



**elf aquitaine norge a/s**

# **FRIGG FIELD TCP2 COMPRESSION FINAL REPORT**

***volume 2/2***

**PROJECT DEVELOPMENT**

#### 6. HOOK-UP AND COMMISSIONING.

The hook-up, precommissioning and commissioning have been managed directly by EAN-TCP2 Compression Department. The preparation phase started in August 1978 and the mission was completed in February 1981 for the hook up works and in June 1981 for commissioning.

## 6.1. PRESENTATION

### OFFSHORE WORKS CHARACTERISTICS

The treatment part of TCP2 platform is under production since 1978. For obvious safety reasons most of compression offshore works had to be done with a completely "cold platform".

Therefore the overall offshore works planning was directly linked to:

- a. the EAN's delivery contract with the British gas corporation.

Target dates:

- TCP2 platform "cold", under nitrogen: May 22nd.
- TCP2 platform ready for "gas in": September 15th.

- b. The completion of full priority systems required by authorities to be operational as soon as possible after starting of Hook-up as they are related with the general safety on the platformd d during the construction period:

- Fire water main ring in "water" connected to TCP2 treatment.
- Portable extinguishing systems and escape ways
- Life boat and life buoies.
- Fire alarm button
- Public address.

- c. The completion of priority systems which have to be operational prior to TCP2 treatment being "Gas-In".

- Fire and gas detection systems not automatically connected.
- Emergency lighting in addition to the normal lighting
- Pressurisation of rooms which have an opening in an area division 2 classification
- Halon working manually inside energized electrical rooms.

d. To physical constraints such as:

- Works on sea water rejection lines in column 5 to be completed, before August 15th (diving operations)
- Hot works inside treatment part and all important welding works in compression prior to TCP2 treatment gas in.

6.2 . P R E P A R A T I O N   P E R I O D

### 6.2.1. INTRODUCTION

Due to the utmost importance of offshore works a great care was brought by EAN management to their preparation. For this purpose an EAN Hook-up manager has been appointed from June 1978.

Hook-up preparation target dates are:

- June 1978 - appointment Hook-up manager
- August 1978 - appointment Kvaerner Technip technical preparation team in Oslo.
- January 1979 - transfer of individuals from technical preparation team in Stavanger and integration in EAN management group.
- October 1979 (23rd) issuing of Hook-up contract bid package.
- December 1979 (18th) - answers to bid package.
- January 1980 (15th) - clarifications and answers to reservations sent to all bidders
- January 1980 (29th) - amended tender proposals were received
- February 1980 (12th) - issue in of bid analysis.
- March 1980 (11th) - telex of intend sent to UIF Norge.
- April 1980 - contract signature
- May 1980 - end preparation period.

The main phases of the Hook-up preparation are described here-after. It is worth nothing that the attached periods are given only for information as some studies or actions of a precise phase were sometimes finalized or completed during the next phase's period.

#### 1.1. Preliminary phase (from August 1978 to December 1978)

During this phase the hook-up of compression modules and pancakes was first approached as a whole for both the hook-up work to be performed offshore and the corresponding required manhours.

Special studies in all disciplines were carried out in order to decrease the future hook-up work.

1.2. Hook-Up scope of work definition phase with preparation of the task sheets (from January 1979 to July 1979 in Stavanger).

Beginning of January the technical preparation team was moved from Oslo to Stavanger and integrated in the EAN management team. During this phase, task sheets defining the elementary works to be performed offshore were completed by all disciplines. Instructions were given to the yards to ensure continuity between onshore and offshore constructions. A material follow-up system was established documentation from this system to be used by the material section at a later stage.

Precommissioning forms and documentations for the different systems were as well prepared by the electrical, instrumentation and mechanical disciplines.

Particular studies or actions were initiated during this phase, specially lifting and installation feasibilities together with surveys on TCP2.

Computer follow-up procedures were defined. Definition technical offshore logistic requirements.

1.3. Hook-up contract preparation phase (from July 1979 to March 1980).

Draft of contract was prepared: Bid package built on, various contractual and technical discussions. Bid package analysis.

1.4. Hook-up preparation finalized phase (from March 1981 to May 1981).

The Hook-up scope of work was further precised during this phase following new information from Engineering, actual completion status of the construction on the different yards and of the TCP2 platform preparation including additional works outside the compression project to be performed during hook-up. 11

Various plannings were prepared together with the Construction as well as procedures for liaisons between offshore and onshore.

## 6.2.2 TASK SHEETS PREPARATION

The Hook-up scope of work was defined by means of task sheets, which are written instructions to complete specified tasks according to specified drawings with specified materials in a given trade.

Each task numbering was codified in such a way that computerized follow-up could be used. Each task was defined by:

- a number directly connected to the task
- functional system for commissioning and start up purpose.
- geographical area
- discipline
- origin of task through a so-called "code program"

### 2.1 Codification

#### 2.1.1 Functional system.

##### Z 01 Structural

A = Structure

B = Architecture

##### Z 02 Grounding, cable trays, polytubes and cables

A = Grounding

B = Cable tray

C = Polytubes, cables and junction boxes.

##### Z 03 Insulation and painting

A = Insulation

B = Painting

##### Z 04 Gas compression line A

##### Z 05 Gas compression line B

##### Z 06 Gas compression line C

##### Z 07 H.P. relief vent (flare)

##### Z 08 L.P.vent

##### Z 09 Desalinated water generation

- Z 10 Desalinated water distribution
- Z 11 Cooling medium
- Z 12 Main sea water cooling
- Z 13 Fuel gas
- Z 14 Diesel oil
- Z 15 Process oily water
  - A = High pressure
  - B = Low pressure
- Z 16 Closed fresh water/T.E.G. drain system
- Z 17 Open drainage
- Z 18 Wash-down system
- Z 19 Instrument and service air
  - A = Air generation
  - B = Instrument air distribution
  - C = Service air distribution.
- Z 20 Power generation
  - A = Turbo generator A
  - B = Turbo generator B
  - C = Switchboard 5,5 KV
  - D = 5,5 KV - 380 V Transformer
- Z 21 Power distribution 380 V
- Z 22 Normal and emergency lightings.
- Z 23 Emergency
  - A = Diesel generator
  - B = Main emergency swithboard 380 V
  - C = Emergency auxiliary switchboard
  - D = Distribution 220 V
  - E = Distribution 110 V
- Z 24 Field electrical interconnection
  - A = TCP 2 Compression to TCP 2 Treatment
  - B = TCP 2 Compression to TP 1
  - C = TCP 2 Compression to QP

- Z 25 Intercommunication: compression and field
  - A = Interphone
  - B = Public address
  - C = Telephone
- Z 26 Safety fire and gas detection
- Z 27 Safety fire fighting
  - A = Fire water
  - B = Deluge system
  - C = Halon
  - D = Extinguishing system
  - E = Life boat
- Z 28 Emergency shut down
- Z 29 H.V.A.C.
- Z 30 Lifting equipment
  - A = Crane
  - B = Hoists and monorails

## 2.1.2 - Codification of the areas

### . Main and upper decks

- A 30 = Module 30
- A 31 = " 31
- A 32 = " 32
- A 33 = " 33
- A 70 = Interface 30 - 31
- A 71 = " 21 - 32
- A 72 = " 32 - 33

. Cellar deck or below

A 40 = Pancake 40  
 A 41 = " 41  
 A 42 = " 42  
 A 43 = " 43  
 A 44 = " 44  
 A 45 = " 45  
 A 46 = " 46  
 A 03 = Column 3  
 A 05 = " 5  
 A 63 = Interface 03 - 41 - 42 - 44 - 45  
 A 65 = " 05 - 42 - 43 - 46  
 A 73 = " 40 - 41  
 A 74 = " 40 / 41 - 44  
 A 75 = " 42 - 43  
 A 76 = " 42 / 43 - 45

. Other areas

A 80 Interface main deck - cellar deck  
 A 78 " TCP 2 T - TCP 2 C  
 A 81 " TCP 2 - Other platforms  
 A 00 Any area with TCP 2 C

2.1.3 - Codifications of the discipline

B = Structural  
 C = Mechanical  
 D = Piping  
 E = Electrical  
 F = Instrumentation  
 G = Insulation  
 H = Painting

2.1.4 - Codifications of the code programs

Each task load a code program attached to it, in order to know the reason for its issuing. Code programs which where proposed are as follows:

A = Internal Hook-Up work given in H.U. contractor scope in Jan. 1st. 1980.

B = Works remaining from yards.

C = Works remaining from platform preparation

D = Works due to late emergency definition (which could not be included in Yards scope)

E = Works outside Compression project.

F = Additional Temporary facilities.

G = Additional engineering requirements.

H = Additional works outside compression.

J = Modifications works due to engineering changes.

K = Repair works (from yard, platform preparat, lifting).

L = Tasks ommitted in H.U. preparation

M = Assistance to commissioning/Start-Up

#### 2.1.5 Task sheet definition

Forms of the task sheet which were to define any elementary work in any disciplines were issued in November 1978 together with a guide for filling them. Elements making up a task sheet were as follows:

- An identification section.

It includes a task number, discipline, code program, system, area, revision number, date of issue, & number of sheets.

- A section for the definition of work.  
It consists of a "description" of documents need, of particular remarks and of testing information.
- A material section.  
This gives a listing of material together with the origin (Client or Contractor) and identification, weight and specification.
- A task acceptance section  
Where representative of both the Client and Contractor were to sign after completion of task.

## 2.2. Number of tasks

The number of tasks issued can be splitted as follows:

- 2.2.1 Type a: tasks issued with bid package. Those tasks are related to the "theoretical Hook up scope of works" with Engineering as known in October 1979 and assuming 100% yards completion.
- 2.2.2 Tasks issued from October 1979 to May 1980:
  - Type b: tasks due to Engineering changes.
  - Type c: tasks due to remaining works from yards (punch lists known end of May).
- 2.2.3 Tasks issued from June 1980 during Hook up works:
  - Type d: tasks due to Engineering changes which occur after Hook up start.
  - Type e: tasks due to remaining works from yards which were not listed on punch lists.
  - Type f: tasks due to repair of lifting damages.
  - Type g: miscell. issued tasks mainly related with commissioning and start-up requirements.

Type h: tasks issued offshore by EAN offshore supervision team (tasks type h are written and included in tasks type d.,e.,f.,g.)

Type k: tasks which have been cancelled (generally due to Engineering changes those tasks became meaningless).

### 2.3 TABLE ISSUE OF TASKS (number)

TYPE	STR	MEC	PIP	ELEC	INST	PAINT INS	TOTAL
a	80	42	307	145	90	15	679
b	7	1	10	12	53	-	83
c	27	18	13	90	52	-	200
d	18	11	46	57	225	-	357
e	27	7	0	41	83	15	173
f	14	11	39	21	25	-	110
g	29	11	68	62	102	-	272
TOTAL	202	101	483	428	630	30	1874
h	62	33	72	67	101	0	335
k	12	24	52	63	45	-	196

### 6.2.3. HOOK-UP CONTRACT AWARD

#### 3.1 List of bidders

8 companies were sent tenders for the hook-up Contract:

- |                              |       |
|------------------------------|-------|
| . UIE Norge                  | (UIE) |
| . Spie - Batignolles / Vigor | (SBV) |
| . Norwegian Contractors      | (NC)  |
| . Brown Aker                 | (BA)  |
| . Heerema - Seaway           |       |
| . Haugesund - De Groot       | (HDG) |
| . P.W. Offshore services     | (PW)  |
| . CJB offshore               |       |

2 of them are British companies "PW offshore services" and "CJB Offshore". The last one did not answer to the tender. Heerema-Seaway made a bid together with Haugesund-De Groot which made a bid on its own as well. There were then 6 bids to be compared.

#### 3.2 Bids comparison

Price elements to be compared were

- The cost of the initial scope of works (tasks submitted with the tender) Table A.
- The unit rates through a scope for expected additional works. Table B.
- The total costs (initial plus additional scope). Table C.

A. Table of comparison of prices and expected manhours  
per bidder and per discipline for initial scope.

-1 MANHOURS (expected)

	KE-TP (Reference)	SBV	PW	UIE	BA	NC	HDG
Structure	20421	30840	32594	38820	54581	79538	32374
Mechanical	21085	21411	35942	21528	41516	58888	21446
Piping	102291	63058	124729	112260	108000	104397	65952
Electrical	50600	31104	12371	16024	63393	39742	32834
Instrument	24070	11330	6478	8752	40267	19391	17004
Mainting	15499	(15499)	(15499)	(15499)	(15499)	(15499)	(15499)
TOTAL	233966	161786	237406	208264	317488	312313	176354

- 2 PRICES (in million of Kroners)

Structure	6.637	7,541	9,391	8,669	24,897	17,179
Mechanical	4,611	8,621	5,209	6,547	18,656	12,807
Piping	14,599	25,729	27,024	16,921	28,451	34,851
Electrical	9,335	2,759	5,862	12,277	11,869	12,402
Instrument	3,100	1,371	3,247	7,769	6,269	6,633
Mainting	0,762	4,592,	2,611	1,539	3,322	6,844
TOTAL	39,047	50,615	53,347	53,726	93,466	90,717

## A - 3 PRICE per Hour (in kroners)

	KE-TP (References)	SBV	PW	UIE	BA	NC	HDG
Structure		215	231	242	177	313	531
Mechanical		215	240	242	158	317	597
Piping		232	207	240	157	273	528
Electrical		300	223	366	194	299	378
Instrument		274	212	371	193	323	390
Painting		(189)	(182)	(240)	(158)	(321)	(1015)
AVERAGE		241	213	256	170	299	514

B. Table of comparison of unit rates through prices and expected manhours per bidder and per discipline for additional scope

## B - 1 MANHOURS

Structural	20000	30303	31746	37736	54054	76923	31746
Mechanical	10000	10204	16949	10204	19698	27778	10204
Piping	50000	30864	60976	54945	52632	51020	32258
Electrical	50000	30675	12225	15823	62500	39370	32468
Instrument	80000	37736	21505	29091	133333	64516	56338
Painting	60000	15760	98360	42250	37740	40000	26090
Insulation	5000	(5000)	(5000)	(5000)	(5000)	(5000)	(5000)
Scaffolding	25000	(25000)	(25000)	(25000)	(25000)	(25000)	(25000)
TOTAL	300000	185452	271761	220049	389867	329867	219104

## B - 2 PRICES (in million of Kroner)

Structural	6,739	6,475	3,818	5,702	3,088	6,021
Mechanical	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Piping	8,223	10,446	7,270	7,602	4,990	13,791
Electrical	6,273	2,674	7,794	10,713	11,055	35,247
Instrument	10,701	4,033	9,198	17,621	13,809	33,695
Painting	5,927	2,422	4,811	5,502	12,034	14,200

C. General table of Comparison of total prices and  
expected manhours per bidder

C - 1 MANHOURS

	KE-TP (Refer)	SBV	PW	UIE	BA	NC	HDG
Original scope	233966	161786	237406	208264	317488	312313	176354
Addit. scopie	300000	185452	271761	220049	389867	329607	219104
Commissioning	20000	(20000)	(20000)	(20000)	(20000)	(20000)	(20000)
Hourly paid	31000	(31000)	(31000)	(31000)	(31000)	(31000)	(31000)
Offshore stand	20000	(20000)	(20000)	(20000)	(20000)	(20000)	(20000)
TAL by	604966	418238	580167	499313	778355	712020	466458

C - 2 PRICES (in million of Kroners)

Tasks (original scope)	39,047	50,615	53,347	53,726	93,466	90,717
Price (Original scope without stand by)	63,420	70,421	68,826	64,794	111,552	104,875
Price (original scope With stand by)	69,892	81,321	75,674	69,546	116,032	110,336
Price (+ additional scope)	121,666	120,297	122,617	131,639	185,540	232,789

C - 3 PRICE per hour (in Kroners)

Tasks (original scope)	241	213	256	170	299	514
ice (original scope without stand by)	392	296	330	204	357	595
Price (+ additional scope)	287	197	226	162	231	505

Notes

1. The number of manhours to be spent for painting in the initial scope and for insulation, scaffolding and commissioning in the additional scope has been taken from KE-TP estimate.
2. The number of hours to be spent for the additional scope has been computed using the same efficiency as for the initial scope relatively to KE-TP figures.
3. Hours mentioned are productive plus non-productive hours.
4. In the mechanical discipline, there was no unit rates proposed.

3.3 Successful bidder

The contract was finally awarded to UIE Norge a/s by EAN general management taking their bid in consideration among other factors.

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#### 6.2.4. HOOK-UP CONTRACT

##### 4.1 MAIN POINTS OF HOOK-UP CONTRACT

##### 4.1.1 Lump sum type contract

Following a new trend in the offshore industry, the hook-up contract was proposed on a lump sum basis. Excluding questions of escalation after a given date, mobilization and demobilization fees, stand - by rates, the contract price was made up from the sum of quotations from the bidder for each individual task submitted to him.

##### 4.1.2 Unit rates and other prices

As the contract was to be awarded beginning of 1980 for a hook-up place during the second part of that year, the bidder was requested to propose unit rates in order to build new quotations for additional or revised tasks which were issued afterwards up to the end of the hook-up. These unit rates were to describe in each discipline any elementary operation in plus or minus relatively to the initial scope.

Other prices the bidder was to propose were:

- hourly or daily rates for
  - . special tools or equipment.
  - . temporary electrical and air supply
  - . a quality control team
  - . personnel to be used under direct supervision of the Company (being understood that a maximum of 10% of Contractor productive personnel could be requested for a given period).
- stand by rates
- mobilization and demobilization fees.
- termination indemnity in case the contract is ended by the company before the remuneration by the Contractor is 150% of the initial scope of works price.

#### 6.2.5. LOGISTICS - SITE FACILITIES

The following support and site facilities had to be provided in order to perform compression Hook-Up works.

#### 5.1 ACCOMODATION AND CATERING FACILITIES

All those working offshore were accomodated "Treasure Supporter" hotel rig which capacity was 500 beds: from those 500 beds 75 were used by flotel permanent crew and catering. Therefore 425 beds were made available to Hook-up contractor/EAN management/visitors/vendors/authorities....

In order to avoid shuttling problems between Treasure Supporter and TCP2, Treasure Supporter was connected with TCP2 by means of a 30 meters long telescopic gangway. The gangway formed a self powered telescopic hydraulic unit with an heavy foot on its free end (TCP2 platform side)

##### 5.1.1 FLOTEL CONTRACT

Target dates were:

- Call for bids April 1st 1979
- Bids comparison July 1st 1979
- Contract signature April 1980

#### 5.2 UTILITIES GENERATION AND DISTRIBUTION

In order to avoid safety problem due to temporary facilities working on a hot platform it was decided to use as soon as possible permanent site facilities to FED site facilities.

- Electrical through 5.5 kv field interconnection net work.

- Air from Compression permanent air compressors.

However, as a temporary solution the contractor was requested to install utilities generation and distribution, part of those utilities being used as generation for permanent safety installation to be energised from the early stage of the work.

- 3 diesel generator sets 250 KVA each (2 running, one stand by) for electrical generation site facilities.
- 2 diesel generators in parallel total 600 KVA equipped with synchronizing unit for electrical generation permanent safety installation (lighting, public address...).
- 2 diesel air supply compressor sets 600 CFM each for site facilities.

### 5.3 STORAGE AREAS

10% of all storage areas hereabove had to set aside if necessary for company's use.

#### 5.3.1 OPEN STORAGE AREAS

##### 5.3.1.1 ON TCP2 PLATFORM

3 temporary pancake where installed to provide storage areas on TCP2 (pancakes 945-946-947). In addition part of 941 was used during Hook-Up cold period.

Total area available: 750 m<sup>2</sup>

#### 5.3.1.2 ON THE FLOTEL

100 m<sup>2</sup> of open storage areas were made available to the contractor.

#### 5.3.2 WARE HOUSES

##### 5.3.2.1 On TCP2 Platform.

A Temporary module (948) was installed on the south east corner of the platform in order to provide offices and warehouses.

110 m<sup>2</sup> warehouse were then put at contractor disposal (500 kg/m<sup>2</sup>).

##### 5.3.2.2. ON THE FLOTEL

100 m<sup>2</sup> storage area plus a 200 m<sup>2</sup> workshop with gantry crane were put at contractor disposal.

#### 5.4 OFFICES

##### 5.4.1 ON TCP2 PLATFORM

Inside 948 module two offices (48 + 30) m<sup>2</sup> were at contractor disposal. Two offices (48 + 38) m<sup>2</sup> being kept for company use.

##### 5.4.2 ON THE FLOTEL

8 containers (4 desks each) were made available close to the bridge landing area for contractor and vendors purpose.

## 5.5 CRANES

- 5.5.1 On TCP2 platform the buchyrus crane located on mod. 04 (Treatment part) was made available for compression hook-up.

The Nylands verksted crane type 30/10 tone located on mod. 32 (compression part) was reputed as available from start of the job. In fact we encountered a lot of problem with it.

In addition a temporary manitowac crane had been installed on the south east corner of the platform in order to ensure full coverage of storage areas and workshop on TCP2.

### 5.5.2 ON THE FLOTEL

Two PHB offshore type cranes were available on the flotel, one of them able to reach landing areas on TCP2.

## 5.6 TOILETS

Toilets were available on TCP2 platform: 20 additional toilets were available on the flotel close to the bridge landing area.

## 5.7 COFFEE CONTAINERS

4 coffee containers have been installed on the flotel close to the bridge landing area plus one as spare in case of flotel disconnection.

## 5.8 TRANSPORTATION

### 5.8.1 PERSONNEL

- A) Home - Stavanger - transportation of contractor personnel was taken care by the contractor and corresponding costs included in their rates. A caravelle type plane was chartered for the french personnel every week during the Hook-Up hot period. Other planes were also chartered for the Norwegian personnel from Trondheim, Oslo or Kristiansand.
- B) Stavanger - Frigg Field: By helicopters with an average capacity of 18 persons.
- C) Treasure Supporter - TCP2 when T.S. was not connected to TCP2 the personnel had to be shuttled by helicopter before and after the working hours, this situation is responsible for approx. 20000 lost hours.

### 5.8.2 MATERIAL

Material and equipment for Hook-Up works were shipped to TCP2 by means of supply boats.

During the period from June to December one additional supply boat was added to the one already used for field. Then there was 3 travels each week (monday, wednesday, Friday) departure from Stavanger.

#### 6.2.6. COMPUTER FOLLOW-UP SYSTEM

In order to have a close follow-up of all operations it was decided to use a computer system. Even if the final decision was only taken in late October 1979, the use of the computer was made possible as tasks sheets numbering was done in view of computer use since the very beginning of preparation phase. Also, all prices in contract price were codified in view of computer use.

#### 6.1 CONTRACT BIDS STUDY

Programs were developed in order to be able to compare bids pancakes.

