Gas Measurement Techniques

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Algeria – April 2002

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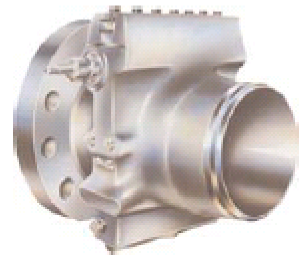
Agenda

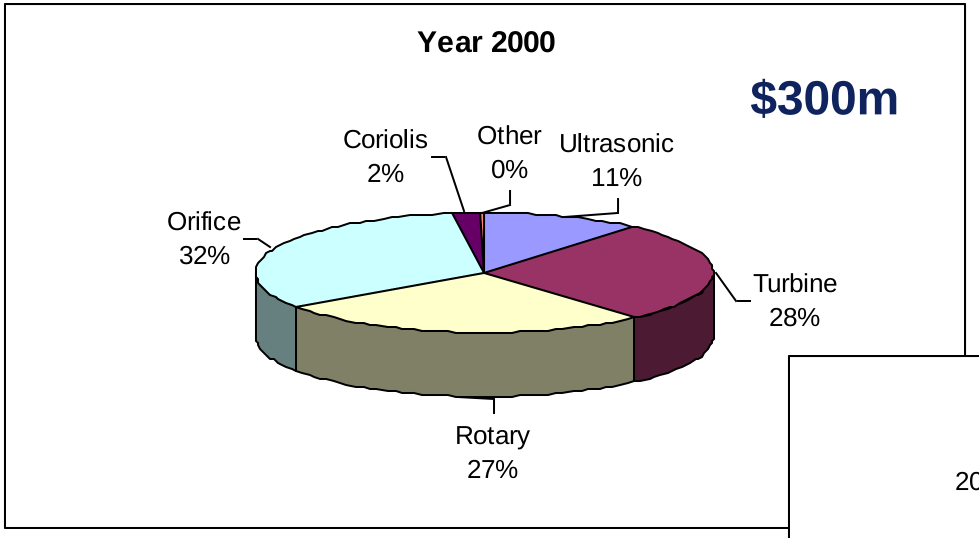
- Introduction
- Overview of Three Metering Technologies
  - Review of Basic Operating Principles
  - Advantages and Disadvantages of Each Technology
- Selecting The Correct Meter Based Upon
  - Fluid type and process properties
  - Required metering performance
  - Installation requirements
  - Economic considerations
- Questions & Discussion

