

FIELD CALIBRATION OF FLOW METERS: A NEW APPROACH USING PITOT TUBES



Faced to the difficulties to calibrate large flow meters in laboratory, a new procedure of field calibration of these flow meters became a necessity.

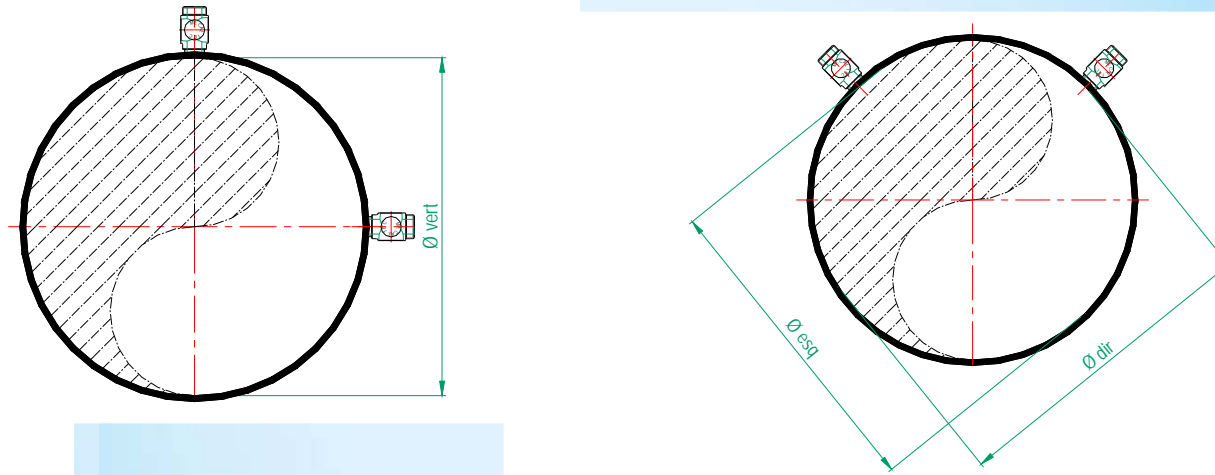
Initially, we searched for new equipments to this type of calibration, but there was a problem because no one of these equipments were standardized. In partnership with IPT we chose to develop a new methodology of calibration with Pitot Tube, using available eletronical resources and basing on international standards (BSI 1042 and ISO GUM Guide).

This methodology can be applied to microprocessed flow meters (differential pressure, electromagnetic, ultrasonic and other types) in pipe lines from 250mm to bigger.

This calibration consists in the direct comparison between the flow read in flow meter and the calculated value obtained by the Pitot Tube in other section of the pipe line. This comparison is made as always as possible in three distinct flows determined by the annual flow histogram.

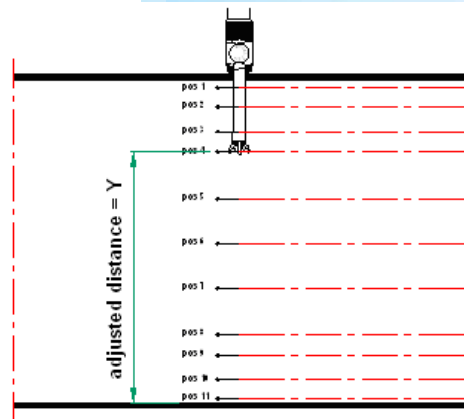
Bellow, the innovations of this methodology:

USING TWO ORTHOGONAL VELOCITY PROFILES



This process corrects small distortions in the velocity profile improving the quality of the test and of the reliability of flow results.