It took two operators during one week and a half to put in all bidders informations (6 bidders). Then all elements printed out have been used as technical back-up to the bid analysis pancake and permit to save calculation and typing time.

Main printed out documents were:

- price and estimated time comparison for each task for all bidders.
- minimum/maximum price for each task or unit rate
- by bidder recapitulating of each price, classification by discipline.
- by bidder calculation of combination of unit rates according to representative scenario.

#### 6.2 PERSONNEL FOLLOW-UP

Programs were developed to trace all personnel involved with the offshore works.

The aim were:

- issuing on a daily base of pre-printed time sheets forms.
- issuing on a daily base of the personnel on board list to be sent to the client.

### 6.3 PLANNING FOLLOW-UP

To each task was attached one "UOE" (unit of effort) indicating of the relative work required for each task sheets in respect of the works.

Programs were developed to summarize and classify total "UOE" and to keep an updated clear view of amount of work to be done, and also during, the course of the works to update the remaining amount of works to be done.

### 6.4 COST FOLLOW-UP

From time sheets filled in offshore and according to tasks approved as being completed it was possible to issue, on a weekly base, support documents for invoicing.

### 6.5. STATISTICS

Statistics reports were printed out from computer.

#### 6.2.7. MATERIAL

A material follow-up documentation was performed for use by the material section. Documents issued as follows:

- A material sheet per task including the following information:
  - a) list of material required for a task (excluding the material supplied by the Hook-up contractor)
  - b) identification of each item on the list
  - c) requisition number of each item
  - d) origin of the material
- Material summary sheets for Company supplied bulk material with information required for their stock follow.up.

Instructions and/or drawings were sent to respective yards for marking of itemized Company supplied material, as well as each piece of material which was to be sea-fastened on modules and pancakes with their exact location. Drawings were later on transmitted to the hook-up contractor for their own use.

To be noted that recollection of material from yards, receiving of material in Stavanger stores and shipment to Frigg Field have been made by a team out of hook-up manager responsibility, 50% of this team being even outside compression responsibility.

#### 6.2.8. PRECOMMISSIONING PREPARATION

The basic idea was to perform precommissioning and commissioning as much as possible on yards.

Positive consequences see were:

- Anything done onshore was not to be done again off-shore.
- The exact status of each yards construction was to be known.

Preparation of precommissioning form and documentation in mechanical, electrical and instrumentation disciplines had been asked for and were performed by the hook-up preparation team under direct supervision of the Commissioning/Start-up Manager. Documentation was split per system or sub-system.

In the piping discipline hydrotest documentation preparation was performed by the hook-up preparation team and under engineering supervision.

#### 6.2.9. YARDS PUNCH LIST

It was planned that hook-up preparation team should finalize task sheets due to works remaining from yard with following informations:

- exception reports in structural, piping, mechanical disciplines to be issued from yards managers.
- precommissioning documents in electrical and instrument disciplines to be filled in by the EAN Management Team.

## 6.2.10. ORGANIZATION AND MANPOWER HISTOGRAM

### 10.1 ORGANIZATION

The hook-up preparation team was created (June 1978) two years before starting of actual offshore works (June 1980) and during 18 months (from January 1979) was completely integrated inside the EAN Management group.

During the main yards construction period (June 1978 - December 1979) the team was under the construction manager responsibility and then (from January 1980) under the direct project manager responsibility.

#### 10.1.1 HOOK-UP MANAGER

Hook-up manager was responsible for the overall project preparation. main objectives and procedures definition and contract preparation. Was also responsible on compression side of the coordination of all activities related with offshore works such as lifting preparation (OCD Management), platform preparation (EAN Eng. department studies, OCD works), flotel contract and technical preparation (administration department responsibility)

Time spent: 24 months ie: 4 300 HRS.

#### 10.1.2 TECHNICAL PREPARATION TEAM

This team was responsible of the preparation of technical dossiers:

- hook-up task sheets
- precommissioning dossiers
- call for bid and contract technical dossiers

The hook-up team made some recommendations to the engineering but never made engineering itself

Time spent: 190 months/men ie: 33 000 HRS which  
can be split as follows:

- technical hook-up dossiers: 22 400 HRS
- elec. inst. mechanical precom dossiers: 7 400 HRS
- piping, hydrotests dossiers: 3 200 HRS.

To be noted that due to the continuous engineering  
changes task sheets had to be changed and altered  
too many times and more than 10 000 hook-up preparation  
could have been saved with a simply "normal engineering".

### 10.1.3 PLANNING FUNCTIONS

The project planning coordination has been involved with hook-up preparation phase partly from May to October 1979 (1/3 time), from October 1979 to February 1980 (1/2 time), and full time from February 1980.

Time spent: 1 200 HRS.

### 10.1.4 COST FUNCTION

The cost control engineer was involved for about 500 HRS with hook-up preparation.

### 10.1.5 MATERIAL FUNCTION

From February 1980, one material coordinator from material section was used for material transfer paper works preparation.

Time spent: 700 HRS.

### 10.1.6 CONTRACT COORDINATOR

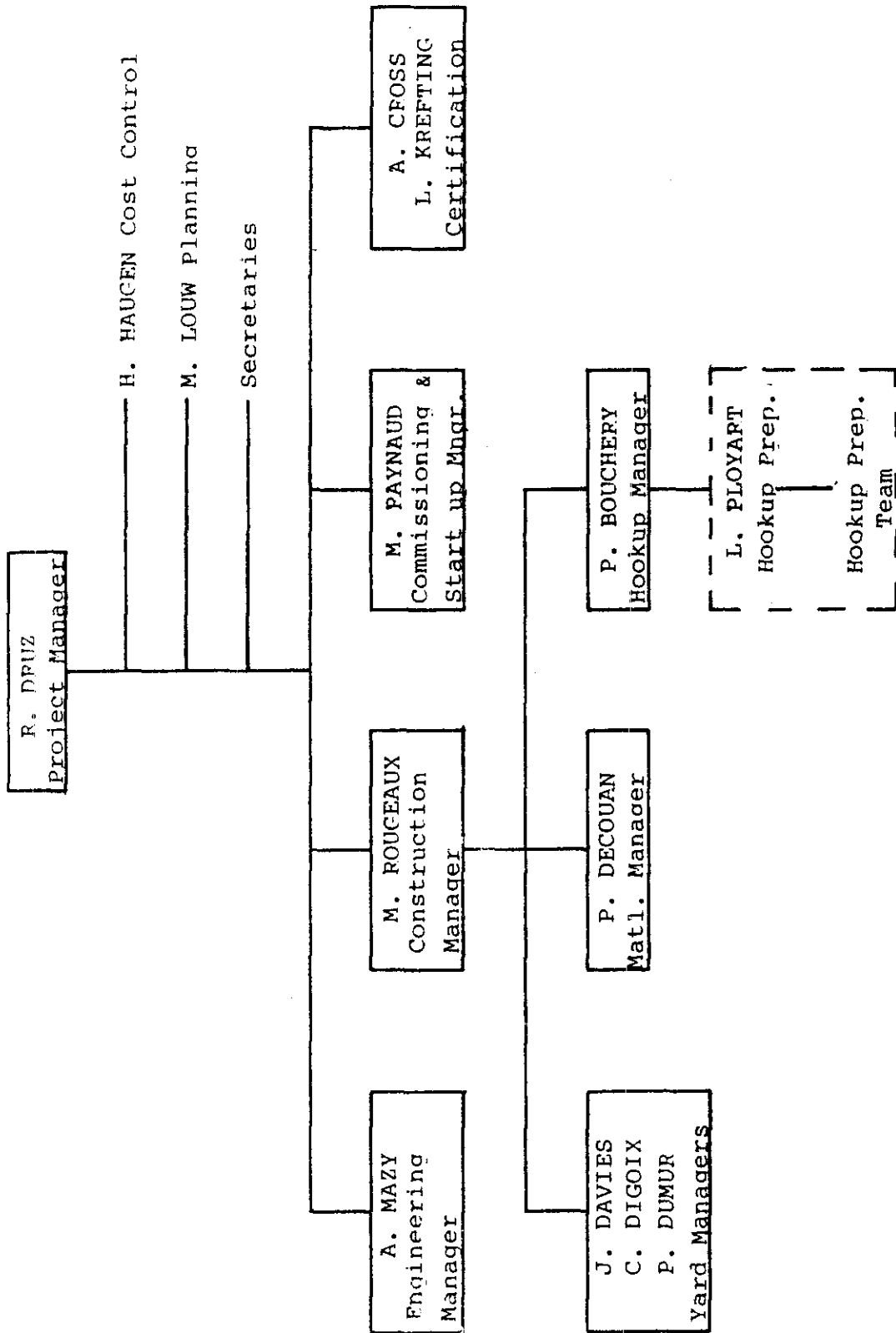
The help of a contract coordinator was needed during call for bid preparation and contract finalization.

Time spent: 500 HRS

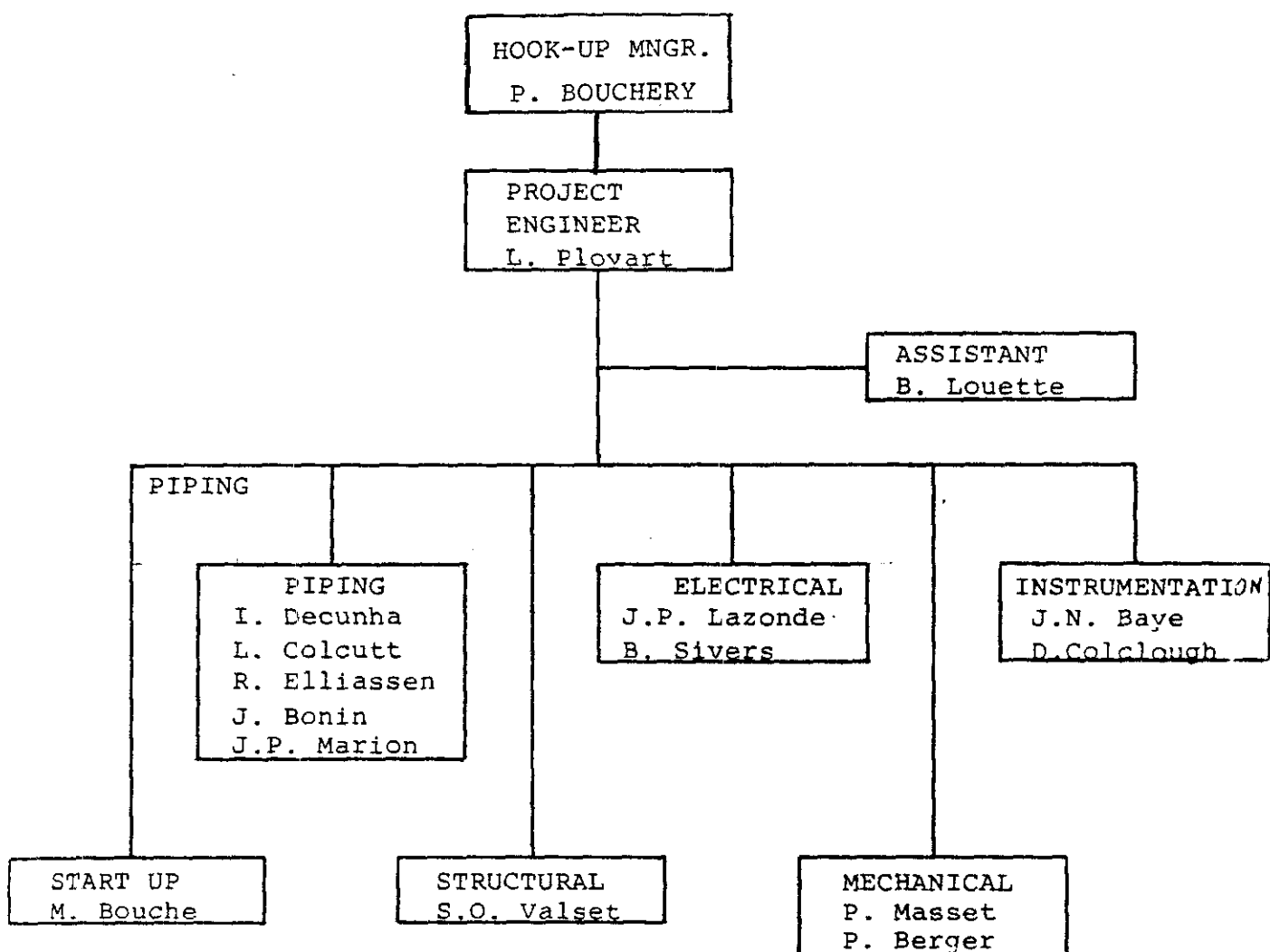
### 10.1.7 HOOK-UP ADMINISTRATIVE

The day to day coordination with EAN Frigg Field organisation was done by a hook-up administrative assigned from March 1980.

Time spent: 500 HRS.



# HOOK-UP PREPARATION ORGANISATION CHART.



During the main hook up preparation the above mentioned team was inserted into the client organisation, details of which are indicated on the following page.



### 6.3 ORGANIZATION OF WORKS

### 6.3.1. OVERALL PRESENTATION

#### 1.1. MAIN OBJECTIVES

The main objectives were:

- a) To permit the restart of TCP2 treatment from September the 15th.
- b) To complete main hook-up activities by the end of the year.

#### 1.2. MAIN EVENTS OF HOOK-UP

The lifting of modules and pancakes was performed with the BALDER, semi submersible lifting rig of HEEREMA from May the 24th.

The Treasure Supporter Flotel rig was made available only on June the 9th and hook-up people had to be accommodated on the "Berge Worker" derrick barge (ex - Sea Troll) in the beginning. The first people were actually sent to Frigg on this barge as there was a helicopter pilot strike during the 4 days following the lifting.

The hook-up started on May 30th (connection date of the bridge Berge-Worker/TCP2).

Treasure Supporter replaced Berge Worker on June 9th. Setting up and connecting gangway during the night. No time lost.

From July 4th to July 17th the site was completely stopped due to the strike of safety personnel in the Norwegian part of the North Sea. Hook-up personnel was kept in stand by on the Treasure Supporter.

From July 31st to August 2nd piping subcontractor was on strike.

From August 28th - August 29th part of Hook-up personnel was on strike.

In addition from mid July to mid September there was several "go slow" actions which deeply disturbed the works proceeding.

However, from mid September all activities related with restart of TCP2 treatment were successfully completed.

Placing in gas of TCP2 treatment took actually place on October 2nd and production started on Sunday, October the 10th as per schedule.

At the end of the year all hook-up activities were completed except:

- a) part of lately defined works by engineering (works defined after end of October).
- b) remaining painting works due to stoppage of all painting (sandblasting!) activities at the end of October at commissioning request (not to jeopardise important mechanical works)
- c) flare piping completion due to late delivery of one 18" Te.
- d) one sea water pump installation due to late delivery
- e) some fire resistant cables due to late delivery

At the end of February all punch lists were cleared out, the flotel was removed from the Field and Hook-up management group ended its mission.

### 1.3. MAIN HOOK-UP PERIODS

#### 1.3.1. So called "lump sum period"

The so called "lump sum period" took place from June to December 1980.

During this time most of the works were performed on a lump sum base with task sheets as technical support.

This period was splitted as follows:

1.3.1.1. Cold period.

From the beginning to the end of September there was no gas on the platform.

1.3.1.2. Hot period.

From gas in of treatment part (beginning October) until the end of the year.

At that time specify safety requirements were in force and mainly the number of people allowed to be on the platform at a time was limited.

1.3.2. So called "hourly rates" period.

At a time it became obvious that it was not more possible to increase the number of tasks (connected with the lump sum contract) as:

- a) The nature of remaining additional works was such that they had to be done on hourly rates (mainly details and modification works)
- b) The volume of remaining additional works should involve a limited number of people for which the contractual lump sum was no more valid.

Accordingly when all workable tasks were completed (December) the lump sum period was declared as closed and the "hourly rate" period started. It lasted from December to end of February.

## 6.3.2. ORGANISATION AND FUNCTIONS OF TEAMS

### 2.1. PARTIES

- Client: Elf Aquitaine Norge A/S acting for and on behalf of a consortium composed of EAN NORGE A/S Total Marine Norsk, Norsk Hydro and Statoil.
- Management: Elf Aquitaine Norge A/S
- General contractor: UIE NORGE

### 2.2. UIE RESPONSIBILITY Offshore works contract S 984

The offshore works contract was awarded as a lump sum job to UIE NORGE in competition with other contractors.

Basically S 984 contract covered Hoo-Up and pre-commissioning works until the "ready for commissioning" phase but UIE performed all posterior works ie: commissioning and assistance to Start-Up mainly.

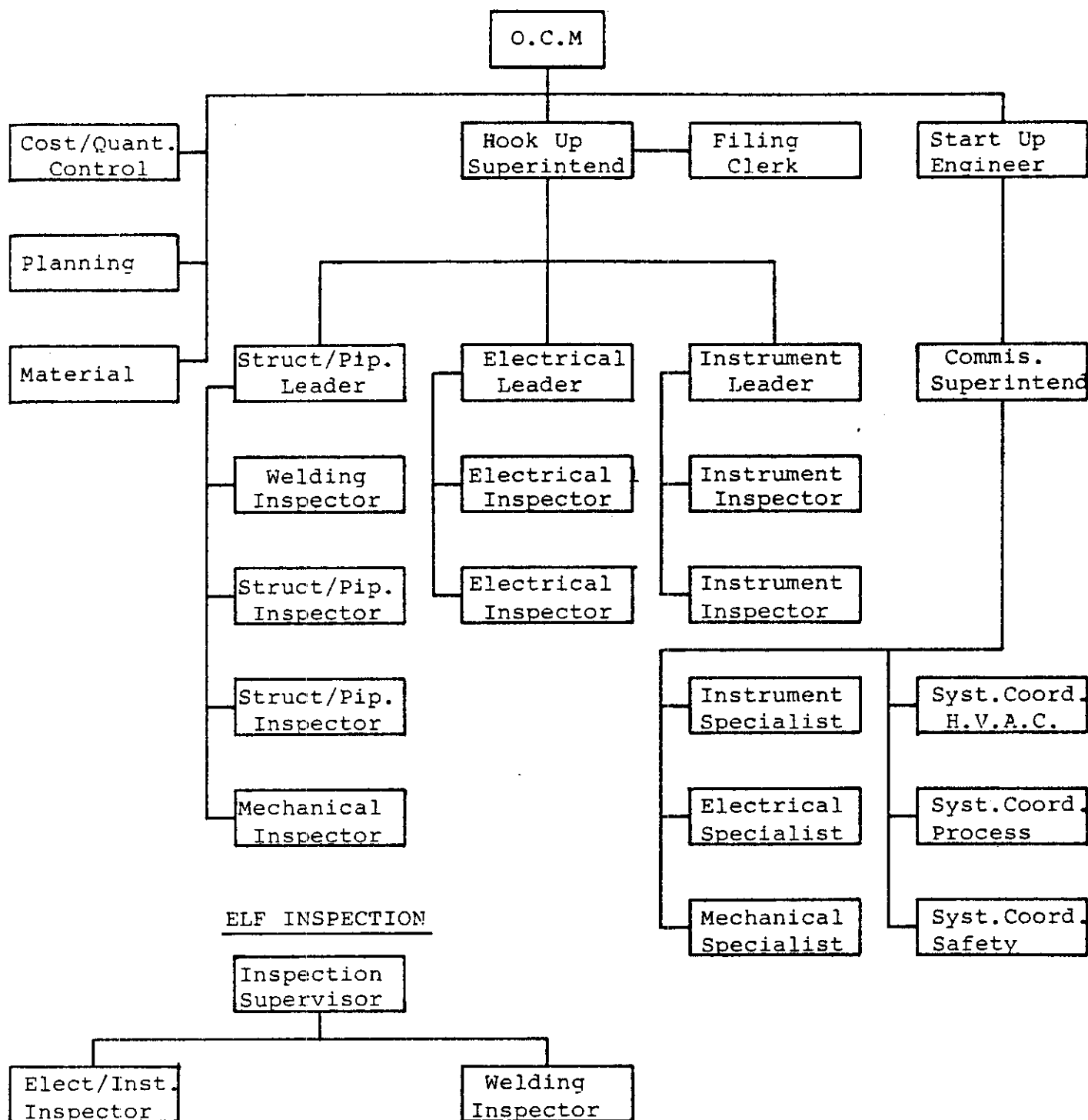
### 2.3. ORGANISATION CHARTS

Refer to attached organisation charts.

## PRESENTATION OF OFFSHORE ORGANISATIONS

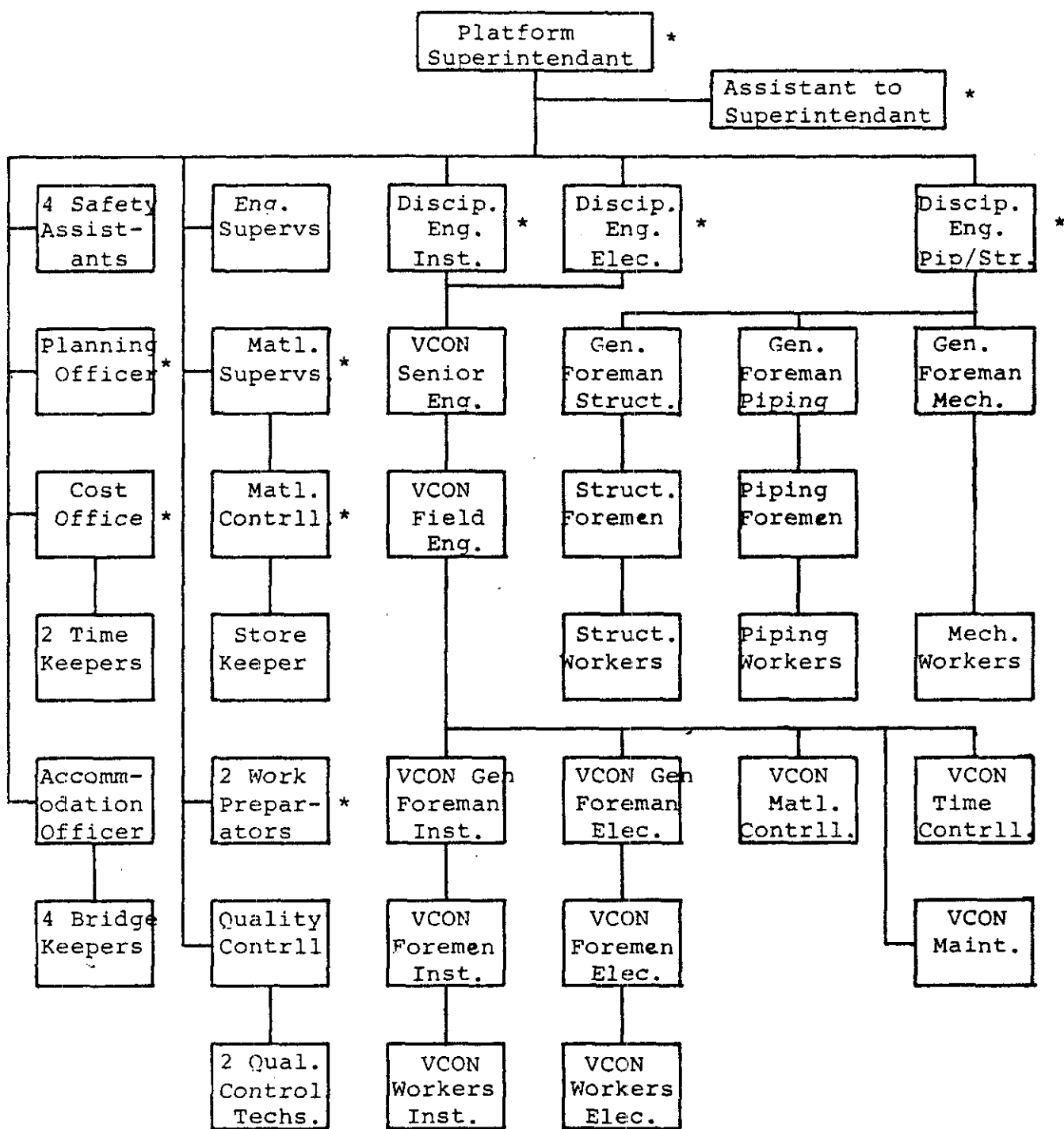
LEAN SUPERVISION TEAM

The organisation chart was as follows.



