Kuwait 4th Flow Measurement Technology Conference

3-5 December 2019
Hilton Kuwait Resort

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Challenges in Gas Metering

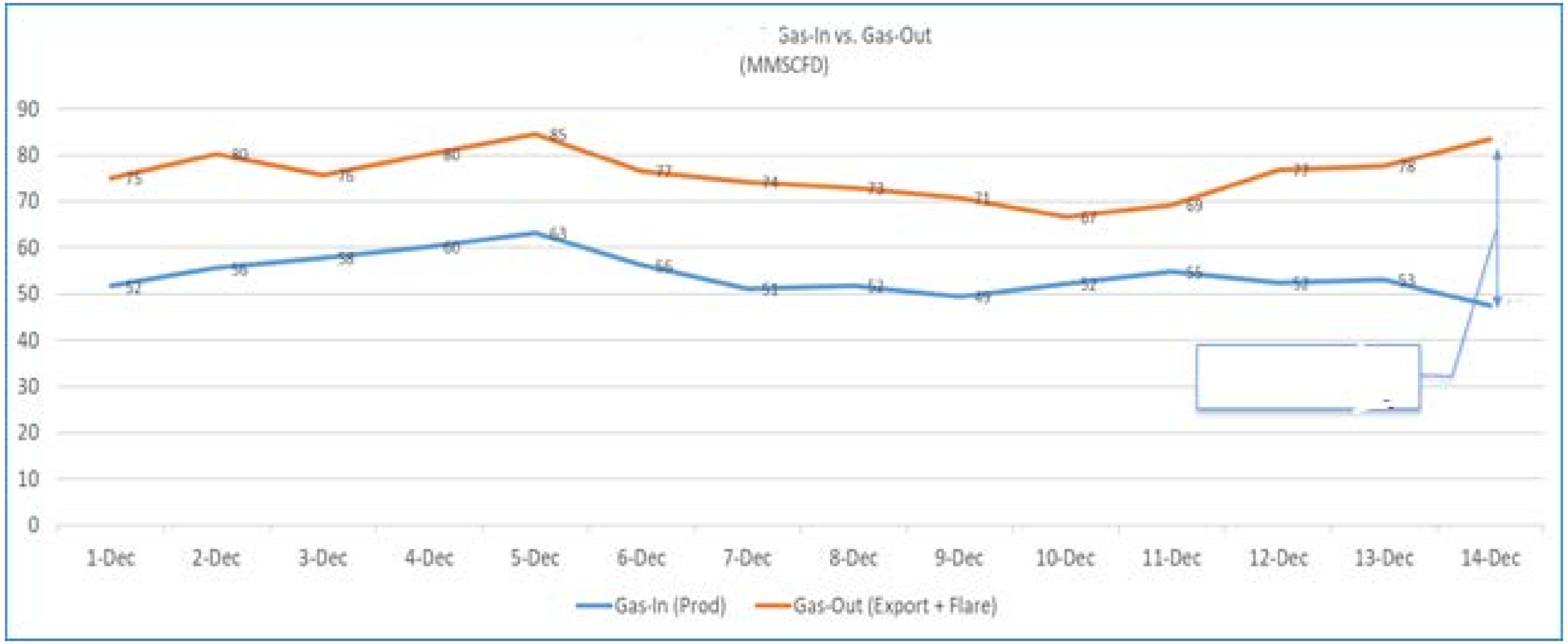
Content

Introduction

- The associated gas produced at various crude production facilities at WK fields was so far processed at local gas compression units or centralized Booster Station.
- In reality, achieving an acceptable mass balance is a challenge.
- Practically, wide discrepancies (30%) between the predicted and the actual flow.
- A TFT was formed to study and resolve this discrepancy by investigating into installation, DCS setup and other Process associated issues.

