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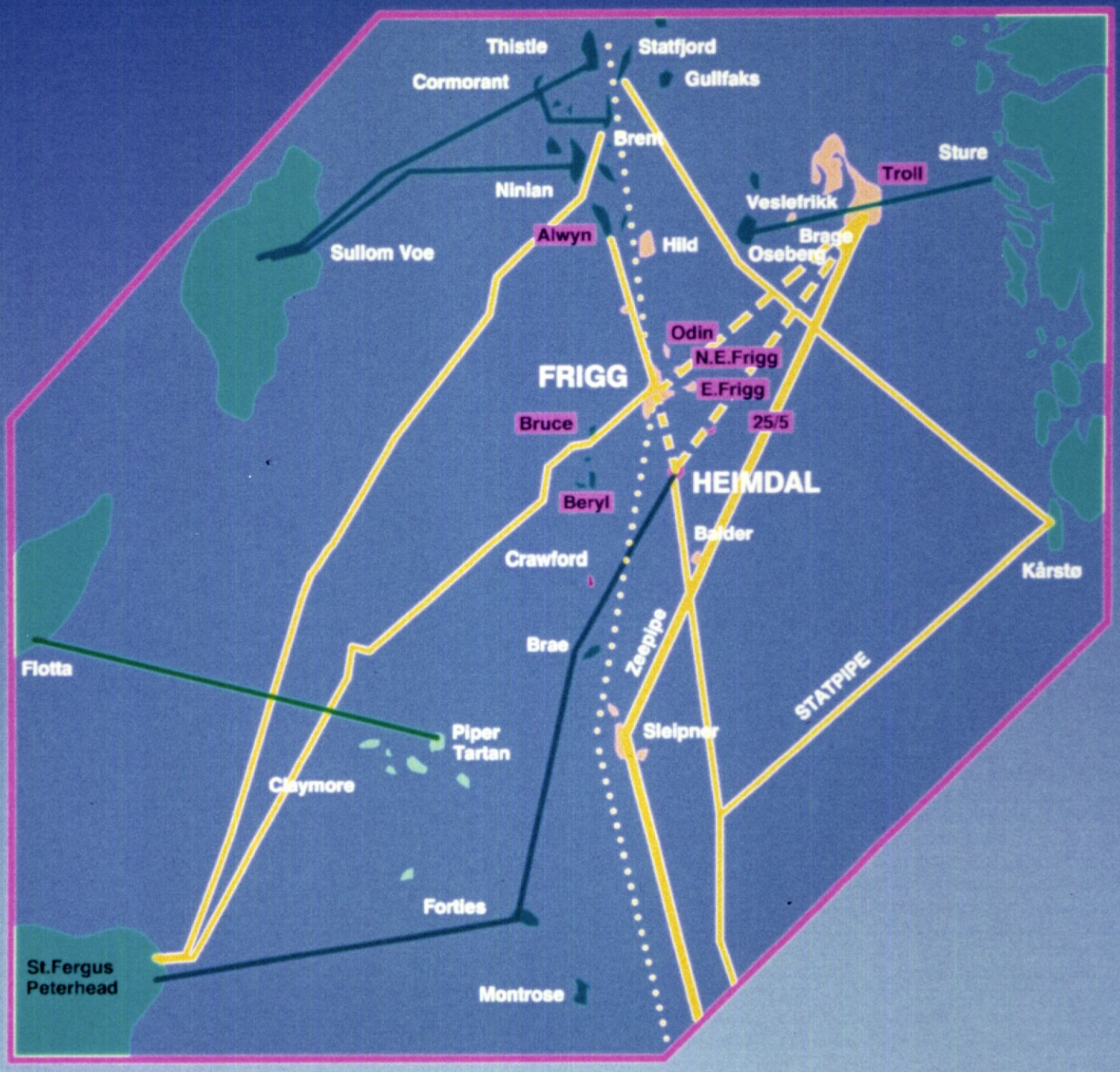
Summary of projects and studies for tie-ins of new fields to Frigg and Heimdal



December 1987

LIST OF CONTENT

1.0 INTRODUCTION

The objective of this summary is to give a brief overview of the various tie-in projects and studies to Frigg and Heimdal performed under the responsibility of the Engineering and Construction Division.

For the actual 2 tie-in projects to Frigg and the third one being completed summer 1988, a factual summary of the key elements of the projects are given. For more detailed information reference is given to the completion files.

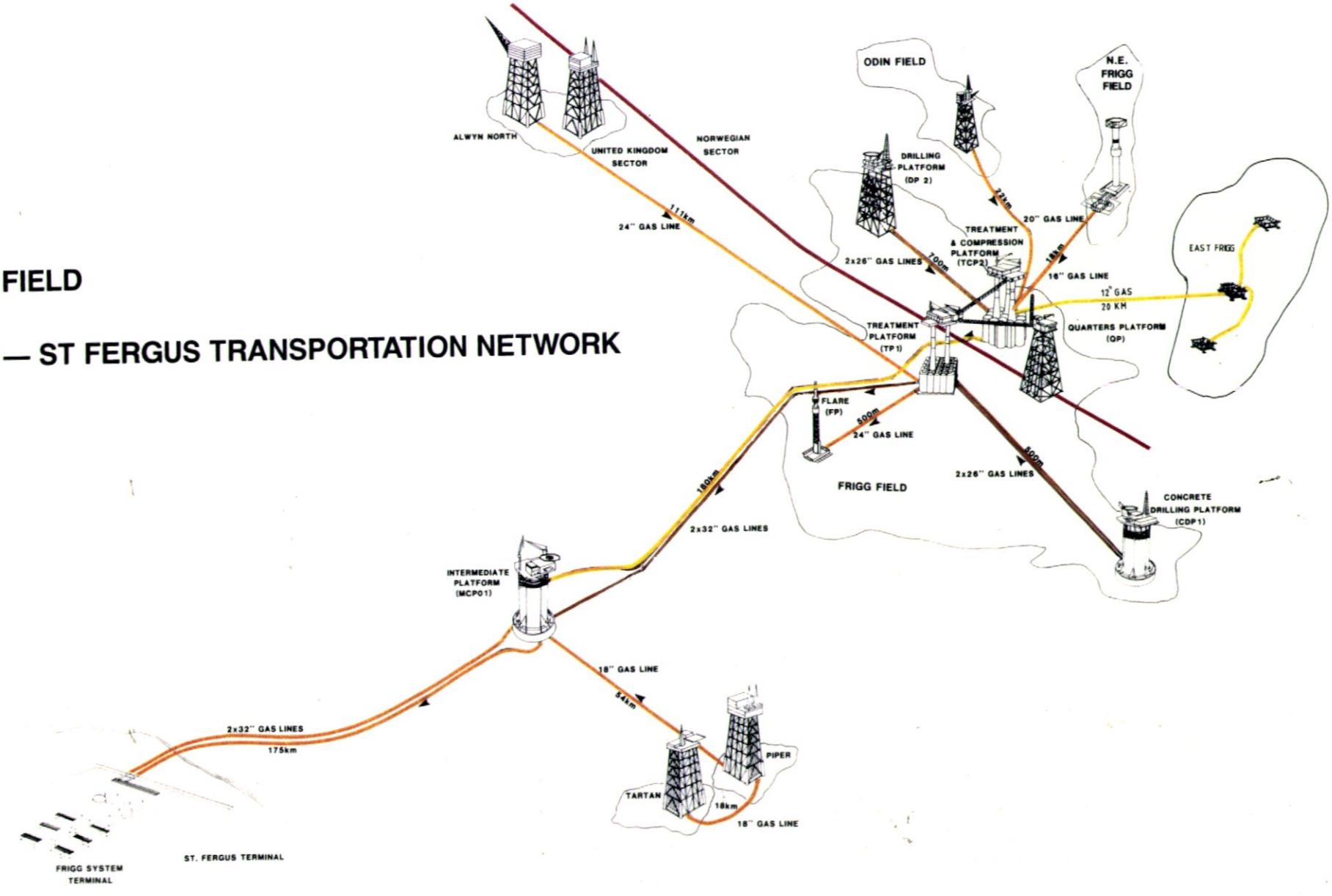
For each tie-in study to Frigg and Heimdal a brief summary is given of the scope of work, assumptions, cost estimates and conclusions. Note that certain reservations may be given in the study reports but not highlighted in this summary.

Each individual project or study documentation is available in Engineering and Construction Division.

Note that this report is made for internal use only.

Erik Hjelde
Engineering and Construction Division
December 1987

FRIGG FIELD
AND
FRIGG — ST FERGUS TRANSPORTATION NETWORK




elf
FRIGG / CENTRAL COMPLEX


elf
HEIMDAL

2.0 ACTUAL TIE-IN PROJECTS:

The following tie-in projects to Frigg have been executed or being executed:

2.1	TCP2 Extension to tie-in NEF and ODIN	: 1980 - 1983
2.2	Alwyn Tie-In	: 1983 - 1987
2.3	East Frigg Tie-In	: 1985 - 1988

Responsible for the above tie-in projects has been the Tie-in and Construction Department.

Costs are given in 1987 value in addition to actual factual figures for the year of project completion.

2.1 TCP2 EXTENSION - TIE-IN OF NEF AND ODIN TO FRIGG

A. SCOPE OF WORK

To tie-in the North East Frigg (NEF) Field and the Odin Field to the Frigg transportation system.

B. PROJECT EXECUTION

The project team was established in Stavanger in November 1980. Prior to that, basic engineering and preparation of engineering tenders had been worked out in Paris.

The total project execution time from the start of the detailed engineering works until production start-up was 36 months.

The engineering and procurement activities were carried out by Sofresid Norge A/S, mainly from Stavanger.

The works started in January 1981, and the major part of the works were completed by spring 1982.

The construction of the modules took place at Ponticelli Freres in Bordeaux from March 1982 until completion in April 1983.

The modules were transported to Stavanger by Neptun Transport Marine Services A.B. and lifted onto TCP2 at the end of May 1983 by K/S Heerema Seaway A/S's SSCV "Balder".

"Treasure Supporter" from W. Wilhelmsen was connected to TCP2 from 1 June until 21 October 1983 during the hook-up period.

Haugesund de Groot Offshore A/S & Co. carried out the hook-up works and assisted in the commissioning works which were managed by the project team.

Gas production started on NEF 10 December 1983.

C. MANHOURS, COSTS

Costs	MNOK 1983 value	MNOK 1987 value
Total project cost	319	404
Purchased value	53	66

Manhours

EAN personnel	166.871
Engineering Contractor	131.448
Yard Construction	217.480
Pre hook-up Construction	12.661
Hook-up Construction	106.720
Commissioning Assistance	7.520

