



EMPIR CALL 2020

Metrology infrastructure for high-pressure gas and liquified hydrogen flows

CFVN, hydrogen flow metering and calibration up to 100 MPa

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What is a sonic nozzle?

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IS	O 9300 provides detailed guidance on:	INTERNATIONAL STANDARD	ISO 9300	
•	Nozzle Geometry		Third edition 2022-06	
•	Manufacturing requirements	Measurement of gas flow by means of critical flow nozzles Mesurage de débit de gaz au moyen de tuyères en régime critique		
•	Installation requirements			

- Operating Conditions
- Calculation Methods



Reference number ISO 9300:2022(E)

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ISO 9300 provides

- Nozzle Geomet
- Manufacturing r
- Installation requ
- Operating Conc
- Calculation Met

Does ISO 9300 still apply for hydrogen up to 100 MPa?



Reference number ISO 9300-2022(F)

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CFVN up to 100 MPa Task 1.1: Design of nozzles and holder



	CFVN1*	R1	DIAM1	CYL	LP	Set B				
	CFVN2**	R1	DIAM1	TOR	LP	Set B	DIAM1	1	mm	
	CFVN3	R1	DIAM2	CYL	LP	Set B	DIAM2	2	mm	
Nozzle set 1	CFVN4	R1	DIAM2	TOR	LP	Set B				
	CFVN5	R2	DIAM1	CYL	LP	Set B	R1	0.05	Ra	μm
	CFVN6	R2	DIAM1	TOR	LP	Set B	R2	0.5	Ra	μm
	CFVN7	R2	DIAM2	CYL	LP	Set B	R3	1	Ra	μm
Nozzle set 2	CFVN8	R2	DIAM2	TOR	LP	Set B				
	CFVN9	R3	DIAM1	CYL	LP	Set B	HP	< 100	MPa	
	CFVN10	R3	DIAM1	TOR	LP	Set B	LP	< 10	MPa	
	CFVN11	R3	DIAM2	CYL	LP	Set B				
Nozzle set 3	CFVN12	R3	DIAM2	TOR	LP	Set B				
	CFVN13*	R1	DIAM1	CYL	HP	Set A				
HP nozzles	CFVN14**	R1	DIAM1	TOR	HP	Set A				

Build nozzles with various geometrical characteristics

CFVN up to 100 MPa Task 1.1: Design of nozzles and holder





High pressure holders

CFVN up to 100 MPa Task 1.1: Design of nozzles and holder



Low pressure calibration with nitrogen in the range (0.3 to 3) MPa





Cylindrical HP nozzle Poor agreement with ISO curve



Toroidal HP nozzle Nice agreement with ISO curve

Traceability scheme Task 1.3: Master meter calibration



Other traceability scheme for higher pressures with hydrogen: Calibration of Coriolis meter in a Hydrogen Refuellling Station and use it as master meter



Traceability scheme Task 1.3: Master meter calibration



Other traceability scheme for higher pressures with hydrogen: Calibration of Coriolis meter in a Hydrogen Refuellling Station and use it as master meter

							1 00			
Volume of collection vessel, L	208			104			1.00	 METAS Meter 	er ± 0.5%	Average
Initial pressure, bar			5	0			0.80	Ŧ		
Final pressure, bar			70	00			0.60			
							- 0 10	·-·-]-·-·-[F ·-·-·	r·-·-·	тт
Mass collected, kg	ass collected, kg 7.4 3.7				(%) U.40	. ! : .	Т	•		
							ي 0.20		i en	
APRR, bar/min	200	200	150	100	75	50	ш ш 0.00 —		T	
Filling time, min	3.25	3.25	4.33	6.50	8.67	13.00	0.00	¹ 0.50	1.00	1.50
							-0.20	ł		
Average mass flow rate,	2.28	1.14	0.85	0.57	0.43	0.28	-0.40			
kg/min							-0.60			
							0.00	Mass	Flow Rate (kg/	min)

Pressure range: (700 to 730) bar



2.00

Calibration of CFVN up to 90 MPa

Task 1.4: High-pressure calibration





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- Calibration method of Coriolis meters up to 90 MPa with hydrogen (Deliverable D1)
- Calibration method of CFVN up to 90 MPa with hydrogen (Deliverable D2)
- Applicability of ISO 9300 to hydrogen up to 90 MPa?
- Potential revision of ISO 9300



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