LOG-LINEAR DISTRIBUTION ALONG THE PIPE DIAMETER



Travers Vertical

	position (y/D)	adjusted distance (mm)	opposite side distance (y) (mm)	velocity (m/s)	ajusted velocity (m/s)	Pitot corrected velocity (m/s)
0	1	403	407	0,00	0,00	0,00
1	0,981	395	399	2,52	2,52	2,52
2	0,923	371	376	3,48	3,48	3,43
3	0,847	340	345	3,77	3,76	3,69
4	0,783	314	319	3,92	3,89	3,89
5	0,639	256	260	4,16	4,11	4,11
6	0,500	199	204	4,21	4,15	4,15
7	0,361	143	147	4,15	4,07	4,06
8	0,217	84	88	3,93	3,84	3,83
9	0,153	58	62	3,79	3,70	3,70
10	0,077	27	31	3,48	3,39	3,38
11	0,019	3	8	2,57	2,50	2,50
12	0,000	-4	0	0,00	0,00	0,00

With this distribution we can position the Pitot Tube directly in the centre of the transversal section providing a better precision in the velocity profile survey to determine the average velocity.

USING STATISTIC TOOLS IN DATA ACQUIRING

11 0 0 0	Mapeamento com tubo de Pitot				Dados do Primário				Tempo do Ensaio	1	d
	OP Pit. Ideal D0 (mmH2O)	DESVPAD D0 (mmH2O)	OP Pit. Cole D1 (mmH2O)	DESVPAD D1 (mmH2O)	Tempo medição (s)	Valor Indic. - Dataloger	DESVPAD - Dataloger	Valor Indic. Secundário SAE mmH2O	DESVPAD Secundário SAE mmH2O		
atual	#REF!		#REF!		25395	1,00		#REF!		02/03/2006 07:03:15	
médica	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!		
veloc.	#DIV/0!		#DIV/0!		Amostragem	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	00/01/1900 00:00:00	
máximo	0,0		0,0			0,0		0,00			
mínimo	0,0		0,0		40	0,0		0,00		0	

This permits us to analyze the quality of the collected data permitting a repetition of dubious points.

CONCLUIDO										
P T O	Mapeamento com tubo de Pitot				Dados do Padrão Primário				Data/hora	
	OP Pit. Ideal D0 (mmH2O)	DESVPAD D0 (mmH2O)	OP Pit. Cole D1 (mmH2O)	DESVPAD D1 (mmH2O)	Tempo medição (s)	Valor Indic. - Dataloger	DESVPAD - Dataloger	Velocidade Secundário SAE (m/s)		DESVPAD Secundário SAE (mmH2O)
REFER										
1										
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INTRODUCTION OF CONCEPTS OF UNCERTAINTIES (ISO/GUM) IN THE MEASURING SYSTEM

PM 035 - Penha

Cálculo de incerteza da velocidade pontual

$v = C_v(2 \cdot AP/\rho)^{0.5}$	0,55	m/s
$C_v =$	0,8860	
$AP =$	190	Pa
$\rho =$	998,202	kg/m ³

incerteza padrão	0,0047	m/s
incerteza padrão %	0,86%	
incerteza expandida	0,01	m/s
incerteza expandida %	1,72%	

Descrição do mensurando - x	Estimativa do mensurando	Distribuição de probabilidade	incerteza padronizada $u(x)$	Coefficiente de sensibilidade c	$c \cdot u$	incerteza combinada $(c \cdot u(x))^2$	Contribuição individual (%)
Pressão diferencial (tipo B)	190	Normal	1,8900	0,0014	0,2736	0,0000738	33,48%
Pressão diferencial (tipo A)	0	Normal	1,6780	0,0014	0,0000	0,0000582	26,39%
Densidade	998,202	Retangular	0,4322	-0,0003	-0,2736	0,0000001	0,06%
Coefficiente de descarga	0,8860	Normal	0,0000	0,6175	0,5471	0,0000000	0,00%
gradiente de velocidade	0	Normal	0,0008	1,0000	0,0000	0,0000067	3,06%
inclinação do tubo de Pitot em relação a direção do escoamento	0	Normal	0,0008	1,0000	0,0000	0,0000067	3,06%
correção da blocagem	0	Normal	0,0027	1,0000	0,0000	0,0000748	33,95%

incerteza padrão	7,09E-03	m/s
incerteza padrão %	1,33%	
incerteza expandida	0,01	m/s
incerteza expandida %	2,66%	

