

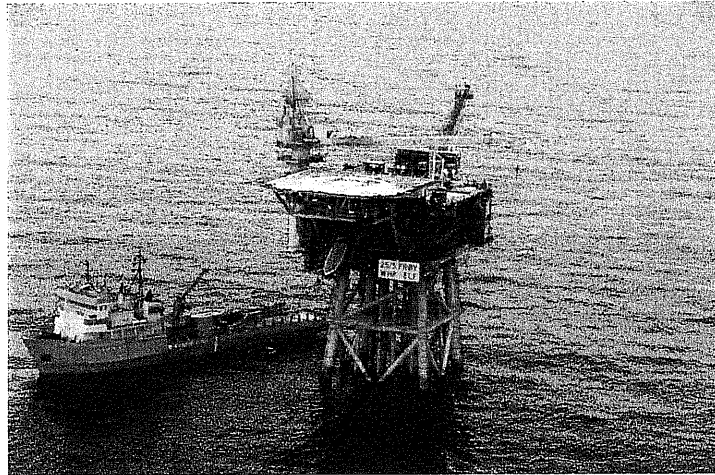
Basic Data for the Frøy platform and the M35 and M52/P48 modules on Frigg



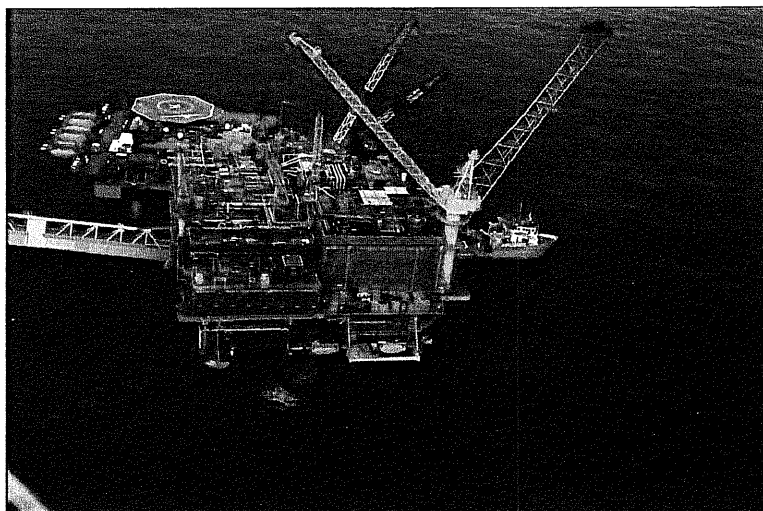
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Basic Data for the Frøy platform



and the M35 and M52/P48 modules on Frigg



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1. Introduction

The Frøy field located in block 25/5 is an oil field which started its production in 1995. Due to unforeseen production complications it will cease its production in year 2000 or 2001 or may be as early as year 1999.

The field installation comprises a Not Normally Manned platform which is linked by several pipelines to the Frigg central complex. Due to the possible early stop of production of this field it could be worth reusing the platform as well as the treatment module M35 located on the Frigg TCP2 platform.

This document contains a brief description and basic data mainly for the M35 module used to treat the Frøy fluids, but in addition data for the M52 and P48 modules partly used by Frøy and Lille Frigg is included. The main use of one or both of these modules/pancakes are to stabilise the crude if needed.

2. Basic data

2.1 Environmental data

2.1.1 Water depth:

Lowest astronomical tide (LAT):	119.6 m
Mean sea level (MSL):	120.3 m
Highest astronomical tide (HAT):	121.1 m

2.1.2 Wave criteria

100 year return period	$H_{\max} = 28.5 \text{ m}$
	$TH_{\max} = 14.2 \text{ m}$

2.1.3 Wind criteria

100 year return period	
1 minute sustained	$V_{\max} = 39.9 \text{ m/s}$
3 second gust	$V_{\max} = 42.0 \text{ m/s}$

Prevailing wind direction South East

Air temperature: $25^{\circ}\text{C}_{\max}$ to $-10^{\circ}\text{C}_{\min}$

2.1.4 Current criteria

100 year return period

Depth (m)	Current (m/s)
-18.5	0.58
-116	0.52

2.2 Frøy platform data

2.2.0 Description

The platform is a 4 legged steel jacket with a 2 level topside. The drilling concept is based on 4 pre-drilled wells through a subsea template with the others drilled by a jack-up rig with the derrick skidded over to Frøy.

The process consist of a one stage productions separator where the gas is exported by a 12" pipeline, 35 km to Frigg for further processing. Prior to export the gas is inhibited with glycol (DEG) to prevent hydrates and to control corrosion. The gas is cooled after separation by a water-gas heat exchanger using imported water-injection water from Frigg.

The liquid (oil and water) is pumped into a 12" oil export line to Frigg for further treatment. The pumping is done in order to avoid hydrate problems in the oil line.

The water for water injection is imported from Frigg through a 16" water injection line . The water is filtered before injection. This water is also used for gas cooling and firewater on the platform.

Both the oil and gas lines have pig launchers. The platform also has a small 25 m vent for emergency flaring.

The platform is also equipped with several spare risers for future connections as well as structural capacity to allow a module for future tie-ins of 400t.

The M35 module receives the inhibited gas and the oil by 2 separate pipelines. In the module the gas and oil are separated in various vessels. The gas is compressed, metered and leaves the module for further treatment . The oil is partly stabilised ,but needs an additional separation stage in order to be fully stabilised.(presently performed by a separator located in module M52). Oil export pumps and metering is however located in the module.

A fuel gas compression package is also located in the module taking gas from the last stage separator located in the other module.

The module do also contain a complete water treatment system for injection water, including injection pumps.

A system to treat produced water is also a part of the module.

