Kuwait 4th Flow Measurement Technology Conference

3-5 December 2019

Hilton Kuwait Resort

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الراعـي الرسمـي

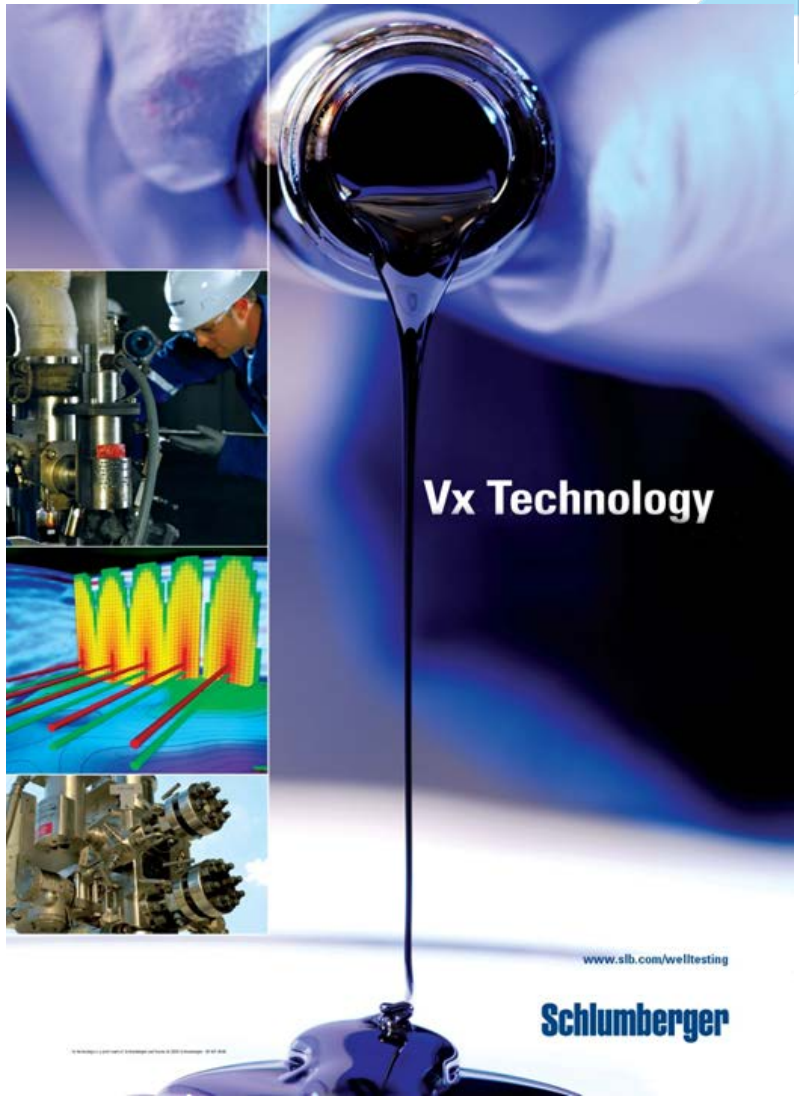
HANAN ALGHASRA

Schlumberger Testing Engineer

Advanced Dual-Energy Multiphase Flow Meter Performance in Challenging Environment

Agenda

- Types of Meters
- Technology Overview
- Principle of Measurements
- Data Case Studies



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Mobile Test Units

Separator

Diligens Spectra

- ✓ Less HSE concerns
- ✓ Smaller footprint
- ✓ Shorter rig-up, preparation, and rigdown Duration
- ✓ Less subject to human error
- ✓ Accurate flow rate measurements during stable or unstable conditions

Mobile Meters

PhaseTester

- ✓ WP: 5000 psi* (6.5k psi Optional)
- ✓ Sizes: 29, 52, 88 mm

Diligens Spectra

- ✓ WP: 1440 psi
- ✓ Sizes: 19, 29, 40 and 65mm (SLM or DLM)
- ✓ Integrated bypass manifold on the skid
- ✓ Dual leg options

