



Titolo: LIBYA – DRILLING & COMPLETION ENGINEER

Codice corso: **RPWA004B**



## DRILLING RIGS

### LIBYA ENABV TRAINING PROJECT

Edizione a cura di : *Eni Corporate University*

COPY FOR DIDACTICAL USE

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## 01. INTRODUCTION

### INDEX

1.1 DEFINITION

1.2 RIG TYPES

### 1.1 DEFINITION

Drilling rigs: equipment and tool used for

- DRILLING
- RE-DRILL OR RE-ENTRIES
- WORKOVERS

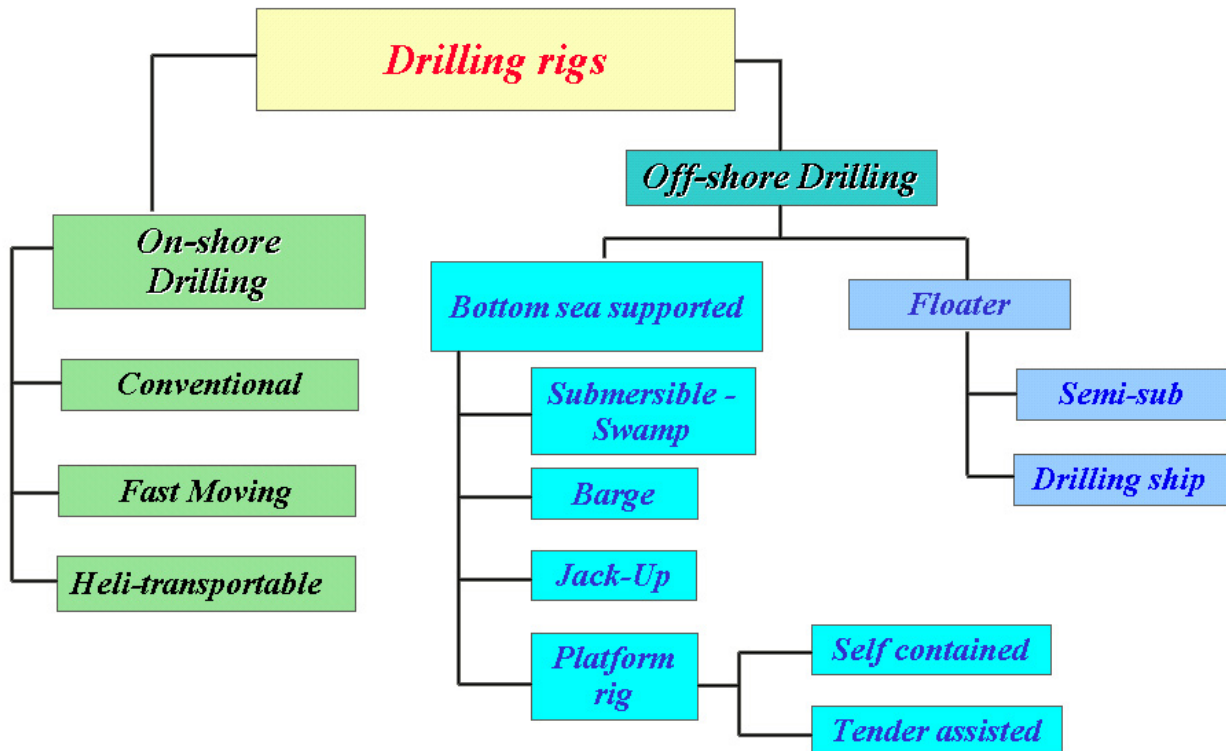
### 1.2 RIG TYPES

#### a. On-shore Drilling

- Conventional
- Fast Moving
- Heli-transportable

#### b. Off-shore Drilling

- b1. Bottom sea supported
  - Submersible -Swamp
  - Barge
  - Jack-Up
  - Platform rig
    - Self contained
    - Tender assisted
- b2. Floater
  - Semi-sub
  - Drilling ship



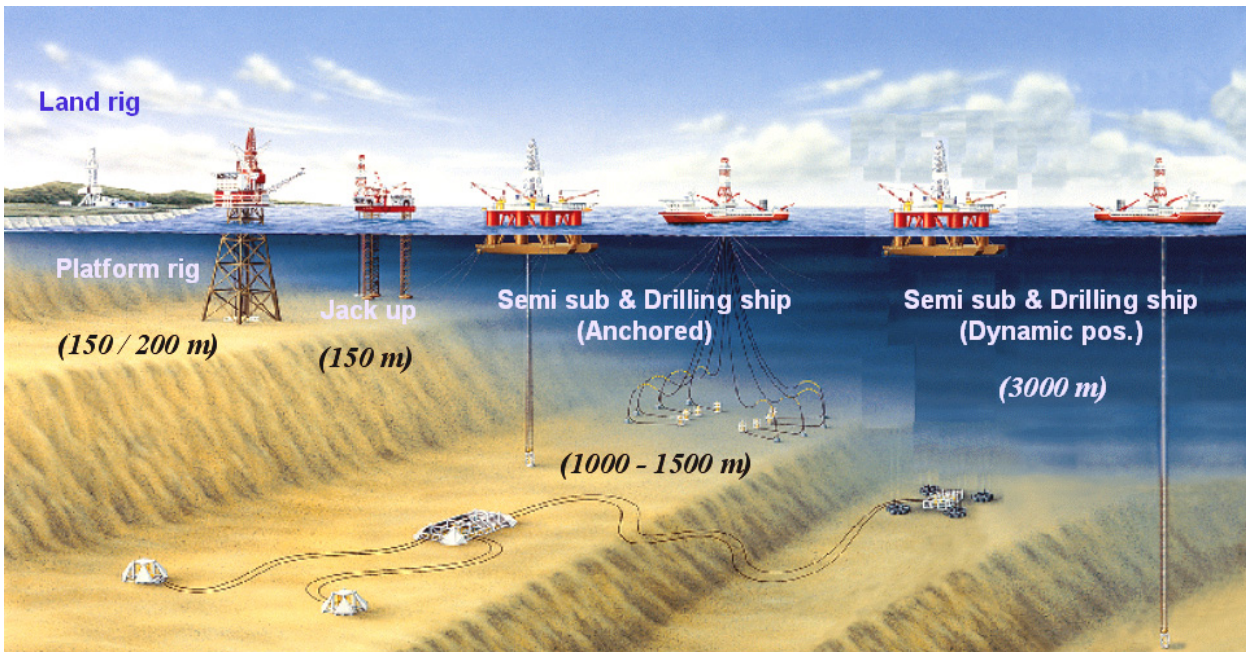
**- Maximum Operating Water Depth**

Bottom sea supported

- Platform rig (150 - 200 m)
- Jack-Up (150 m)

Floater

- Semi-sub and Drilling ship (Anchored) (1000 - 1500 m)
- Semi-sub and Drilling ship (Dynamic pos.) (3000 m)



## 02. ON-SHORE RIGS

### INDEX

#### 2.1 DUTY

#### 2.2 TYPES

- Conventional rig
- Fast Moving rig
- Heli-rig

#### 2.3 DRILLING RIG MAIN SYSTEMS

- HOISTING & ROTATION SYSTEM
- POWER GENERATION SYSTEM
- MUD CIRCULATING SYSTEM
- WELL CONTROL SYSTEM

#### 2.1 DUTY

ENI E&P divides the rig type in five main levels depending on HP and nominal maximum depth with 5" DP.



*ENI Classification*

| DUTY                 | I         | II        | III       | IV        | V    |
|----------------------|-----------|-----------|-----------|-----------|------|
| DRAWWORKS HP         | 700       | 1000      | 1500      | 2000      | 3000 |
| MAX DEPTH WITH 5" DP | 2500<br>m | 3500<br>m | 4500<br>m | 5500<br>m | More |

## 2.2 TYPES TRANSPORT

### - CONVENTIONAL RIG

Land rigs work on dry land. They are the most common rigs.

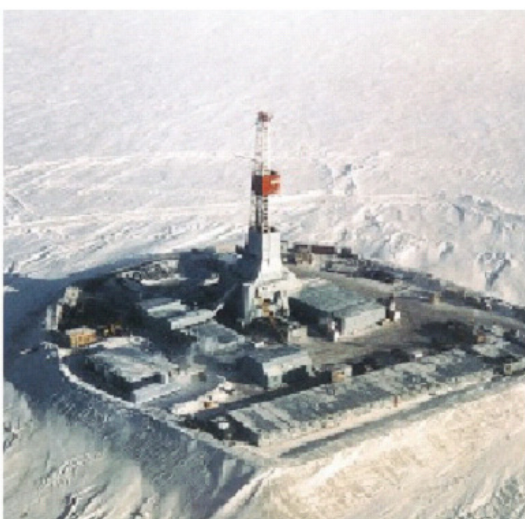
#### - Conventional Land Rig



#### - Conventional Land Rig for Cold Zone



#### - Winterized land rig



#### - Conventional Land Rig for Desert Zone



## - FAST MOVING RIG

They usually have low power and belong to - duty I e II of ENI E&P classification.  
They are dimensioned for: shallow wells, workover and abandonment.  
Their main advantage is their capability to rig up, move, and rig down quickly and easily.

### Fast Moving Land Rig G-200 Soilmec

This rig handles stands of **range III drill pipe** (completely automatic racking system)

- Fast moving rig example
- P/U and rotary system
- Racking system

*Fast Moving Rig Example*



*- Land Rig: Fast Moving Trailer Mounted*



## - HELI-RIG

### Land rig type heli-transported

Not very common.  
Used where there are not roads (bush, forest)

- Transport by helicopter
- All parts are dimensioned to be transported by helicopter.



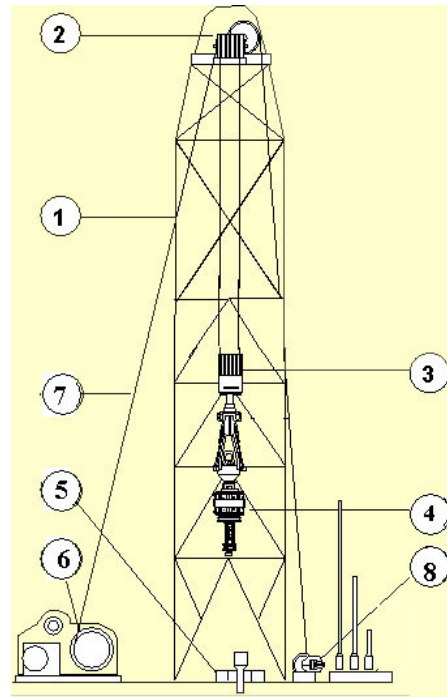
## 2.3 DRILLING RIG MAIN SYSTEMS

There are 4 main systems on a drilling rig:

- HOISTING & ROTATION SYSTEM
- POWER GENERATION SYSTEM
- MUD CIRCULATING SYSTEM
- WELL CONTROL SYSTEM

### - HOISTING & ROTATION SYSTEM

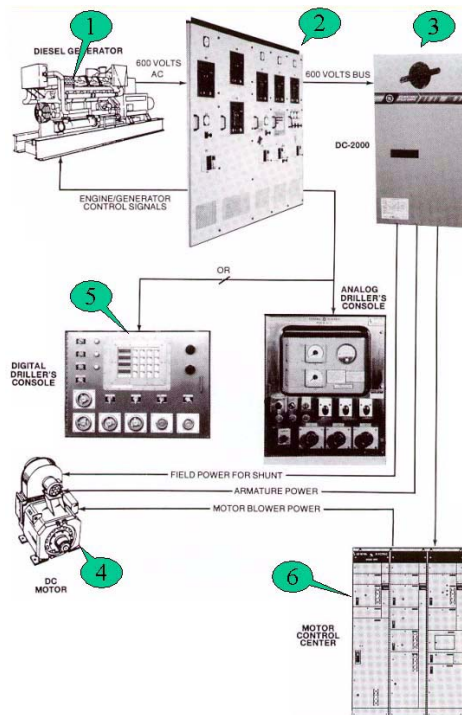
1. MAST & SUBSTRUCTURE
2. CROWN BLOCK
3. TRAVELLING BLOCK
4. TOP DRIVE
5. ROTARY TABLE
6. DRAWWORKS
7. DRILLING LINE
8. DEADLINE ANCHOR



### - POWER GENERATION SYSTEM

#### AC-DC POWER GENERATION STATION EXAMPLE

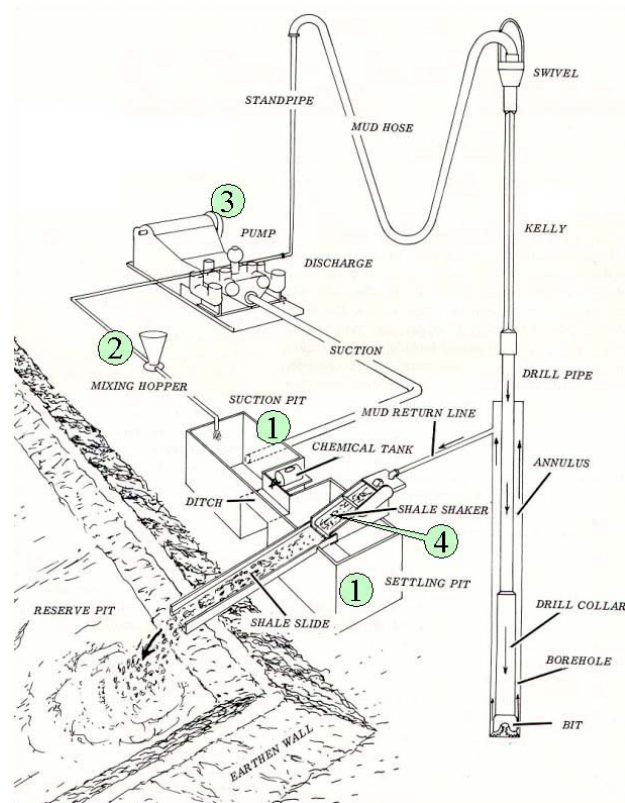
1. GENERATORS
2. CONTROL PANELS
3. TRANSFORMER
4. DC MOTOR
5. DIGITAL DRILLER'S CONSOLE
6. MOTOR CONTROL CENTER





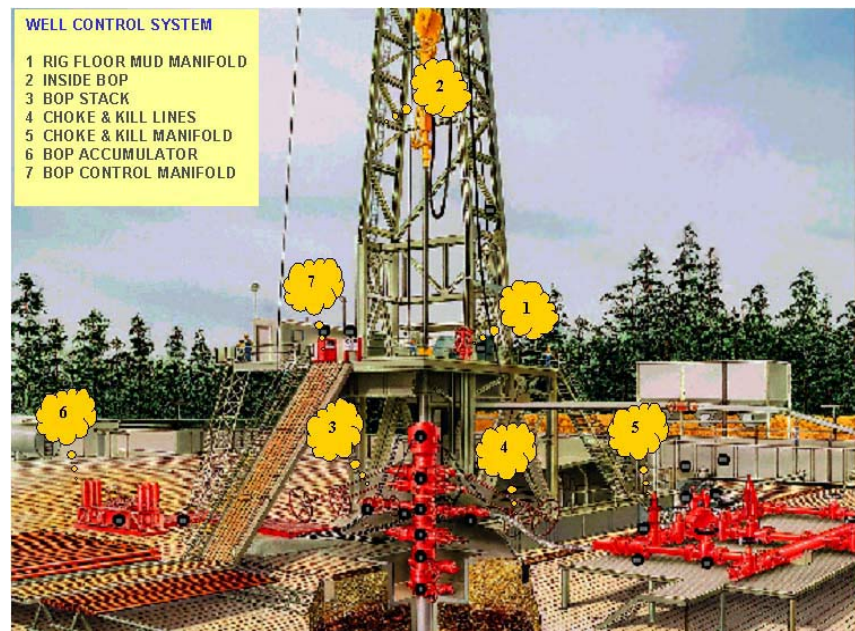
## - MUD CIRCULATING SYSTEM

1. MUD PITS
2. MUD MIXING HOPPER
3. MUD PUMPS (HI AND LOW PRESSURE)
4. SHAKERS



## - WELL CONTROL SYSTEM

1. RIG FLOOR MUD MANIFOLD
2. INSIDE BOP
3. BOP STACK
4. CHOKE & KILL LINES
5. CHOKE & KILL MANIFOLD
6. BOP ACCUMULATOR
7. BOP CONTROL MANIFOLD



### **03. RIG SITE**

#### **INDEX**

##### **3.1 RIG SITE**

Dimensions and Safety

Lay-out examples

Civil works on location

##### **3.2 CELLAR DIMENSIONS**

##### **3.3 WASTE PIT DIMENSIONS**

### **3.1 RIG SITE**

#### **- Dimensions and Safety**

##### **- Dimensions**

Rig site dimensions depend on different factors:

- Place (village, mountain, desert, forest)
- Local laws and regulations
- Rig type
- Drilling programme and risks (H<sub>2</sub>S, HP/HT, etc.)
- Water supply (water well, river, trucks with pits, etc.)
- Operating and economical factors

##### **- Safety**

For the safety of the people, the rig and the environment, some aspects must be considered in the project phase:

- rig must be positioned following the main wind direction; above all if H<sub>2</sub>S is foreseen;
- Emergency escape roads must be prepared in different direction;
- Different access way must be prepared in case the main road is inaccessible (i.e. Blow-out);
- Observe minimum distance between equipments according to laws and regulations.

##### **- Standard references**

European Directive 94/9/EC (ATEX 95)

"Equipment intended for use in potentially explosive atmosphere"

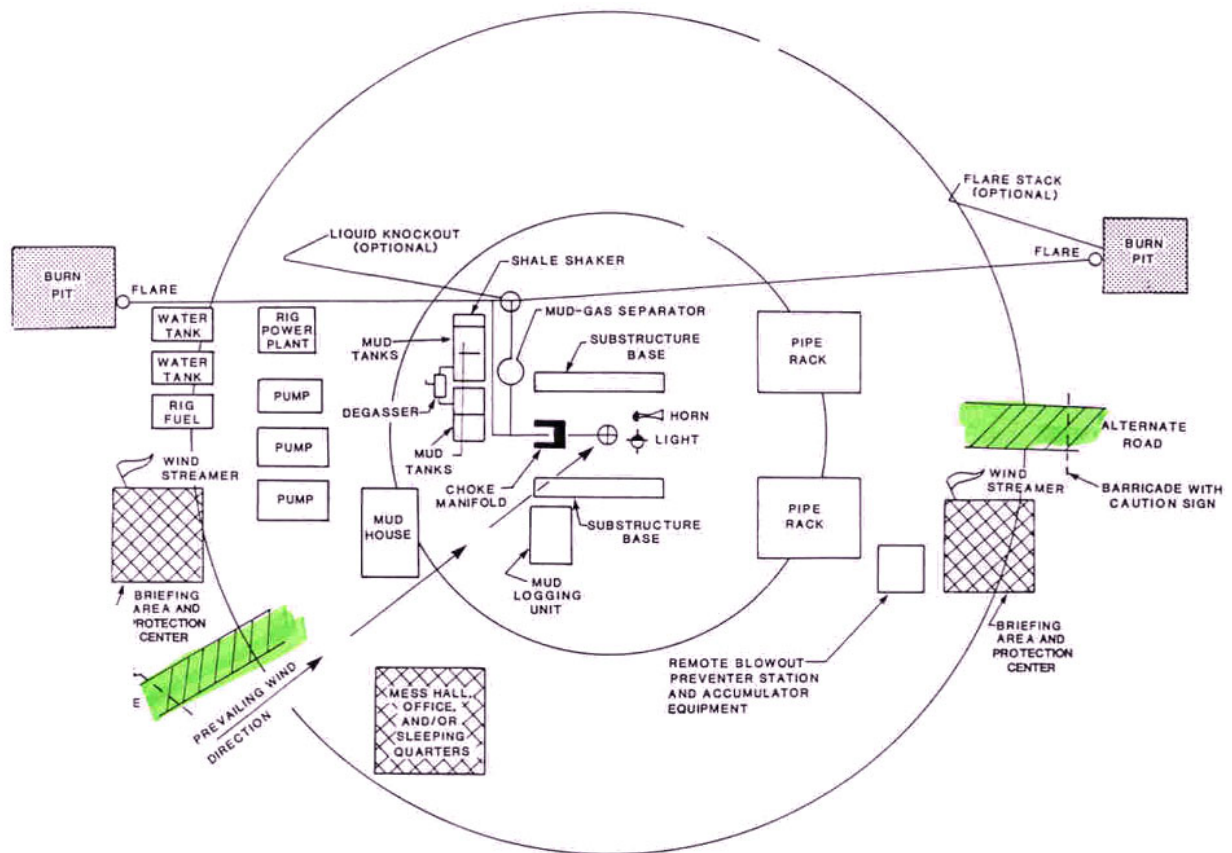
API RP 500

"Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division I and Division 2"

API RP 49

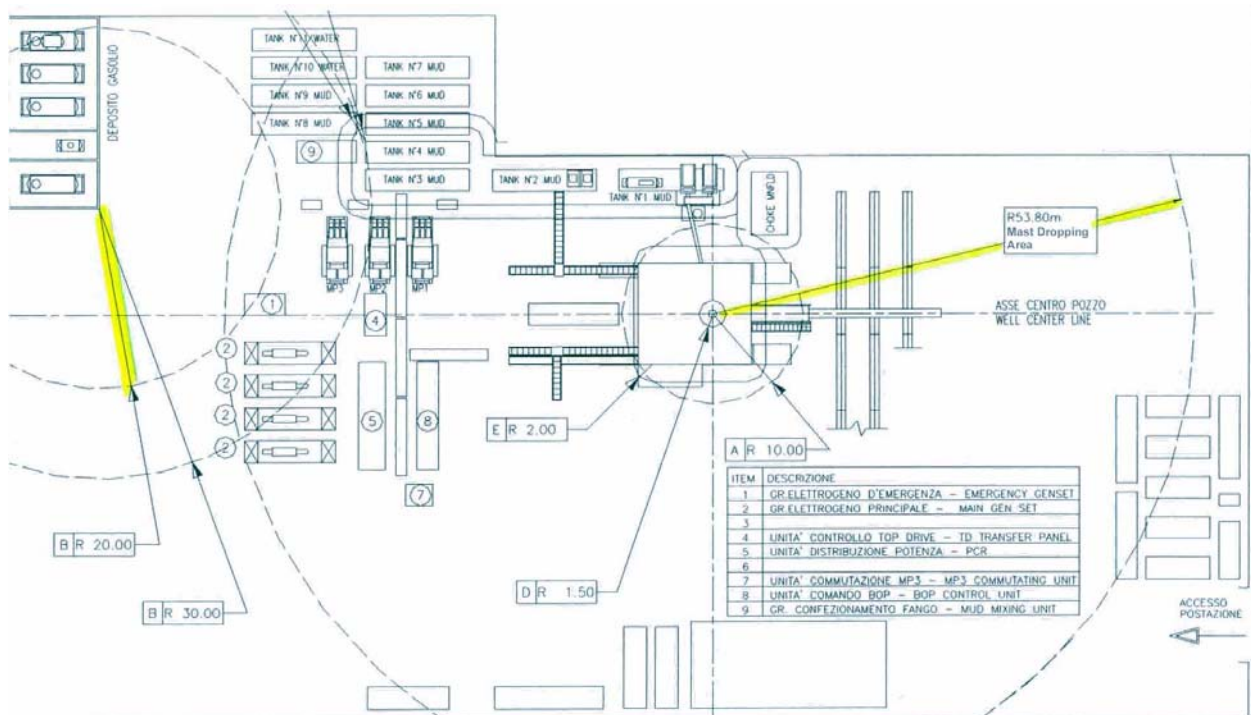
"Recommended practice for drilling and well servicing operations involving hydrogen sulfide" Third Edition

### API RP-49 Standard rig site



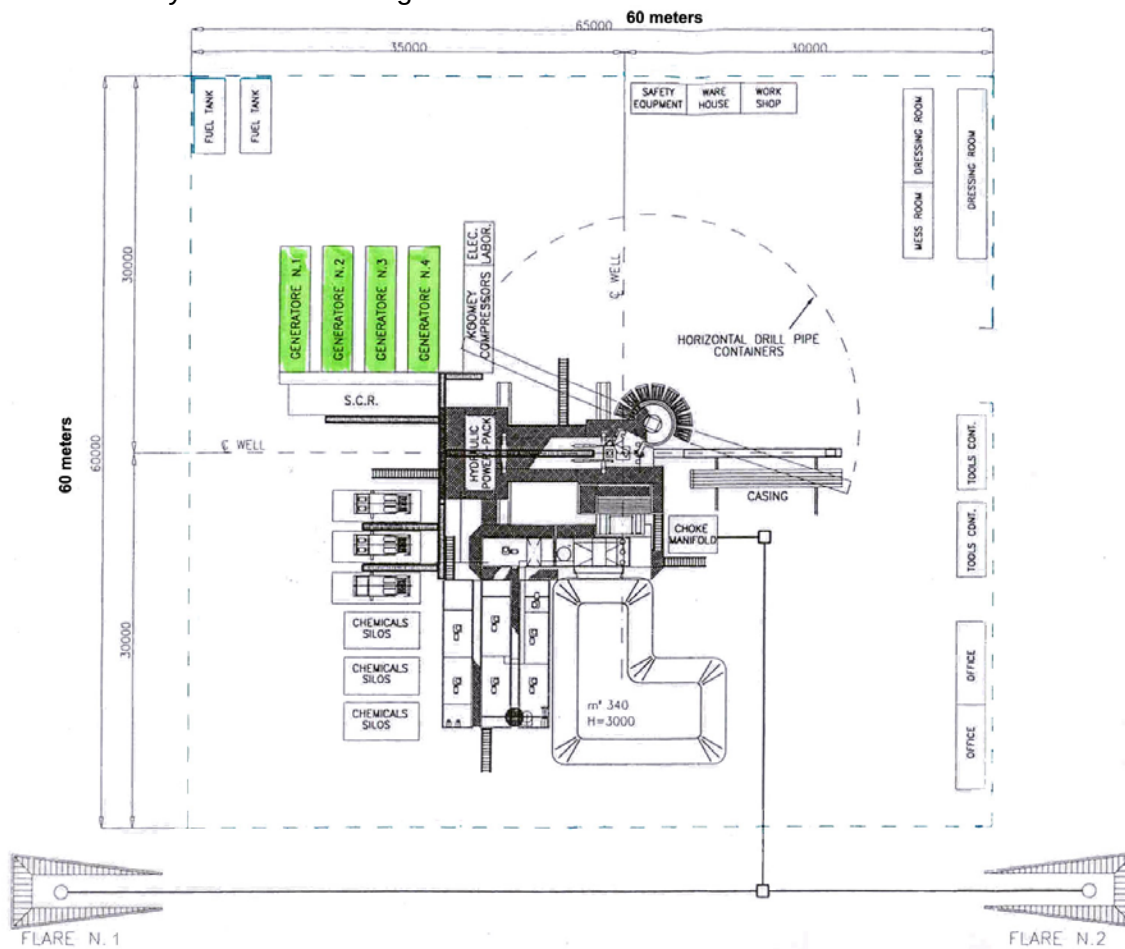
### - Example of Hazardous area classification - Plans

Minimum distances according to Italian and European laws.

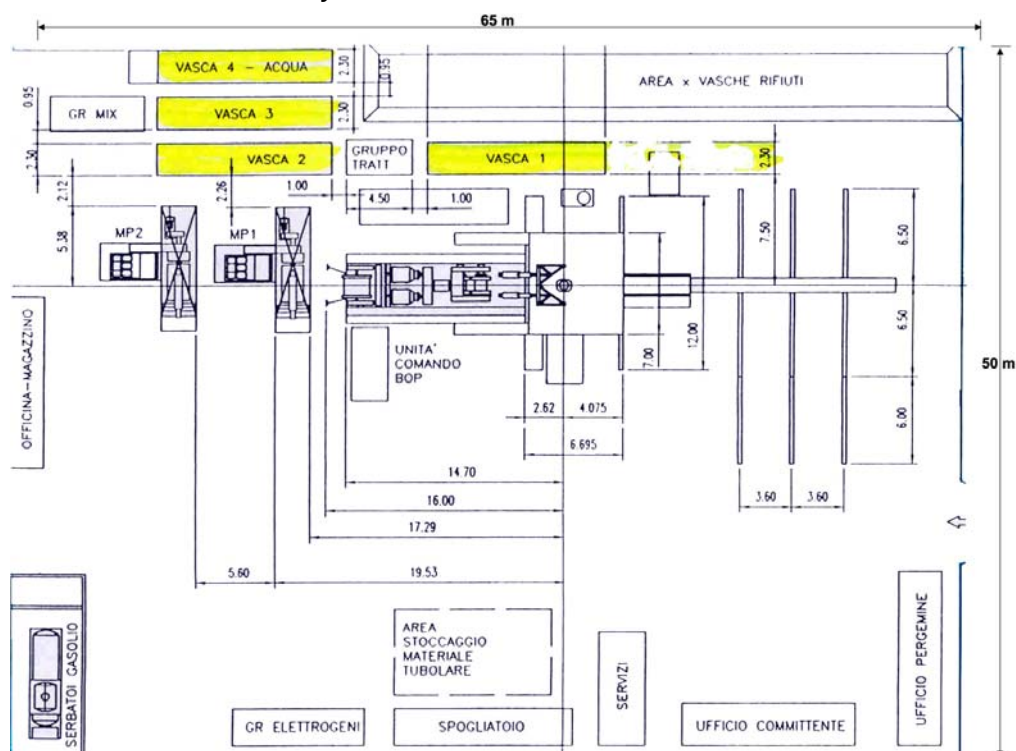


## - Lay-out Examples

- Minimum Lay Out for G125 Rig

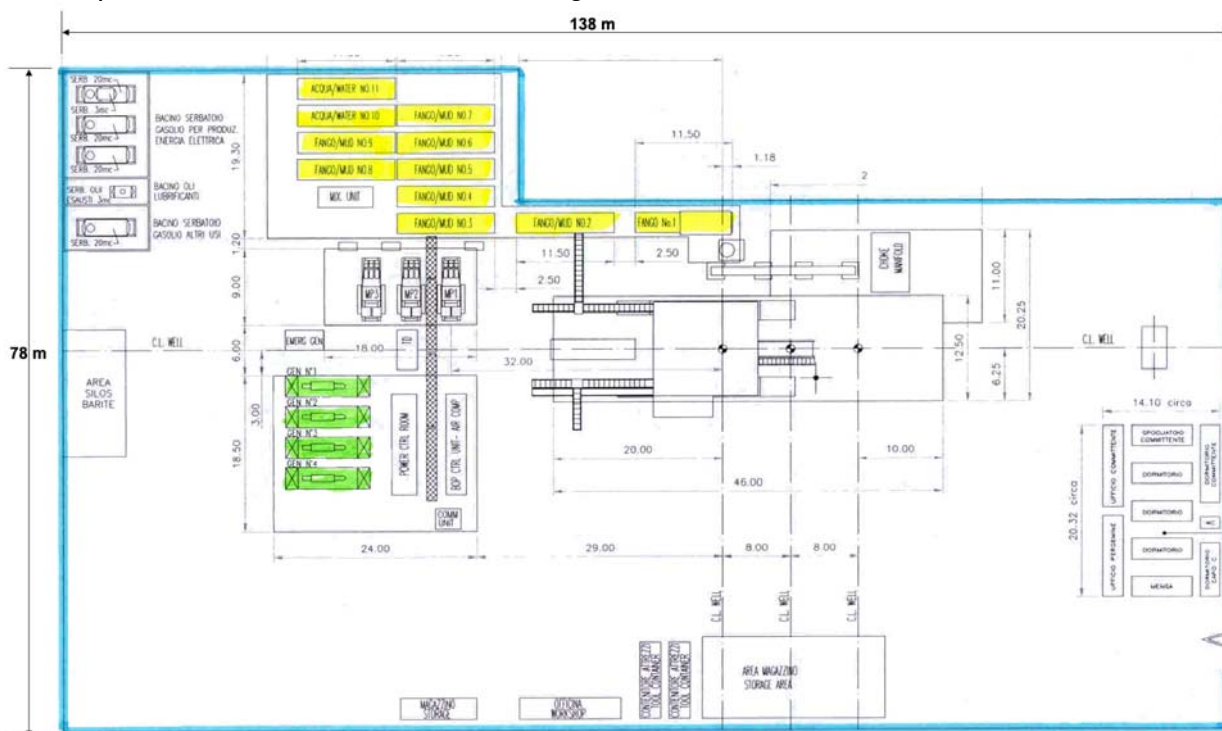


- Example of Massarenti 7000 Lay Out

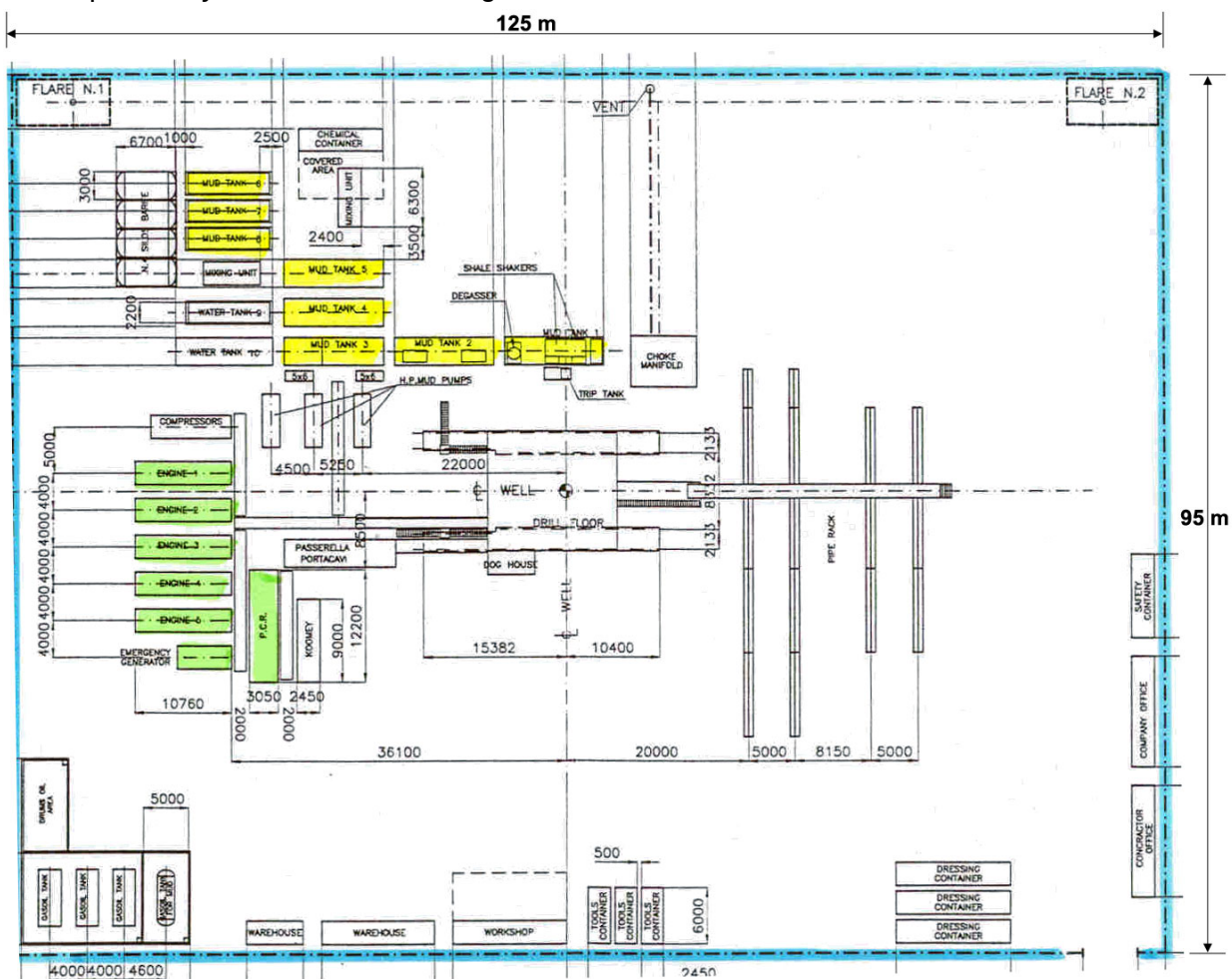




- Example of 3 Well Cluster for 2000 HP Rig



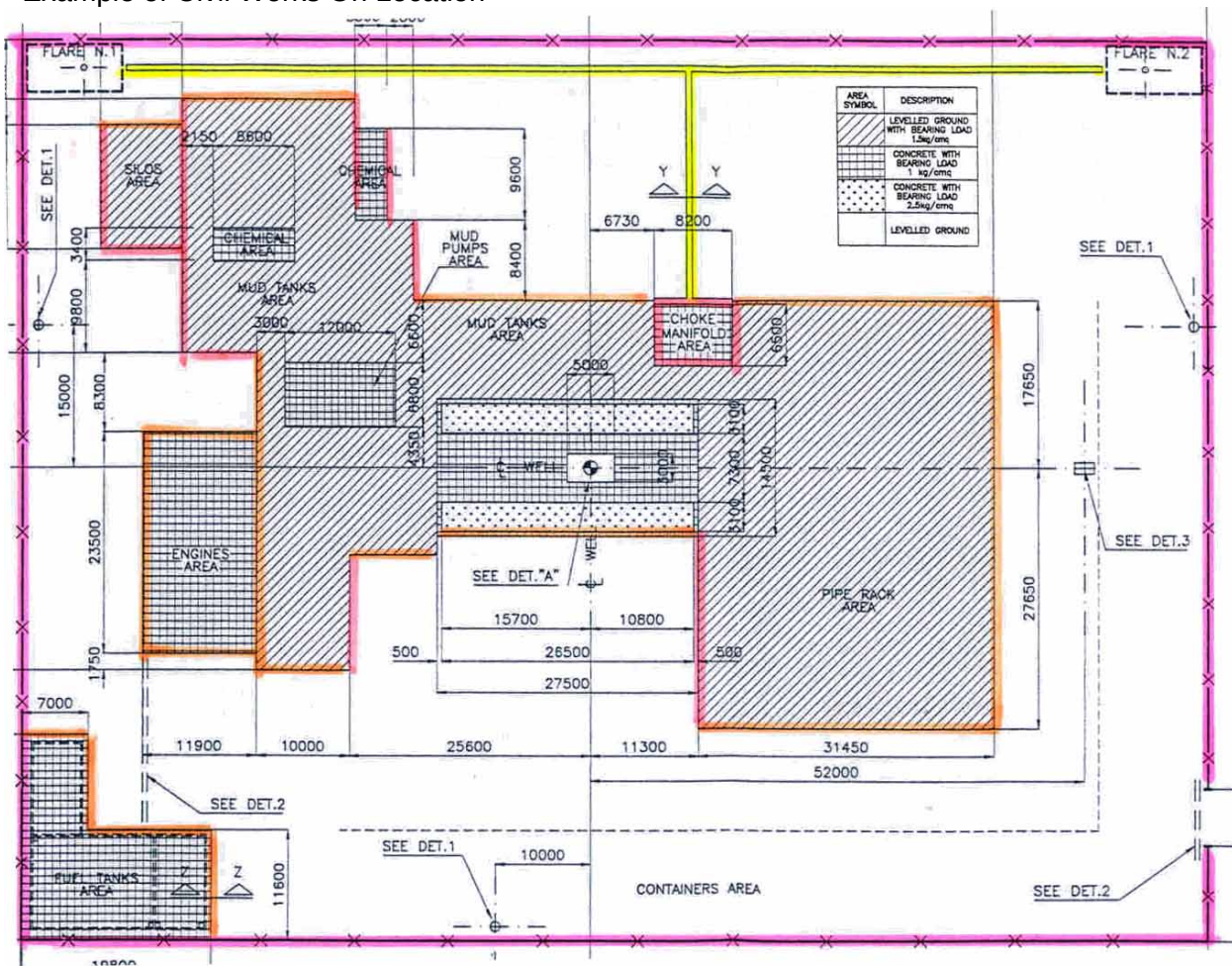
- Example of Lay Out for 3000 HP Rig





- Civil Works on Location

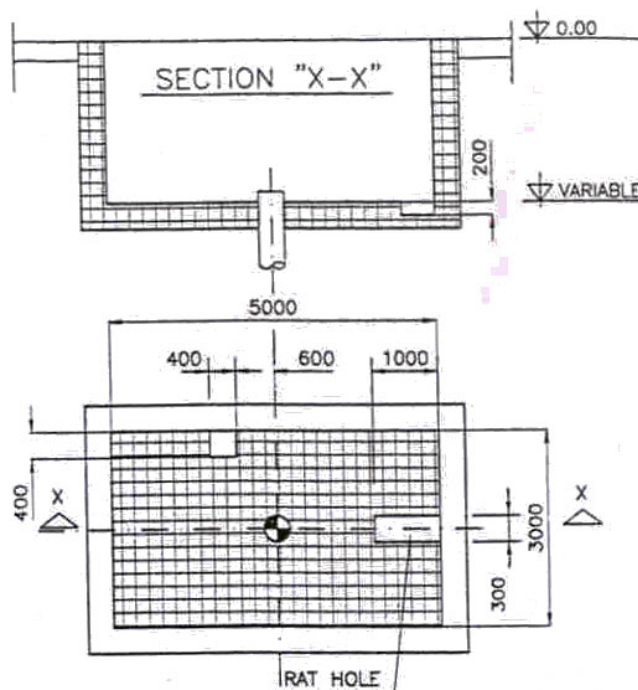
- Example of Civil Works On Location



### 3.2 CELLAR DIMENSIONS

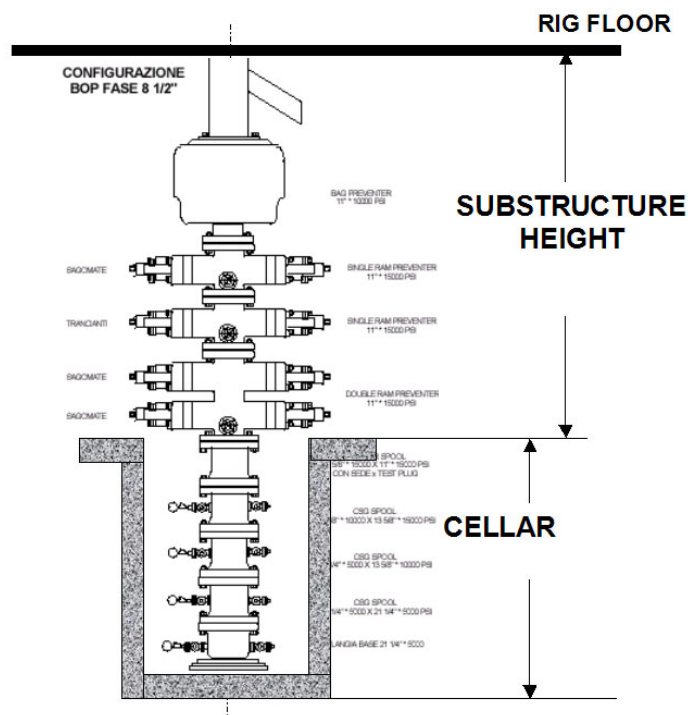
**- Cellar breadth**

Cellar breadth is usually decided with the Rig Contractor, considering well head, BOP and substructure. The cellar is usually cased in concrete to avoid collapse with the weight of the rig.