2.2.1 Jacket data

Type:	piled steel, lift installed
Water depth:	120m
Dimensions (top):	16 x 16 m
(base):	41 x 41 m
Lifting weight (t):	6850
Piles (t):	3350

2.2.2. Topside

2.2.2.0 Topside dimensions

Dimensions	40mL x 20m x 10mH
Deck levels:	2
Lifting weights (t):	2375
Well slots:	15

2.2.2.0 Manifolds

Wells manifold	14" ANSI 1500#, 185 bar design pressure
Produced oil manifold pressure	14" ANSI 900#, 143 bar design pressure
Test manifold	8" ANSI 900#, 143 bar design pressure
Water injection manifold	ANSI 1500#, 185 bar design pressure
Gas lift manifold	

2.2.2.3 Design rates

Gas flow: 1,4 MSm ³ /d
Liquid (oil & water): 8300 m ³ /d

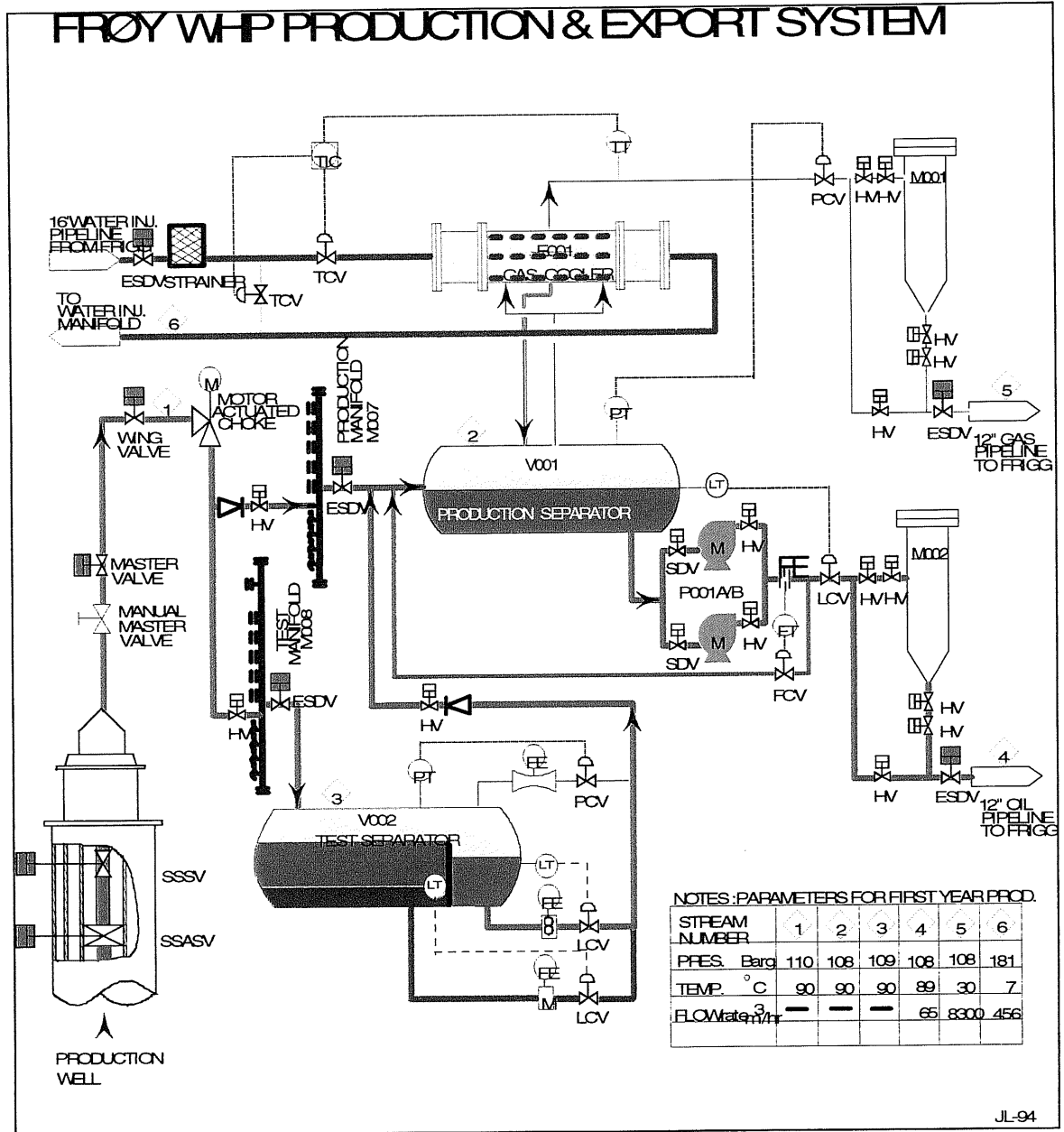
2.2.2.4 Piping material

Production flowlines:	SS 6%Mo ASTM A312 S31254
Production & test header:	SS 6%Mo ASTM A312 S31254
Gas piping out of separators:	SS 6%Mo ASTM A312 S31254
Oil piping out of separators:	CS ASTM A333 Gr6/LF3
Gas piping dwnstr. cooler:	CS ASTM A333 Gr6/LF3
Gas riser:	CS API 5L X65
Oil riser:	CS API 5L X65 with 0.5% Cr
Waterinjection piping:	CS API 5L X52 and CS API 5L X 65

2.2.2.5 Production Equipment

Equipment type	Size	Rating	Des. press	Des. temp
Test separator	L=6500 (T-T) x 2336 OD	18" ANSI 900#	143 b	-40/105
Production sep.	L=8900 (T-T) x 2656 OD	12" ANSI 900#	143 b	-40/105
Liquid export pump	351 m3/hr	279 Kw	28.6m head	
Gas cooler	L=9348 x 1460 OD	2900 kW/hr		-40/105
Oil pig launcher	L=5390 x 395.3 OD		143 b	-40/105
Gas pig launcher	L=5390 x 395.3 OD		143 b	-40/105
Vent knock-out drum	L=5980 x 2123 OD		3 b	-75/95
Flare/Vent	25 m at 45° angle			-55/95
Atmospheric vent				
Drain				
Fresh water	L=3710 x 2010 OD	5.82 m3		