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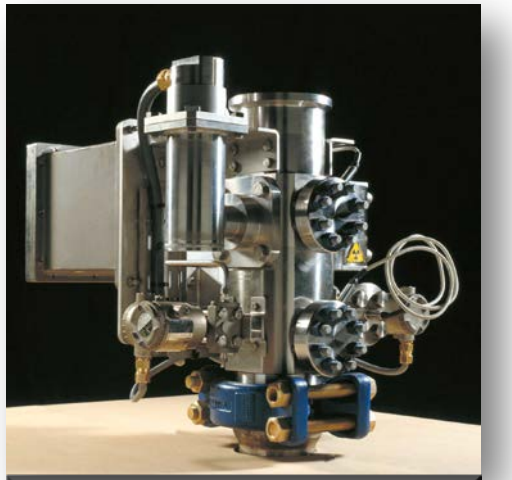
Permanent Meters



PhaseWatcher

- ✓ Surface (topside)
- ✓ Product – belongs to client
- ✓ Sizes: 29, 52, 65 & 88 mm

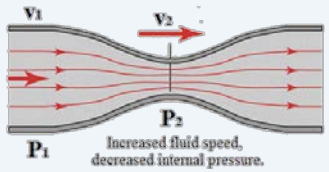
Spectra

- ✓ Surface (topside)
- ✓ WP: 5000 psi
- ✓ Sizes: 19, 29, 40 & 65 mm

Principle of MPFM

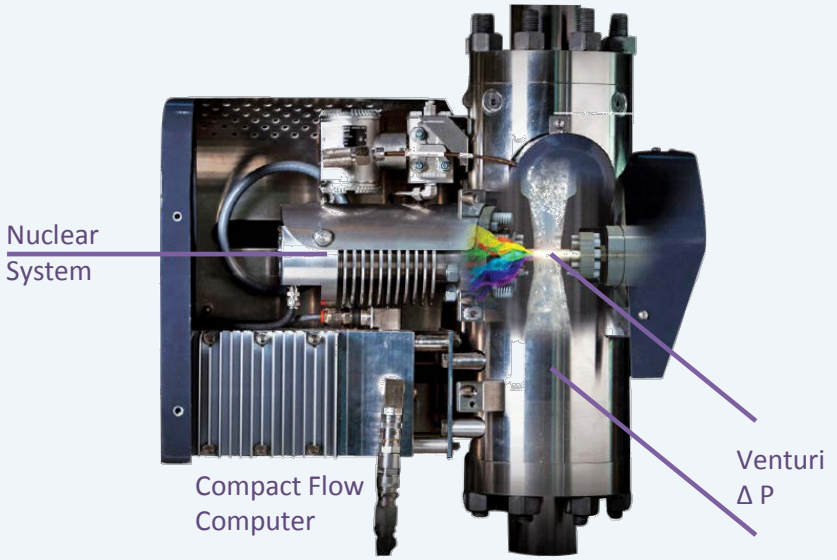
(1) Fluid Mechanics

Venturi → ΔP → Bernoulli - Total Mass Flow Rate @ LC



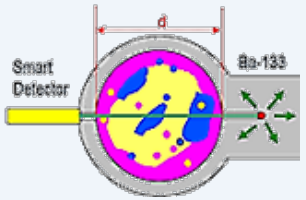
(2) Nuclear Equations

3 Phase Fractions → Volumetric flow rate @ LC



(3) Fluid Behaviour – PVT Model

PVT Model → Volumetric flow rates @ St. conditions (**Oil**, **Gas**, **Water**)