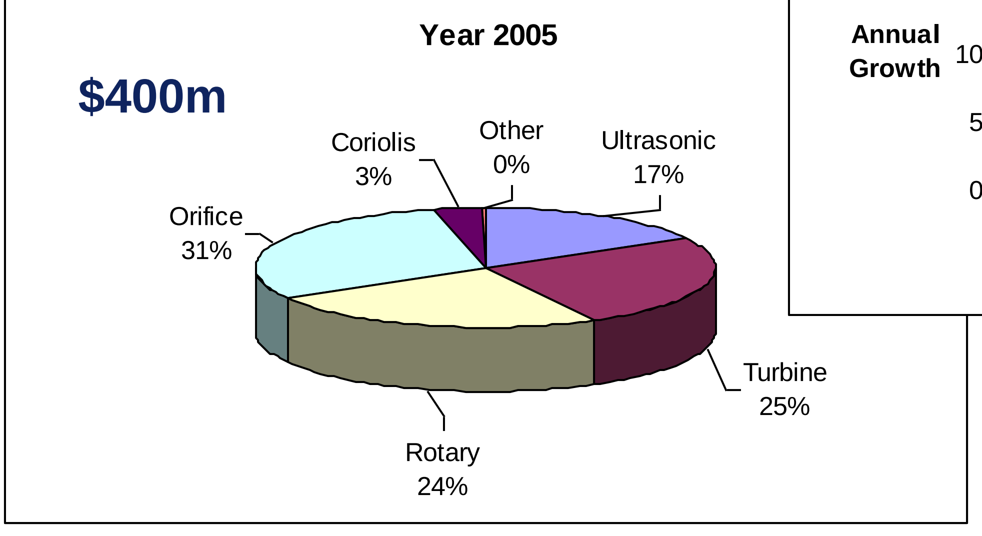
Introduction

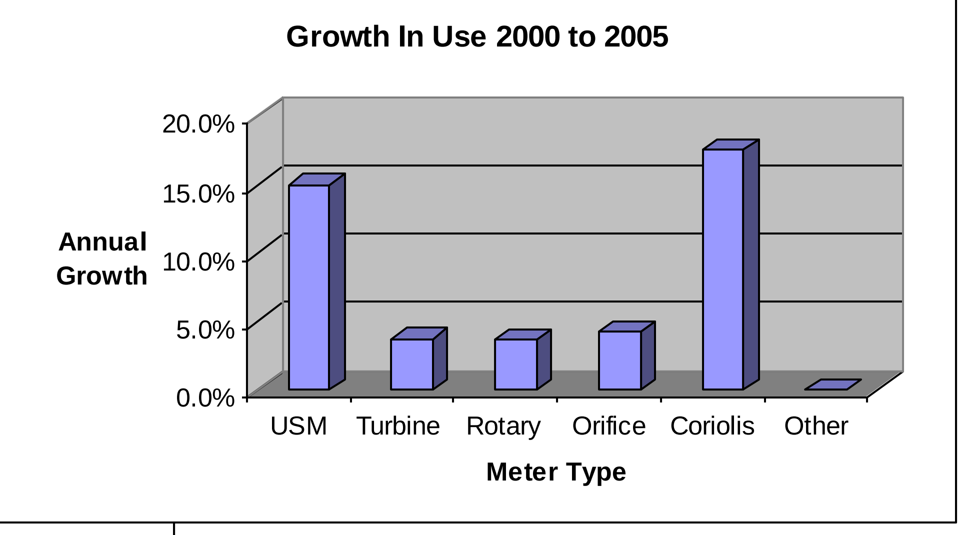





Utilisation Of Different Gas Meters







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ORIFICE METERING

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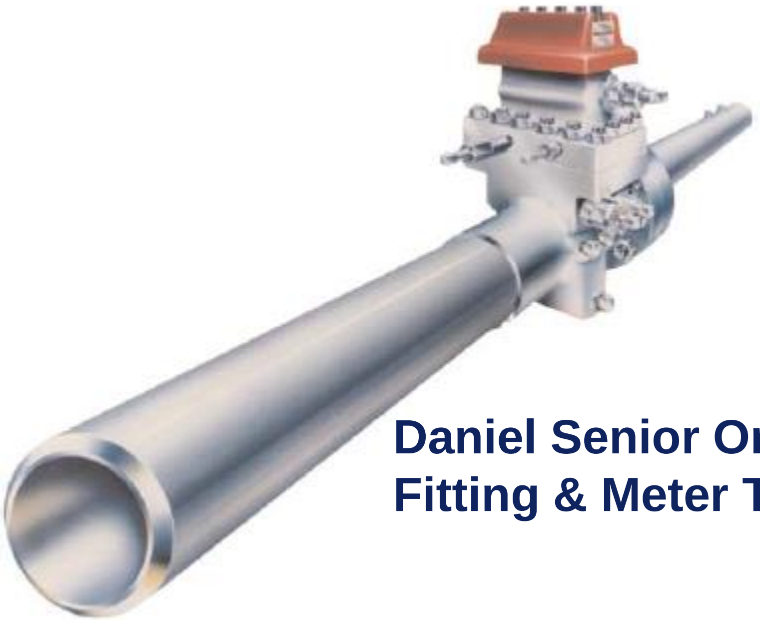
Background

- Orifice Meters Are Differential Pressure Devices
  - Differential Pressure Is Related To Flowrate
- Have Been Used In Gas Measurement For 70+ Years
  - Fully Accepted & Standardised
- Accuracy Relies On Correct
  - Application
  - Location
  - Flow Conditioning
  - Meter Tube Design
  - Operation



Daniel Senior Orifice Fitting & Meter Tube

Operating Principle - Orifice Plate

$$p_1 + \frac{1}{2}\rho_1 U_1{}^2 + \rho_1 g z_1 = p_2 + \frac{1}{2}\rho_2 U_2{}^2 + \rho_2 g z_2$$

Bernoulli Equation

$$U_1 = U_2 \left(\frac{A_2}{A_1} \right)$$

Continuity Equation

$$Q = \frac{C_d \varepsilon A_2}{\sqrt{1 - (A_2 / A_1)^2}} \sqrt{\frac{2\Delta P}{\rho}}$$

Orifice Flow Equation

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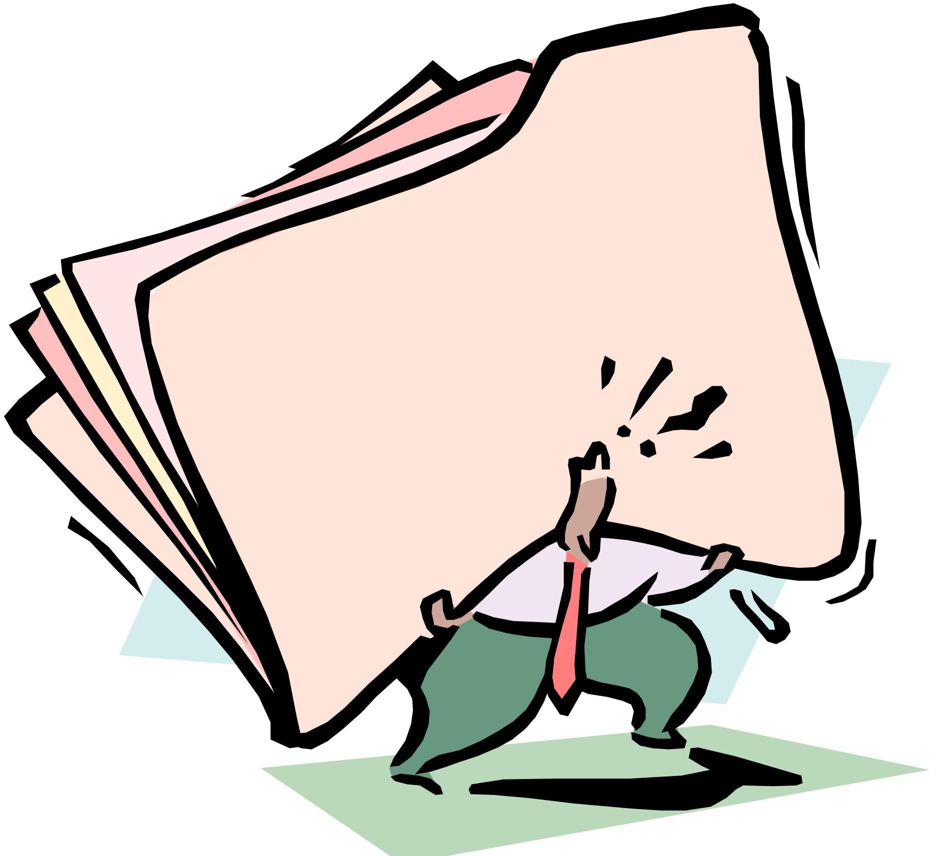
International Standards

