



National Engineering
Laboratory

ISO 5167: past and present



Michael Reader-Harris, National Engineering Laboratory

GLOBAL FLOW
MEASUREMENT WORKSHOP
measuring for the energy transition

ISO 5167: past and present

- History

- 2022 Revision

- Items affecting all or most parts

- Items affecting single parts

Flow measurement standards

1

1000

2000

Frontinus
De Aquis 97-98

AGA Report
No 1 1930

BS 1042
1943

ISO/R 541 1967
ISO/R 781 1968

Stolz Equation

ISO 5167 1980

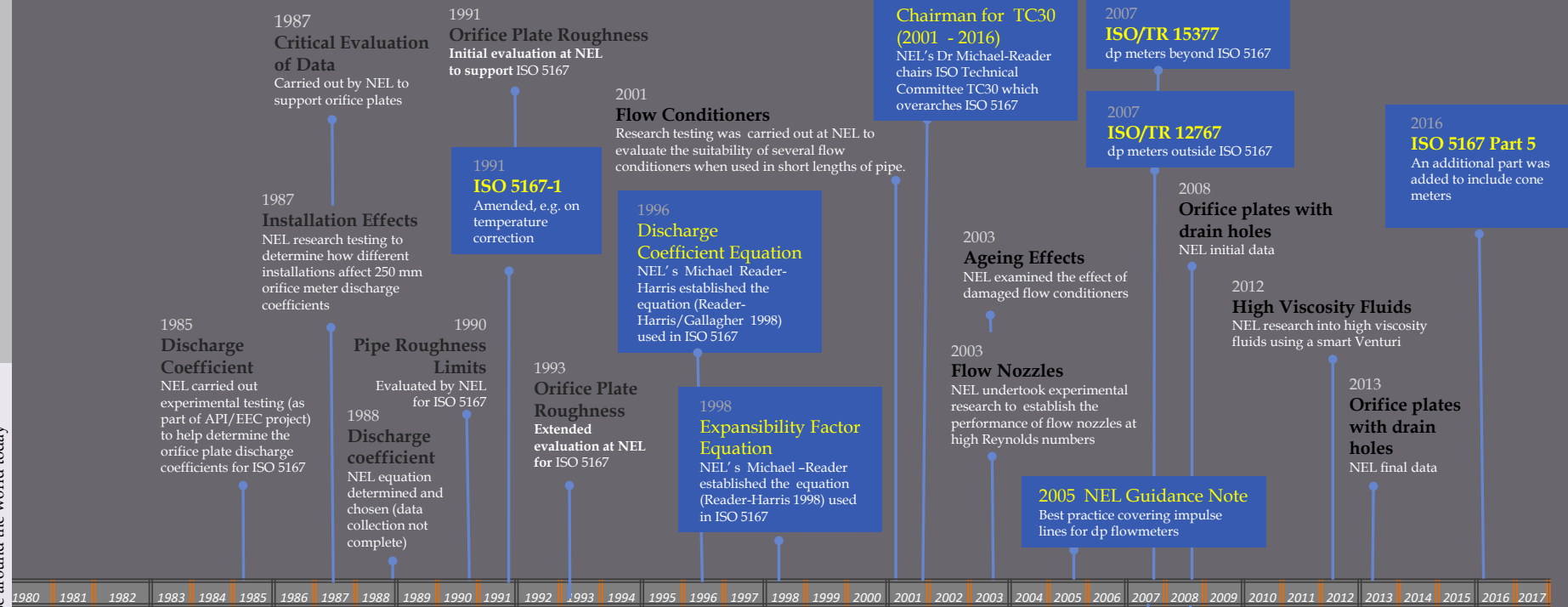
Reader-Harris/Gallagher
(1998) Equation

ISO 5167-1 1991/Amd. 1
1998

ISO 5167 covers differential pressure meters (dp)

High industry confidence in ISO 5167 sees a large uptake in dp meter, which equate to around 40% of all flowmeters in use around the world today

If meters are designed and used to the ISO 5167 they do not require calibration



The ISO 5167 Story (1980 – 2017)