**- Cellar depth**

Cellar depth depends on substructure height, BOP and well head dimensions.

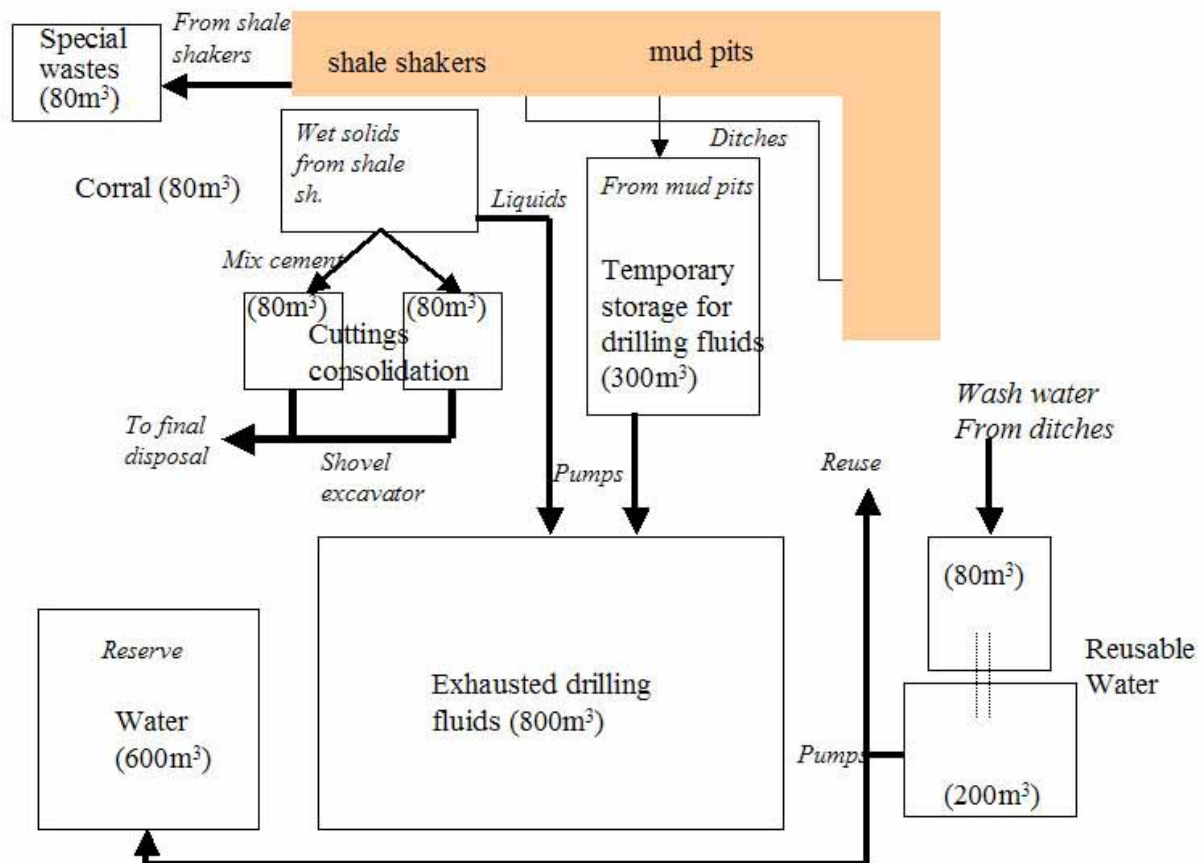


### 3.3 WASTE PIT DIMENSIONS

Waste pit dimensions must take into account:

- Total mud volume
- Total cuttings volume
- Cuttings treatment (on location or transported)
- Estimated drilling time.
- Weather conditions.

### Waste Pits And Treatment Layout example



## 04. SUBSTRUCTURE

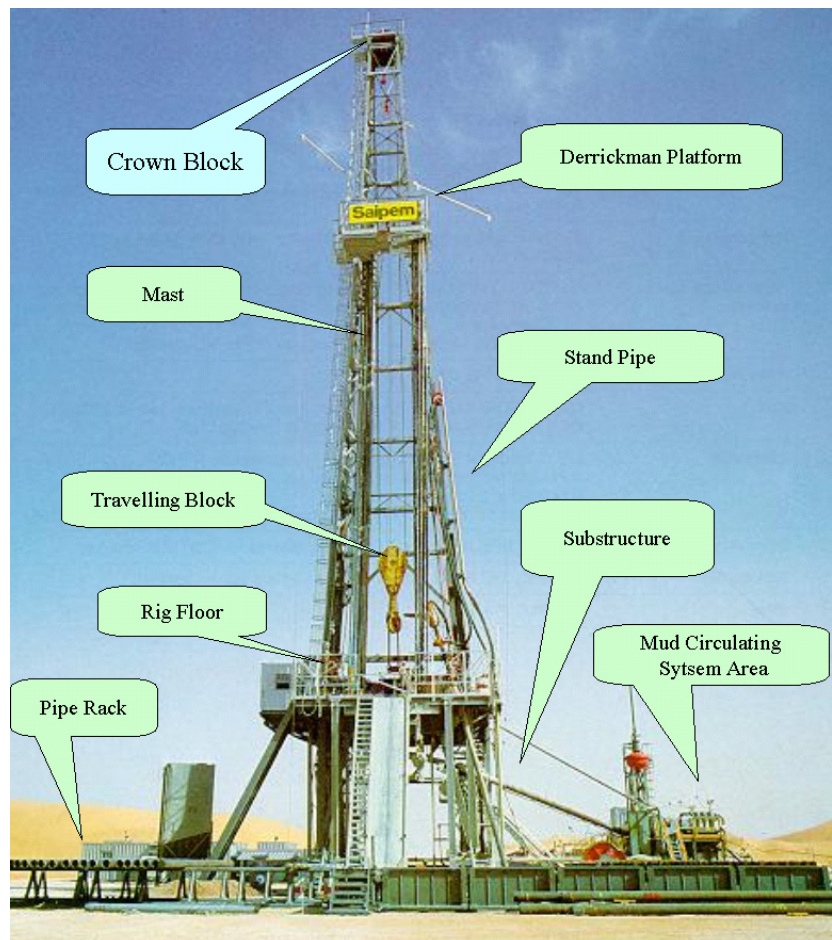
### INDEX

- 4.1 FUNCTION
- 4.2 SUBSTRUCTURE LOAD and DIMENSIONS
- 4.3 TYPES AND CHARACTERISTICS
- 4.4 RIG UP SYSTEMS
  - "SWING UP" - PYRAMID
  - "SWING LIFT" - BRANHAM
  - "SLING SHOT" - DRECO
- 4.5 INSPECTIONS

### 4.1 FUNCTION

The substructure has the function of supporting the drawworks, rotary table, stands of DP and derrick. The top side is generally called the rig floor.

Substructure are made following API STD 4E or 4F regulations. There is usually a plate mounted on the substructure identifying its main characteristics.





**- API Plate**

A - NAME OF THE BUILDER

B - ADDRESS

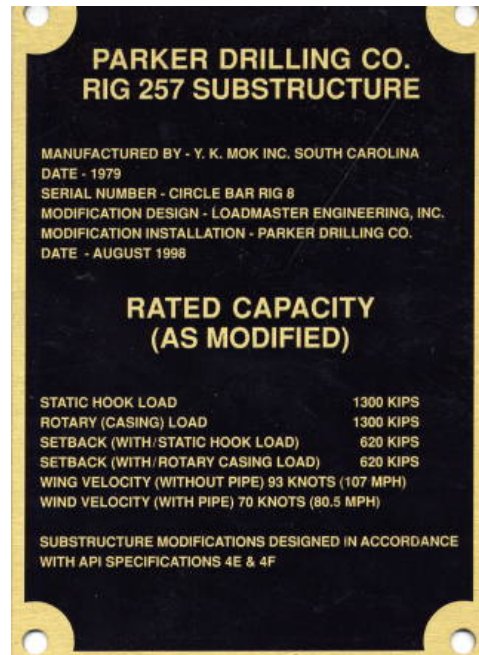
C - API STANDARD (ie API 4F)

D - SERIAL NUMBER

E - HEIGHT (ft)

F - MAXIMUM STATIC LOAD OF ROTARY TABLE

G - MAXIMUM SETBACK STATIC LOAD



**4.2 SUBSTRUCTURE LOAD and DIMENSIONS**

**- Substructure Load**

A Derrick or mast weight

B Rig Floor and equipment

C Maximum load of pipe that can be set back in the derrick

D Maximum hook load

**- Dimensions**

Substructure dimensions are proportional to the rig power.

**PYRAMID Dimensions**

| Mast<br>Clear<br>Height |        | Width<br>At<br>Floor |        | Static<br>Hook<br>Capacity |      | No. Lines<br>To Travel<br>Block | Substructure<br>Height |           |
|-------------------------|--------|----------------------|--------|----------------------------|------|---------------------------------|------------------------|-----------|
| ft.                     | meters | ft.                  | meters | lbs.                       | m.t. | std.                            | ft.                    | meters    |
| 132                     | 40.5   | 18                   | 3.04   | 390,000                    | 177  | 8                               | 22                     | 6.70      |
| 132                     | 40.5   | 18                   | 3.04   | 475,000                    | 215  | 10                              | 22                     | 6.70      |
| 142                     | 43.28  | 21                   | 6.40   | 530,000                    | 241  | 10                              | 22                     | 6.70      |
| 142                     | 43.28  | 21                   | 6.40   | 600,000                    | 273  | 10                              | 22                     | 6.70      |
| 142                     | 43.28  | 21                   | 6.40   | 730,000                    | 331  | 12                              | 22                     | 6.70      |
| 142                     | 43.28  | 25                   | 7.62   | 730,000                    | 331  | 12                              | 26                     | 7.92      |
| 142                     | 43.28  | 25                   | 7.62   | 840,000                    | 381  | 12                              | 26 or 30               | 7.92/9.14 |
| 142                     | 43.28  | 25                   | 7.62   | 1,000,000                  | 454  | 12                              | 26 or 30               | 7.92/9.14 |
| 152                     | 46.32  | 30                   | 9.14   | 1,275,000                  | 578  | 14                              | 30 or 35               | 9.14/10.6 |
| 152                     | 46.32  | 30                   | 9.14   | 1,600,000                  | 726  | 14                              | 30 or 35               | 9.14/10.6 |
| 152                     | 46.32  | 30                   | 9.14   | 2,000,000                  | 909  | 16                              | 35                     | 10.6      |



### 4.3 TYPES AND CHARACTERISTICS

#### - Substructure Types

Land rigs are made for frequent Rig Up, moving and Rig Down.

This is the main reason why different substructure types have been developed.

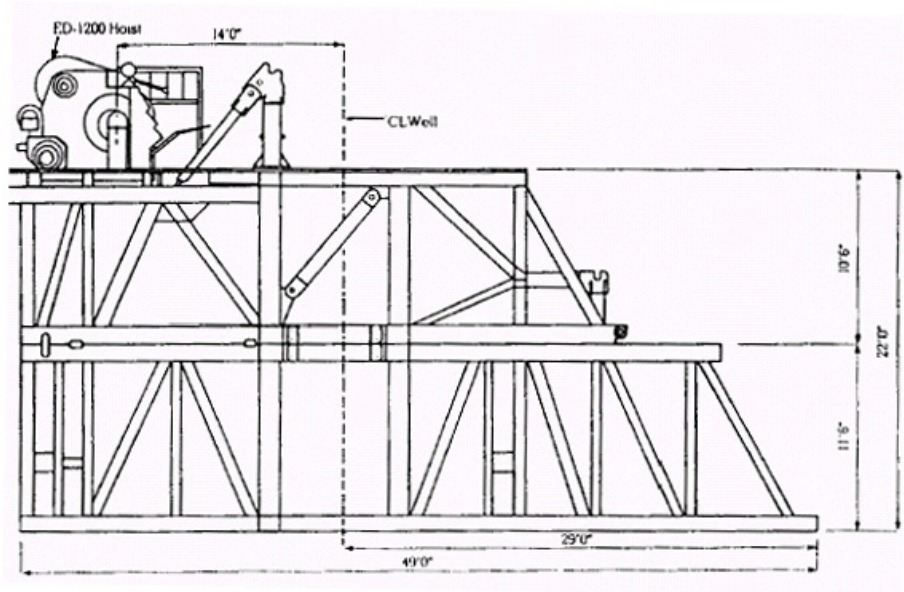
Two main types

- Type Box on Box
- Type: High Floor Substructure

#### - Type Box on Box

Different modules or boxes are positioned to raise the rig floor.

The numbers of boxes depends on the height required to install the wellhead and BOP stack.



#### - Type: High Floor Substructure

These have been developed to accommodate higher BOP stacks and wellheads.

Although each builder has their own model, they all have the following characteristics:

Enables the drawworks and derrick to be rigged up at ground level, eliminating the need for big cranes;  
Uses the rig's drawworks to raise the floor and derrick (some models use hydraulic pistons).



#### 4.4 RIG UP SYSTEMS

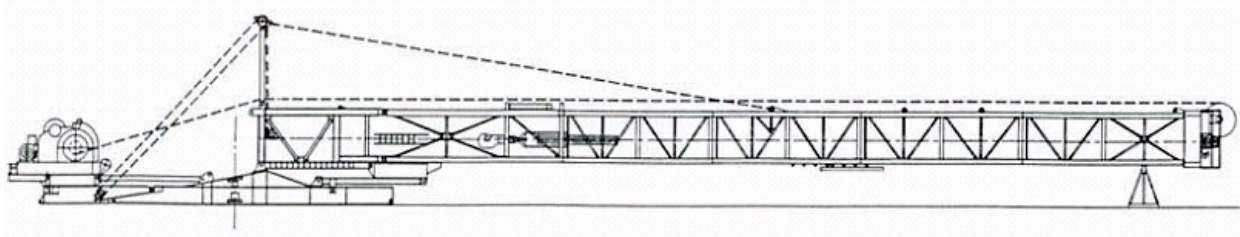
- "SWING UP" - PYRAMID
- "SWING LIFT" - BRANHAM
- "SLING SHOT" - DRECO

##### - SWING UP - PYRAMID

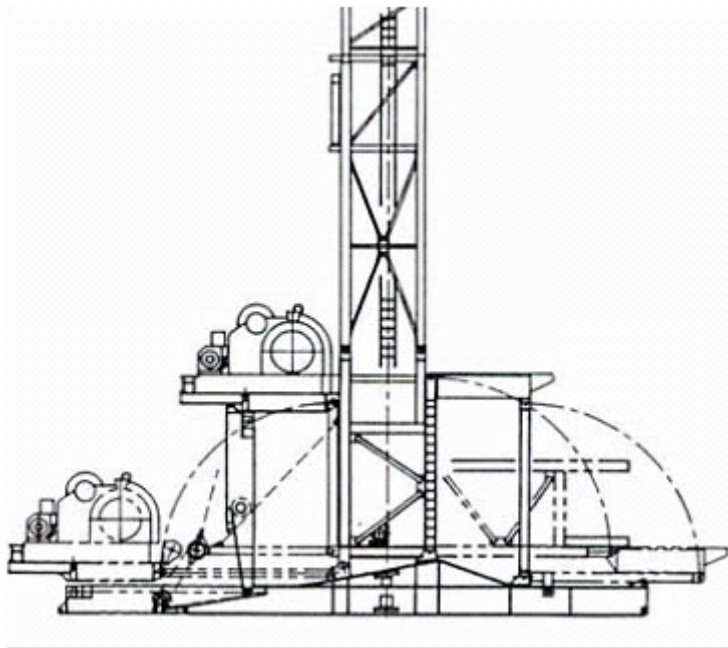
Drawwork lifts the mast, the substructure and the complete rig floor.

Only 2 main lifts are required

- 1st lift to pick up mast and part of rig floor



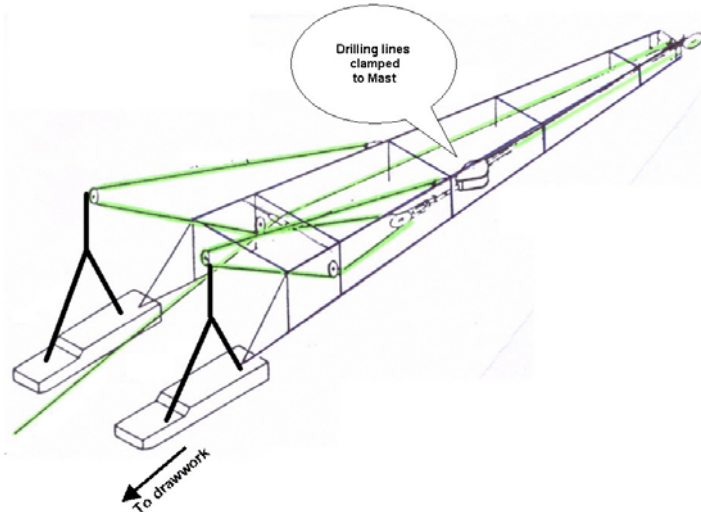
- 2nd lift to pick up draw work and aft part of rig floor.



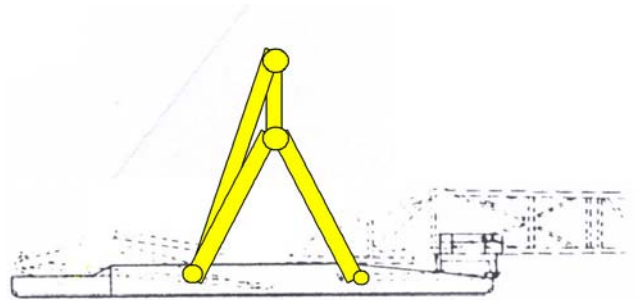
## - SWING LIFT - BRANHAM

- Position of lifting cables
- 1st PHASE: A-frame positioning
- 2nd PHASE : Lifting the Mast
- 3rd PHASE : Lifting the Drawworks

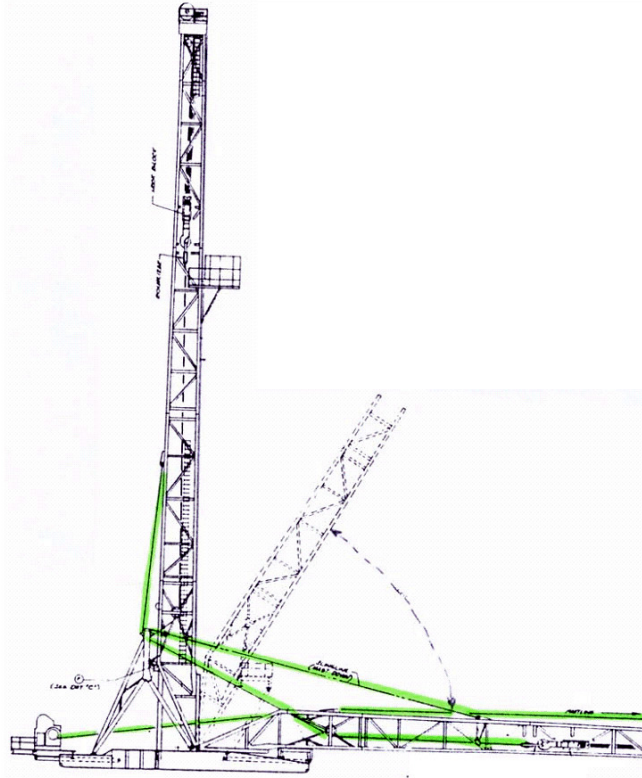
Lifting Cables - Scheme



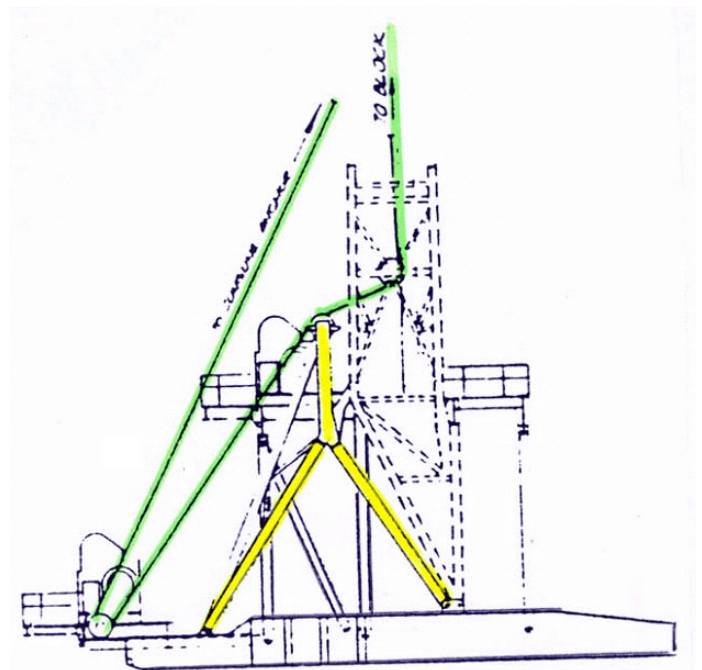
1st A-frame Positioning - Scheme



2nd Lifting the Mast - Scheme



3rd Lifting the Drawworks - Scheme





### **- SLING SHOT DRECO**

Dedicated hydraulic pistons to lift derrick, substructure and complete rig floor.

Lifting sequence

- Beginning

- After 3 minutes

- After 6 minutes

- After 9 minutes



## **4.5 INSPECTIONS**

Periodical inspections

Substructure, derrick and lifting equipment must have periodical inspections, (every six months) following the builder's instructions and the API regulations:

API RP 4G ed API RP 54.

International Organization for Standardization (ISO)

ISO 13534.

ENI rules ask also a complete re-certification of the derrick/mast every 5 years.

## 05. DERRICK

### INDEX

#### 5.1 CONCEPTUAL DESIGN

#### 5.2 TYPES AND CHARACTERISTICS

- DERRICK
- MAST
- RAM RIG

#### 5.3 RIGGING UP

#### 5.4 DRILLING LOADS

- Calculation of Drilling Loads at Crown Block
- Definition of Gross Nominal Capacity

#### 5.5 INSPECTION

### 5.1 CONCEPTUAL DESIGN

#### - Derricks

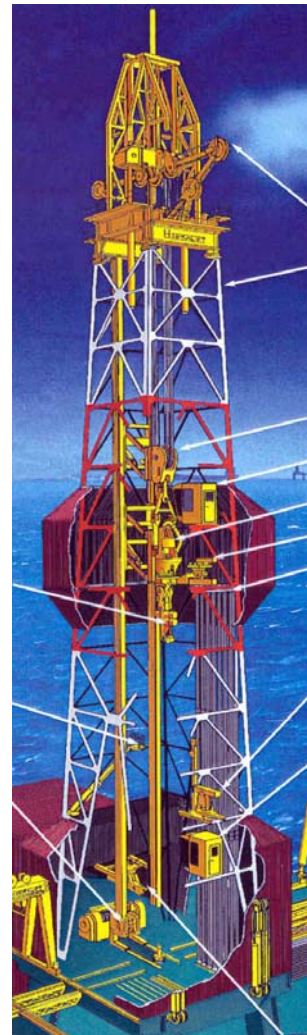
Derricks and Masts consist of a steel framework with a square or rectangular cross-section. Their purpose is to support the hoisting equipment and rack the tubulars while tripping.

The number of joints in a stand (single-double-triple) that the rig can pull is dependent on the height of the derrick.

#### - Manufacturer Specifications

Derricks are manufactured in accordance with API 4F or related ISO (International Organization for Standardization) 13626 draft.

This specifications covers the design, manufacture, and use of derricks, portable masts, crown block assemblies and substructures.





### **- Nameplate Information**

Derricks built within API/ISO specs must have a specification nameplate attached in a visible place containing the following information:

- a. MANUFACTURER'S NAME.
- b. PLACE OF CONSTRUCTION.
- c. STANDARD ADOPTED (ex. API 4F).
- d. SERIAL NUMBER.
- e. HEIGHT ( ft ).
- f. MAXIMUM STATIC HOOK LOAD ( lbs) FOR STATED NUMBER OF LINES TO TRAVELLING BLOCKS.
- g. MAX. RATED WIND VELOCITY (Knots) WITH RATED CAPACITY OF PIPE RACKED.
- h. EDITION OF THE API SPEC. USED
- l. GUYING DIAGRAM (when applicable)
- j. The following note: "CAUTION: ACCELERATION OR IMPACT, ALSO SETBACK AND WIND LOADS WILL REDUCE THE MAXIMUM RATED STATIC HOOK LOAD CAPACITY."
- k. LOAD DISTRIBUTION DIAGRAM.
- l. GRAPH PLOTTING MAX. ALLOWABLE STATIC HOOK LOAD VERSUS WIND VELOCITY.
- m. MAST SETUP DISTANCE FOR MAST WITH GUY LINES.

### **5.2 TYPES AND CHARACTERISTICS**

There are 3 different types of derricks:

- DERRICK
- MAST
- RAM RIG

#### **- DERRICK**

Pyramidal steel framework with square or rectangular cross section assembled as fixed structure.

##### **- API Definition**

A semipermanent structure of square or rectangular cross-section having members that are latticed or trussed on all four sides.

This unit must be assembled in the vertical or operation position, as it includes no erection mechanism. It may or may not be guyed.

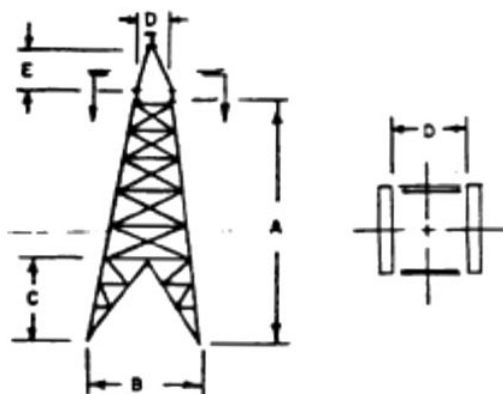
- Derrick dimensions

Table 1 - Derrick Sizes and General Dimensions

Table B-1—Derrick Sizes and General Dimensions

| (1)                 | (2)    |     | (3)                    |     | (4)                         |     | (5)                 |     | (6)     |     | (7)                   |     |
|---------------------|--------|-----|------------------------|-----|-----------------------------|-----|---------------------|-----|---------|-----|-----------------------|-----|
|                     | Height |     | Nominal<br>Base Square |     | Drawworks<br>Window Opening |     | v Window<br>Opening |     | Opening |     | Gin Pole<br>Clearance |     |
| Derrick<br>Size No. | ft.    | in. | ft.                    | in. | ft.                         | in. | ft.                 | in. | ft.     | in. | ft.                   | in. |
| 10                  | 80     | 0   | 20                     | 0   | 7                           | 6   | 23                  | 8   | 5       | 6   | 8                     | 0   |
| 11                  | 87     | 0   | 20                     | 0   | 7                           | 6   | 23                  | 8   | 5       | 6   | 8                     | 0   |
| 12                  | 94     | 0   | 24                     | 0   | 7                           | 6   | 23                  | 8   | 5       | 6   | 8                     | 0   |
| 16                  | 122    | 0   | 24                     | 0   | 7                           | 6   | 23                  | 8   | 5       | 6   | 8                     | 0   |
| 18                  | 136    | 0   | 26                     | 0   | 7                           | 6   | 23                  | 8   | 5       | 6   | 12                    | 0   |
| 18A                 | 136    | 0   | 30                     | 0   | 7                           | 6   | 23                  | 8   | 5       | 6   | 12                    | 0   |
| 19                  | 140    | 0   | 30                     | 0   | 7                           | 6   | 26                  | 6   | 7       | 6   | 17                    | 0   |
| 20                  | 147    | 0   | 30                     | 0   | 7                           | 6   | 26                  | 6   | 6       | 6   | 17                    | 0   |
| 25                  | 189    | 0   | 37                     | 6   | 7                           | 6   | 26                  | 6   | 7       | 6   | 17                    | 0   |

Tolerances: A  $\pm 6$  in.; B,  $\pm 5$  in.; C, + 3 ft., 6 in.; D,  $\pm 2$  in.; E,  $\pm 6$  in.



A - The vertical distance from the top of the base plate to the bottom of the Crown Block support Beam.

B - The distance between heel to heel of adjacent legs.

C - The window opening measured in the clear and parallel to the center line of the derrick side from top of base plate.

D - The smallest clear dimension at the top of the derrick that would restrict passage of crown block.

E - The clearance between the horizontal header of the gin pole and the top of the crown support beam.

## Derrick Types

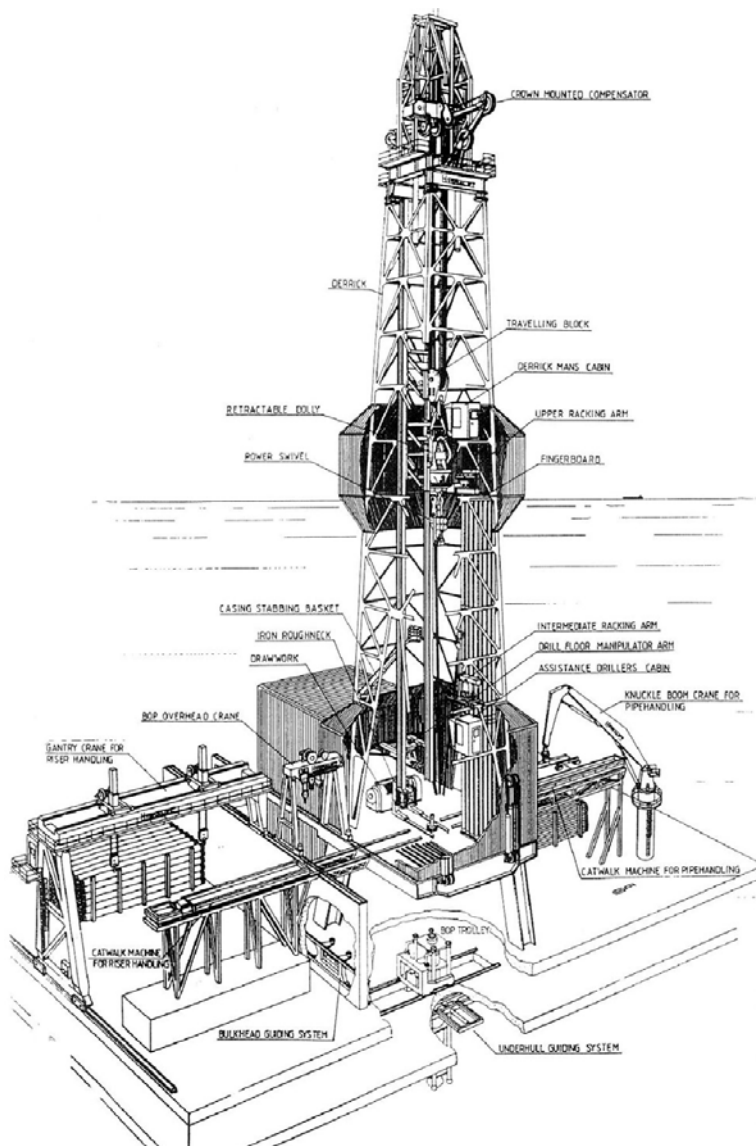
Derrick are normally used on Offshore rigs and can be divided into categories:

- Stationary Derrick

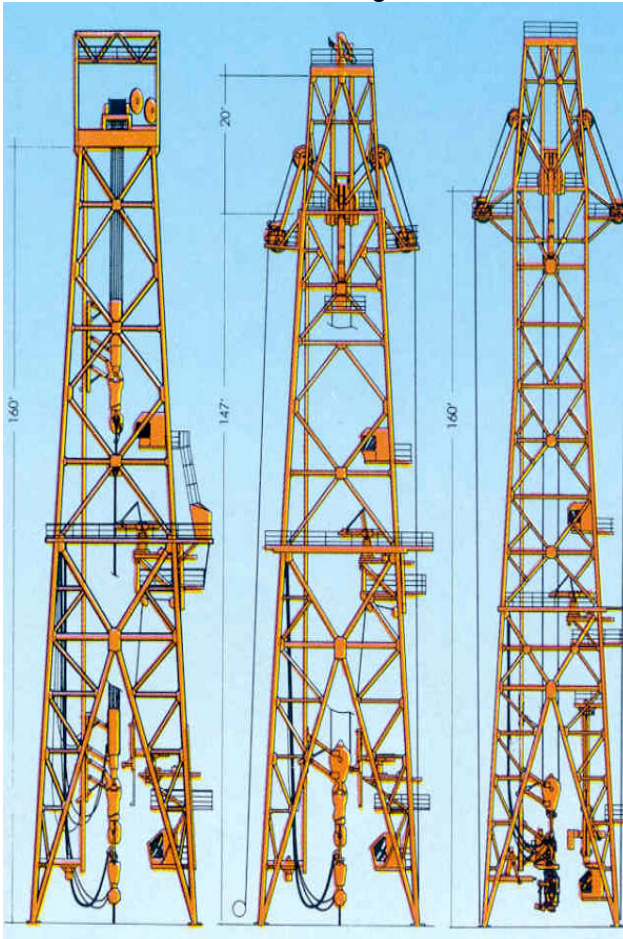
Derrick used on offshore fixed structures

- Dynamic Derrick

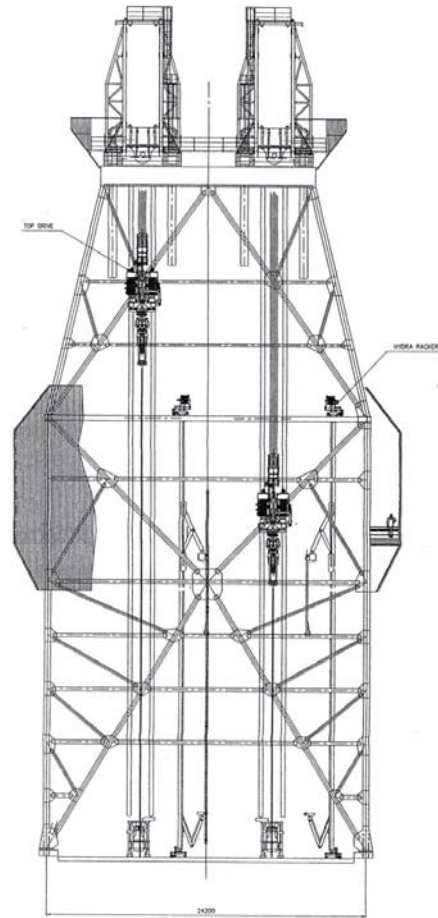
Heavyweight derrick used on floating rigs subjected to marine stress.