- ISO 5167
- AGA-3



Advantages & Disadvantages For Orifice Plates

Advatages	Disadvantages
Well Documented In Standards	Low Rangeability
Industry Acceptance	High Pressure Loss
Low Capital Cost	Flow Profile Sensitive
No Moving Parts	Not Self Cleaning
Dry Calibration Acceptable	Frequent Recalibration of DP Cells
No Operation Limits (P&T)	Can Be Damaged By Excessive Flowrates
Mechanically Robust	

Application Of Orifice Meters

- Production
- Gas Reception
- Transmission
- Industrial Gas Consumers

Typical Daniel Senior Orifice Application

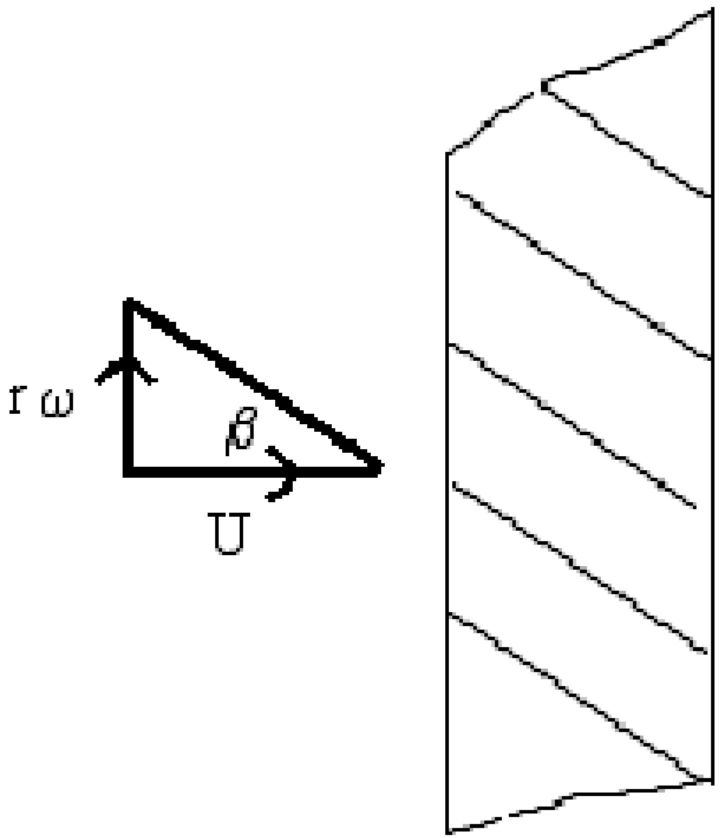
TURBINE METERING

Background

- First Patented In 1886
- By 1950s Established In Jet Engine Industry
- By 1970s Established In Petroleum Industry
- By 1980s Established In Natural Gas Industry – Especially Continental Europe

Daniel Turbine Meter

Operating Principle - Turbine Meter

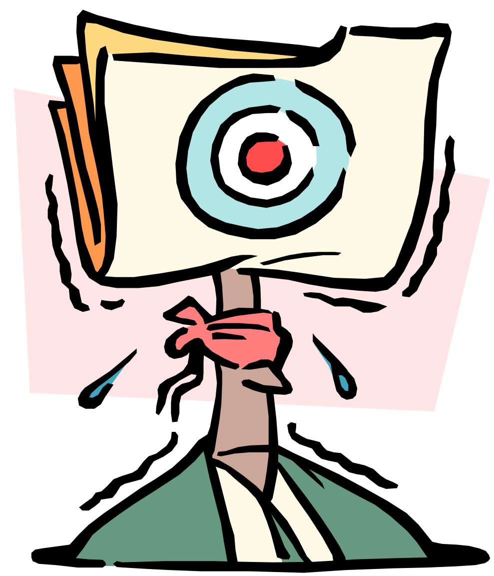


1. Mean Stream Velocity Is Proportional To Rotational Velocity
2. Volumetric Flowrate Is Proportional To Mean Stream Velocity

$$\omega = \frac{U}{r} \tan \beta$$

International Standards

- ISO 9951: Measurement of gas flow in closed conduits – Turbine Meters
- AGA7: Measurement of gas by Turbine Meters