Cálculo de incerteza da velocidade média

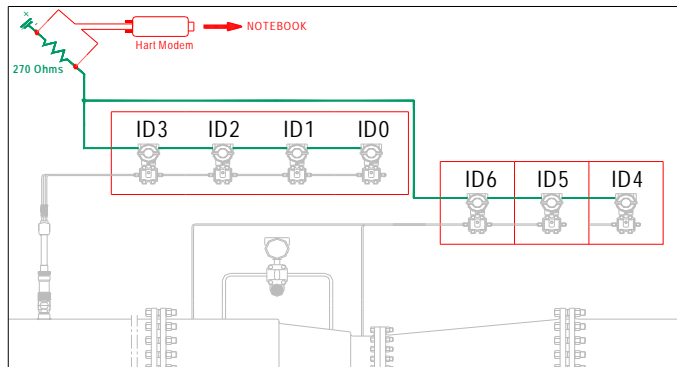
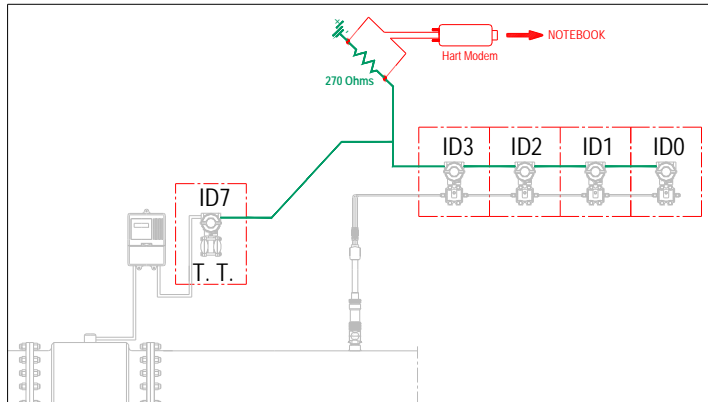
0,53	m/s
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Descrição do mensurando - x	Estimativa do mensurando	Distribuição de probabilidade	incerteza padronizada $u(x)$	Coefficiente de sensibilidade c	$c \cdot u$	incerteza combinada $(c \cdot u(x))^2$	Contribuição individual (%)
velocidade média	0,53	Normal	0,0000	0,0000	0,0000	0,00E+00	0,00%
medição de velocidade local	0	Normal	0,0047	1,0000	0,0000	2,20E-05	43,80%
dispersão da velocidade ao longo do perfil	0	Normal	0,0053	1,0000	0,0000	2,83E-05	56,20%

incerteza padrão	7,09E-03	m/s
incerteza padrão %	1,33%	
incerteza expandida	0,01	m/s
incerteza expandida %	2,66%	

The use of these concepts helps us to make a quantitative evaluation of the expanded combined uncertainty involved in the flow determination and consequently increases the reliability of the results.

USING HART ON LINE ACQUIRING DIGITAL SYSTEM



With this system we can correct eventual problems occurred during the data acquiring exactly when the problem happens, with no necessity of returning to the local to remake the test afterwards.

MORE RELIABLE RESULTS

Spreadsheet for determining the flow by mapping Pitometry -

reference : ISO 3966/77 e B SM 042/2A/73

Method of mapping the distribution hypothesis "log normal" for 11 points, a vertical traversal