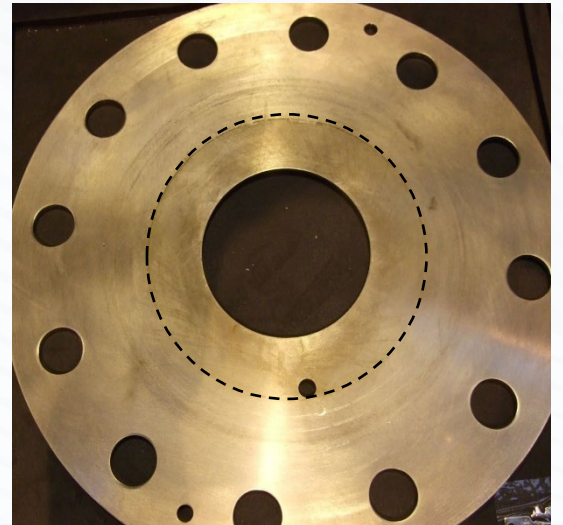
2003 Revision

- Four parts
- Orifice upstream straight lengths
- Flow conditioner compliance test
- Orifice expansibility equation
- Isenthalpic temperature correction
- Pipe roughness limits for orifice plates
- Permitted steps in pipework
- Venturi tube upstream straight lengths
- Venturi tube surface roughness