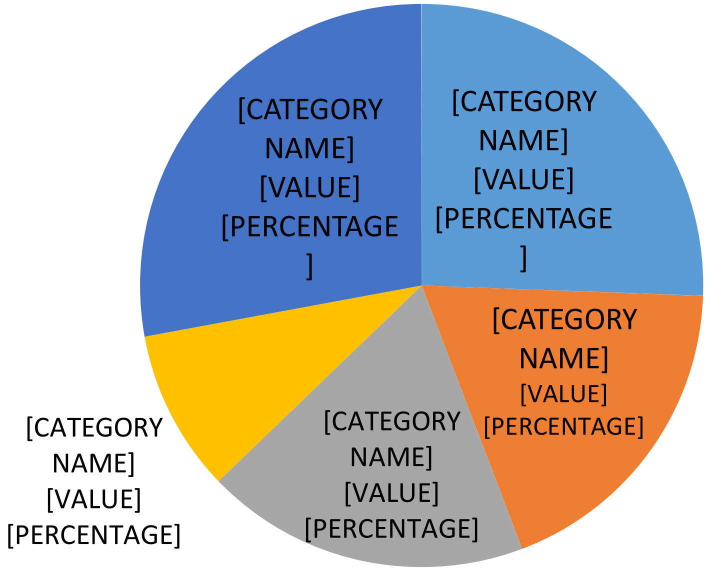
Finding

❿ A significant discrepancy was found in gas mass balance in a typical facility as shown below:



Gas Meter Selection

⑩ Gas flow measurement in a typical facility in WK is handled by four different types of flow meters, Orifice, Nozzle - Long Radius, Ultrasonic, and Annubar. They are distributed typically as follows:



Flow Meter Application

Meter Type	Service / Location
Orifice & Senior Orifice	Most common Specifically, HP Sep gas outlet
Long Radius Nozzle	LP Sep gas outlet
Ultrasonic	Tank gas outlet (0.5” -5”) TV flare & HP flare (5” – 45#) HP & LP gas export 45# to 900#)
Annubar	TV compressors suction and HP flare header.

Investigation

- Investigation used the Gas Meter Datasheets and P&IDs as the basis.
- Investigation acquired the PVT gas analysis report for every gas stream for summer and winter cases
- Field FM Installations were inspected and the following were observations:
  - FMs have not been inspected ever since commissioning.
  - Impulse lines were found long with many bends
  - US flow meters were not reading correctly
  - Some flow transmitters are field configured for square root extraction
- DCS Configurations were inspected and the following were the observations
  - DCS configured in a conventional manner for the datasheet case (only for pressure and temperature variation).
  - Some flow meter ranges were found less than the actual flow.
  - DCS for Long Radius Nozzle was configured as for orifice
  - DCS Configuration cannot deal with the gas compositional changes for summer and winter.

Gas Calculation Methodology & Standards

- The TFT implemented the following modifications in DCS configuration:
  - AGA-8 and AGA-3 modules were used for configuring all orifice flow meters.
  - Orifice module wrongly selected for the Long Radius Nozzle was corrected and reconfigured based on ISO 5167.
  - Annubar & US flow meters were reconfigured based on Vendor's sizing calculation.

Field Recalibrations

- All Impulse lines were flushed clean and Transmitters recalibrated without field square root extraction.
- US flow meters were zero checked by vendor