Advantages & Disadvantages for Turbine Meters

Advatages	Disadvantages
Accurate Over Linear Flow Range Industry Acceptance Medium Capital Cost Medium Rangeability At High Pressure Electronic Output Available Natuyral Flow Totaliser	Requires Flow Calibration Relatively High Pressure Loss Moving Parts Require Maintenance Cannot Tolerate Dirty or Wet Gas Requires Swirl Free Flow Can Be Damaged By Excessive Flowrates

Application Of Turbine Meters

- Gas Reception
- Transmission
- Industrial Gas Consumers
- Distribution

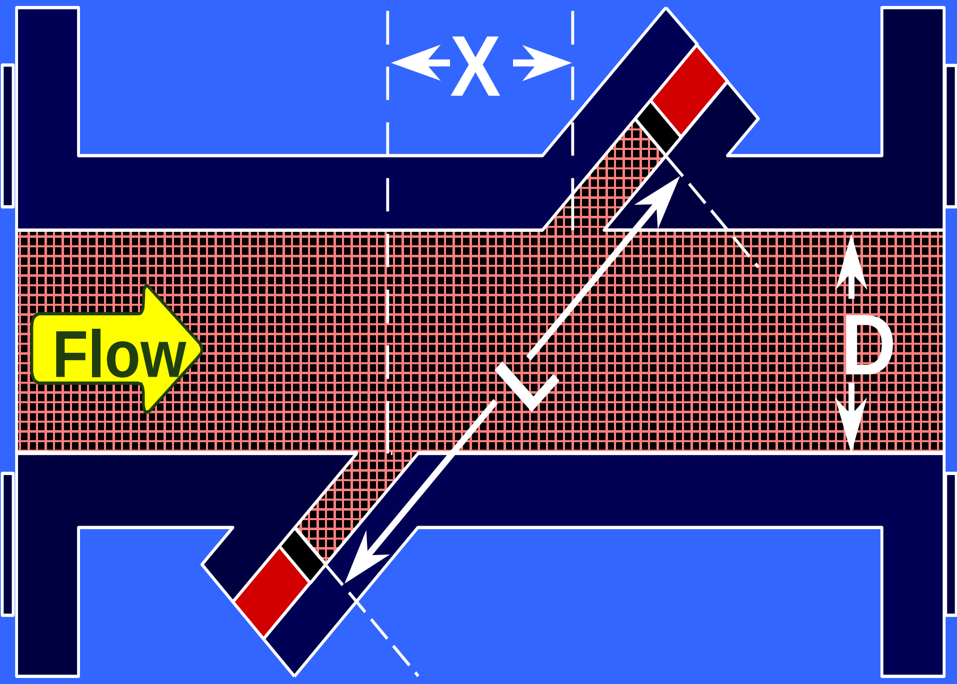
Typical Daniel Turbine Application

ULTRASONIC METERING

Background

- Acoustic techniques for flow measurement first proposed in 1935
- First practical working meter produced in 1948
- Reliable meters since advancement of electronics in the mid 1960's
- British Gas developed multipath gas meter until mid 1980s
- Daniel Industries awarded license in 1985 and continued development
- Other Manufacturers Realise Benefits Of USM & Begin Development

For an individual chord



$$t_{up} = \frac{L}{C - [V \cos n]}$$

$$t_{down} = \frac{L}{C + [V \cos n]}$$

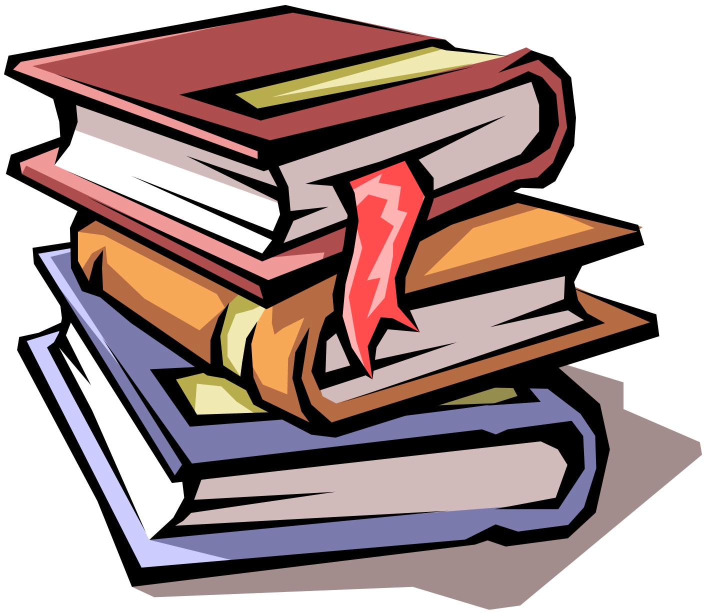
$$V = \frac{L^2}{2x} \cdot \frac{[t_{up} - t_{dn}]}{t_{up} \cdot t_{dn}}$$

$$C = \frac{L}{2} \cdot \frac{[t_{up} + t_{dn}]}{t_{up} \cdot t_{dn}}$$

Transit Time Technique - Basic Equations

International Standards

- AGA 9
- BS 7965:2000
- ISO/TC 30/SC 5/WG1 (Draft Form)