Frøy WHP PFD

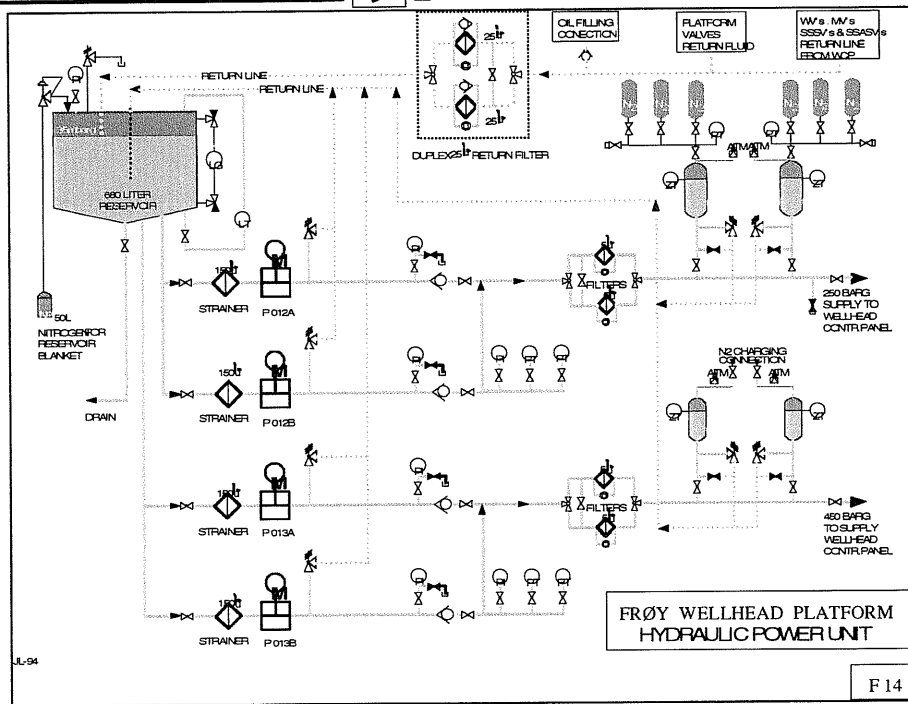


NOTES: PARAMETERS FOR FIRST YEAR PROD.

STREAM NUMBER	1	2	3	4	5	6
PPRES. Bar(g)	110	108	109	108	108	181
TEMP. °C	90	90	90	89	30	7
FLOWrate m ³ /hr	-	-	-	65	8300	456

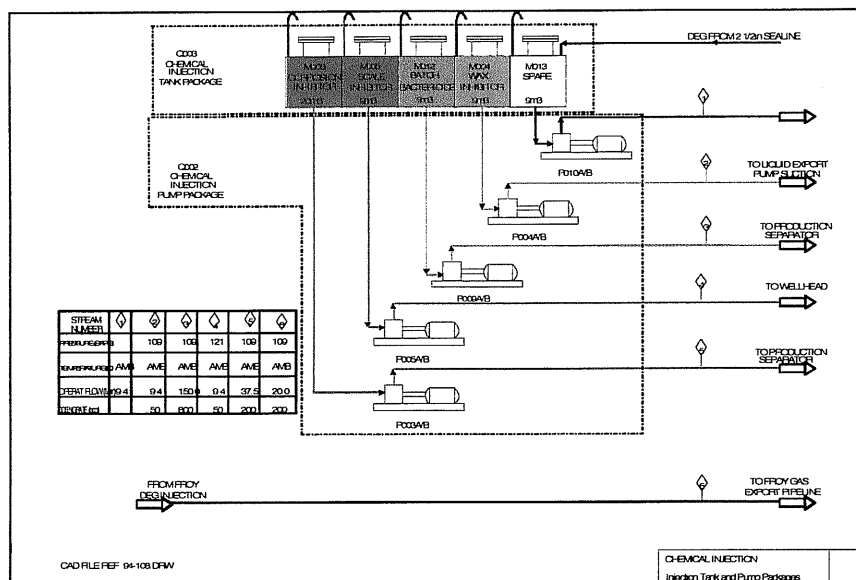
2.2.2.6 Utilities

Power generation:	No, import from Frigg
Firewater pumps:	No, import from Frigg
Emergency diesel pumps:	No, import from Frigg
Hydraulic system:	Yes, 680 litres, 450 bars



Chemical inhibition:

- Corrosion inhibitor: 50ppm or 0.5 m³/d , 180 bars , 21.74 m³ storage
- Wax inhibitor: 100ppm or 0.25 m³/d, 180 bars , 9.74 m³ storage
- Scale inhibitor: 50ppm or 0.225 m³/d, 180 bars , 9.74 m³ storage
- Batch bactericide 800ppm or 3.6 m³/d, 180 bars , 9.74 m³ storage
- Spare: 180 bars , 9.74 m³ storage
- Glycol inhibitor: Yes, import from Frigg



2.2.2.7 Main connections

- Pipeline
 - Gas: 12"
 - Oil: 12"
 - Water injection: 16"
 - Service/gas lift line: 2 1/2"
- Cables:
 - Power: 22 kV-2.5 mA
 - Control: 16 fibres in power cable

2.2.2.8 J-tubes and risers

Designation	ID x WT	Material	Pres.
J1	466.8 x 20.6 (20" OD)	API 5L X-52	
J2	415.8 x 20.6 (18" OD)	"	
J3	415.8 x 20.6 (18" OD)	"	
J4	618.8 x 20.6 (26" OD)	"	
J5	365.2 x 20.6 (16" OD)	"	
R1	295 x 22.2 (12" OD)	API 5L X-65	149 b
R2	295 x 22.2 (12" OD)	"	149 b
R3	365.2 x 23.3 (16" OD)	"	220 b
R4	403 x 27 (18" OD)	"	135 b
R5	352.4 x 27 (16" OD)	"	230 b
R6	352.4 x 27 (16" OD)	"	230 b
R7	59 x 7.8 (2 1/2" OD)	API 5L X-52	373 b