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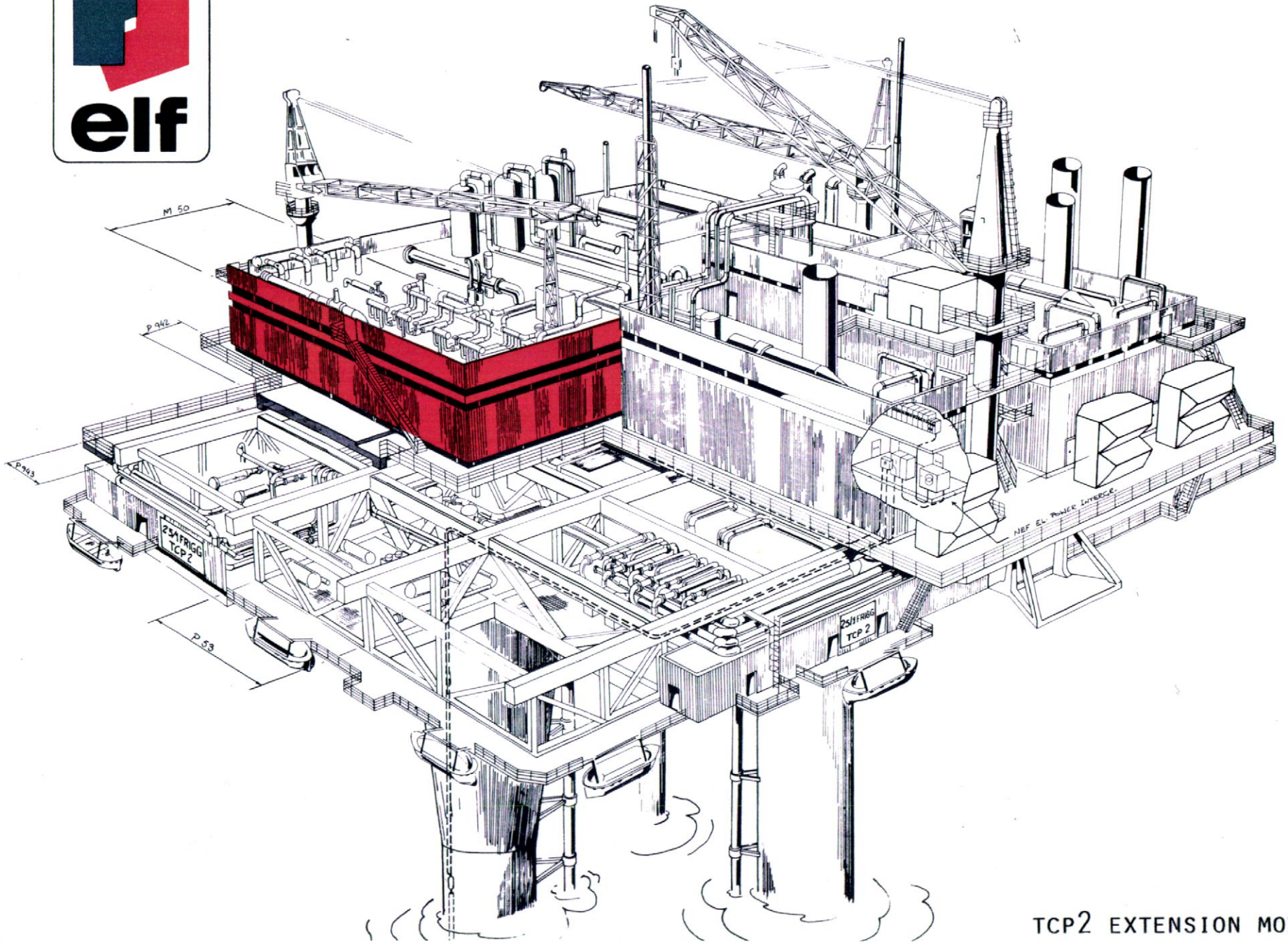
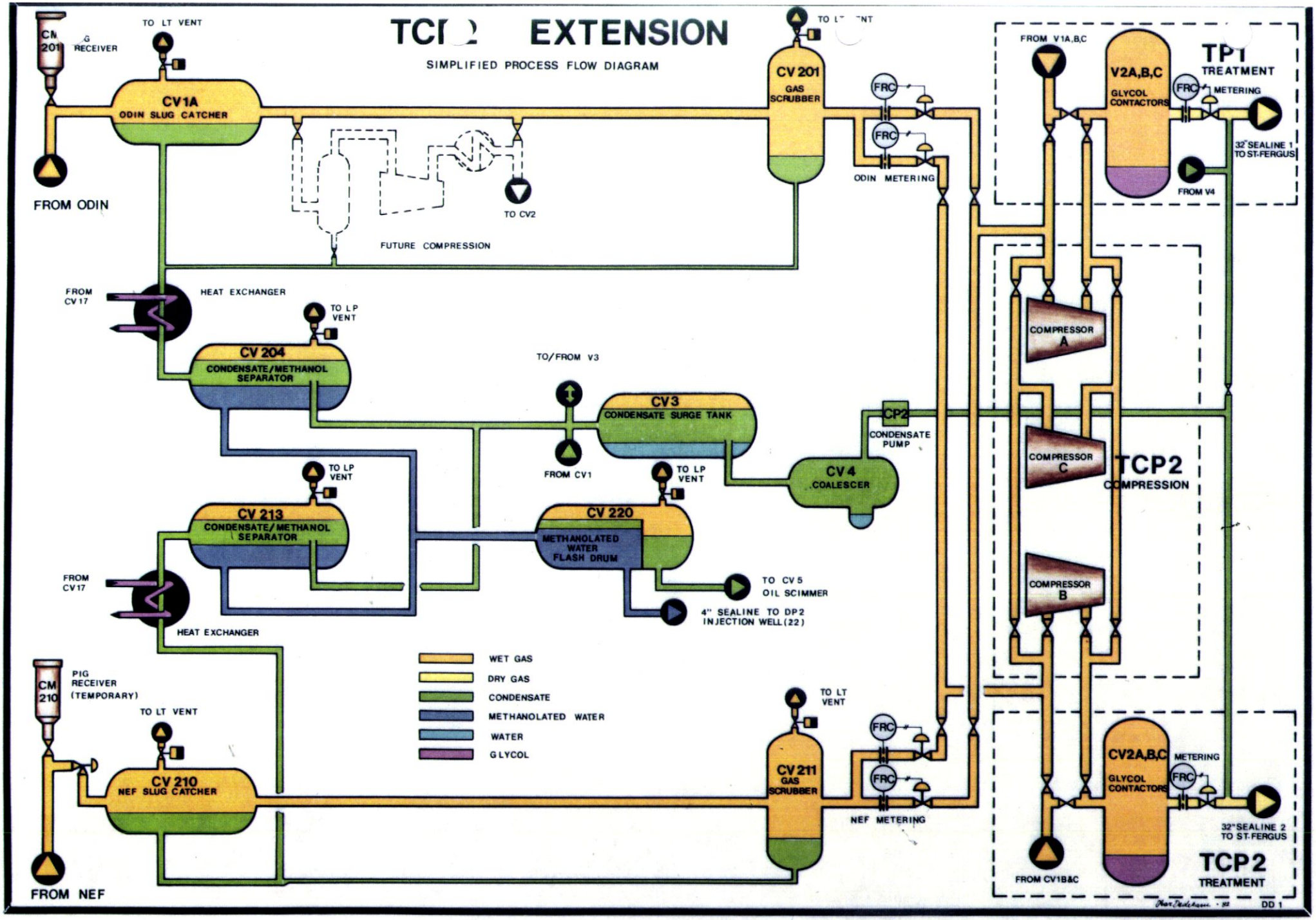


TCP2 EXTENSION MODULE


TCP2 EXTENSION
SIMPLIFIED PROCESS FLOW DIAGRAM
CM 201
G RECEIVER
TO LT VENT
CV1A
ODIN SLUG CATCHER
FROM ODIN
TO CV2
FUTURE COMPRESSION
CV 201
GAS SCRUBBER
TO LT VENT
FRC
FRC
ODIN METERING
FROM V1A,B,C
V2A,B,C
GLYCOL CONTACTORS
FRC
METERING
32" SEALINE 1 TO ST-FERGUS
FROM V4
TP1
TREATMENT
FROM CV17
HEAT EXCHANGER
TO LP VENT
CV 204
CONDENSATE/METHANOL SEPARATOR
TO/FROM V3
CV3
CONDENSATE SURGE TANK
FROM CV1
CP2
CONDENSATE PUMP
CV 4
COALESCER
COMPRESSOR A
COMPRESSOR C
COMPRESSOR B
TCP2
COMPRESSION
TO LP VENT
CV 213
CONDENSATE/METHANOL SEPARATOR
TO LP VENT
CV 220
METHANOLATED WATER FLASH DRUM
TO CV 5
OIL SCIMMER
4" SEALINE TO DP2 INJECTION WELL (22)
FROM CV17
HEAT EXCHANGER
WET GAS
DRY GAS
CONDENSATE
METHANOLATED WATER
WATER
GLYCOL
CM 210
PIG RECEIVER (TEMPORARY)
TO LT VENT
CV 210
NEF SLUG CATCHER
FROM NEF
TO LT VENT
CV 211
GAS SCRUBBER
FRC
FRC
NEF METERING
CV2A,B,C
GLYCOL CONTACTORS
METERING
FRC
32" SEALINE 2 TO ST-FERGUS
FROM CV1B&C
TCP2
TREATMENT
DD 1

2.2 ALWYN TIE-IN

A. SCOPE OF WORK

To tie-in the Alwyn Field to the Frigg transportation and communication systems. The gas is to be transported from the Alwyn Field to Frigg/TP1 via a 24" pipeline.

B. PROJECT EXECUTION

The project was established in October 1984 and was finalized in March 1987.

The engineering and procurement was performed by the EAN personnel assisted by Borregaard Sofresid Norge A/S integrated.

The offshore construction was performed as a twenty months continuous hook-up.

C. MANHOURS, COSTS

Costs	MNOK 1983 value	MNOK 1987 value
Total project cost	235	275
Purchased value	31	36
Start-up costs		18

Manhours

EAN personnel	94.988
Engineering Contractor	56.217
Yard Construction	15.591
Pre hook-up Construction	7.800
Hook-up Construction	178.050
Commissioning Assistance	6.112

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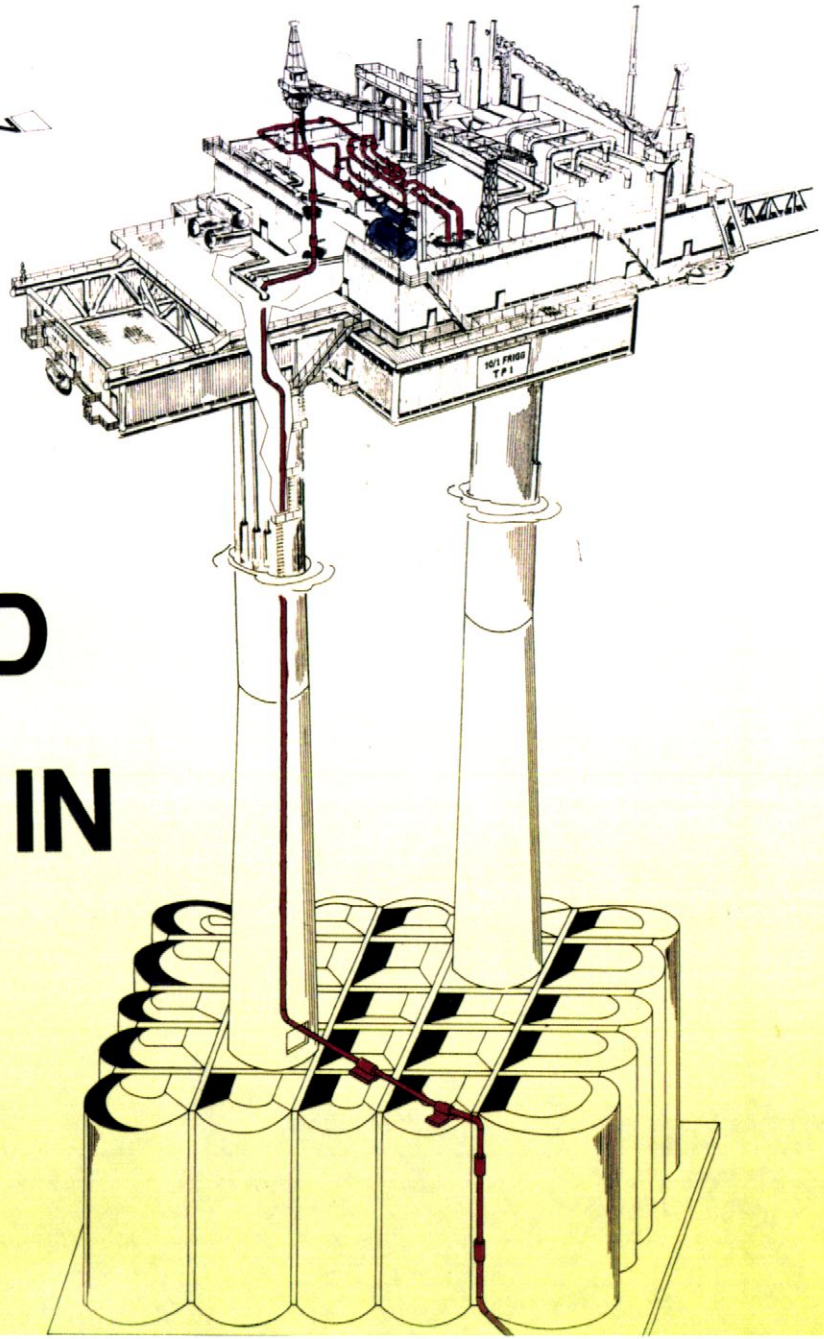
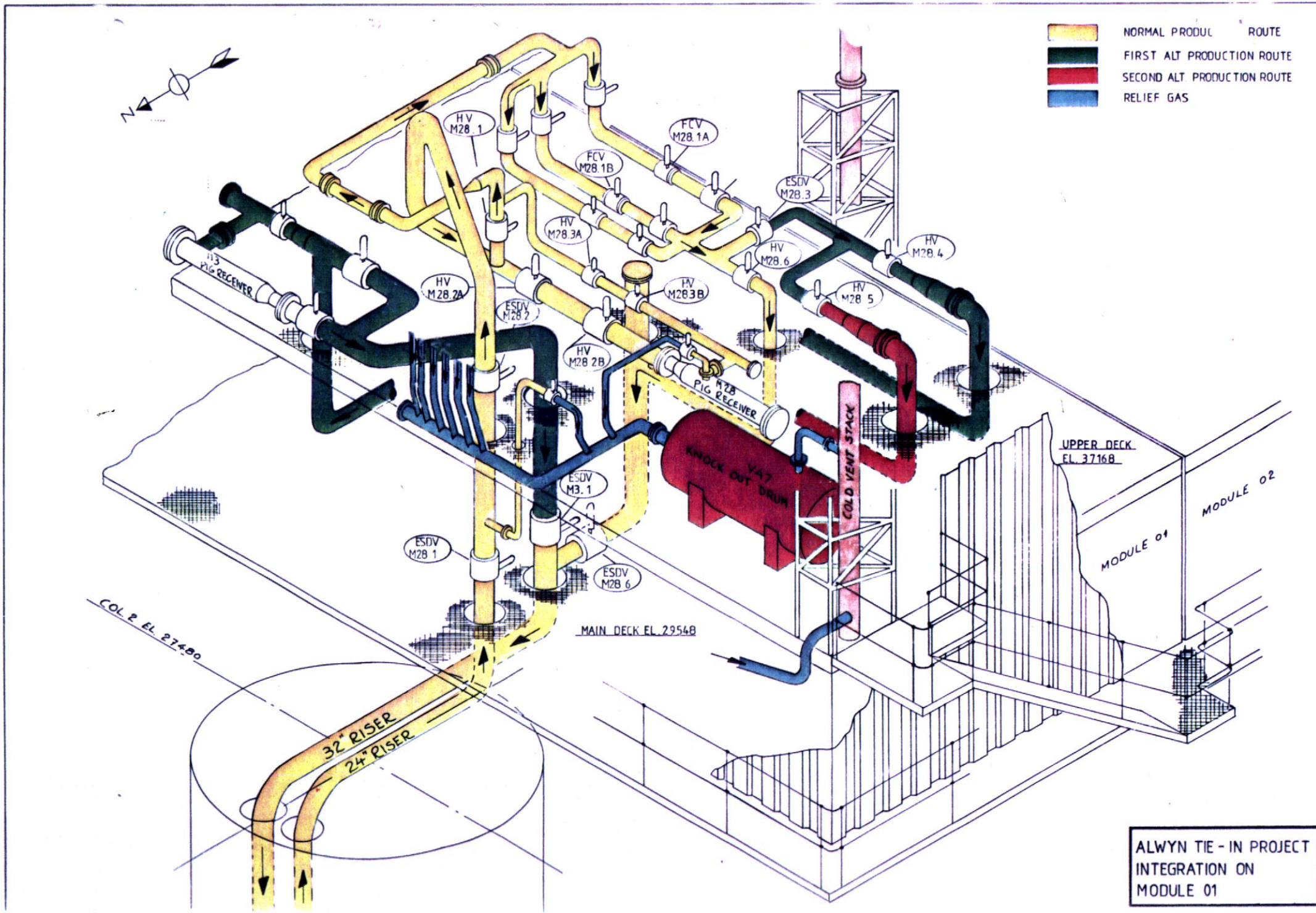
1986