Advantages & Disadvantages For Ultrasonic Meter

Advatages	Disadvantages
No Flow Calibration Required High Accuracy Large Rangeability No Additional Pressure Drop No Moving Parts Low Operation Cost Low Project CAPEX	Not Fully Accepted By Industry No ISO Standard Control Valve Noise

Application of Ultrasonic Meters

- Production
- Gas Reception
- Transmission
- Distribution
- Industrial Gas Consumers
- Domestic

Typical Application of The Daniel SeniorSonic

SELECTING THE CORRECT METER

FLUID & PROCESS PROPERTIES

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Fluid & Process

	Pressure	Temperature		Gas or Liquid	Bi-phase
		Min	Max		
Orifice	700 bar	Minus 20 C	250 C	G , L	Limited
Turbine	400 bar	Minus 20 C	100 C	G , L	No
Ultrasonic	700 bar	Minus 20 C	100 C	G , L	Limited

METERING PERFORMANCE

Metering Performance

	Accuracy	Repeatability	Linearity	Turndown		Pressure Drop
				Normal	Extended	
Orifice	1.00%	(-)	(-)	3 to 1	12 to 1	500mbar
Turbine	0.70%	0.20%	0.50%	10 to 1	30 to 1	300mbar
Ultrasonic	0.50%	0.10%	0.10%	30 to 1	100 to 1	NIL

INSTALLATION REQUIREMENTS

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Installation Requirements

	Uni or Bi Directional	Upstream Requirements	Downstream Requirements	Filtration	Sizes Available
Orifice	Uni	42D	7D	Advisable	To 50"
Turbine	Uni	20D	5D	Yes	To 24"
Ultrasonic	Bi	10D	3D	No	To 48"

COST CONSIDERATIONS

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Cost Considerations

	Unit Price	Installation Price	Calibration Cost	Operational Cost	Maintenance Cost
Orifice	Low	High	Low	Moderate	Moderate
Turbine	Med	High	High	Moderate	High
Ultrasonic	High	Low	Low	Low	Low

Example Process Requirement

CAPEX Comparison

Flowrate	1 900 000Nm^3/hr
Accuracy	+/- 1.0% Std Vol
Pressure	80 bar
Temperature	38 degC

Two Potential Solutions

1. Orifice System (ISO 5167)

2. SeniorSonic System (AGA 9)

System Components

COMPONENT	ORIFICE SYSTEM	ULTRASONIC SYSTEM
No of Streams	3 x 24” runs	1 x 24” 100% run
Isolation Valves	Six	Two
DP Cells	Three	None
Pressure Cells	Three	One
Temperature	Three	One

System Performance

PARAMETER	ORIFICE SYSTEM	USM SYSTEM
Maximum Flow	1 900 000Nm3/hr	2 800 000Nm3/hr
Minimum Flow	1 260 00Nm3/hr	34 100Nm3/hr
Turndown	15:1	83:1
Accuracy	+/-1.0% Std Vol	+/-0.5% Std Vol

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Installtion Requirements

	ORIFICE SYSTEM	ULTRASONIC SYSTEM
Upstream Length	42D	10D
Downstream Length	7D	3D
End to End Length	37m	11m
Width	5m	2m
Weight	37 tonnes	6 tonnes

Installation Costs (CAPEX)