2003-2020

- ISO 2186:2007 Impulse lines revised
- ISO 5167-5:2016 Cone meters
- ISO/TR 15377:2018 Orifices beyond ISO 5167 – revised (drain holes)
- ISO 5167-6:2019 Wedge meters
- ISO 5167-3:2020 Nozzles – revised (throat-tapped nozzles)



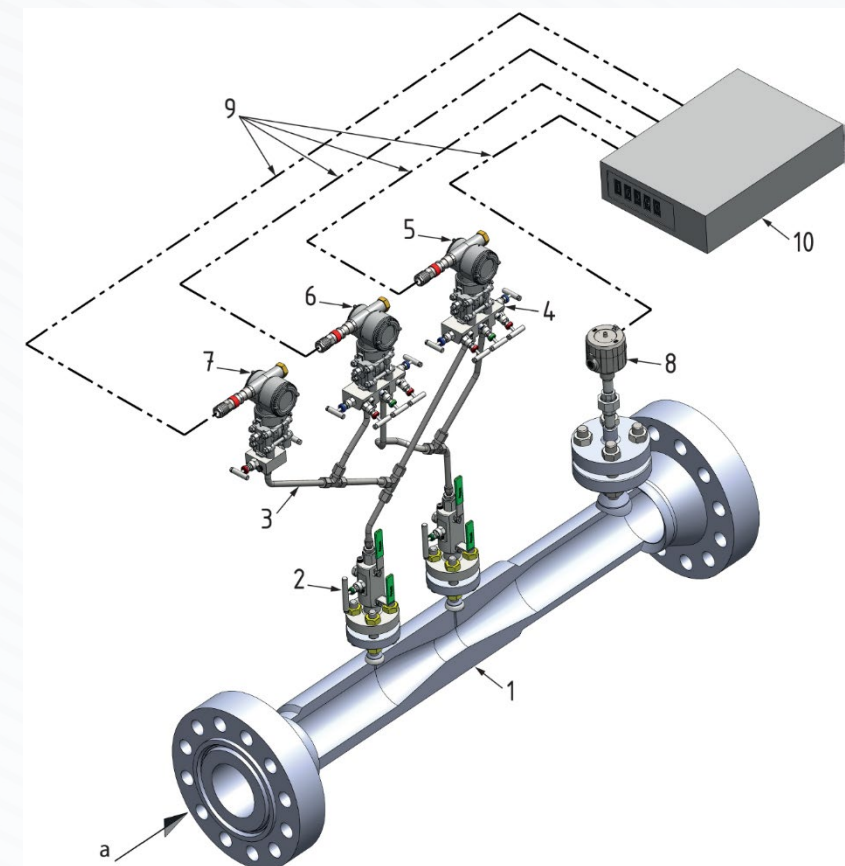
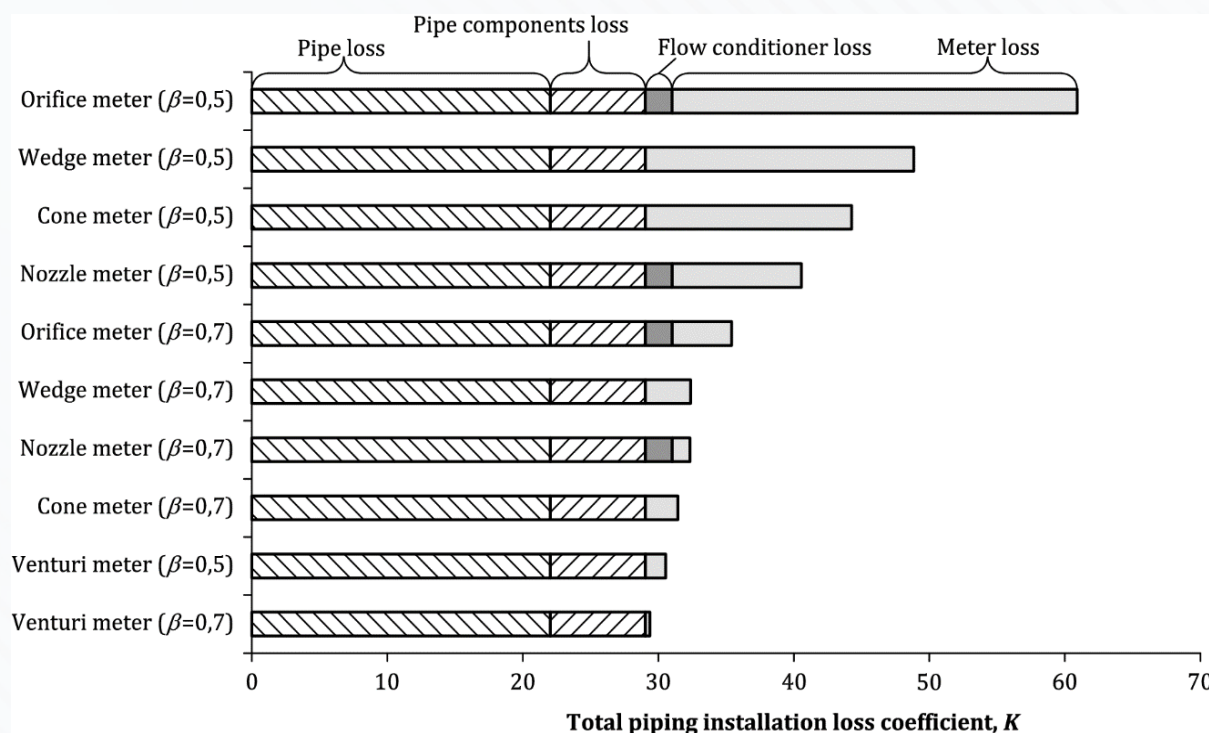
2022 Revision: all or many parts