Installation on offshore floating unit



Dynamic Derrick mounted on DS SAIPEM 10000



## - MAST

A Mast is a steel framework with square or rectangular cross-section comprised of multiple sections assembled together.

Mast are normally used on land rigs; they are rarely used on offshore rigs.

Most masts have one side open (window side), while others have both the front and rear side open (full view).

Generally masts are assembled on the ground in horizontal position and are raised using the drawworks. Some masts use telescopic sections and are assembled in vertical (boot strap).

### - API Definition

3.16 mast: A structural tower comprised of one or more sections assembled in a horizontal position near the ground and then raised to the operating position.

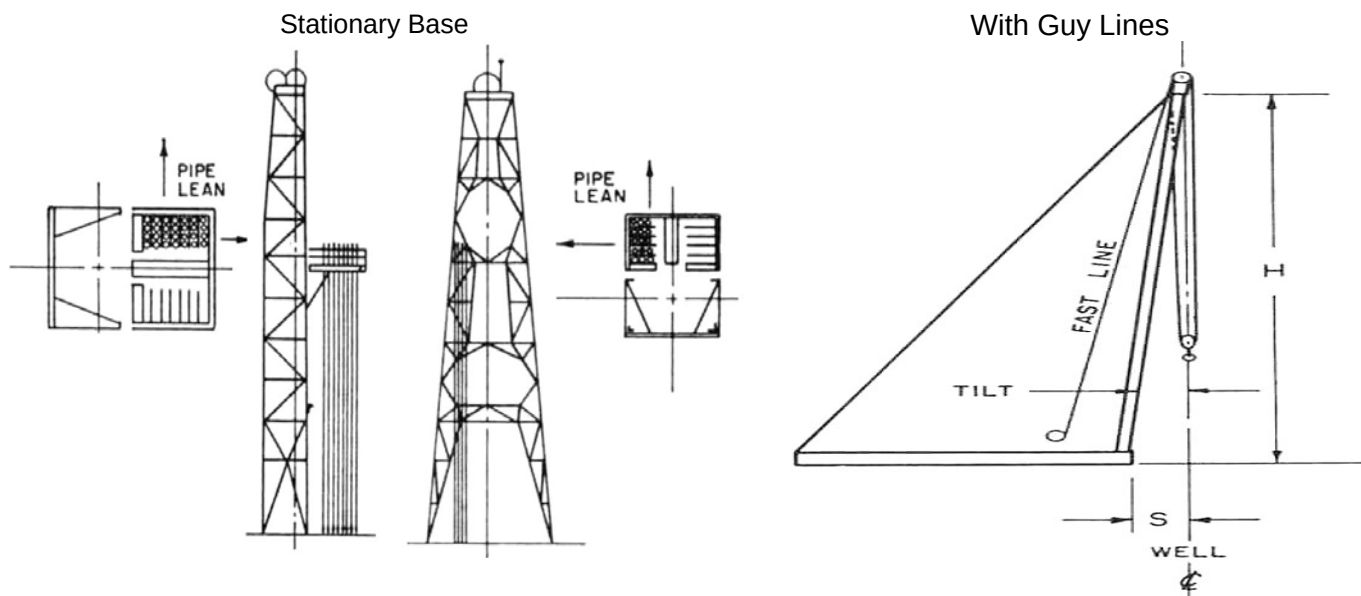
If the unit contains two or more sections, it may be telescoped or unfolded during the erection procedure.



## Mast Types

There are 2 different types of masts for land drilling and service rigs:

- STATIONARY BASE
- WITH GUY LINES



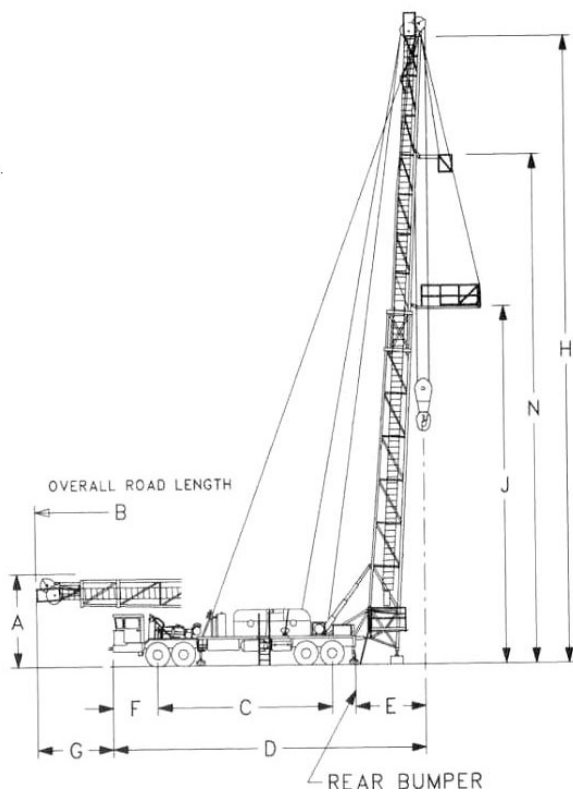
- Pyramid Mast sizes table

| Mast Clear Height |        | Width At Floor |        | Static Hook Capacity |      | No. Lines To Travel Block | Approximate Drilling Depth Range |              |
|-------------------|--------|----------------|--------|----------------------|------|---------------------------|----------------------------------|--------------|
| ft.               | meters | ft.            | meters | lbs.                 | m.t. | std.                      | (x 1000 ft.)                     | (Kilometers) |
| 112               | 30.49  | 16             | 4.57   | 275,000              | 125  | 6                         | 4/6                              | 1.21/1.82    |
| 132               | 40.23  | 18             | 5.48   | 390,000              | 177  | 8                         | 5/8                              | 1.52/2.43    |
| 132               | 40.23  | 18             | 5.48   | 475,000              | 0    | 10                        | 8/10                             | 2.42/3.03    |
| 142               | 43.28  | 21             | 6.40   | 530,000              | 241  | 10                        | 10/14                            | 3.04/4.8     |
| 142               | 43.28  | 21             | 6.40   | 600,000              | 273  | 10                        | 12/16                            | 3.65/4.87    |
| 142               | 43.28  | 21             | 6.40   | 730,000              | 331  | 12                        | 14/18                            | 4.26/5.49    |
| 142               | 43.28  | 25             | 7.62   | 730,000              | 331  | 12                        | 14/18                            | 4.26/5.49    |
| 142               | 43.28  | 25             | 7.62   | 840,000              | 381  | 12                        | 16/20                            | 4.87/6.09    |
| 142               | 43.28  | 25             | 7.62   | 1,000,000            | 454  | 12                        | 18/22                            | 5.49/6.71    |
| 152               | 46.32  | 30             | 9.14   | 1,275,000            | 578  | 14                        | 20/25                            | 6.0 /7.62    |
| 152               | 46.32  | 30             | 9.14   | 1,600,000            | 727  | 14                        | 25/30                            | 7.6 /9.1     |
| 152               | 46.32  | 30             | 9.14   | 2,000,000            | 907  | 16                        | 30+                              | 9.1+         |

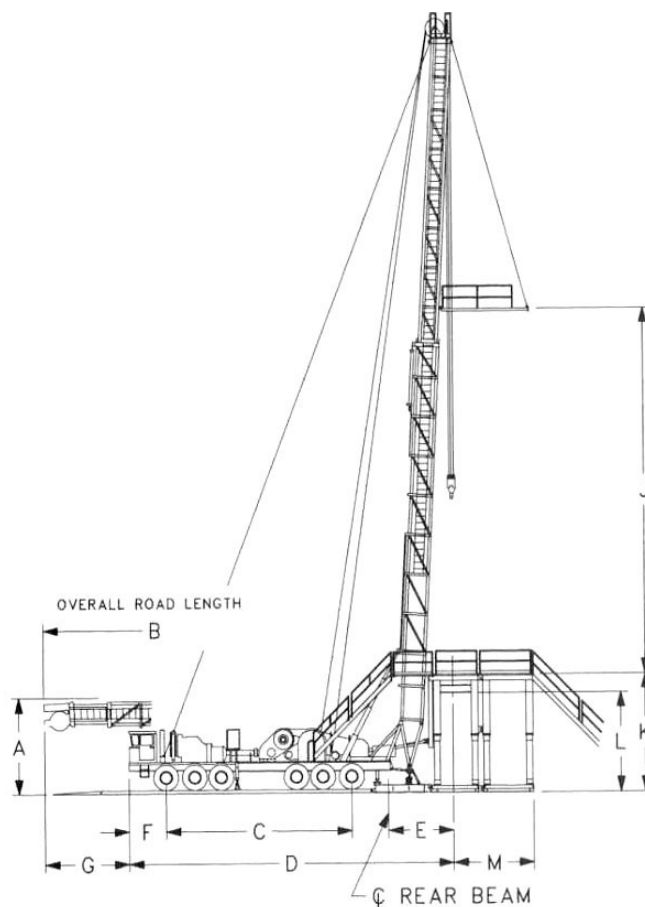
**NOTE:** The above data reflects our standard designs; however, Pyramid will fabricate according to customer's specifications.

## Example of MAST with GUY LINES

Example 1



Example 2



## - RAM RIG

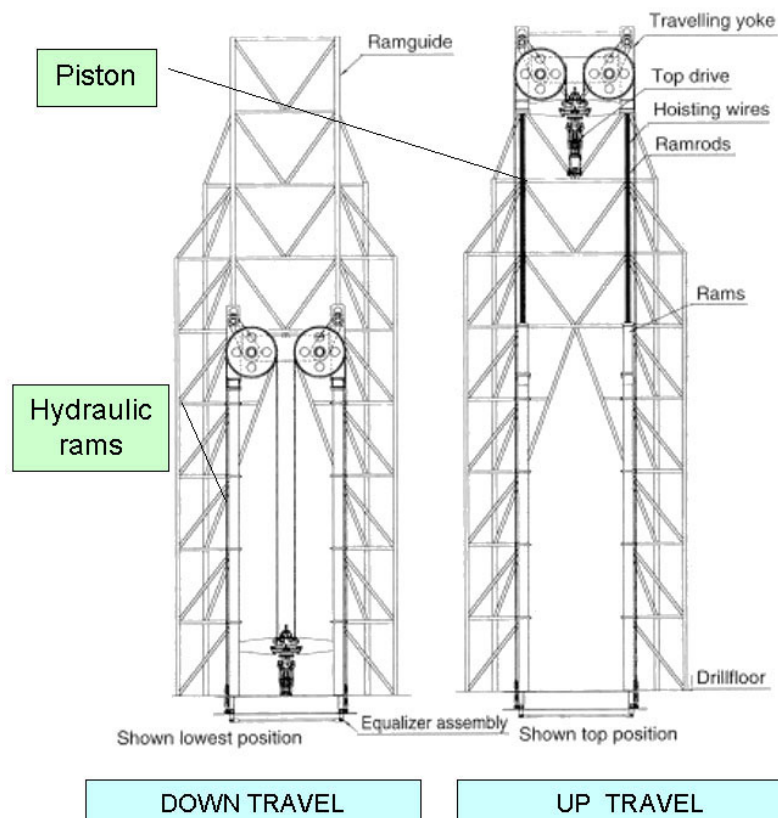
The RAM RIG is a new concept used to hoist the drill string.

The Drawwork and the drilling line are replaced with a system of hydraulic pistons and rams. Ram rigs can be used with singles or stands, depending on the height of the derrick.

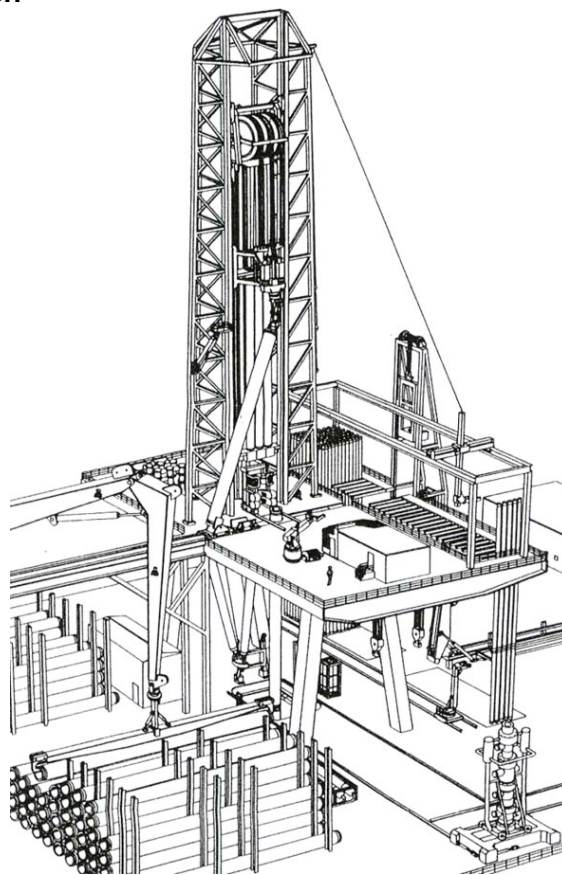
They have only recently been developed and are not yet classified within API/ISO Specs



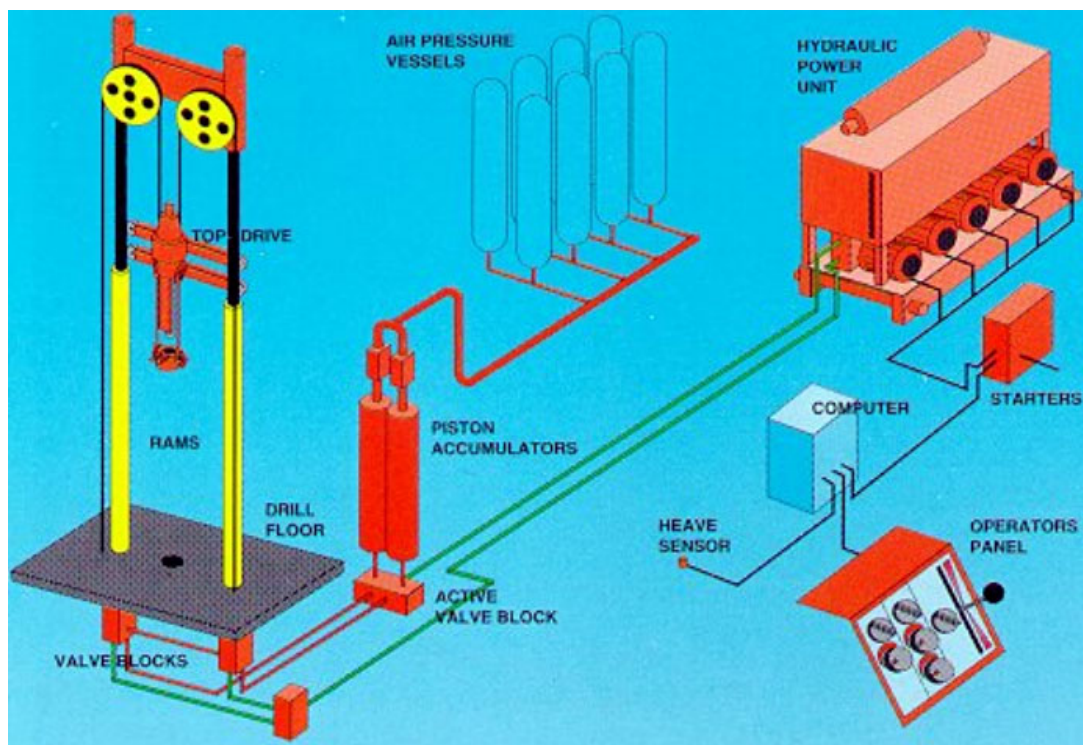
## - Hydraulic System



- Semisub Ram Rig Sketch



- Ram Rig System Scheme



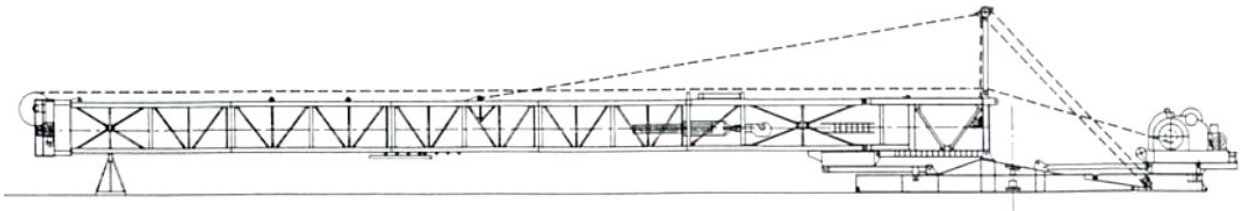


### 5.3 RIGGING UP

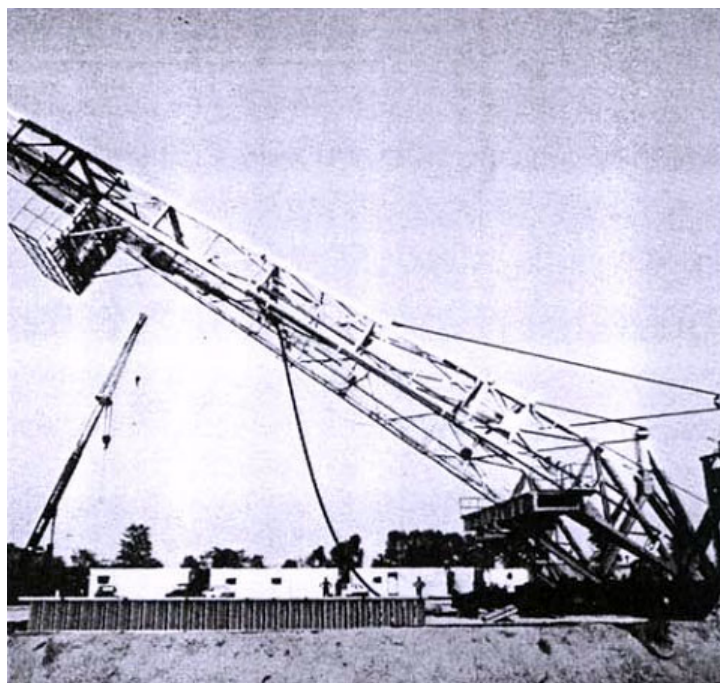
#### - **Conventional Mast (Land rig)**

Erection sequence

##### - Phase 1



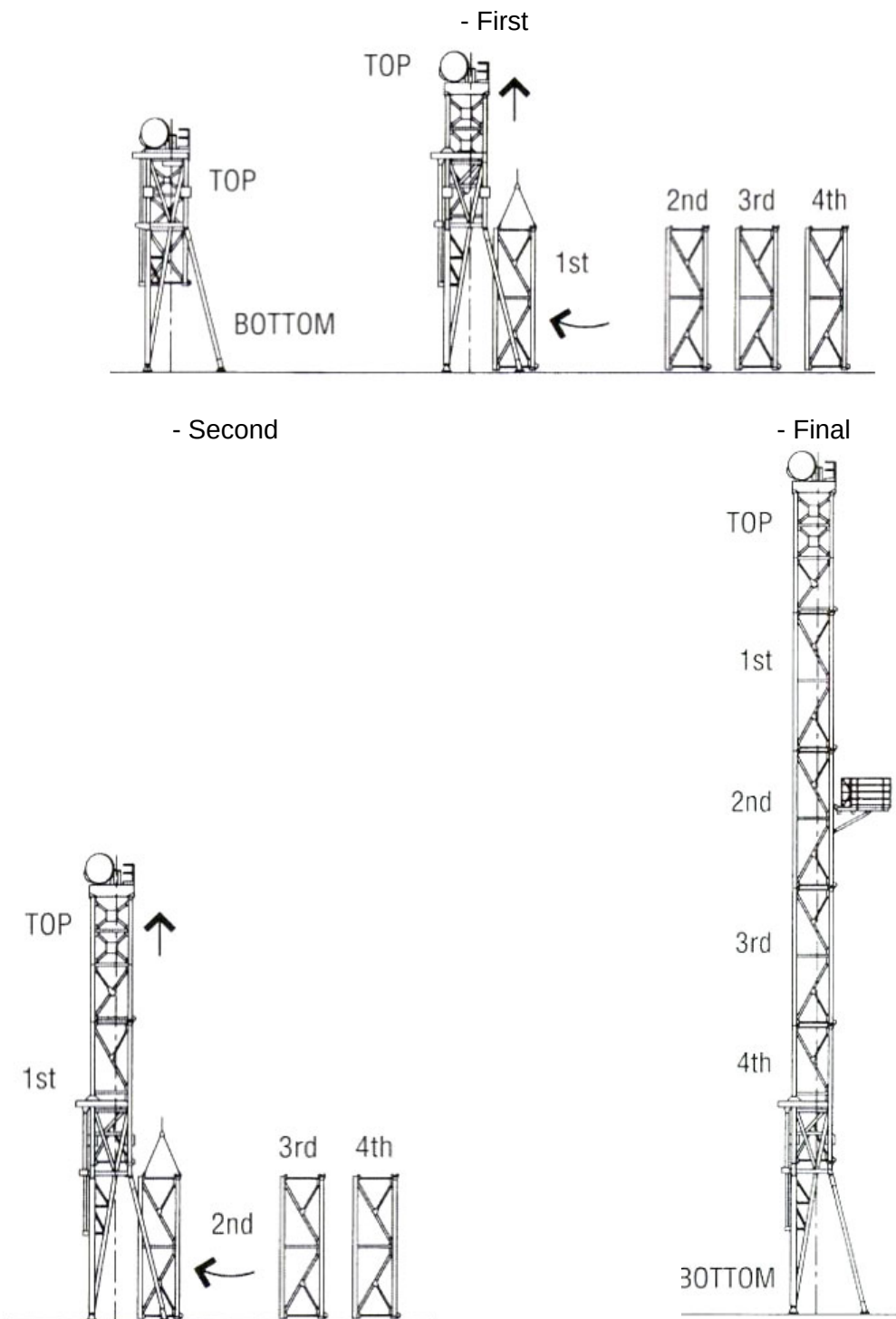
##### - Phase 2





**- Vertical Mast (offshore Rig)**

Boot Strap sequence:

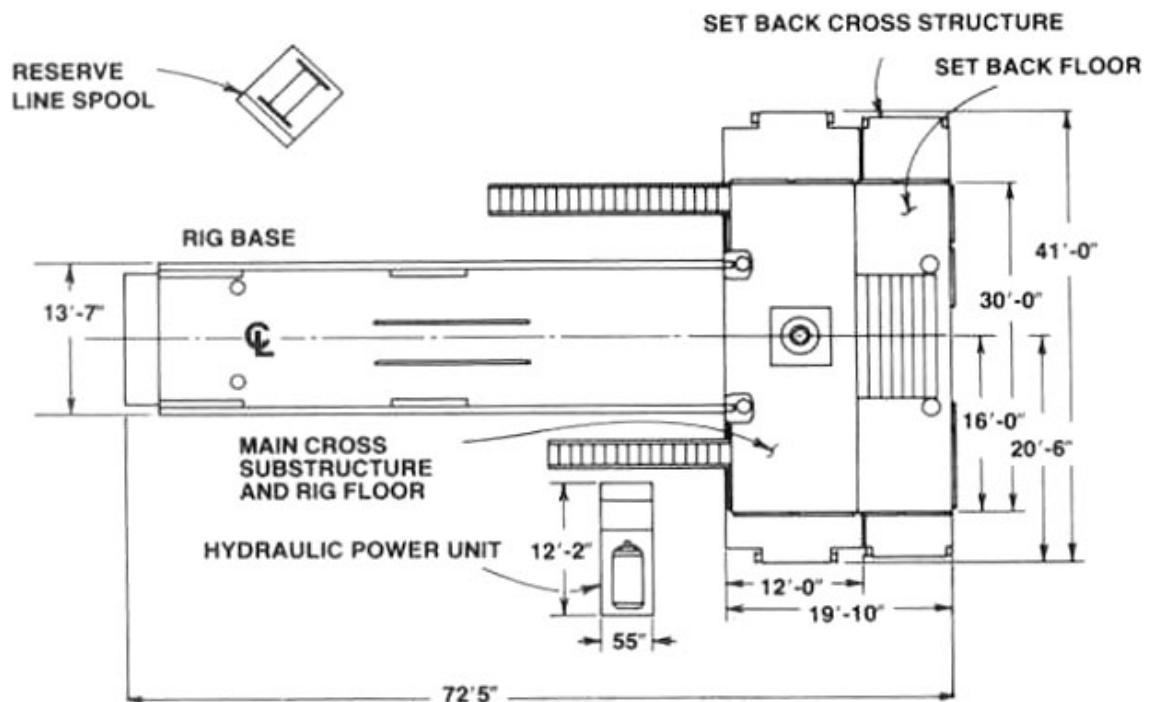


## - Trailer Mounted Rig

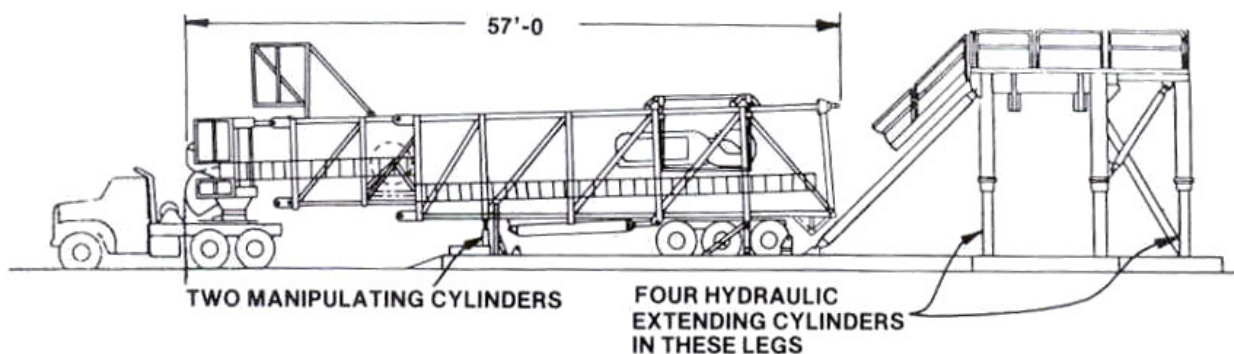
### Rigging Up Sequence of a Trailer Mounted Rig

- a) Deploying of substructure base
- b) Anchoring of trailer to substructure base
- c) Extension of the telescopic sections
- d) Installation of the hydraulic rams
- e) Anchoring the mast to the substructure
- f) Raising the mast in vertical position
- Final Position

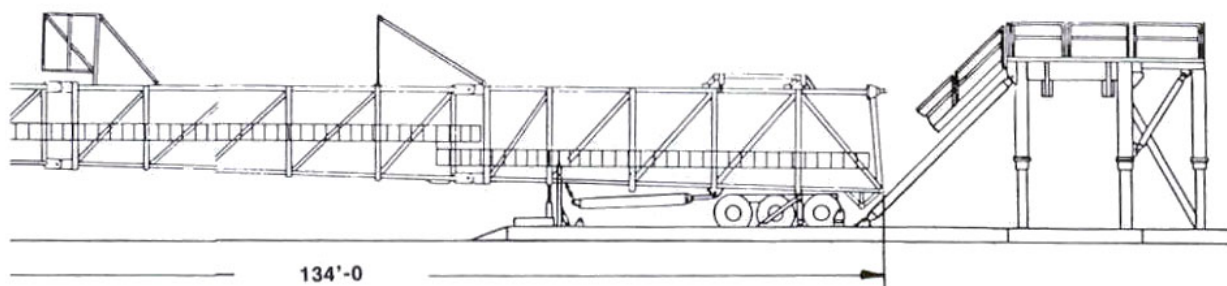
#### a) Deploying of substructure base



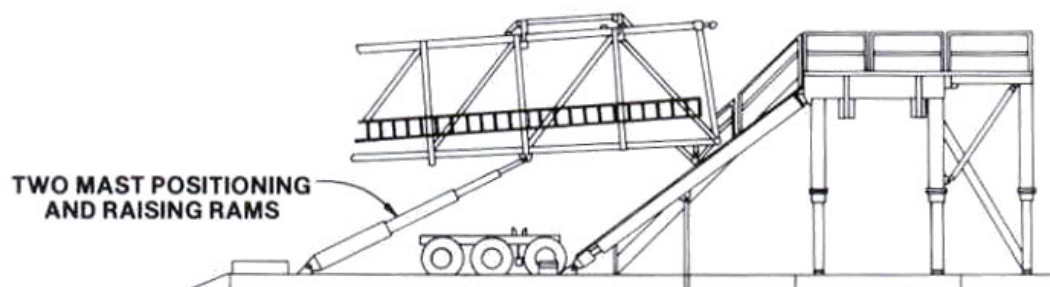
#### - b) Anchoring of trailer to substructure base



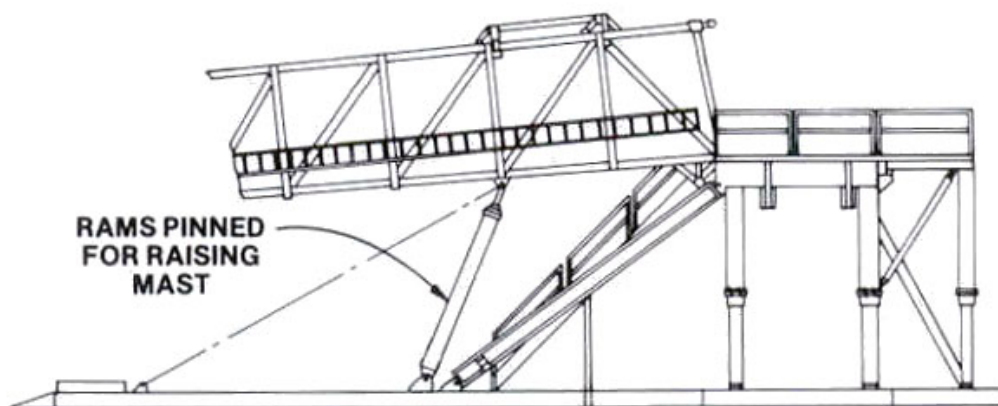
- c) Extension of the telescopic sections



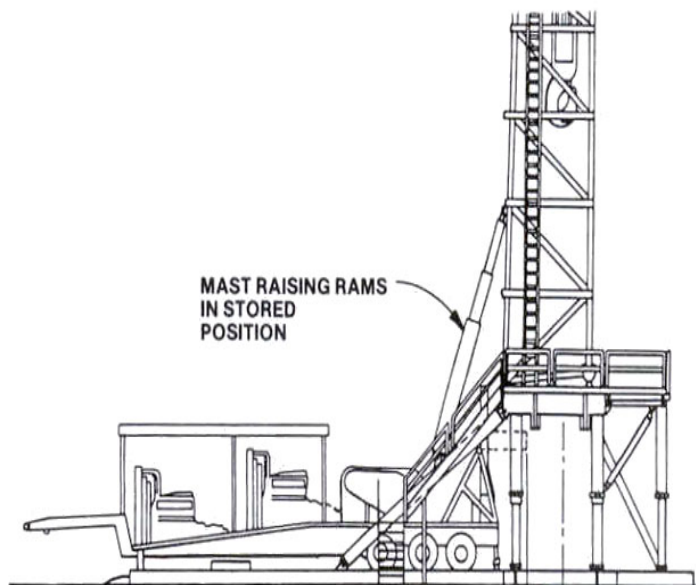
- d) Installation of the hydraulic rams



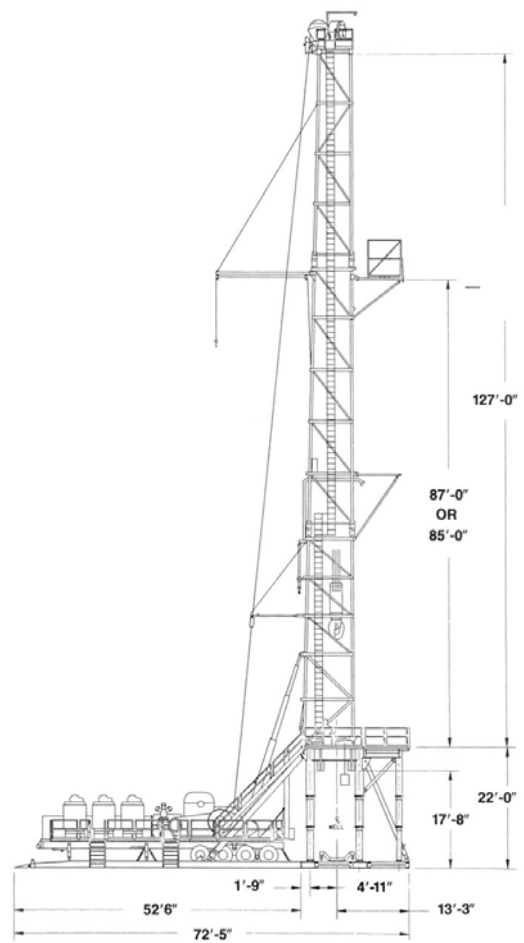
- e) Anchoring the mast to the substructure



- f) Raising the mast in vertical position



- Final Position



## 5.4 DRILLING LOADS

### - Forces on the Derrick

Derricks are subjected to :

- Weight of the derrick itself
- Wind load
- Stress induced by Floating hull motion (for floating vessels)
- Horizontal component load of the drill string when racked back
- Hoisting load

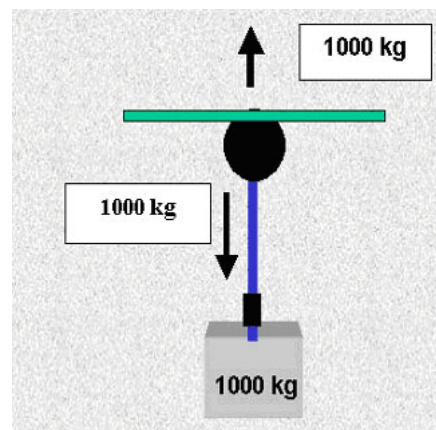
The first 3 forces are considered in the structural design of the derrick.

### - Calculation of Drilling Loads at Crown Block

#### Cases

#### Case 1: Suspended load

The load on the support is equal to the weight being hung.

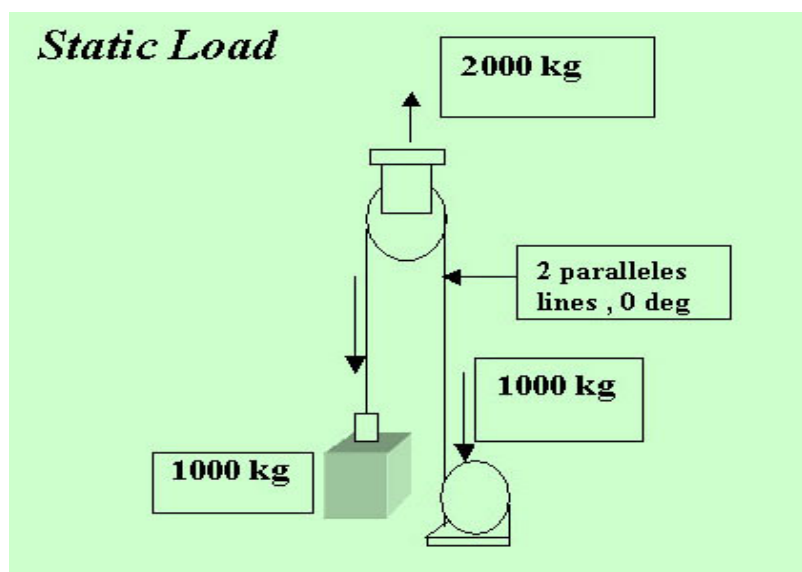


#### Case 2a : Static Load

Drilling load is at rest, hoisted by the Drawworks over a single sheave on the Crown Block

The load on the drawworks is equal to the weight being hung from the crown sheave.

The crown supports both the drilling load and drawworks tension, so the force supported is double the weight being hung.