2.2.2.9 Caissons

Sewage pump: 168.2 x 25.48mm
 Drilling chute: 457.2 x 25.4 mm

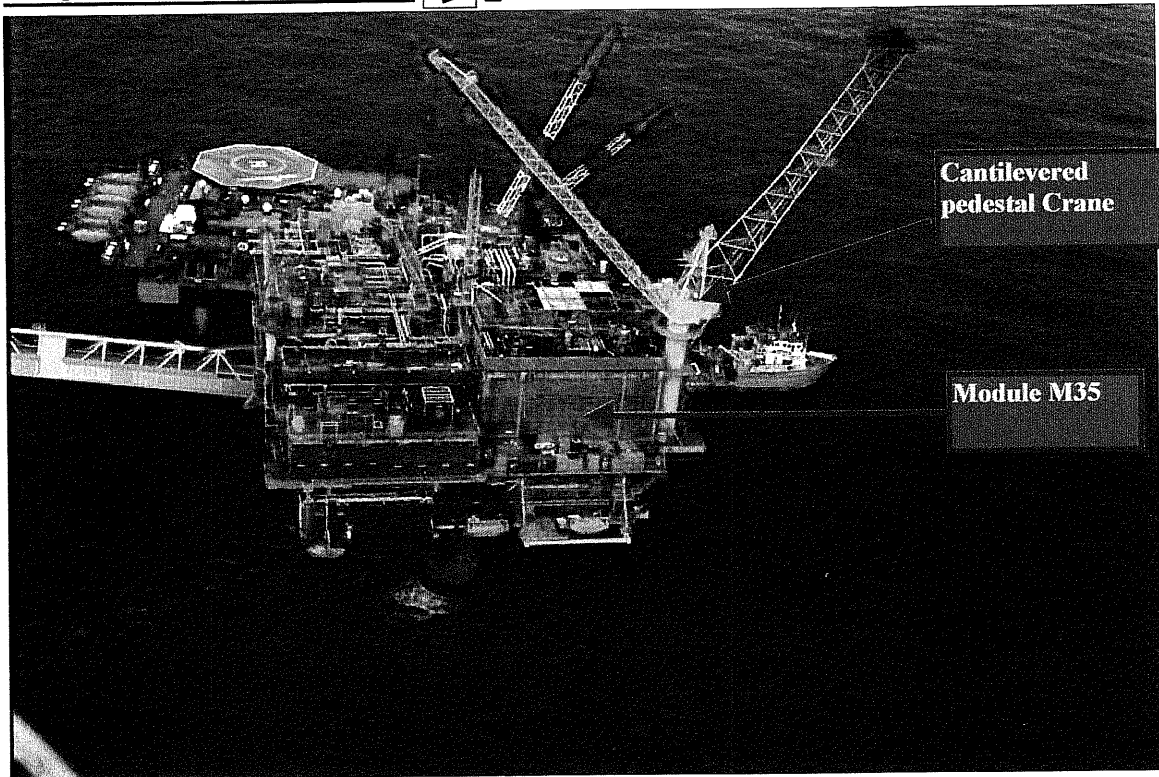
2.2.2.10 Design lifetime

The design lifetime is 20 years.

2.3 Module M35 Description

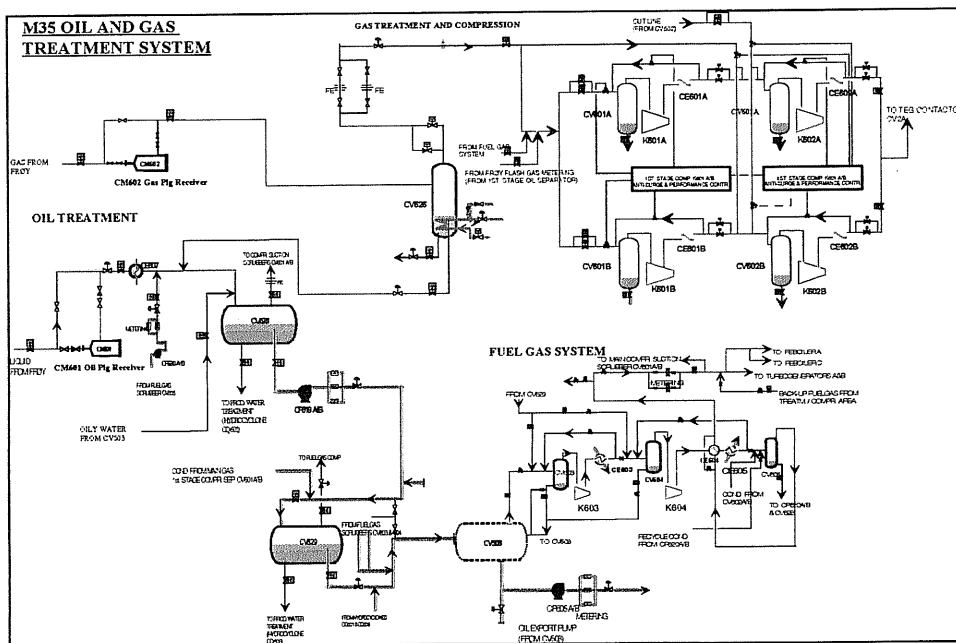
The module contains equipment for treatment of oil and gas comprising the following main functions:

- Pig Traps
- Heat Exchangers, oil heaters
- Separators
- Oil export pumps
- Gas and oil Metering
- Gas compression
- Fuel gas compression
- Produced water treatment
- Injection water treatment and pumps



The module is also equipped with a pedestal crane at the SE corner of the module. The crane has the following working radius and SWL:

- 36 tons between a radius of: 9 - 30 m
- 12 tons with a maximum radius of : 60 m



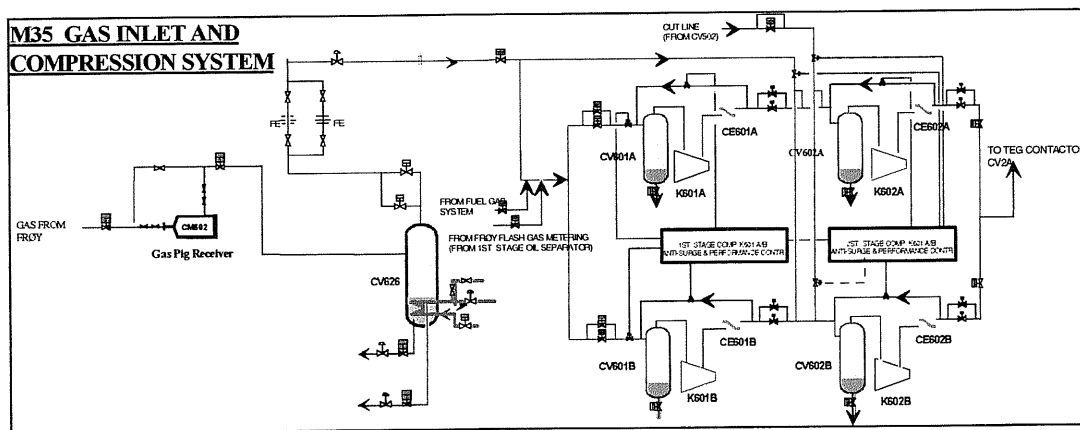
2.4 Process description

2.4.1 General

The M35 module receives the inhibited gas and the oil by 2 separate 12" pipelines. The module is equipped with one pig receiver for each line.