# CONTRACTOR ORGANISATION

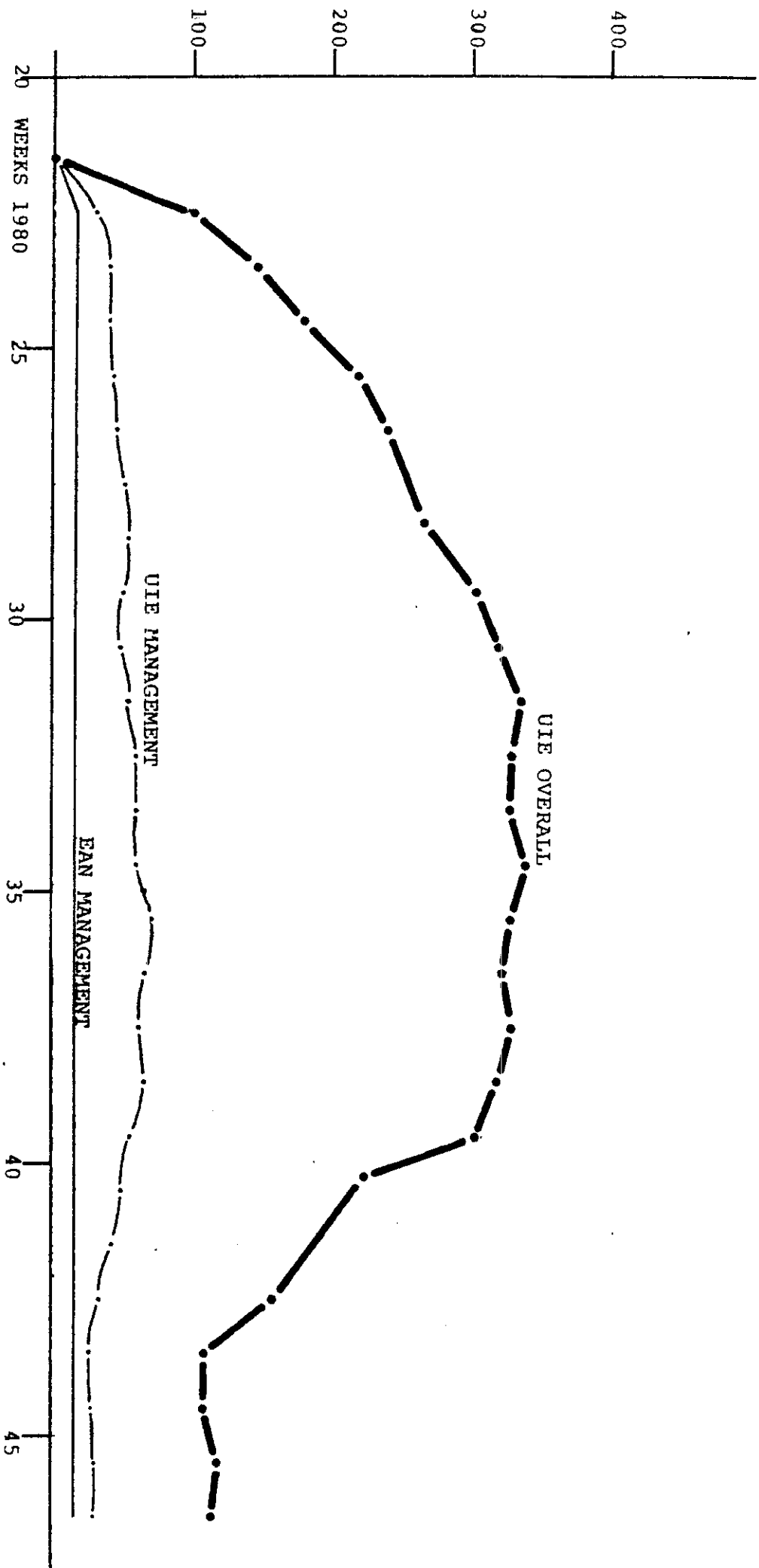
The contractor offshore organisation was as follows.



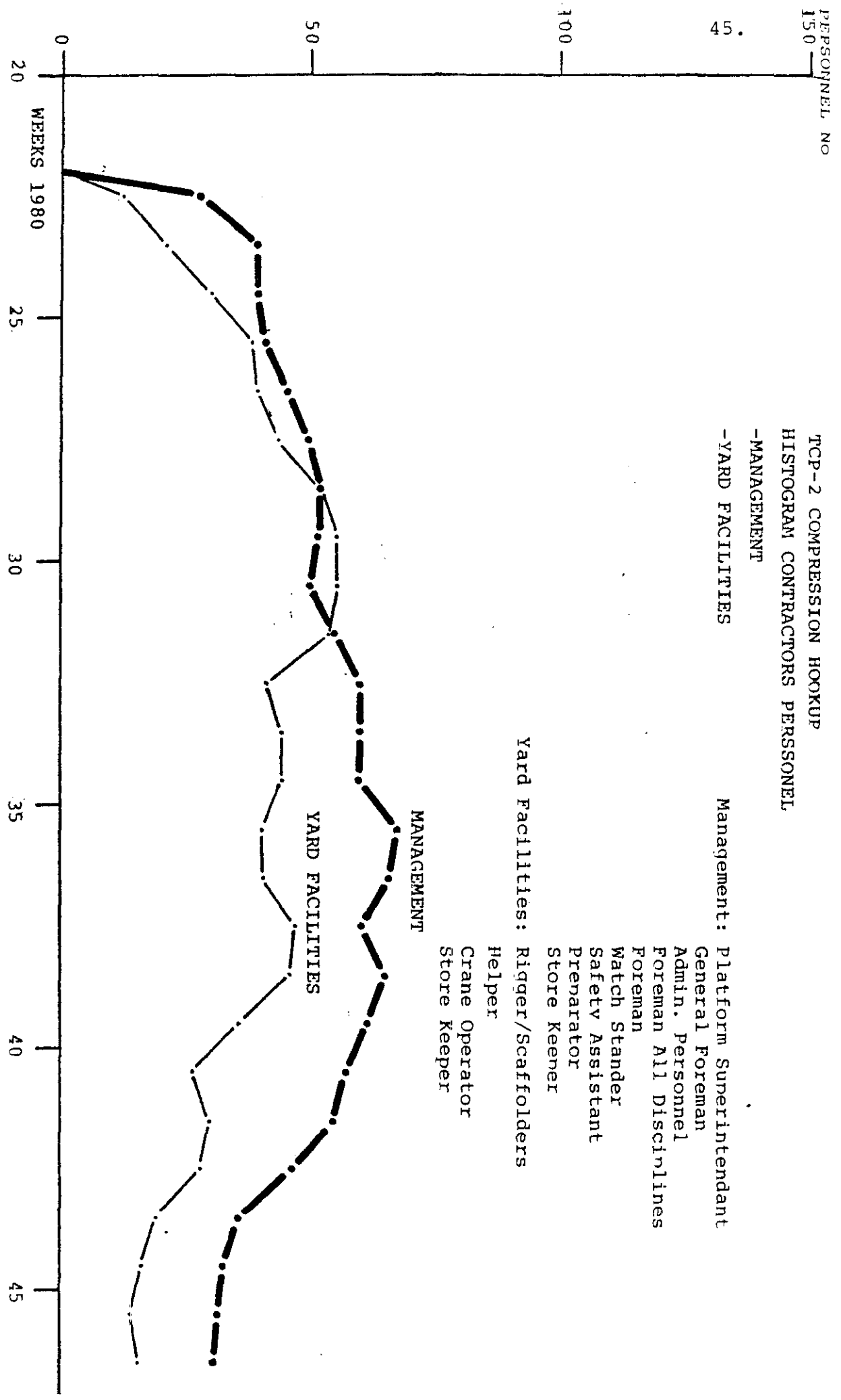
NOTES: VCON= Instrument and Electrical Subcontractors.

\* = French.

TCP-2 COMPRESSION HOOK UP  
HISTOGRAM CLIENT/CONTRACTORS PERSONNEL  
OVERALL CURVES



TCP-2 COMPRESSION HOOKUP  
HISTOGRAM CONTRACTORS PERSONNEL



-MANAGEMENT  
-YARD FACILITIES

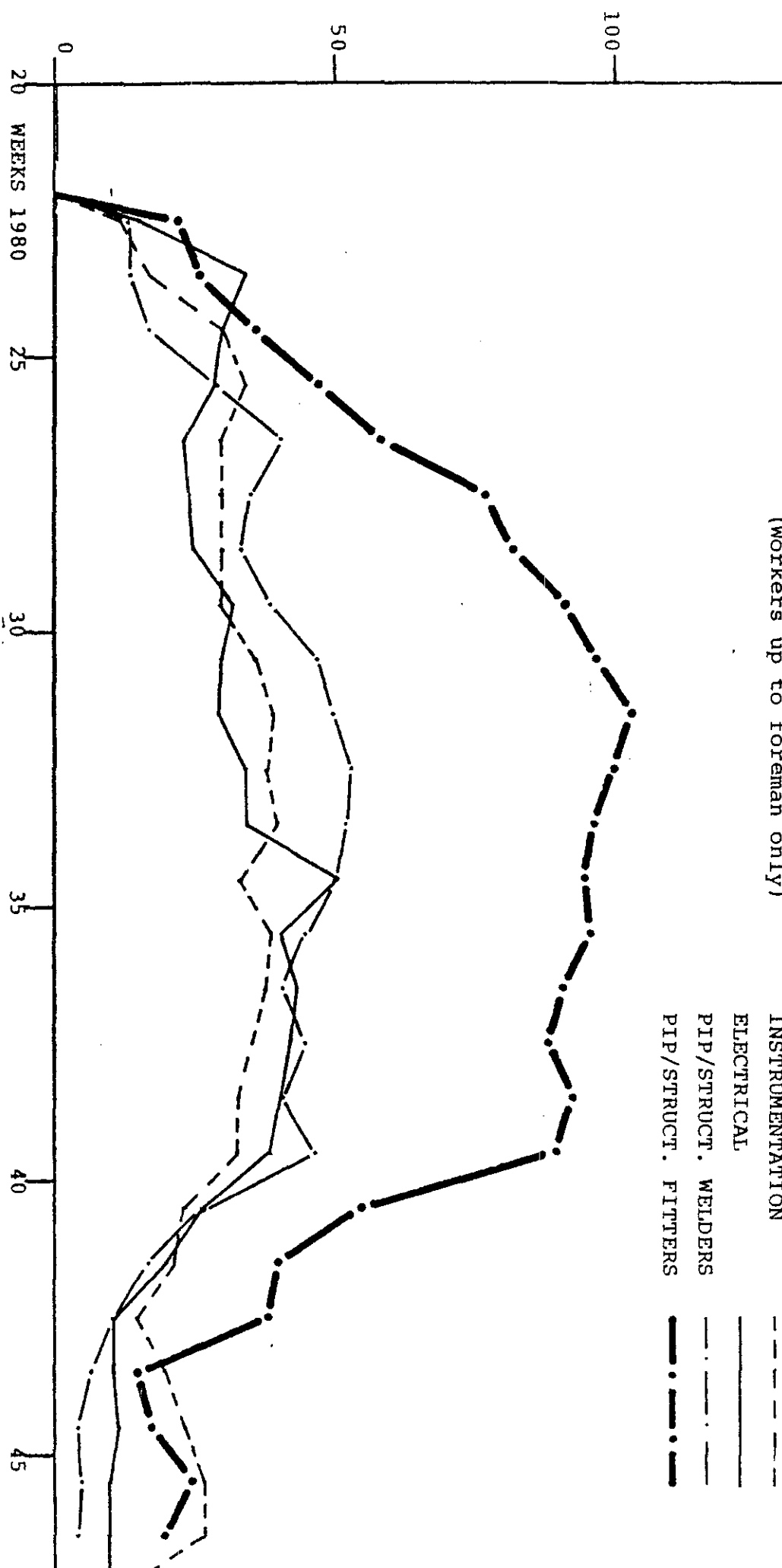
- Management:
- Platform Superintendent
  - General Foreman
  - Admin. Personnel
  - Foreman All Disciplines
  - Foreman
  - Watch Stander
  - Safety Assistant
  - Preparator
  - Store Keeper
- Yard Facilities:
- Rigger/Scaffolders
  - Helper
  - Crane Operator
  - Store Keeper

MANAGEMENT  
YARD FACILITIES

**ELECTRICAL  
STEELWORKS**

(workers up to foreman only)

INSTRUMENTATION  
ELECTRICAL  
PIP/STRUCT. WELDERS  
PIP/STRUCT. FITTERS



6.3.3. Computer use.

A computer terminal was installed in the onshore management offices and an another one offshore.

Telecommunication were done through the satellites lines. The system was proven to be feasible.

In puts were made offshore, treatments were made offshore treatments were mande onshore.

The offshore terminal was kept from end May to end December.

6.3.4. Tasks sheets follow-up progress reports.

All tasks were entered with an estimate of points ( corresponding roughly to the productive and non-productive hours).

On a weekly base the percentage of completion by task was established by offshore EAN Management team. This progress was put in computer and overall progress reports could be issued very soon.

The attached progress curves - must be used only as reflect of the site progress.

To be noted that even if tasks were amended offshore the points were not changed in order to avoid continuous updationg of computer sheets.