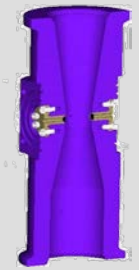


Calculations overview

Direct Measurements

ΔP, P_L & T_L

Venturi & Delta P



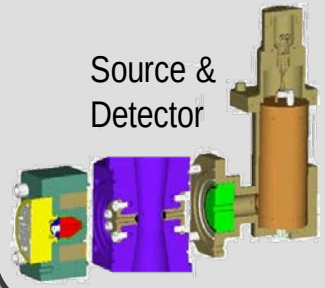
Bernoulli → Venturi

Primary outputs

$Q_{total\ mass}$ @ LC

Photons count

Source & Detector



Nuclear → Model

GVF & WLR

Phases Hold-ups

- % Water
- % Oil
- % Gas

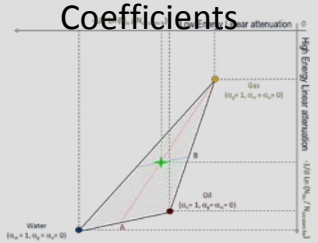
+

User Inputs

- ✓ Fluid Densities

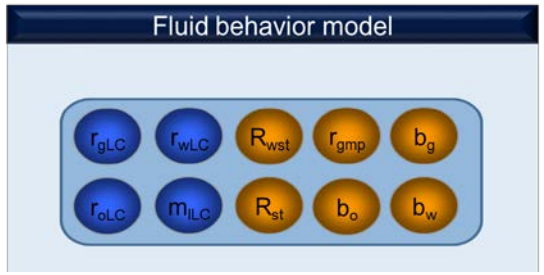
- ✓ Oil and Water Viscosity

- ✓ Mass Attenuation Coefficients



Volumetric rates @ Line Conditions

+

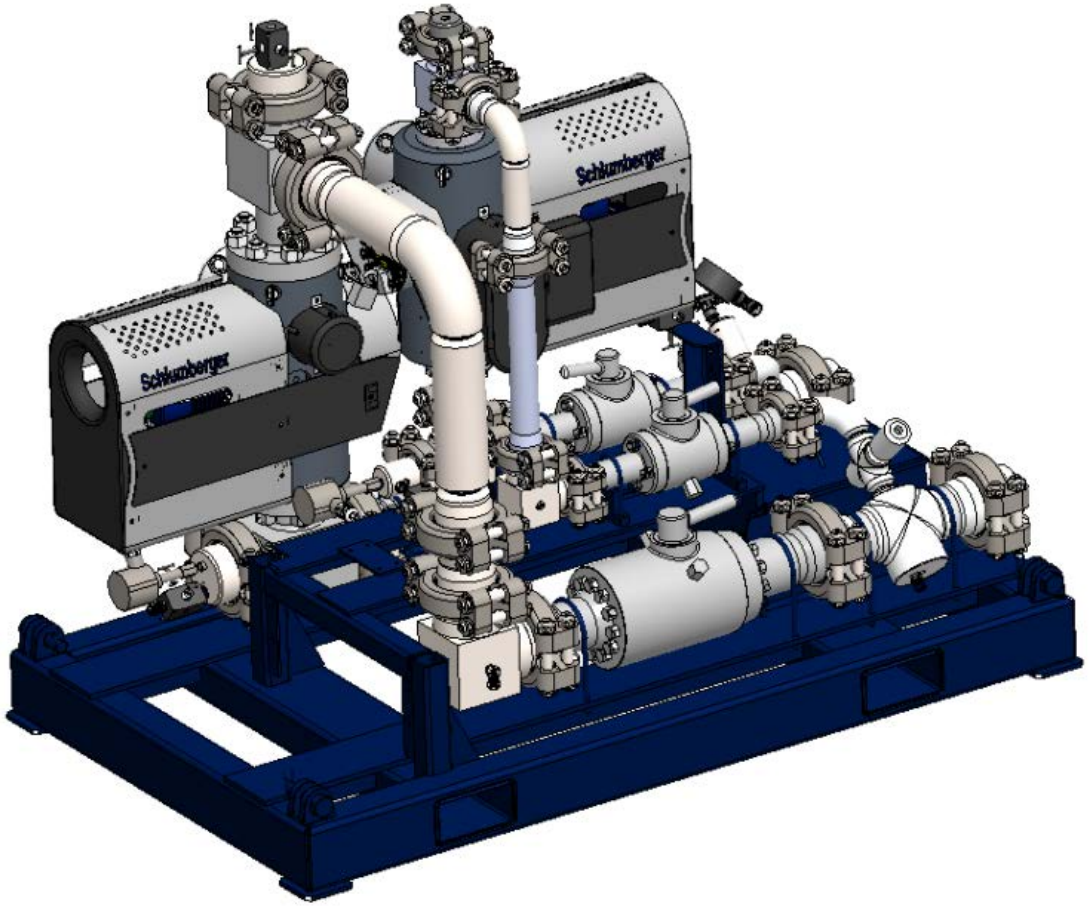


Density	: ρo, ρw, ρg
Volume Factor	: bo, bw, bg
Stock tank Gas Oil Ratio	: Rst (GOR2)
Gas Phase Condensate Gas Ratio	: rgmp (CGR)
Stock Tank Gas Water Rati	: Rwst
Liquid viscosity	: μ