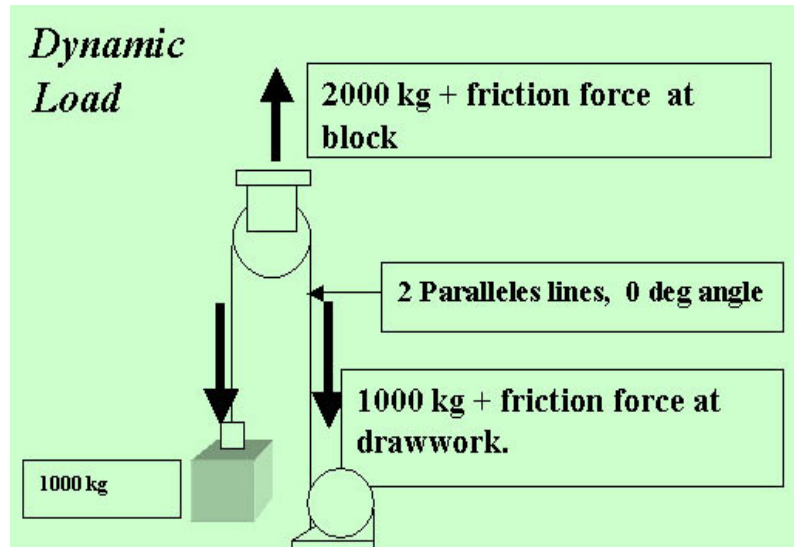


### Case 2b : Dynamic Load

Drilling load is in motion, hoisted by the Drawworks over the single sheave on the Crown Block

The load on the drawworks is equal to the weight being hung from crown sheave PLUS frictions.

The crown block supports both the drilling load and the drawworks tension PLUS frictions, so the force supported is more than the weight being hung.

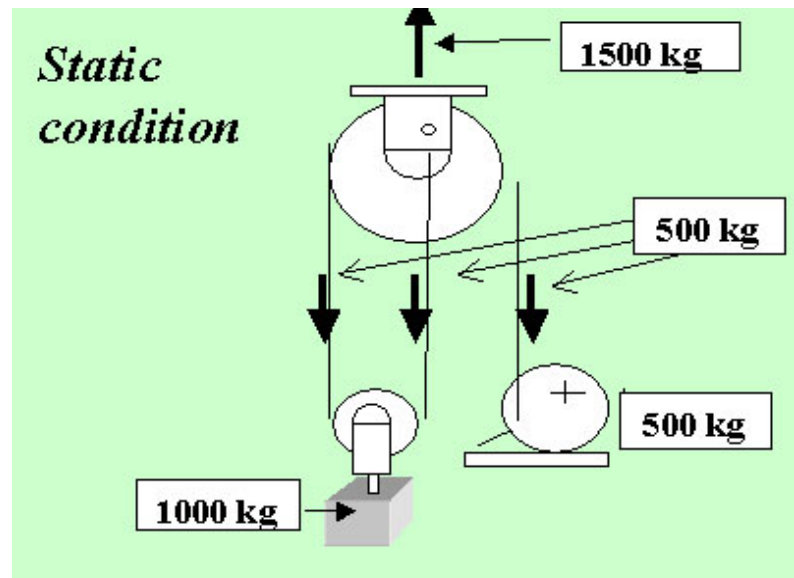


### Case 3: Drilling load is in motion

Drilling load is in motion, hoisted by the Drawworks through a series of sheaves on the Crown and Travelling Blocks

The load supported by the Crown Block is the sum of the load supported by each of the lines.

In this example with 3 lines, the load supported by Crown block is 1500 kg



The load supported by the Drawworks is the drilling load divided by the number of lines on the traveling block.

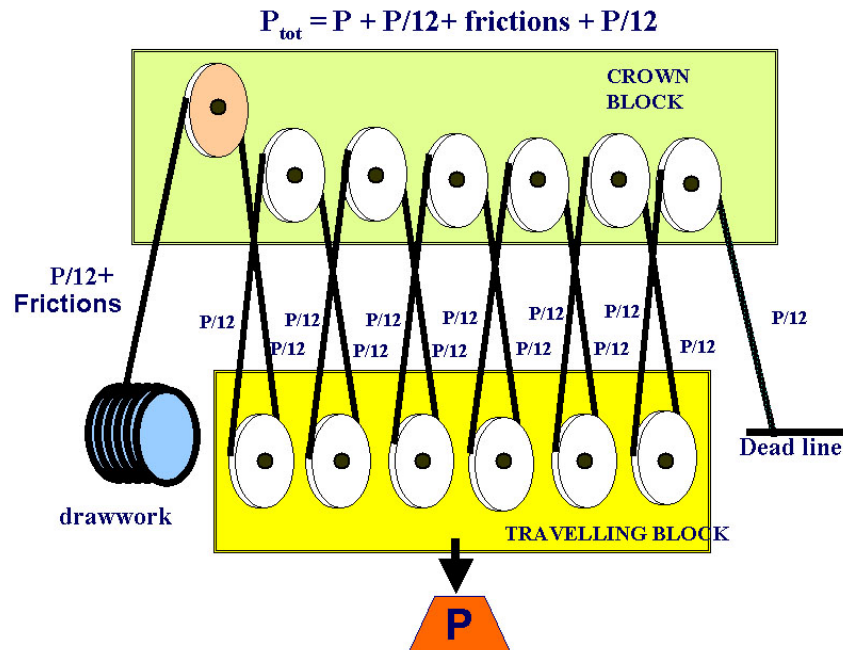
In this example the force required by the drawworks to hoist a weight of 1000 kg is reduced by using a travelling block with one sheave.

The series of sheaves in Crown-Travelling Blocks system reduces the load necessary to hoist a weight.

### - Series of sheaves and Lines

#### - Load Supported by the Drawworks

The series of sheaves in Crown-Travelling Blocks system reduces the load necessary to hoist a weight. The load supported by the drawworks is related to the number of lines installed on the Travelling Block.

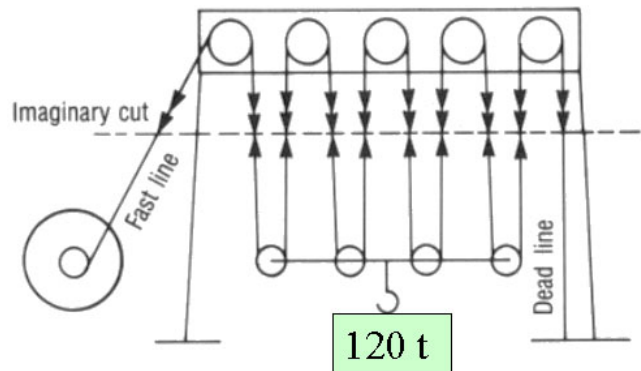


#### - Example:

In this case the travelling block has 4 sheaves and 8 lines. The crown block has 5 sheaves and 10 lines (8 lines from the travelling block + Fastline and Dead line.)

Applying a Drilling Load of 120 ton,  
The load on each line is:  $120 / 8 = 15 \text{ ton}$

The load at the crown block is:  
 $15 \times 10 = 150 \text{ ton}$



## - Definition of Gross Nominal Capacity

### - Gross Nominal Capacity

Gross nominal capacity is defined as the MAXIMUM STATIC LOAD with a stated number of drilling lines.

API regulation takes in consideration only the capability for hoisting the drill string.

### - Calculation of GNC for Mast

In a MAST the maximum load to the crown block (Gross Nominal Capacity) is calculated as follows:

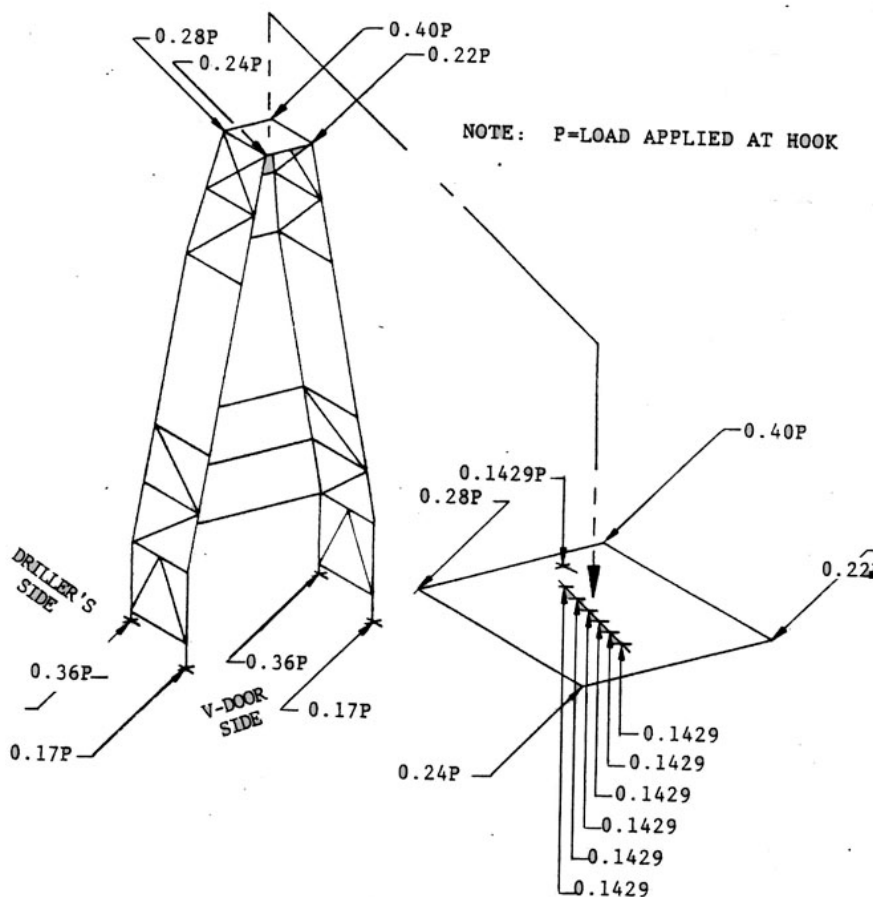
$$GNC = SHL + 2 \frac{SHL}{n}$$

with:

GNC = Gross Nominal capacity;

n = lines number

SHL = Maximum static Hook Load.



Example of Load distribution on a Mast

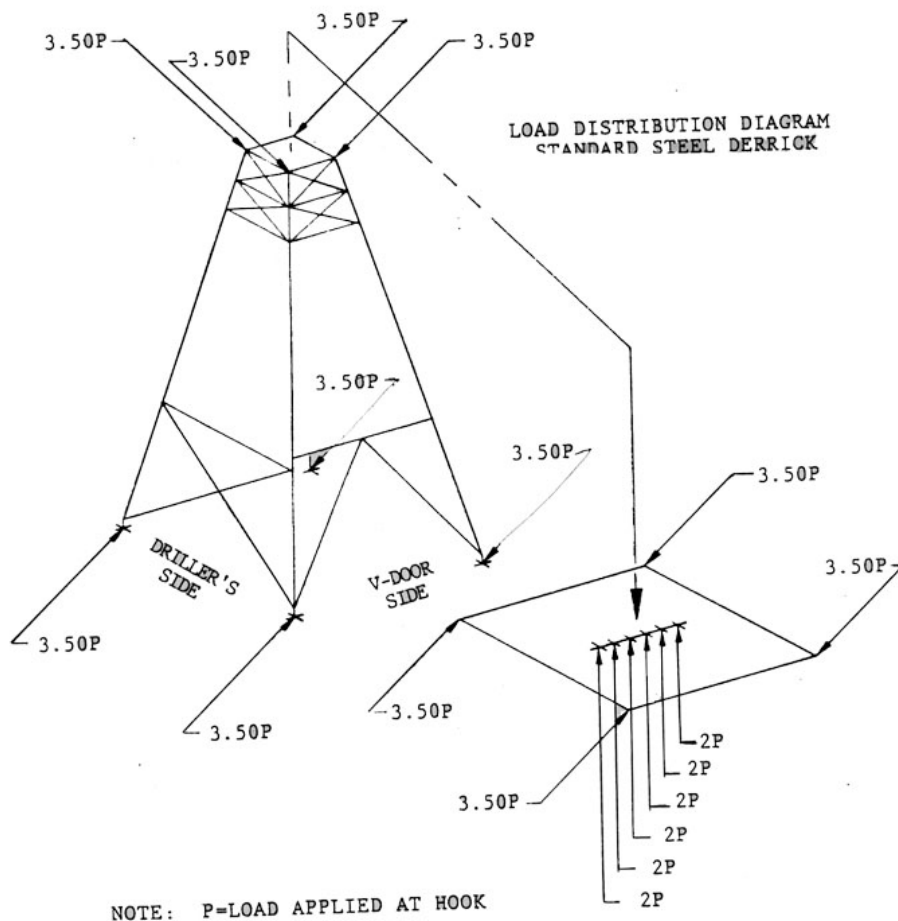
### - Calculation of GNC for Derrick

In a DERRICK the maximum load applied at the crown block (Gross Nominal Capacity) is equally divided on its 4 legs and its calculated as follows:

$$\text{GNC} = \frac{n + 4}{n} \times \text{SHL}$$

with:

GNC = Gross Nominal Capacity  
n = Lines number  
SHL = Maximum static Hook Load



Example of Load distribution on a Derrick

## 5.5 INSPECTION

### - Periodic inspections

The API applicable references are:

API RP 4G and API RP 54 (chapt. 9.2 and 9.3). and the Manufacturer's recommendations.

ENI policy is more strict and requires the API Category IV inspection (as per API RP 4G) every 5 years instead of 10.

Mast/derricks and substructures on mobile offshore drilling units or fixed platforms are exempted from the requirements of a Category IV inspection.

## 06. DRAWWORKS

### INDEX

- 6.1 FUNCTION
- 6.2 TYPES AND CHARACTERISTICS
- 6.3 MAIN SYSTEMS
  - Main Drum
  - Catheads
  - Stationary Brake (Main brake)
  - Auxiliary brake
- 6.4 POWER CALCULATION
- 6.5 INSPECTIONS

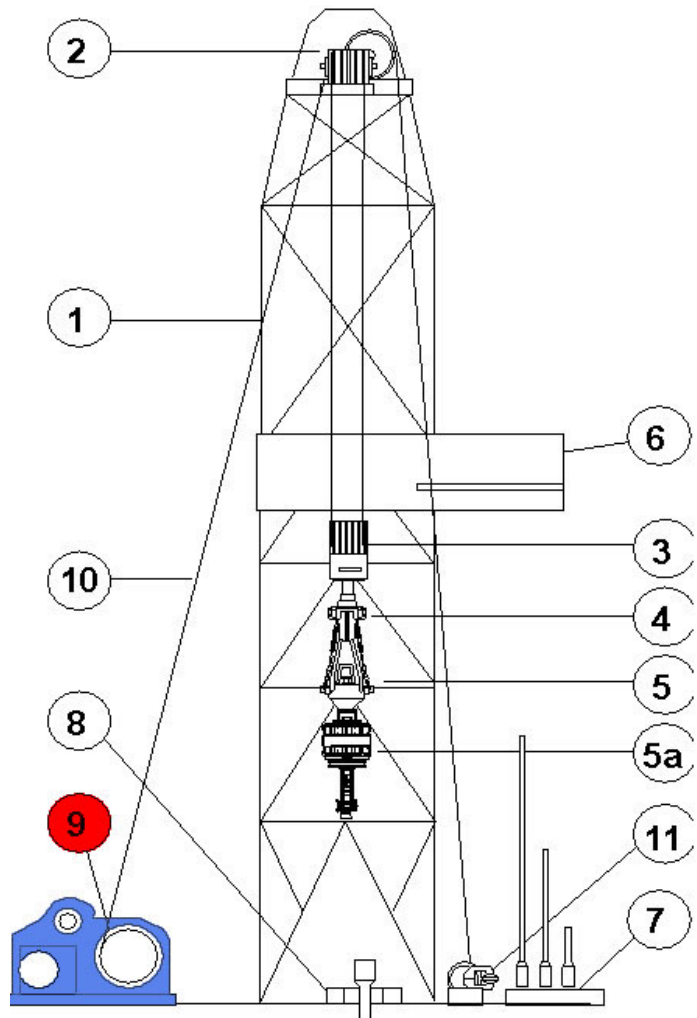
### 6.1 FUNCTION

#### - Drawworks Functions

The Drawworks is one of most important equipment on drilling rig.

The unit supplies the hoisting power, the drawworks spools the drilling line as pipe is run into and pulled out from the well.

The drilling line spools out under gravity and is reeled in by an electrical or diesel engine.

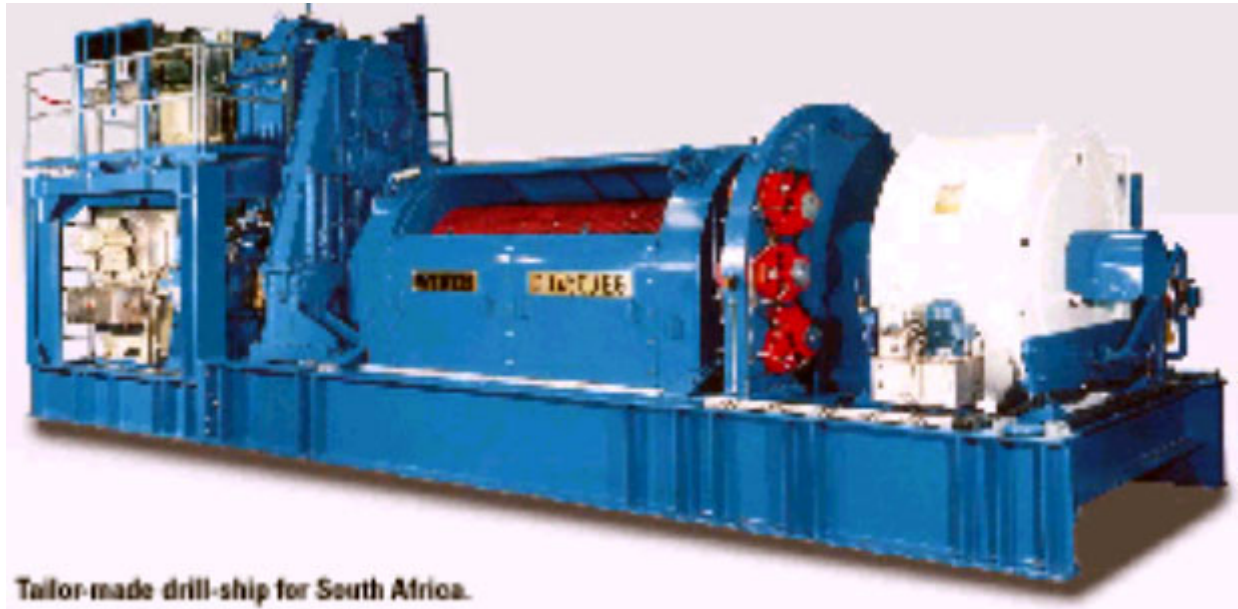


Schematic Draw



### - Manufacture specifications

The Drawworks is built in according to specifications in API 7K or related ISO (International Organization for Standardization) 14693.



Drawworks

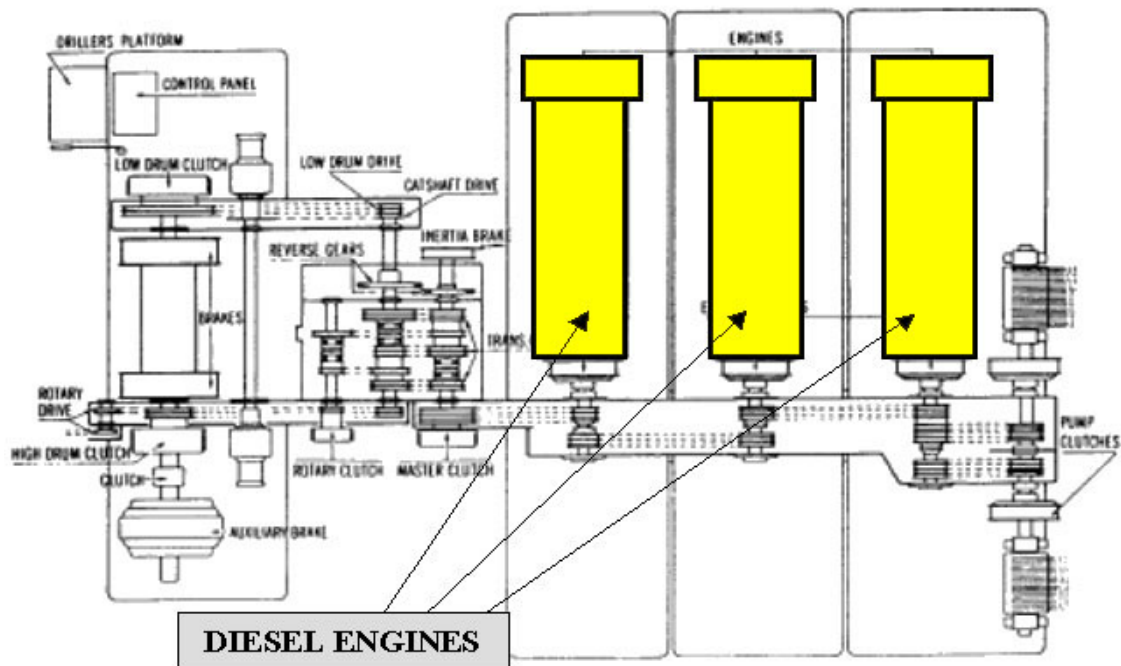
## 6.2 TYPES AND CHARACTERISTICS

Depending on the engines on the rig, the drawworks can be either:

- MECHANICAL
- ELECTRICAL

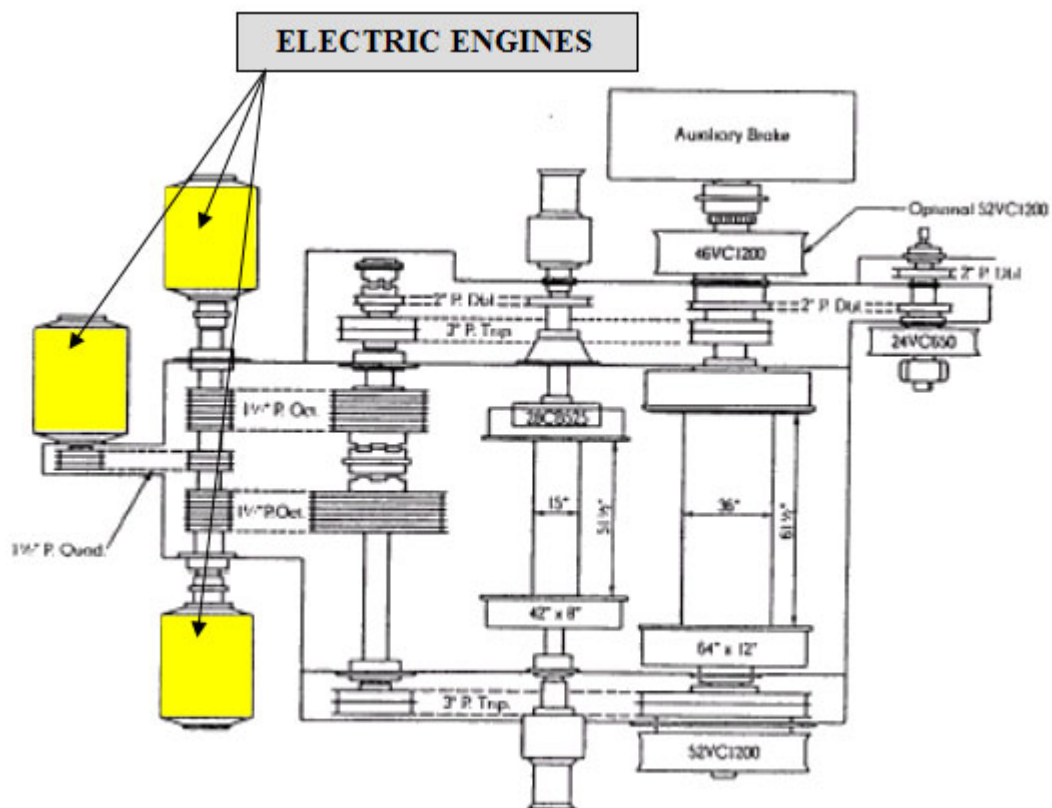
### - MECHANICAL

Diesel engines are directly connected (compounded) to the drawwork by chain. This system is still in use for small Drilling Rigs (under 1500 HP), but is no longer used on medium-Hi powered rigs( 1500 & 3000 HP).



#### - ELECTRICAL

Electrical systems are normally used today on land rigs and is the only system in use on offshore rigs. The drawworks are generally connected to 1000 HP D.C. engines, although A.C. engines are now being used as well.

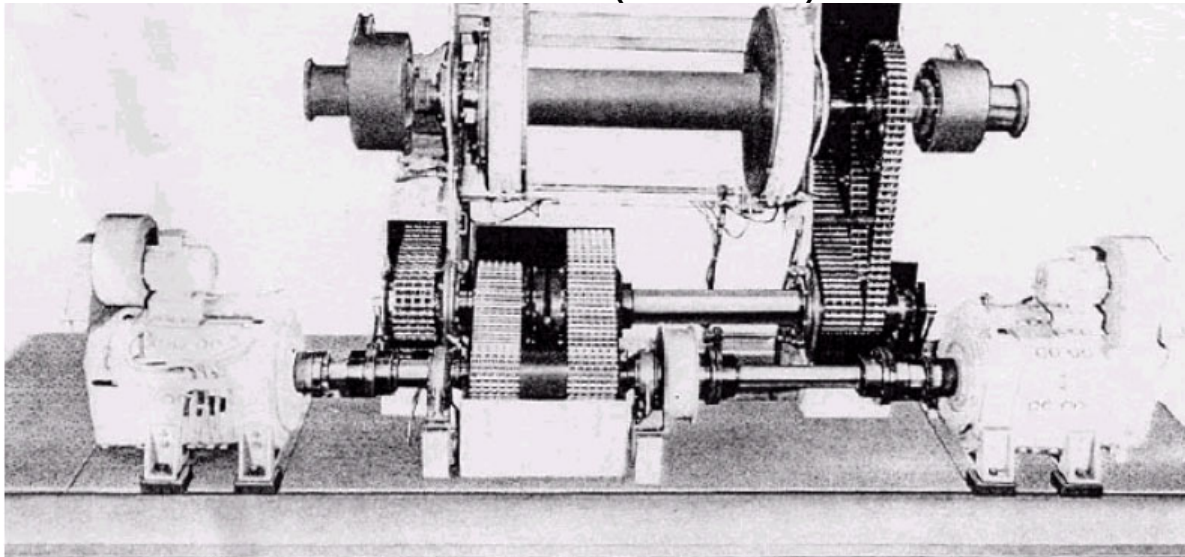


**- Connection Drawworks-Engines**

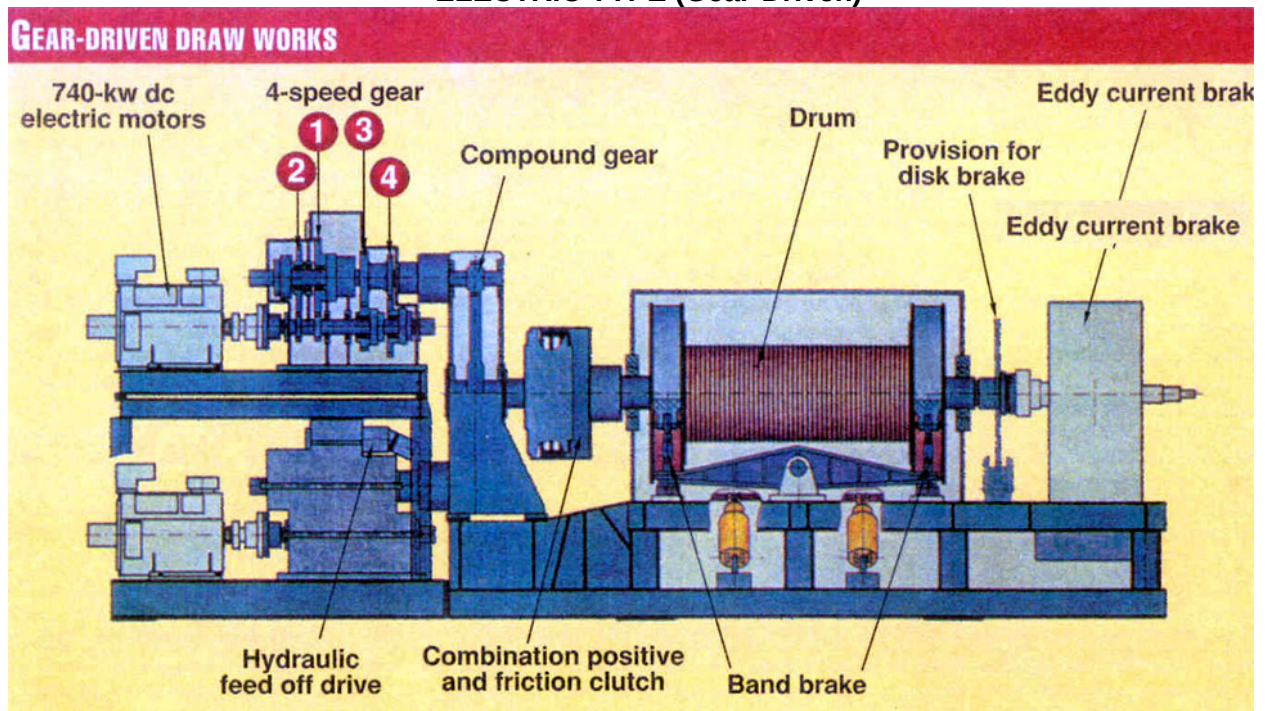
The connection between the drawworks and the engines can be either:

- CHAIN DRIVEN
- GEAR DRIVEN

**ELECTRIC TYPE (Chain-Driven)**



**ELECTRIC TYPE (Gear-Driven)**





- Technical Data

Mechanical Type (Technical Data)

|  <b>NATIONAL OILWELL</b> |                                     | Mechanical Drawworks            |                                 |                                  |                                  |                                  |                         |
|-----------------------------------------------------------------------------------------------------------|-------------------------------------|---------------------------------|---------------------------------|----------------------------------|----------------------------------|----------------------------------|-------------------------|
| Model No.                                                                                                 | 370                                 | 610                             | 80-B                            | 110-M<br>110-UDBM                | 1320-M<br>1320-UDBM              | 1625-M<br>1625-UDBM              | M-3000<br>M-3000UDB     |
| Horsepower rating (Kw)                                                                                    | 550<br>(410)                        | 750<br>(559)                    | 1000<br>(746)                   | 1500<br>(1119)                   | 2000<br>(1492)                   | 3000<br>(2238)                   | 3000<br>(2238)          |
| Nominal depth range, ft.(m)                                                                               | 3000 to 7000<br>(914 to 2134)       | 6000 to 10000<br>(1829 to 3048) | 8000 to 12000<br>(2438 to 3658) | 11000 to 16000<br>(3353 to 4877) | 13000 to 20000<br>(3962 to 6096) | 16000 to 25000<br>(4877 to 7620) | 30000<br>(9144)         |
| Wireline size, inches                                                                                     | 1 1/4                               | 1 1/2                           | 1 1/4 - 1 1/2                   | 1 1/4 - 1 1/2                    | 1 1/4 - 1 1/2                    | 1 1/2 - 1 3/4                    | 1 1/2 - 1 3/4           |
| Hoisting drum size, in.(mm)                                                                               | 18 x 38 1/4<br>(457 x 984)          | 20 x 46 1/4<br>(508 x 1187)     | 25 x 49<br>(635 x 1245)         | 27 x 49<br>(686 x 1245)          | 30 x 56 1/4<br>(762 x 1429)      | 36 x 61 1/4<br>(914 x 1556)      | 36 x 62<br>(914 x 1575) |
| Width for transportation ft./in.(mm)                                                                      | Less console<br>9'-8 1/2"<br>(2959) | Less engines -<br>12' (3658)    | 8'-0"<br>(2438)                 | 8'-11 1/2"<br>(2723)             | 8'-0"<br>(2438)                  | 8'-0"<br>(2438)                  | 10'-0"<br>(3048)        |
| Height, overall ft./in.(mm)                                                                               | 6'-10 1/2"<br>(2086)                | 8'-1"<br>(2464)                 | 18'-5 1/2"<br>(2578)            | 18'-11"<br>(2718)                | 19'-6"<br>(2896)                 | 19'-6 1/4"<br>(2915)             | 9'-9 1/2"<br>(2996)     |
| Length, overall ft./in.(mm)                                                                               | On Appl.*                           | On Appl.*                       | 22'-11"<br>(6985)               | 23'-2"<br>(7061)                 | 25'-6"<br>(7772)                 | 26'-8"<br>(8128)                 | 25'-3"<br>(7696)        |
| Weight, lbs. (Kgs.) less optional equipment                                                               | 26,880<br>(12,193)                  | 33,600<br>(15,241)              | 44,370<br>(20,126)              | 52,590<br>(23,855)               | 75,720<br>(34,346)               | 87,140<br>(39,526)               | 78,000<br>(35,381)      |

UDB = Universal Disc Brake. \*Varies with drive group selected. †With coring reel.

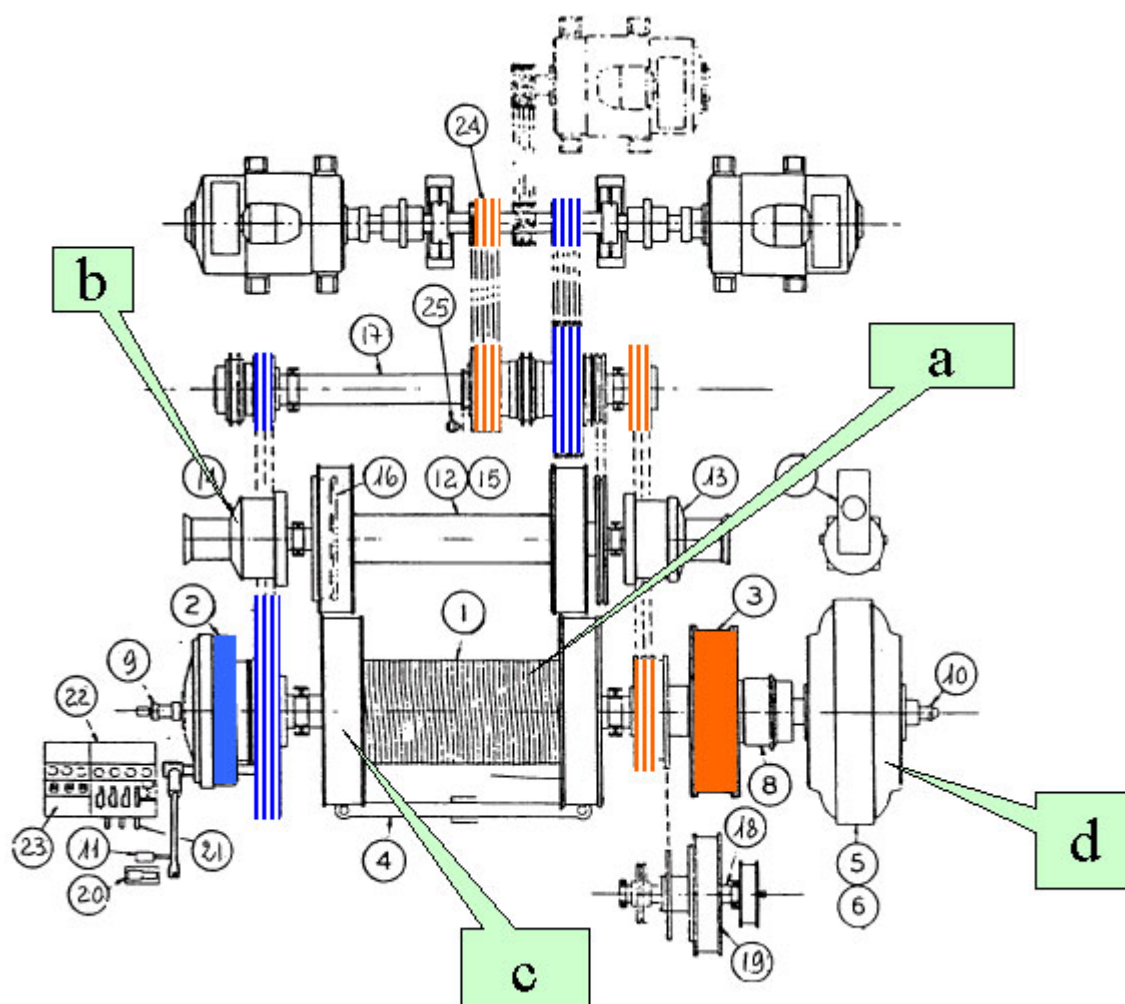
Electric Type (Technical Data)

|  <b>NATIONAL OILWELL</b> |                                     | Electrical Drawworks          |                               |                               |                                |                                |                                |                       |                                       |
|-------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------------------------|-------------------------------|-------------------------------|--------------------------------|--------------------------------|--------------------------------|-----------------------|---------------------------------------|
| Model No.                                                                                                   | 370-E                               | 610-E                         | 610-EP                        | 80-UE                         | 110-UE<br>110-UDBE             | 1320-UE<br>1320-UDBE           | 1625-DE<br>1625-UDBE           | E-3000<br>E-3000UDB   | 2040-UDBE                             |
| Horsepower rating (Kw)                                                                                      | 550<br>(410)                        | 750<br>(559)                  | 1250<br>(933)                 | 1000<br>(746)                 | 1500<br>(1119)                 | 2000<br>(1492)                 | 3000<br>(2238)                 | 3000<br>(2238)        | 4000<br>(2983)                        |
| Nominal depth range, ft.(m)                                                                                 | 3000 - 7000<br>(914 - 2134)         | 6000 - 10000<br>(1829 - 3048) | 6000 - 10000<br>(1829 - 3048) | 8000 - 12000<br>(2438 - 3658) | 11000 - 16000<br>(3353 - 4877) | 13000 - 20000<br>(3962 - 6096) | 16000 - 25000<br>(4877 - 7620) | 30,000<br>(9144)      | 20,000 -<br>40,000<br>(6096 - 12,192) |
| Wireline size, inches                                                                                       | 1 1/4                               | 1 1/2                         | 1 1/2                         | 1 1/4 - 1 1/2                 | 1 1/4 - 1 1/2                  | 1 1/4 - 1 1/2                  | 1 1/2 - 1 3/4                  | 1 1/2 - 1 3/4         | 1 1/2 - 2                             |
| Width, overall ft./in.(mm)                                                                                  | 10'-11 1/4"<br>(3334)               | 12"<br>(3658)                 | 10' - 6"<br>(3200)            | 11'-8 1/2"<br>(3572)          | 11'-11 1/2"<br>(3645)          | 14'-0"<br>(4267)               | 18'-0"<br>(5486)               | 17'-11 1/4"<br>(5467) | 23'-11"<br>(7290)                     |
| Width for transportation ft./in.(mm)                                                                        | Less console<br>9'-8 1/2"<br>(2959) | 12'<br>(3658)                 | 10'-6"<br>(3200)              | 8'-9"<br>(2667)               | 8'-9 1/2"<br>(2680)            | 8'-0"<br>(2438)                | 9'-11"<br>(3023)               | 10'-0"<br>(3048)      | 11'-11"<br>(3632)                     |
| Height, overall ft./in.(mm)                                                                                 | 16'-10 1/2"<br>(2086)               | 18'-1"<br>(3419)              | 7'-7 1/4"<br>(2315)           | 18'-5 1/2"<br>(2578)          | 18'-11 1/2"<br>(2723)          | 19'-6"<br>(2896)               | 19'-10"<br>(2997)              | 9'-9 1/2"<br>(2996)   | 11'-2 1/2"<br>(3419)                  |
| Length, overall ft./in.(mm)                                                                                 | 20'-0"<br>(6096)                    | 19'-6"<br>(5944)              | 20'-8 1/4"<br>(6322)          | 22'-11"<br>(6985)             | 23'-3"<br>(7087)               | 25'-6"<br>(7772)               | 25'-10"<br>(7874)              | 25'-3"<br>(7696)      | 31'-7"<br>(9728)                      |
| Weight, lbs. (Kgs.) less optional equipment                                                                 | 27,525<br>(12,485)                  | 32,270<br>(14,638)            | 33,410<br>(15,155)            | 45,640<br>(20,702)            | 52,205<br>(23,680)             | 73,780<br>(33,466)             | 83,620<br>(37,930)             | 82,000<br>(37,195)    | 118,500<br>(53,751)                   |

UDB = Universal Disc Brake. †With coring reel.