FRIGG FIELD

ALWYN TIE - IN

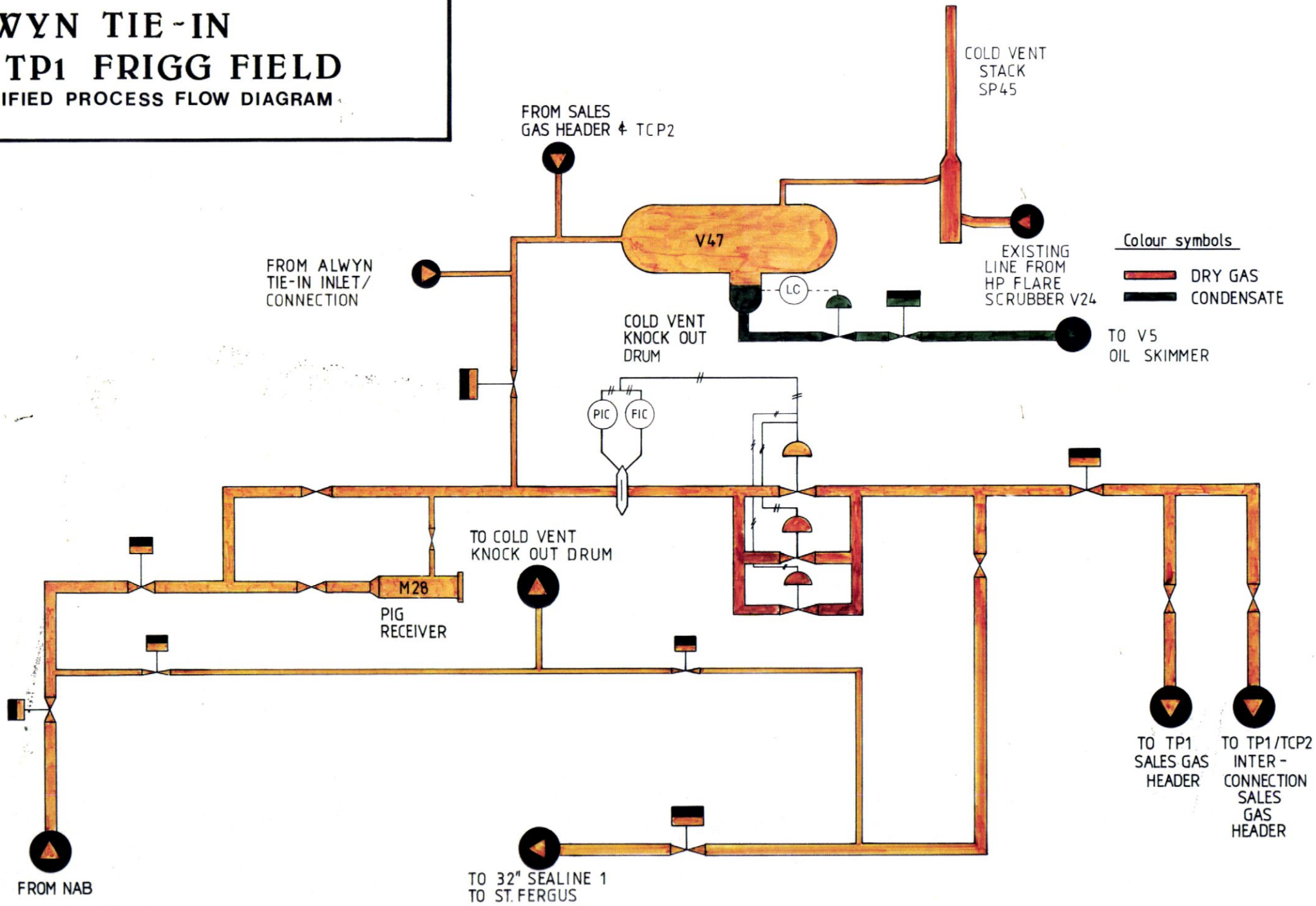
TP1




NORMAL PRODUC ROUTE
FIRST ALT PRODUCTION ROUTE
SECOND ALT PRODUCTION ROUTE
RELIEF GAS
N
HV M28.1
FCV M28.1A
FCV M28.1B
ESDV M28.3
HV M28.3A
HV M28.6
HV M28.4
HV M28.5
HV M28.3B
HV M28.2A
ESDV M28.2
HV M28.2B
M3 PIG RECEIVER
M28 PIG RECEIVER
V47 KNOCK OUT DRUM
COLD VENT STACK
ESDV M3.1
ESDV M28.1
ESDV M28.6
UPPER DECK EL. 37168
MODULE 01
MODULE 02
MAIN DECK EL. 29548
COL. 2 EL. 27480
32" RISER
24" RISER
ALWYN TIE - IN PROJECT
INTEGRATION ON
MODULE 01

ALWYN TIE-IN AT TP1 FRIGG FIELD

SIMPLIFIED PROCESS FLOW DIAGRAM



2.3 EAST FRIGG TIE-IN

A. SCOPE OF WORK

To tie-in the East Frigg Field via a process module to the existing treatment facilities on TCP2 for further transportation to St. Fergus.

B. PROJECT EXECUTION

The project was established in April 1985 and is planned finalized October 1988. The engineering and procurement was performed by Aker Engineering.

Contract for construction of process Module 51 and pancake PC 950 was awarded to ACMP - Marseilles.
Completion planned February '88.

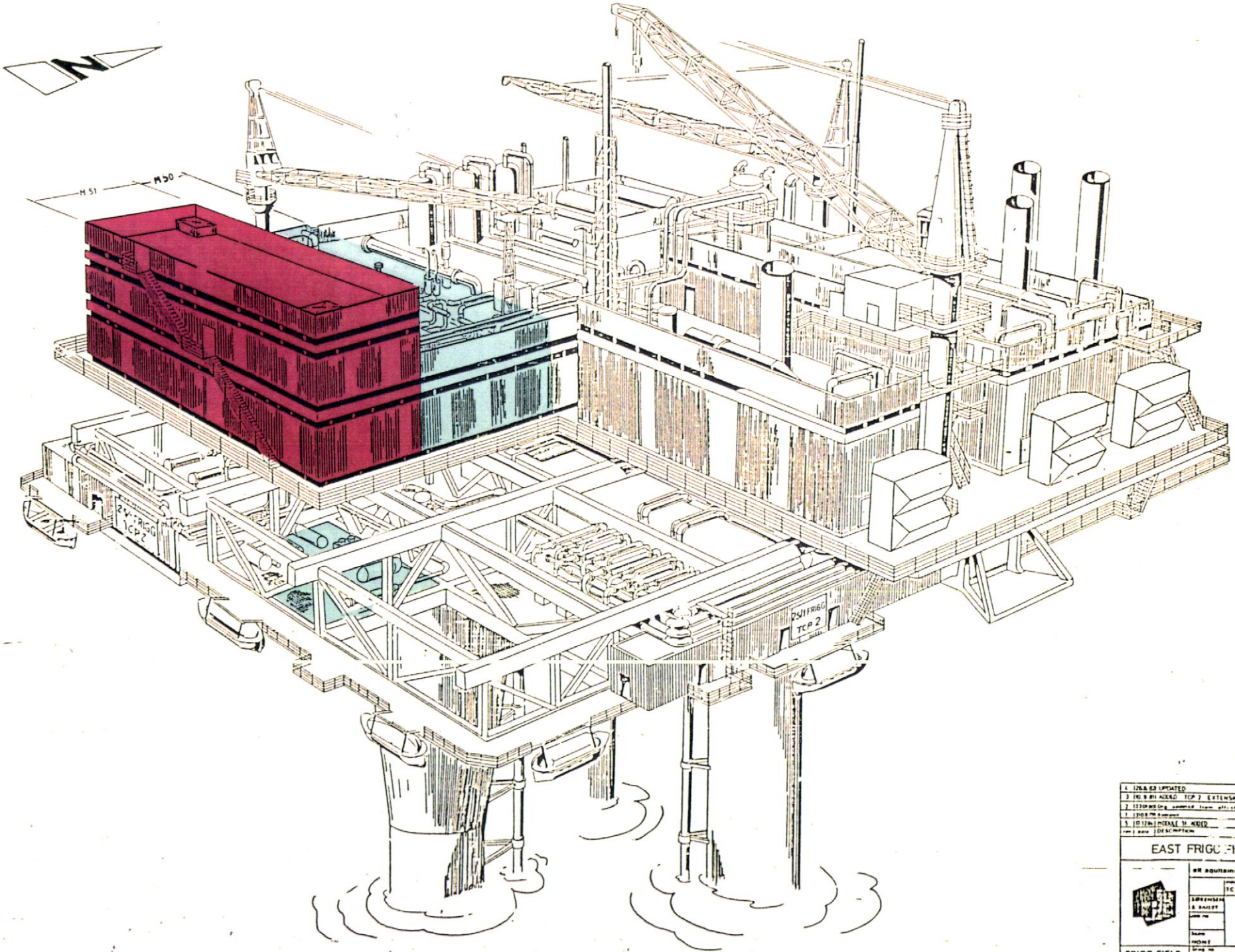
Lifting contract was awarded to Mc. Dermott, DB 102 with lifting scheduled 1 May '88. The offshore works started with pre hook-up by Aker Norsco summer '87 and will be completed with the hook-up from May '88 to October '88.