Volumetric rates @ St. Conditions

Well test setup

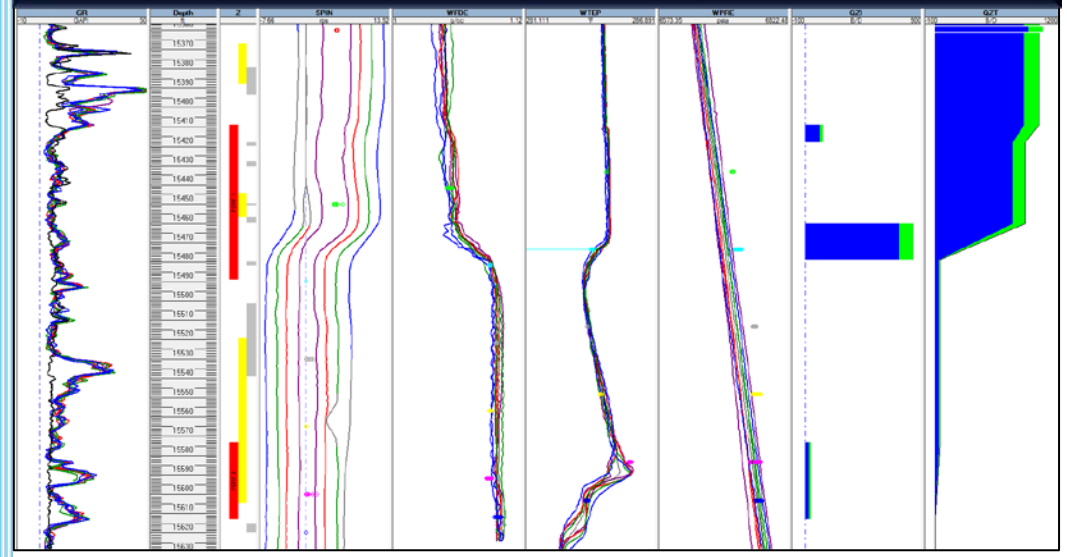
- ✓ 19 & 40 mm independent meters mounted on a skid
- ✓ Venturi selection based on well condition



Case Study 1

Well : RA-0285
Formation : Middle Marrat
Interval : 15,370’ - 15,640’ MD

PLT



	From ft	To ft	Temperature °F	Pressure psia	Zonal water production dQw res. B/D	dQw s.c. STB/D	%	Zonal oil production dQo res. B/D	dQo s.c. STB/D	%	PERF #
Inflow 1	15409	15418.1	284.6	6659.2	111	105	13	26	13	18	PERF 1
Inflow 2	15419.7	15428.1	284.8	6674.1	0	0	0	0	0	0	
Inflow 3	15432	15449.8	284.8	6678.8	0	0	0	0	0	0	
Inflow 4	15450.7	15456.7	284.8	6688.8	0	0	0	0	0	0	
Inflow 5	15459.9	15478.7	284.8	6692.7	728	685	83	111	55	74	
Inflow 6	15485.2	15489	283.9	6703.5	0	0	0	0	0	0	
Inflow 7	15573	15613	284.1	6722.5	31	29	4	11	6	8	PERF 2
			Totals		870	820		149	73		

MPFM

Schlumberger

Kuwait Oil Company
RAUDHATAIN / RA-0285 T / Vx#5

Main Result

Job No.: SLBT-170049
Test Date: 7-Feb-17
WT Supervisor name: Mostafa/Rafael
Unit Number Vx#5

Flow period/ String	Start date / time	End date / time	Test Duration	Choke Size	WHT	WHP	Flow Line Pressure	Critical flow	DownStream Pressure	CO2 (in Gas)	H2S (in Gas)
	yyyy.mm.dd hh:mm	yyyy.mm.dd hh:mm	hrs	/64	deg F	psig	psig	Y / N	psig	%	ppm
1	2017/02/08 16:00	2017/02/09 01:45	9:45	32	154	192	Pit	Y	15	3.00	140,000
2											
3											