TCP2 COMPRESSION

## HOOK-UP PROGRESS

## REPORT

End of week : 49

Date : 07.12.80

DISCSUM 17:21 12/07/80

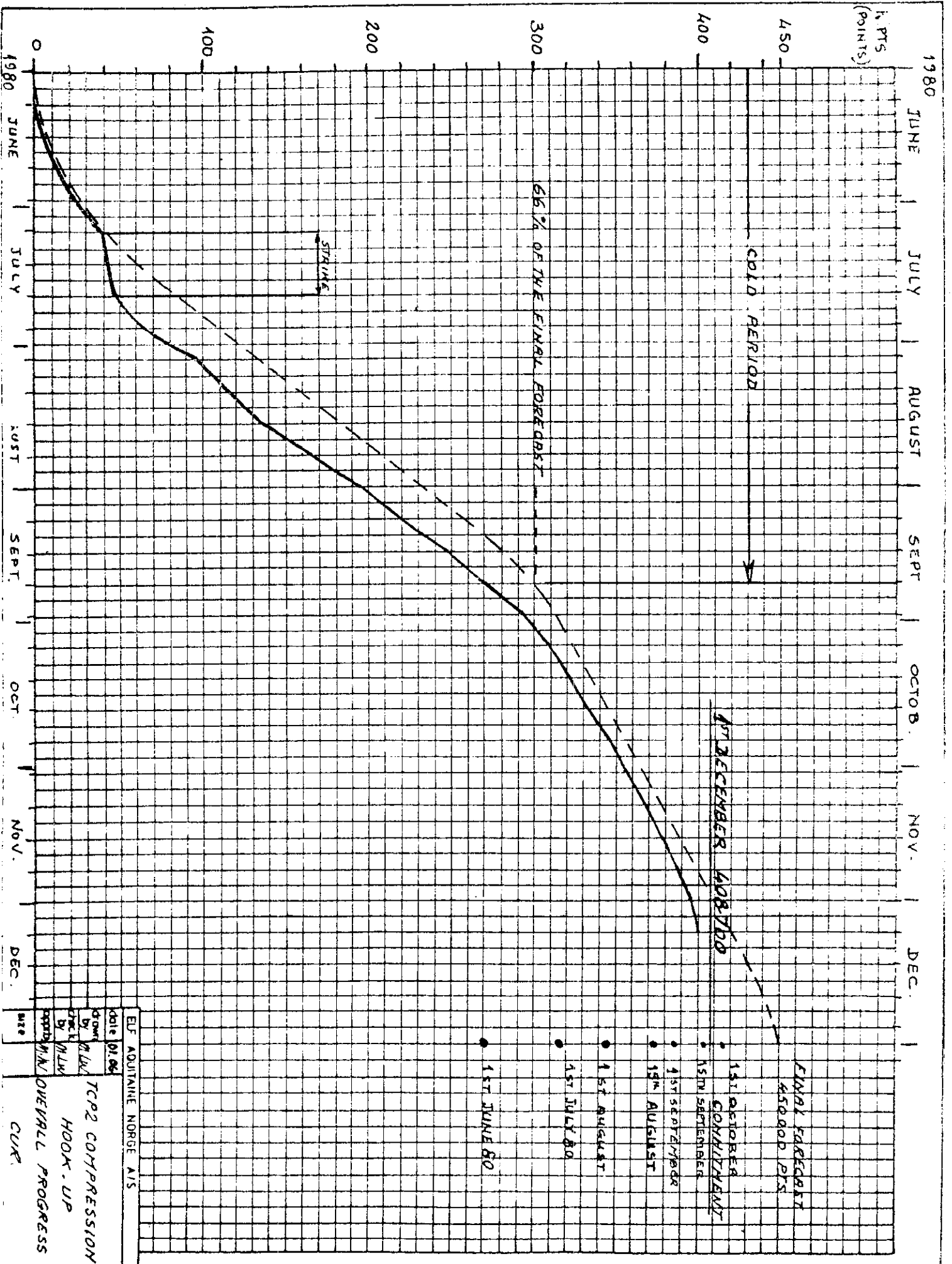
TOPS COMPRESSION - TRACK SHEET FOLLOW UP  
DISCIPLINE SUMMARY REPORT

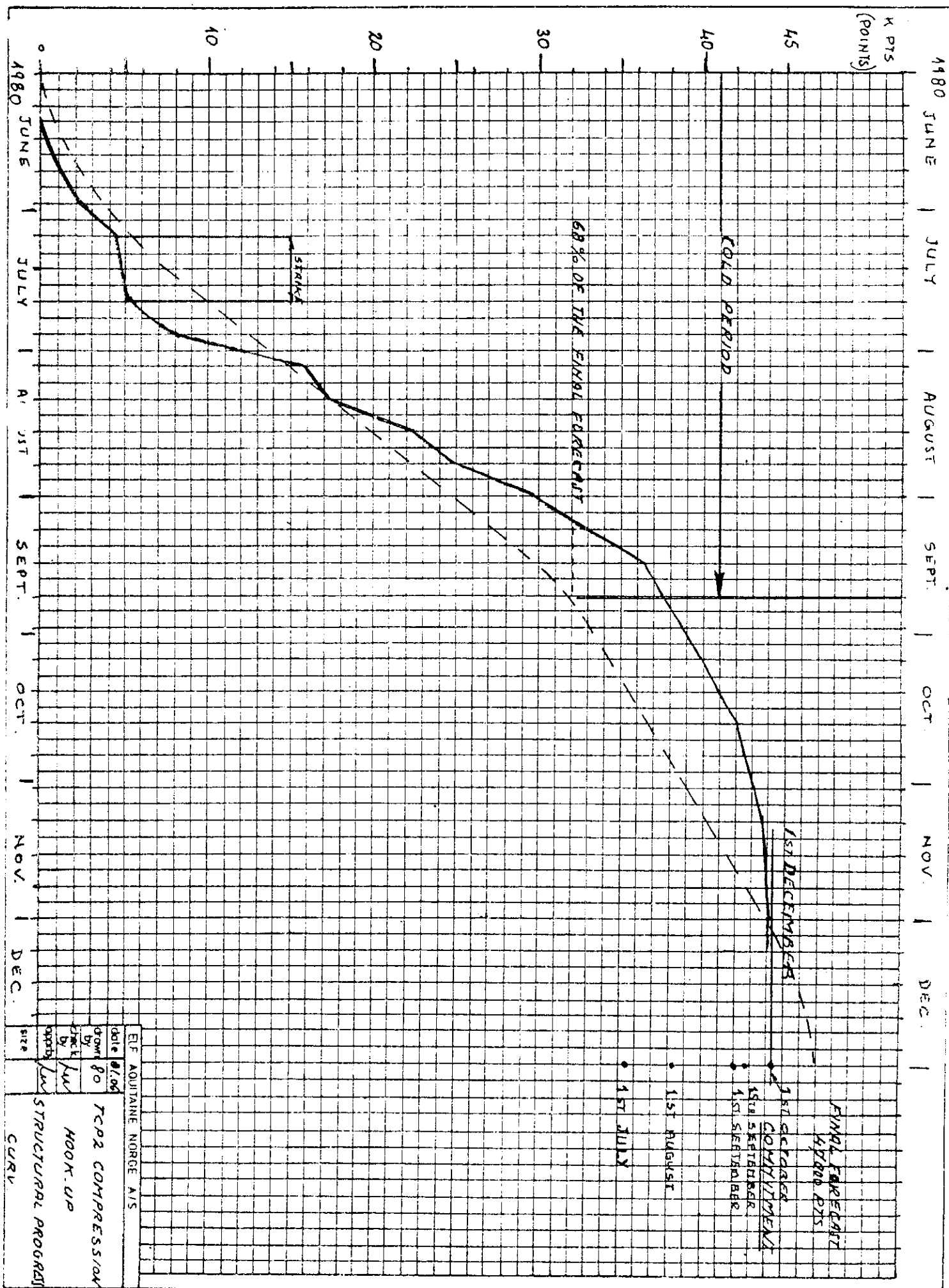
DATE: 80/12/05

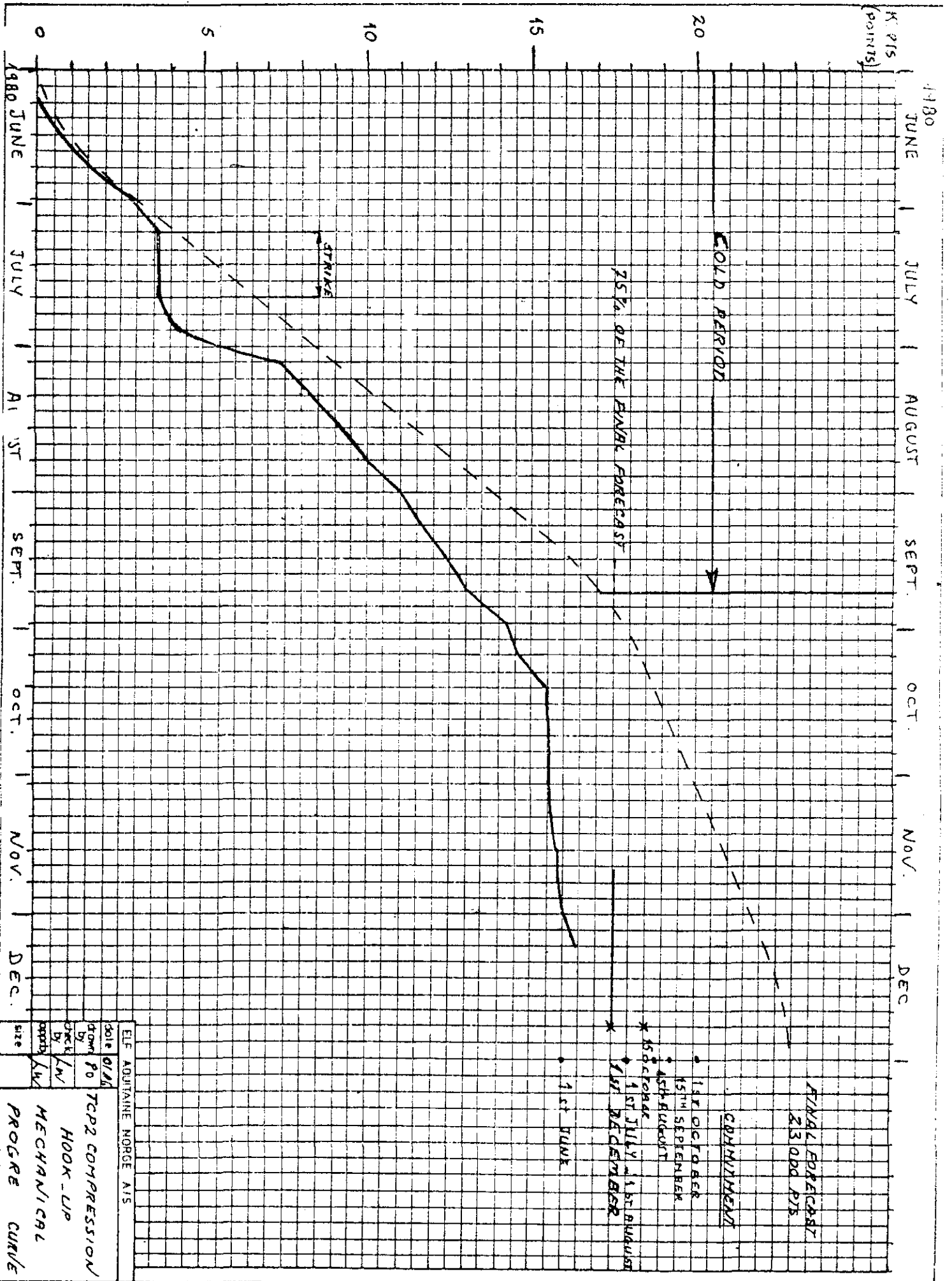
DISCIPLINE	TOTAL POINTS	POINTS NONE	NONE PERIOD	COM. %	TO BE NONE
F STRUCTURAL	44284	44084	38	99.5	200
C MECHANICAL	12484	16527	623	94.5	957
D PIPING	134492	133338	636	99.1	1161
E ELECTRICAL	104914	101874	1191	97.1	3040
G INSTRUMENTATION	96412	93692	1827	97.2	2719
S INSULATION	3044	1740	262	57.2	1304
H PAINTING	7999	7999	0	100.0	0
TOTAL ALL DISCIPLINES	408636	399254	4626	97.7	9382
	=====	=====	=====	=====	=====

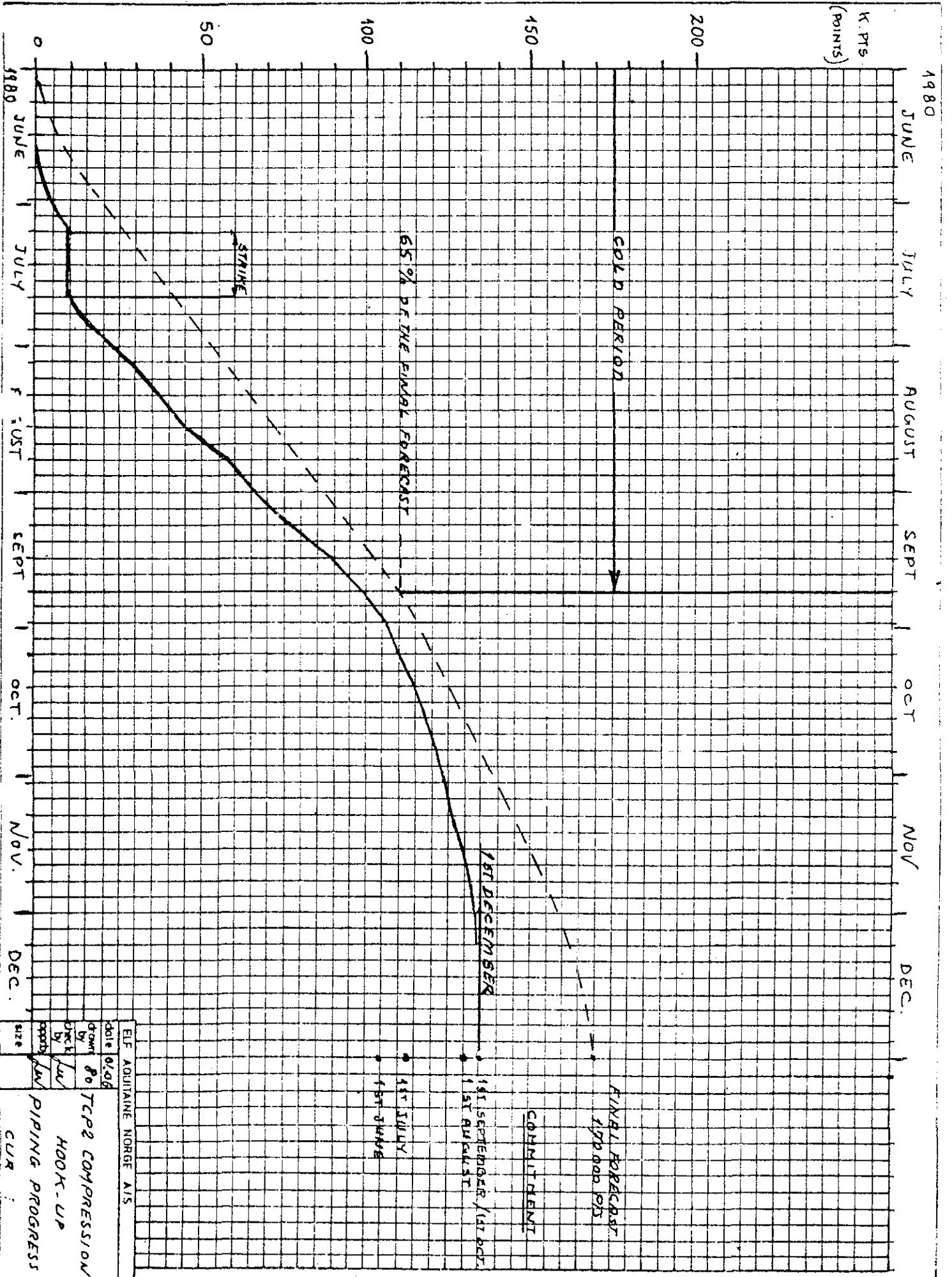
READY

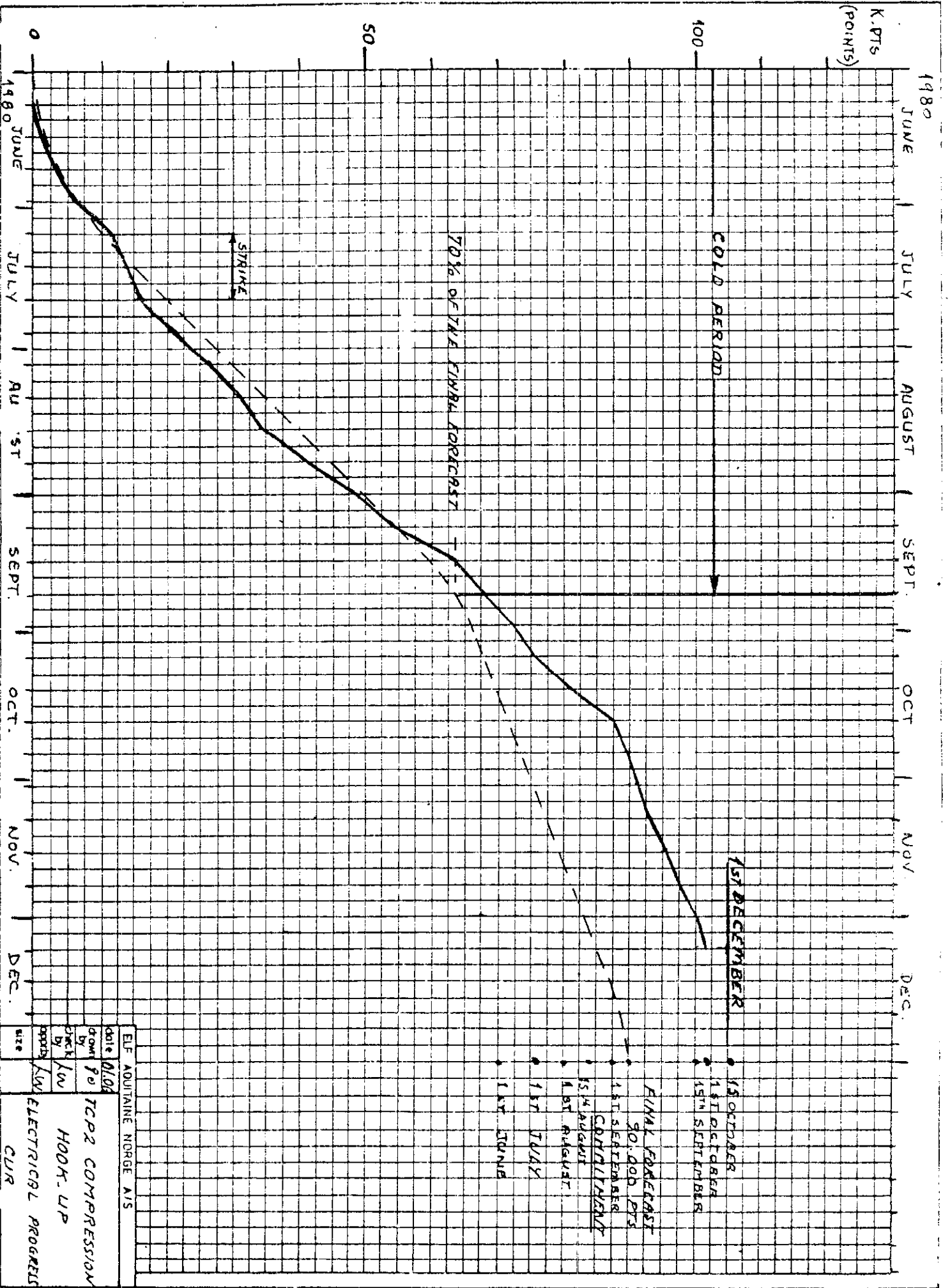
END OF WEEK 49



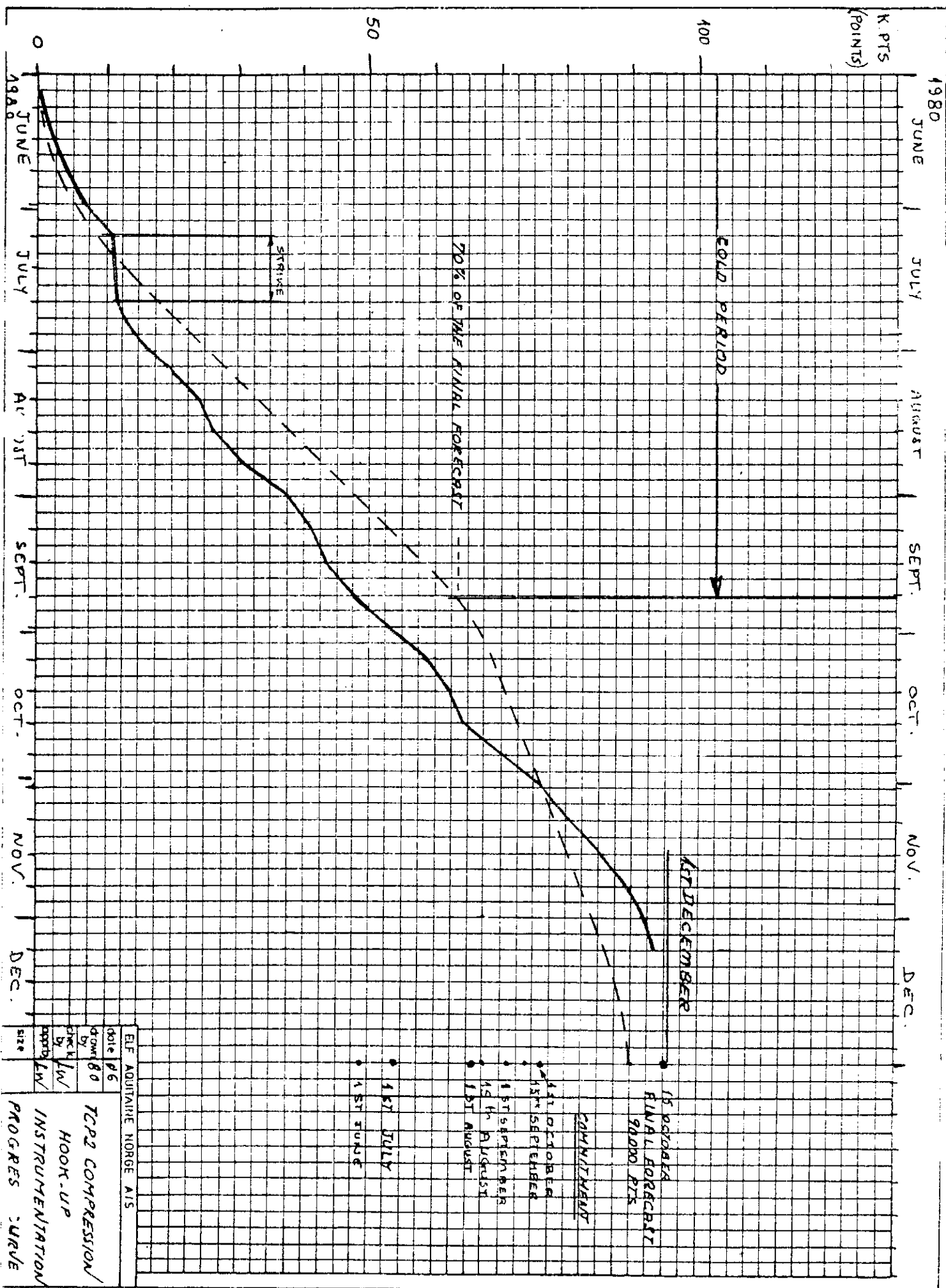








ELF ADUTTAINE NORGE A/S  
 date 01.08  
 drawn by Jw  
 checked by Jw  
 project Jw  
 size  
 TCP2 COMPRESSION  
 HOOK-UP  
 ELECTRICAL PROGRESS  
 CUR



6.3.5. Costs progress reports.

5.1 Task sheets.

Tasks could only be reported as 100% completed when the task was stamped "completed" and approved as being such by the EAN Hook-up superintendant.

Contractually tasks were paid when approved as completed (there was no payment linked with percentage completion except 100%).

On a weekly base it was possessed to print out from computer the weekly cost report (Tasks/that was used as support document for invoicing).

5.2 Unit rates paid personnel and equipment - stand by.

The preprinted daily time sheets forms were filled in and approved offshore. Then all hours approved were put in computer (offshore).

On a weekly base it was issued a weekly cost report (Personnel - equipment stand by) that was used as support document for invoicing.

6.3.6. Material follow-up.

Bulk material was contracor furnished.

Main material and equipment was delivered by EAN.

Each task sheet included a material take-off. Therefore each material was identified by a task number and an item number.

The EAN management material section was in charge of collecting task sheets and to issue corresponding material movement sheets to the Purchasing Department.

6.3.7. Commissioning - Start up assistance.

Most of commissioning and start-up resources were taken from the main hook-up contractor forces.

To be noted that hook-up, commissioning and start up activities were in fact, closely linked due to the nature of the works and the obligation to have systems running from the very beginning of the hook-up period.

Commissioning and start-up assistance teams were under the direct management of EAN start-up manager and were at hourly rated cost.

6.3.8. Vendors assistance.

Vendors assistance was requested for:

- Assistance to installation of main mechanical items (pumps mainly).
- Assistance to commissioning of main equipments.
- Direct contract installation and/or modifications to specific equipments such as:

Sea water piping, electrical shut down modification.

6.4    H O O K   U P   S U M M A R Y .

## HOOK-UP MANHOURS - CONTRACTOR: UIE NORGE

SPENT				ESTIMATE	
	June - Dec. 1980 Works Assistance to commissioning	January - February 1981 Works Assistance	Feb. 1980 - Hook-up bid analysis	Tasks defined	Additional tasks
Structural	65.000			20.420	20.000
Piping	103.000	13.000		102.000	50.000
Mechanical	16.000	10.000	13.000	21.000	10.000
Electrical	55.000	17.000	5.700	50.600	50.000
Instruments	73.000	14.000	8.200	24.000	80.000
Insulation/ Painting	8.000	13.500		16.000	65.000
Mob. - Demob	7.300				
Offshore Mngm Preparation	62.000	3.500			
Quality cont.	7.000				
Handling	35.000	1.000	600		25.000
Scaffolding	35.000				
TOTAL	466.300	42.000	27.500	234.220	300.000
July strike	45.000			Hourly paid	31.000
Offshore standby	23.500			Assist. Commission.	20.000
				Stand by	20.000
TOTAL	534.800	42.000	27.500	234.220	371.000
	576.000		91.500		
Total offshr.		668.300			605.220