C. MANHOURS, COSTS

Costs	MNOK 1985 value	MNOK 1987 value
Total project cost	348	406
Purchased value	58	68

Manhours

EAN personnel	185.520	(not completed)
Engineering Contractor	143.210	" "
Yard Construction	167.310	" "
Pre hook-up Construction	20.000	" "
Hook-up Construction	20.000	" "
Commissioning Assistance	11.000	" "



4	12.6.8.82 UPDATED	HA
3	10.9.81 ADDED TCP 2 EXTENSION FACILITIES	
2	12.3.81 Orig. corrected from offshore issue	
1	2.10.80 First issue	
5	10.12.84 MODULE SI ADDED	
rev	date	DESCRIPTION

EAST FRIGG FIELD TIE-IN TCP-2

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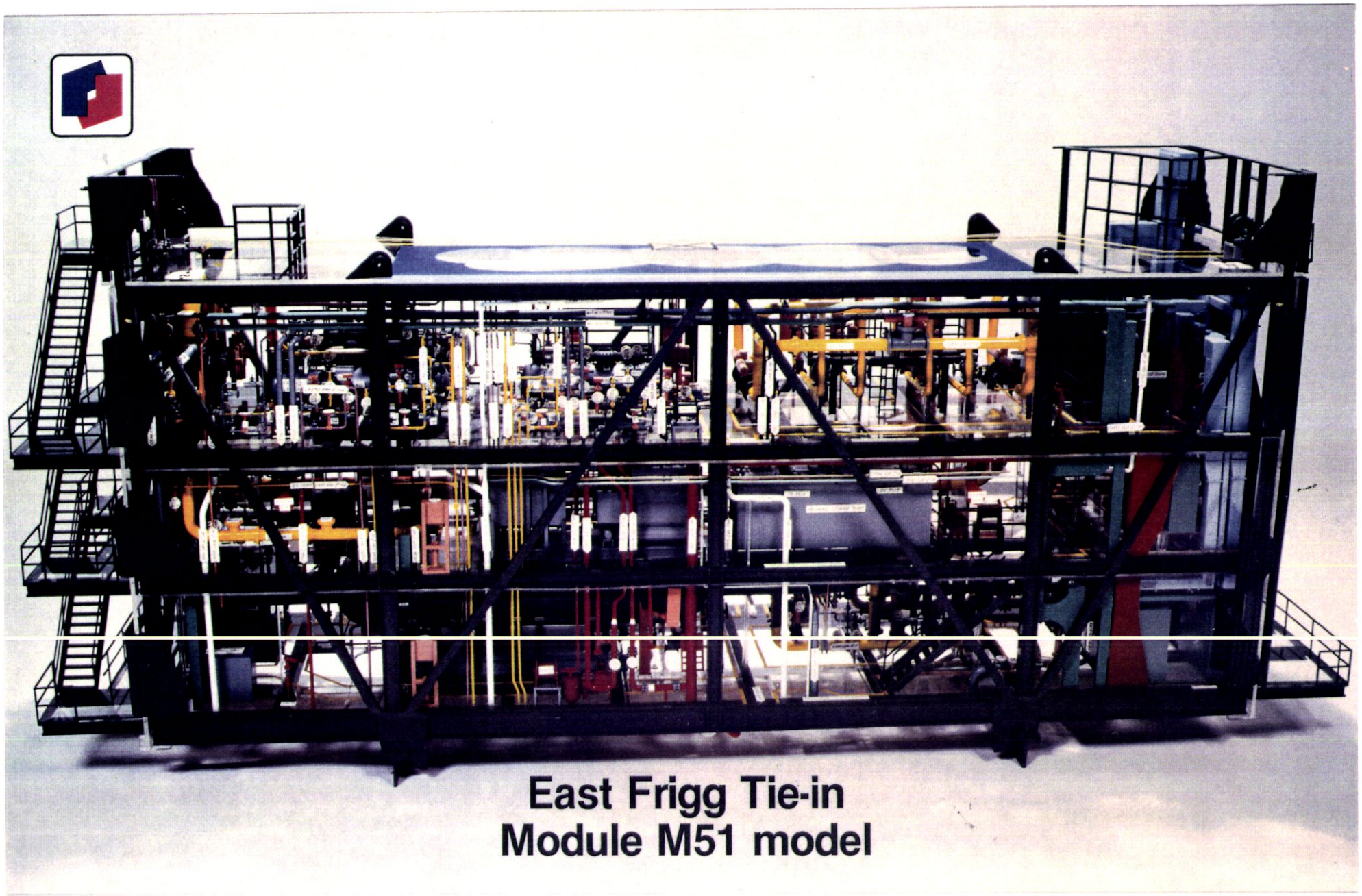
TCP 2 GENERALITIES

SØRENSEN & DAHLEF

PERSPECTIVE OF TCP 2 PLATFORM

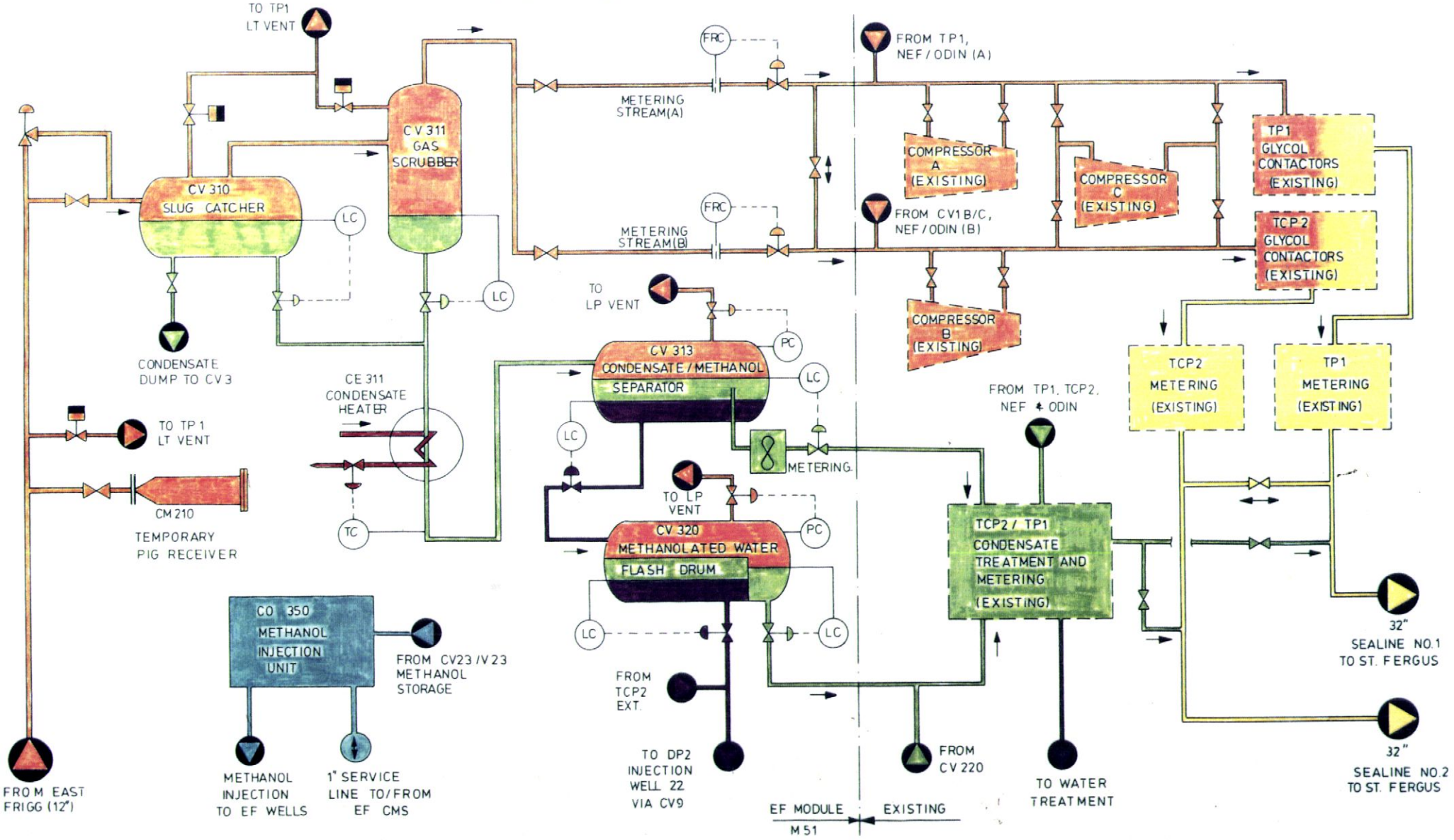
FRIGG FIELD

FT 85 00 00 10 00 S



East Frigg Tie-in
Module M51 model

SIMPLIFIED PROCESS FLOW DIAGRAM
EAST FRIGG TIE-IN TO FRIGG TCP2



TIE - IN DEPT. 86

3.0 SUMMARY OF TIE-IN STUDIES

The following tie-in studies to Frigg and Heimdal have been performed so far:

	Name of Study	Requested by	Issued
3.1	Studies related to Troll Tie-in		
3.1.1	Troll Tie-in to Frigg/Heimdal	Norsk Hydro	June '85
3.1.2	Tie-in of Troll to Frigg/ Heimdal	Statoil	May '86
3.1.3	Tie-in of Troll to Frigg and Heimdal Supplementary report to 3.1.2	Statoil	Sept. '86
3.1.4	Future use of Frigg and Heimdal for Norwegian Gas Transportation	Statoil	Sept. '87
3.2	Studies related to Odin Compression		
3.2.1	Odin Compression Concept Study	EAN	March '84
3.2.2	Odin Compression - Dedicated Module	EAN	Sept. '87
3.2.3	Odin Compression - Integrated Concept	EAN	Oct. '87
3.3	Studies related to FAS Tie-in		
3.3.1	FAS Tie-in to DP2	EAN/FAS Project	Dec. '85
3.3.2	Tie-in of FAS to Frigg	EAN/FAS Project	Aug. '86
3.3.3	Tie-in of FAS to Frigg Supplementary report to 3.3.2	EAN/FAS Project	Oct. '86
3.4	Tie-in of Bruce/Beryl to Frigg	Total	Jan. '85
3.5	Tie-in of GAMMA prospect to Frigg	EAN	Oct. '86

Tie-in of 25/5 to Frigg or Heimdal is now being studied (Dec. '87).

3.1 STUDIES RELATED TO TROLL TIE-IN

3.1.1 TROLL TIE-IN TO FRIGG/HEIMDAL (June '85)

A. SCOPE OF WORK

To perform a feasibility study covering the production of gas/ condensate from Troll East to Frigg/Heimdal - St.Fergus/Ekofisk distribution/Brae.

Give a cost estimate and schedule for the necessary modifications on Frigg and Heimdal to facilitate the production of Troll East via Frigg/Heimdal.

Predict expected Inspection, Maintenance, Repair (IMR) costs after 1994.

Perform a calculation of two phase flow in the line between Troll East and Frigg.

B. ASSUMPTIONS

Gas dehydration and compression on Frigg.
Two production Base Cases were defined, leading to two project phases:

Phase 1 Year 1995 to 2005, Gas flow : 36 MSCM/D
Phase 2 Year 2005 to 2025, Gas flow : 72 MSCM/D

C. COST ESTIMATES (including 30 % contingency)

The total costs for modifications needed on Frigg and Heimdal is for:

	MNOK 1985 value	MNOK 1987 value
Phase 1	2 058	2.365
Phase 2	1 103	1.263

Total modification costs for the two projects: 3 161 MNOK (1985)
3 620 MNOK (1987)

D. CONCLUSION

The study has shown that the Frigg and Heimdal installations can be utilized for the purpose of transportation link for the East Troll gases to Great Britain and the Continent. Although the Frigg platform were installed in 1976, the study shows that the fatigue life time can be extended up to year 2025 for the Central Complex platforms. Normal maintenance will then keep the installations fit for their purposes.

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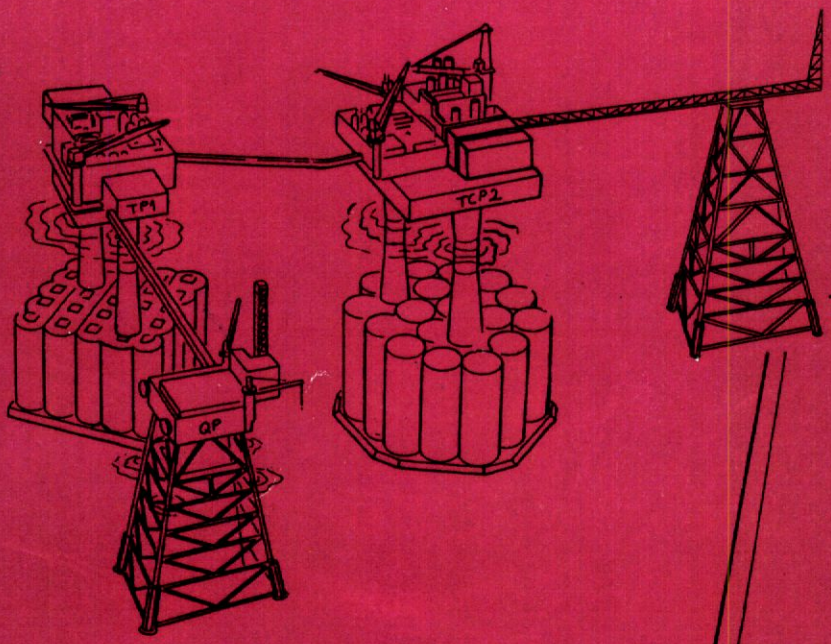
TROLL



VOLUME I

TROLL TIE-IN FRIGG / HEIMDAL

STUDY REPORT MAY 1985

HEIMDAL

REV. 1 JUNE 1985

TIE - IN DEPARTMENT

3.1.2 TIE-IN OF TROLL TO FRIGG/HEIMDAL (May '86)

A. SCOPE OF WORK

The study investigates the possibility of using Frigg and Heimdal installations as links for the transportation of TROLL gas to shore. Two main options, A and B, have been studied. Option A involves a 42" pipeline from Troll to be tied in at Frigg, with a new 42" pipeline from Frigg via Heimdal and to the Continent, and a 24" pipeline to Frigg for possible export to UK.