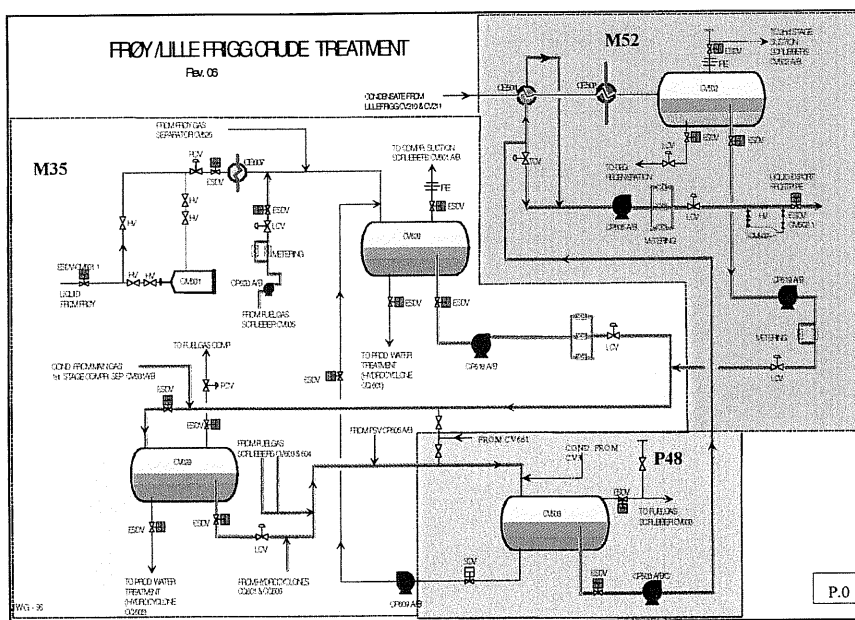
2.4.2 Gas system

The gas is routed to vertical three-phase separator with a heating coil in the liquid phase to and heated from 5 °C to 20 °C to enhance the separation of rich DEG from condensate. The gas from the separator is metered before it goes to compression. The compression is done in two stages, the first from approx. 14 bar to 44 bar, the second from 44 bar to 99 bar, and there are two parallel trains with 100% capacity each.



2.4.3 Oil system

The oil is heated to approx. 60 - 70 °C in an inlet heater before going through three phase separators at 14 bars.



The flash gas from the first stage separation is metered before it enters the first stage main gas compressors. The water is routed to the produced water system. The oil is sent via transfer pumps and metering and today mixed with condensate from another field before entering the second stage separation at about 4.2 bars and 60 °C.

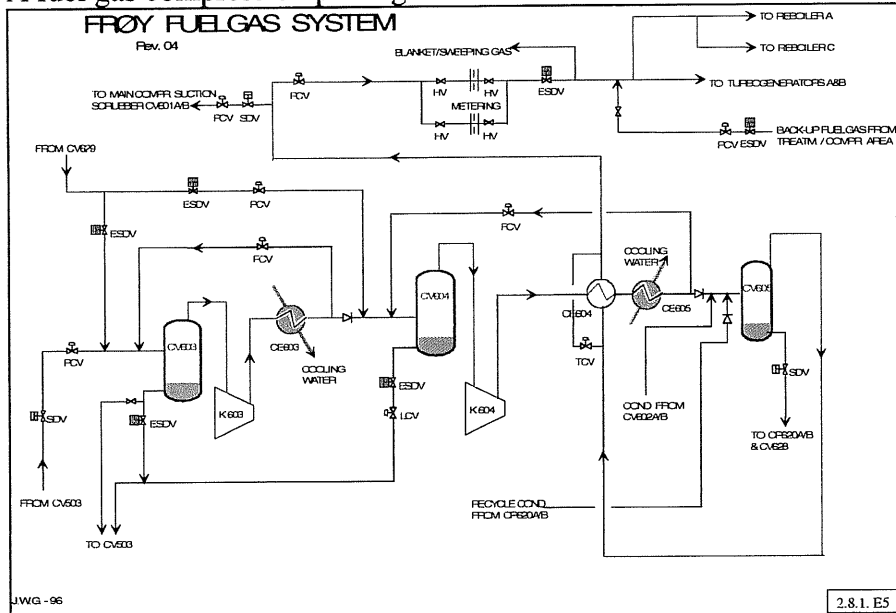
Today the oil then leaves the module and is further stabilised in another separator at 0.4 bar and 46° C. (could for a new case be performed by a separator located in module M52). Oil export pumps and metering is however located in the module.

2.4.4 DEG recovery

Glycol with pH stabiliser collected in the gas inlet separator is routed outside the module for regeneration.

2.4.5 Fuel gas compression

A fuel gas compression package is also located in the module and the purpose of the fuel gas compression system is to increase the pressure of the fuel gas from CV503 and CV629 so it can be used as fuel gas. On one skid there are two electrical driven, fixed speed centrifugal compressor on one shaft. The speed of the electrical motor is 1486 rpm. A gear is installed to



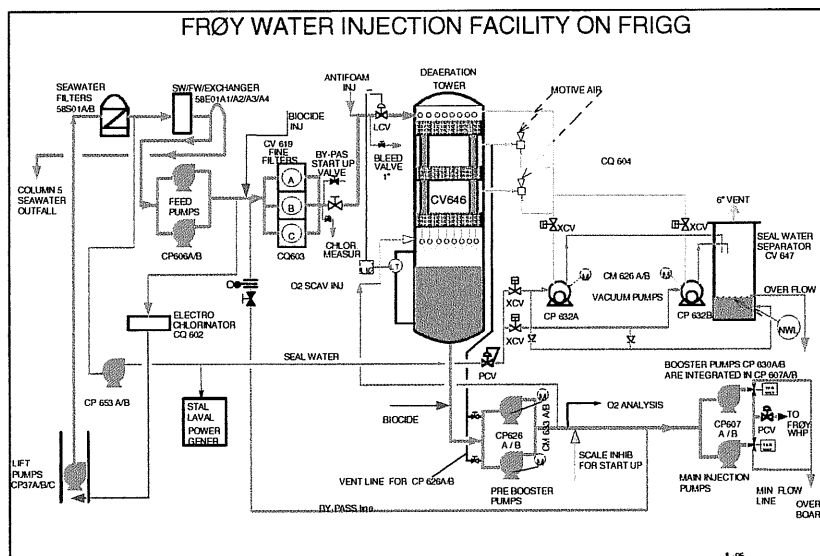
increase the speed to 8262 rpm of the compressors. The two compressors compress the gas from 1.4 to 5.7 bara, at the first stage, and from 5.7 bara to 21 bara at the second stage which is required feed pressure for fuel gas consumers.

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2.4.6 Water injection system

The module do also contains a complete water treatment system with filters, vacuum deaeration, electrochlorination for treatment of injection water and the module also contains 2 injection pumps.



The water injection facilities are designed to remove the oxygen from the water (less than 10 ppm O₂), filter and chemical treat the water. The water injection system can be split into 4 packages:

2.4.6.1 Electro-chlorination system

One electrochlorination unit CQ602 is producing hypochlorite by electrolysis of seawater for injection into 3 seawater lift pumps (outside M35). The feed is taken from the outlet of the water injection feed pumps. The system is designed to give a chlorination level of up to 2ppm and the flowrate of the unit is 10.8 m³/hr.

The injection of hypochlorite will kill 90% of the organic microbes and the rest will be removed fine filters and injection of biocide.