- GUM
 - Expanded uncertainty ($k = 2$)
 - Combining standard uncertainties in Part 1
 - An example in Part 1
- Spacing of multiple fittings
 - Improved wording; lengths unchanged
- Flow calibration
- Harmonization



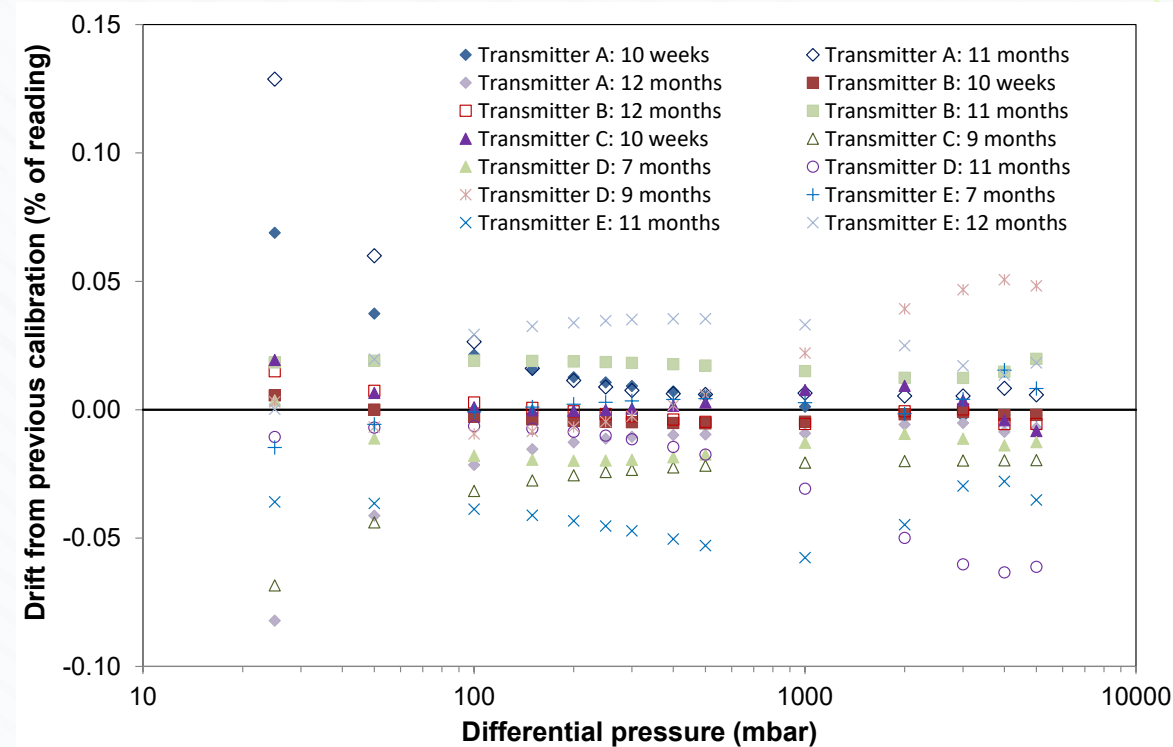
2022 Revision: Part 1: context

- Setting a primary element as part of a metering system
- Pressure loss



2022 Revision: Part 1: accuracy

- Diagnostics and CBM
 - Pressure transmitter internal diagnostics
 - Use of multiple transmitters
 - Multiple measurements
 - Pressure profile analysis
 - Data reconciliation
- Flow range and turndown
 - Improved transmitters
 - From 2:1 to c. 11:1 on flow