CONTRACTOR: UTE NORGE

TCP2-C Hook-up

1980

MANHOURS

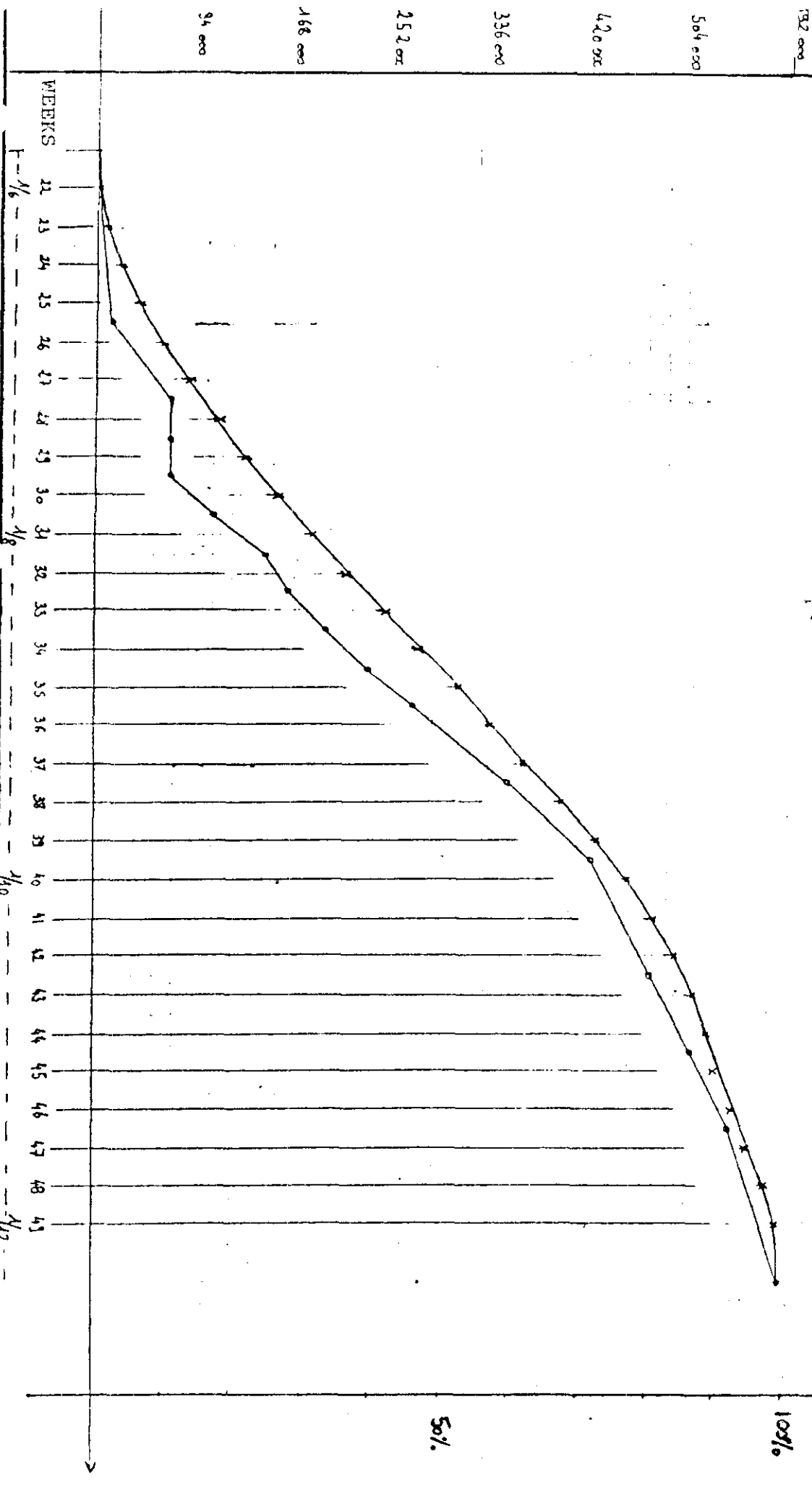
3

OFFSHORE MANHOURS  
PROGRESS

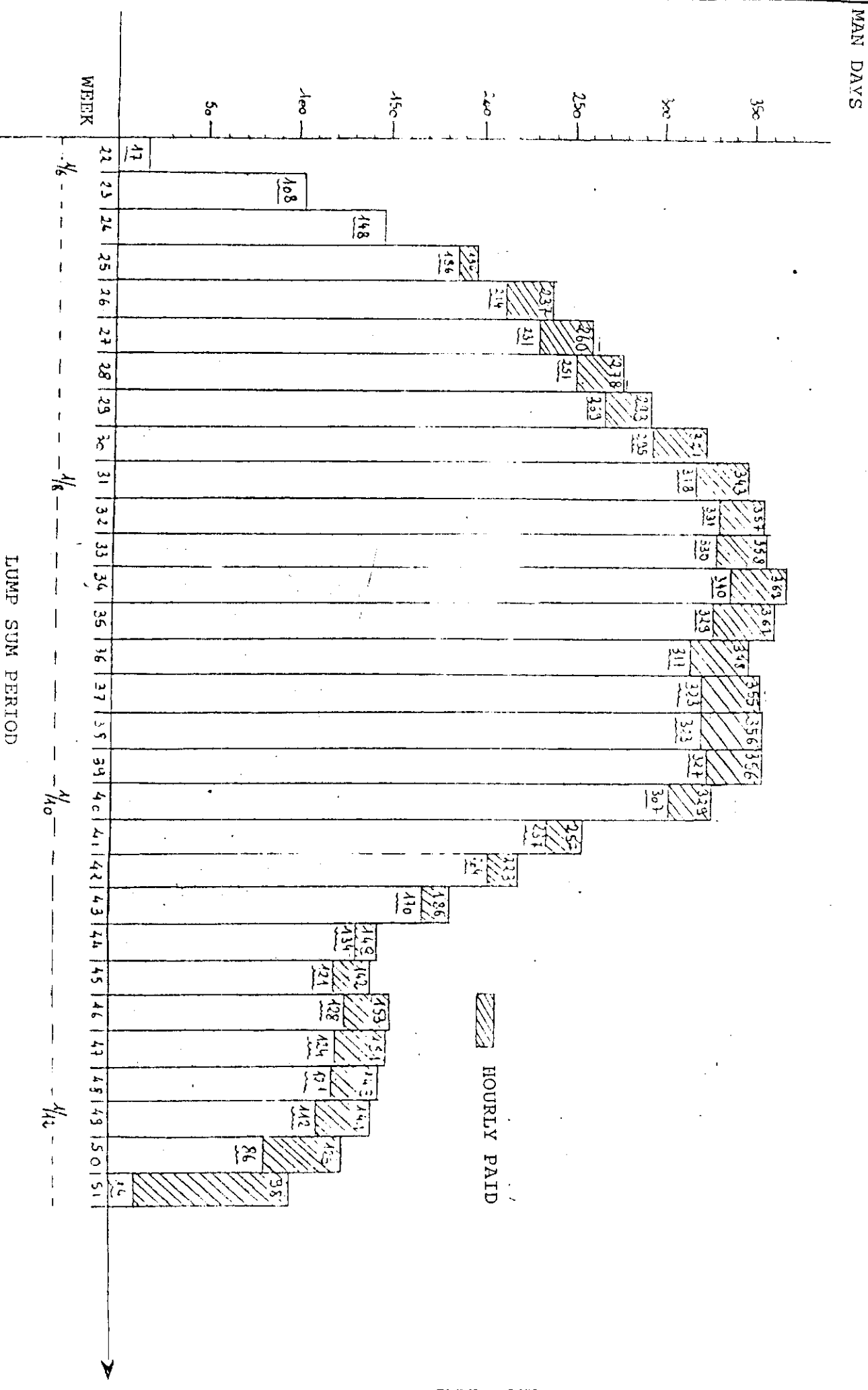
PROGRESS

50%

100%



JMP SUM PERIOD



1. Hook up works some informations

1.1	Onshore manhours	22.750	Management onshore works	19.600 3.150
-----	------------------	--------	--------------------------	-----------------

1.2	Average personnel offshore		Productive	198
	(lump sum period)	255	Non product.	59
	Maxi.:	369		

1.3 Quality Control (subcontractor MAPEL)

Average	5 $\frac{1}{2}$ men
Duration	18 weeks
No. of films	3707

1.4 Material installed during hook upElectricity

Cable trays	2800 meters
Power cables	5400 "
Control cables	31500 "
Earthing	2600 "
Connections	12000 units

Instruments

Cable trays	2900 meters
Polytube	3900 "
Cables	24500 "
Earthing	1400 "
Connection cables	28500 units
Connection polytubes	5500 "

Piping

Number of spools	736
Piping weight	167800 kg
Total length	3254 meters
Total welding length	825 "
Number of controlled welds	1293 units
Number of repaired welds	163

2. EAN hook-up management.'

Hook-up preparation (06/78 to 05/80)	30000 hours
Onshore management (06/80 to 02/81)	18000 "
Offshore management (06/80 to 02/81)	42000 "

---

90000 hours  
=====

## 6.5 PRECOMMISSIONING / COMMISSIONING START-UP

The scope of work of this section was to

1. Check the conformity of the installations against the specific ations (engineering and vendors documents, standard, rules....) and make preliminary adjustments Precommissioning
2. Make running tests of equipment and systems with simulated or real operating conditions Commissioning
3. Integrate the functions of the different systems in the operating logic according to design process parameters and make performance tests Start-up

The split in work has been done according to API 700.

Precommissioning, normally under construction or Hook-Up responsibility, has been given to Commissioning since the same company teams were involved in managing this work.

The main priority were the safety of personnel and equipment and the respect of planning.

If had been decided, in order to minimize offshore work, to perform as much as possible of precommissioning onshore, and even commissioning of some equipments.

The different phases of the works were the following:

- review of basic documents, definition of scope of work, of organization, of teams, preparation of Start-up and Operating manual, assistance to Training for training programs and manuals.
- Preparation of precommissioning and commissioning documents by a team shared with Hook-up.
- Hiring of personnel.
- Limited precommissioning / commissioning and assistance on yards.
- Precommissioning and commissioning offshore.

A) Chronology

October 1978. Installation of commissioning Start up section within the Compression project.

May 1979. Arrival of the first commissioning superintendant and beginning of preparation of precommissioning documents.

January 1980. Arrival of the first specialists and interventions on construction yards, very limited before this date.

April 1980. Arrival of the second commissioning superintendant.

May 1980. The commissioning team is complete and preparing offshore intervention.

June 1980. Beginning of offshore works during Hook-Up Arrival of Start-up engineers. Cold period.

October 1980. Gas in of TCP2 treatment. Hot period work.

December 1980. (end) The Start-up team is complete.

February 1980. End of Hook-Up. Transfert of remaining personnel to commissioning / Start-Up.

March 1980. First Start-Up of turbo generators.

April 1980. First Start-Up of line B turbo compressor.

May 1980. (end) End of commissioning organization, transfert of remaining personnel to Production Start-Up.

B) Precommissioning preparation:

A team, common with Hook-Up, began precommissioning preparation, in second quarter 1979.

From this date and for one year, the work was normally done for precommissioning, but was frequently interrupted for Hook-Up needs which had priority.

The first commissioning superintendant animated this team composed of:

electrician leader and one helper.

instrumentalist leader and one helper.

mechanical leader.

The work was heavy, especially for the instrument part, and in regard of the many revisions to be done.

Basic task sheets were established and then filled according to Engineering documentation to serve as check lists for execution personnel on yards onshore and offshore.

Simultaneously, the Commissioning Superintendant began with the first specialists and system coordinators the preparation of the Commissioning manual to gather all the different procedures and tasks sheets necessary to Commissioning. In the fourth quarter of 1979 a study was conducted to compare the feasibility of temporary versus definitive safety systems during Hook-Up hot period. Temporary safety systems were ruled out.

Instrumentation precommissioning preparation was incomplete due to late delivery of engineering documentation. Commissioning documentation and preparation was hardly begun before the offshore period, with the exception of electrical part, done by a commissioning specialist, for the same reasons: late delivery of engineering and vendor documentations.

Intervention on onshore contraction yards:

Intervention on yards began quite early with piping inspection, hydrotests follow-up, but was always very limited. There was nearly no precommissioning at all on the main onshore yard due to delays and hectic construction work up to the end. In fact the people hired for this job were transferred to construction to help.

The main notable exception was on yard no. 2 with the commissioning of the emergency electrical supply system, which was a key for starting the systems necessary for Hook-Up works, "hot period", and which was successful.

Offshore precommissioning and commissioning:

Work and supporting documentation has been organized along functional system lines.

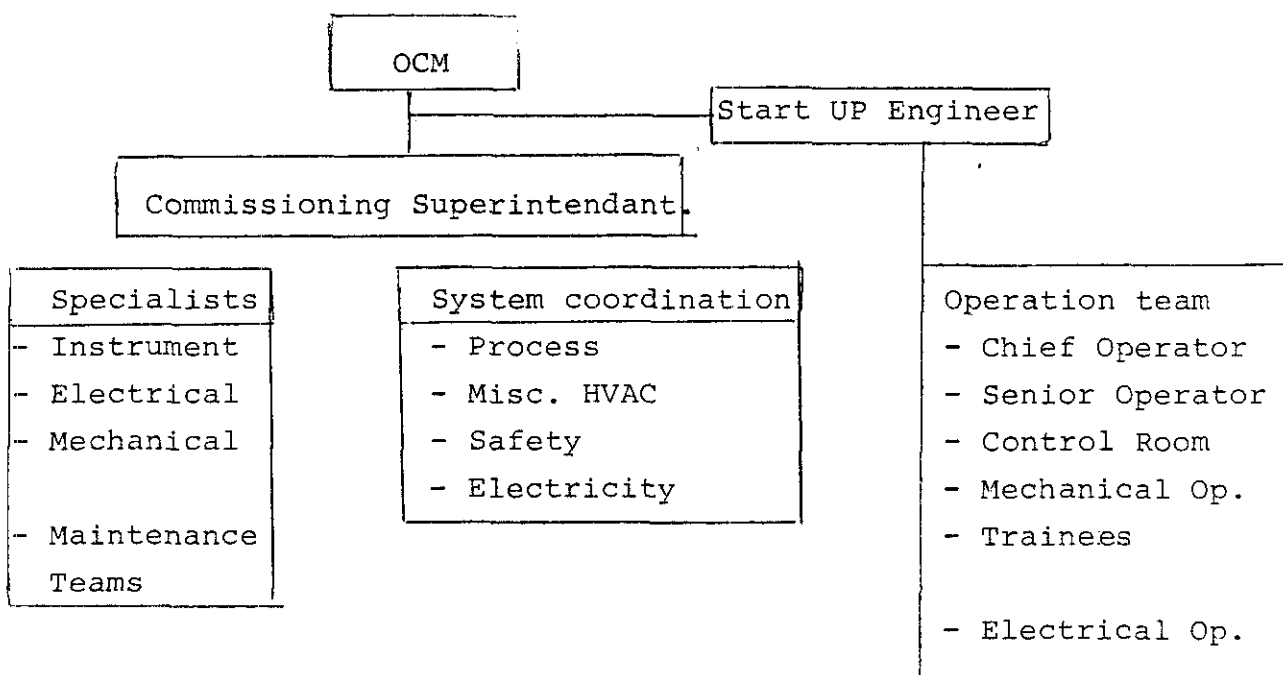
The commissioning team included system coordinators and specialists under commissioning superintendant supervision.

The Start Up team included production and maintenance people, that is the future operation team reinforced to avoid stress on normal Field manpower for supervision. This team is headed by a Start Up engineer.

Both teams work in close cooperation on the systems in their respective fields of capacity.

The overall coordination is done by the Start Up engineer.

These teams were offshore under the responsibility of the Offshore Construction Manager until the end of Hook-Up (End February 1980) and after that date under the Field Superintendent. They were management teams in charge of supervising and coordinating. Execution work (excepting start up) was done by teams of trade workers provided by contractors: instruments, mechanics, electricians.



- Commissioning team worked according to a two weeks on /two weeks off schedule.
- Operating team according to Field Production schedule.

During precommissioning the Hook-Up team was responsible for the equipments

When the precommissioning, in a system, was finished, (the part corresponding to Hook-up works being done by Hook-Up teams) the system was transferred to Commissioning. A certificate "Ready for Commissioning Certificate" signed by the involved parties, marked this transfert.

From this point, the rules in force on the Frigg Field were applied i.e. operation by Start-Up teams, work permit if relevant....

When the system or subsystem was successfully commissioned was transferred to the final responsables as per Frigg Field rules: Administration, Safety, Maintenance, Production. A "Final Acceptance Certificate" signed by the involved parties marked this transfer.

Start Up accepted on behalf of Production. Since this final transfert was to be supported by an adequate transfert of documentation: as build drawings, updated vendor data..... which were sometimes delayed, the Start-Up took charge of some systems during a transation period before their final responsables. This allowed for some flexibility and reduced the load on the Commissioning organization since the Maintenance works proved important (prevention or operating) on such a large installation during a rather extended period.

Offshore precommissioning and commissioning works were conducted in different phases according to program constraints. The main of which was the necessity of restarting the production part of TCP2 at the beginning of October 1980 and thus to have in service at this date all the systems allowing work in this kind of environment: while complying with the safety rules in force.

This first goal was achieved and at the beginning of October 1980 the following systems and subsystems were in service:

- Fire and gas detection up to local alarms control room (temporarily manned)
- Fire fighting with main ring connected to Field fire water supply, hose reels, monitors.
- Normal and extra fire extinguishers.
- Fire alarm buttons.
- Telephone and public address.
- Marking for exits, escape ways.....
- Life boat.
- Emergency electrical supply and lighting, including generation by emergency diesel, batteries and inverters, distribution switchboards, emergency lighting.
- Part of normal lighting.
- Electrical (5.5. KV) interconnection with the Field with local control, and transformers.
- Ventilation systems with local control.
- Crane

Some temporary adaptations had been made for manual halon release and ventilation control to allow for operation until completion of the full automatic control through the control room.

At the same time, separate precommissioning had been done on various systems as well as preventive maintenance on mechanical equipment.

This phase required a close cooperation and coordination with Hook-Up and put stresses on both organizations their more efficient way of working were not the same: Hook-Up was organized along specialties and areas lines (task sheets computer followed), Commissioning was organized along process functional lines (systems). The synthesis between the two at intermediate steps required a heavy work.

After that, it was decided to limit such interferences minimum necessary for the quickest preparations of one compression line (line B) and the Stal Laval turbo generators. Hook-up worked according to its logic and Commissioning concentrated on the vendors packages (which were outside Hook-Up responsibility) and took charge of the systems when they were ready

This second phase lasted until the end of the Hook-Up organization (end of February 1981) at which date the remaining Hook-up team and its supervisor were transferred to Start-Up.

At this time, almost all the utilities and safety systems had been commissioned and the work concentrated on the main items i.e. electrical turbo generators and turbocompressors.

The authorization for gas in, in Compression area, was obtained end of February for Fuel gas tests.

First firing on both Stal Laval turbines occurred end of March 1981. These machines and the alternators were tested during April and May, first isolated in Compression, then integration in the Frigg Field network. By end of May they were operational.

At the beginning of April, closed loops tests were begun on turbocompressor line B.

Tests were rather smooth and quick on the turbine, but two problems on the compressor process circuit appeared rather a weak design of the compressor inlet filter, the antisurge recycling valves were not designed to handle any liquid (which happened to be specially present during the closed loop tests) and were quickly eroded.

The inspection of the other equipment:  
compressor, exchanger, lines showed no other problems.

While waiting for improved spare parts, the lines were dismantled and thoroughly cleaned prior to flushing with gas through production units. The work was performed during inspection work in TCP2 columns 3 which prevented from using compression cooling circuit and thus any compression tests.

End of May 1981 the commissioning organization was ended and its responsibilities transferred to Production Start-Up.

Comments:

Apart from the well known offshore work problems we can only stress again the importance of preparation and organization.

The offshore environment enhances the problems encountered both in personnel and in material matters.

The loss of information between teams is very easy and when it happens very castly.

Everything which can be prepared before hand must be: procedures, task sheets, documentation, reporting and information lines. Planning must be generalized at every stage and level. Everything which can be routine must be kept as such, it is the only way to retain spare flexibility for the unexpected which happens all to easily and can throw a too loose organization off balance.

When the amount of information increases, a computer solution should be used, with a carefully prepared program and trained people to use it offshore.

For this job, that would have been useful, especially for coordination Hook-Up/Commissioning. Unfortunately preparation before hand was not possible due to late and not engough reliable information. This lead to a preparation section offshore which allowed, especially in instrumentation to keep the situation under control.

A good onshore coordination and back up including engineering is a key factor.

All these principle are well known and simple but to stick to them is not, though it appears the only way to keep costs and delays reasonable in an environment full of constraints but wihtout any special or new challenges.

One characteristic of the work was the integration of a large addition to an existing installation and organization. The main technical problems were related to electrical and safety integration (in the larger sense including process). These were taken care of by specialists in both discipline already acquainted with Frigg Field, and required careful coordination.

Another key factor was close cooperation with Hook-Up, both onshore and offshore, somewhat strained due to, as mentioned above, the difference in working logic. One obvious example is the control room, a major point in instrumentation commissioning. Its conception is very centralized and work in it was very important and late. So it happened that for systems, that it was necessary to have in operation for Hook-Up and commissioning work during hot period, some parts of cabinets were in service while other parts were to be completed. Since the subcontractors involved were not the same, conflicts of responsibility arose, which were in fact never satisfactorily settled.

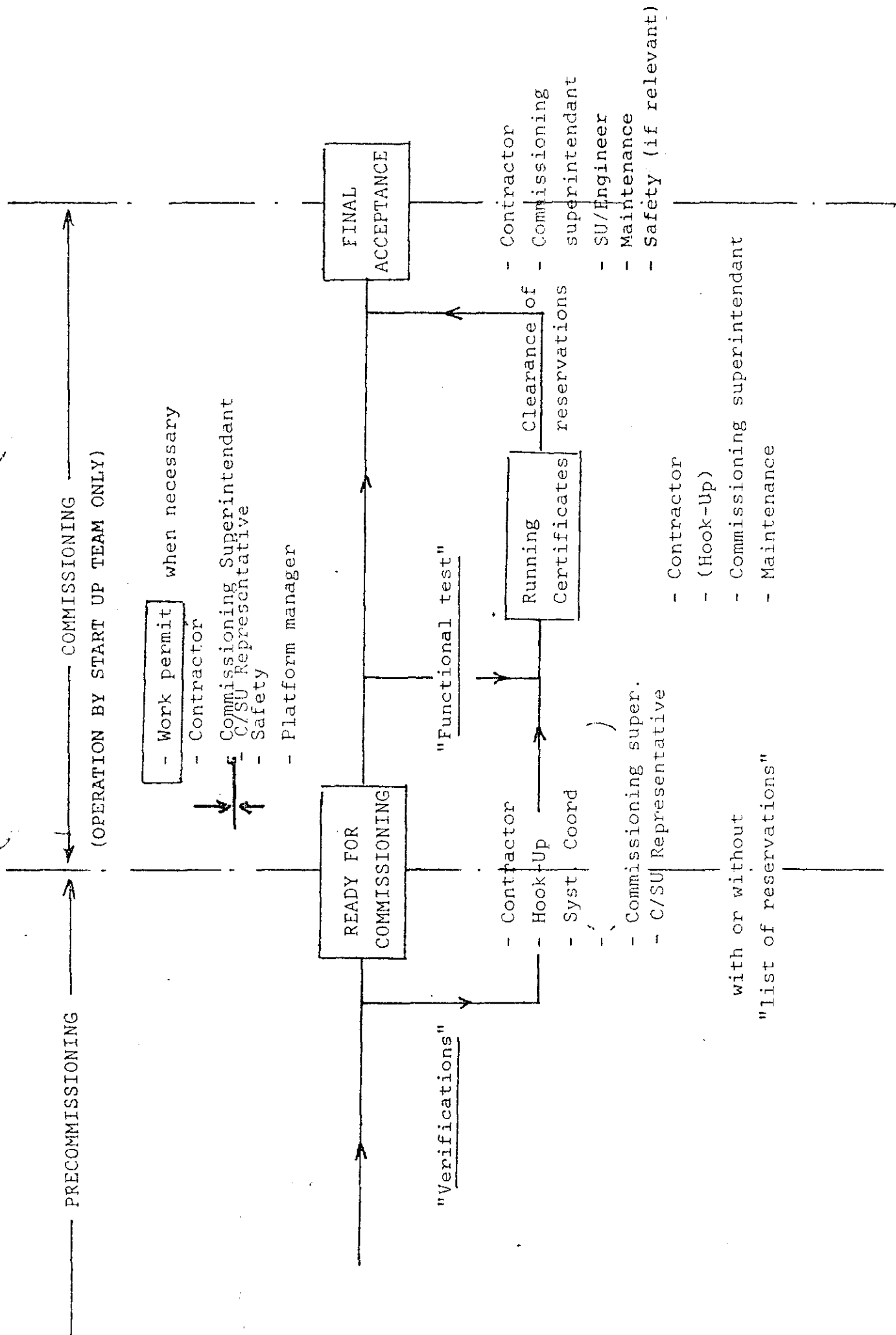
Others main points to be mentioned.

- Mechanical equipment should be conditioned for long conservation in the factories of vendors, delivered as such on construction yards and the minimum done there.
- Avoid end of fabrication and tests, in this environment An independent maintenance team should be present on construction yards to be take care of all the preventive maintenance problems which could arise. Reconditioning offshore is much more costly.
- The intervention of vendors has been rather heavy, sometimes due to insufficient inspection and some complicated associations between the main supplier and his subcontractors.

- (Commissioning and start up people should be involved as early as possible in the different phases of the project (process and equipment choices, inspection) but that can be very difficult since it involves different specialists over a lengthy period of time - for, to be really effective such a cooperation requires the very right persons, and not approximate replacements.)
- The flushing of compressor seal oil system is a lengthy operation requiring a clean environment.
- Although the work was organized to allow the departure of the flotted at the forecasted date, its absence proved to be a strain on the start up and commissioning teams, given the tight accommodation situation on the Frigg Field during this active work phase.

Documents:

- List of systems
- Commissioning and Start-Up planning.
- Progress follow-up, main hours and curves.
- Responsibility for systems logic chart.
- Ready for commissioning certificate.
- Final acceptance certificate.