### 6.3 MAIN SYSTEMS

- a - Main Drum
- b - Catheads
- c - Stationary Brake (Main brake)
- d - Auxiliary brake





### a - Main Drum

#### - Main Drum Diameter

The diameter of the main drum is a function of the diameter of the drilling line being used.

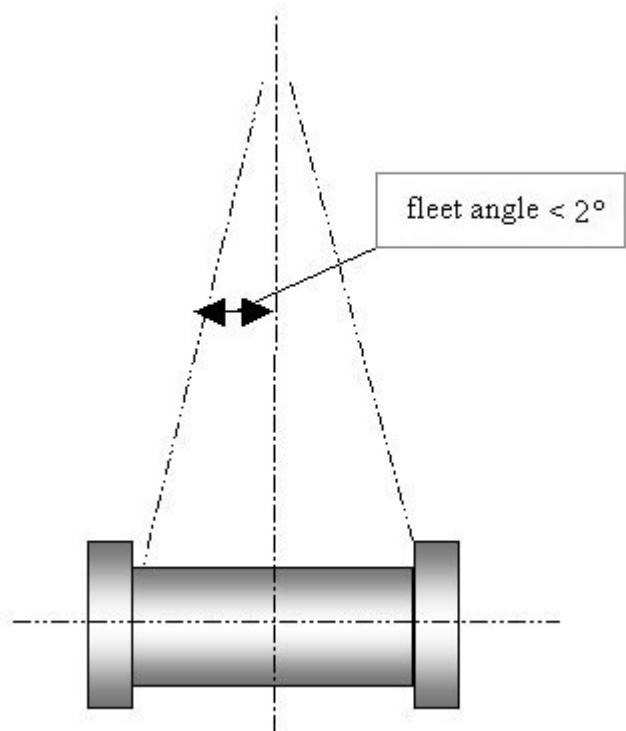
It is preferable to have the drum as large as possible to reduce the number of wraps and the bending of the cable.

#### - Drum Length

The length of the drum is a function of the distance between Crown block and Drawworks.

#### - Fleet Angle

To reduce the wear on the drilling line, it is good practice to keep the angle alpha under 2 degrees.  
(see pictures)



### b - Catheads

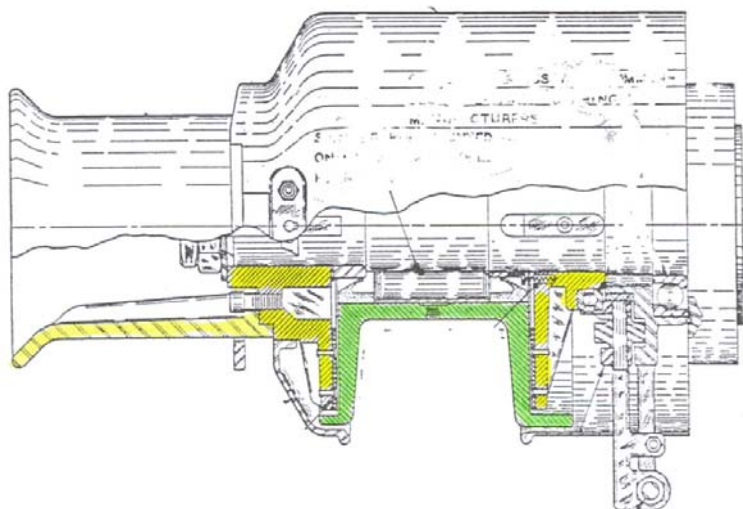
#### - Spinning line and Breakout Cathead

Catheads are winches with pneumatic clutch and are mounted on the extremity of the secondary drum of the drawworks.

The make up cathead is located beside the driller's console and the break-out cathead is located on the opposite side of the driller's console.

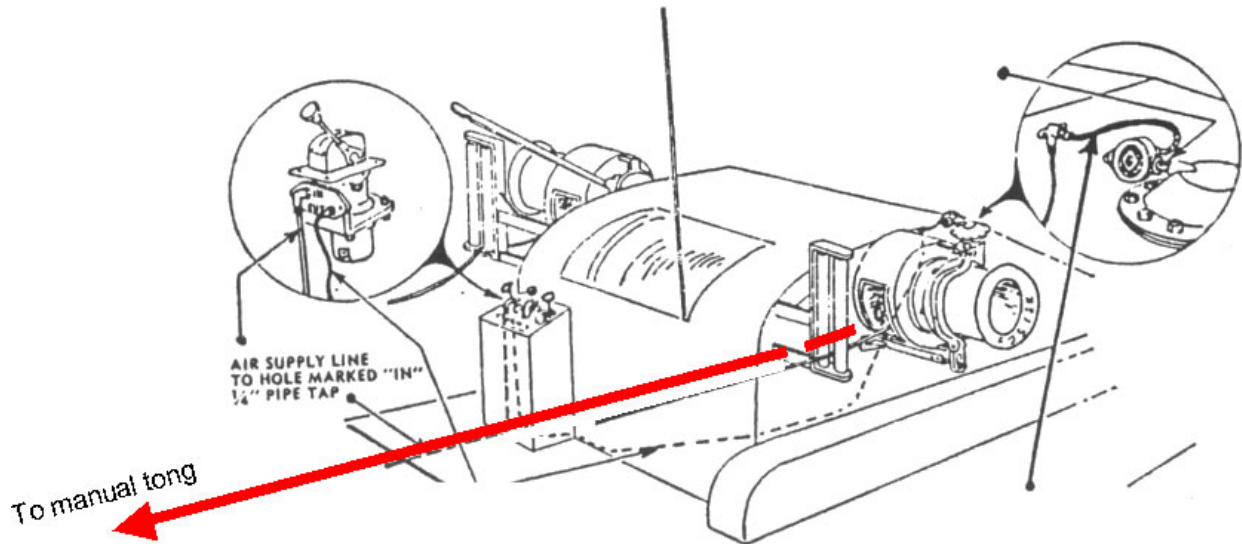
The catheads apply the pulling force on the hand tongs connections.

- Model 16 Spinning line Cathead
- Model 16 Breakout Cathead



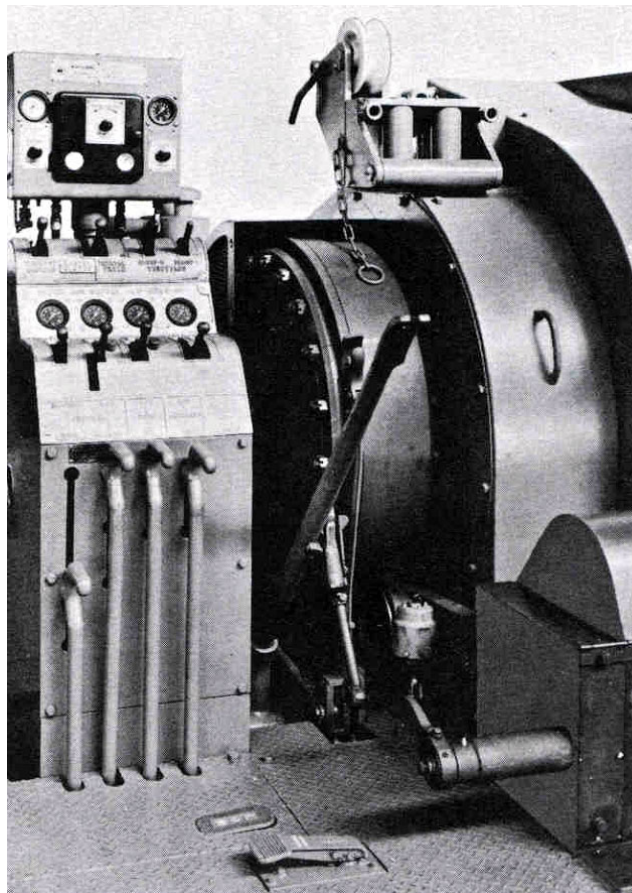
### - Employment scheme

For safety reasons and convenience their employment comes supplanted from the dedicated equipments.



### c - Stationary Brake

- Band Brake
- Disk Brake
- Regenerative Brake System



### - **Band Brake**

#### - Description (parts)

- BRAKE HANDLE
- LEFT BAND
- RIGHT BAND
- BALANCE BAR

#### - Braking action

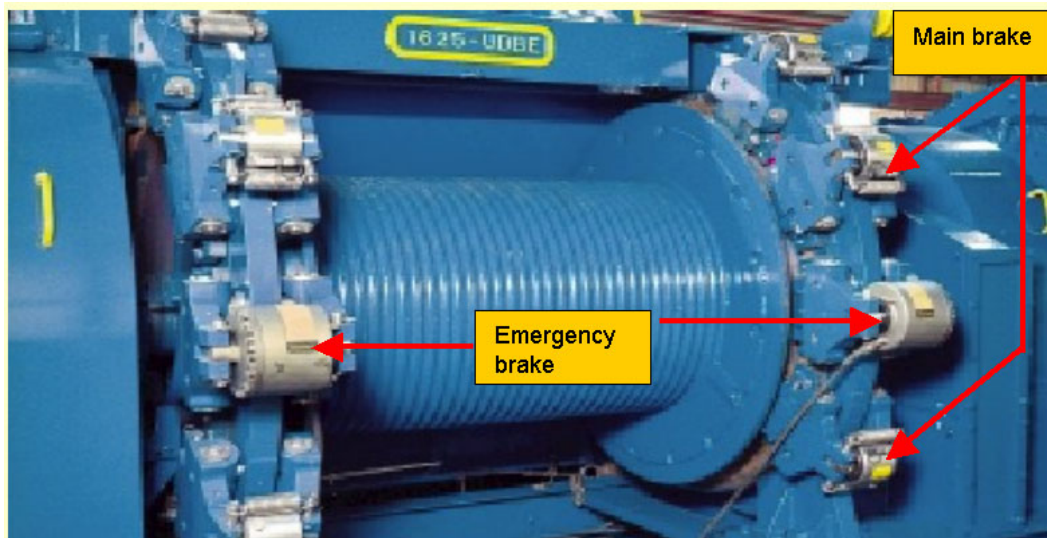
Braking action is activated by pushing the Brake handle down towards the floor. Through a strength multiplier system, the braking force is transmitted on the balance bar, then to the brake bands, and finally to the two drums on either side of main drum. Heat produced by the braking action is dissipated through the circulating water cooling system.

### - **Disk Brake**

Depending of the size the drawworks, there are 2 to 4 hydraulically-actuated calipers. In addition to these main calipers, each disc brake system has 2 dedicated calipers (normally closed) that are used as the emergency and parking brake.

These calipers are actuated by an independent hydraulic system.

Disk brakes can be mounted on Drawworks that was originally equipped with band brake.



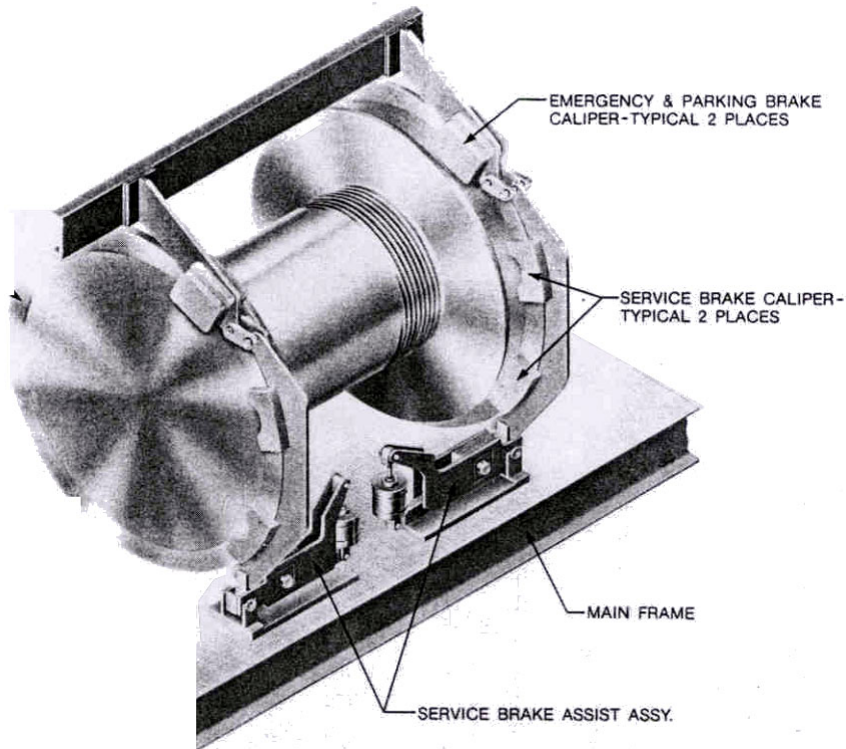
- Advantages

The advantages are:

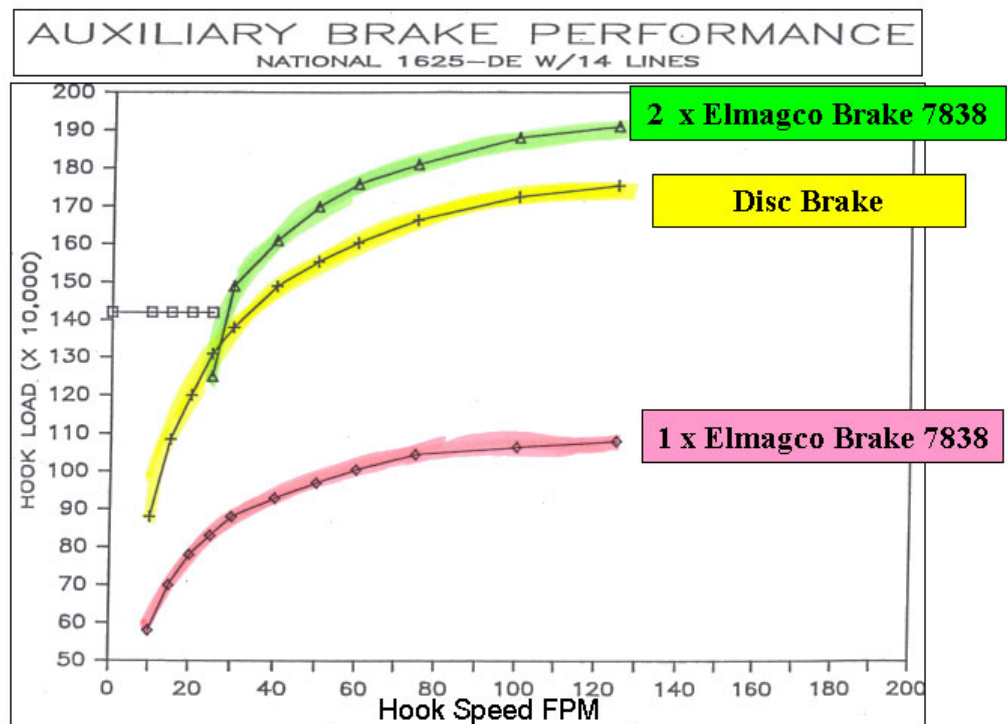
- Greater braking capability
- Emergency braking system
- Possibility of Remote control
- Significant noise reduction during drilling

- Use

Disk Brake is a development of the band brake, due to the necessity to handle heavier loads



- Performance  
Comparison  
diagram of 3  
brake  
combinations





### - Regenerative Brake System

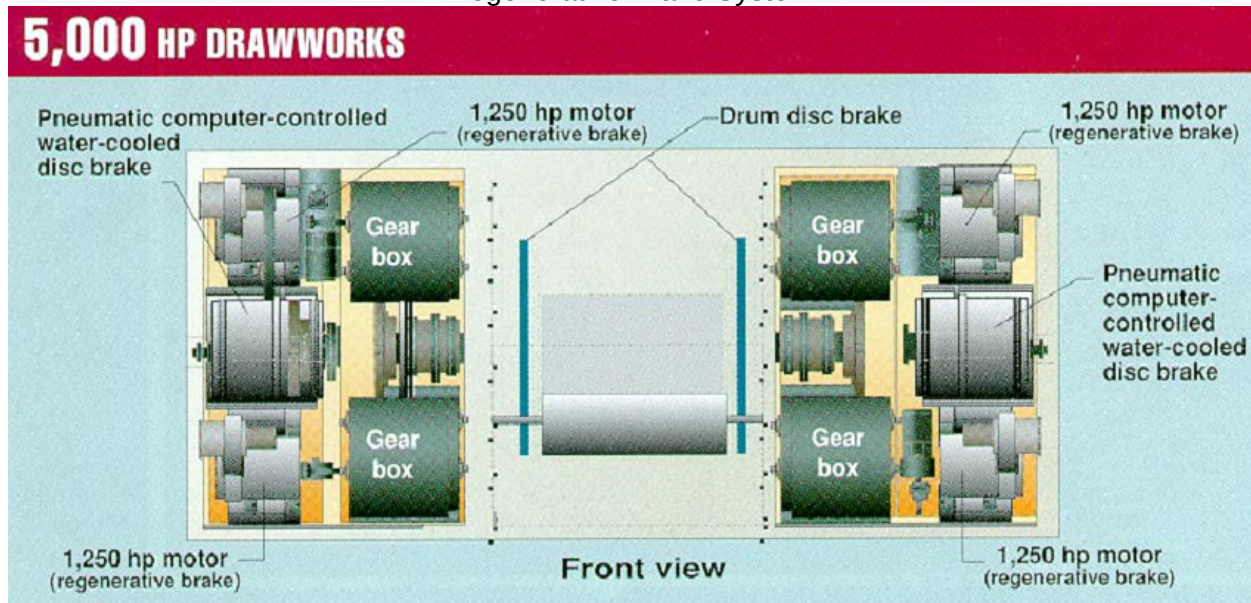
- New generation of drawworks

The newest generation of drawworks (4000-5000 HP), mounted on ultradeep offshore rigs, have a direct drive transmission system, permanently connecting the drawworks to the motors.

When the travelling block descends in the derrick, the motors turn in the opposite direction, producing an opposite current and hence a braking action.

- NOTE: This braking system, is not able to hold, when the motors are at rest, hence the need for emergency and parking the disk brake system.

Regenerative Brake System



### d - Auxiliary brake / dynamic brake

The function of the auxiliary brake is to assist the main braking system during rapid descent of the blocks with heavy string weights. The auxiliary brake prevents the overheating and premature wear of main brakes.

Types:

- Hydrodynamic Brake
- Electromagnetic Brake



### - Hydrodynamic Brake

That system is still in use on small drawworks. However, on medium-Hi powered drawworks, this system has been replaced by the **Electromagnetic brake**.

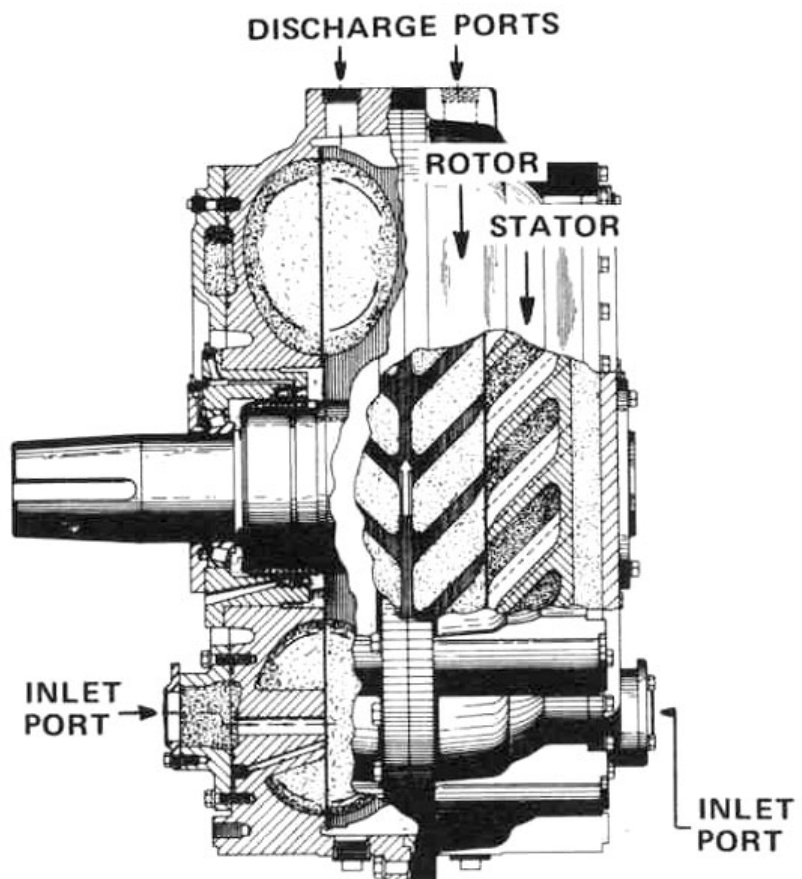


### - Description

The Hydrodynamic brake consisting of two box with a rotor pressed onto the main drive shaft and two stators.

When the main shaft rotates the rotor drags water against the two stators, producing a braking action.

Braking capability can be regulated by increasing or decreasing the water levels in the "Hydraulic Brake box".

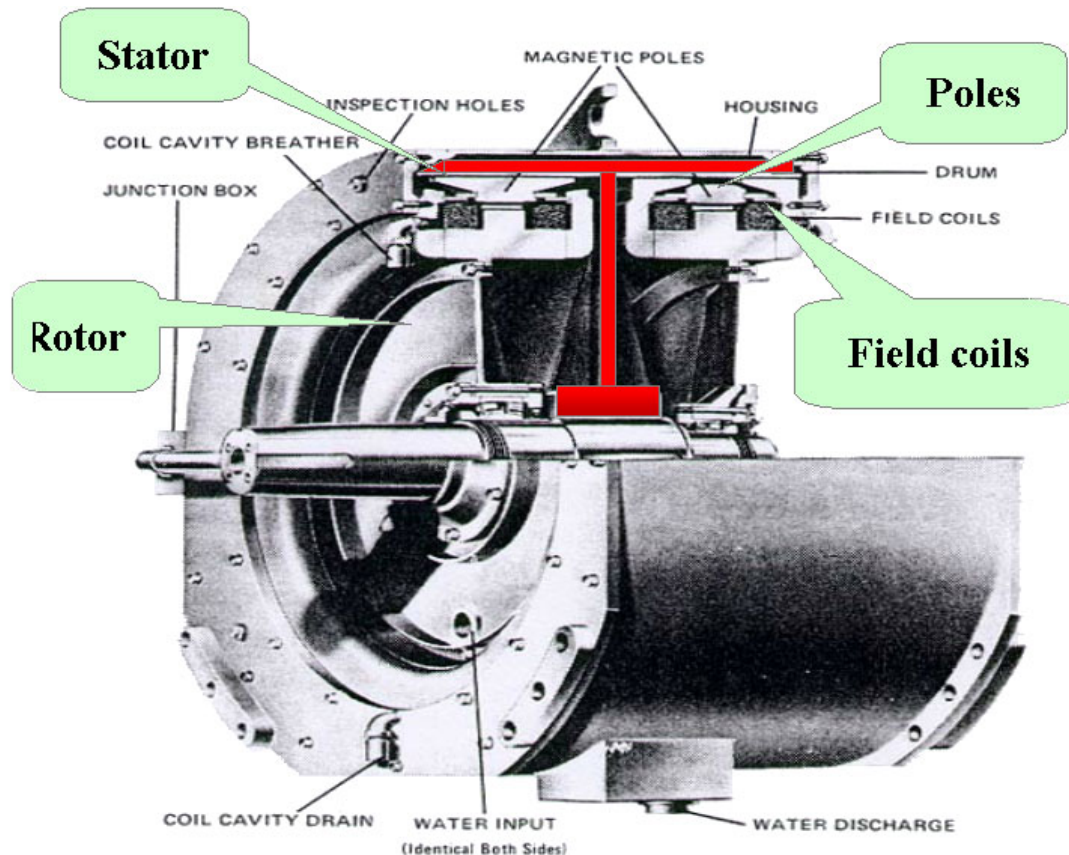


### - Hydrodynamic Brake

The electromagnetic brake consists of a stator with coil, two magnetic poles and a rotor pressed onto the main drive shaft.

When the driller activates the brake control, a magnetic field is produced by 4 electromagnetic coils mounted concentrically inside the drum.

By varying the amount of current to these stationery coils, the driller can control the amount of braking torque applied to the rotating drum.

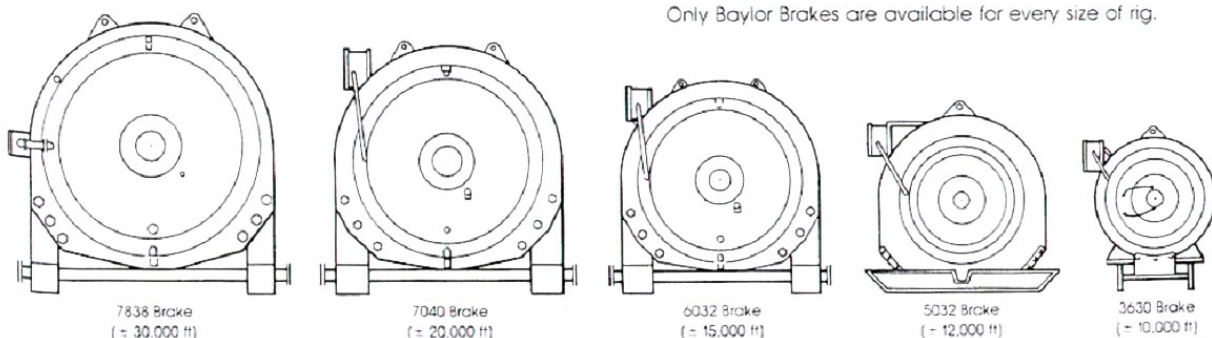


### - "Baylor" brakes

The use of electromagnetic brake began with diesel-electric rigs. Almost all drawworks today are equipped with "Baylor" brakes.

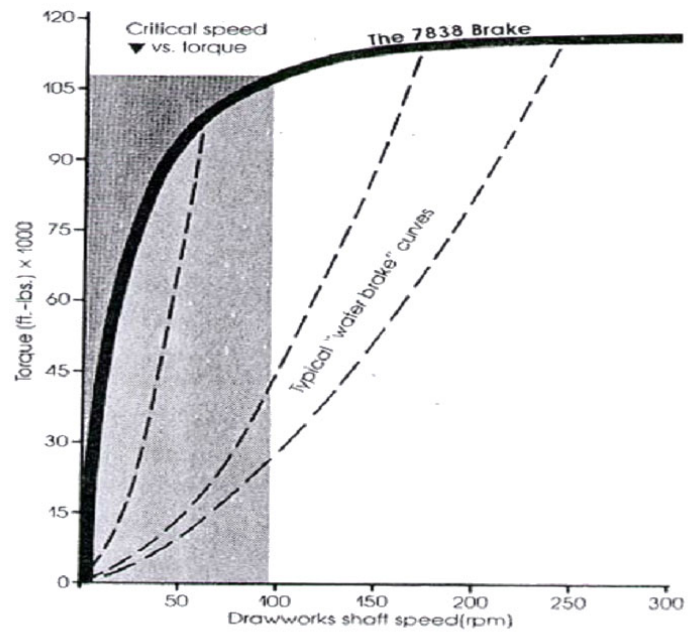
Baylor Brakes are manufactured in 5 standard sizes for nominal drilling depths up to 30,000 feet.

Only Baylor Brakes are available for every size of rig.



### - Braking force

The diagram shows the values of braking force as a function of rpm of the drawworks shaft. Notice how the electromagnetic brake is also effective at low speeds.

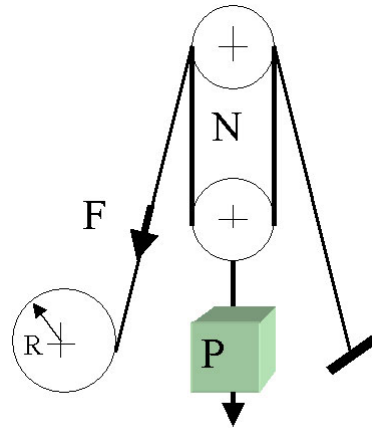


7838 Brake  
Braking Force Diagram

## 6.4 POWER CALCULATION

WORK = Force x Step

POWER= Force x Pooh velocity



### - Hook Power

$$P_h = \frac{P \times V_e}{75}$$

$P_h$  = Hook Power (HP)  
 $V_e$  = Pooh velocity (m/s)  
 $P$  = Weight on Hook (kg)

### - Drawwork Power

$$P_a = \frac{F \times V_f}{75 \times E}$$

$F$  = Pull to Fast line equal to:  
 $P$  (Weigh on Hook) /  $N$  (Number of lines)

$V_f$  = fast line velocity equal to:  
 $V_e * 2 R n$  (rpm drawwork shaft)

$E$  = Efficiency of sheaves. This value (empiric) provided by API in function of number of lines.

## 6.5 INSPECTIONS

### - Periodic inspections

The API applicable references are:

API RP 7L and API RP 54 (chapt. 9.4 and 9.5).  
 and the Manufacturer's recommendations.

ENI policy requires the API Category IV inspection (as per API RP 7L) every 5 years.



Drawwork Inspection

## 07. CROWN BLOCK

### INDEX

#### 7.1 FUNCTION

#### 7.2 TYPES AND CHARACTERISTICS

#### 7.3 INSPECTIONS

### 7.1 FUNCTION

#### - Crown block definition

The Crown Block is a fixed set of pulleys (called sheaves) located at the top of the derrick or mast, over which the drilling line is threaded.

The companion blocks to these pulleys are the travelling blocks. By using two sets of blocks in this fashion, great mechanical advantage is gained, enabling the use of relatively small drilling line to hoist loads many times heavier than the cable could support as a single strand.

#### - Sheave characteristics

The number of sheaves on the two Blocks (Crown and Travelling ) can range from 5 to 8 and is a function of the Hoisting system capability.

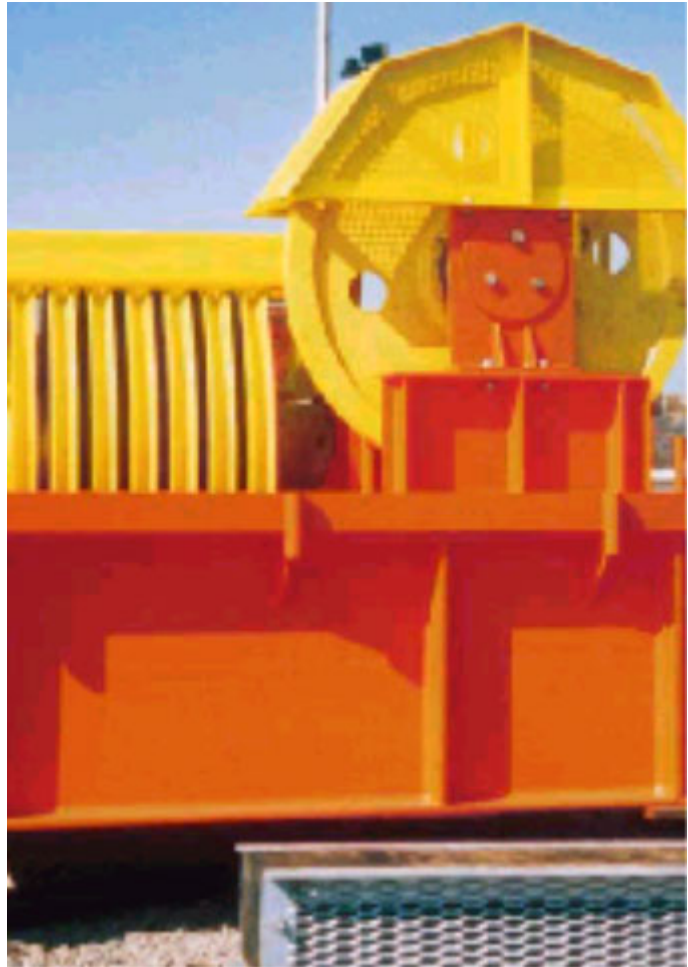
The rating of the Crown Block must be higher than the Travelling Blocks.

The diameter and the groove of sheaves depends on the diameter of drilling line in use. This values are established by the builder based the recommendations of API RP 9B.

The ratio of sheaves diameter to drilling line diameter should be between 30-40.

#### - API specifications

The Crown Block, Travelling Block and the Hook are built in accordance with API specifications 8A or 8C.



*Crown Block*

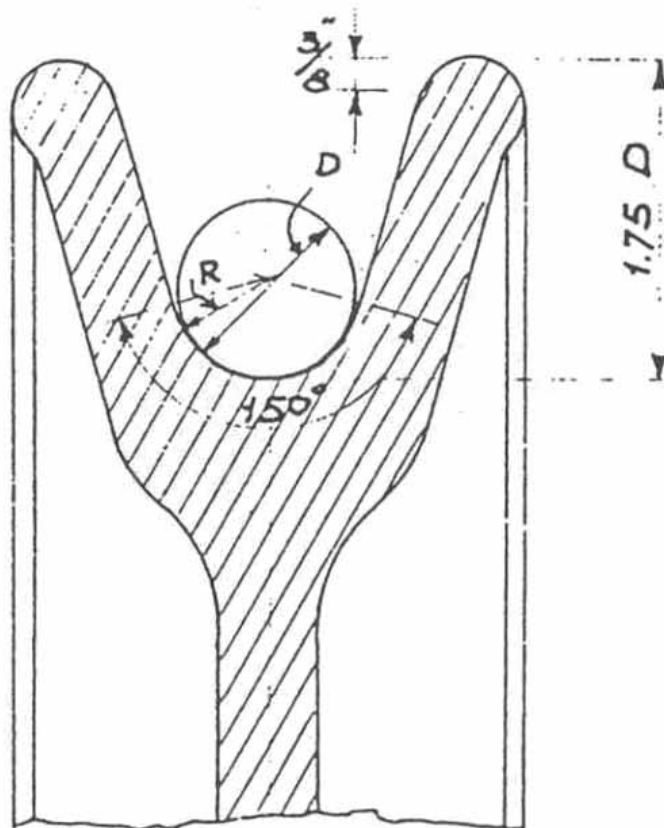


## 7.2 TYPES AND CHARACTERISTICS

### - Groove size

The groove on the sheaves must be same size as the diameter of drilling line used to provide the right support. (Fig. 77)

A groove too wide will flatten the drilling line, while a groove too narrow will cause high friction and excessive wear on the drilling line.



