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Resitting examination paper for TPG4230 – Field Development and Operations

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Permitted examination support material: A single sheet of paper with relevant formulas and equations is permitted. Approved calculator permitted

Other information:

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Number of pages enclosed:

Informasjon om trykking av eksamensoppgave	
Originalen er:	
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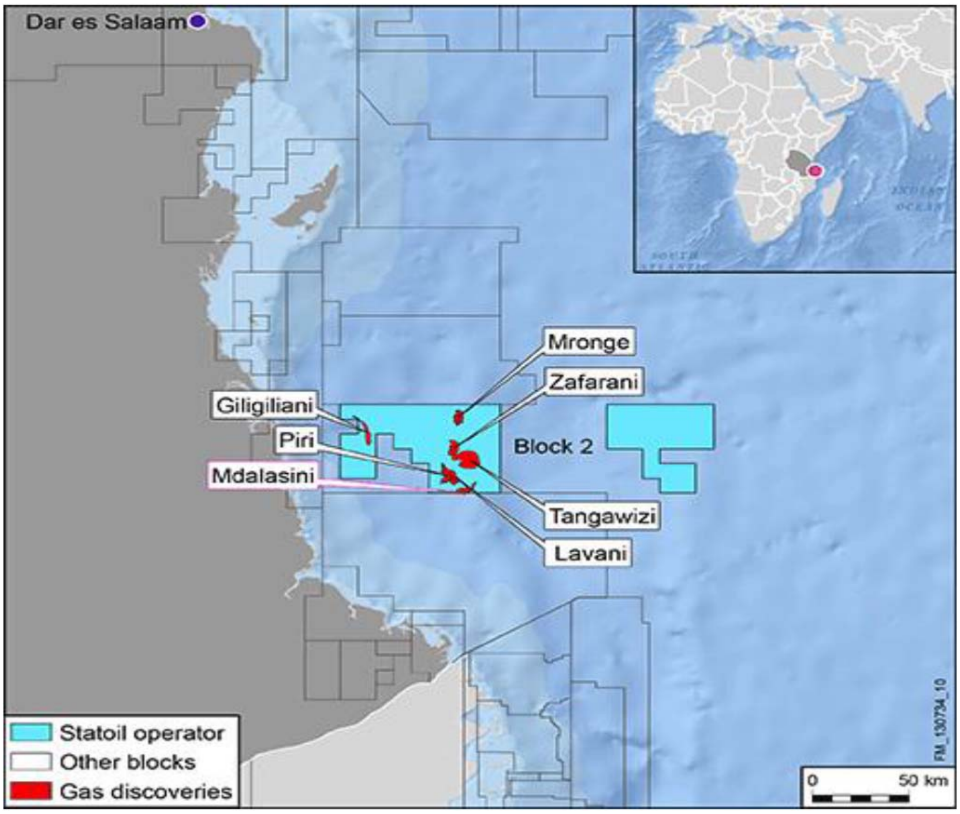
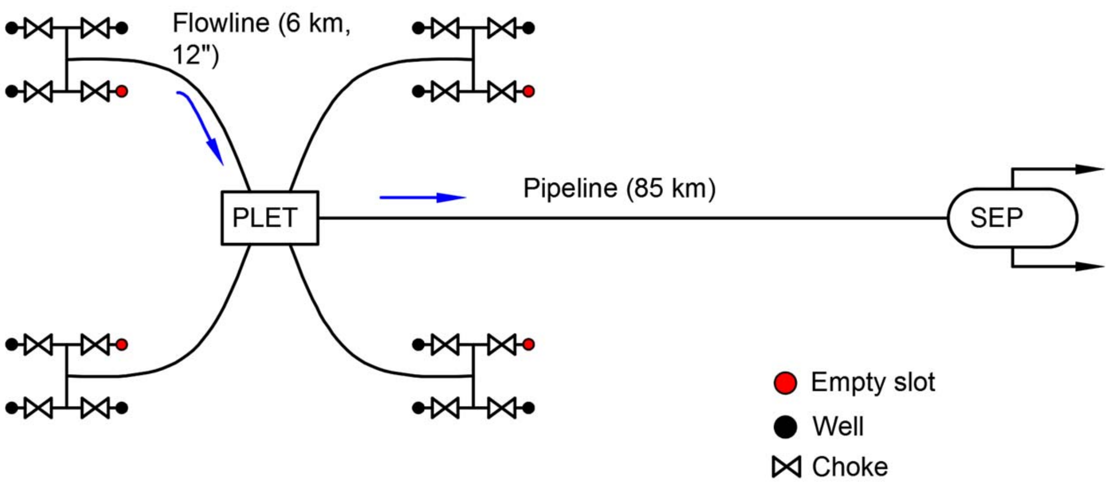
<u>EXERCISE 1</u> (60 POINTS)

Statoil is currently operating the license of Block 2 (mapped in the figure below) offshore Tanzania.