TCP2 COMPRESSION

# COMMISSIONING PROGRESS REPORT

End of week: 20

Date: 18-05-81

# TCPE COMPRESSION - COMMISSIONING START UP PROGRESS FOLLOW UP -

 SHEET  
20  
1/2

REF	SYSTEM DESCRIPTION	ESTIMATION DATE	POINTS ESTIMATED	PROGRESS %	POINTS DONE	COMMENTS
04	GAS COMPR. LINEA	15-12-80	13 938	47	6551	
05	GAS COMPR. LINEB		13 938	99	13799	
06	GAS COMPR. LINEC		13 938	62	8642	
07	H.P. RELIEF		720	100	720	
08	L.P. VENT		288	100	288	
09	DES. WATER GENERAT.		2199	95	2089	
10	DES. WATER DISTRIB.		1551	100	1551	
11	COOLING MEDIUM		2530	97	2454	
12	MAIN SEA WATER COOLING		4260	98	4175	
13	FUEL GAS & METHANOL INT.		10 005	99	9905	
14	DIESEL OIL		933	100	933	
15	PROCESS OIL		315	100	315	
18	WASHDOWN SYST.		1158	100	1158	
19	INSTR. & AIR SERV.		5310	100	5310	
TOTAL						

81.

# TCP2 COMPRESSION - COMMISSIONING START UP PROGRESS FOLLOW UP -

SHEET 20 2/2

END OF WEEK

POINTS DONE

PROGRESS %

POINTS ESTIMATED

ESTIMATION DATE

SYSTEM DESCRIPTION

REF

COMMENTS

11152

99

11265

15-12-80

20A POWER GENERATION A

11040

98

11265

20B POWER GENERATION B

3198

100

3198

21 POWER DISTRIB. 380V

7020

100

7020

22 LIGHTING

5277

98

5385

23 EMERG. POWER & DISTRIB.

4230

100

4230

24 FIELD ELECTR. INTERCOM.

3675

100

3675

25 INTERCOM.

8700

100

8700

26 SAFETY FIRE & GAS DETECT.

10526

99

10632

27 SAFETY & FIRE FIGHTING

4888

77

6348

28 EMERGENCY SHUT DOWN

10122

100

10122

29 HEATING (HVAC)

4087

98

4170

30 LIFTING EQUIPMENT

648

45

1440

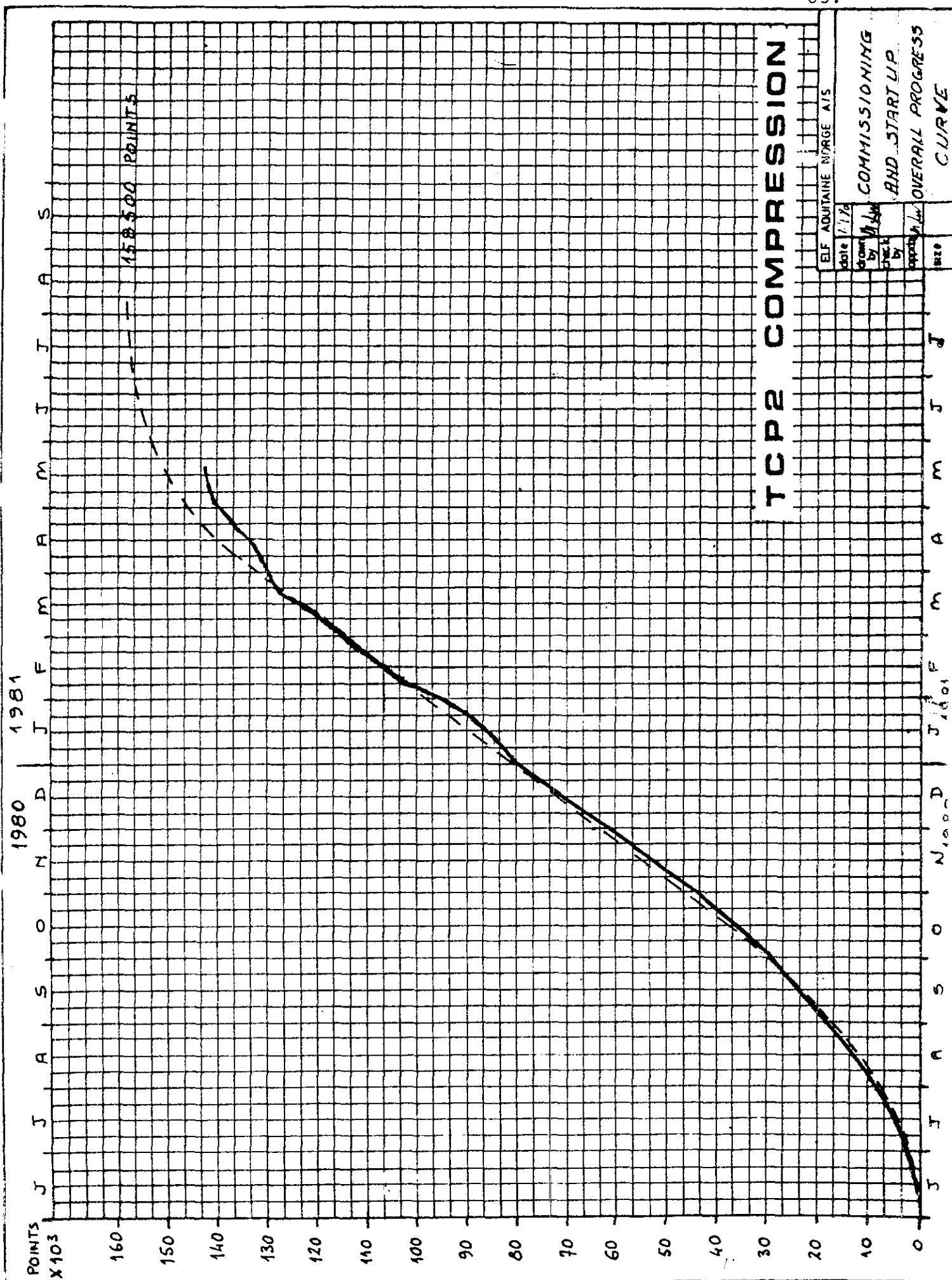
NITROG. TEST

142.453

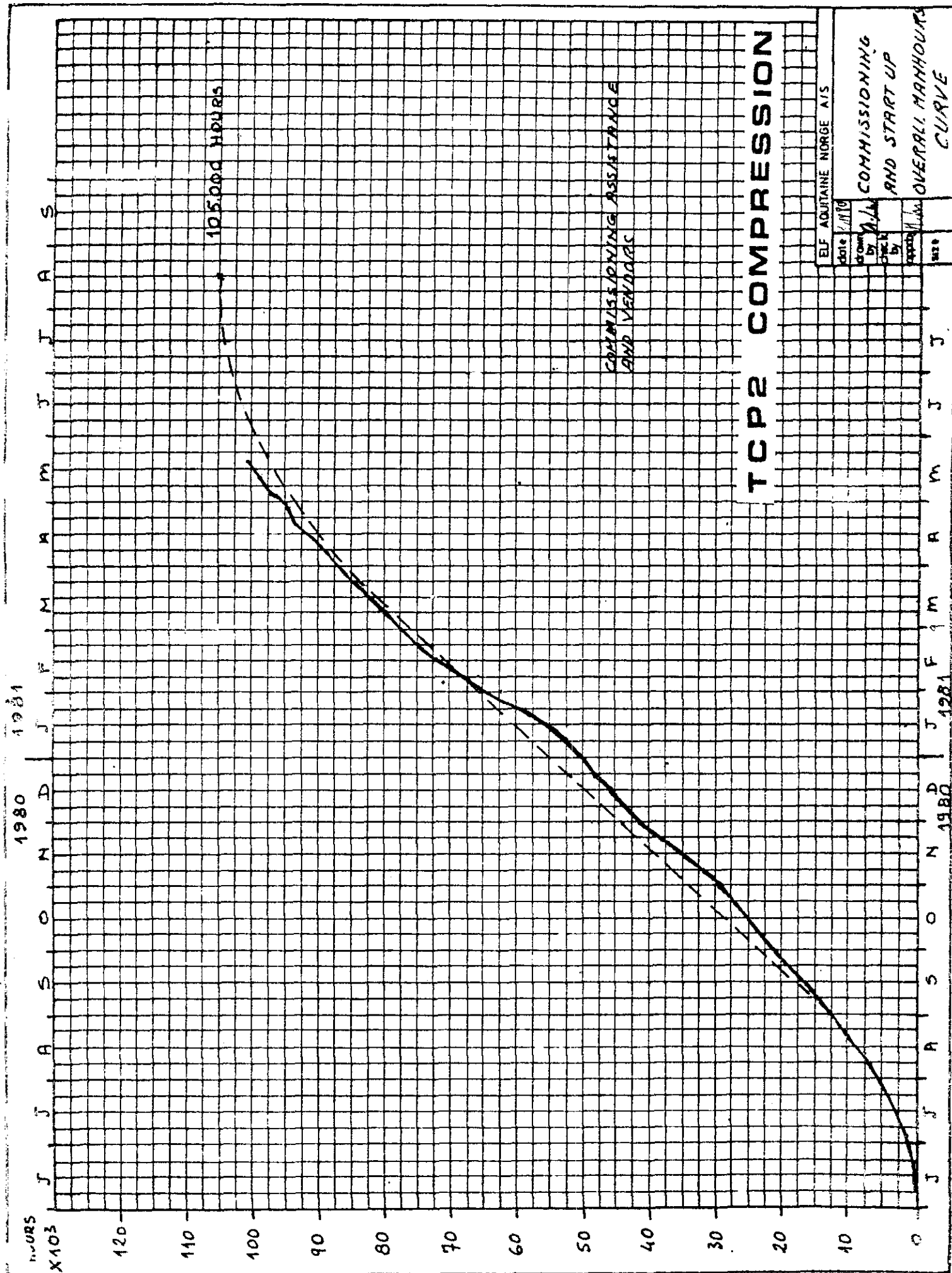
89.9

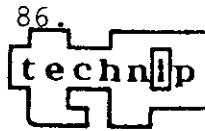
158.533

TOTAL



WEEK END OF WEEK IN MARCH 81	MECHAN.	ELECTR.	INSTR.	MAINTEN	VENDOR	OTHERS CLEAN.	STAND BY	TOTAL	FORECAST	% SPENT
	12559	20572	28649	3140	10259	4337	2425	81941	105.689	77.5
12	576	552	168	118	444	539	—	2397		79.8
13	731	144	480	36	722	138	108	2359		82.0
14	447	136	558	32	438	24	—	1635		83.6
15	270	84	372	759	9945	148	—	26275		86.1
16	710	138	330	146	468	512	—	2304		88.2
17	503	48	354	120	414	—	—	1439		89.6
18	613	168	450	—	586	—	—	1817		91.3
19	726	96	508	188	278	74	—	1870		93.1
20	103	—	292	98	510	987	—	1990		95.0
20	17238	21938	32161	4637	151135	6759	2533	100379, 5	105.685	95.0 <sup>84</sup>





## SYSTEM LIST

## COMMISSIONING MANUAL

## WORKING SYSTEMS

SYSTEM	SUB/S	
Z 01		STRUCTURAL
	a	Structure
	b	Architecture
Z 02		GROUNDING - CABLE TRAYS
	a	Grounding
	b	Cable - trays
	c	General instrument installation
Z 03		INSULATION - PAINTING
	a	Insulation
	b	Painting
Z 04		GAS COMPRESSION LINE A
	a	Process line
	b	Compressor (+ utilities)
	c	Turbine (+ utilities)
Z 05		GAS COMPRESSION LINE B
	a	Process line
	b	Compressor (+ utilities)
	c	Turbine (+ utilities)
Z 06		GAS COMPRESSION LINE C
	a	Process line
	b	Compressor (+ utilities)
	c	Turbine (+ utilities)
Z 07		H.P. RELIEF
Z 08		L.P. VENT
Z 09		DESALINATED WATER GENERATION
Z 10		DESALINATED WATER DISTRIBUTION
Z 11		COOLING MEDIUM
Z 12		MAIN SEA WATER COOLING
Z 13		FUEL GAS
Z 14		DIESEL OIL
Z 15		PROCESS OILY WATER
	a	High pressure
	b	Low pressure

SYSTEM	SUB/S	
Z 16		CLOSED DRAIN
Z 17		OPEN DRAINING
Z 18		WASHDOWN
Z 19		AIR
	a	Air generation
	b	Instrument air distribution
	c	Service air distribution
Z 20		POWER GENERATION 5.5 kv
	a	Turbo generator A
	b	Turbo generator B
	c	Switchboard 5.5
	d	5.5 kv to 380 V. Transform
Z 21		POWER DISTRIBUTION 380 V
Z 22		LIGHTING
	a	Normal
	b	Emergency
Z 23		EMERGENCY POWER
	a	Diesel generator
	b	Main emergency SWBD 380 V
	c	Emergency AUX SWBD
	d	Distribution 220 V
	e	Distribution 110 V
Z 24		FIELD INTERCONNECTION
	a	TCP2 Comp to TP2
	b	TCP2 to TP1
	c	TCP2 to QP
Z 25		INTERCOMMUNICATION
	a	Interphone
	b	Public address
	c	Telephone
	d	Telemetry
Z 26		SAFETY F & G DETECTION
	a	Fire
	b	Gas

SYSTEM	SUB/S			
Z 27		SAFETY FIRE FIGHTING		
	a	Fire water		
	b	Deluge system		
	c	Halon protected areas		
	d	Extinguishing system		
	e	Life boat		
Z 28		EMERGENCY SHUT DOWN		
	a	Hydraulic		
	b	P.L.C.		
Z 29		HVAC		
	a	In compression	mod. 30	54x01
	b	compression	" 31	54x02
	c	control room	" 32	54x05
	d	workshop	" 32	54x07
	e	fan room & substation	" 32	54x04
	f	transformation room	" 32	54x16
	g	compression	" 33	54x03
	h	turbo generator room	" 41	54x09
	i	diesel fire pump room	" 42	54x10
	j	battery room	" 44	54x12
	k	emergency substation	" 44	54x13
	l	diesel generator room	" 44	54x15
	m	diesel fire pump room	" 46	54x14
Z 30		LIFTING EQUIPMENT		
	a	Crane		
	b	Hoists		



## COMMISSIONING & START UP PLANNING

SYS	DESCRIPTION	TIME																																									
		DEC.	1981 JAN					FEB		MAR		APR		MAY		JUNE		JULY		AUG																							
		49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
21	POWER DISTRIBUTION, 380V.																																										
22	LIGHTING																																										
23	EMERGENCY POWER & DISTRIB.																																										
24	FIELD ELECTRIC INTERCON.																																										
25	INTERCOMMUNICATION																																										
26	SAFETY & FIRE GAS DETECTION																																										
27	SAFETY & FIRE LIGHTING																																										
28	EMERGENCY SHUT DOWN																																										
29	HEATING (HUBC)																																										
30	LIFTING EQUIPMENT																																										
	NITROGEN TEST																																										

## COMMISSIONING & START UP PLANNING

Page: 1 of: 2

S/N	DESCRIPTION	TIME																																							
		DEC	1984 JAN					FEB					MAR					APR					MAY					JUNE					JULY					AUG.			
		49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
04	GAS COMP. LINE B COMPRESSOR																																								
"	" TURBINE																																								
05	GAS COMP. LINE B COMPRESSOR																																								
"	" TURBINE																																								
06	GAS COMP. LINE C COMPRESSOR																																								
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14	DIESEL OIL																																								
15	PROCESS OILY WATER																																								
16	CLOSED DRAIN																																								
17	OPEN DRAIN																																								
18	WASHDOWN SYST.																																								
19	INSTR. & AIR SERV.																																								
20R	POWER GENERATION R																																								
20B	POWER GENERATION B																																								
20C/A	POWER DISTRIBUTION																																								
▽ FINAL ACCEPTANCE																																									

 frigg field elf aquitaine norge	<b>FINAL ACCEPTANCE CERTIFICATE</b>	<b>TCP 2 compression phase 1</b> Date:
---	---	---

This certificate concerns the system.....  
 subsystem.....  
 equipment.....

This certificate

- relieves contractor or vendor of his responsibility as far as safekeeping, protection and performance tests are concerned with the exception of outstanding works as per "exception report" attached, if any
- releases the system, subsystem or equipment from commissioning responsibility and transfers to "Elf start-up" the responsibility of operation and maintenance.

	contractor	syst. coord.	com. superint	S.U. engineer	maintenance
Name					
Signature					
Date					

#### Supporting documents

Commissioning task sheet status ☐  
 instrumentation ☐  
 electrical ☐  
 mechanical ☐  
 Exception reports instrumentation..... ☐  
 electrical ☐  
 mechanical ☐  
 piping ☐  
 Documentation reference..... ☐ Spare parts list..... ☐

Distribution			Certificate no.
<u>Stavanger</u>	<u>Platform</u>	Manager..... <input type="checkbox"/>	
Engineering..... <input type="checkbox"/>		Syst. coord..... <input type="checkbox"/>	
Hook-up..... <input type="checkbox"/>		Com. superint..... <input type="checkbox"/>	
Start-up..... <input type="checkbox"/>		S.U. engineer..... <input type="checkbox"/>	
		Safety..... <input type="checkbox"/>	
		Contractor..... <input type="checkbox"/>	
	<u>Field</u>	Superintendent..... <input type="checkbox"/>	
		Maintenance..... <input type="checkbox"/>	



friggg field

elf aquitaine norge

# READY FOR COMMISSIONING CERTIFICATE

**TCP 2**  
 compression  
 phase 1

Date:

 The system.....  
 subsystem.....  
 equipment.....

will be ready for commissioning

date: year:..... month:..... day:..... hour:.....

The Elf system coordinator will be

Mr. ....

The contractor representative will be

Mr. ....

At this date, safety regulations will be enforced. All personnel involved in the work on this system, subsystem or equipment must have a work permit. The work permit will be obtainable from the Elf system coordinator in conjunction with Frigg Field work permit and isolation procedures.

	Contractor	Hook-up	Syst. coord.	Com superint	S.U engineer
Name					
Signature					
Date					

Punch list - list of reservations - Hook-up exception report

See annexes

 Instrumentation No.....  
 Electrical No.....  
 Mechanical No.....  
 Piping No.....

Distribution		Manager..... <input type="checkbox"/> Hook-up..... <input type="checkbox"/> Contractor..... <input type="checkbox"/> Syst. coord..... <input type="checkbox"/> Com. superint..... <input type="checkbox"/> S.U. engineer..... <input type="checkbox"/> Safety..... <input type="checkbox"/> Superintendant..... <input type="checkbox"/> Maintenance..... <input type="checkbox"/>	Certificate no
Stavanger	Platform		
Engineering..... <input type="checkbox"/> Hook-up..... <input type="checkbox"/> Start-up..... <input type="checkbox"/>	Field		



frigg field

# PROVISIONAL ACCEPTANCE CERTIFICATE

**TCP 2**  
**compression**  
**phase 1**

elf aquitaine norge

Date:

This certificate concerns the system .....  
 subsystem.....  
 equipment.....

This certificate

- relieves contractor or vendor of his responsibility as far as safe-keeping and protection of the work are concerned with the exception of outstanding works as per "exception report" attached, if any
- releases the system or, subsystem or equipment from commissioning responsibility and transfers to Elf start-up the responsibility of operation and maintenance.

	Contractor	Syst. Coord.	Com. superint	S.U. eng.	Maintenance
Name					
Signature					
Date					

## Supporting documents

Commissioning      task sheet status      ☐  
                          instrumentation      ☐  
                          electrical      ☐  
                          mechanical      ☐

Exception reports      instrumentation      ☐  
                          electrical      ☐  
                          mechanical      ☐  
                          piping      ☐

Documentation reference ☐Spare parts list ☐

## Distribution

### Stavanger

Engineering.....☐  
 Hook-up.....☐  
 Start-up.....☐

### Platform

Manager.....☐  
 Syst. coord.....☐  
 Com. superint.....☐  
 Start-up eng.....☐  
 Safety.....☐  
 Contractor.....☐  
 Superintendant.....☐  
 Maintenance.....☐

### Field

Certificate no.



MANHOURS FOR COMMISSIONING

1.	Management EAN	
	Preparation (01/80 to 05/80)	12000 hours
	Onshore management (06/80 to 02/80)	3000 hours
	Offshore management (06/80 to 02(81)	60000 hours
2.	Main hook-up contractor assistance	
	Time base assistance (06/80 to 12/80)	42000 hours
	Time base assistance (12/80 to 02/81)	27500 hours
	(3/81 to 31.05.81)	30000 hours
3.	Vendors assistance (till 31.05.81)	22000 hours

## 6. GENERAL COMMENTS.

### 6.1. Hook-up

Generally speaking it can be estimated that the hook-up was performed with a satisfactory result if one consider the existing conditions:

- construction on the yards not completed
- unclear state of engineering in electricity and instrument disciplines.
- limited shut-down period of TCP2 and gas in for treatment before October 1st 1980.
- safety requirements allowing a maximum contractor manpower:

during cold period:	190 persons
during hot period:	120 persons for day shift
	100 persons for night shift

- unexpected strikes
- numerous disconnections of the flotel.

The main target were reached:

- TCP2 was ready for gas-in by the end of September 1980.
- Main hook-up works were completed by the end of December 1980.

This is obviously the result of a very good knowledge of the project and preparation of the works performed before and during the hook-up by the responsible team. It must be also noticed that the relationships between EAN and the main contractor UIE were excellent during the whole period of the hook-up. All daily problems were solved quickly and not any claim was presented by the contractor.

However several points can be underlined.

- 1.1 The task sheets system used for definition of the hook-up works has finally proved to be adequate. At the beginning of the works it was strongly critized by the contractor who found it too heavy.

We think that it is the only way to obtain a good preparation which is a noticeable part of the work itself. In fact after few days it was recognized that the system was a good tool provided that the offshore contractor organization is established accordingly.

The organization foreseen by the contractor must be in the line with the required degree of preparation. The use of a computer for the progress follow up and invoicing control is also more easy with this system.

- 1.2 The task sheets issued before the beginning of the hook-up were only 65% of the scope of works. In addition a high percentage of the tasks were revised or altered offshore after their issue or during their performance. This was mainly due to the electrical and instrument disciplines which were the most critical ones during the whole life of the project. In the other disciplines the engineering was more accurate and the consequence on the hook-up more satisfactory. (see attached tables 1 and 2).
- 1.3 It can be estimated that 50% of the hook-up works and 70% of the offshore commissioning should have been saved with a better performance of the main Engineering Contractor and no delay in delivery of some equipments, allowing the construction completion and precommissioning on the yards.
- 1.4 A non negligible amount of manhour was spent for repairing the damages caused to some equipment during the transport and the lifting. As indicated in the chapter 5, a better design for padeyes and slinging could save extra offshore manhours.
- 1.5 Some extra works performed by the hook-up contractor were not in direct relation with the project. It was the case for the replacement of the 32" valves on the sea-line N 2.

On another hand the hook-up contractor was not in charge of some works relating to the project but located on Q.P. and TP1 platforms.

This splitting was done for a better clearness in the management and organization and the result was satisfactory.