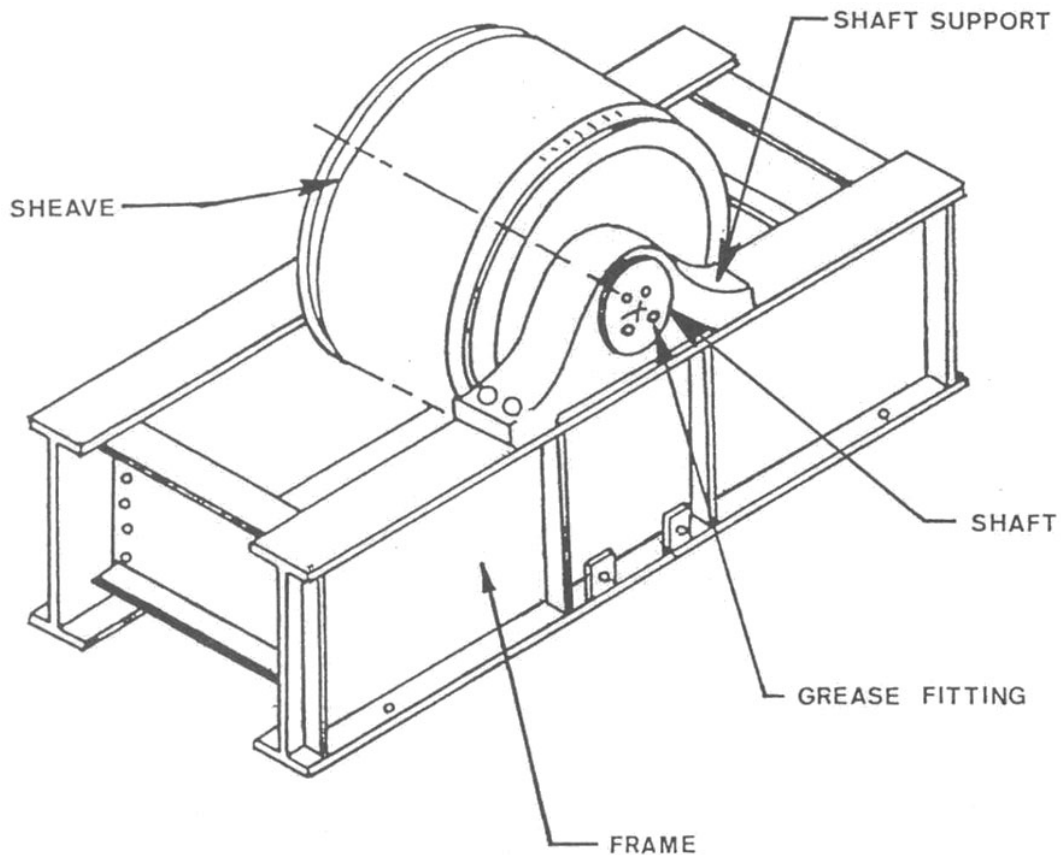
Groove (Fig. 77)

### - Typical Derrick Crown Block

#### TYPICAL DERRICK CROWN BLOCK SIZES AND SPECIFICATIONS

| Capacity (Tons) | Rated Static Hook Load Capacity (Tons) | Number of Sheaves | Sheave Diameter | Groove Diameter |
|-----------------|----------------------------------------|-------------------|-----------------|-----------------|
| 420             | 350                                    | 6                 | 42"             | 1 1/4", 1 3/8"  |
| 583             | 500                                    | 7                 | 50"             | 1 3/8", 1 1/2"  |
| 583             | 500                                    | 7                 | 60"             | 1 3/8", 1 1/2"  |
| 743             | 650                                    | 8                 | 60"             | 1 1/2", 1 5/8"  |
| 857             | 750                                    | 8                 | 60"             | 1 1/2", 1 5/8"  |
| 1,125           | 1,000                                  | 9                 | 72"             | 1 5/8", 2"      |

### 7.3 INSPECTIONS



#### - Periodic inspections

The Crown Block, as with all Hoisting equipment, must have periodic inspections according to the builder's recommendations and API RP 8B.

ENI procedures stipulate that the Crown Block be certified every 5 years, in addition to the mandatory periodic inspections.

#### - Frequency of Periodic Inspections

The frequency of periodic inspections is:

- Daily
- Monthly
- Semi-annual
- Annual
- Five-year

- Table: Periodic Inspection and Maintenance Categories and Frequencies

## - API Recommended Practice 8B

### CATEGORIES

#### Category I

Observation of equipment during operation for indications of inadequate performance.

#### Category II

Category I inspection, plus further inspection for corrosion; deformation; loose or missing components; deterioration; proper lubrication; visible external cracks; and adjustment.

#### Category III

Category II inspection, plus further inspection which should include NDE of exposed critical areas and may involve some disassembly to access specific components and identify wear that exceeds the manufacturer's allowable tolerances.

#### Category IV

Category III inspection, plus further inspection where the equipment is disassembled to the extent necessary to conduct NDE of all primary load carrying components as defined by the manufacturer.

### FREQUENCY

The owner or user of the equipment should develop his own schedule of inspections based on experience, manufacturer's recommendations, and consideration of one or more of the following factors:

- environment;
- load cycles;
- regulatory requirements;
- operating time;
- testing;
- repairs;
- remanufacture

As an alternative the owner or user may use Table 1.

Table 1—Periodic Inspection and Maintenance Categories and Frequencies

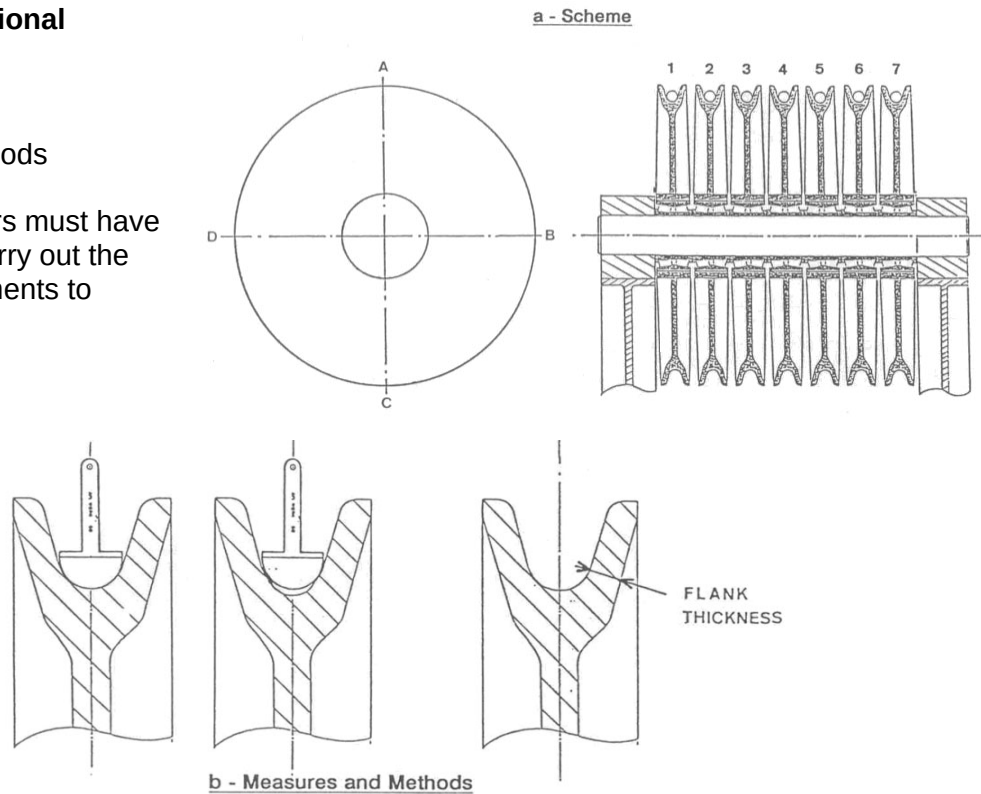
| Equipment                                                                                 | Daily | Weekly | Monthly | Semi Annually | Annually | Other Frequency |
|-------------------------------------------------------------------------------------------|-------|--------|---------|---------------|----------|-----------------|
| Hooks (other than sucker rod hooks)                                                       | I     | II     |         | III           |          | IV (5-year)     |
| Traveling blocks, hook block, block to hook adapter, and crown block sheaves and bearings | I     | II     |         | III           |          | IV (5-year)     |
| Connectors and link adapters                                                              | I     | II     |         | III           |          | IV (5-year)     |
| Sucker rod hooks                                                                          | I     | II     |         | III           | IV       |                 |
| Elevator links                                                                            | I     |        |         | III           | IV       |                 |
| Casing, tubing, drill pipe and drill collar elevators                                     | II    |        |         | III           | IV       |                 |
| Sucker rod elevators                                                                      | II    |        |         | III           | IV       |                 |
| Swivel bail adapters                                                                      | I     | II     |         | III           | IV       |                 |
| Rotary swivels                                                                            | I     | II     |         | III           |          | IV (5-year)     |
| Power swivels                                                                             | I     | II     |         | III           |          | IV (5-year)     |
| Power subs                                                                                | I     | II     |         | III           |          | IV (5-year)     |
| Spiders capable of being used as elevators                                                | II    |        |         | III           | IV       |                 |
| Dead line tie downs/wire line anchors                                                     | I     | II     |         | III           |          | IV (5-year)     |
| Drill string motion compensators                                                          | II    |        |         | III           |          | IV (5-year)     |
| Kelly spinners capable of being used as hoisting equipment                                | I     | II     |         | III           |          | IV (5-year)     |
| Riser and wellhead running tools capable of being used as hoisting equipment              | II    |        |         | III           | IV       |                 |
| Safety clamps when capable of being used as hoisting equipment                            | I     | II     |         | III           | IV       |                 |

## - Example of Dimensional Inspection

a. scheme

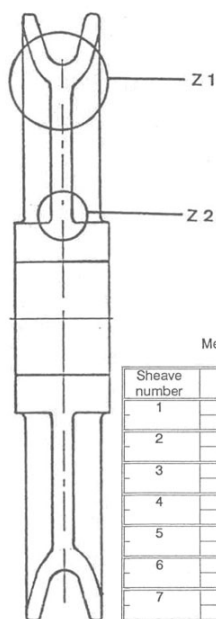
b. Measures and Methods

The Drilling Contractors must have a sheave gauge to carry out the checks and measurements to evaluate wears.



| Sheave number             | Groove profile |   |   |   | Flank thickness        |   |   |   | Sheave play          | Deformation Damage | Corrugations Scouring |
|---------------------------|----------------|---|---|---|------------------------|---|---|---|----------------------|--------------------|-----------------------|
|                           | A              | B | C | D | A                      | B | C | D |                      |                    |                       |
| 1                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 2                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 3                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 4                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 5                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 6                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 7                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| Controlled with API gauge |                |   |   |   | Measured with calipers |   |   |   | Appreciated with bar | Visual observation |                       |

## - Example of NDT Inspection



Method : Magnetic Particle Inspection

| Sheave number | Zones | Cracks | Others | Remarks |
|---------------|-------|--------|--------|---------|
| 1             | Z1    |        |        |         |
|               | Z2    |        |        |         |
| 2             | Z1    |        |        |         |
|               | Z2    |        |        |         |
| 3             | Z1    |        |        |         |
|               | Z2    |        |        |         |
| 4             | Z1    |        |        |         |
|               | Z2    |        |        |         |
| 5             | Z1    |        |        |         |
|               | Z2    |        |        |         |
| 6             | Z1    |        |        |         |
|               | Z2    |        |        |         |
| 7             | Z1    |        |        |         |
|               | Z2    |        |        |         |

## 08. TRAVELLING BLOCK

### INDEX

- 8.1 FUNCTION
- 8.2 TYPES AND CHARACTERISTICS
- 8.3 INSPECTIONS

### 8.1 FUNCTION

The **Travelling Block** is a set of sheaves (pulleys) that move up and down in the derrick.

The drilling line is threaded (reeved) over the sheaves on the crown and through the sheaves in the travelling block. This provides a great mechanical advantage to the drilling line, enabling it to lift heavy loads of pipe and casing.

The **number of the pulleys** used on the two Blocks can vary from 5 to 8, providing a variable capacity to the Hoisting system.



Travelling Block

#### - Manufacture Specifications

The **diameter** and **groove** of the pulleys depends on the dimensions of the drilling line to be used. These values are determined by manufacturer in accordance with **API RP 9B**.

The ratio of sheave diameter to drilling line should be between 30-40:1.

The travelling blocks is built in accordance with **API Spec. 8A and 8C**.

The reference standards adopted by ENI is: **ISO 13535**

### 8.2 TYPES AND CHARACTERISTICS

\

#### - Groove size

The **size of the groove** should be the same as the diameter of drilling line in order to provide the proper support.

A pulley groove too large could flatten the drilling line and a groove too small can cause high friction and excessive wear on the drilling line.

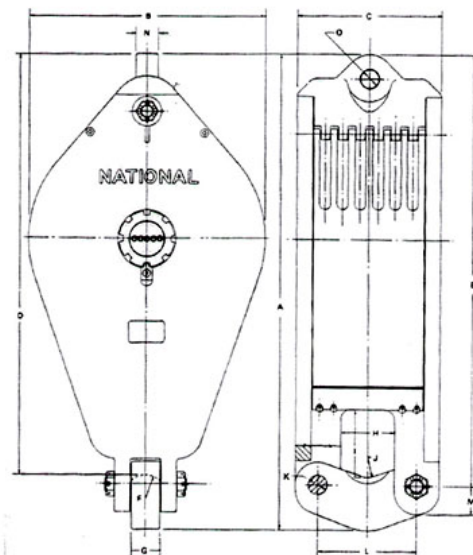


Groove



## Standard Type

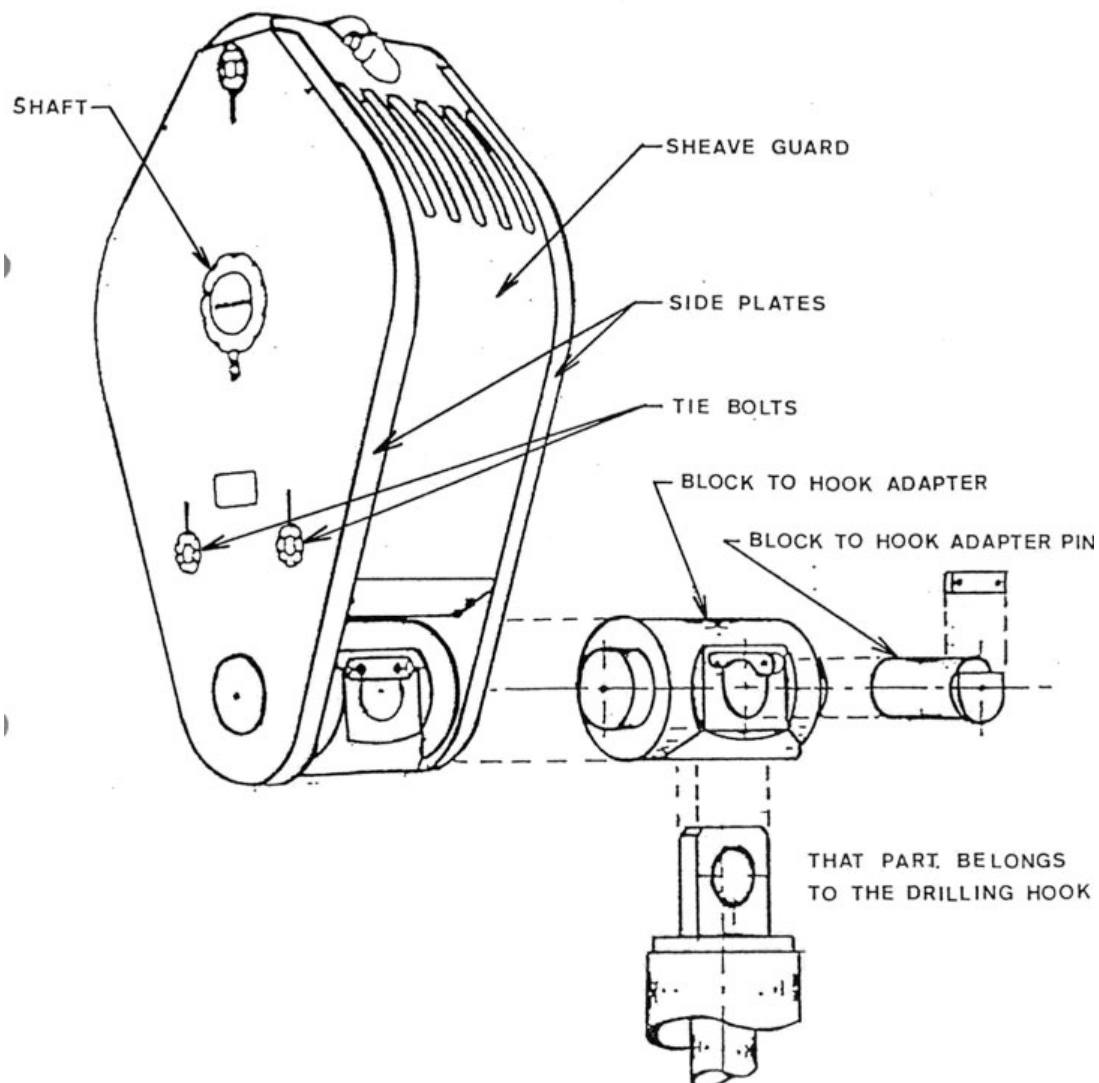
- Standard Travelling Block
- Dimensional characteristics



|                   | 545H350 | 650H500 | 660H500 | 760H650 | 760H750 | 766H750 | 860H750 | 866H750 | 872H1000 |
|-------------------|---------|---------|---------|---------|---------|---------|---------|---------|----------|
| No. of sheaves    | 5       | 6       | 6       | 7       | 7       | 7       | 8       | 8       | 8        |
| Sheave O.D., in.  | 45      | 50      | 60      | 60      | 60      | 66      | 60      | 66      | 72       |
| Load rating, tons | 350     | 500     | 500     | 650     | 750     | 750     | 750     | 750     | 1000     |
| Line sizes, in.   | 1¼, 1½  | 1½, 1½  | 1½, 1½  | 1½, 1½  | 1½, 1½  | 1½, 1¾  | 1½, 1½  | 1½, 1¾  | 1½, 2    |
| Weight, lbs.      | 9380    | 13500   | 18760   | 21800   | 24500   | 26250   | 27300   | 29400   | 34000    |
| A, in.            | 90¾     | 103     | 121     | 125     | 127½    | 137¾    | 127½    | 137¾    | 148¼     |
| B, in.            | 47      | 52      | 63      | 63      | 63      | 69      | 63      | 69      | 75       |
| C, in.            | 26½     | 31¾     | 31¾     | 38      | 38½     | 38½     | 52¼     | 52¼     | 52¼      |
| D, in.            | 79¾     | 90½     | 108½    | 111½    | 113     | 122¼    | 113     | 122¼    | 131¼     |
| E, in.            | 80¾     | 92      | 110     | 113     | 115½    | 124¾    | 115½    | 124¾    | 132¾     |
| F, in.            | 4       | 4       | 4       | 4       | 6       | 6       | 6       | 6       | 6        |
| G, in.            | 6       | 6¾      | 6¾      | 6¾      | 7¾      | 7¾      | 7¾      | 7¾      | 8¾       |
| H, in.            | 8½      | 11¾     | 11¾     | 11¾     | 13½     | 13½     | 13½     | 13½     | 17       |
| I, in.            | 13¾     | 15      | 15      | 16      | 17      | 17      | 17      | 17      | 20       |
| J, in.            | 3½      | 3½      | 3½      | 3½      | 4½      | 4½      | 6½      | 6½      | 6½       |
| K, in.            | 4       | 4½      | 4½      | 5       | 5½      | 5½      | 5½      | 5½      | 6¼       |
| L, in.            | 17½     | 21¾     | 21¾     | 22¼     | 26      | 26      | 31      | 31      | 31       |
| M, in.            | 5½      | 6½      | 6½      | 7       | 7¾      | 7¾      | 7¾      | 7¾      | 8½       |
| N, in.            | —       | 4       | 4       | 4       | 4       | 4       | 4½      | 4½      | 4½       |
| O, in.            | —       | 3⅝      | 3⅝      | 3⅝      | 3⅝      | 3⅝      | 3⅝      | 3⅝      | 3½       |

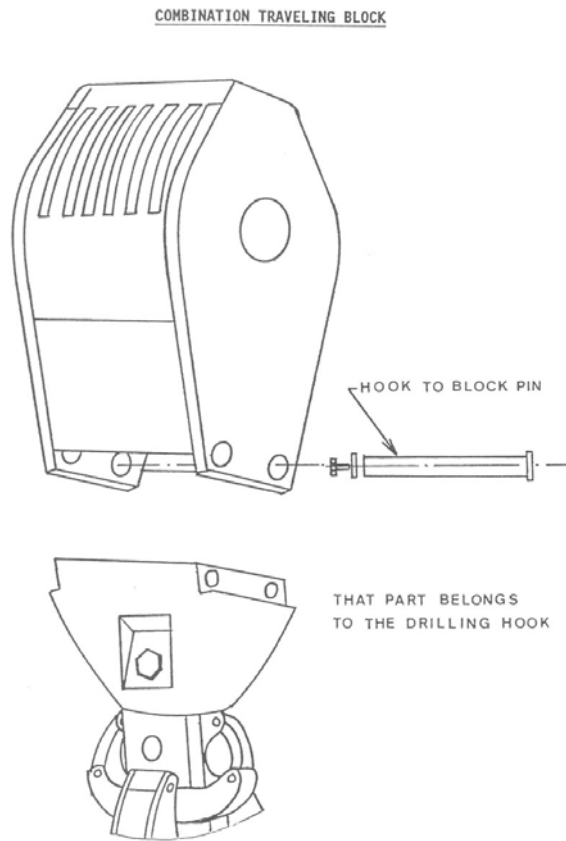
## Unitized

- Scheme and Nomenclature
- Unitized Type



### Combination With Hook

- Scheme and Nomenclature
- Combination Travelling Block



Combination Travelling Block - Scheme



Combination Travelling Block

### Maritime Travelling Block



### 8.3 INSPECTIONS

#### - Periodic inspections

The Travelling Block, as with all Hoisting equipment, must be inspected according to the manufacturers recommendations and **API RP 8B** or related **ISO** (International Organization for Standardization) **13534**.

ENI policy requires the **Category IV** inspection (as per API RP 8B and ISO 13534) every 5 years.

#### - Frequency of Periodic Inspections

The frequency of periodic inspections is:

- Daily
- Monthly
- Semi-annual
- Annual
- Five-year

**Table 1—Periodic Inspection and Maintenance Categories and Frequencies**

| Equipment                                                                                 | Daily | Weekly | Monthly | Semi Annually | Annually | Other Frequency |
|-------------------------------------------------------------------------------------------|-------|--------|---------|---------------|----------|-----------------|
| Hooks (other than sucker rod hooks)                                                       | I     | II     |         | III           |          | IV (5-year)     |
| Traveling blocks, hook block, block to hook adapter, and crown block sheaves and bearings | I     | II     |         | III           |          | IV (5-year)     |
| Connectors and link adapters                                                              | I     | II     |         | III           |          | IV (5-year)     |
| Sucker rod hooks                                                                          | I     | II     |         | III           | IV       |                 |
| Elevator links                                                                            | I     |        |         | III           | IV       |                 |
| Casing, tubing, drill pipe and drill collar elevators                                     | II    |        |         | III           | IV       |                 |
| Sucker rod elevators                                                                      | II    |        |         | III           | IV       |                 |
| Swivel bail adapters                                                                      | I     | II     |         | III           | IV       |                 |
| Rotary swivels                                                                            | I     | II     |         | III           |          | IV (5-year)     |
| Power swivels                                                                             | I     | II     |         | III           |          | IV (5-year)     |
| Power subs                                                                                | I     | II     |         | III           |          | IV (5-year)     |
| Spiders capable of being used as elevators                                                | II    |        |         | III           | IV       |                 |
| Dead line tie downs/wire line anchors                                                     | I     | II     |         | III           |          | IV (5-year)     |
| Drill string motion compensators                                                          | II    |        |         | III           |          | IV (5-year)     |
| Kelly spinners capable of being used as hoisting equipment                                | I     | II     |         | III           |          | IV (5-year)     |
| Riser and wellhead running tools capable of being used as hoisting equipment              | II    |        |         | III           | IV       |                 |
| Safety clamps when capable of being used as hoisting equipment                            | I     | II     |         | III           | IV       |                 |

**- API Recommended Practice 8B**

**- CATEGORIES**

**Category I**

Observation of equipment during operation for indications of inadequate performance.

**Category II**

Category I inspection, plus further inspection for corrosion; deformation; loose or missing components; deterioration; proper lubrication; visible external cracks; and adjustment.

**Category III**

Category II inspection, plus further inspection which should include NDE of exposed critical areas and may involve some disassembly to access specific components and identify wear that exceeds the manufacturer's allowable tolerances.

**Category IV**

Category III inspection, plus further inspection where the equipment is disassembled to the extent necessary to conduct NDE of all primary load carrying components as defined by the manufacturer.

**- FREQUENCY**

The owner or user of the equipment should develop his own schedule of inspections based on experience, manufacturer's recommendations, and consideration of one or more of the following factors:

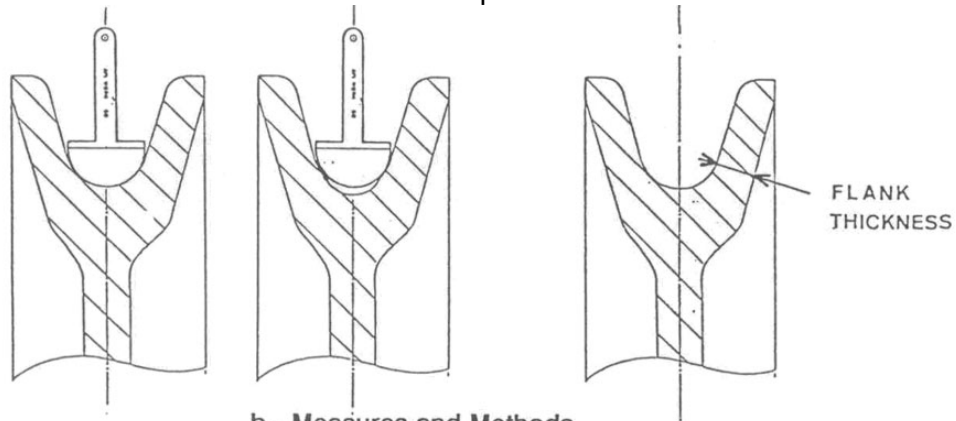
- environment;
- load cycles;
- regulatory requirements;
- operating time;
- testing;
- repairs;
- remanufacture.

As an alternative the owner or user may use Table 1.



## - Dimensional Inspection

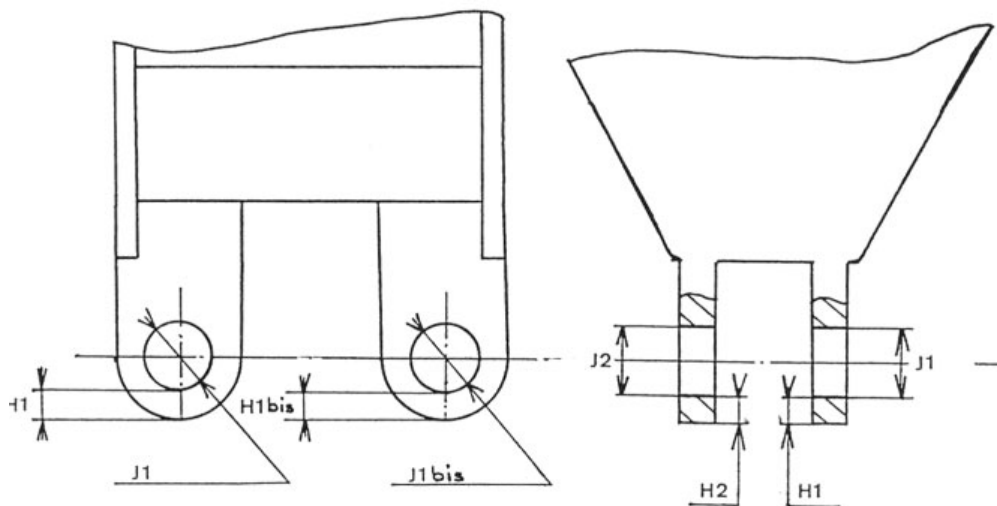
### - Dimensional Inspection 1



**b - Measures and Methods**

| Sheave number             | Groove profile |   |   |   | Flank thickness        |   |   |   | Sheave play          | Deformation Damage | Corrugations Scouring |
|---------------------------|----------------|---|---|---|------------------------|---|---|---|----------------------|--------------------|-----------------------|
|                           | A              | B | C | D | A                      | B | C | D |                      |                    |                       |
| 1                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 2                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 3                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 4                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 5                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 6                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| 7                         |                |   |   |   |                        |   |   |   |                      |                    |                       |
| Controlled with API gauge |                |   |   |   | Measured with calipers |   |   |   | Appreciated with bar | Visual observation |                       |

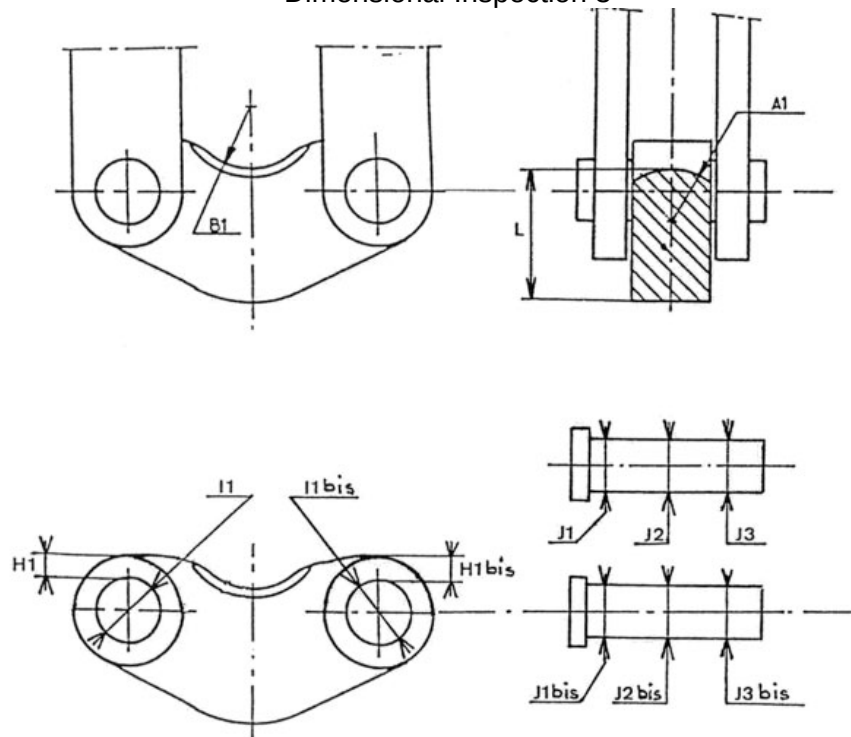
### - Dimensional Inspection 2



**b - Measures and Methods**

|                          | J1                           | H1 | J2 | H2 | J1bis | H1bis | J2bis | H2bis |
|--------------------------|------------------------------|----|----|----|-------|-------|-------|-------|
| Nominal size             | As specified by manufacturer |    |    |    |       |       |       |       |
| Measured size            |                              |    |    |    |       |       |       |       |
| Rejection size           | As specified by manufacturer |    |    |    |       |       |       |       |
| Controlled with calipers |                              |    |    |    |       |       |       |       |

- Dimensional Inspection 3



**b - Measures and Methods**

|                | L                            | I1 | I1bis | H1 | H1bis | J1 | J2 | J3 | J1bis | J2bis | J3bis |
|----------------|------------------------------|----|-------|----|-------|----|----|----|-------|-------|-------|
| Nominal size   | As specified by manufacturer |    |       |    |       |    |    |    |       |       |       |
| Measured size  |                              |    |       |    |       |    |    |    |       |       |       |
| Rejection size | As specified by manufacturer |    |       |    |       |    |    |    |       |       |       |

Controlled with calipers

|              | A1 | B1 |
|--------------|----|----|
| Nominal size |    |    |
| API size     |    |    |
| GO           |    |    |
| NO GO        |    |    |

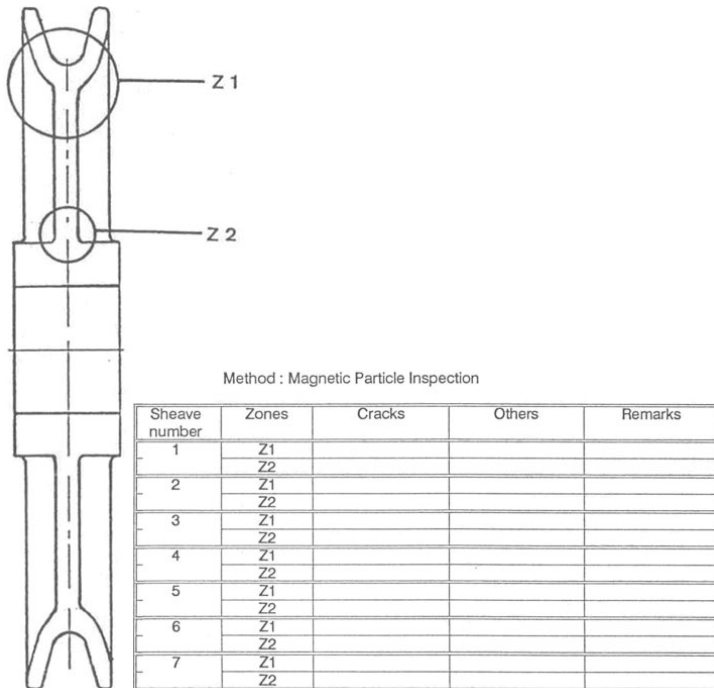
Controlled with shape

**API CONTACT SURFACE RADII**

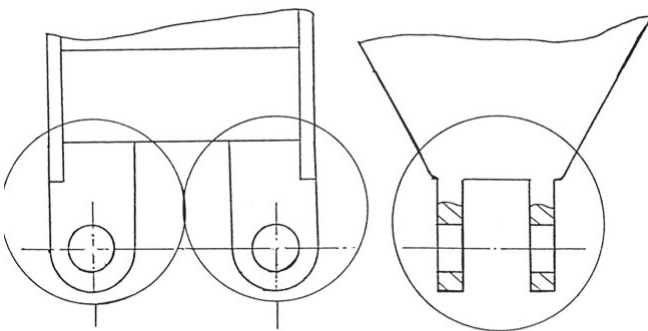
| Hoisting capacities | A1-max | B1-min |
|---------------------|--------|--------|
| 25/150              | 2"3/4  | 3"1/4  |
| 151/350             | 4"     | 3"1/4  |
| 351/650             | 4"     | 3"1/2  |
| 651/750             | 6"     | 3"1/2  |

## - NDT Inspection

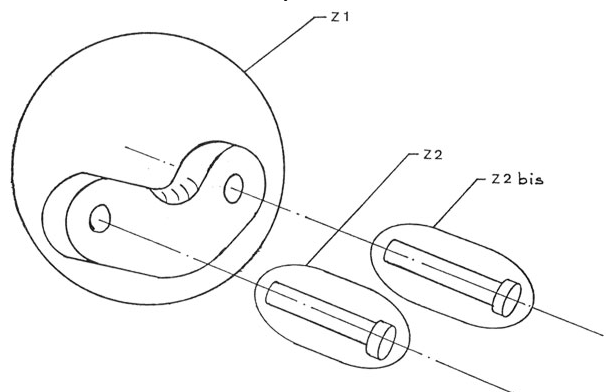
### - NDT Inspection 1



### - NDT Inspection 2



### - NDT Inspection 3



## 09. HOOK

### INDEX

#### 9.1 FUNCTION

#### 9.2 TYPES AND CHARACTERISTICS

#### 9.3 INSPECTIONS

### 9.1 FUNCTION

#### - Description

Attached to the bottom of the travelling blocks, the hook is required to hang the swivel and kelly (for drilling), and the elevator bales (for tripping pipe and casing).



Hook

#### - Manufacture Specifications

The Hook blocks is built in accordance with **API Spec. 8A or 8C**.

The reference standards adopted by ENI is:  
**ISO13534 / 13535"**



Hook

## 9.2 TYPES AND CHARACTERISTICS

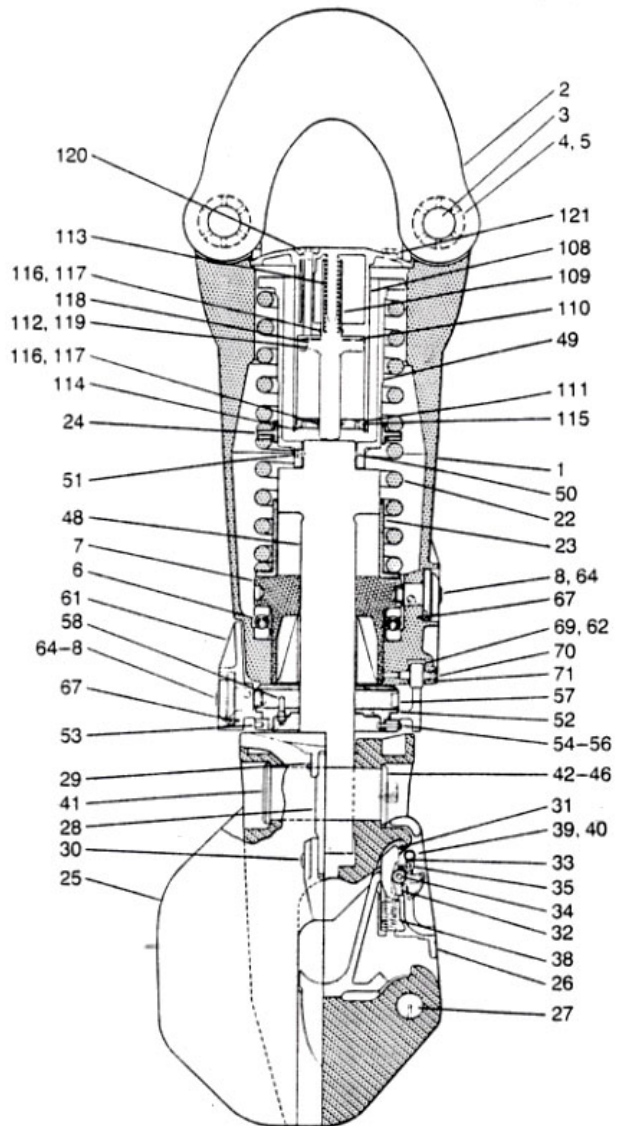
### Standard Hook

#### - Structure and components

The hook is composed of 2 parts: **upper** and **lower**.

The **upper part** has a spring that absorbs the bouncing action when tripping pipe.

