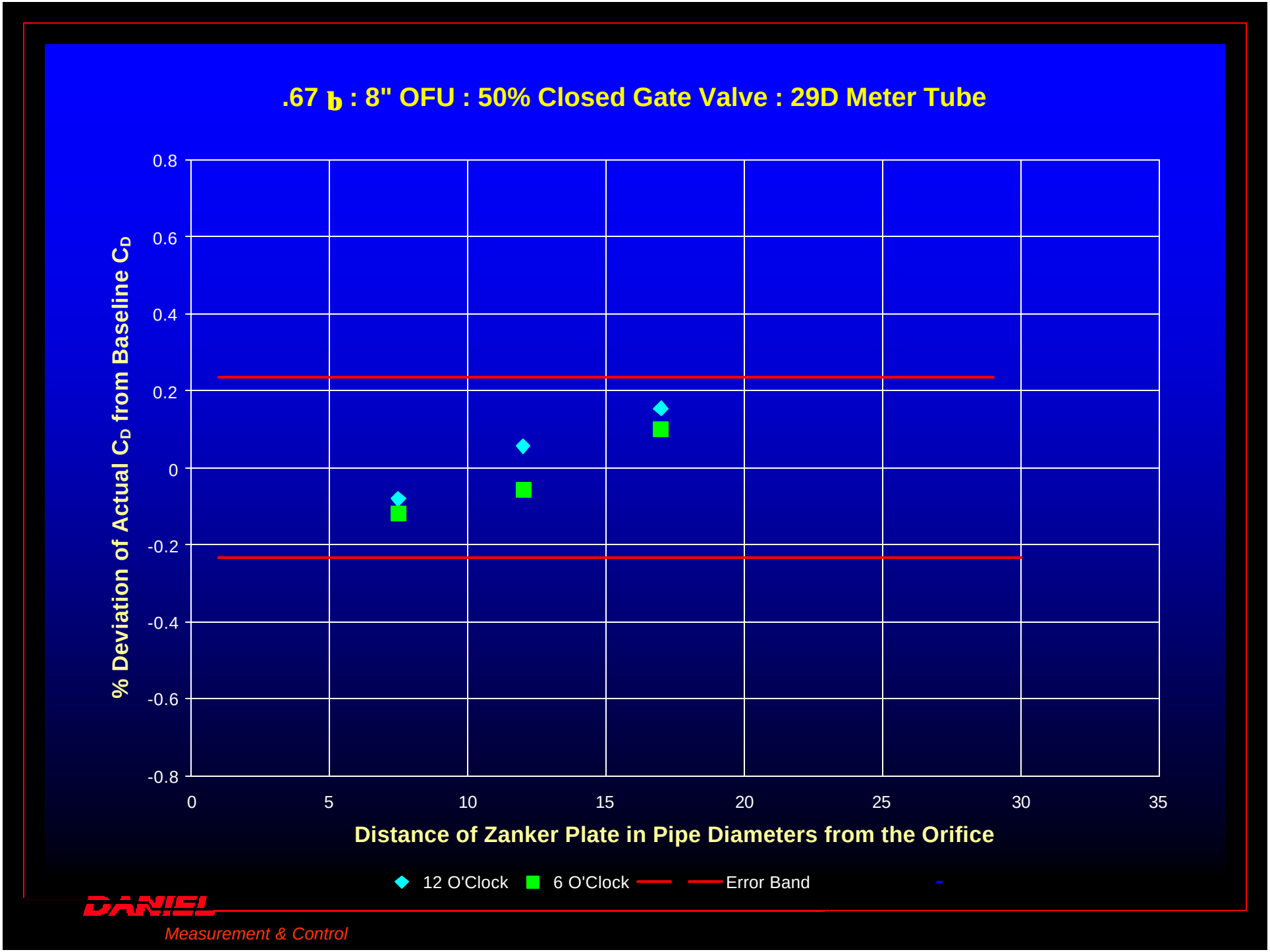

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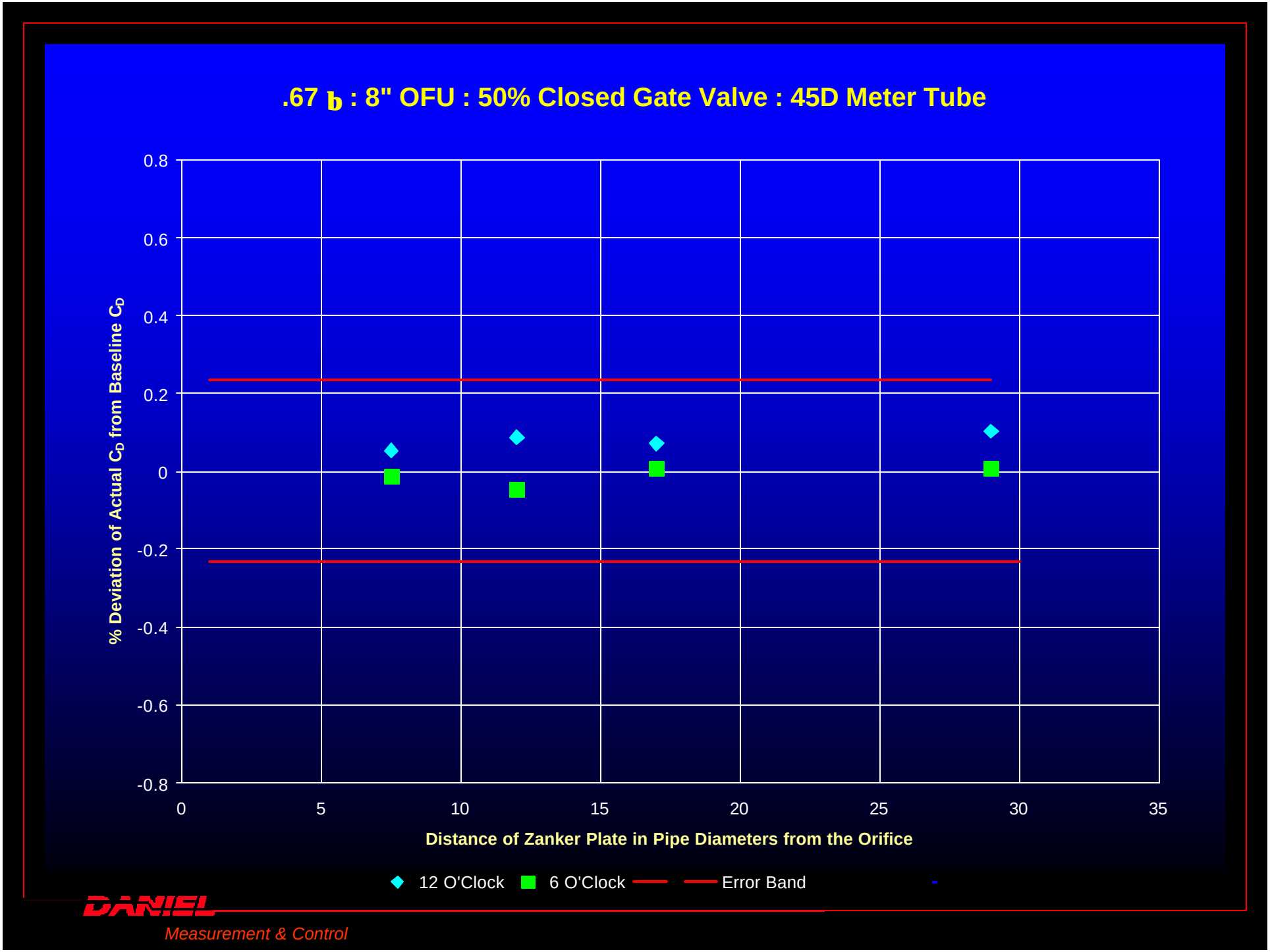
.67 β : 8" OFU : 50% Closed Gate Valve : 45D Meter Tube
% Deviation of Actual C_D from Baseline C_D
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
5
10
15
20
25
30
35
Distance of Zanker Plate in Pipe Diameters from the Orifice
12 O'Clock
6 O'Clock
Error Band
DANIEL
Measurement & Control

Conclusions

- The three pairs of taps are not always all in tolerance
- The high swirl test requires better definition
- The Zanker Flow Conditioner has passed all the type approval tests
- This makes a reasonably priced non-proprietary flow conditioner available to the industry

Conclusions

- Recommendation: - use 17D meter tube with conditioner 7.5D from the orifice plate, as this arrangement passed all tests
- The conditioner can be used as follows:
  - Beta up to 0.67
  - with any disturbance
  - in any pipe size
  - with no upper limit on Reynolds Number