The Relative Costs Are

1. Orifice System	2.50 units
2. Ultrasonic System	1.00 units

Case Study

South Morecombe Metering Station

British Gas HRL , U.K

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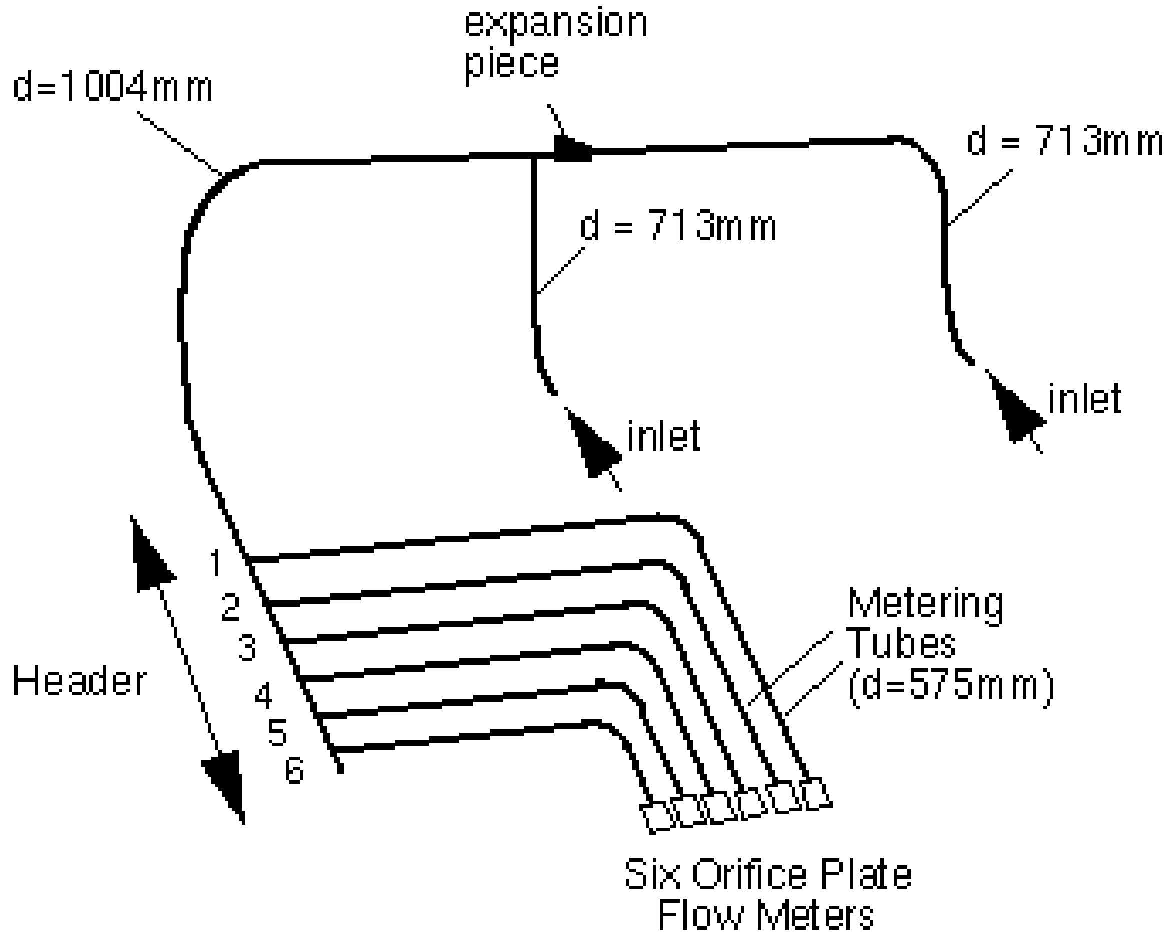
Recent Daniel Project

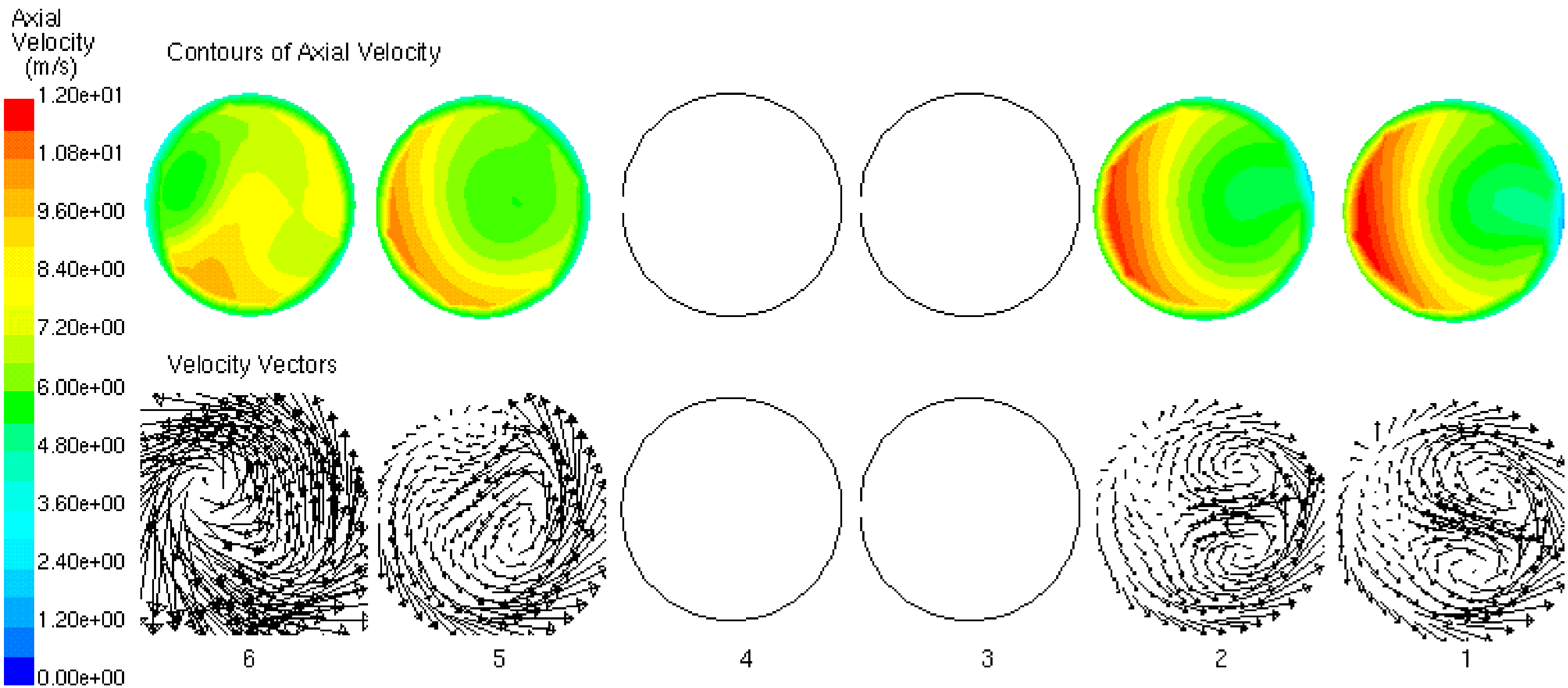
Client	British Gas HRL
Originally Constructed	Constructed 1985
Capacity	50 MMSCFD
Metering	6 x 24” Orifice Systems