2.4.6.2 Fine filter system

The water injection feed pumps feeds the water injection fine filter package for removal of particles larger than 5 microns in 3 x 50% parallel cartridge filters. The flowrate is 480m³/hr at 6.5 barg and 5 to 25 °C. The filters are regenerated by using sulphuric acid, supplied from a storage tank within the system.

2.4.6.3 Deaeration system

The deaeration system consists of a deaeration tower, a seal water separator, vacuum pumps, 2nd stage ejector and 3rd stage ejector. The flowrate is 480 m³/hr.

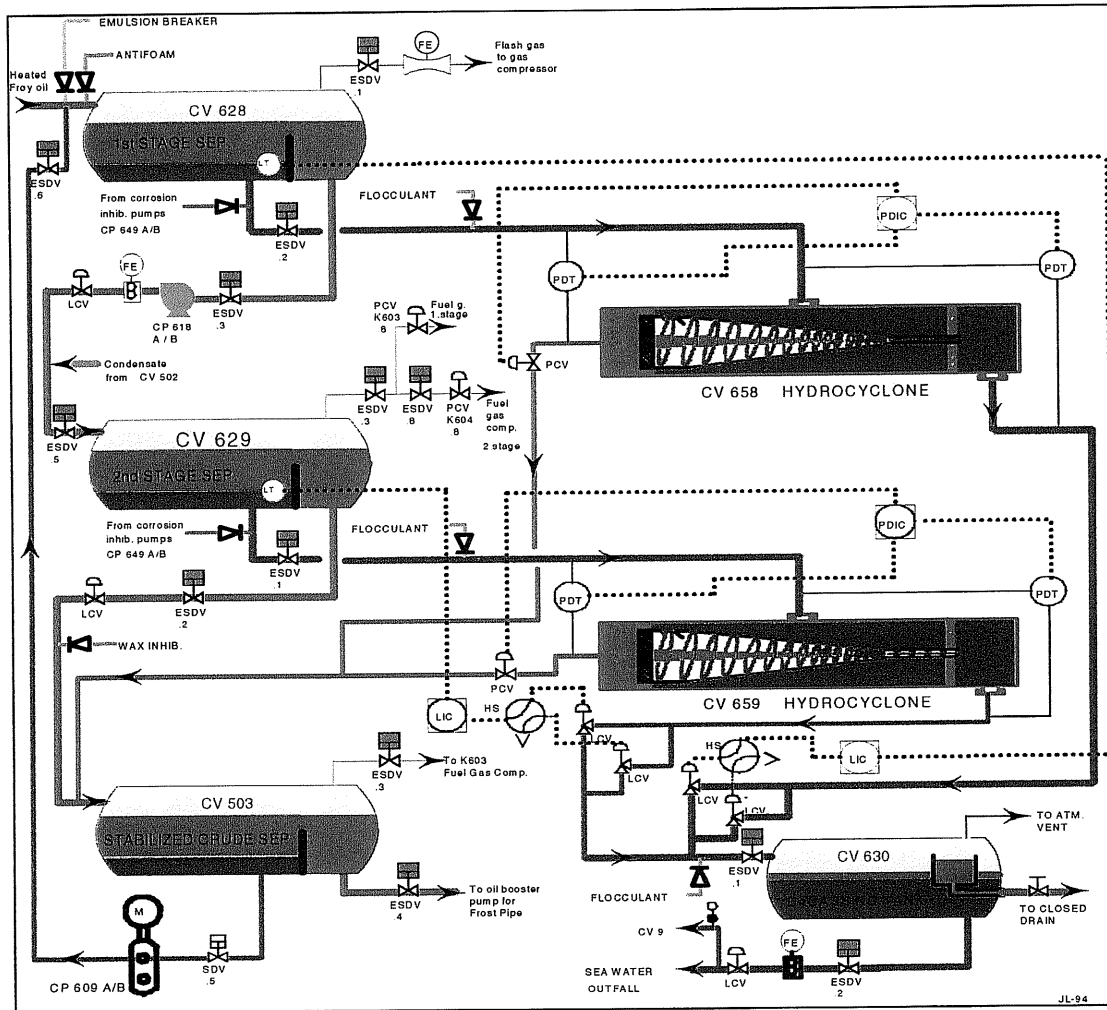
The Deaerator tower is 3 stage vacuum deaerator vessel operating at -0.991 barg (0.009 bara). The oxygen content at the bottom of the tower is less than 10 ppb. Operating temp. is between 5 to 25° C.

2.4.6.4 Water injection pumps

After deaeration the water is routed to the two 100% water injection prebooster pumps at a pressure of 2.1 barg. The water then passes through a 2 x 50% pump sets in two stages. In the first from 2.1 to 21 barg and the second up to 156 barg. The water is exported in a 16" pipeline.

2.4.6.5 Produced water system

The produced water is collected from 2 sources, 1st stage separator CV628 and 2nd stage separator CV629 in addition to water re-circulated from the final stage separator. The water is then sent to the 2 hydrocyclone vessels CV658 and CV659 where oil with as much as 99% water is rejected and clean water is sent to the degassing tank CV630. The system is designed to treat the water to a HC level less than 40ppm.



2.4.6.6 Heating medium system

The heating medium system is supplied from an external source. The total system is a closed loop working at pressure of 20 bar and a temperature of 180 °C. The heating medium is a solution of 15% - 30% TEG and 85% - 70% water.

2.4.6.7 Chemical injection system

The module has chemical injection system for: acid, wax inhibitor, bactericide inhibitor, scale inhibitor, liquid export pipelines corrosion inhibitor, antifoam inhibitor and oxygen scavenger inhibitor. The system is split in two packages: one named CQ605 for the water injection system an another named CQ608 for the process systems. The chemical are supplied by 4.5 m3 tote tanks.

2.4.6.8 Electrical system

The M35 main switchboard is supplied by an external source by a HV system of 5.5 kV. The HV switchboard feeds the following consumers:

- HV motors for:

Crude oil export pumps:	1100 kW
Oil transfer pumps	150 kW
Water injection pumps:	1900 kW
1 st stage compr.trains	2850 kW
2 nd stage compr.train	2850 kW
Fuel gas compressor:	1850 kW
Water inj.feed pump:	180 kW

- The M35 LV distribution board via parallel transformers
- The 5.5/22 kV Frøy WHP transformers
- The 4.4 kV A and B startbusbars via autotransformers

2.4.6.9 Miscellaneous

In addition the systems above the module has: drain system, vent/flare system, hydraulic system, Fire and Gas system etc.