From elaborator: Fernando R. Garcia

inc: 20/12/2001

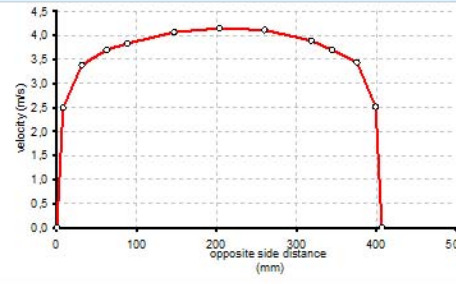
Latest version: Nelson M. Tolin

inc: 1/8/2013

Work :	IFT-SABESP MACM	Pipe diameter :	400 mm	section area :	0,130740 m ²
measurement address :	pav 232	nominal diameter :	407 mm	equivalent diameter :	408 mm
measurement date :	02 August 2006	Vertical diameter measured :	407 mm	tip diameter :	4,35 mm
Performed by :	Reinhardt / Edmilson	Horizontal diameter measured :	409 mm		

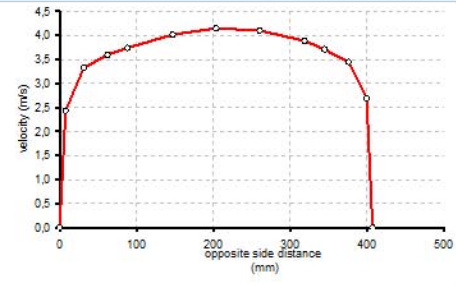
Traverse Vertical

	position (y/D)	adjusted distance (mm)	opposite side distance (y) (mm)	velocity (m/s)	adjusted velocity (m/s)	Pitot corrected velocity (m/s)
0	1	403	407	0,00	0,00	0,00
1	0,981	395	399	2,52	2,52	2,52
2	0,923	371	376	3,48	3,48	3,43
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10	0,077	27	31	3,48	3,39	3,38
11	0,019	3	8	2,57	2,50	2,50
12	0,000	-4	0	0,00	0,00	0,00



Traverse Horizontal

	position (y/D)	adjusted distance (mm)	opposite side distance (y) (mm)	velocity (m/s)	adjusted velocity (m/s)	Pitot corrected velocity (m/s)
0	1	403	407	0,00	0,00	0,00
1	0,981	395	399	2,69	2,69	2,69
2	0,923	371	376	3,50	3,49	3,45
3	0,847	340	345	3,79	3,77	3,71
4	0,783	314	319	3,91	3,89	3,89
5	0,639	256	260	4,15	4,10	4,10
6	0,500	199	204	4,21	4,15	4,15
7	0,361	143	147	4,09	4,02	4,01
8	0,217	84	88	3,83	3,74	3,74
9	0,153	58	62	3,69	3,60	3,59
10	0,077	27	31	3,42	3,33	3,33
11	0,019	3	8	2,51	2,44	2,43
12	0,000	-4	0	0,00	0,00	0,00



Average Flow (m ³ /s)			K Factor (m ³ /s/mH ² O ^{1/2})		
value	uncertainty		value	uncertainty	
0,458	0,010	2,2%	0,3258	0,0073	2,2%

	Velocity (m/s)		Center	α velocity	velocity amplitude
	Vertical average	Horizontal average			
Average	3,51	3,49	4,15	0,06	0,0183
1 st half	3,53	3,56			
2 nd half	3,49	3,42			

FWV_1	FWV_2	FWV_3	FWV_4	FW Amplitude
0,851	0,842	0,859	0,824	0,005
FWV average	0,847	FWH average	0,842	

With the combination of all these factors we reach a more reliable result in the flow measuring with Pitot Tube and consequently a field calibration also with reliability.

It is important to emphasize that to have a reliable flow measuring system it is necessary that this system be submitted to periodic calibrations.

In the implantation of standards and quality systems, it is observed the necessity of periodic calibrations to guarantee que quality. Thus, today the flow meter calibration is not only a way to check how the flow meter is measuring but it is an exigence of the quality systems.

With large flow meters up to 2,500mm we have problems that don't permit their removal from the pipe line to make the calibration in laboratory, what would be ideal.

Instead of its involved uncertainties are around 3.5%, the field calibration using Pitot Tubes is still a very good option of flow meter calibration.

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THANKS TO:

Sabesp

IPT

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