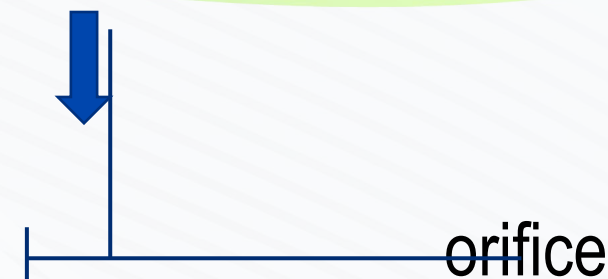
5 Yokogawa EJX110A

2022 Revision: Part 1: tidying up

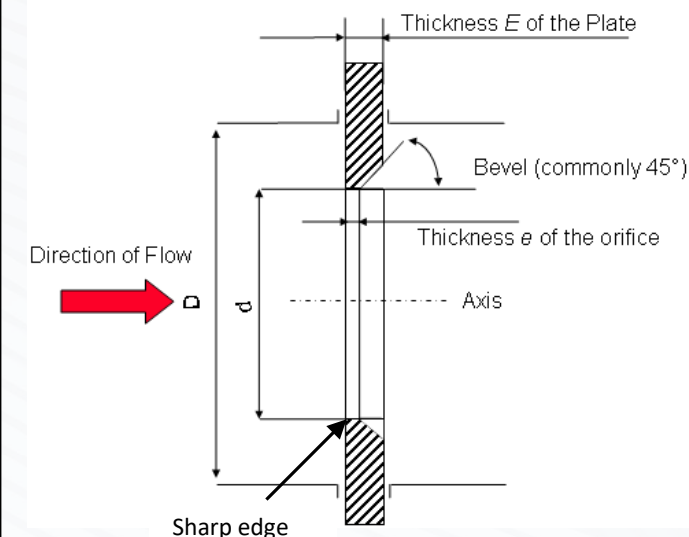
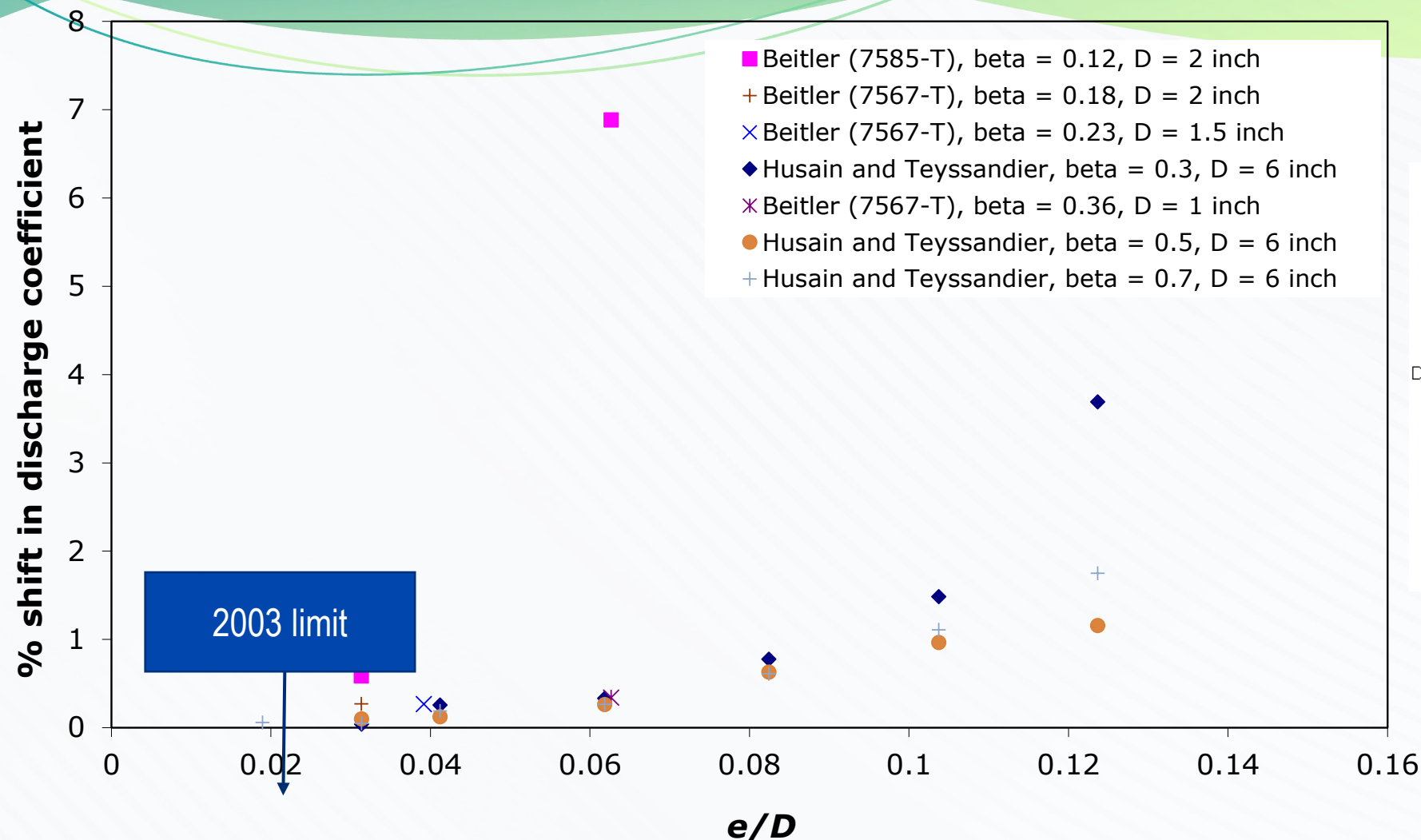
- Limitation on the use of 'the 5 % 2° rule' for an acceptable profile
 - Headers Consortium data
- Flow straighteners and conditioners
 - Removal of those not used with dp meters