The development concept chosen is subsea tie back to an onshore Liquefied Natural Gas (LNG) plant. The field is developed subsea with 4 subsea templates, each with 4-slots (well bay). **Only three wells are completed** in each template. The production rate is controlled using the wellhead chokes.

For the purpose of your calculations it will be assumed that well templates are symmetrically positioned at 6 km away from the subsea Pipeline Entry Terminal (PLET). Each template is connected by flowline to the PLET where the production streams of all templates are commingled (combined and mixed). The PLET is on the seabed approximately 85 km from shore and is connected by the main field export pipeline to the slug catcher (separator) on shore.



All wells are identical (in layout, productivity and all other design and operation parameters) and produce from the same reservoir. You can also assume that a simple gas material balance is good enough to represent its behavior.

Due to the fact that all wells are identical and symmetrical, it is possible to perform flow equilibrium calculations considering only the flowpath: wellbore-tubing, flowline from template to PLET and pipeline. However, **remember to use the appropriate rate in each pipe segment.**

Task 1 (5 POINTS): A single multiphase flow meter (MPM) will be installed in the PLET template to test the wells periodically. The PLET template will also have a subsea pig launcher. Propose a simplified P&I diagram of the PLET template indicating the well stream, routing valves and necessary manifolds.

Task 2 (20 POINTS): Calculate the production profile for the first 32 years of production of the field. You are asked to perform your analysis on an **8 year basis (estimate G_p every eight years)**. The plateau rate to produce is 20 E06 Sm^3/d.

- Plot the evolution of all relevant pressures in the system (p_R, p_{wf}, p_{wh}, p_{temp}, p_{PLET} and p_{sep}) versus time.
- Compute the choke ΔP for each time.
- When (approximately) do you estimate is the end of the plateau?.

Use the following equations:

Material balance: $p_R = p_i \cdot \left(1 - \frac{G_p}{G}\right)$	With G = 300 E09 Sm^3 Use 360 operational days per year when calculating G_p The variation of the gas deviation factor Z, is neglected in this equation. P_{Ri}, initial reservoir pressure is 390 bara.
Inflow equation: $q_g = C_R \cdot \left(p_R^2 - p_{wf}^2\right)^n$	C_R Inflow backpressure coefficient, 123 Sm^3/bar^{2n} n, inflow backpressure exponent, 1

Tubing equation: $q_{gsc} = C_T \cdot \left(\frac{p_{wf}^2}{e^S} - p_{wh}^2 \right)^{0.5}$	C_T, tubing coefficient, 35 000 Sm^3/bar S, tubing elevation coefficient, 0.155
Flowline Template-PLET: $q_{gsc} = C_{FL} \cdot \left(p_{TEMP}^2 - p_{PLET}^2 \right)^{0.5}$	C_{FL}, flowline coefficient, 2.8 E05 Sm^3/bar
Pipeline equation PLET-shore: $q_{gsc} = C_{PL} \cdot \left(p_{PLET}^2 - p_{sep}^2 \right)^{0.5}$	C_{PL}, pipeline coefficient, 3.5 E05 Sm^3/bar p_{sep}, separator pressure, 30 bara.

Task 3 (17 POINTS). Calculate the cash flow and the NPV of the project for the first 4 years considering the following:

Production starts end of year 3 (beginning of year 4).
CAPEX: 4.2 E09 USD and is distributed evenly during the first three years.
OPEX: 120 E06 USD/year. It is not necessary to update this number due to inflation
DRILLEX: 1200 E06 USD and is distributed evenly during the first three years.
Discount rate: 8%

Consider that the condensate gas ratio (CGR) of the field is 1.5E-4 Sm^3/Sm^3
Gas price: 0.15 USD/Sm^3
Condensate price: 370 USD/Sm^3
-The formula for NPV:

$$\mathrm{NPV}(i,N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

Where t is year counter, i is the discount factor (in fraction) and Rt is the cashflow for the year.
Start your calculations at the end of year 1.