- 1.6 Due to the constraints of the dead line for gas-in the hook-up contractor was required to give a first priority to the completion of several critical systems. which had to be necessarily operational in due time. With a lump sum contract it is obvious that the contractor prefer to organize his job by area, which is more logic and efficient in preparation, logistics, and use of tasks and equipment.

These constraints must be clearly indicated in the call for bid and formally included in the contract in order to avoid future claims during the works.

A certain flexibility can be accepted provided that the main objective is priority-holder.

- 1.7 Some delays were noticed in piping activity at the beginning of the hook-up due to some difficulties in the welding procedures approvals and quality of the first welds.

These problems must be clarified on shore, as soon as the hook-up contract is obtained by the contractor, in order to avoid a time lost offshore.

- 1.8 The level of the offshore stand-by manhours for the contractor's manpower is not negligible (total 33.000). This is the result of the numerous disconnections of the brigde installed between TCP2 platform and the flotel "Treasure Supporter" which was more sensitive to the sea conditions than a previous one "West Venture" used on the field (see table 3).

#### 1.9 Conclusions

If we except the unavoidable events as strikes or bad weather conditions it is evident that the results obtained in this kind of job are closely dependent of the complete knowledge of the works to be done:

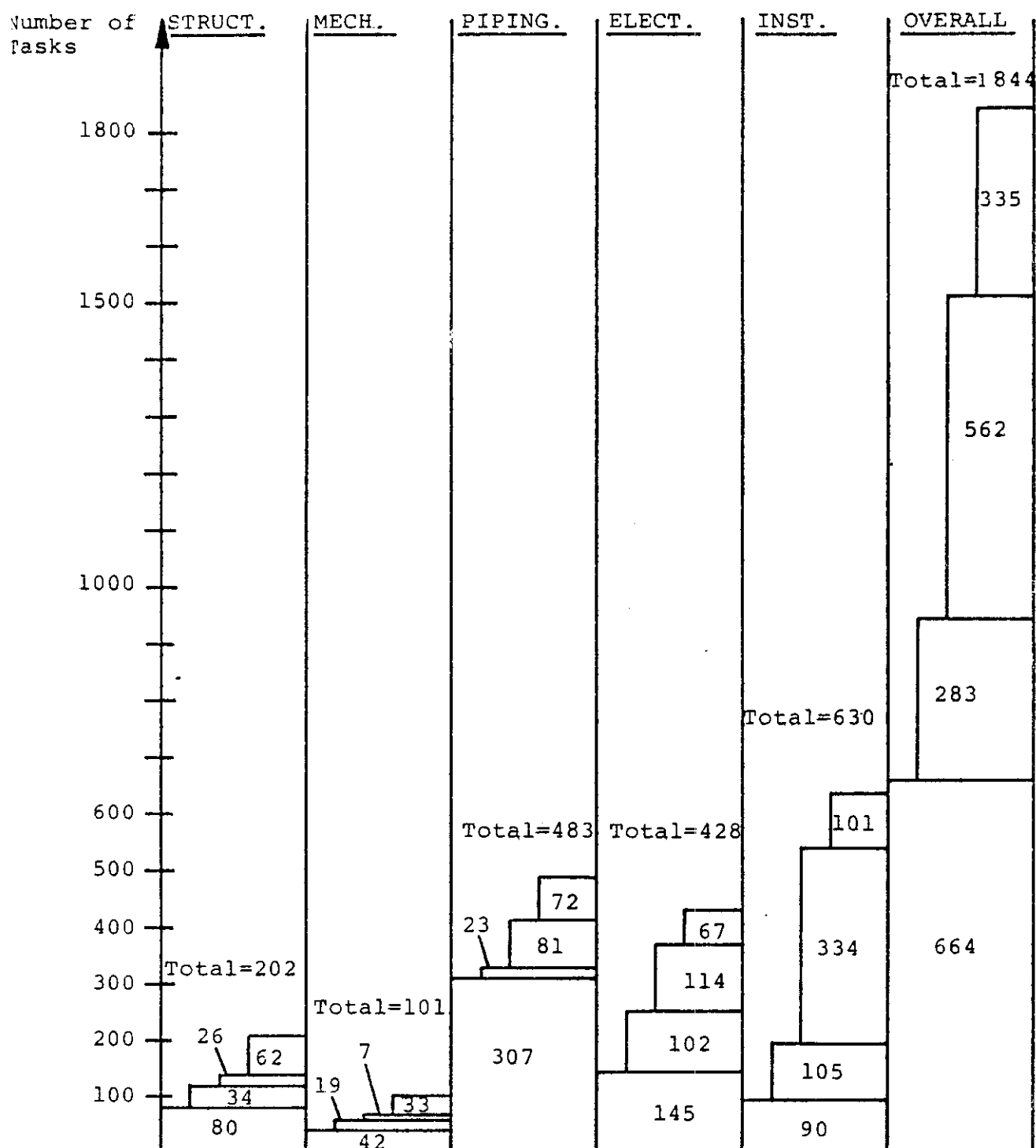
- Accuracy of engineering
- Exhaustive punch list of remaining works if the onshore construction is not completed.

Only if these minimal conditions are fulfilled, one experienced team is able to prepare the hook up work in a sufficiently detailed way, allowing a qualified contractor to perform his job with the best chance of success.

TABLE ISSUE OF TASKS (in numbers)

TABLE 1.

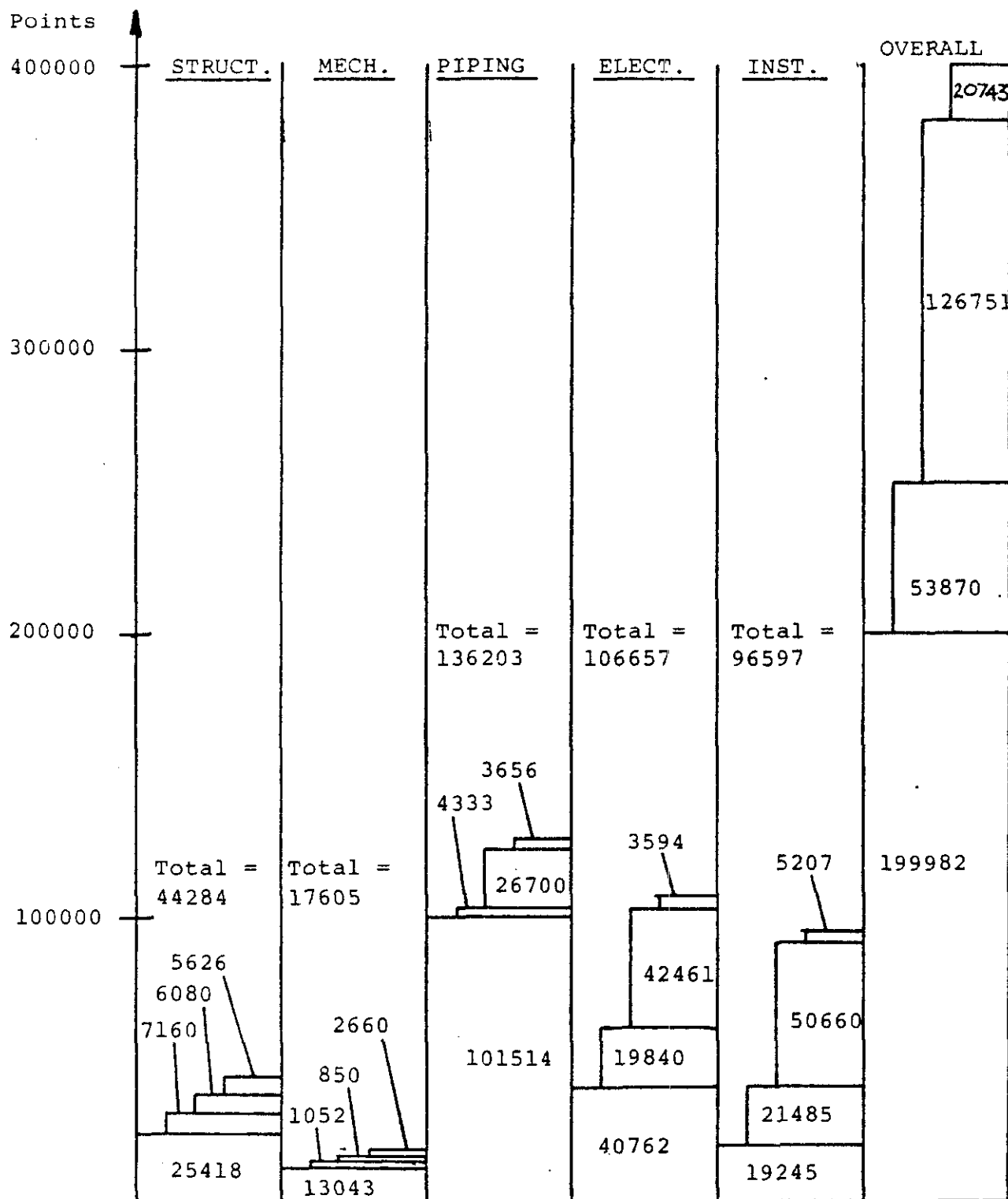
(For the 5 main disciplines)

LEGEND

- Tasks issued by offshore supervisory team.
- Tasks issued by hookup prepar. team.
- -during hookup
- -after contract award & before hookup
- -before contract award.

TABLE ISSUE OF TASKS (in points)  
(For the 5 main disciplines)

TABLE 2.



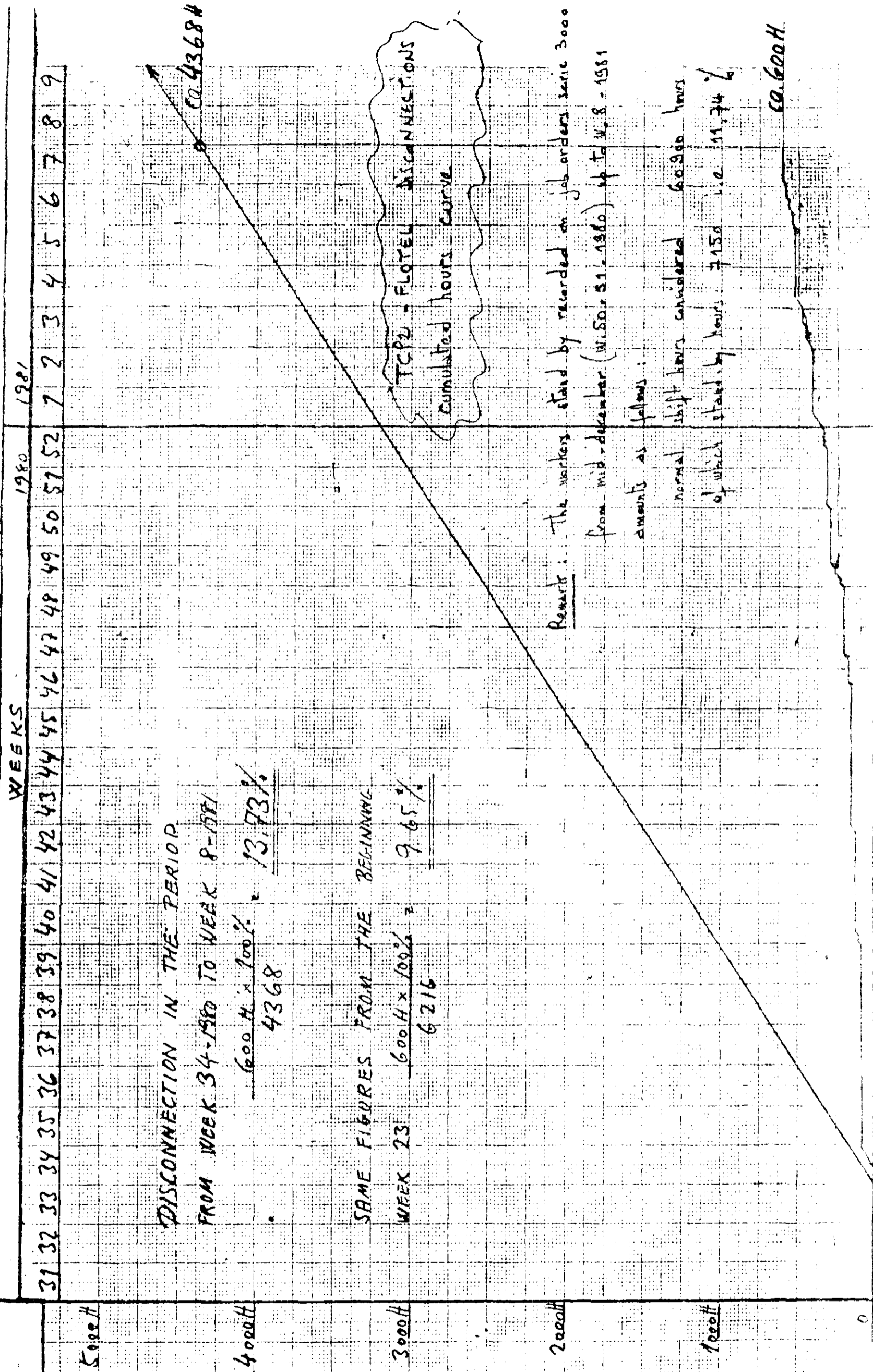
- NOTES: 1. See precedent list  
 2. Other disciplines not included in "overall"  
 INSULATION 3084 points in 17 tasks  
 PAINTING 7999 points in 13 tasks

TCP-II FRIGG COMPRESSION

HOOK-UP

PROGRAMME

by: page of  
re: date:



## 6.2. Commissioning

The offshore commissioning works were higher than initially expected. The intercutions on the yards were very limited except on the yard No. 2 for emergency electrical supply system.

As shown in the chapter 5 the total manhours spent by the hook-up contractor for assistance to the commissioning was 69.500 hours from June 1980 till end of February 1981 to compare with the estimate done in February 1980 (20.000 hours). The main reasons explaining this discrepancy are:

- non accuracy of engineering in electricity and instrument disciplines which are the most critical ones for detailed checking.
- construction not completed on the yards
- in certain cases, consequences of an insufficient protection of some mechanical equipment in the factory of vendor for a long conservation.
- damages caused to the small equipment (mainly instruments) during the hook-up works, or due to the atmospheric conditions.

A protection of this kind of material should be foreseen, or in some cases, the installation postponed till the start-up

- noticeable lacks in the factory of vendors of the equipments. This explain the heavy offshore intervention of vendors, which could be reduced with a correct control in the workshops, performed by a well qualified inspector.

7. Integration of the compression facilities.

The treatment part of TCP2 platform is under production since 1978, and the new compression facilities had to be wholly integrated into the Frigg Field.

This integration was a very important job involving a lot of details and requiring a carefull follow-up.

In parallel and in close cooperation with the Compression project itself, the studies related to this job were performed by EAN Engineering Department and the corresponding works managed under the responsibility of EAN Off-shore Construction Department (OCD).

### 7.1. Organization

In order to perform the maximum of the possible works before the hook-up phase of the compression modules and pancakes, on TCP2 platform as well as the necessary works on the other platforms TP1 and Q.P. of the central complex for the whole integration of the new equipment, it has been estimated that the best way was to give the responsibility of these particular jobs to the concerned Departments within the EAN's normal organization.

The TCP2 Compression Department was remaining in charge of:

- Complete engineering of modules and pancakes
- Procurement of corresponding equipment and materials.
- On shore construction and precommissioning
- Offshore hook-up and commissioning

The necessary coordination between different Departments involved:

- TCP2 Compression
- Engineering
- Offshore construction

was assumed at the level of Construction Sub. Division.

(See attached organization chart.)

### 7.2. Engineering

The Engineering Department was in charge of the studies, the issue of the engineering package and the material purchase requests related to:

- The preliminary works necessary to allow the setting up of modules and pancakes on the support frame.
- the different modifications to be done on the existing networks for the new needs
- the connection of the new equipments with the existing ones.
- the installation of some new facilities for temporary use during the hook-up or permanent use after completion.

A special temporary team including specialists in the main disciplines, created within the Engineering Department, was in charge of that.

- For each specific task a Modification Request was issued, discussed with all Departments involved, Production, Maintenance, or OCD and Safety-Inspection, case by case, before the final approval following the internal procedures in force.
  - About 85 different Modification Requests were issued (see attached list)
  - The total of manhours spent by this EAN Engineering special team was about 32 000 hours.
  - subcontracted engineering works: 4.700.000 NOK
  - main equipment ordered: 4.850.000 NOK
- Among these jobs a very important one concerned the complete rebuilding of the 5,5 KV electrical network.
- Previously the Frigg field was feeded from the existing turbo generators included in the treatment units.
- 3 generators driven by a Ruston gas turbine on TP1, 2,9 MW each.
  - 3 generators driven by a Kongsberg gas turbine on TCP2, 1,2 MW each.

The new needs of electrical power, mainly for the gas cooling system after compression, requiring an additional capacity, it was planned to install two new turbo-generators, each one being able to feed alone the whole field with the future compression phase II in operation. The existing generators are kept in stand by.

These two generators Stal-Laval, 13.5 MW each, were installed in the pancake 41, built under the responsibility of TCP2 Compression Department.

As a result of this new concept, it was obvious that the 5,5 KV distribution network had to be rearranged accordingly, requiring the installation of a complete new control desk, main feeders, protections and interlocking system.

This important study was sucessfully completed under EAN Engineering Department management.

### 7.3. Offshore works

The EAN Offshore Construction Department was in charge of the realization of all works related to the studies performed by EAN Engineering Department, as it is the case within the normal organization:

- issue the call for bids to outside contractor
- bid analysis
- selection of the contractor
- planning of the works according to various constraints  
as: production and safety requirements - beds availability -  
weather conditions - target dates - etc.
- supervision and commissioning of the offshore works

As it was done within the EAN Engineering Department a special temporary team has been created in OCD Department.

For the integration works 17 contracts were issued and awarded to different contractors. Each contract included several jobs, for various modifications tasks, in the same discipline, in order to allow a great flexibility and to avoid an high stand-by level for some unforeseen reasons.

The total amount of these outside contracts was about 14.300.000 NOK (procurement of the main material excluded)

The total manhours spent onshore by OCD for preparation was about 20.000 hours.

All these works were managed:

- On Q.P. and TP1, by ODC till the end of the jobs.
- On TCP2:
  - by ODC till the beginning of the compression hook up (01.06.80).
  - by the compression hook-up team for the jobs not completed by 01.06.80.

This splitting was decided in order to avoid some practical difficulties and interferences in the works.

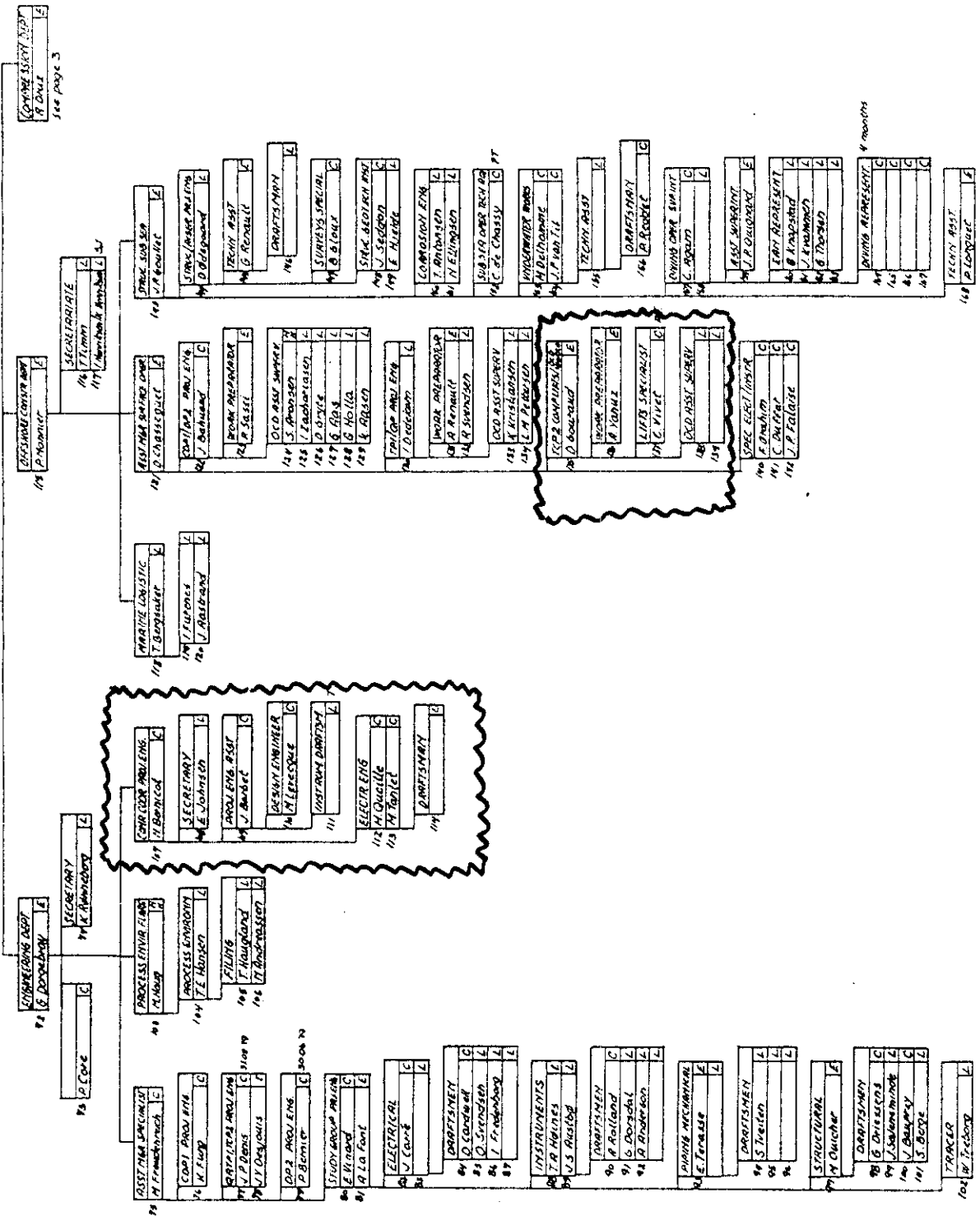
The compression hook-up team was in charge of all works on the platform, including some of them not in direct relation with the Compression project itself, as the replacement of three 32" ESD valves on the sea-line 2.

The result of this splitting was very positive.

In addition to the works mentioned hereabove it must be noticed that OCD was in charge of the transport and lifting for modules and pancakes (see chapter 5) and the marine assistance (supply boats - anchor handling).

#### 7.4. General comments

No major problems were encountered in this part of the project. The efficiency of the Engineering and Offshore Construction Department has been excellent. In spite of a great deal of details concerning the various jobs, all works have been completed in due time. The production level was maintained as scheduled during the "cold period" of the hook up, and the start-up of TCP2 treatment was effective without any delay.