The module is also equipped with the following technical rooms:

- Instrument room
- Low voltage room
- Low voltage emergency room
- High voltage room

2.5 M35 module data

2.5.0 Design Life

The module has a design life of 30 years, with a start of production in 1993.

2.5.1 Module dimensions

Dimensions 40.5mL x 24m x 24.8mH
Lifting weights (t): 3216

2.5.2 Piping headers

Gas inlet and compr. 12"/10" ANSI 600/900#, 35/149 b des. pr.
Oil inlet 12" ANSI 900#, 149 bar design pressure
Oil treatment 12" ANSI 150#, 18.5 bar design pressure
Water de-oxygenation 16" ANSI 150#, 10 bar design pressure
Water injection manifold 16" ANSI 1500#, 185 bar design pressure

2.5.3 Main equipment

Tag no	no	Equipment type	Size		Rating	Des. press	Des. temp
CM601	1	Oil pig receiver	L=7200 x 800 x 1060	H	12" ANSI 1500#	149 b	-10/90
CM602	1	Gas pig receiver	L=7200 x 800 x 1060	H	12" ANSI 1500#	149 b	-30/35
CV626	1	Gas inlet separator	L=5200 (T-T) x 1521 ID	H	10" ANSI 900#	149 b	-30/35
CV628	1	Oil 1 st stage sep.	L=8600 (T-T) x 2800 ID	H	12" ANSI 150#	18.5 b	-10/75
CV629	1	Oil 2 nd stage sep.	L=8600 (T-T) x 2800 ID	H	12" ANSI 300#	18.5 b	-10/75
CV630	1	Prod.water degassing	L=3000 (T-T) x 1700 ID	H	6" ANSI 150#	3.7 b	-10/80
CV601A/B	2	1 st st. suct.scrubber A	H=1995 (T-T) x 990 ID	V	12" ANSI 300#	35 b	-20/90
CV602A/B	2	2 nd st. suct.scrubber A	H=2815 (T-T) x 900 ID	V	8" ANSI 600#	60 b	-20/70
CV603	1	Fuel gas suct.scrubber	H=1845 (T-T) x 900 ID	V	16" ANSI 150#	18.5 b	-20/75
CV604	1	Fuel gas int. st.scrubber	H=3000 (T-T) x 1000 ID	V	12" ANSI 150#	18.5 b	-20/70
CV605	1	Fuel gas disc.scrubber	H=4450 (T-T) x 1370 ID	V	6" ANSI 300#	27 b	-20/55
CQ603	1	Water inj. fine filter pack.	Lxwxh=8800x3750 x5550	V	8" ANSI 150#	10 b	-10/60
CV646	1	Deaeration tower	H=16300 (T-T) x 2750 ID	V	12" ANSI 150#	vac./0.5	-10/35
CQ602	1	Electrochlorination pack	Lxwxh=4600x2100 x3100	H	2" ANSI 150#	10 b	-10/40
CQ604	1	Vacuum pump skid	Lxwxh=3900x3100 x1780	H	8" ANSI 150#	10 b	-10/60
CQ605	1	WI chem. Inj. package	Lxwxh=5200x3250 x3250	H	2" ANSI 150#	atm	-20/35
CQ606	1	Chem. Inj. package	Lxwxh=6300x3500 x3130	H	2" ANSI 150#	3.5 b	n/a
CV658	1	Hydrocyclone vessel	L=2700 (T-T) x 500	H	6" ANSI 150#	18.5 b	75
CV659	1	Hydrocyclone vessel	L=2700 (T-T) x 600	H	3" ANSI 150#	18.5 b	75
CE601A/B	2	1 st stage aftercooler	Lxwxh=1130x810 x1130	H	3082 kW	60 b	-20/170
CE602A/B	2	2 nd stage aftercooler	Lxwxh=930x1100 x1500	H	4615 kW	150 b	-20/135
CE607	1	Oil inlet heater	L=3220 x 891	H	5413 kW	28 b	-20/205
CE603	1	1 st stage FG aftercooler	L=8100 x 651	H	1611 kW	18.5 b	-20/135
CE604	1	FG gas/gas heat exch.	L=550 x 310 x 520	H	71.5 kW	18.5 b	-20/135
CE605	1	2 nd stage FG aftercooler	L=1050 x 960 x 1170	H	3050 kW	27 b	-20/130
K601A/B	2	1 st stage compressor	Lxwxh=7000x2500 x3200	H	2850 kW	130 b	-45/120
K602A/B	2	2 nd stage compressor	Lxwxh=7000x2500 x3200	H	2850 kW	150 b	-45/120
K603	1	1 st stage FG compressor	Lxwxh=7000x2500 x3200	H	824 kW	27 b	-45/130
K604	1	2 nd stage FG compressor	Lxwxh=7000x2500 x3190	H	486 kW	27 b	-45/130
CP605A/B	2	Oil export pump	Lxwxh=5630x1700 x2450	H	964 kW	99.3 b	-20/55
CP607A/B	2	Water inj. pump	Lxwxh=4630x2100 x3100	H	1900 kW	205 b	50
CP618A/B	2	Oil transfer pump	Lxwxh=1150x1150 x2950	H	170 kW	23.5 b	-10/5
CP620A/B	2	Recycled cond. pump	Lxwxh=560x730 x1650	H	8.3 kW	33 b	-20/45

2.5.4 Main connections

Import	Untreated gas and oil:	12"
	Untreated injection water:	10"
Export:	Rich gas/fuel gas:	8"/4"
	Partly treated oil:	16"
	Deoxygenated water:	16"