Two sub-options, B1 and B2, have been defined within Option B;

B1 - Conversion of the Heimdal platform to a compressor platform by 1988.
B2 - Use of Heimdal facilities by locating a new compressor platform nearby.

B. ASSUMPTIONS

Gas flow : 54 MSCM/D
Gas coming from TROLL meets sales gas specifications. Compression and metering are required.

Using the existing installations on Frigg and Heimdal with minimum modifications.

C. COST ESTIMATES (including 30 % contingency)

The total costs for modifications needed for Frigg and Heimdal are:

	MNOK 1986 value	MNOK 1987 value	
Option A	2 518	2 719	
Option B1	2 278	2 460	
Option B2	250	270	(operating costs of HMP1)
(only cost of having utilities from HMP1)	150	162	(investment costs for tie-in of utilities)

D. CONCLUSION

The study concludes that both options are technically feasible. The lifetime of the platforms can be extended until 2025 for Frigg Central Complex and HMP1. The Heimdal platform can be transformed to a compression platform by mid 1998.

In addition, the Heimdal platform can supply sufficient utilities and accommodation for a future compression platform nearby.

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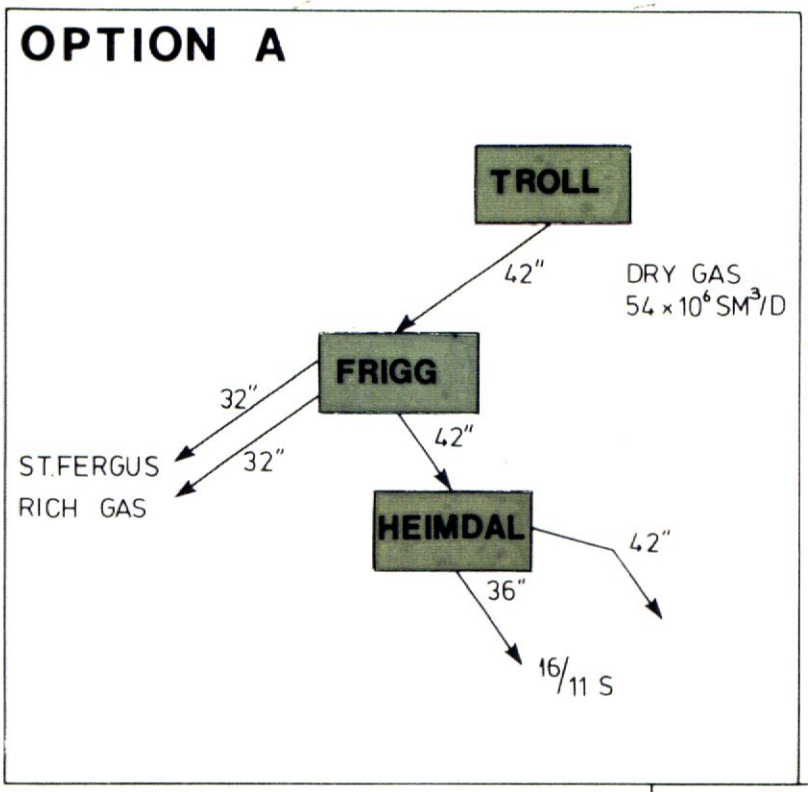
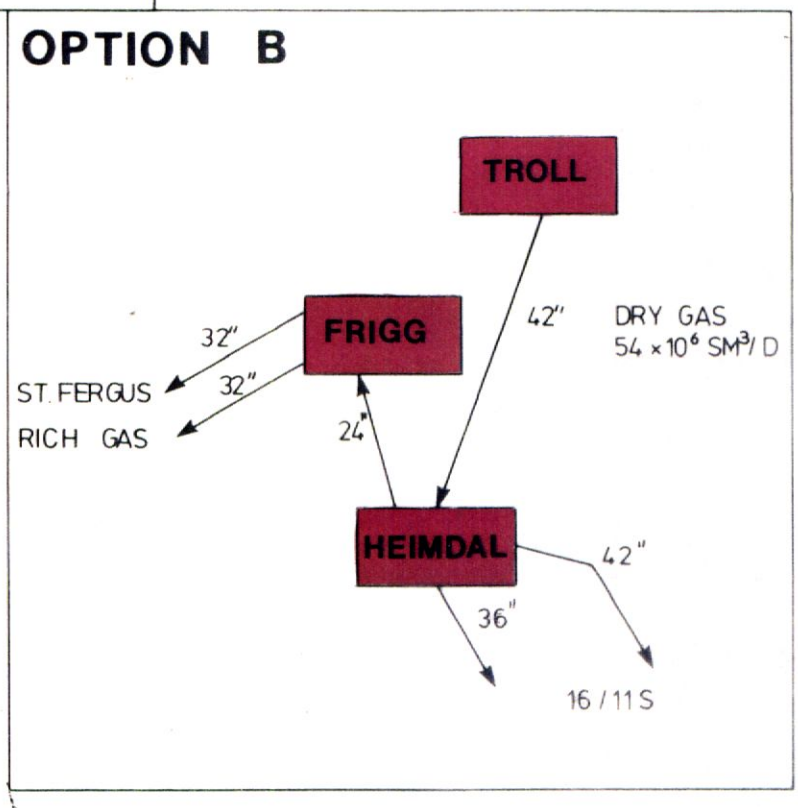


TIE-IN OF TROLL TO FRIGG / HEIMDAL



SUMMARY REPORT

MAY 1986

REV : 01
TIE-IN DEPT.

3.1.3 TIE-IN OF TROLL TO FRIGG/HEIMDAL (Sept. '86)

(Supplement to study of May '86 - item 3.1.2)

A. SCOPE OF WORK

Five options were considered. See attached sketches.

B. ASSUMPTIONS

Gas flow : 33 MSCM/D
Gas coming from TROLL meets sales gas specifications. Compression and metering are required.

Using the existing installations on Frigg and Heimdal with minimum modifications.

C. COST ESTIMATES (including 30 % contingency)

	MNOK 1986 value	MNOK 1987 value
Option 1:	738	797
Option 2:	1 775	1 917
Option 3:	1 071	1 157
Option 4:	942	1 017
Option 5:	1 024	1 106

D. CONCLUSION

All options investigated have been found to be technically feasible. Option 1 represents the most straight forward tie-in of a Troll gas pipeline to Heimdal, and another from Heimdal to Frigg.

Outside the economic considerations of a Troll tie-in, additional future tie-ins at Frigg could be achieved using the riser support structure principle forming the basis of Option 5.

The riser platform solution can only be considered cost beneficial if additional suitably sized spare risers are pre-installed for future tie-ins.

The extent of modifications required for Options 3 and 4 would only be feasible in the event of complete depletion of that part of Frigg now served by DP2. Both options require extensive activity subsea at Heimdal and Frigg. At Frigg in particular the work inside the shafts would be difficult and prolonged.

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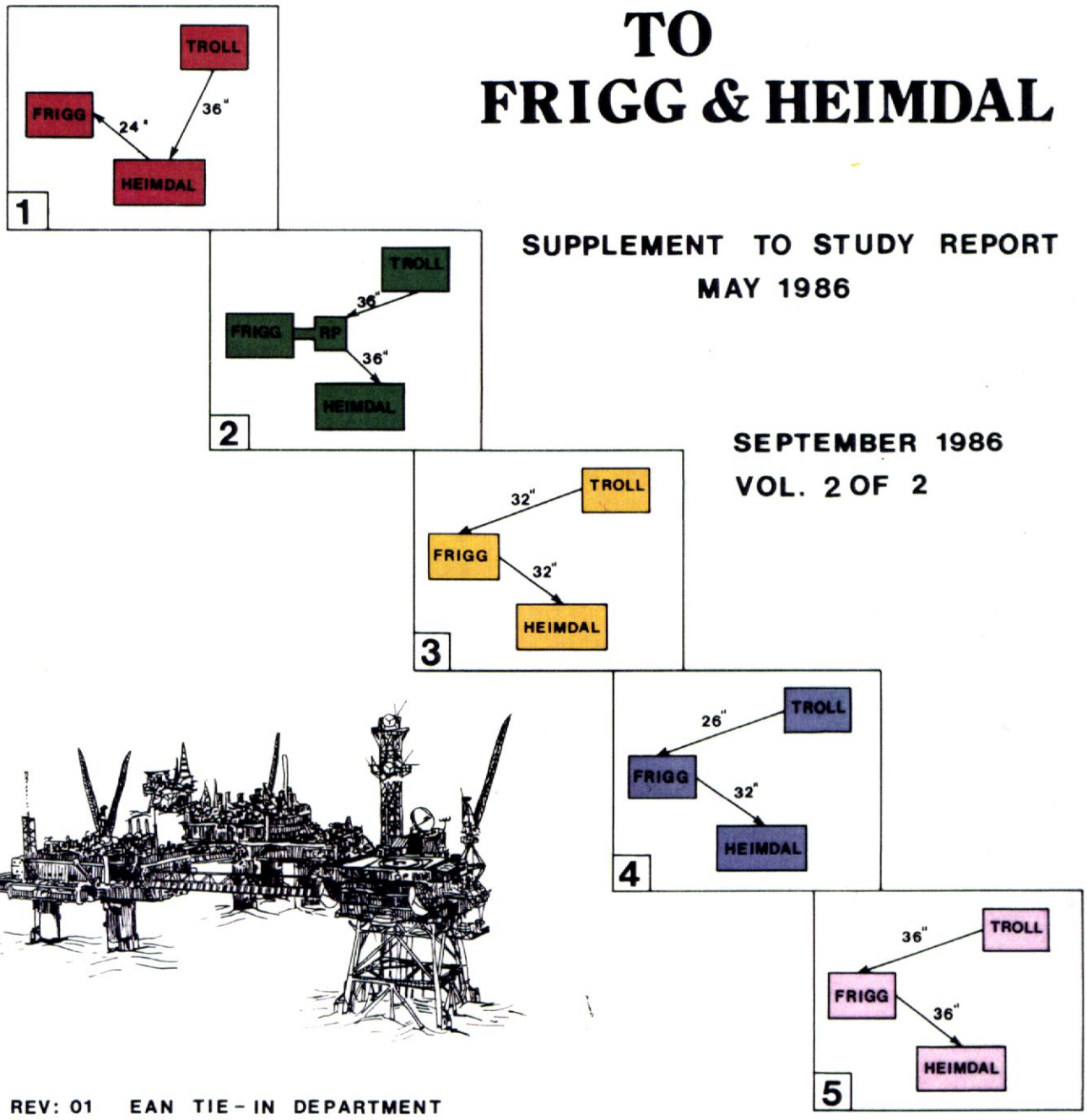
TIE - IN OF TROLL TO FRIGG & HEIMDAL



SUPPLEMENT TO STUDY REPORT
MAY 1986

SEPTEMBER 1986
VOL. 2 OF 2

REV: 01 EAN TIE - IN DEPARTMENT

3.1.4 FUTURE USE OF FRIGG AND HEIMDAL FACILITIES FOR NORWEGIAN GAS TRANSPORTATION (Sept. '87)

A. SCOPE OF WORK

This conceptual study is to perform the evaluation of three alternatives and two different gas flow scenarios for the connection of pipelines from Troll to Frigg and Statpipe gas pipeline systems.

Alternatives are depending on gathering points:

- Alternative 1: Frigg
- Alternative 2: Heimdal
- Alternative 3: Frigg and Heimdal

Scenarios are depending on gas flows:

- Scenario A: 55 Million Sm^3/day for Troll split into:
  15 Million to UK and 40 Million Sm^3/day to Statpipe
- Scenario B: 70 Million Sm^3/day from Troll split into:
  30 Million to UK and 40 Million Sm^3/day to Statpipe

B. ASSUMPTIONS

- The period of time considered spans between 1995 and 2025.
- Gas coming from Troll complies with continental specifications, requiring no gas treatment. Only compression and metering are considered.
- Only the use of FNA Frigg - St. Fergus line is considered for transportation of Troll gas to UK.
- Operation and manning level on Frigg and Heimdal are based only on handling of Troll gas.

C. COST ESTIMATES (1987 values including 30 % contingency)

Investment costs range from 2 760 MNOK to 4 446 MNOK.