2022 Revision: Part 2

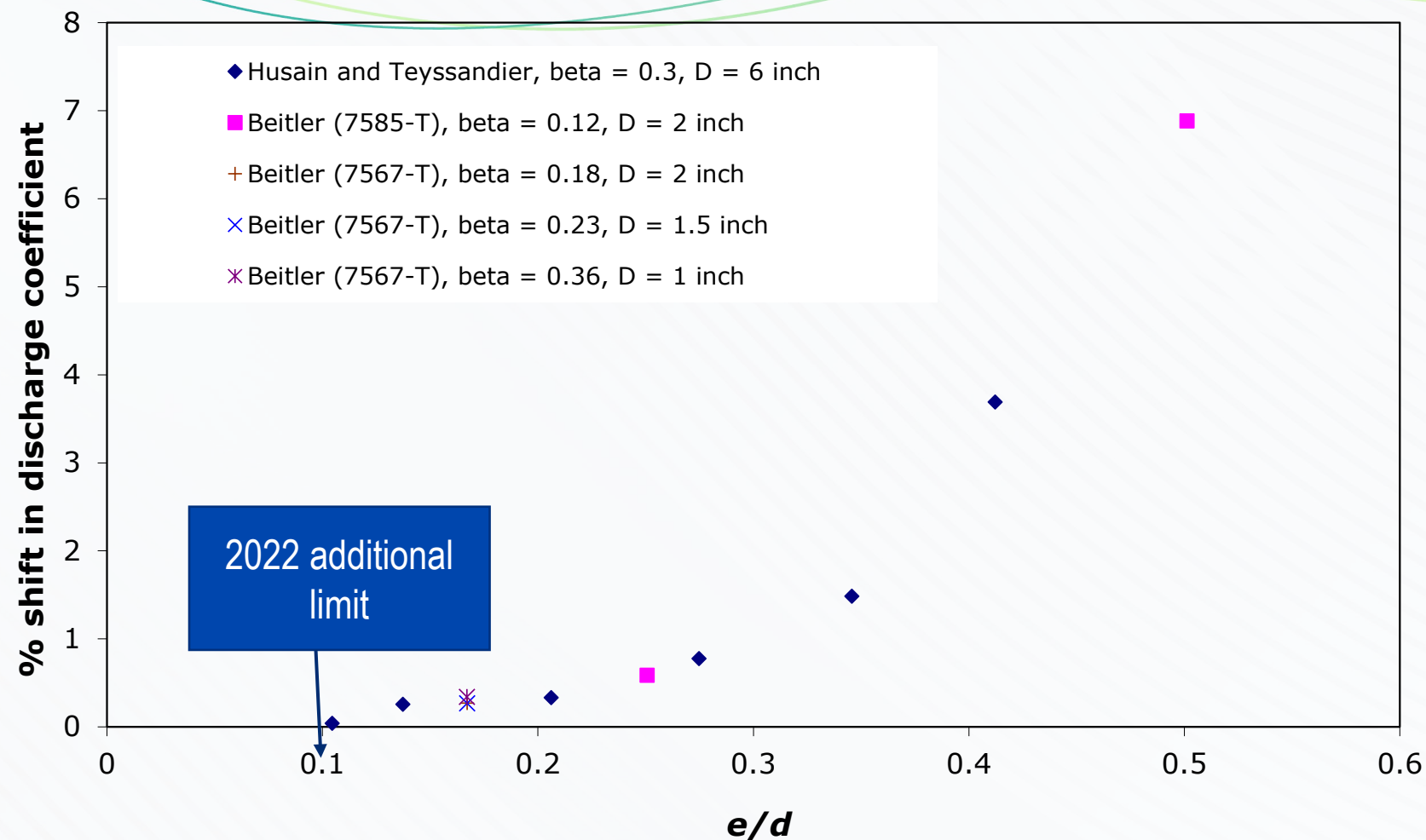
- Required spacing between two 45° bends
 - Original data are for $22D$ spacing not $2D$
- Clearer specification for the tee
- Maximum orifice edge thickness for $\beta < 0.2$



Effect of orifice edge thickness - 1



Effect of orifice edge thickness – 2: $\beta < 0.4$



Make $e/d \leq 0.1$ (only a change if $\beta < 0.2$)