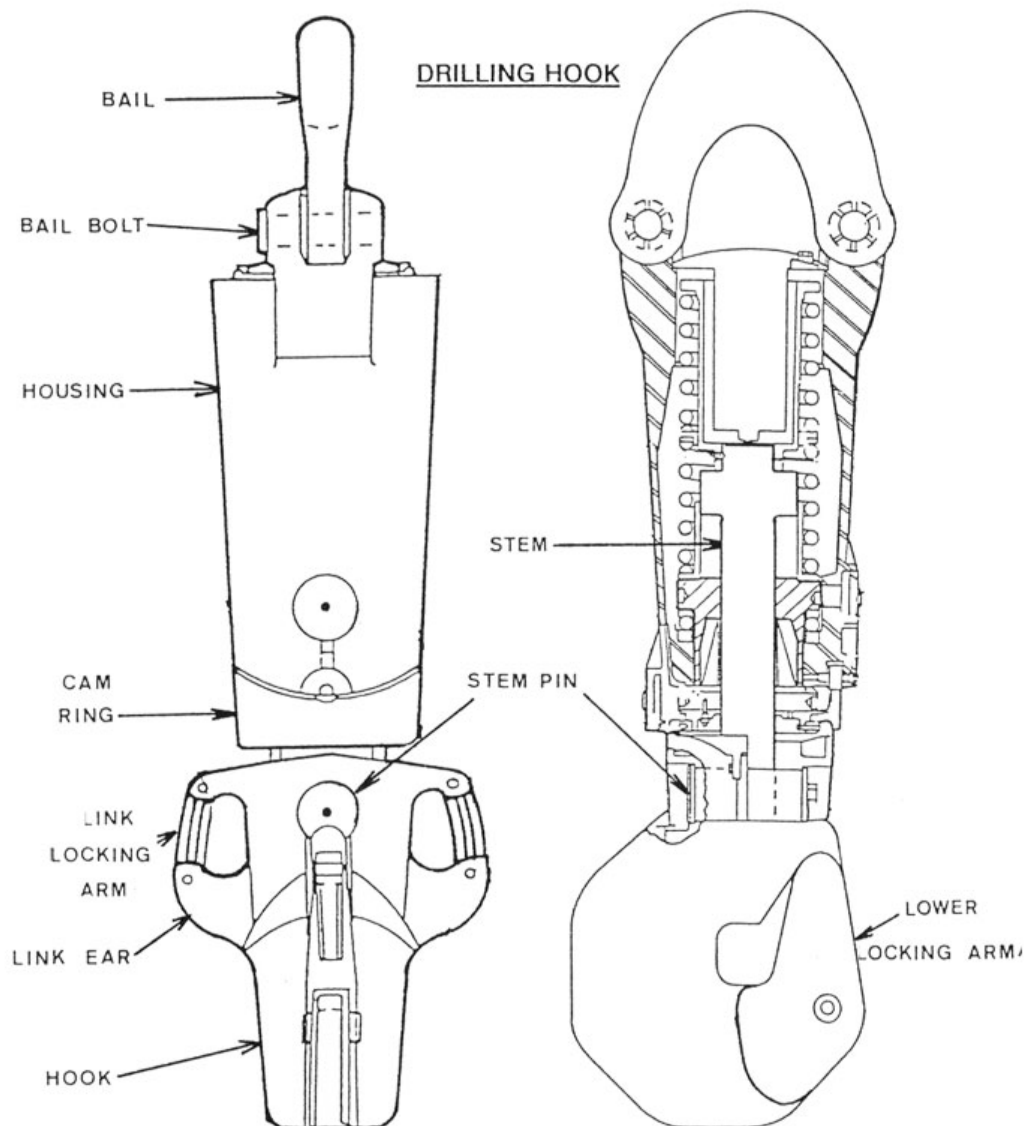
The **lower part** allow the hook to rotate facilitate different operations. It can also be locked to avoid undesired rotation, such as when tripping.



Standard Hook



- Nomenclature



### - BJ Model

**BJ Model 5750 Dynaplex hook**, equipped with high-volume hydraulic snubber and optional hook positioner that automatically rotates elevator into correct position for derrickman.

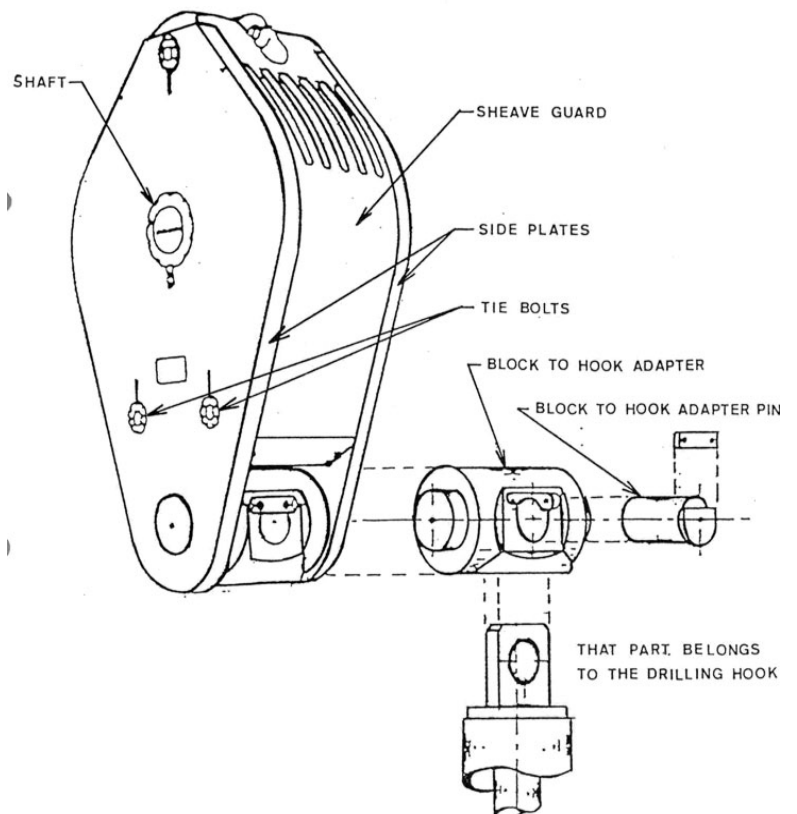


### Unitized Hook

- Untized Hook



- Untized scheme



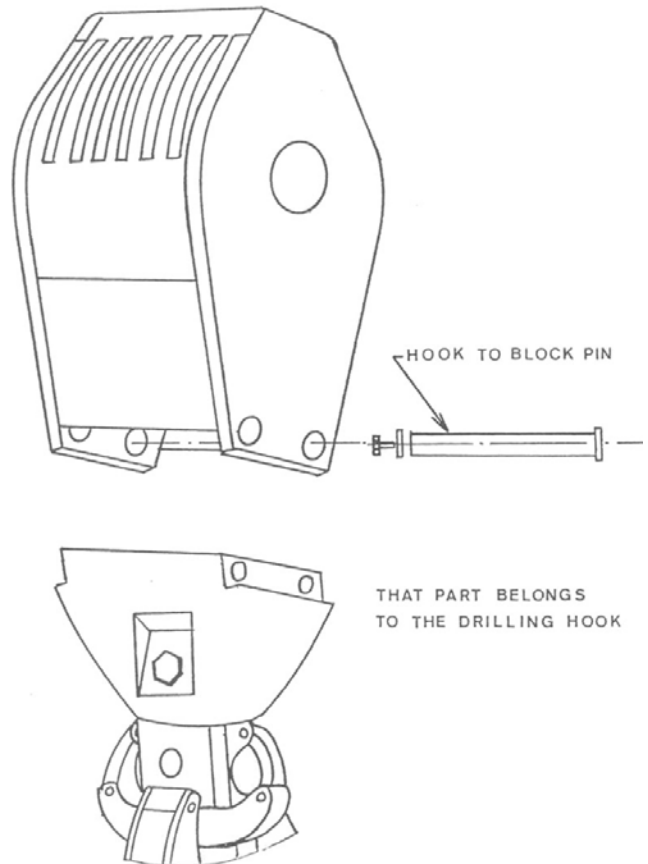
## Combination Travelling Block and Hook

### - Travelling Block and Hook



### - Combination scheme

COMBINATION TRAVELING BLOCK



- Example of National Hook Blocks

## Hook Blocks

| Model:                              | 435G175                                                       | 540G250                                                       | 545G350                                                       | B650GA500                                                     | B660GA500                                                     | B760GA650                                                     |
|-------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Number of sheaves                   | 4                                                             | 5                                                             | 5                                                             | 6                                                             | 6                                                             | 7                                                             |
| Sheave O.D.,<br>in. (mm)            | 35<br>(889)                                                   | 40<br>(1016)                                                  | 45<br>(1143)                                                  | 50<br>(1270)                                                  | 60<br>(1524)                                                  | 60<br>(1524)                                                  |
| Load rating,<br>tons (tonnes)       | 175<br>(158)                                                  | 250<br>(226)                                                  | 350<br>(317)                                                  | 500<br>(453)                                                  | 500<br>(453)                                                  | 650<br>(589)                                                  |
| Line size,<br>in. (mm)              | 1 <sup>1</sup> / <sub>8</sub> , 1 <sup>1</sup> / <sub>4</sub> | 1 <sup>1</sup> / <sub>8</sub> , 1 <sup>1</sup> / <sub>4</sub> | 1 <sup>1</sup> / <sub>4</sub> , 1 <sup>3</sup> / <sub>8</sub> | 1 <sup>3</sup> / <sub>8</sub> , 1 <sup>1</sup> / <sub>2</sub> | 1 <sup>3</sup> / <sub>8</sub> , 1 <sup>1</sup> / <sub>2</sub> | 1 <sup>1</sup> / <sub>2</sub> , 1 <sup>5</sup> / <sub>8</sub> |
| Width overall<br>in. (mm)           | 26 <sup>1</sup> / <sub>2</sub><br>(673)                       | 29<br>(737)                                                   | 31 <sup>1</sup> / <sub>2</sub><br>(800)                       | 34 <sup>1</sup> / <sub>2</sub><br>(876)                       | 34 <sup>1</sup> / <sub>2</sub><br>(876)                       | 38<br>(966)                                                   |
| Length overall,<br>in. (mm)         | 129 <sup>7</sup> / <sub>8</sub><br>(3299)                     | 142 <sup>3</sup> / <sub>4</sub><br>(3626)                     | 158 <sup>1</sup> / <sub>8</sub><br>(4016)                     | 176 <sup>1</sup> / <sub>2</sub><br>(4483)                     | 191 <sup>1</sup> / <sub>2</sub><br>(4864)                     | 201<br>(5105)                                                 |
| Max. dia. across<br>guard, in. (mm) | 37<br>(940)                                                   | 42<br>(1067)                                                  | 47<br>(1194)                                                  | 52<br>(1321)                                                  | 63<br>(1600)                                                  | 63<br>(1600)                                                  |
| Hood load capacity*<br>lb. (kg)     | 20080<br>(9108)                                               | 16400<br>(7438)                                               | 20740<br>(9407)                                               | 98750<br>(44792)                                              | 93500<br>(42410)                                              | 88220<br>(40015)                                              |
| Weight,<br>lb. (kg)                 | 7920<br>(3592)                                                | 11600<br>(5261)                                               | 15260<br>(6922)                                               | 21250<br>(9639)                                               | 26500<br>(12020)                                              | 31780<br>(14415)                                              |

## 9.3 INSPECTIONS

### - Periodic inspections

The Hook, as with all Hoisting equipment, must be inspected according to the manufacturer's recommendations and **API RP 8B**.

**ENI procedures** stipulate that the hook must be re-certified every 5 years, in addition to the required periodic inspections.

### - Frequency of Periodic Inspections

The frequency of periodic inspections is:

- Daily
- Monthly
- Semi-annual
- Annual
- Five-year

Table 1—Periodic Inspection and Maintenance Categories and Frequencies

| Equipment                                                                                 | Daily | Weekly | Monthly | Semi Annually | Annually | Other Frequency |
|-------------------------------------------------------------------------------------------|-------|--------|---------|---------------|----------|-----------------|
| Hooks (other than sucker rod hooks)                                                       | I     | II     |         | III           |          | IV (5-year)     |
| Traveling blocks, hook block, block to hook adapter, and crown block sheaves and bearings | I     | II     |         | III           |          | IV (5-year)     |
| Connectors and link adapters                                                              | I     | II     |         | III           |          | IV (5-year)     |
| Sucker rod hooks                                                                          | I     | II     |         | III           | IV       |                 |
| Elevator links                                                                            | I     |        |         | III           | IV       |                 |
| Casing, tubing, drill pipe and drill collar elevators                                     | II    |        |         | III           | IV       |                 |
| Sucker rod elevators                                                                      | II    |        |         | III           | IV       |                 |
| Swivel bail adapters                                                                      | I     | II     |         | III           | IV       |                 |
| Rotary swivels                                                                            | I     | II     |         | III           |          | IV (5-year)     |
| Power swivels                                                                             | I     | II     |         | III           |          | IV (5-year)     |
| Power subs                                                                                | I     | II     |         | III           |          | IV (5-year)     |
| Spiders capable of being used as elevators                                                | II    |        |         | III           | IV       |                 |
| Dead line tie downs/wire line anchors                                                     | I     | II     |         | III           |          | IV (5-year)     |
| Drill string motion compensators                                                          | II    |        |         | III           |          | IV (5-year)     |
| Kelly spinners capable of being used as hoisting equipment                                | I     | II     |         | III           |          | IV (5-year)     |
| Riser and wellhead running tools capable of being used as hoisting equipment              | II    |        |         | III           | IV       |                 |
| Safety clamps when capable of being used as hoisting equipment                            | I     | II     |         | III           | IV       |                 |

**- API Recommended Practice 8B**

**- CATEGORY**

**Category I**

Observation of equipment during operation for indications of inadequate performance.

**Category II**

Category I inspection, plus further inspection for corrosion; deformation; loose or missing components; deterioration; proper lubrication; visible external cracks; and adjustment.

**Category III**

Category II inspection, plus further inspection which should include NDE of exposed critical areas and may involve some disassembly to access specific components and identify wear that exceeds the manufacturer's allowable tolerances.

**Category IV**

Category III inspection, plus further inspection where the equipment is disassembled to the extent necessary to conduct NDE of all primary load carrying components as defined by the manufacturer.

**- FREQUENCY**

The owner or user of the equipment should develop his own schedule of inspections based on experience, manufacturer's recommendations, and consideration of one or more of the following factors:

- environment;
- load cycles;
- regulatory requirements;
- operating time;
- testing;
- repairs;
- remanufacture.

As an alternative the owner or user may use Table 1.



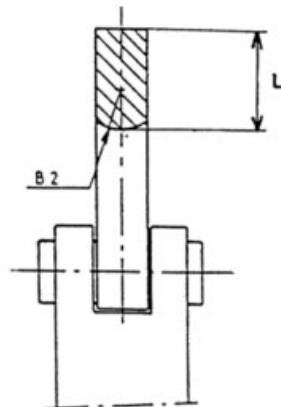
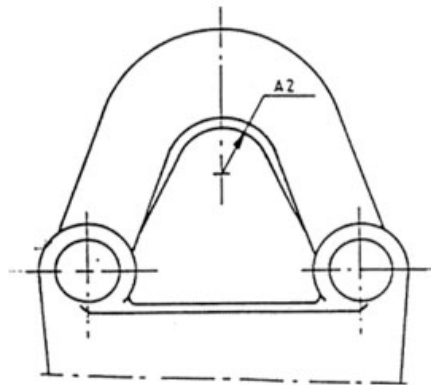
- Dimensional Inspection

- Bail and Bolts

**b - Measures and Methods**

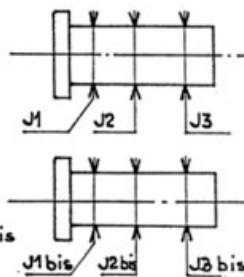
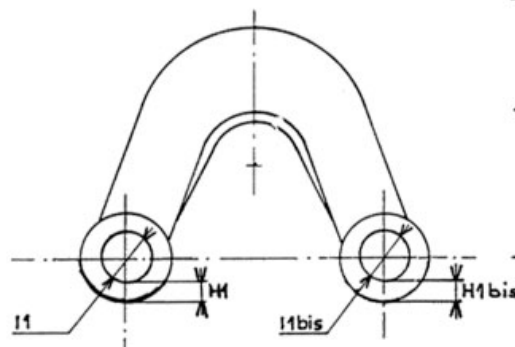
|                | L                            | I1 | I1bis | H1 | H1bis | J1 | J2 | J3 | J1bis | J2bis | J3bis |
|----------------|------------------------------|----|-------|----|-------|----|----|----|-------|-------|-------|
| Nominal size   | As specified by manufacturer |    |       |    |       |    |    |    |       |       |       |
| Measured size  |                              |    |       |    |       |    |    |    |       |       |       |
| Rejection size | As specified by manufacturer |    |       |    |       |    |    |    |       |       |       |

Controlled with calipers



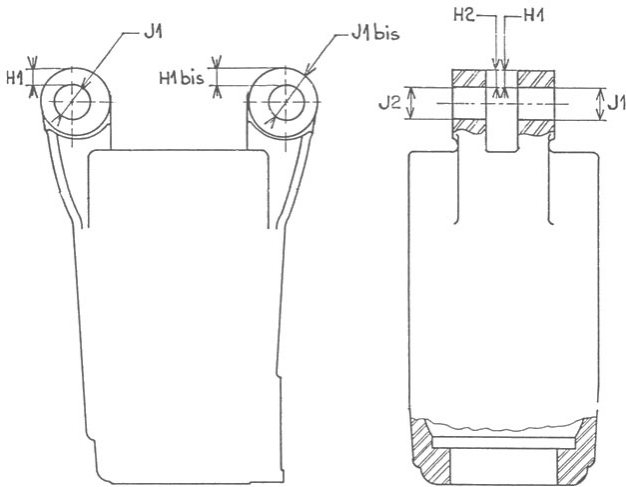
|              | A2 | B2 |
|--------------|----|----|
| Nominal size |    |    |
| API size     |    |    |
| GO           |    |    |
| NO GO        |    |    |

Controlled with shape



### - Housing Inspection

#### HOUSING

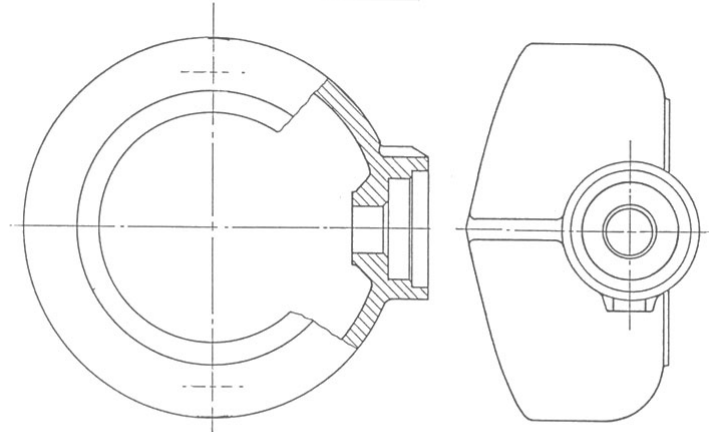


b - Measures and Methods

|                          | J1                           | H1 | J2 | H2 | J1bis | H1bis | J2bis | H2bis |
|--------------------------|------------------------------|----|----|----|-------|-------|-------|-------|
| Nominal size             | As specified by manufacturer |    |    |    |       |       |       |       |
| Measured size            |                              |    |    |    |       |       |       |       |
| Rejection size           | As specified by manufacturer |    |    |    |       |       |       |       |
| Controlled with calipers |                              |    |    |    |       |       |       |       |

### - Cam Ring Inspection

#### CAM RING

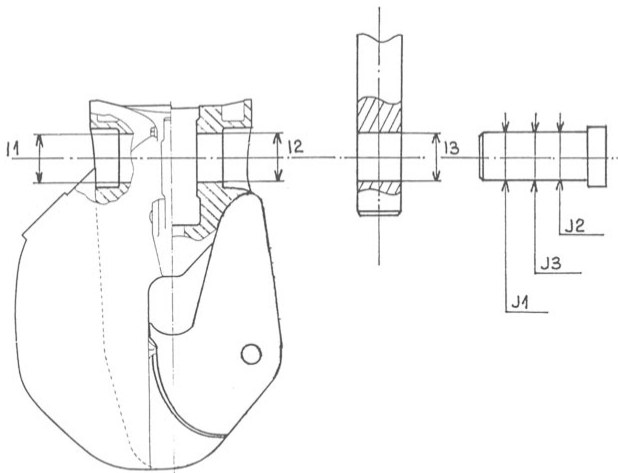


b - Measures and Methods

|                |                              |  |  |  |  |  |  |  |
|----------------|------------------------------|--|--|--|--|--|--|--|
| Nominal size   | As specified by manufacturer |  |  |  |  |  |  |  |
| Measured size  |                              |  |  |  |  |  |  |  |
| Rejection size | As specified by manufacturer |  |  |  |  |  |  |  |

### - Hook Stem Inspection

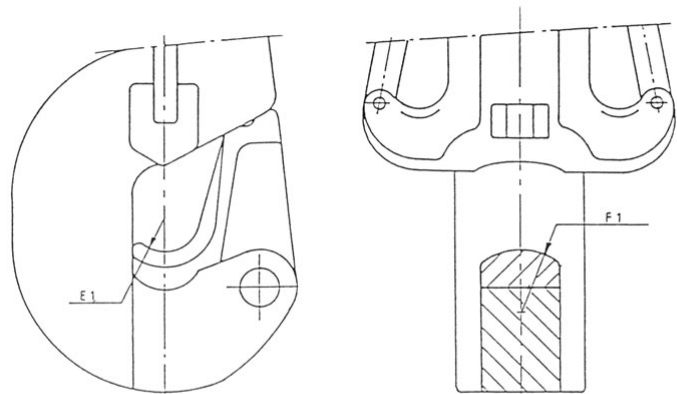
#### HOOK STEM, HOOK STEM BORE AND STEM PIN



|                          |                              |    |    |    |    |    |
|--------------------------|------------------------------|----|----|----|----|----|
|                          | I1                           | I2 | I3 | J1 | J2 | J3 |
| Nominal size             | As specified by manufacturer |    |    |    |    |    |
| Measured size            |                              |    |    |    |    |    |
| Rejection size           | As specified by manufacturer |    |    |    |    |    |
| Controlled with calipers |                              |    |    |    |    |    |

### - Hook and Lower Locking Arm Inspection

#### HOOK AND LOWER LOCKING ARM



#### API CONTACT SURFACE RADII

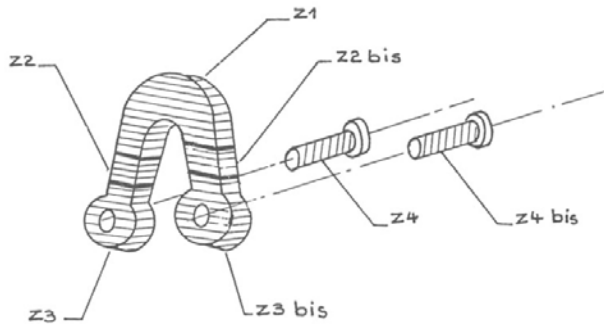
| Hoisting capacities | E1-min | F1-max |
|---------------------|--------|--------|
| 101/150             | 2"1/2  | 4"1/2  |
| 151/250             | 2"3/4  | 4"1/2  |
| 251/350             | 3"     | 4"1/2  |
| 351/650             | 3"1/2  | 4"1/2  |

|              | E1 | F1 |
|--------------|----|----|
| Nominal size |    |    |
| API size     |    |    |
| GO           |    |    |
| NO GO        |    |    |

Controlled with shape

## - NDT Inspection

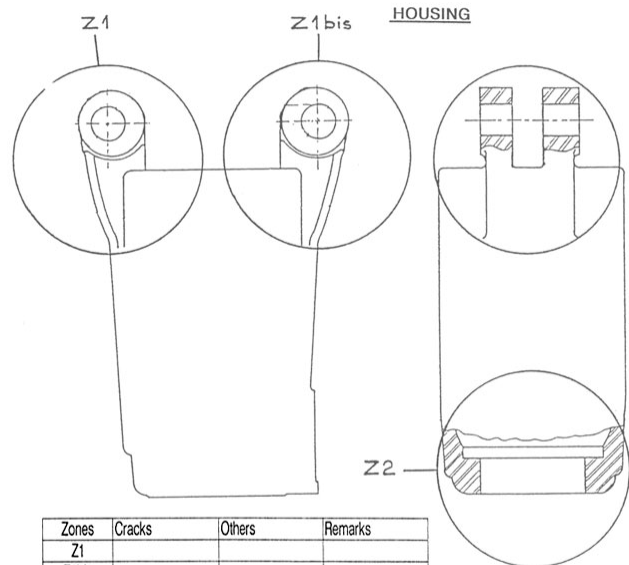
### - Bail and Bolts NDT Inspection - BAIL AND BAIL BOLTS



Method : Magnetic Particle Inspection

| Zones | Cracks | Others | Remarks |
|-------|--------|--------|---------|
| Z1    |        |        |         |
| Z2    |        |        |         |
| Z2bis |        |        |         |
| Z3    |        |        |         |
| Z3bis |        |        |         |
| Z4    |        |        |         |
| Z4bis |        |        |         |

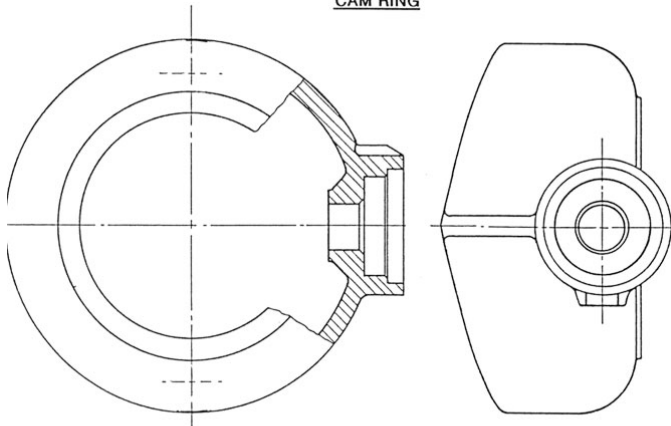
### - Housing NDT Inspection



| Zones | Cracks | Others | Remarks |
|-------|--------|--------|---------|
| Z1    |        |        |         |
| Z1bis |        |        |         |
| Z2    |        |        |         |

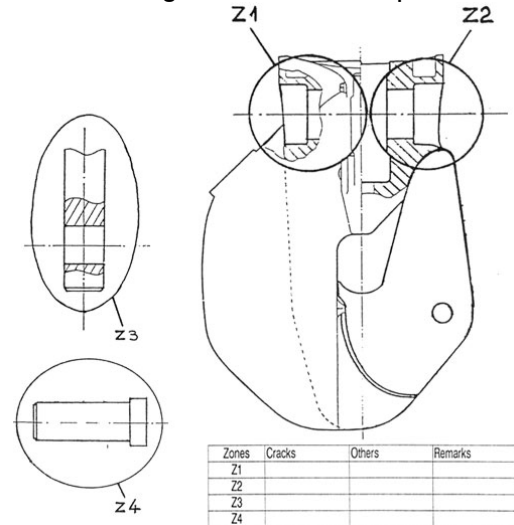
### - Cam Ring Z1 NDT Inspection

CAM RING



| Zones | Cracks | Others | Remarks |
|-------|--------|--------|---------|
| Z1    |        |        |         |
| Z2    |        |        |         |

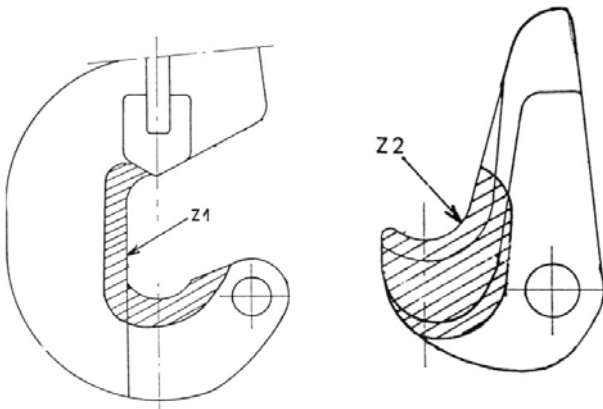
### - Cam Ring Z2 - Z4 NDT Inspection



| Zones | Cracks | Others | Remarks |
|-------|--------|--------|---------|
| Z1    |        |        |         |
| Z2    |        |        |         |
| Z3    |        |        |         |
| Z4    |        |        |         |

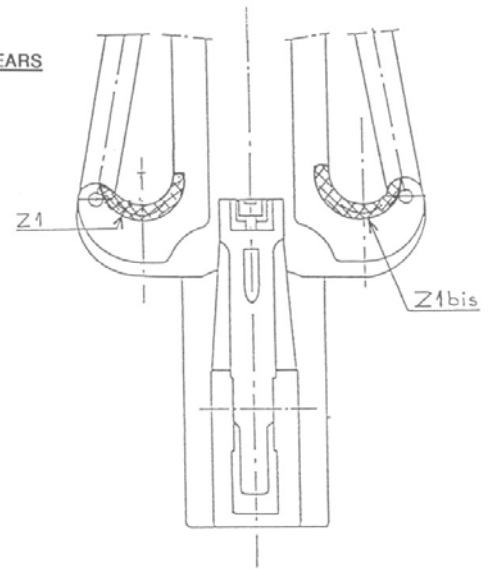
### - Hook and Lower Locking Arm NDT Inspection

### - Link Ears NDT Inspection



| Zones | Cracks | Others | Remarks |
|-------|--------|--------|---------|
| Z1    |        |        |         |
| Z2    |        |        |         |
|       |        |        |         |

LINK EARS



| Zones | Cracks | Others | Remarks |
|-------|--------|--------|---------|
| Z1    |        |        |         |
| Z1bis |        |        |         |
|       |        |        |         |

## 10. DRILLING LINE

### INDEX

- 10.1 DRILLING LINE STRUCTURE
- 10.2 TYPES AND CHARACTERISTICS
- 10.3 DRILLING LINE REEVING
- 10.4 DEADLINE ANCHOR
- 10.5 SAFETY FACTOR
- 10.6 DRILLING LINE WEAR
  - SLIP AND CUT TON-MILES CALCULATION
  - SLIP AND CUT
- 10.7 DRUM

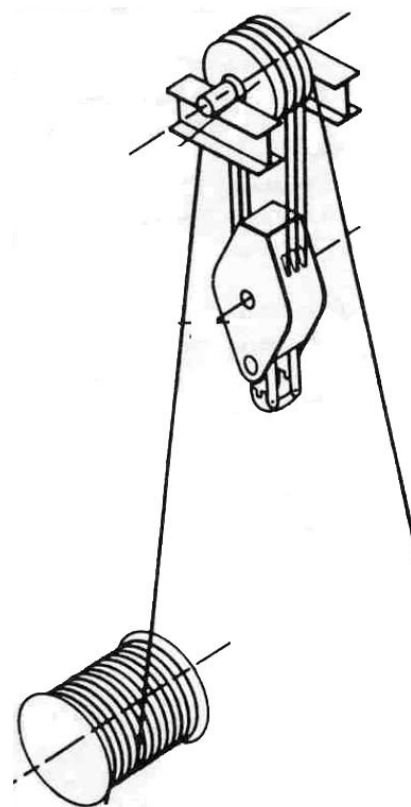
### 10.1 DRILLING LINE STRUCTURE

#### - Drilling line choice

The factors to consider in the **drilling line choice** are:

Diameter  
Breaking strength  
Flexibility  
Elasticity  
Corrosion strength  
Abrasion resistance  
Distortion strength

The drilling line shall be in compliance with:  
**API 9A** and **API RP 9B**.



Drilling line



## - Wire rope

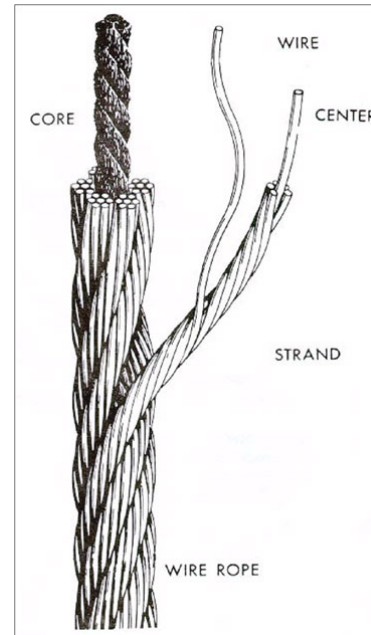
Wire rope is an intricate network of close tolerance, precision made steel wires, much on the order of a machine, where each part has a job to do.

Wire Rope is composed three parts:

- the **CORE**,
- the **STRAND** and
- the **WIRE**.

**API 9A** defines drilling lines with abbreviations in function of:

- Type of core (Steel or fiber)
- Number of strands
- Number of wires per strand



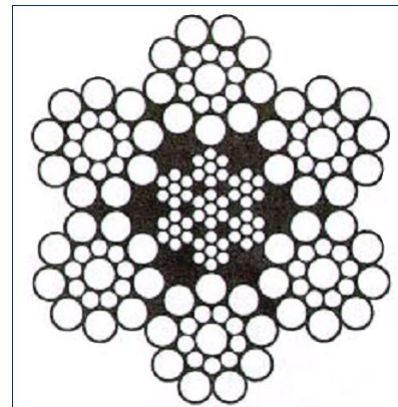
Wire rope

## - CORE

The center wire of the drilling line can be one of two types:

**FIBER CORE:** Either of natural fiber such as sisal or man-made fiber such as polypropylene.

**WIRE ROPE CORE:** Steel wire



### - LAY: Direction

The first element in describing lay is the **DIRECTION** the strands lay in the rope - Right or Left.

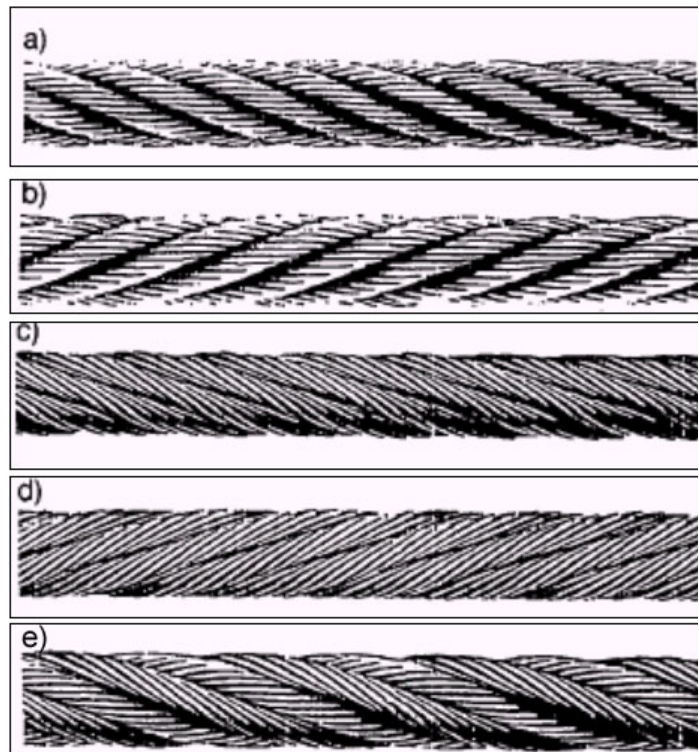
When you look along the rope, strands of a Right Lay rope spiral to the right. Left Lay spirals to the left.

The second element describing lay is the relationship between the direction the strands lay in the rope and the direction the wires lay in the strands. In regular Lay, wires are laid opposite the direction the strands lay in the rope.

In appearance, the wires in Regular Lay are parallel to the axis of the rope.

In Lang Lay, wires are laid the same direction as the strands lay in the rope and the wires appear to cross the rope axis at an angle.

- a) RIGHT REGULAR LAY
- b) LEFT REGULAR LAY
- c) RIGHT LANG LAY
- d) LEFT LANG LAY
- e) RIGHT ALTERNATE LAY

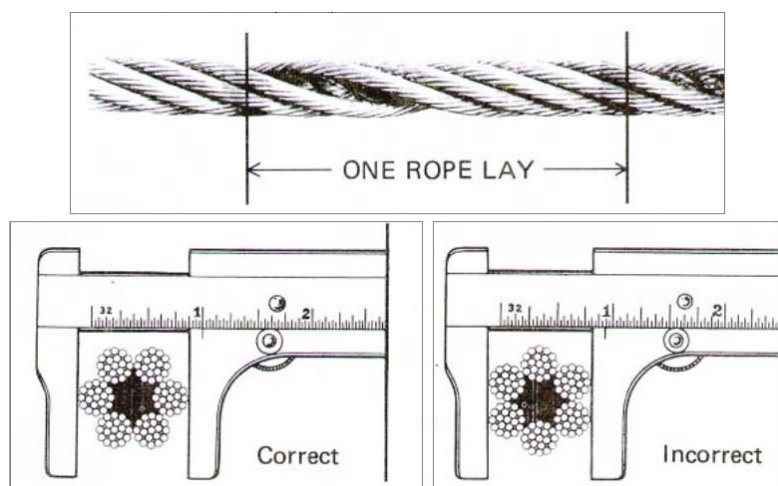


LAY

### - LAY: Length of the Rope Axis

The third element in describing lay is that one rope lay is length the rope axis which one strand uses to make one complete helix around the core.

For API 9A regulations one rope lay is usually 7 to 8 times the nominal diameter.