Flow period / String	Oil Q	Water Q	Total Liquids	Gas Q	GOR 1	GOR 2	Total GOR	BS&W	Water salinity	SG OIL	OIL	SG WATER	SG GAS
	bbls/day	bbls/day	bbls/day	MMSCF/day	SCF/bbl	SCF/bbl	SCF/bbl	%	ppm	@ 60 deg F	Deg API	@ 60 deg F	(air=1)
1	73	863	936	0.117	1583	16	1589	92.2	230,000	0.795	46	1.158	0.950

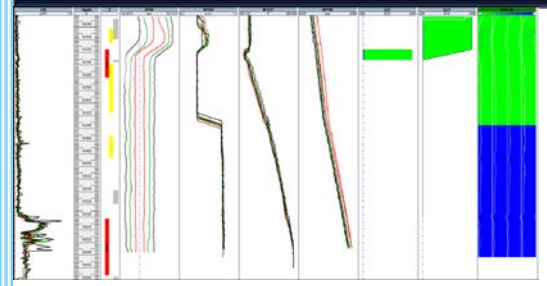
Flow period / String	Oil Q /L/C	Water Q /L/C	Total Q /L/C	Gas Q /L/C	pH
	bbls/day	bbls/day	bbls/day	MMSCF/day	
1	76	877	953	0.0660	7

General comments: Main result is taken from the last reading of the flow period. Production GOR Test is conducted on 32/64" Fixed choke along with Schlumberger wireline PLT. No FID been applied.

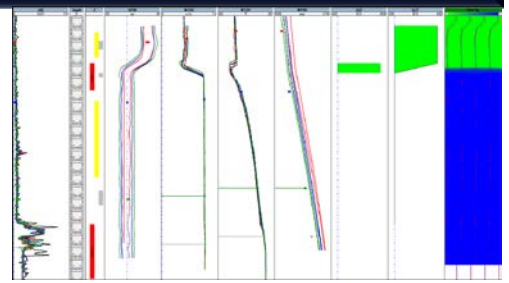
Case Study 2

Well : NWRA-0007
Formation : Lower & Middle Marrat
Interval : 16,315 – 16,360 ft MD
16,582 – 16,672 ft MD

PLT



Flowing Survey @ 16/64" – Flow Profile



Flowing Survey @ 24/64" – Flow Profile

	From ft	To ft	Temperature °F	Pressure psia	Zonal water production dQw res. B/D	dQw s.c. STB/D	%	Zonal oil production dQo res. B/D	dQo s.c. STB/D	%	Zonal gas production dQg res. B/D	dQg s.c. Mscf/D	%
Inflow 1	16315	16332.1	283.8	6253.9	25	24	100	2188	1091	100	0	1854.42	100
Inflow 2	16335.4	16360	283.7	6263.9	0	0	0	0	0	0	0	0.00	0
Inflow 3	16582	16672	285.8	6313.8	0	0	0	0	0	0	0	0.00	0
			Totals		25	24		2188	1091		0	1854.42	

Flowing Survey @ 24/64" – Flow Profile

	From ft	To ft	Temperature °F	Pressure psia	Zonal water production dQw res. B/D	dQw s.c. STB/D	%	Zonal oil production dQo res. B/D	dQo s.c. STB/D	%	Zonal gas production dQg res. B/D	dQg s.c. Mscf/D	%
Inflow 1	16315	16331.6	283.6	5625.4	21	20	100	3507	1727	100	0	2936.48	100
Inflow 2	16338.4	16360	283.3	5635.3	0	0	0	0	0	0	0	0.00	0
Inflow 3	16582	16672	285.7	5697.4	0	0	0	0	0	0	0	0.00	0
			Totals		21	20		3507	1727		0	2936.48	

MPFM

Schlumberger

Kuwait Oil Company
NWRA / NWRA-0007 T

Main Result

Job No.: SLBT-160102
Test Date: 27-Jan-16
WT Supervisor name: Mostafa Elgendi
Unit Number Vx#5