## COMPRESSION INTEGRATION - STUDIES AND MODIFICATION

CONSTRUCTION NUMBER:	REQUESTED ON:	DESCRIPTION:
87035	16.10.78	TCP2 SSF geometrical survey
036	18.10.78	TCP2 structural studies
037	05.12.78	Electr. interconnection studies (5,5 kV) FRIGG FIELD-Electr.-interconnections- 5,5 kV
040	16.10.79	CDP1-DP2-TP1-Interface room modification for 5,5 kV network
041	05.12.78	TCP2 Interface room modification for compression integration
042	05.12.78	TCP2 Cable routing between compression and treatment interconnection cabinets
043	05.12.78	TCP2 Interface room modification for new 5,5 kV network
044	05.12.78	QP Main-control room modification for new 5,5 kV network. Electrical mimic panel
045	05.12.78	QP Main control room modification for compression process integration
047	05.12.78	QP TCP2 Telephone system modification
048	05.12.78	Public address interconnection
049	05.12.78	QP TCP2 Telemetry system modification
050	24.11.78	Temporary deck installation
051	18.12.78	Platform cleaning before modules installation
052	24.11.78	Safety aspects
053	24.11.78	Life boats and life rafts study

CONSTRUCTION NUMBER:	REQUESTED ON:	DESCRIPTION:
87054	24.11.78	Temporary sidings removal study
055	04.12.78	Feasibility study temporary warehouse and offices module SRHU6: Auxiliary module
056	22.01.79	TCP2 Compression pressurized drainage systems connection to CV3 & CV5
058	06.02.79	TCP2 Support frame deflection analysis - Vertical translation
059	06.02.79	TCP2 Compression deck crane - Maintenance platform
060	16.02.79	SRHU.10. Installation of additional rescue stations
061	16.02.79	TCP2 MCC-room. Extension for control desk installation
062	13.02.79	TCP2 Provisional status booklet (NPD document)
063	13.02.79	TCP2 General basis of design (Documentation for NPD)
064	01.03.79	TP1 Bridge lines shut-down
065	15.03.79	QP Computer modification
066	16.03.79	TCP2 Installation of ESD valves and spacers on the 24" 26" gas lines
067	06.03.79	FRIGG FIELD HP Relief System - Compatibility with Compression
068	19.02.79	Electrical ESD system general philosophy QP-TP1-TCP2 Electrical shut-down system
069	22.03.79	FRIGG FIELD Main electrical power supply
070	26.03.79	Diesel tank ventilation duct-relocation (TCP2)

CONSTRUCTION NUMBER:	REQUESTED ON:	DESCRIPTION:
87072	05.03.79	TCP2 New bridge to flotel
073	16.03.79	Power supply for Manitowoc crane
074	16.03.79	Piping modifications for compression tie-ins
075	09.04.79	TCP2 Shaft 3 gas detection
076	05.04.79	Auxiliary module 948 - connections with TCP2
077	06.04.79	Column 3 electrical supply and staircase modifications
078	16.03.79	Electrical modifications for compression tie-ins
081	03.05.79	Columns sea and fire water casings reconditioning
082	26.04.79	TP1/TCP2 Gasflow adjustment upstream compression facilities. TCP2-CV1 ABC connection to compression plant
084	28.05.79	TCP2 Blow-down system integration
087	10.07.79	TCP2 Low pressure vent. stack
088	21.08.79	TCP2 Bridge lines and local pneumatic 3rd level shut-down
089	22.08.79	TCP2 Trouble shooting diagrams
090	31.08.79	Interconnections between compression and electrical control desk
091	05.09.79	TP1-TCP2 4th level shut-down system modification
092	10.09.79	TCP2 As-built drawings
093	08.08.79	Procurement of new electrical control desk

CONSTRUCTION NUMBER:	REQUESTED ON:	DESCRIPTION:
87094	08.08.79	TCP2 5,5 kV network. Procurement of protection relays
096	10.09.79	TCP2 Structural modification top column 5
097	10.09.79	TCP2 Top Column 3 - Modification for sea water installations
098	10.09.79	TCP2 Structural modification top column 3
099	10.09.79	TCP2 Column 5 Cleaning and general safety improvement
100	10.09.79	TCP2 Installation of temporary bridge control weather protection on bridge TCP2-TP1
101	20.08.79	TCP2/QP Teletransmission. Useless information
102	02.10.79	TCP2 Compression Synopsis
103	01.10.79	TCP2 Temporary telecommunication installation
105	22.10.79	TCP2 Open drains modification
106	14.11.79	TCP2 Sea water rejection shaft seals
107	07.11.79	TCP2 Compression level survey
108	28.11.79	TCP2 Relief and flare systems NPD documentation
109	15.11.79	TCP2 Compression life boat. Electrical power supply
110	17.12.79	Area 46 preparation

CONSTRUCTION NUMBER:	REQUEST ON:	DESCRIPTION:
87111	14.11.79	TCP2 Compressors blow-down valves connection to TP1 HP vent
112	20.12.79	TCP2 SRHU27 Column 5. Rejection concrete bends templates
113	29.02.80	TCP2 Compression tie-ins to treatment Checking of tie-ins points
114	20.03.80	TCP2 Sea water rejection shafts tools
115	23.05.80	TP1/TCP2 sales gas header protection
116	24.06.80	TCP2 Column 3 Sea water pumps
117	27.07.80	All platforms 5,5 kV earthing interlock system
118	29.06.80	TCP2 Fire water supply to fire hose reel South East corner, cellar deck
119	14.08.80	QP/TCP2 Compression fuel gas metering modification
120	18.07.80	TP1/TCP2 Sales gas header PSV trim modification
121	04.09.80	TCP2 Support frame stress analysis 1980
122	05.09.80	TCP2 Compression - Engineering Modification of UTI Spreader beams
123	10.11.80	TCP2 Support frame - Deflection analysis 1980 with up-dated loads of compression phase I
125	28.02.81	5,5 kV Generator interlocking
126	06.03.81	Installation of winch for UTI turbine hatch removal
127	07.04.81	Reinforcement of PC 46 Floor

## COMPRESSION INTEGRATION - STUDIES AND MODIFICATIONS

CONSTRUCTION NUMBER:	REQUEST ON:	DESCRIPTION:
87128	23.04.81	Deenergisation sequence/ESD function fault alarm
130	21.05.81	Information from treatment to TCP2 Compression
131	08.07.81	Hoist on Compression modules
132	08.07.81	HALON system. Entrance warning
137	29.09.81	Reinforcement of structure pancake 41
138	07.09.81	Modification of F.G. pipes

## 8. CERTIFICATION

### 1. Definition

Certification was within the project a general "term" which covered all matters related to documentation, inspection, testing etc. required by the relevant authorities in order for the authorities to be certain that the installation, systems, and components comply with governing rules, regulations and safe practice.

### 2. Object of Certification

When the authorities are satisfied that the installations, systems and components meet the governing rules, regulations and safe practice, they - Norwegian Petroleum Directorate - will issue a "Consent to start operation".

This consent is in essence the permit which allows the operator to take the installation into use and is thus the ultimate "goal" for the certification work.

### 3. Organization

The Certification Section was placed in staff under the project manager with a responsible line to SIR divisions management which were responsible for the establishment and maintenance of all contacts with the Authorities.

### 4. Design phase

During the design phase it was the responsibility of the "Certification" to check that the design work were consistent with appropriate codes and standards and legislative requirements where they applied.

"Certification" was also responsible for defining, and the compiling of documentation for the relevant Authorities and their consultants.

The documentation was compiled in packages within each dicipline and presented to the Authorities as required by the regulation.

## 5. Construction Phase (Onshore & Offshore)

During the construction phase the major workload for the "Certification" were to perform and organize inspections to ensure that all work was carried out in accordance with the intention of the designer as set out in the drawings, specifications, codes and standards approved by the Authorities.

To perform these inspections "Certification" utilized both Internal specialists and External consultants (DnV).

During the construction period offshore "Certification" employed DnV inspector through Inspection department to perform the necessary quality control with the work of the hook-up contractors.

The assignment of DnV inspectors for quality control purposes covered the discipline Electrical, Instrumentation, Welding (both piping and structural and partly mechanical).

## 6. Start up Preparation

The involvement of the "Certification" prior to start-up was the preparation and implementation of an internal control document - start up procedure - for the start-up of the Fuel Gas Equipment, gas turbine/compressor A, B and C.

The start up of fuel gas unit was the "milestone" for which a consent to start operation was required.

This "Start-up Procedure Manual" which was established through the joint efforts between the various departments within EAN, under the coordination of "Certification", together with the final status meetings with NPD, formed the basis on which NPD granted EAN the start up consent.

The consent arrived EAN 24.02.81 and start up took place successfully 25.02.81.

The start up of compressor train B, C and A were performed under the supervision of EAN's internal control system, with no consent from NPD, as outlined in the Start up Procedure, and agreed with NPD.

## 7. Termination of contract between NPD/DnV

Both during the design and construction period of TCP2 compression DnV were engaged as consultant to NPD.

As EAN (TCP2 Compression and Certification) utilized the services of DnV as a part of their internal control a "Conflict of interest" arose, which ended in the termination of the contract between NPD and DnV 22.03.80.

To ensure the continuation of the independent verification of the remaining construction work onshore EAN engaged DnV as consultant for the remaining/terminated part of the above mentioned contract.

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9. START-UP

The start-up of the compression facilities was done progressively, as soon as one equipment or system was fully commissioned.

Due to the safety requirements some of these equipments had to be operational at the end of the "cold period", when the treatment section of TCP2 was put in operation after the main shut down which took place between mid of May and end of September 1980. This aim was reached without major difficulties and TCP2 treatment was restarted on October 2nd 1980 as planned.

The final aim was to have one line of compression started up and tested before October 1st 1981 in order to fulfill the gas requirements from this date.

This objective was also reached in spite of some problems which were successfully solved in due time.

9.1 Organization (see attached chart)

At the end of May 1981, the commissioning was nearly completed and the major part of the commissioning team was demobilized with the exception of some specialists.

The start up team, already in charge of the start-up preparation, took over the remaining matters.

It was obvious that, after the detailed control performed by the commissioning specialists, the start-up of the compressors had to be solved in very close cooperation with the production responsables in order not to disturb the required gas deliveries.

The best coordination was expected by the integration of the start-up team within the Field Production Sub-Division, the Compression Engineering team remaining in charge of

technical assistance for all unexpected problems.

A tests program was established in order to check the reliability of the machines in front of some foreseeable incidents which can occur in the normal operation of the field. The complementary aim of these tests was also to complete the training of the future operating personnel and to up-date the production instructions.

## 9.2 Turbo-compressors start-up

Due to the initial planning of the works to be performed in the summer period 1981 on TP1 platform it was decided to prepare the first tests on the line B which is linked only on TCP2 treatment.

For all details and data concerning the turbo-compressor start-up refer to the special report dispatched under reference number 311E Com./81/JF/BC dated 23th November 1981.

### 9.2.1 A main problem encountered in the preparation of this machine was related to the seal oil circuit.

The machines were delivered on the yard no. 1 with the oil circuits not completely installed. The completion works on the yard was done in very poor environment conditions without a sufficient protection of the oil circuit for an acceptable cleanliness before the start-up.

It was necessary to remove the main bearings and the seal-oil rings and to flush the complete circuit with heated oil during several weeks till the circuit was completely clean, for each machine. Drastic precautions must be taken to avoid such a problem during the whole period of construction, on the yards as well as offshore.

### 9.2.2 The first attempt of the machine B was done mid of April 1981 on a closed loop basis by recirculating on the anti-surge valves. Two types of problems were located which led to stop the tests:

- \* collapse of temporary gas inlet filter
- \* very quick destruction of the internal parts of the anti surge valves.

9.2.3 The temporary gas filter was installed on the inlet nozzle of the compressor in order to prevent the entrance in the machine of some solid particles remaining in the piping during the first running hours.

This filter improperly designed was unable to accept the normal gas flow through the machine. A new type of filter, designed by Nuovo Pignone was requested at that time and it was decided to perform a mechanical cleaning of the gas piping completed by a flushing with normal gas at a very high flow. This operation required the complete compressor barrel to be removed in order not to get an uncontrolled speed of the compressor and free turbine during the flushing. The compressor casing was plugged at each end with special flanges and a part of the spare barrel was installed for a proper protection of the O-ring gasket face inside the body of the machine.

9.2.4 The recycling valve were found very damaged after about 10 hours of service, the anti-noise special cage being completely destroyed.

The damage was attributed to the liquid remaining in the system, this liquid being recycled with a high velocity leading to a severe internal erosion and shocks.

A new set of internals less sophisticated and less fragile than the previous ones was ordered to the valve manufacturer.

This incident shown that it is necessary to clean the gas circuit, as well as possible before start of the machine and to be very careful of the circuit purging. This task must be included in the normal commissioning work.

- 9.2.5 The flushing of the gas lines was performed in June and July 1981. In the same time some mandatory works inside the column 3 and 5 on TCP2 platform were carried out, and during the dewatering of the columns the cooling system for compressors and turbo-generators was unavailable.

Another event occurred in the same period. Due to some cracks discovered on all vessels CV1 and CV2, in the treatment part of TCP2, and the uncertainty of the time required for their repair it was decided to prepare the compressor line C which can be used either with TP1 or TCP2 treatment instead of line B which can only be connected to TCP2. The flushing of the compressor C was done mid of July but the new designed gas filter collapsed at a limited gas flow of 9 MMSCMD.

This filter was then definitively removed taken into account that the line had been cleaned and the compressor body should be re-opened for final equipment.

The flushing done without gas filter allowed a flow rate of 32 MMSCMD without problems.

- 9.2.6 The start-up of the compressor C, equipped with the new internal parts of the recycling valves took place on closed loop basis, mid of August 1981, without any major problems. All possible precautions were taken to drain the loop during the first running hours. After 10 hours the recycling valves were inspected and found in perfect conditions.

An in-line test was performed and a significant flow of 30 MMSCMD with a maxi inlet pressure of 100 bars and discharge pressure of 162 bars was reached without difficulties. No vibrations, piping resonance or repetitive trips were observed.

- 9.2.7 After about 50 running hours an oil leak occurred on the free turbine bearing seals, and it became compulsory to trip the machine.

A new type of seals, recommended by UTI since 1979 and now used on all FT4-C3F machines, was not installed on the

FRIGG turbines due to the poor environment conditions during the yard construction and hook-up phase.

The replacement was done on the three machines in September 1981.

- 9.2.8      On September 23rd the compressor C was put in operation. After adjustment of the anti-surge valves in closed loop test the machine has been put in line without any particular difficulties.

By the end of September this first machine was declared operational as scheduled, and used since October for gas boosting. Several tests were successfully performed in order to check the reactions of the machine in case of unexpected incident in the normal operation of the field.

- 9.2.9      The two other machines were tested and put in normal operation
- machine A:    October 14th
  - machine B:    November 20th.

For this last one the maximum allowed working pressure was reduced from 172 bars to 163 bars due to the limited MAWP accepted by the Norwegian authorities for the vessels CV1 and CV2 after the cracks discovery.

The test was done also with the previous internals of the recycling valves, the new type being unavailable at that time.

Some noticeable vibrations were observed during the closed loop test but not during the in-line operation. It is planned to replace the internal parts as soon as they will be received. (November 1981).

- 9.2.10      One particular point remained to be classified on the three machines.

The seal oil system was not fully satisfactory, the oil flow rate through the seal-rings being higher than foreseen and nearly by the full capacity of one seal-oil pump.

The manufacturer was requested to take the necessary actions in order to solve definitively this problem.

A new set of the seal-oil rings were installed by the end of November on the machine C and the result was correct, the oil flow being reduced to a lower value. The same type of rings is planned to be installed on the other machines as soon as they will be delivered.

- 9.2.11 Another point related to the fuel gas quality must be investigated. It was observed in several cases some small quantities of condensate in the fuel gas towards the turbo-compressors and turbo-generators.

The separator installed on the fuel gas treatment unit have a rather poor efficiency which seems due to the very low ratio liquid volume over gas volume and the very small size of liquid particles.

In any case the fuel gas quality must be improved to prevent a possible slug and severe damage to the gas turbines. Action in that way is taken by Production Department.

### 9.3 Turbo-generators start-up

The start-up of the turbo-generators required a rather long time because of the numerous problems encountered in electrical and instrument tie-ins but no incident was recorded during this phase.

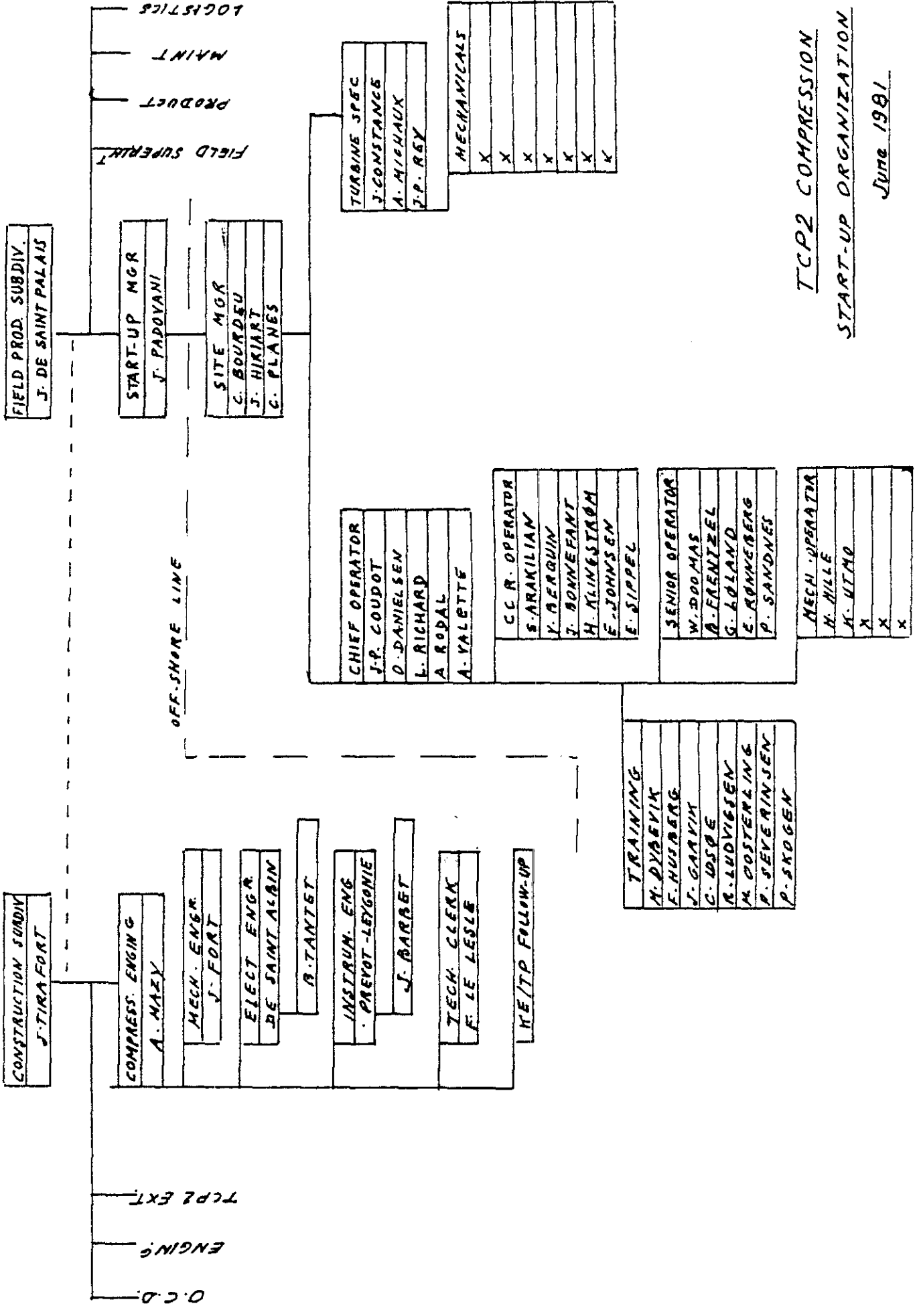
The first turbo-generator group G01A (called Elias) was connected to the network for the first time on 17th of April 1981.

The second turbo-generator group G01B (called Monika) was connected to the network for the first time on 4th of May 1981.

#### 9.4 Other equipments.

The start-up of other equipment can be divided in three phases:

- Equipments needed for working environment (normal and emergency lighting, compressed air network, temporary offices) performed just after lifting in May/June 1980.
- Equipments needed to allow the works on a "hot platform (part of gas, fire, smoke detection networks and monitoring, part of sea-water fire fighting system, public address...) performed between June and October 1980.
- Remaining equipments: Performed all along the period of time October 1980 - October 1981 as soon as they were declared commissioned. For comments regarding the start-up and test refer to related paragraphs in Engineering sections.



TCP2 COMPRESSION

START-UP ORGANIZATION

June 1981

10. COST SUMMARY

For all detail concerning the cost of the project refer to the special report, volume 3.

Hereafter is included a cost summary split in the different cost codes.

## TCP2 COMPRESSION PROJECT

TCP2PR/PRODDCC3

## AMOUNTS IN KNOK

2361	EXPENDITURES IN TERMS OF WORK					TOTAL
	NOK (000)	1972 to 1979	1980	1981		
10	ENGINEERING/MANAGEMENT	136.825	32.032	5.143		174.000
11	MAIN EQUIPMENT	140.264	20.721	1.515		162.500
12	BULK EQUIPMENT	57.301	31.392	4.107		92.800
13	SPARE PARTS	-	562	158		720
14	YARD SUPERVISION, COMMON EXPENSES	30.189	13.441	-		43.630
15	OFFSHORE LOGISTIC	750	98.711	33.119		132.580
16	HOOK-UP AND COMMISSIONING	58	151.588	47.354		199.000
17	INTEGRATION, PREHOOK-UP, TRANSPORT	24.936	36.414	2.600		63.950
20	CONTROL ASSISTANCE	46.204	60.964	24.132		131.300
25	OVERHEADS AND STAVANGER EXPENSES	15.924	25.526	5.350		46.800
30	CONSTRUCTION OF MODULES YARD I	72.012	103.033	1.014		176.059
31	CONSTRUCTION OF MODULES YARD II	10.884	10.836	-		21.720
32	CONSTRUCTION OF MODULES YARD III	13.133	8.456	-		21.589
33	SAFETY TRAINING, CONTRACTOR	-	7.367	2.295		9.662
34	SAFETY TRAINING, EAN	-	558	-		558
35	STRIKE CONSEQUENCES	-	19.599	-		19.599
99	CONTINGENCY	-	-	-		-
	TOTAL	548.480	621.200	126.787		1.296.467
	INSURANCE CLAIM	-	-	(3.233)		(3.233)
	TOTAL	548.480	621.200	123.554		1.293.234