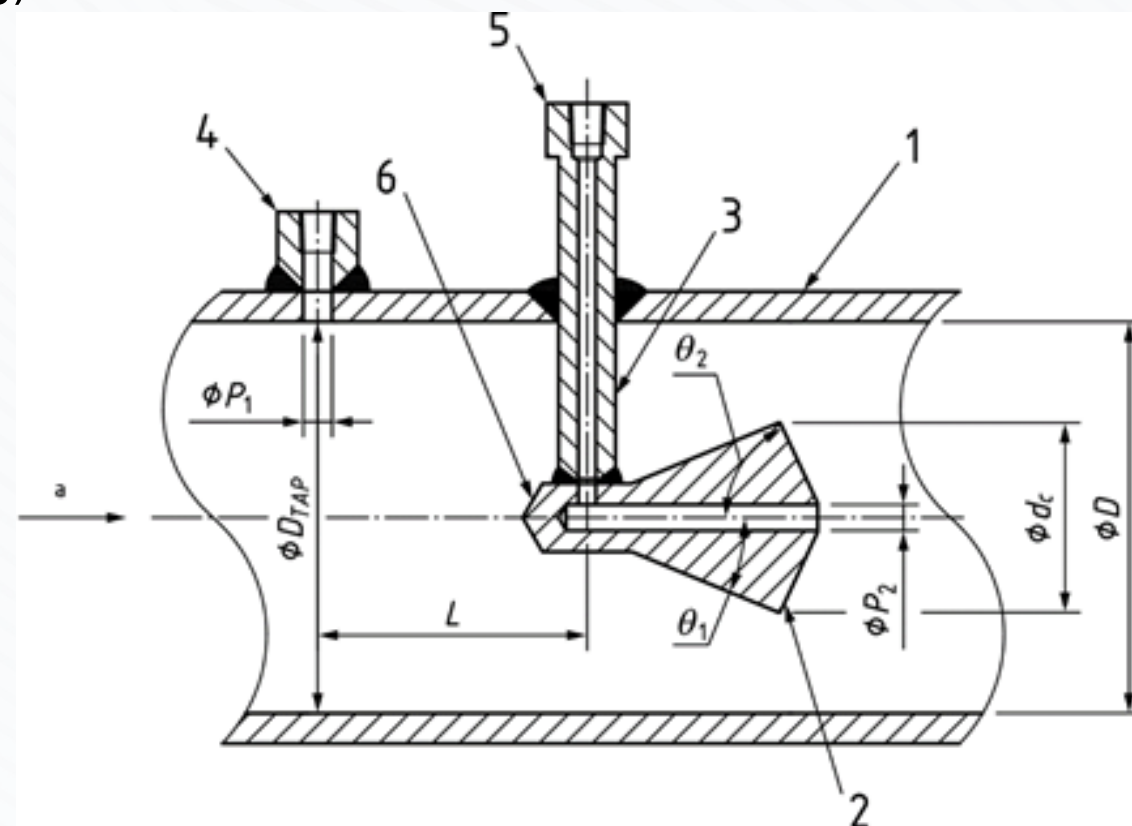
Don't miss out on a flow range up to 500:1

2022 Revision: Part 4

- Single pressure tapplings ✓
 - Note on straight lengths
- The discharge coefficient with a machined convergent for $Re_D > 10^6$
 - A. COLLINS, S. CLARK Additional data supporting the 2022 updates to the ISO 5167 standards. Flow Measurement and Instrumentation, Vol. 86, Article 102193, August 2022
 - 398 Venturi tubes
 - Discharge coefficient 1.000
 - Expanded uncertainty 1.8 %
 - In the body of the standard

2022 Revision: Part 5

- Two corrections to ISO 5167-5:2016
 - Figure 2: key (to be consistent with the drawing)
 - 5.2.7: frustum internal angles
- Relative uncertainty for the expansibility