Flow period/ String	Start date / time	End date / time	Test Duration	Choke Size	WHT	WHP	Flow Line Pressure	Critical flow	DownStream Pressure	CO2 (in Gas)	H2S (in Gas)
	yyyy.mm.dd hh:mm	yyyy.mm.dd hh:mm	hrs	/64	deg F	psig	psig	Y / N	psig	%	ppm
1	2016/01/29 19:15	2016/01/30 07:45	12:30	16	135	2726	1104	Y	1104	2.00	40,000
2	2016/01/30 08:00	2016/01/30 14:00	6:00	24	164	2250	1290	Y	1290	2.00	40,000
3	2016/01/30 14:00	2016/01/30 21:00	7:00	32	187	1677	1276	N	1276	2.00	40,000
4	2016/01/30 21:20	2016/01/31 09:20	12:00	SI	NA	2922	NA	NA	NA	NA	NA

Flow period / String	Oil Q	Water Q	Total Liquids	Gas Q	GOR 1	GOR 2	Total GOR	BS&W	Water salinity	SG OIL	OIL	SG WATER	SG GAS
	bbls/day	bbls/day	bbls/day	MMSCF/day	SCF/bbl	SCF/bbl	SCF/bbl	%	ppm	@ 60 deg F	Deg API	@ 60 deg F	(air=1)
1	**1117**	**12**	**1128**	**1.646**	1077	399	**1476**	1.1	260,000	0.796	46	1.128	0.753
2	**2000**	**0**	**2000**	**2.896**	1090	359	**1449**	0.0	NA	0.796	46	NA	0.749
3	**2646**	**0**	**2646**	**3.998**	1202	310	**1512**	0.0	NA	0.796	46	NA	0.745

Flow period / String	Oil Q /L/C	Water Q /L/C	Total Q /L/C	Gas Q /L/C	pH
	bbls/day	bbls/day	bbls/day	MMSCF/day	
1					7
2					NA
3					NA

General comments: Values are taken as AVERAGE of each flow periods or the nearest available value where applicable. Well was initially shut in. Production GOR Test was being conducted on 16/64" Fixed choke as FP#1, 24/64" Fixed choke as FP#2 and 32/64" Fixed choke as FP#3 as per test program, well wasthen shut in for 12 hours as FP#4. BS&W, Salinity and PH are taken every one hour, H2S, CO2 and Gas gravity are taken twice on each choke.