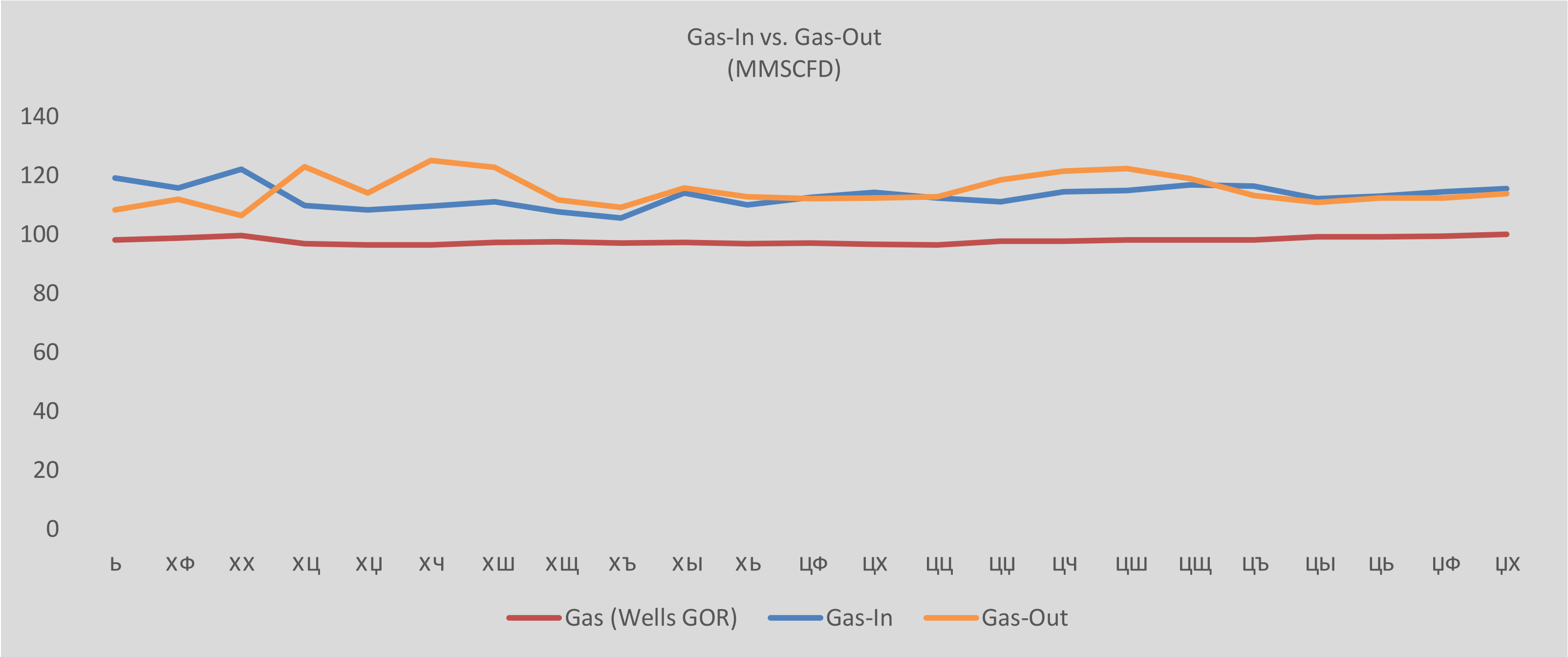
Improvement Activities

- the following activities were implemented as part of a MOC to improve the gas flowmeters calculations in this GC:

- AGA-3 calculations implemented in all orifice meters.
- Flow calculations for all Nozzle - Long Radius meters corrected as per the original FDS of RS-3 DCS.
- Ultrasonic flow calculations verified and corrected based on vendor calibration reports
- Annubar flow calculations verified and corrected based on manufacturer vendor data.
- Base conditions considered for all meters corrected.
- Process parameters considered for all meters corrected based on instrument data sheets.
- DCS range scale matched with the Instrument range.
- Offline Flow calculation models were created in MS Excel and tested for the flow meters. Based on this, the parameters are being corrected in DCS.

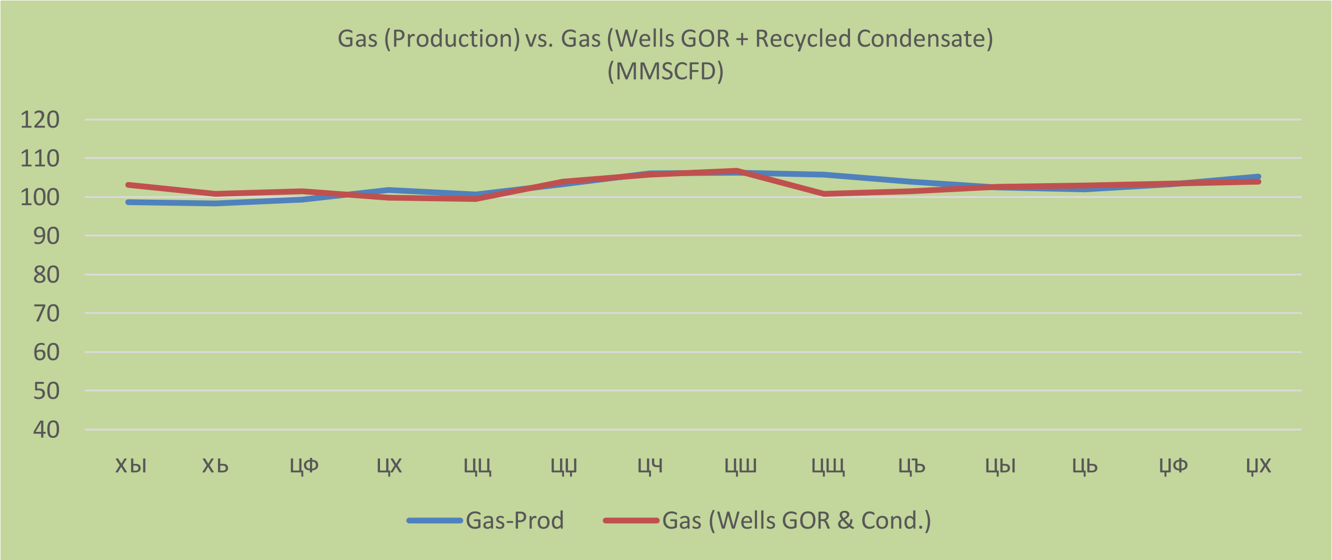
Result

➓ After implementing the modifications, GC gas production figures were consistently found satisfactory and achieve the desired mass balance between produced (Gas in) and export (Gas out):