Task 4: (18 POINTS)
Consider that reservoir pressure is 130 bar. Is it possible to produce plateau rate of 20E06 if a subsea compressor is placed on the PLET? If yes, Estimate the required compressor ΔP and output temperature. Use the information provided below

Assume a polytropic compression exponent n of 1.43. T_{in} is 70 °C.

$$\frac{T_{out}}{T_{in}} = \left(\frac{p_{out}}{p_{in}} \right)^{\frac{n-1}{n}}$$

Block 2 offshore Tanzania

G=IGIP	300E+09	Sm3
Production days per year	360	day
T_R	70	°C
Pi, initial Res pressure	390	bara
C, inflow Back pressure coefficient	123	Sm3/bar^2n
n, backpressure, exponent	1	
Ct, Tubing coefficient	3.50E+04	Sm3/bar
Tubing elevation coeff, S	0.155	
$C_{FL.Flowline}$ Template-PLET	2.80E+05	Sm3/bar
$C_{PL.Pipeline}$ PLET-Shore	3.50E+05	Sm3/bar
Separator (slug catcher) pressure	30	bara
Number of templates	4	
Number of wells per template	3	
qfield	20.0E+6	[Sm^3/d]

time [years]	qwell [Sm^3/d]	qfield [Sm^3/d]	ΔGp [Sm^3]	Gp [Sm^3]	RF [-]	pR [bara]	Z [-]	pwf [bara]	pwh [bara]	Psep [bara]	Pplet [bara]	qtemp [Sm^3/d]	ptemp [bara]	Deltpchoke [bara]	pplet avail [bara]	Dp comp [bara]	qpp_well [Sm^3/d]
0	1.67E+06	20.0E+6	000.0E+0	000.0E+0	0.00	390.0		372.2	341.2	30.0	64.5	5.00E+06	67.0	274			
8	1.67E+06	20.0E+6	57.6E+9	57.6E+9	0.19	315.1		292.8	266.8	30.0	64.5	5.00E+06	67.0	200			
16	1.67E+06	20.0E+6	57.6E+9	115.2E+9	0.38	240.2		210.2	188.6	30.0	64.5	5.00E+06	67.0	122			
24	1.67E+06	20.0E+6	57.6E+9	172.8E+9	0.58	165.4		117.4	97.7	30.0	64.5	5.00E+06	67.0	31			
32	7.17E+05	8.6E+6	57.6E+9	230.4E+9	0.77	90.5		48.6	40.0	30.0	38.8	2.15E+06	39.5	0			
	1.67E+06	20.0E+6	-99.1E+9	131.3E+9	0.44	130.0		57.9	24.5	30.0	64.5	5.00E+06	67.0	-42	16.805462	47.7	

CGR	0.000	Sm^3/Sm^3
Gas price	0.150	USD/Sm^3
Condensate	370.000	USD/Sm^3

Tin	343.15
pin	16.805462
tout	241.135829
Pout	64.5
n	1.43

time years	CAPEX [1E06 USD]	DRILLEX [1E06 USD]	OPEX [1E06 USD]	ΔGp [Sm^3]	Gas sales [1E06 USD]	ΔNp [Sm^3]	Condensate sales [1E06 USD]	Revenue [1E06 USD]	Expenses [1E06 USD]	Cash flow [1E06 USD]	DCF [1E06 USD]
1	1.4E+3	400.0E+0	000.0E+0	0.00	0.0	0.000	0.0	0.0	1800.0	-1800.0	-1.67E+03
2	1.4E+3	400.0E+0	000.0E+0	0.00	0.0	0.000	0.0	0.0	1800.0	-1800.0	-1.54E+03
3	1.4E+3	400.0E+0	000.0E+0	0.00	0.0	0.000	0.0	0.0	1800.0	-1800.0	-1.43E+03
4	000.0E+0	000.0E+0	120.0E+0	##########	1080.0	1080000.000	399.6	1479.6	120.0	1359.6	9.99E+02
											-3.64E+03