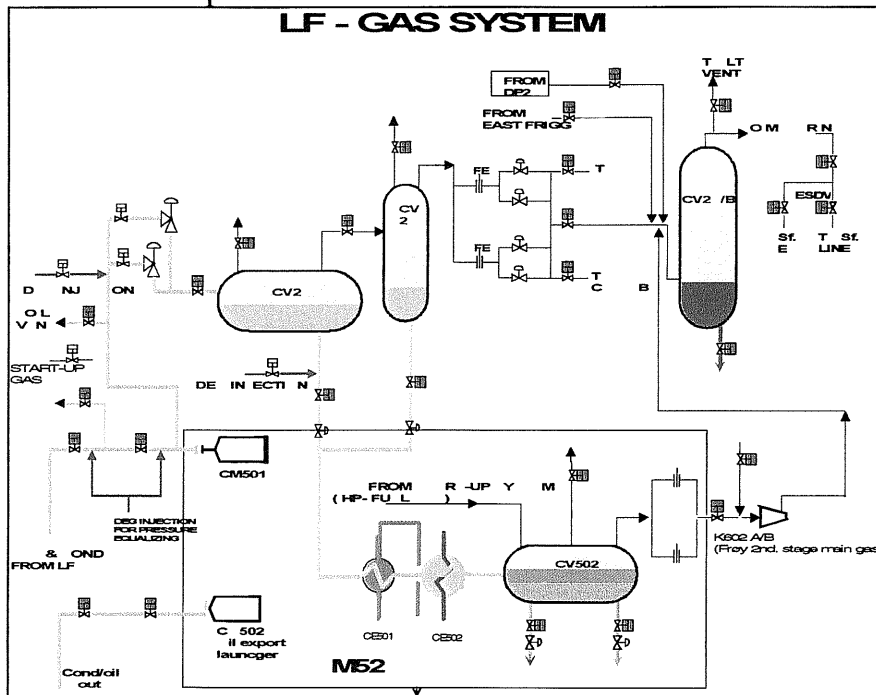
2.5.5 Piping material

Gas and oil riser:	API 5L X65 with 0.5% Cr
Gas piping system:	CS ASTM A333 Grade 6 and CS ASTM A106 B with exception of gas piping out of aftercooler K 601 A and B which is in SS ASTM A312 TP 316L
Oil piping system:	CS ASTM A333 Grade 6 and CS ASTM A106 B
Fuel gas piping:	CS ASTM A333 Grade 6 and CS ASTM A106 B. Liquid out of CV 605 and recycle fuel gas in SS ASTM 312 TP 316L.
Prod. water piping:	CS ASTM A120 Galv.
Water injection:	GRE and ASTM B 337 grade 2 upstream of booster pumps. API-5L GR X 52 downstream.

2.6 Module M52 Description

The modules which is located on the support frame of TCP2 contains equipment for treatment of condensate and gas comprising the following main function

- Pig Traps (16" Frostpipe out, 10" Lille Frigg in)
- Condensate heaters
- Separator (LF 2nd stage)
- Pumps
- Gas Metering
- Gas lift-compressor



Picture of M52 during lifting

2.6.0 Design Life

The module has a design life of 30 years, with a start of production in 1993

2.6.1 Module dimensions

Dimensions (L x W x H) 31.3m x 11.3m x 8.2m

Lifting weights (t): 573

2.6.2 Main connections /Piping headers

Gas inlet 10" ANSI 530 b design pressure
 Cond. treatment 8" ANSI 600#, 66 bar design pressure
 Oil export 16" ANSI 900#, 145 bar design pressure
 Gas lift gas outlet 3" ANSI 2500#, 249 bar design pressure

2.6.3 Main equipment

Tag no	no	Equipment type	Size		Rating	Des. press	Des. temp
CE501	1	Cond. Exchanger	L=8600 (T-T) x 580 ID	H	8" ANSI 600#	66 b	-20/75
CE502	1	Cond.heater	L=7400 (T-T) x 530 ID	H	8" ANSI 600#	66 b	-20/250
CM501	1	Gas pig receiver	L=6400 x 270 x 320	H	10" ANSI 900#	145 b	-40/72
CM502	1	Oil pig receiver	L=5200 x 460 x 410	H	16" ANSI 900#	145 b	-40/72
CV502	1	Glycol/cond.separator	L=9100 (T-T) x 2470 ID	H	8" ANSI 600#	50 b	-0/100
K506	1	Gas lift compressor	Lxwxh=7500x3400 x4000	H		250 b	30/111
CP501A/B	2	Cond. export pump	Lxwxh=4400x1480 x1540	H	200 kW	50 b	6.5
CP619A/B	2	Cond. metering pump	Lxwxh=560x730 x1650	H	75 kW	65 b	n/a

2.6.4 Piping material

Lille-Frigg process: CS ASTM A 106B and ASTM A333 GR 6

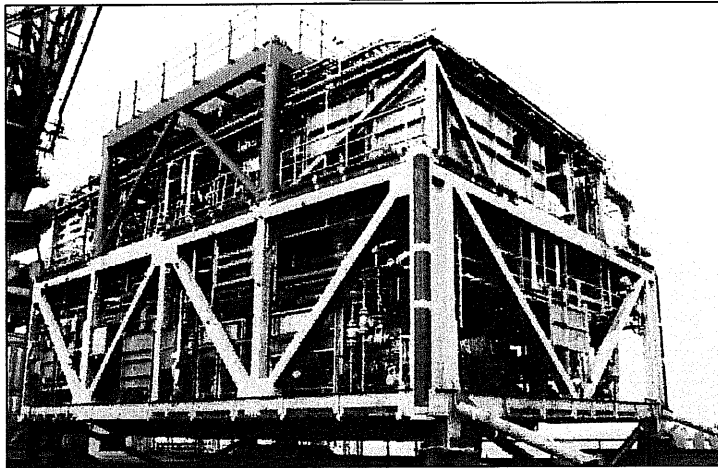
Lille-Frigg riser: CS API 5L X65

FROST riser: CS API 5L X52

2.7 Pancake P48 Description

The modules which is located inside the support frame of TCP2 contains equipment for stabilisation of condensate and oil and gas comprising the following main function

- Separator (3rd stage)
- DEG and condensate pumps
- Condensate metering
- Fuel gas compressor (not in use)



Picture of P48 on lifting barge

2.7.1 Design Life

The module has a design life of 30 years, with a start of production in 1993

2.7.2 Module dimensions

Dimensions (L x W x H) 16.2 m x 12.2m x 5.2m

Lifting weights (t): 296

2.7.3 Main connections /Piping headers

Oil inlet 16" ANSI 150#, 18.5 bar design pressure
 Oil export 16" ANSI 150#, 18.5 bar design pressure
 Gas lift gas outlet 6" ANSI 150#, 22 bar design pressure

2.7.4 Piping material

Oil piping: CS ASTM A 106 B
 Fuel gas compressor piping: CS ASTM A 333 Grade 6
 DEG/MeOH inj. pump pipe: CS ASTM A 106 B and CS ASTM A 519 GR 4130

2.7.5 Main equipment

Tag no	no	Equipment type	Size		Rating	Des. press	Des. temp
CV503	1	Crude separator	L=11200 (T-T) x 2564 ID	H	20" ANSI 150#	18.5 b	-0/100
CP 502	3	DEG inj. pumps	Lxwxh=2260x1380 x1250	H	20" ANSI 150#	590 b	30
K504/K505	1	Fuel gas compressor	Lxwxh=5000x4500 x3700	H	710 kW	250 b	30/111