Result

- Therefore, for a representative comparison, gas production was compared with gas obtained from wells GOR plus recycled condensate equivalent gas.
- The graph show nearly perfect match.



CONCLUSION

- It has been found that the performance of separator gas flow meters is least satisfactory, compared to other areas flowmeters, mainly due to the large quantity and different type of meters installed at this area.

- Many of the flowmeters problems are inherited from the original design of the facility, such as Orifice/Flow Nozzles installation issues (straight length requirement, pressure tabs locations, impulse tubes layout) at separators area in the GC.

- Other issues were found maintenance related, such as no recent inspection and calibration were performed to detect abnormality and measure the performance of the reading instrument.

RECOMMENDATIONS

- Project Phase
  - Engineering shall use Appropriate Datasheet for the selected meters (such as Long Radius Nozzle)
  - P&IDs shall have distinct symbology for various flow meters selected for a Project.
  - Ensure meter installations are in accordance with Company Hook-up standards.
  - DCS Configurations shall be set up for upstream production facilities as below:
    - Configure flow meter for winter and summer cases
    - Implement AGA-8 and AGA-3 for orifice flow meters
    - Model other types of flow meters such as Annubar, Long Radius Nozzle, ultrasonic in order to provide dynamically correction
- Operation Phase
  - Inspect all flow meters at every Major survey.
  - Periodically analyze the gas compositions and accordingly enter into AGA-8 module

THANK YOU

Long Radius Flow Meter Modelling

Long Radius Flow Meter Modelling

Dynamic Links

FIT (Dp)	DP Transmitter (without field square extraction) (in H2O)
PIT (pf)	Line Pressure (PSIG)
TIT (Tf)	Line Temperature (Deg C)

User (Manual) Enties

d	Nozzle Diameter (inch)
D	Line ID (inch)
µ	Viscosity (cP)
η	Isentropic
Pb	base Pressure (14.659 psig)
Tb	base Temperature (15.6 deg C)
MW	Molecular Weight
Zb	Compressibility factor
Zf	Compressibility factor

SuperCompressibility

Fpv = Sqrt(Zb/Zf)

Beta Calculator "β"

Beta Ratio (β) = $d/(D)$

Density Calulation

Flowing Density (Df) = $((Pf+Pb)*6895*9.86923x10**-6*MW)/(0.08203*Zf*(Tf+273.15))$

Base Density (Db) = $((Pb)*6895*9.86923x10**-6*MW)/(0.08203*Zb*(Tb+273.15))$

Expansion Factor "Y"

Expansion Factor (Y) = $1-((0.41+0.35*\beta**2.5)\ Dp/((Pf+Pb)*6895*\eta)$

Flow Calculator for Cd=1 "Qm"

Flow (Qm) = $(Y*\pi*(d*0.254)**2*sqrt(Df*Dp*248.7))/(4*Sqrt(1-\beta**4))$

Reynolds No Calculation

Reynolds No (Re) = $(4*Qm)/(\pi*\mu*0.001*D*0.0254)$

Discharge Coefficient Calculator "Cd"

Cd = 0.9965- 0.00653*sqrt(β * 10**6)/Re)

Flow Corrected for Cd "Qcorr"