Morecombe Bay Orifice System



Computational Fluid Dynamics Study Undertaken To See if Flow Profile is Fully Developed

Results of CFD Study



Computational Fluid Dynamics Study

Revealed Flow Profile Not Fully Developed

Swirl Angle > 2 Deg

Vendor Selection Criteria

- **Price**
- **Delivery**
- **Technical Acceptance**

“...as the chosen meters were of the chordal design they didn’t use a Reynolds number correction algorithm thus changes in the meters roughness were unlikely to affect its performance.” - Extract From Published Paper


Thank You For Your Attention
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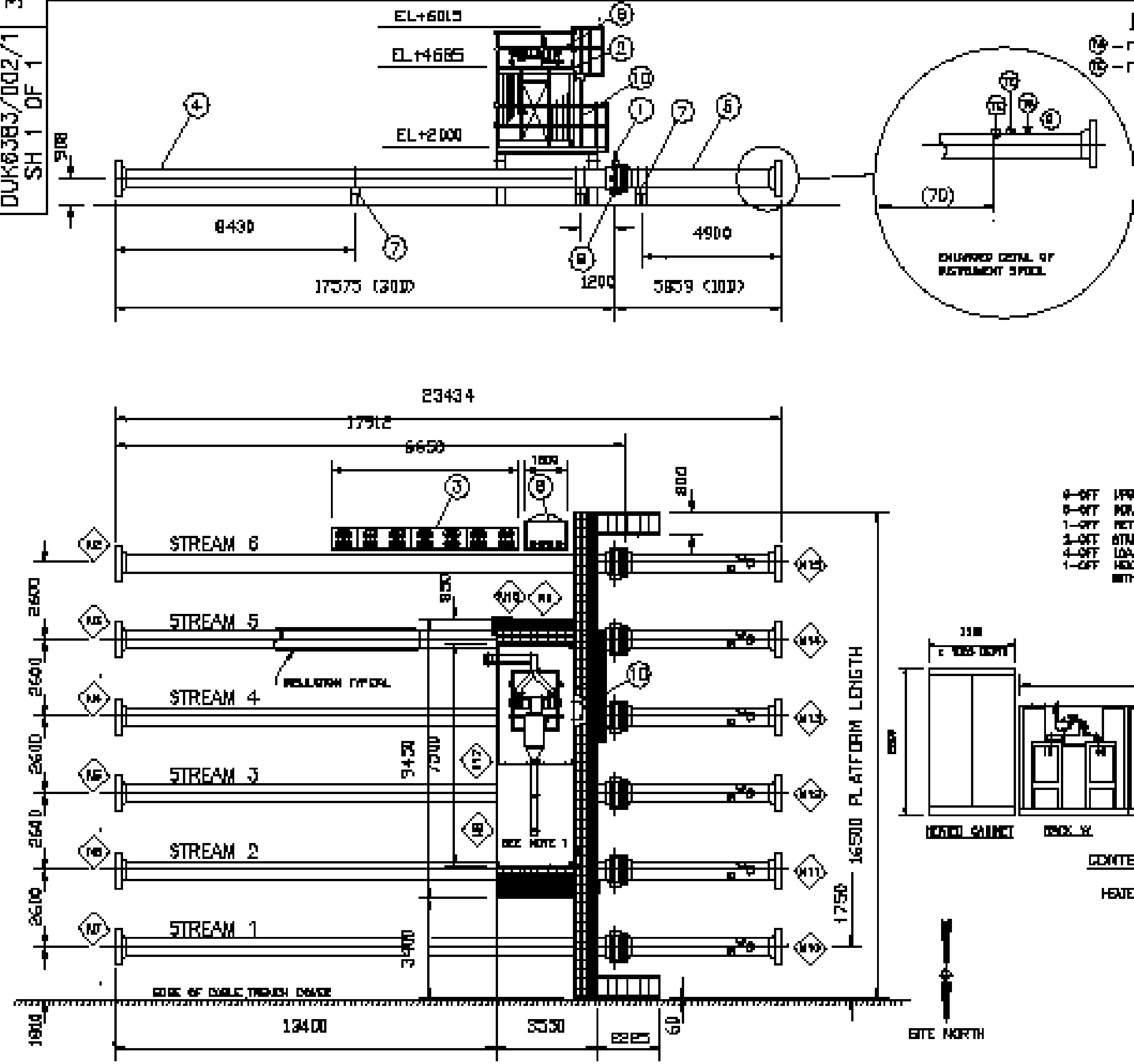