Case Study 3

Well : UN-0009
Formation : Lower Fars

Accurate Measurement in Unconsolidated Low Rate Heavy Oil

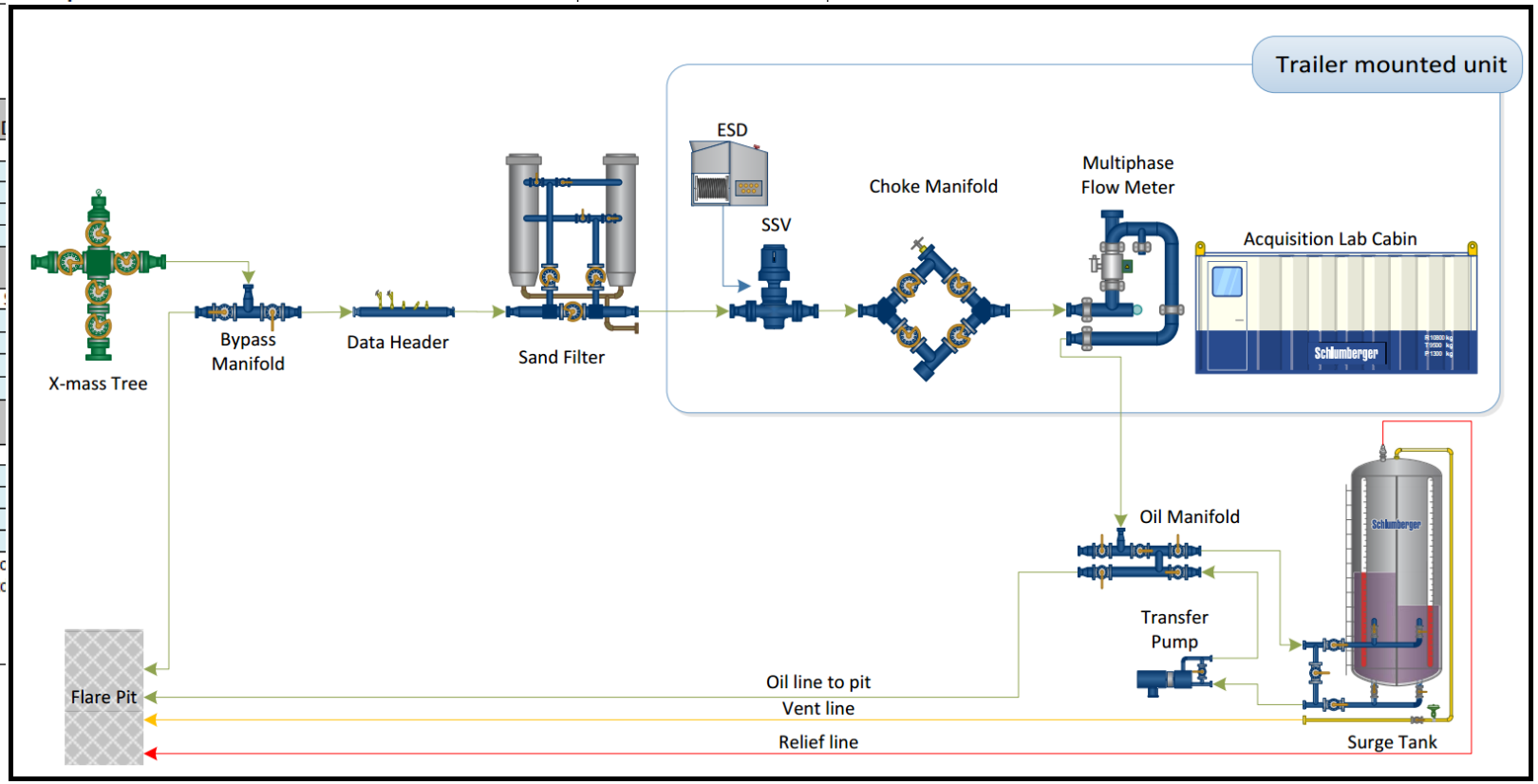
Schlumberger	Kuwait Oil Company Umm Niqa / UN-0091T+C/ VX#3	Main Result

Flow period/ String	Start date / time	End date / time
	yyyy.mm.dd hh:mm	yyyy.mm.dd hh:mm
1	2017/02/25 00:12	2017/02/25 08:30
2	2017/02/25 08:30	2017/02/25 18:10
3	2017/02/25 18:10	2017/02/25 23:00

Flow period / String	Oil Q	Brine Q	Total Liquids	Gas Q
	bbls/day	bbls/day	bbls/day	MMSCF/day
1	153	152	305	0.013
2	329	14	342	0.022
3	384	3	387	0.026

Flow period / String
1
2
3

General comments	Values are taken at the FINAL of flow peric as FP#1,2,3, . As per the program instructc