Qcorr = Qm * Cd*Fpv

Orifice Modelling

User (Manual) Enties								
	28-FE-2408		28-FE-2518		28-FE-2009		28-FE-2550	
	28-FIT-2408		28-FIT-2518		28-FIT-2009		28-FIT-2550	
	28-PIT-		28-PIT-		28-PIT-		28-PIT-	
	28-TIT-		28-TIT-		28-TIT-		28-TIT-	
	V-5201		V-6201		V-1201		V-1202	
Pb (psig)	14.69		14.69		14.69		14.69	
Tb (deg C)	15.6		15.6		15.6		15.6	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
N2	0.237	0.203	0.237	0.203	0.237	0.203	0.367	0.026
CO2	9.958	10.438	9.958	10.438	9.958	10.438	10.715	12.348
H2S	2.83	2.807	2.83	2.807	2.83	2.807	6.736	6.759
C1	60.185	62.576	60.185	62.576	60.185	62.576	27.008	31.063
C2	15.381	14.76	15.381	14.76	15.381	14.76	22.627	24.296
C3	7.676	6.613	7.676	6.613	7.676	6.613	19.432	17.283
iC4	0.635	0.491	0.635	0.491	0.635	0.491	2.073	1.539
nC4	1.795	1.313	1.795	1.313	1.795	1.313	6.048	4.149
iC5	0.353	0.234	0.353	0.234	0.353	0.234	1.329	0.761
nC5	0.481	0.305	0.481	0.305	0.481	0.305	1.802	0.966
pC6	0.3	0.177	0.3	0.177	0.3	0.177	1.153	0.545
pC7	0.119	0.063	0.119	0.063	0.119	0.063	0.467	0.19
pC8	0.043	0.018	0.043	0.018	0.043	0.018	0.181	0.062
pC9	0.007	0.002	0.007	0.002	0.007	0.002	0.054	0.013
pC10	0	0	0	0	0	0	0.008	0
Total	100	100	100	100	100	100	100	100
MW	25.54	25.54	25.54	25.54	25.54	25.54	35.61	32.98
Gas Gravity (Air=1	0.882	0.847	0.882	0.847	0.882	0.847	1.229	1.139
Gas Density (kg/r	1.079	1.038	1.079	1.038	1.079	1.038	1.501	1.393
Gross Heat Value	1228	1165	1228	1165	1228	1165	1693	1518
Net Heat Value (	1117	1059	1117	1059	1117	1059	1552	1389
Zb	0.893373	0.90122	0.932391	0.90122	0.85173835	0.90122	0.932391	0.928424
Zf	0.89148	0.923499	0.949196	0.923499	0.89163229	0.923499	0.949196	0.930437

