FPSO Mooring & Offloading System Alternatives for Deepwater West Africa

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FMC SOFEC Floating Systems



Assumptions

- Deepwater
- FPSO
- Offloading Tanker
- Field Life
- Oil Production Rate
- Offloading Rate
- Parcel Sizes

1,000m + 2.2 mm bbls storage 320,000 dwt Tanker of opportunity 25/30 years 200,000 bopd 50,000 bbs/hr 1 or 2 million bbls



Design Criteria Factors

- Environment
- Field Characteristics
- Production Criteria
- Field Life
- Flexibility
- Operability
- Risk



Available Options

FPSO Mooring:

- Spread Mooring
 - Turret (Internal and External)



Spread-Moored System





Turret System – Internal & External







Available Options

Oil Offloading

- Tandem
- Remote CALM
- Side by Side



Tandem





Remote CALM



Side by Side



FPSO Mooring Systems Not Recommended for Deepwater West Africa

- External Turret
 - Riser Limitation





Oil Offloading Systems Not Recommended for Deepwater West Africa

- Side by side
- Spread Mooring in Tandem
 - High collision risk





Very Large Turret - VLT









DESIGN BASIS

WATER DEPTH:	1,400m
SERVICE LIFE:	30 years
VESSEL:	320,000 DWT
STORAGE:	2,200,000 BBLs
MAXIUM OFFLOADING PARCEL:	2,000,000 BBLs
OIL PRODUCTION:	200,000 BOPD
GAS PRODUCTION (MAX):	270 MMsfd
PRESSURE at VESSEL:	85-200 BARS
OFFLOADING RATE:	50,000 BBLs/hr - min.

CASE - RISERS

6" PRODUCTION:	22
4" GAS LIFT:	22
UMBILICALS:	28
FUTURE:	8

Total:

80 + 8 Spares

INCLUDES COST OF HEADERS & PULL-IN EQUIPMENT FOR SPREAD MOORING & TURRET SYSTEMS

INCLUDES COST OF PUMPING CRUDE THRU BUOY FROM SPREAD MOORING SYSTEM



Case Study

Case 1 – Very Large Turret (VLT) Mooring System with Tandem Offloading

Case 2 – Spread Moor (Remote Offloading) Near Surface Termination of Offloading Flowlines

Case 3 – Spread Moor (Remote Offloading) Mid Water Termination of Offloading Flowlines



Case 1 – Very Large Turret (VLT) Mooring System with Tandem Offloading

ANCHOR LEGS: TOP CHAIN - 88mm R4 STUDLESS: WIRE - 88mm SPR2 + UNSHEATHED: BOTTOM CHAIN - 88mm R4 STUDLESS: PRETENSION : PULL-IN WINCH (es):

SUCTION PILE:

MAX. INTACT LOAD MAX. DAMAGED LOAD FORCE ANGLE FROM HORIZONTAL:

CHAIN STOPPERS:

CALM BUOY:

OFFLOADING LINES

1 X 20" OFFLOADING HOSE SYSTEM from FPSO

8 150m 2,200m 150m 120mt 150mt

8 300mt 425mt 28 DEGREES

8

Not Required

520m



Case 1 – Very Large Turret (VLT) Mooring System with Tandem Offloading



Note: Assumed no weather related production downtime all systems



Case 1 - Comparison Summary

Disadvantages

Turret

Tandem offloading requires heavy tug assistance

Limits flexibility in number of risers

Advantages

Turret

Weathervaning allows Tandem offloading

Risers can approach thru 360°

Fewer and less heavy anchor legs

Good motion characteristics



Case 2 – Spread Moor (Remote Offloading) Near Surface Termination of Offloading Flowlines

ANCHOR LEGS: TOP CHAIN - 119mm R4 STUDLESS: WIRE - 119mm SPR2 + UNSHEATHED: BOTTOM CHAIN - 114mm R4 STUDLESS: PRETENSION (Varies) : PULL-IN WINCH (es):	15 150m 2,200m 150m 140mt 200mt	CALM BUOY: ANCHOR LEGS: TOP CHAIN - 78MM R4 STUDLESS: WIRE - 70mm SPR2 + UNSHEATHED: BOTTOM CHAIN - 78mm R4 STUDLESS: PRETENSION: PULL-IN CHAIN JACK:	25m x 10m 7 180m 1,345m 50m 150mt 180mt
SUCTION PILE: MAX. INTACT LOAD MAX. DAMAGED LOAD FORCE ANGLE FROM HORIZONTAL: CHAIN STOPPERS:	15 475mt 575mt 28 DEGREES 15	SUCTION PILE: MAX. INTACT LOAD MAX. DAMAGED LOAD FORCE ANGLE FROM HORIZONTAL:	7 260mt 350mt 28 DEGREES
		OFFLOADING LINES	