LEGEND

TW — TEST WELL
TE — TEMPERATURE ELEMENT

DESCRIPTION

1. 24"NB RF FLANGED ... JUNIOR ORIFICE FITTING.
2. METERING HOUSE.
3. GAS BOTTLE ENCLOSURE.
4. UPSTREAM METER TUBE (INSULATED BY OTHERS)
5. DOWNSTREAM METER TUBE (INSULATED BY OTHERS)
6. VENTILATION UNIT
7. CLAMPED PIPE TUBE SUPPORTS (BY OTHERS) RESTING ON CONCRETE PLINTHS.
8. CALIBRATION GAS BOTTLE CABINET.(4 OFF BOTTLES,HEATED)
9. INSTRUMENT CONNS TO ACCEPT ... INSULATION.
10. HARD ACCESS LADDER.

NOZZLE

N2 – N7 600mm INLET (TYP.6-OFF)

N8 METER HOUSE SAMPLE ... STREAM 'A' ...mm O/D TUBE (SEE NOTE 1)

N9 METER HOUSE SAMPLE VENT ...mm 150# (SEE NOTE 1)

N10 – N15 ...mm OUTLET (TYP.6-OFF)

N16 INSTRUMENT AIR 40mm 150# (SEE NOTE 1)

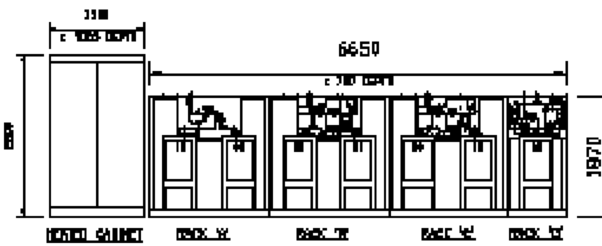
N17 METER HOUSE SAMPLE ... STREAM 'B' ...mm O/D TUBE (SEE NOTE 1)

NOTE 1:- FOR POSITIONS OF NOZZLES AND HVAC INLET REFER TO DRG. DUK6383/003/1

SYSTEM WEIGHTS

		UNIT	TOTAL
6-OFF	UPSTREAM METER TUBE	7500kg	45,000kg
6-OFF	DOWNSTREAM METER TUBE	[illegible]	[illegible]
1-OFF	METER HOUSE & SUPPORT	11000kg	11,000kg
2-OFF	ATTENUATOR	400kg	800kg
4-OFF	LOADED BOTTLE ENCLOSURE	1150kg	4600kg
1-OFF	HEATED BOTTLE CABINET WITH BOTTLES	1050kg	1050kg

SYSTEM TOTAL 71,[illegible]kg



CONTENTS OF BOTTLE ENCLOSURES

HEATED CABINET – CALIBRATION GAS 4 OFF
(IN SERVICE – 2 OFF, SPARE – 2 OFF)

RACK 'A' – NITROGEN 8 OFF
(IN SERVICE – 4 OFF, SPARE – 4 OFF)

RACK 'B' – HC FREE AIR 8 OFF
(IN SERVICE – 4 OFF, SPARE – 4 OFF)

RACK 'C' – HELIUM 8 OFF
(IN SERVICE – 4 OFF, SPARE – 4 OFF)

RACK 'D' – HYDROGEN 4 OFF
(IN SERVICE – 2 OFF, SPARE – 1 OFF)

INTERCONNECTOR ONSHORE WORKS PROJECT NO. 6504

ISSUE	DATE	CHANGE	CHKD	APPD
3	[illegible]	[illegible]		
2	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]
0	[illegible]	[illegible]	[illegible]	[illegible]
C	[illegible]	FOR APPROVAL	[illegible]	[illegible]
B	[illegible]	[illegible]	[illegible]	[illegible]
A	[illegible]	FOR TENDER	[illegible]	[illegible]

DRG SCALE	NTS A1
DIMENSIONS IN	mm
REF	SD 8242

DANIEL EUROPE LIMITED

GENERAL ARRANGEMENT
UK/CONTINENT GAS INTERCONNECTOR
Z305 EXPORT GAS FISCAL METERING

DRAWING NUMBER: DUK6383/002/1 SH 1 OF 1

ISSUE: 3

DRAWING NUMBER DUK6383/002/1 SH 1 OF 1 ISSUE 3