Long Radius Nozzle Flow Meter | NozzleTest Data | Ultrasonic | Orifice | Annubar

Ultrasonic Modelling

Ultrasonic Modelling

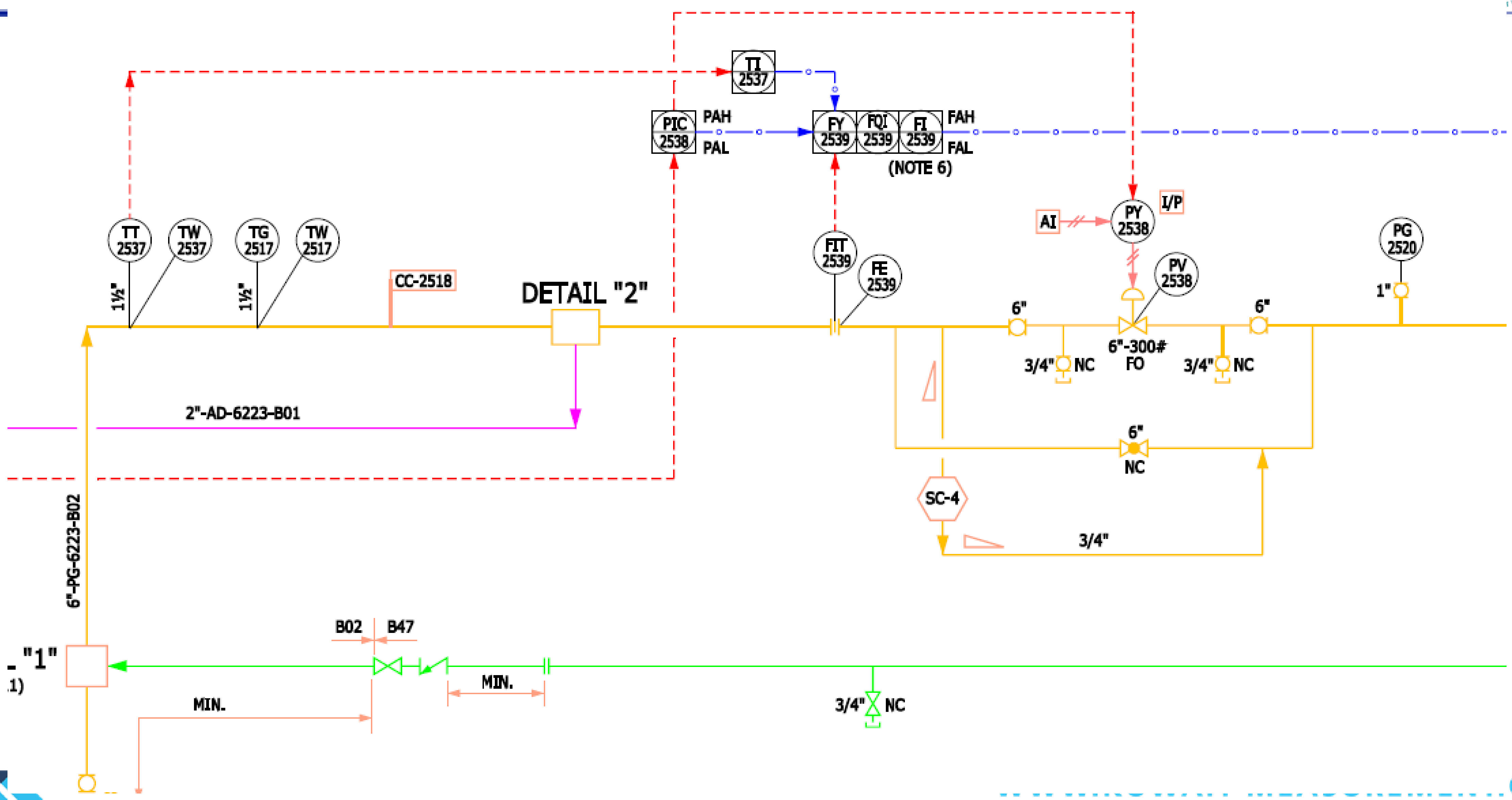
Dynamic Links						
FIT (Qa)	Ultrasonic (ACFH)					
PIT (Pf)	Line Pressure (PSIG)					
TIT (Tf)	Line Temperature (Deg C)					
					Density Calulation	
						Flowing Density (Df) = $((Pf+Pb)*6895*9.86923x10**-6*MW)/(0.08203*Zf*(Tf+273.15))$
User (Manual) Enties						
Pb	base Pressure (14.659 psig)					Base Density (Db) = $((Pb)*6895*9.86923x10**-6*MW)/(0.08203*Zb*(Tb+273.15))$
Tb	base Temperature (15.6 deg C)				Flow Calculator "Qs"	
MW	Molecular Weight					
Zb	Compressibility factor					Qs = Qa * Df / Db
Zf	Compressibility factor					
GC-28 Flow Meter						
Ultrasonic Flow Meter						
Volumetric	597,312.15	ACFH	2,755,830.50	SCFH	66,139,931.96	66,237,570.11
			2,754,758.53	SCFH	66,114,204.67	
MW		36.88				
P base	Psig	14.69				
Tbase	def F	15.6				
T	deg C	19.3				

INSTRUMENT DATA SHEET	ORIFICE PLATES and FLANGES					SHEET 23 OF 122
	Rev.	BY	CHK'D	APPR.	DATE	Specification No.:WK00-RP-IN-0131
	0	QMY	TCQ	WYM	20,11.,97	Contract NO.:95G071
	1	HZY	TCQ	WYM	25,06,99	
						Requisition No.:WK01-ER-IN-0131
						Purchase Order: PA/B-2007-051

Document No.:	P & ID DWG. No. : GC28-DW-PR-2203 1/1
GC28-SP-IN-0131	Service : LIG. CRU. OIL SEP. GAS OUTLET

RIFICE PLATES	ORIFICE FLANGES
Other **Nozzle-long Radius**	7. Taps: Flange ☐ Vena Contracta ☐ Pipe ☐ **Radius** ☑
Other **ASME MFC-3M**	8. Tap Size: 1/2in. ☑ Other
Nearest 1/8" ☐	9. Type: Weld Neck ☐ Threaded ☐ Slip On ☑
316 SS ☑ Other	10. Material: Steel ☑ Other
--	11. Flanges Included ☐ By Others ☑
PECO/Asme long radius flow nozzle	

Tag Number	28-FE-2539


TI 2537
PIC 2538
PAH
PAL
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(NOTE 6)
I/P
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DETAIL "2"
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6"
NC
SC-4
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B02
B47
"1"
MIN.
MIN.
3/4" NC

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