2 X 22" RIGID FLOWLINES FPSO to CALM	2,000m
2 X 20" OFFLOADING HOSE SYSTEM from CALM	360m



Case 2 – Spread Moor (Remote Offloading) Near Surface Termination of Offloading Flowlines





Note: Assumed no weather related production downtime all systems



Case 3 – Spread Moor (Remote Offloading) Mid Water Termination of Offloading Flowlines

ANCHOR LEGS: TOP CHAIN - 119mm R4 STUDLESS: WIRE - 119mm SPR2 + UNSHEATHED: BOTTOM CHAIN - 119mm R4 STUDLESS: PRETENSION (Varies) :	15 150m 2,200m 150m 140mt	SUCTION PILE: MAX. INTACT LOAD MAX. DAMAGED LOAD FORCE ANGLE FROM HORIZONTAL:	6 260mt 350mt 28 DEGREES
PULL-IN WINCH (es):	200mt	SUBMERGED FTB:	3 TANKS, 9 COMPARTMENTS
SUCTION PILE:	15	ANCHOR LEGS:	4
MAX. INTACT LOAD	475mt	TOP CHAIN - 58MM R4 STUDLESS:	100m
MAX. DAMAGED LOAD	575mt	WIRE - 62mm SPR2 + UNSHEATHED:	1,075m
FORCE ANGLE FROM HORIZONTAL:	28 DEGREES	BOTTOM CHAIN - 58mm R4 STUDLESS:	20m
CHAIN STOPPERS & FAIRLEADS:	15	SUCTION PILE: MAX. INTACT LOAD	4 260mt
CALM BUOY:	14.5m x 6.3m	MAX. DAMAGED LOAD	350mt
ANCHOR LEGS:	6	FORCE ANGLE FROM HORIZONTAL:	28 DEGREES
TOP CHAIN - 58MM R4 STUDLESS:	180m		
WIRE - 111mm POLYESTER ROPE:	1,345m	OFFLOADING LINES	
BOTTOM CHAIN - 58mm R4 STUDLESS:	50m	2 X 22" RIGID FLOWLINES FPSO to FTB	2,000m
PRETENSION:	45mt	2 X 24" SUBSEA HOSES FTB to CALM	400m
PULL-IN WINCH:	66mt	2 X 20" OFFLOADING HOSE SYSTEM from CALM	420m



Flowline Termination Buoy (FTB)







Case 3 – Spread Moor (Remote Offloading) Mid Water Termination of Offloading Flowlines



Note: Assumed no weather related production downtime all systems



Case 2 and 3 Comparison Summary Disadvantages

Spread Moor

Additional anchor legs and mooring points on vessel

Fixed orientation increases mooring loads and vessel motions

Issues regarding offloading flowlines in deepwater

- Fatigue (steel)
- Flow assurance

Advantages

Spread Moor

High flexibility for additional risers

Remote location of offloading terminal mitigates FPSO/Tanker collision risk

Higher weather tolerance than tandem for offloading



CAPEX Summary

CAPEX - CASE WEST AFRICA DESIGN BASIS - 200,000 bopd 80 Risers + 8 Spares



ASE 1 - VERY LARGE TURRET (VL MOORING SYSTEM w/ TANDEN OFFLOADING ASE 2 - SPREAD MOOR (REMOTE OFFLOADING) NEAR SURFACE TERMINATION OF REMOTE OFFLOADING FLOWLINES

ASE 3 - SPREAD MOOR (REMO OFFLOADING) MID WATER TERMINATION OF REMOTE OFFLOADING FLOWLINES



OPEX Summary

OPEX COST COMPARSION AVERAGE OVER FIELD LIFE





US DOLLARS PEF YEAR

Case Oil Production - West Africa 200,000 BOPD Over 30 Years



■ ESTIMATED OIL PRODUCTION/YR:



Present Value Summary

CASE - WEST AFRICA



FMC EnergySystems

FMC SOFEC Floating Systems