Operating costs range from 200 MNOK/year for Scenario A to 300/350 MNOK/year for Scenario B alternatives for which operation of compressors are necessary.

Subsea connections at Frigg and Heimdal cuts the operating costs down to 30 MNOK/year since all platforms are bypassed and only pipelines need to be maintained.

D. CONCLUSION

The evaluation concludes that Alternative 3 (Frigg and Heimdal) and Alternative 1 (Frigg) with a new riser platform on Frigg are among the most attractive schemes according to technical/economical criteria.

Alternative 1 requires a 42" pipeline from Troll to Frigg, a 36" pipeline from Frigg to Heimdal. A subsea connection at Heimdal is possible in that case.

Alternative 3 requires a 32" pipeline from Troll to Frigg and a 36" pipeline from Troll to Heimdal. Subsea connections at Frigg and Heimdal are feasible in Scenario A.

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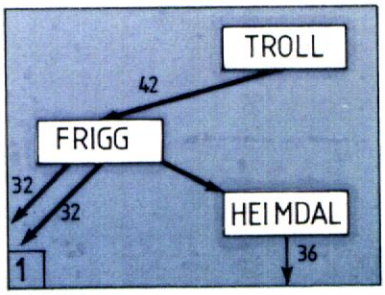
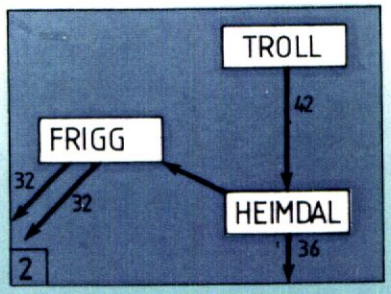
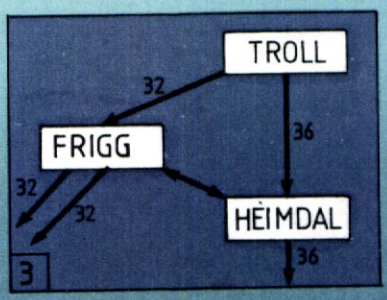
FUTURE USE OF FRIGG & HEIMDAL FACILITIES FOR NORWEGIAN GAS TRANSPORTATION







CONCEPTUAL STUDY

SEPTEMBER 1987

3.2 STUDIES RELATED TO ODIN COMPRESSION

3.2.1 ODIN COMPRESSION - CONCEPT STUDY (MARCH '84)

A. SCOPE OF WORK

The feasibility study covers the various technical and economical aspects for the installation of ODIN gas compression facilities on TCP2.

Due to uncertainties regarding the extent of water drive in the ODIN reservoir, two different pressure declines have been defined, and the consequences have been studied.

B. ASSUMPTIONS

In both cases, it has been assumed that the ODIN gas will be compressed up to Frigg well head pressure, and that the Frigg compressors have sufficient capacity to ensure further compression of NEF, ODIN and Frigg gas up to the required sea line pressure.

Gas flow ranges from 10 MSCM/D in 1984 to 3 MSCM/D in 1992.
ODIN gas arrival pressure at Frigg ranges from 100 Bars in 1986 to 50 Bars in 1992 (Case A) and from 85 Bars in 1986 to 17 Bars in 1992 (Case B).

C. COST ESTIMATES

Total cost estimate for both cases is approximately the same:

	MNOK 1983 value	MNOK 1987 value
Excl. contingency :	400	514
With contingency :	500	643

D. CONCLUSION

The ODIN gas should be compressed to phase one compression suction pressure and use as much as possible of TCP2 existing facilities.

Compression should be performed by one single centrifugal compressor without interstage cooling.

Both electric motor drive and turbine drive were considered. The recommended solution is the electric alternative as it is possible to supply the required power from the existing generating plant and it would reduce both investment and operating costs.

The required cooling water will be taken from the existing network by the installation of a new set of plate heat exchangers.

The above conclusions are valid for any new TCP2 gas compression up to 11 MW.

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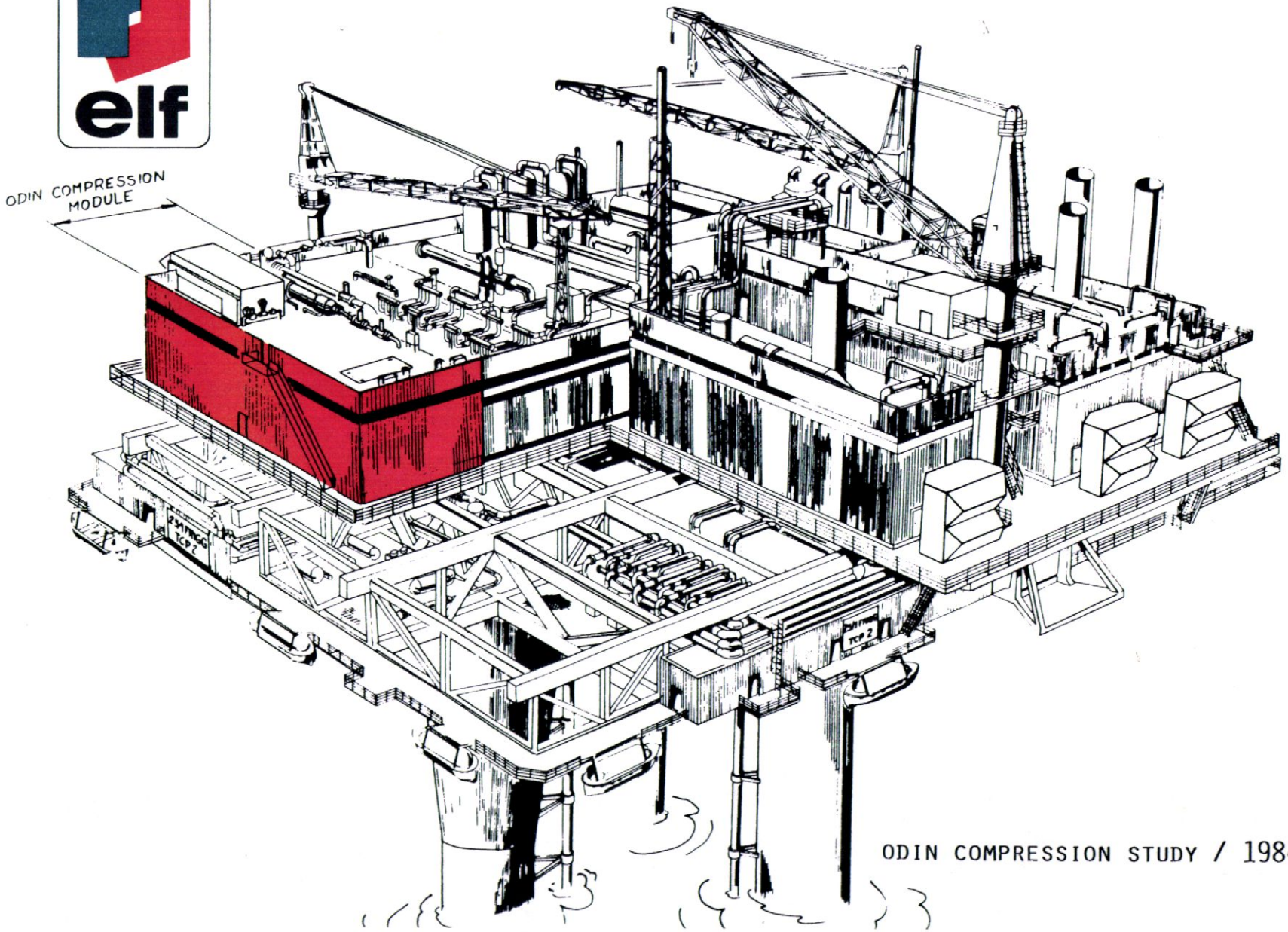

ODIN COMPRESSION STUDY / 1984

3.2.2 ODIN COMPRESSION STUDY - DEDICATED MODULE (Sept. '87)

A. SCOPE OF WORK

This study looks into the feasibility and cost of installing a dedicated module on TCP2 to boost Odin gas arrival to Frigg.

3 schemes are considered:

1. One compression train rated at 100 % of the flow. No back up.
2. Three compression trains in parallel, each of them rated at 50 % of the flow - 50 % back-up.
3. Two compression trains in parallel, each of them rated at 100 % of the flow - 100 % back-up.

B. ASSUMPTIONS

Gas flow ranges from 8 MSCM/D in 1993 to 5 MSCM/D in 1998
Eventual arrival pressure at TCP2: 8 - 11 bars.
Compression from 8 - 11 bars to 100 bars.

C. COST ESTIMATES (including 20 % contingency)

	MNOK 1987 value
Scheme 1:	660
Scheme 2:	1 152
Scheme 3:	1 008

D. CONCLUSION

- Scheme 1 requires one module of 1440 tons
- Scheme 2 requires one module of 2980 tons
- Scheme 3 requires two identical modules as in Scheme 1 with one compression train in each module; i.e. 2 x 1440 tons = 2880 tons.

No modifications of existing compressors on TCP2. Installation of dedicated booster with 100 bars discharge pressure.

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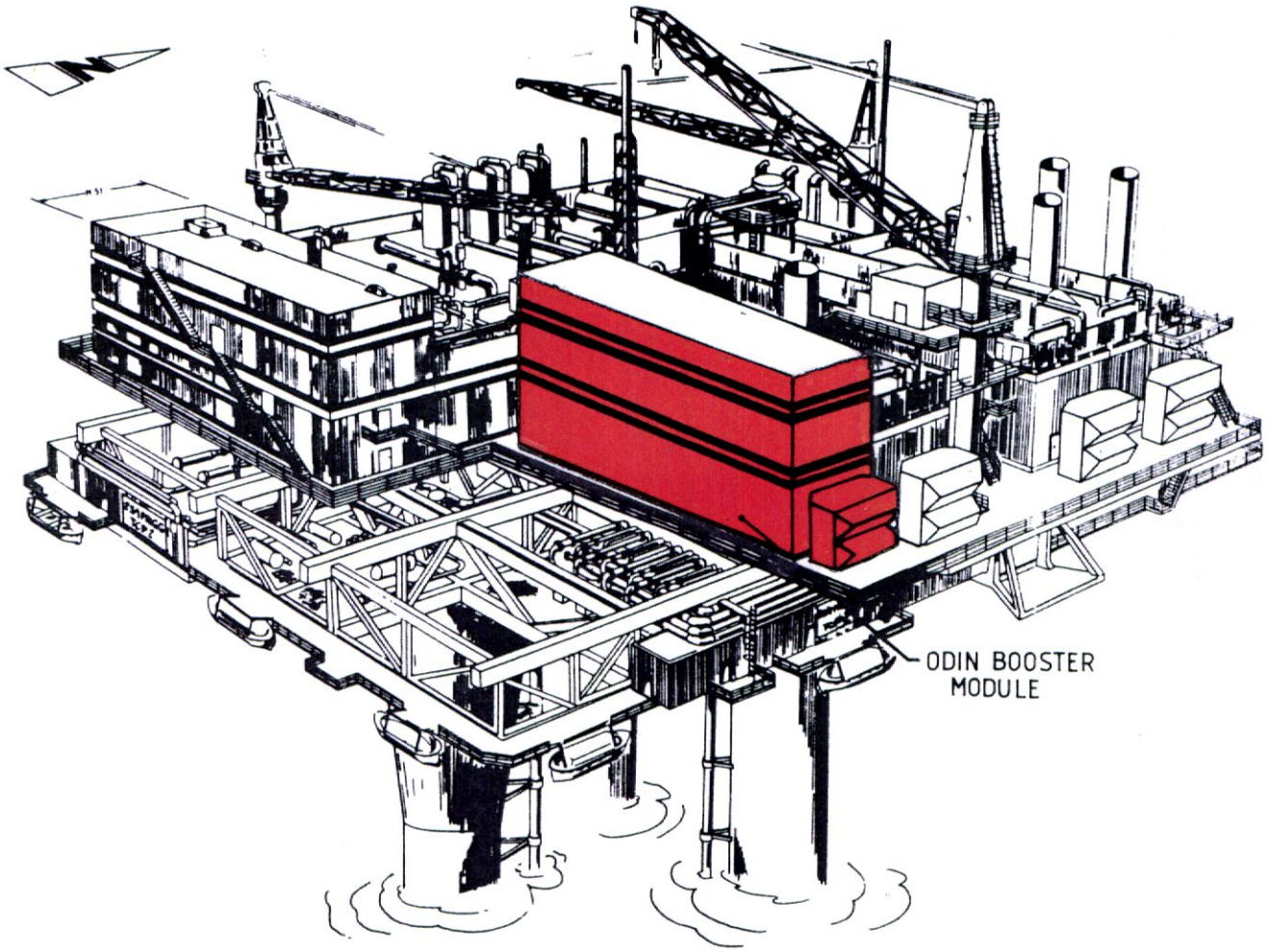


FRIGG FIELD

ODIN BOOSTER

FEASIBILITY STUDY AND COST EVALUATION

TIE-IN DEPARTMENT

SEPTEMBER 1987

3.2.3 ODIN COMPRESSION STUDY - INTEGRATED CONCEPT (Oct. '87)

A. SCOPE OF WORK

This study looks into the feasibility and cost of utilizing existing Frigg compressors on TCP2 to boost Odin gas.