Case Study 4

Well : UN-0121
Formation : Lower Fars

Accurate Measurement in Unconsolidated Low Rate Heavy Oil

Schlumberger

Kuwait Oil Company
UMM NIGA / UN-0121 T+C / Vx#3

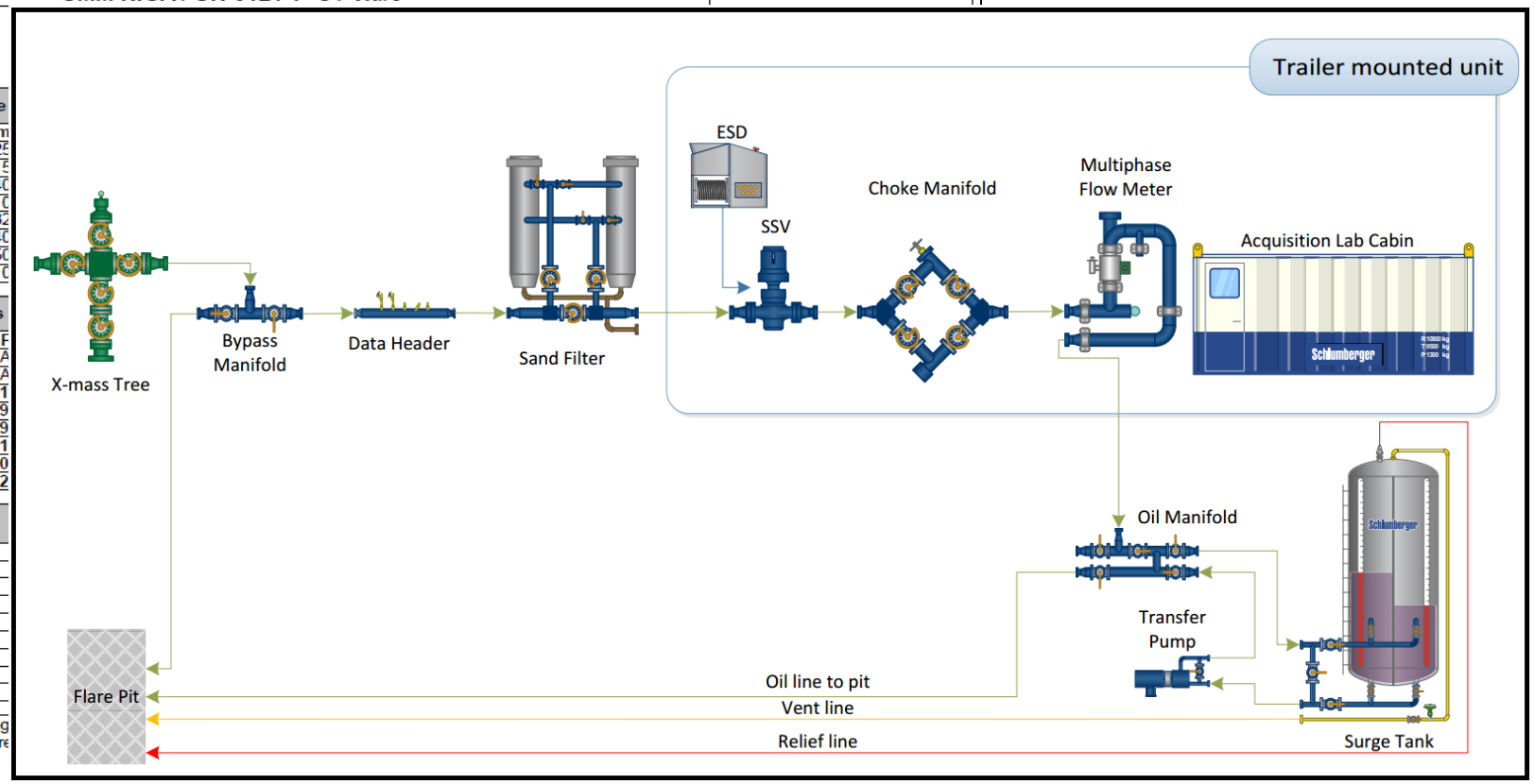
Main Result - 1

Flow period/ String	Start date / time	End date / time
	yyyy.mm.dd hh:mm	yyyy.mm.dd hh:m
1	2017/06/21 19:30	2017/06/22 03:25
2	2017/06/22 03:25	2017/06/22 07:15
3	2017/06/22 07:15	2017/06/24 20:40
4	2017/06/24 20:40	2017/06/25 01:10
5	2017/06/25 01:10	2017/06/25 05:32
6	2017/06/25 05:45	2017/06/25 19:40
7	2017/06/25 19:40	2017/06/25 23:50
8	2017/06/25 23:50	2017/06/26 02:10

Flow period / String	Oil Q	Brine Q	Total Liquids	Gas
	bbls/day	bbls/day	bbls/day	MMSCF
1	0	61	**61**	N/A
2	0	138	**138**	N/A
3	227	24	**251**	**0.11**
4	185	17	**202**	**0.09**
5	216	6	**222**	**0.09**
6	202	15	**217**	**0.11**
7	163	13	**176**	**0.10**
8	169	18	**187**	**0.12**

Flow period / String				
1				
2				
3				
4				
5				
6				
7				
8				

General comments	Main result is from the last reading
	140 , 150) RPM . FP#1&2 liquid re



THANK YOU