2022 Revision: Part 6

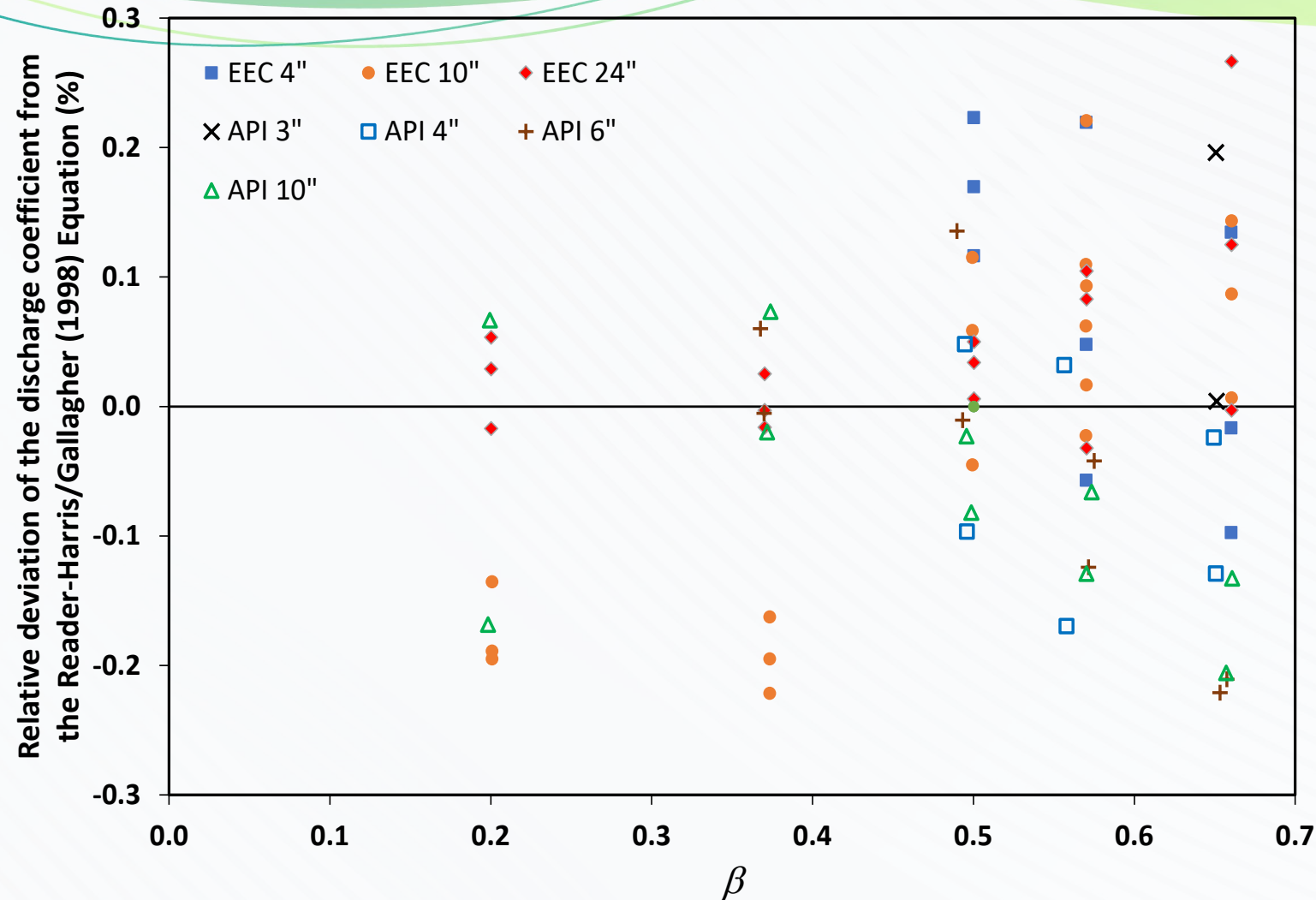
- One correction to ISO 5167-6:2019
 - Annex B: definition of Kd^2
- Relative uncertainty for the expansibility

$$Kd^2 = C \frac{d_{in}^2}{\sqrt{1 - \beta^4}}$$

$$d_{in} = \sqrt{\frac{4A_t}{\pi}}$$

where A_t is the wedge throat area in square inches

Deviations of mean points from the RG (1998) Equation



Combining uncertainties for orifice plates

	β	0.2	0.3	0.4	0.5	0.6	0.67
	Distribution						
Base uncertainty for calculated pipe roughness and edge sharpness	Normal	0.261	0.261	0.261	0.261	0.261	0.315
Pipe roughness	Rectangular	0.10	0.15	0.20	0.25	0.25	0.31
Installation effects	Rectangular	0.255	0.24	0.23	0.22	0.22	0.235
Edge sharpness	Rectangular	0.15	0.15	0.15	0.15	0.15	0.15
Plate bending at manufacture	Rectangular	0.1	0.1	0.1	0.1	0.1	0.1
Plate bending due to differential pressure	Rectangular	0.1	0.1	0.1	0.1	0.1	0.1
Eccentricity	Rectangular	0.09	0.09	0.09	0.09	0.09	0.09
Steps in pipe size	Rectangular	0.003	0.007	0.018	0.039	0.068	0.1
Expanded uncertainty: total		0.476	0.483	0.500	0.524	0.527	0.606

Conclusions

- Those are the changes to ISO 5167
 - Corrections
 - Clarifications
 - Greater consistency internally and with the GUM
 - Broader focus
- The changes are not very extensive
- The absence of major change suggests the standard is robust

Acknowledgements

BEIS: the Flow Programme

ISO/TC 30/SC 2/WG 11

Especially Alistair Collins, Steve Clark, Richard Steven

michael.reader-harris@tuvsud.com