B. ASSUMPTIONS

Eventual arrival pressure at TCP2: 8 - 11 bars.

C. COST ESTIMATES (1987 value including contingencies)

- Phase 1: 11 MNOK (incl. 20 % contingency)
- Phase 2: 54 MNOK (incl. 30 % contingency)
- Phase 3: 355 MNOK (incl. 40 % contingency)

D. CONCLUSION

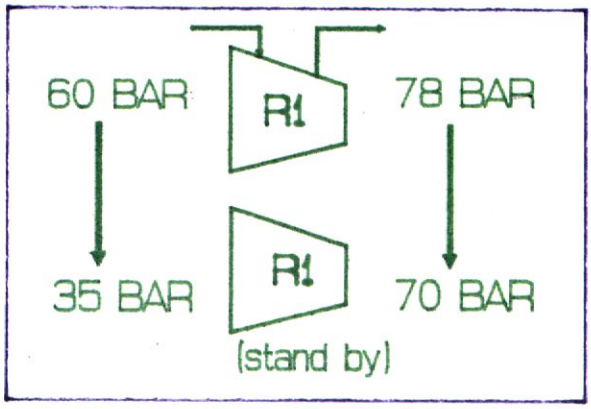
Need for compression can be met by integration with existing TCP2 compression.

Phase 1: Change the internal of two of the compressors.
Operational between Oct. '89 to Oct. '92.

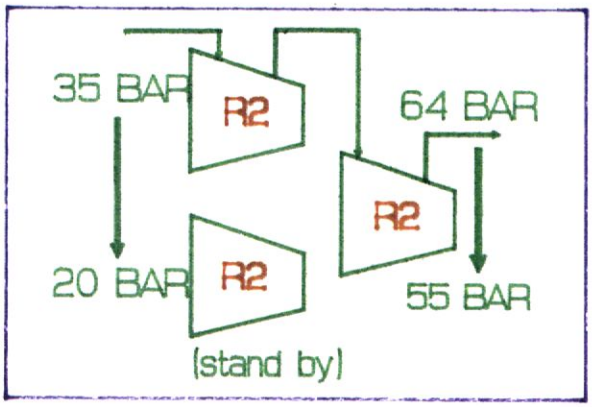
Phase 2: Change the internal of the third compressor and install two new anti surge lines.
Operational between Oct. '92 to Oct. '94.

Phase 3: Installation of two new double compressors with three coolers.
Operational beyond Oct. '94.

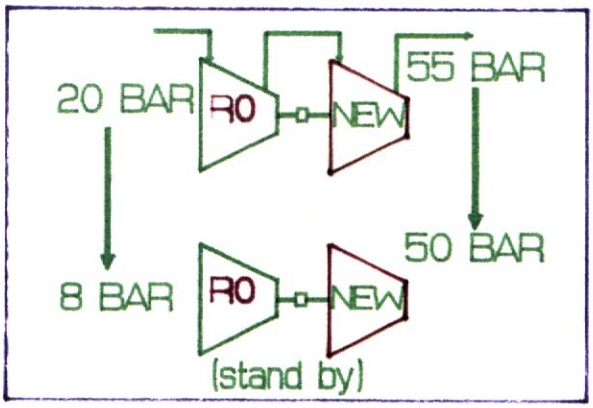
ODIN BOOSTER BASED ON EXISTING COMPRESSORS



Oct. 89 - Oct 92



Oct. 92 - Oct 94



Oct. 94 - Oct 96

3.3 STUDIES RELATED TO FAS TIE-IN

3.3.1 FRIGG ADDITIONAL SUBSEA (F.A.S.) TIE-IN TO DP2 (Dec. '85)

A. SCOPE OF WORK

- Evaluate the landing on the Frigg Field (DP2 alternative as base case) of all lines coming from 2 subsea clusters (F.A.S. Project):
  - two 12" gas line risers
  - two 8" kill and test lines
  - two 6" umbilicals
  - two 3" electrical cables
- Location on DP2 of the following installations:
  - Subsea wells hydraulic unit
  - Subsea wells control unit
  - Methanol supply
  - Electrical power supply
- Cost estimate and schedule analysis for implementation of FAS tie-in to the DP2 platform.

B. ASSUMPTIONS

Gas flow : 8 to 12 MSCM/D
Gas dehydration and compression on Frigg.

C. COST ESTIMATES (including 30 % contingency)

The overall cost of integrating FAS gas on the DP2 platform is estimated to:

MNOK 1985 value	MNOK 1987 value
280	320

Estimated cost for installation of additional lattice structure and risers clamped to DP2 jacket is 50 MNOK included in the 280 MNOK.

D. CONCLUSION

The feasibility of tie-in FAS gas on DP2 is acceptable from a technical point of view.

Some systems will, however, have to be further investigated in order to upgrade them in accordance with present Statutory Requirements.

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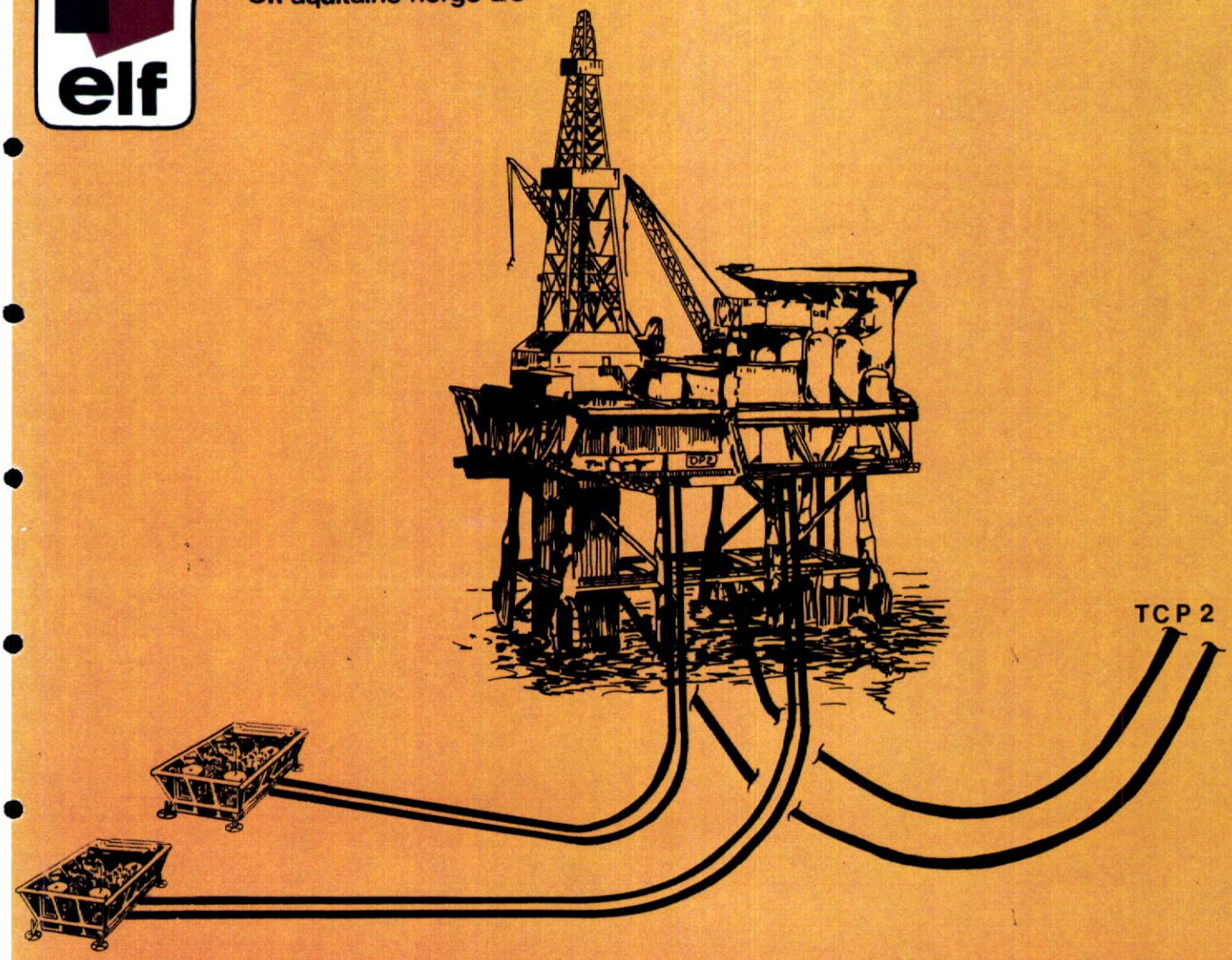

FAS TIE-IN TO DP2 STUDY REPORT

DECEMBER 1985

3.3.2 TIE-IN OF FRIGG ADDITIONAL SUBSEA (F.A.S.) TO FRIGG (Aug. '86)

A. SCOPE OF WORK

Evaluate the landing on Frigg platforms of all lines coming from subsea wells:

- one 16" or 18" production line (diameter depending upon the tie-in option)
- two 10" production, test and kill lines
- two umbilicals (6.5" and 4.5")
- two electrical cables (2.5")

Propose possible locations for topside process and utility facilities:

- choke valves, test separator, simple metering and tie-in to Frigg gas treatment
- hydraulic power unit to subsea valves, methanol injection unit to wells, electrical power supply and subsea control equipment.

Three tie-in options have been investigated:

Option 1: All equipment on DP2
Option 2: Process on DP2, utilities on TCP2
Option 3: All equipment on TCP2 in one module

B. ASSUMPTIONS

Gas flow : 8 MSCM/D
Gas dehydration and compression on Frigg.

FAS gas is mixed with Frigg production upstream existing slug catchers before separation and dehydration, therefore no additional gas treatment facilities are needed for FAS production.

C. COST ESTIMATES (including 30 % contingency)

	MNOK 1986 value	MNOK 1987 value	
Option 1:	367	396	
Option 2:	455	491	
Option 3:	434*	469	* with 10" rigid risers
	390*	421	* with 10" flexible risers pulled inside 26" existing risers

D. CONCLUSION

The Tie-in Study of FAS to Frigg concludes that tie-in is feasible whatever option is considered.

Option 3 with flexible risers is recommended for the following reasons:

- Connection only to Central Complex which has a more secure future than well platforms and limit the manning on DP2.
- Simple conception of one complete module on TCP2 which means, quick hook-up, possibility of onshore commissioning, easy operation.
- Overall construction cost, which is in between the two other option costs.

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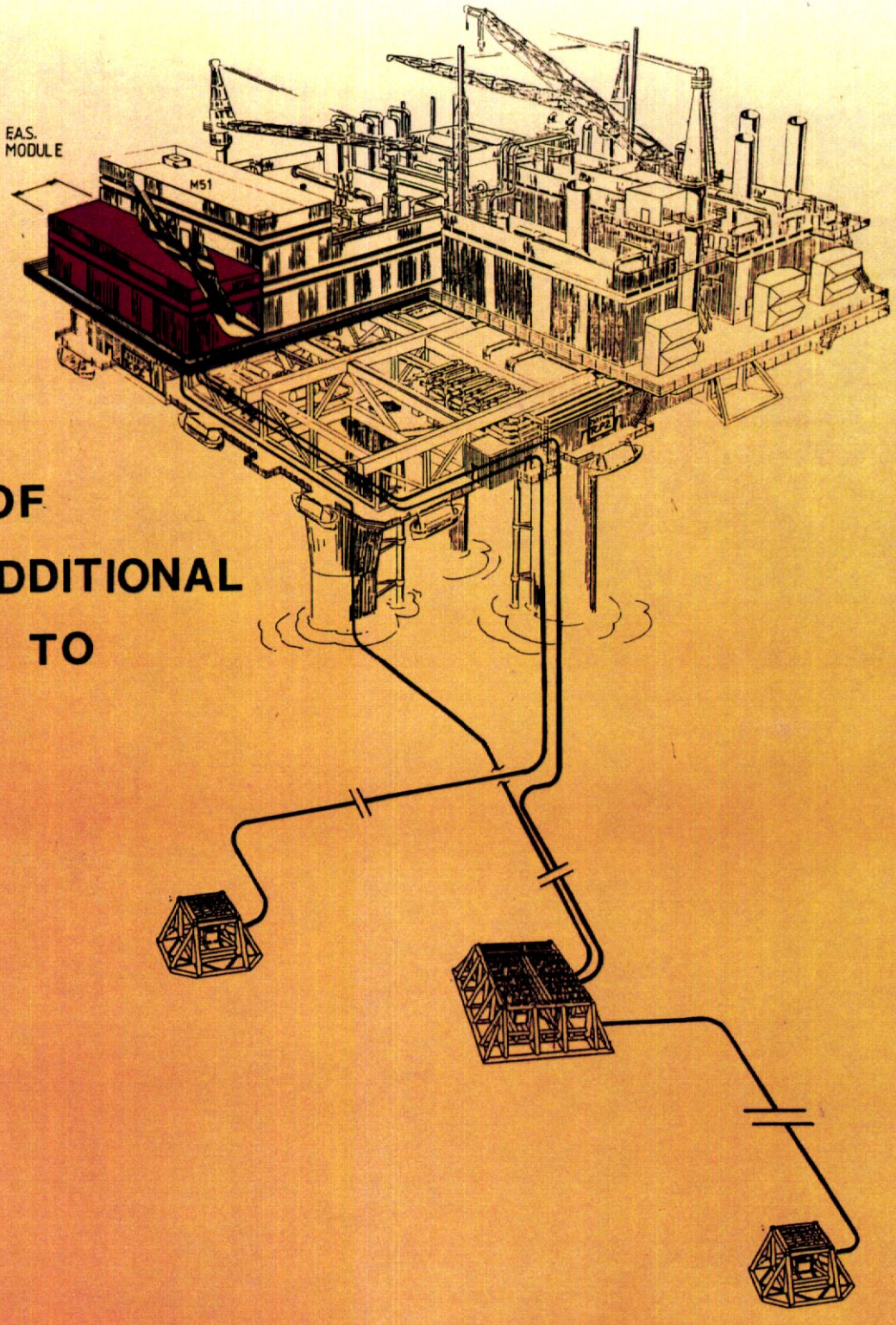


TIE-IN OF FRIGG ADDITIONAL SUBSEA TO FRIGG

STUDY REPORT

AUGUST 1986

3.3.3 TIE-IN OF FRIGG ADDITIONAL SUBSEA (F.A.S) TO FRIGG (Oct. '86)

A. SCOPE OF WORK

Supplement to "Tie-in of FAS to Frigg" issued in Aug. '86.

1) Additional description of option 3:
   Tie-in points location, routing of risers in the topsides, PID's.

B. ASSUMPTIONS

Same as for previous study.

C. COST ESTIMATES (including 30 % contingency)

Same as for previous study.

D. CONCLUSION

Same as for previous study.

3.4 TIE-IN OF BRUCE/BERYL TO FRIGG (JAN. '85)

A. SCOPE OF WORK

To assess technical feasibility of tie-in BRUCE/BERYL to TP1 and to identify preliminary cost.

Three scenarios are studied:

1. Bruce/Beryl mixed, through one 32" riser
2. Bruce/Beryl mixed, through one 24" riser
3. Bruce and Beryl in parallel through two risers, a 32" and a 24".

B. ASSUMPTIONS

Flow ranges from 15 to 30 MSCM/D at 152 bars abs.
Gas dehydrated and without condensate at 152 bars abs.
Production foreseen from 1990 until 2005.

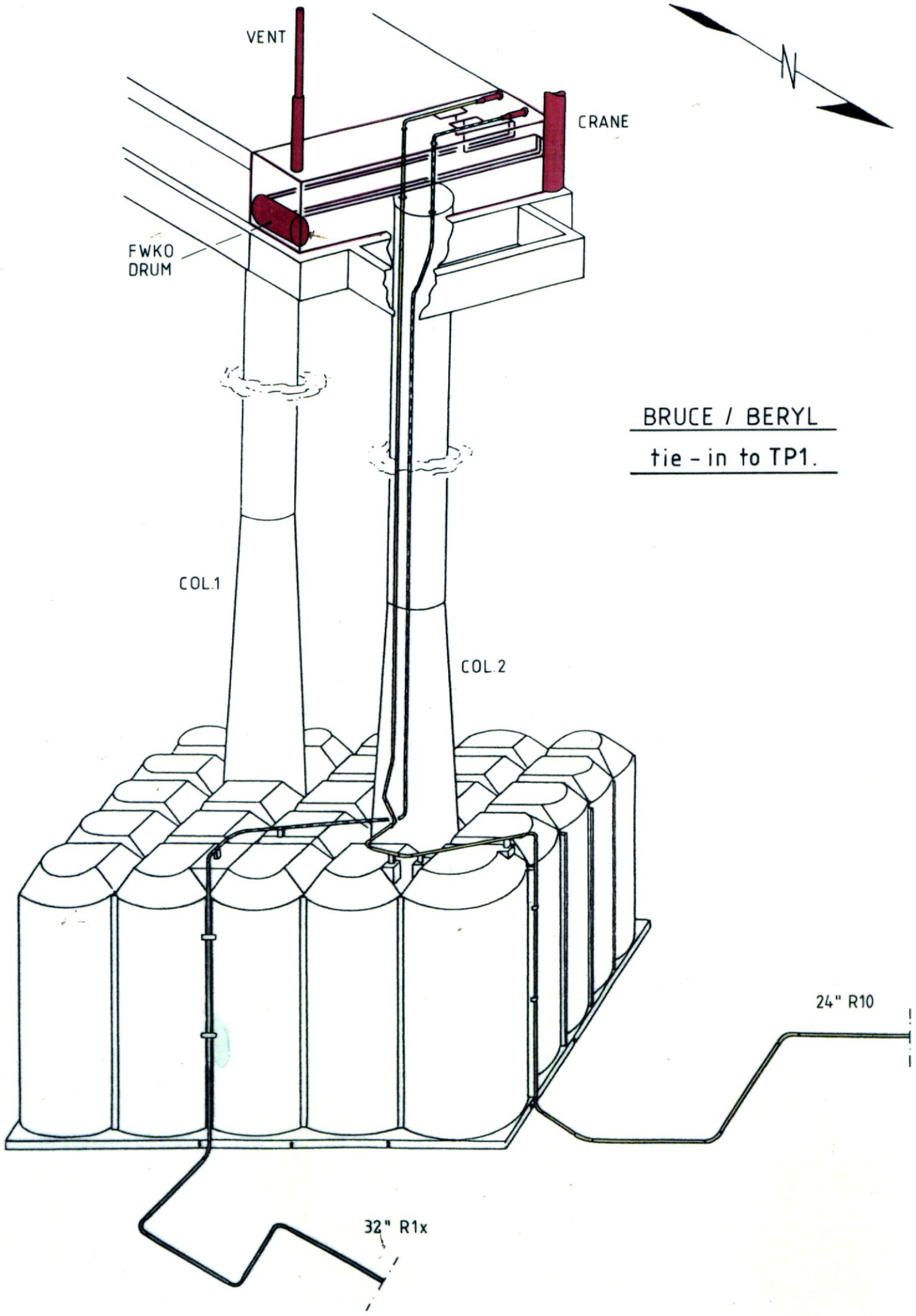
C. COST ESTIMATES (including 30 % contingency)

	MNOK 1983 value	MNOK 1987 value
Scenario 1:		
- Total cost	349	448
- Option without metering	339	435
Scenario 2:		
- Total cost	389	500
- Option without metering	379	488
Scenario 3:		
- Total cost	495	636
- Option without metering	480	617

D. CONCLUSION

All 3 scenarios are feasible.
New module to be installed with a new crane (for all scenarios)- Pig receiver - fiscal metering (option without) - blowdown system - interconnection pipework and valves - technical room on the module for the instrumentation. "Line of sight" telecom link between Bruce and Frigg with 2 antennas on QP.

Riser 32": Use of existing 32" R1X riser in column C2, connection to pipeline.
Riser 24": Install a new riser 24" using an existing 32" penetration in column C2, connection to pipeline.



BRUCE / BERYL

tie - in to TP1.

3.5 TIE-IN OF GAMMA PROSPECT TO FRIGG

A. SCOPE OF WORK

The study evaluates two alternatives for the tie-in of GAMMA subsea wells to Frigg:

- Option 1: Gas sealines linked to East Frigg subsea manifold. Umbilical linked to East Frigg module on TCP2.
- Option 2: Gas sealine and umbilical linked to East Frigg module with a simple metering or with a fiscal metering.

B. ASSUMPTIONS

- Nominal gas production : 2 MSCM/D
- Gas pressure at Frigg : 80 - 90 Bars

C. COST ESTIMATES (including 30 % contingency)

	MNOK 1986 value	MNOK 1987 value	
- Option 1:	72	78	
- Option 2:	126*	136	* with simple metering
:	465*	502	* with fiscal metering

D. CONCLUSION

Option 1:

A 10" pipeline is needed from GAMMA to East Frigg manifold (9 km) with an umbilical and an eletrical cable linked to Module 51.

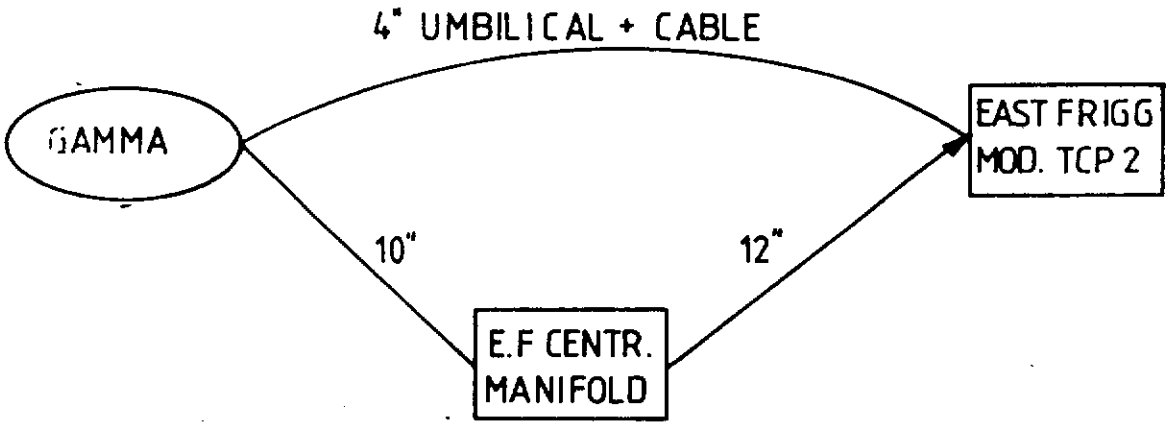
Option 2:

A 10" pipeline is needed from GAMMA to TCP2. A 10" flexible riser can be pulled inside a 26" existing riser on TCP2 column 3.

The option with fiscal metering requires a new module to accomodate a slug catcher, a metering scrubber, gas metering tubes and condensate metering.

GAMMA DEVELOPMENT
TIE-IN OPTIONS

OPTION 1 GAS LINE FROM GAMMA WELL LINKED TO EAST FRIGG CENTRAL MANIFOLD



OPTION 2 GAS LINE FROM GAMMA FIELD TO EAST FRIGG MODULE ON TCP 2

SUBOPTION 2A : SIMPLE METERING
SUBOPTION 2B FISCAL METERING

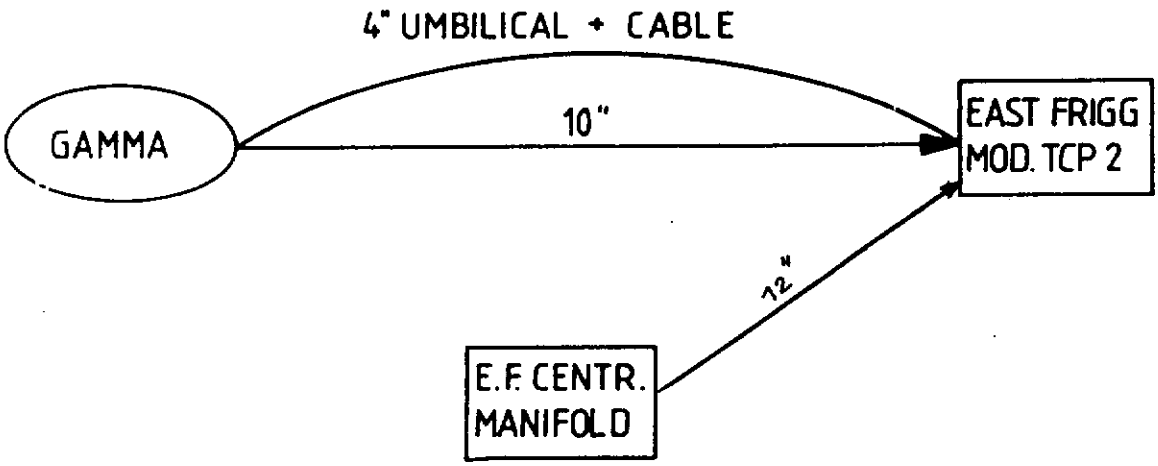


FIGURE 1