Drilling line nominal diameter measurement

## - Nomenclature Example

**1" x 5000' 6 x 19 S PFR RRL IPS IWRC**

- 1"** = Diameter of Line  
**5000'** = Length of Line  
**6'** = Number of Strands per Line  
**19** = Number of Wires per Strand  
**S** = Seale Pattern; Seale All layers contain the same number of wires.  
**PFR** = Preformed Strands are helically formed into the final shape.  
**RRL** = Right Regular Lay  
**IPS** = Improved Plow Steel with breaking strength between 1770 and 1960 MPa.  
**IWRC** = Independent Wire Rope Core

## 10.2 TYPES AND CHARACTERISTICS

- **Table: Typical sizes** and Constructions of Wire Rope for Oilfield Service

2

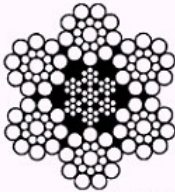
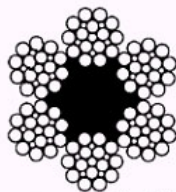
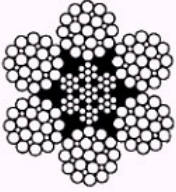
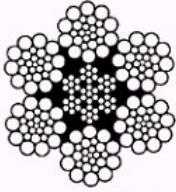
API RECOMMENDED PRACTICE 9B

Table 1—Typical Sizes and Constructions of Wire Rope For Oilfield Service

| 1                                               | 2                    | 3              | 4                                                                       |
|-------------------------------------------------|----------------------|----------------|-------------------------------------------------------------------------|
| Service and Well Depth                          | Wire Rope<br>in.     | Diameter<br>mm | Wire Rope Description (Regular Lay)                                     |
| Drilling Lines—Coring and Slim-Hole Rotary Rigs |                      |                |                                                                         |
| Shallow                                         | 7/8, 1               | 22, 26         | 6 × 26 WS, PF, RL, IPS or EIPS, IWRC                                    |
| Intermediate                                    | 1, 1 1/8             | 26, 29         | 6 × 19 S or 6 × 26 WS, PF, RL, IPS or EIPS, IWRC                        |
| Drilling Lines—Rotary Rigs                      |                      |                |                                                                         |
| Shallow                                         | 1, 1 1/8             | 26, 29         | } 6 × 19 S or 6 × 21 S or 6 × 25 FW or FS, PF, RL, IPS<br>or EIPS, IWRC |
| Intermediate                                    | 1 1/8, 1 1/4         | 29, 32         |                                                                         |
| Deep                                            | 1 1/4 to 1 3/4 incl. | 32, 45         |                                                                         |
| Winch Lines—Heavy Duty                          | 5/8 to 7/8 incl.     | 16 to 22       | 6 × 26 WS or 6x31 WS, PF, RL, IPS or EIPS, IWRC                         |
|                                                 | 7/8 to 1 1/8 incl.   | 22 to 29       | 6 × 36 WS, PF, RL, IPS or EIPS, IWRC                                    |
| Offshore Anchorage Lines                        | 7/8 to 2 3/4 incl.   | 22 to 70       | 6 × 19 Class, Bright or Galv., PF, RL, IPS or EIPS, IWRC                |
|                                                 | 1 3/8 to 4 3/4 incl. | 35 to 122      | 6 × 37 Class, Bright or Galv., PF, RL, IPS or EIPs, IWRC                |
|                                                 | 3 3/4 to 4 3/4 incl. | 96 to 122      | 6 × 61 Class, Bright or Galv., PF, RL, IPS or EIPs, IWRC                |
| Mast Raising Lines <sup>c</sup>                 | 1 3/8 and smaller    | thru 35        | 6 × 19 Class, PF, RL, IPS or EIPS, IWRC                                 |
|                                                 | 1 1/2 and larger     | 38 and up      | 6 × 37 Class, PF, RL, IPS or EIPS, IWRC                                 |
| Guideline Tensioner Line                        | 3/4                  | 19             | 6 × 25 FW, PF, RL, IPS or EIPS, IWRC                                    |
| Wire Rope Description (Lang Lay)                |                      |                |                                                                         |
| Riser Tensioner Lines                           | 1 1/2, 2             | 38, 51         | 6 × 37 Class or PF, RL, IPS or EIPS, IWRC                               |

Typical sizes

## - Classification Example

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Abbreviations</b></p> <p><b>EIPS</b> = Extra Improved Plow Steel<br/> <b>FC</b> = Fiber Core<br/> <b>FS</b> = Flattened Stand<br/> <b>FW</b> = Filler Wire<br/> <b>IPS</b> = Improved Plow Steel<br/> <b>IWRC</b> = Independent Wire Rope Core<br/> <b>LL</b> = Left Lay<br/> <b>NPF</b> = Non Pre-Formed<br/> <b>PF</b> = Pre-Formed<br/> <b>PS</b> = Plow Steel<br/> <b>RL</b> = Right Lay<br/> <b>S</b> = Seale<br/> <b>WS</b> = Warrington Seale</p> | <div style="display: flex; flex-wrap: wrap; justify-content: space-around;"> <div style="text-align: center;">  <p>Figure 12—6 x 19 Seale IWRC</p> </div> <div style="text-align: center;">  <p>Figure 13—6 x 21 Filler Wire FC</p> </div> <div style="text-align: center;">  <p>Figure 14—6 x 25 Filler Wire IWRC</p> </div> <div style="text-align: center;">  <p>Figure 15—6 x 26 Warrington Seale IWRC</p> </div> </div> <p style="text-align: center;">6 x 19 CLASSIFICATION</p> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## - Nominal Strength of Drilling Line (API 9A)

Drilling Line 6 x19 Bright or Drawn Galvanized, independent Wire Rope Core

Table 8—6 x 19 Classification Wire Rope, Bright (Uncoated) or Drawn-Galvanized Wire, Independent Wire Rope Core

See Section 6 for typical wire rope constructions.

| (1)              | (2)  | (3)          | (4)  | (5)                 | (6)  | (7)           | (8)                       | (9)  | (10)          | (11)                            | (12) | (13)          |
|------------------|------|--------------|------|---------------------|------|---------------|---------------------------|------|---------------|---------------------------------|------|---------------|
| Nominal Strength |      |              |      |                     |      |               |                           |      |               |                                 |      |               |
| Nominal Diameter |      | Approx. Mass |      | Improved Plow Steel |      |               | Extra Improved Plow Steel |      |               | Extra Extra Improved Plow Steel |      |               |
|                  |      |              |      | lb                  | kN   | Metric Tonnes | lb                        | kN   | Metric Tonnes | lb                              | kN   | Metric Tonnes |
| 1/2              | 13   | 0.46         | 0.68 | 23,000              | 102  | 10.4          | 26,600                    | 118  | 12.1          | 29,200                          | 130  | 13.2          |
| 9/16             | 14.5 | 0.59         | 0.88 | 29,000              | 129  | 13.2          | 33,600                    | 149  | 15.2          | 37,000                          | 165  | 16.8          |
| 5/8              | 16   | 0.72         | 1.07 | 35,800              | 159  | 16.2          | 41,200                    | 183  | 18.7          | 45,400                          | 202  | 20.6          |
| 3/4              | 19   | 1.04         | 1.55 | 51,200              | 228  | 23.2          | 58,800                    | 262  | 26.7          | 64,800                          | 288  | 29.4          |
| 7/8              | 22   | 1.42         | 2.11 | 69,200              | 308  | 31.4          | 79,600                    | 354  | 36.1          | 87,600                          | 389  | 39.7          |
| 1                | 26   | 1.85         | 2.75 | 89,800              | 399  | 40.7          | 103,400                   | 460  | 46.9          | 113,800                         | 506  | 51.6          |
| 1 1/8            | 29   | 2.34         | 3.48 | 113,000             | 503  | 51.3          | 130,000                   | 678  | 59.0          | 143,000                         | 636  | 64.9          |
| 1 1/4            | 32   | 2.89         | 4.30 | 138,800             | 617  | 63.0          | 159,800                   | 711  | 72.5          | 175,800                         | 782  | 79.8          |
| 1 3/8            | 35   | 3.50         | 5.21 | 167,000             | 743  | 75.7          | 192,000                   | 854  | 87.1          | 212,000                         | 943  | 96.2          |
| 1 1/2            | 38   | 4.16         | 6.19 | 197,800             | 880  | 89.7          | 228,000                   | 1010 | 103           | 250,000                         | 1112 | 113           |
| 1 5/8            | 42   | 4.88         | 7.26 | 230,000             | 1020 | 104           | 264,000                   | 1170 | 120           | 292,000                         | 1300 | 132           |
| 1 3/4            | 45   | 5.67         | 8.44 | 266,000             | 1180 | 121           | 306,000                   | 1360 | 139           | 338,000                         | 1500 | 153           |
| 1 7/8            | 48   | 6.50         | 9.67 | 304,000             | 1350 | 138           | 348,000                   | 1550 | 158           | 384,000                         | 1710 | 174           |
| 2                | 52   | 7.39         | 11.0 | 344,000             | 1630 | 156           | 396,000                   | 1760 | 180           | 434,000                         | 1930 | 197           |

Nominal Strength



### 10.3 DRILLING LINE REEVING

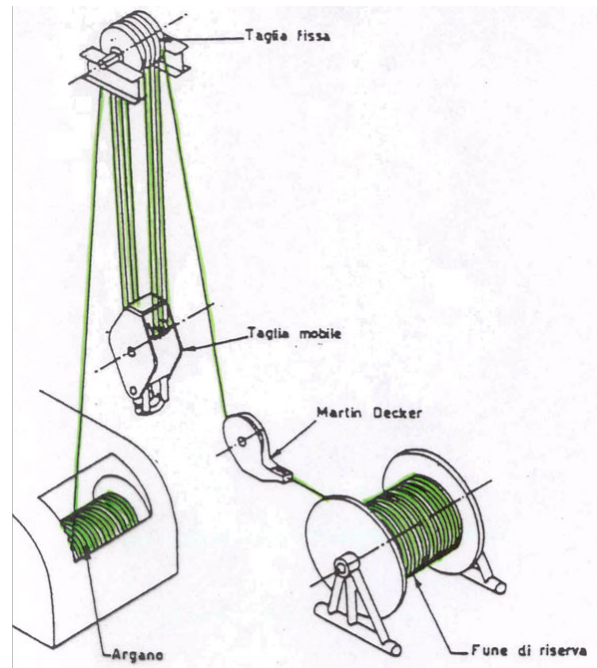
#### - Total length of drilling line

Depending on the height of the derrick and the number of lines to be strung, the total length of drilling line can vary from 650 to 1750 feet.

#### - Heavy wear

Heavy wear occurs in 3 localized areas:

1. Where the drilling line makes contact with the crown block and the travelling block sheaves
2. The position of the drilling line on the sheaves when the slips are set and pulled
1. 3. The position on the drum where each wrap of the drilling line crosses over the layers below

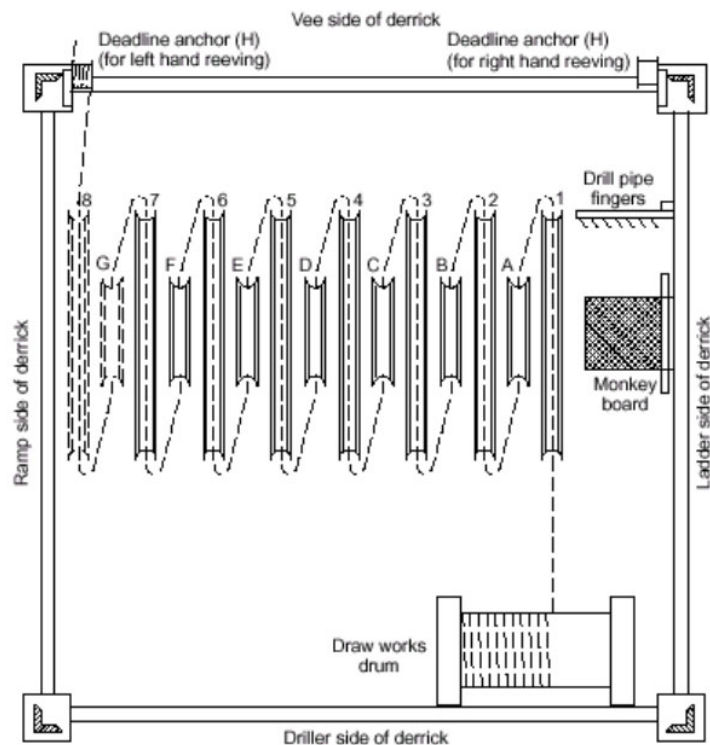


Reeving

#### - Typical Reeving Diagram

Typical Reeving Diagram for  
14-Line String-Up With  
8-Sheave Crown Block and  
7-Sheave Travelling Block: Left  
Hand Reeving

(See Arrangement no. 1 in  
Table 3)



8—Typical Reeving Diagram for 14-Line String-Up With 8-Sheave Crown Block and 7-Sheave Traveling Block: Left Hand Reeving  
(See Arrangement No. 1 in Table 3)



Table 3—Recommended Reeving Arrangements for 12, 10, 9, and 6-Line String-Ups Using 7-Sheave Crown Blocks With 6-Sheave Traveling Blocks and 6-Sheave Crown Blocks With 5-Sheave Traveling Blocks

| Arrange-<br>ment<br>No. | No. of Sheaves |                | Type of<br>String-Up | No. of<br>Lines to | Reeving Sequence                                                                                              |   |   |   |   |   |   |   |   |
|-------------------------|----------------|----------------|----------------------|--------------------|---------------------------------------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|
|                         | Crown<br>Block | Trav.<br>Block |                      |                    | (Read From Left to Right Starting with Crown Block and<br>Going Alternately From Crown to Traveling to Crown) |   |   |   |   |   |   |   |   |
|                         |                |                |                      |                    |                                                                                                               |   |   |   |   |   |   |   |   |
| 1                       | 8              | 7              | Left Hand            | 14                 | Crown Block                                                                                                   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|                         |                |                |                      |                    | Trav. Block                                                                                                   | A | B | C | D | E | F | G |   |
| 2                       | 8              | 7              | Right Hand           | 14                 | Crown Block                                                                                                   | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|                         |                |                |                      |                    | Trav. Block                                                                                                   | G | F | E | D | C | B | A |   |
| 3                       | 7              | 6              | Left Hand            | 12                 | Crown Block                                                                                                   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |   |
|                         |                |                |                      |                    | Trav. Block                                                                                                   | A | B | C | D | E | F |   |   |
| 4                       | 7              | 6              | Right Hand           | 12                 | Crown Block                                                                                                   | 7 | 6 | 5 | 4 | 3 | 2 | 1 |   |
|                         |                |                |                      |                    | Trav. Block                                                                                                   | F | E | D | C | B | A |   |   |
| 5                       | 7              | 6              | Left Hand            | 10                 | Crown Block                                                                                                   | 1 | 2 | 3 |   | 5 | 6 | 7 |   |
|                         |                |                |                      |                    | Trav. Block                                                                                                   | A | B |   | D | E | F |   |   |
| 6                       | 7              | 6              | Right Hand           | 10                 | Crown Block                                                                                                   | 7 | 6 | 5 |   | 3 | 2 | 1 |   |
|                         |                |                |                      |                    | Trav. Block                                                                                                   | F | E |   | C | B | A |   |   |

Table 3: Recommended Reeving Arrangements

#### - Method of Attaching Clips for lifting operations

Figure 6: Correct Method

Figure 7: Incorrect Methods



Figure 6—Correct Method of Attaching Clips to Wire Rope

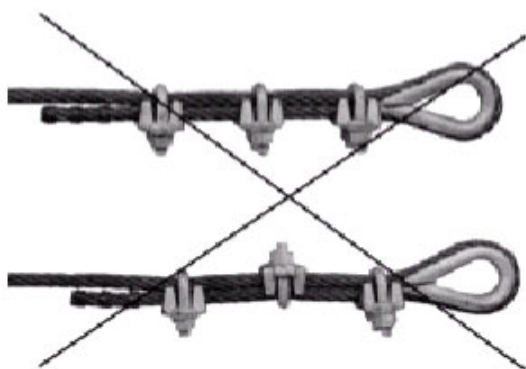


Figure 7—Incorrect Methods of Attaching Clips to Wire Rope

#### - Table: Attachment of Clip

Table 2—Attachment of Clips  
See 3.7.2 and 3.7.6

| 1                |      | 2               | 3                          |      | 4      |      |
|------------------|------|-----------------|----------------------------|------|--------|------|
| Diameter of Rope |      | Number of Clips | Length of Rope Turned Back |      | Torque |      |
| in.              | mm   |                 | in.                        | mm   | ft-lb  | N•m  |
| 1/8              | 3    | 2               | 3 1/4                      | 83   | 4.5    | 6.1  |
| 3/16             | 5    | 2               | 3 3/4                      | 95   | 7.5    | 10   |
| 1/4              | 6.5  | 2               | 4 3/4                      | 121  | 15     | 20   |
| 5/16             | 8    | 2               | 5 1/4                      | 133  | 30     | 41   |
| 3/8              | 9.5  | 2               | 6 1/2                      | 165  | 45     | 61   |
| 7/16             | 11   | 2               | 7                          | 178  | 65     | 88   |
| 1/2              | 13   | 3               | 11 1/2                     | 292  | 65     | 88   |
| 9/16             | 14.5 | 3               | 12                         | 305  | 95     | 129  |
| 5/8              | 16   | 3               | 12                         | 305  | 95     | 129  |
| 3/4              | 19   | 4               | 18                         | 457  | 130    | 176  |
| 7/8              | 22   | 4               | 19                         | 483  | 225    | 305  |
| 1                | 26   | 5               | 26                         | 660  | 225    | 305  |
| 1 1/8            | 29   | 6               | 34                         | 864  | 225    | 305  |
| 1 1/4            | 32   | 7               | 44                         | 1117 | 360    | 488  |
| 1 3/8            | 35   | 7               | 44                         | 1120 | 360    | 488  |
| 1 1/2            | 38   | 8               | 54                         | 1372 | 360    | 488  |
| 1 5/8            | 42   | 8               | 58                         | 1473 | 430    | 583  |
| 1 3/4            | 45   | 8               | 61                         | 1549 | 590    | 800  |
| 2                | 51   | 8               | 71                         | 1800 | 750    | 1020 |
| 2 1/4            | 57   | 8               | 73                         | 1850 | 750    | 1020 |
| 2 1/2            | 64   | 9               | 84                         | 2130 | 750    | 1020 |
| 2 3/4            | 70   | 10              | 100                        | 2540 | 750    | 1020 |
| 3                | 77   | 10              | 106                        | 2690 | 1200   | 1630 |

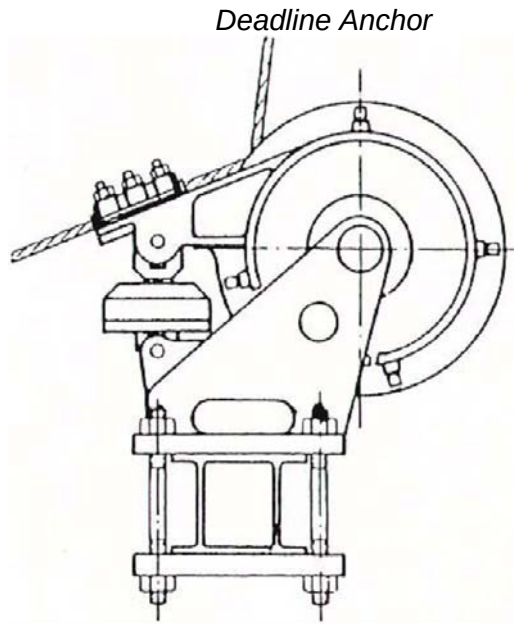
## 10.4 DEADLINE ANCHOR

### - Deadline Anchor

The deadline anchor provides for the attachment of the Martin Decker weight indicator and can be either on the drilling floor or underneath the floor in the substructure.

### - Anchor Size

The anchor must be least 15 times the diameter of the drilling line.



### - Anchor Size



## 10.5 SAFETY FACTOR

### - Design factor

$$\text{Design Factor } DF = \frac{B}{W}$$

where

**B** = Nominal Strength

**W** = Weight (fast line side)

### - "Design factor" of the main equipment:

|                                                         | Minimum Design Factor |
|---------------------------------------------------------|-----------------------|
| Cable tool-line                                         | 3                     |
| Stand line                                              | 3                     |
| Rotary drilling line                                    | 3                     |
| Hoisting service other than rotary drilling             | 3                     |
| Mast raising and lowering line                          | 2.5                   |
| Rotary drilling line when setting casing                | 2                     |
| Pulling on stuck pipe and similar infrequent operations | 2                     |

**- Fast Line pull calculations (API RP 9B)**

**- CASE A**

$$\text{Fast Line Tension} = \text{Fast Line Factor} \times \text{Load}$$

$$\text{Fast Line Factor} = \frac{1}{N \times \text{Efficiency}}$$

$$\text{Efficiency} = \frac{(K^N - 1)}{K^S N (K - 1)}$$

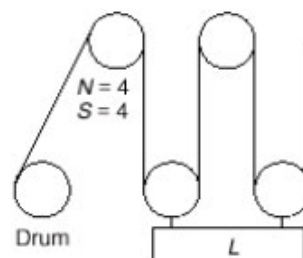
---

**Roller Bearing Sheaves**  
 $K = 1.04^a$

---

**CASE A**

**One Idler Sheave**



$L$  = Load  
 $S$  = No. of sheaves  
 $N$  = No. of rope parts supporting load

**Fast Line pull calculations**

**- Fast Line Table**

| N°<br>LINEE | EFFICIENCY | FAST LINE<br>FACTOR |
|-------------|------------|---------------------|
| $N$         | Case<br>A  | Case<br>A           |
| 2           | 0.943      | 0.530               |
| 3           | 0.925      | 0.360               |
| 4           | 0.908      | 0.275               |
| 5           | 0.890      | 0.225               |
| 6           | 0.874      | 0.191               |
| 7           | 0.857      | 0.167               |
| 8           | 0.842      | 0.148               |
| 9           | 0.826      | 0.135               |
| 10          | 0.811      | 0.123               |
| 11          | 0.796      | 0.114               |
| 12          | 0.782      | 0.106               |
| 13          | 0.768      | 0.100               |
| 14          | 0.755      | 0.095               |
| 15          | 0.741      | 0.090               |

**- Design Factor calculations**

i.e.: Drilling line 1 3/8" EIPS

n : Number of lines 10  
 Pg: Total load 400.000 lb (181.4 tonne)  
 R : Sheave efficiency x 10 lines= 0.811  
 B : Nominal strength 87.1 ton

$$W = \frac{Pg}{n \times Rc} = \frac{181.4}{10 \times 0.811} = 22,3 \text{ tonne}$$

$$\text{Design Factor DF} = \frac{B}{W} = \frac{87.1}{22.3} = 3.9$$

**Tool Pusher Manual Safety factor**

| HOOK<br>LOAD |    | FAST LINE<br>LINES | LOAD/LBS | DESIGN FACTOR |      |        |      |        |      |        |      |        |      |        |      |        |      |        |      |
|--------------|----|--------------------|----------|---------------|------|--------|------|--------|------|--------|------|--------|------|--------|------|--------|------|--------|------|
|              |    |                    |          | 1"            |      | 1 1/8" |      | 1 1/4" |      | 1 3/8" |      | 1 1/2" |      | 1 5/8" |      | 1 3/4" |      | 1 7/8" |      |
|              |    |                    |          | I.P.          | EIPS | I.P.   | EIPS | I.P.   | EIPS | I.P.   | EIPS | I.P.   | EIPS | I.P.   | EIPS | I.P.   | EIPS | I.P.   | EIPS |
| 200 M        | 6  | 38,200             |          | 2.3           | 2.7  | 3.     | 3.4  | 3.6    | 4.2  | 4.4    | 5.   | 5.2    | 6.   |        |      |        |      |        |      |
|              | 8  | 29,600             |          | 3.            | 3.5  | 3.8    | 4.4  | 4.7    | 5.3  | 5.6    | 6.5  | 6.7    | 7.7  |        |      |        |      |        |      |
|              | 10 | 24,600             |          | 3.6           | 4.2  | 4.6    | 5.3  | 5.6    | 6.5  | 6.8    | 7.8  | 8.     | 9.2  |        |      |        |      |        |      |
| 250 M        | 6  | 47,750             |          | 1.9           | 2.1  | 2.4    | 2.8  | 2.9    | 3.3  | 3.5    | 4.   | 4.2    | 4.8  |        |      |        |      |        |      |
|              | 8  | 37,000             |          | 2.4           | 2.8  | 3.     | 3.5  | 3.7    | 4.3  | 4.5    | 5.2  | 5.3    | 6.1  |        |      |        |      |        |      |
|              | 10 | 30,750             |          | 2.9           | 3.4  | 3.7    | 4.2  | 4.5    | 5.2  | 5.3    | 6.2  | 6.4    | 7.4  |        |      |        |      |        |      |
|              | 12 | 26,500             |          | 3.4           | 3.9  | 4.2    | 4.9  | 5.2    | 6.   | 6.3    | 7.2  | 7.5    | 8.6  |        |      |        |      |        |      |
| 300 M        | 6  | 57,300             |          |               |      | 2.     | 2.3  | 2.4    | 2.8  | 2.9    | 3.3  | 4.     |      |        |      |        |      |        |      |
|              | 8  | 44,400             |          | 2.            | 2.3  | 2.5    | 2.9  | 3.1    | 3.6  | 3.7    | 4.3  | 4.5    | 5.1  |        |      |        |      |        |      |
|              | 10 | 36,900             |          | 2.4           | 2.8  | 3.     | 3.5  | 3.7    | 4.3  | 4.5    | 5.2  | 5.3    | 6.2  |        |      |        |      |        |      |
|              | 12 | 31,800             |          | 2.8           | 3.2  | 3.5    | 4.1  | 4.4    | 5.   | 5.2    | 6.   | 6.2    | 7.1  |        |      |        |      |        |      |
| 350 M        | 6  | 66,850             |          |               |      |        |      | 2.1    | 2.4  | 2.5    | 2.9  | 2.9    | 3.4  |        |      |        |      |        |      |
|              | 8  | 51,800             | 1.7      | 2.            | 2.2  | 2.5    | 2.7  | 3.1    | 3.2  | 3.7    | 3.8  | 4.4    | 4.4  | 5.1    | 5.1  | 5.9    |      |        |      |
|              | 10 | 43,050             | 2.1      | 2.4           | 2.6  | 3.     | 3.2  | 3.7    | 3.9  | 4.5    | 4.6  | 5.3    | 5.3  | 6.0    | 6.2  | 7.1    |      |        |      |
|              | 12 | 37,100             | 2.4      | 2.8           | 3.   | 3.5    | 3.7  | 4.3    | 4.5  | 5.2    | 5.3  | 6.1    | 6.2  | 7.1    | 7.1  | 8.2    |      |        |      |
| 400 M        | 8  | 59,200             |          |               |      | 1.9    | 2.2  | 2.3    | 2.7  | 2.8    | 3.2  | 3.3    | 3.8  | 3.9    | 4.5  | 4.5    | 5.2  |        |      |
|              | 10 | 49,200             | 1.8      | 2.1           | 2.4  | 2.6    | 2.8  | 3.2    | 3.4  | 3.9    | 4.   | 4.6    | 4.6  | 5.3    | 5.4  | 6.2    |      |        |      |
|              | 12 | 42,400             | 2.1      | 2.4           | 2.7  | 3.     | 3.3  | 3.8    | 3.9  | 4.5    | 4.6  | 5.3    | 5.3  | 6.2    | 6.3  | 7.2    |      |        |      |
| 450 M        | 8  | 66,600             |          |               |      |        |      | 2.0    | 2.4  | 2.5    | 2.8  | 2.9    | 3.4  | 3.4    | 4.0  | 4.0    | 4.7  |        |      |
|              | 10 | 55,350             |          |               | 2.0  | 2.3    | 2.5  | 2.8    | 3.0  | 3.4    | 3.6  | 4.1    | 4.2  | 4.8    | 4.8  | 5.5    |      |        |      |
|              | 12 | 47,700             |          |               | 2.3  | 2.7    | 2.9  | 3.3    | 3.5  | 4.0    | 4.1  | 4.8    | 4.8  | 5.5    | 5.5  | 6.4    |      |        |      |
| 500 M        | 8  | 74,000             |          |               |      |        |      | 1.9    | 2.1  | 2.2    | 2.6  | 2.7    | 3.1  | 3.1    | 3.6  | 3.6    | 4.1  |        |      |
|              | 10 | 61,500             |          |               | 1.8  | 2.1    | 2.2  | 2.6    | 2.7  | 3.1    | 3.2  | 3.7    | 3.7  | 4.3    | 4.3  | 5.0    |      |        |      |
|              | 12 | 53,000             |          |               | 2.1  | 2.4    | 2.6  | 3.     | 3.1  | 3.6    | 3.7  | 4.3    | 4.2  | 5.0    | 5.0  | 5.7    |      |        |      |
|              | 14 | 47,500             |          |               | 2.3  | 2.7    | 2.9  | 3.3    | 3.5  | 4.0    | 4.1  | 4.8    | 4.8  | 5.5    | 5.6  | 6.4    |      |        |      |
| 600 M        | 8  | 88,800             |          |               |      |        |      | 1.9    | 2.1  | 2.2    | 2.5  | 2.6    | 3.0  | 3.0    | 3.0  | 3.4    |      |        |      |
|              | 10 | 73,800             |          |               |      |        |      | 1.9    | 2.1  | 2.2    | 2.6  | 2.7    | 3.1  | 3.1    | 3.6  | 3.6    | 4.1  |        |      |
|              | 12 | 63,600             |          |               | 1.8  | 2.     | 2.2  | 2.5    | 2.6  | 3.     | 3.1  | 3.6    | 3.6  | 4.1    | 4.2  | 4.8    |      |        |      |
|              | 14 | 57,000             |          |               | 2.0  | 2.2    | 2.4  | 2.8    | 2.9  | 3.3    | 3.4  | 4.0    | 4.0  | 4.6    | 4.6  | 5.3    |      |        |      |
| 700 M        | 8  | 103,600            |          |               |      |        |      |        |      | 1.9    | 2.2  | 2.2    | 2.5  | 2.5    | 2.5  | 3.0    |      |        |      |
|              | 10 | 86,100             |          |               |      |        |      |        |      | 1.9    | 2.2  | 2.3    | 2.6  | 2.7    | 3.0  | 3.1    |      |        |      |
|              | 12 | 74,200             |          |               |      |        | 1.8  | 2.1    | 2.2  | 2.6    | 2.7  | 3.1    | 3.1  | 3.5    | 3.6  | 4.1    |      |        |      |
|              | 14 | 66,500             |          |               |      |        | 2.0  | 2.4    | 2.5  | 2.8    | 2.9  | 3.4    | 3.4  | 3.9    | 4.0  | 4.6    |      |        |      |
| 800 M        | 8  | 118,400            |          |               |      |        |      |        |      |        |      |        |      | 1.9    | 2.2  | 2.2    | 2.6  |        |      |
|              | 10 | 98,400             |          |               |      |        |      |        |      | 1.7    | 1.95 | 2.0    | 2.3  | 2.3    | 2.6  | 2.7    | 3.1  |        |      |
|              | 12 | 84,800             |          |               |      |        |      |        |      | 1.97   | 2.28 | 2.3    | 2.7  | 2.7    | 3.1  | 3.1    | 3.6  |        |      |
|              | 14 | 76,000             |          |               |      |        |      |        |      | 2.2    | 2.53 | 2.6    | 3.0  | 3.0    | 3.4  | 3.5    | 4.0  |        |      |
| 900 M        | 8  | 133,200            |          |               |      |        |      |        |      |        |      |        |      | 1.70   | 1.9  | 2.0    | 2.3  |        |      |
|              | 10 | 110,700            |          |               |      |        |      |        |      |        | 1.74 | 1.79   | 2.05 | 1.87   | 2.3  | 2.3    | 2.7  |        |      |
|              | 12 | 95,400             |          |               |      |        |      |        |      | 1.75   | 2.01 | 2.08   | 2.39 | 2.41   | 2.7  | 2.8    | 3.2  |        |      |
|              | 14 | 85,400             |          |               |      |        |      |        |      | 1.96   | 2.25 | 2.32   | 2.67 | 2.7    | 3.1  | 3.1    | 3.58 |        |      |
| 1000 M       | 10 | 123,000            |          |               |      |        |      |        |      |        |      |        |      | 1.85   | 1.89 | 2.14   | 2.16 | 2.49   |      |
|              | 12 | 106,000            |          |               |      |        |      |        |      |        | 1.81 | 1.86   | 2.15 | 2.17   | 2.5  | 2.51   | 2.89 |        |      |
|              | 14 | 95,000             |          |               |      |        |      |        |      |        | 2.02 | 2.08   | 2.4  | 2.42   | 2.78 | 2.80   | 3.22 |        |      |
|              | 16 | 86,000             |          |               |      |        |      |        |      |        |      | 2.3    | 2.6  | 2.6    | 2.8  | 2.8    | 3.5  |        |      |



## 10.6 DRILLING LINE WEAR

### - Drilling line Wear

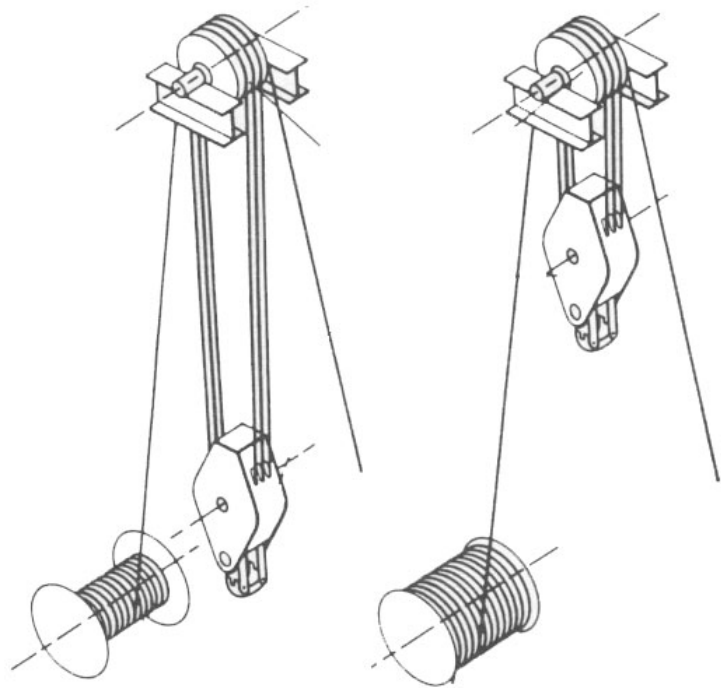
In working the line, heavy wear occurs a few localized sections: where the rope makes contact with the travelling block sheaves, the crown block sheaves and the drum.

### - Slipping and cutting drilling line

For this reason there is the procedure of SLIPPING AND CUTTING DRILLING LINE

Cut is done every 2 - 4 slipping.

Slipping new rope through the system shifts the drilling line through these critical wear areas and distributes the wear more uniformly along the length of the rope



Extreme positions in the operations of run and pool out of hole

## SLIP AND CUT TON-MILES CALCULATION

### SLIP AND CUT TON MILES CALCULATIONS AS PER API RP9B

#### - Work Done During Round-Trip

The only complicated part of a cut-off procedure is the determination of how much work has been done by the wire rope.

Methods such as counting the number of wells drilled or keeping track of days between cuts are not accurate because the loads change with the depth and with different drilling conditions.

For an accurate record of the amount of work done by a drilling line, it's necessary to calculate the weight being lifted and the distance it is raised and lowered. In engineering terms, work is measured in foot-pounds.

On a drilling rig the loads and distance are so great that we use "ton-miles". One Ton-mile equals 10,560,000 foot-pounds.

$$T_r = \frac{D(L_s + D)W_m}{10,560,000} + \frac{D(M + \frac{1}{2}C)}{2,640,000}$$

where

$T_r$  = ton-miles [weight in tons (2,000 lb) times distance moved in miles],

$D$  = depth of hole, ft,

$L_s$  = length of drill-pipe stand, ft,

$N$  = number of stands of drill-pipe,

$W_m$  = effective weight per foot of drill-pipe, lb, from Figure 13,

$M$  = total weight of traveling block-elevator assembly, lb,

$C$  = effective weight of drill collar assembly from Figure 13, minus the effective weight of the same length of drill-pipe, lb, from Figure 13.



### - Work Done During Reaming

With reaming after drilling the stand  
Without reaming after drilling the stand

#### WORK DONE DURING REAMING

$$T_d = 3(T_2 - T_1)$$

With reaming after drilling the stand

where

$T_d$  = ton-miles drilling,

$T_1$  = ton-miles for one round trip at depth  $D_1$  (depth where drilling started after going in hole, ft),

$T_2$  = ton-miles for one round trip at depth  $D_2$  (depth where drilling stopped before coming out of hole, ft).

$$T_d = 2(T_2 - T_1)$$

Without reaming after drilling the stand

### - Work Done During Drilling with Top Drive (with stands)

#### WORK DONE DURING DRILLING WITH TOP DRIVE (with stands)

Definition of Terms:

WDS = Buoyant weight of drill string (drill pipe & BHA)

M = Weight of traveling equipment

LS = Length of a stand

Drilling Operation Cycle:

- 1) Drill down length of stand (LS)
- 2) Raise stand and ream back down full length
- 3) Set slips and break out at pipe handler
- 4) Raise traveling equipment; pick up next stand and make up
- 5) Pick up off slips and begin again

Ton Miles Generated Per Cycle Segment:

- 1)  $((WDS + M) \times LS) / (2000 \times 5280)$
- 2)  $(2 \times (WDS + M) \times LS) / (2000 \times 5280)$
- 3) N/A
- 4)  $(M \times LS) / (2000 \times 5280)$
- 5) N/A

Ton Miles Per Stand Drilled =  
 $(LS \times (3 WDS + 4 M)) / (2000 \times 5280)$

### - Work Done During CSG

The ton-miles of work done in setting casing would be one-half the ton-miles done in making a round trip if the weight of the casing were the same as the weight of the drill pipe.

$$T_s = \frac{D(L_{cs} + D)W_{cm}}{10,560,000} + \frac{DM}{2,640,000} \times \frac{1}{2}$$

where

$T_s$  = ton-miles setting casing,

$L_{cs}$  = length of joint of casing, ft,

$W_{cm}$  = effective weight per foot of casing, lb, may be estimated from data given on Figure 13 for drill pipe, or calculated as follows:

$$W_{cm} = W_{ca} (1 - 0.015B)$$

where

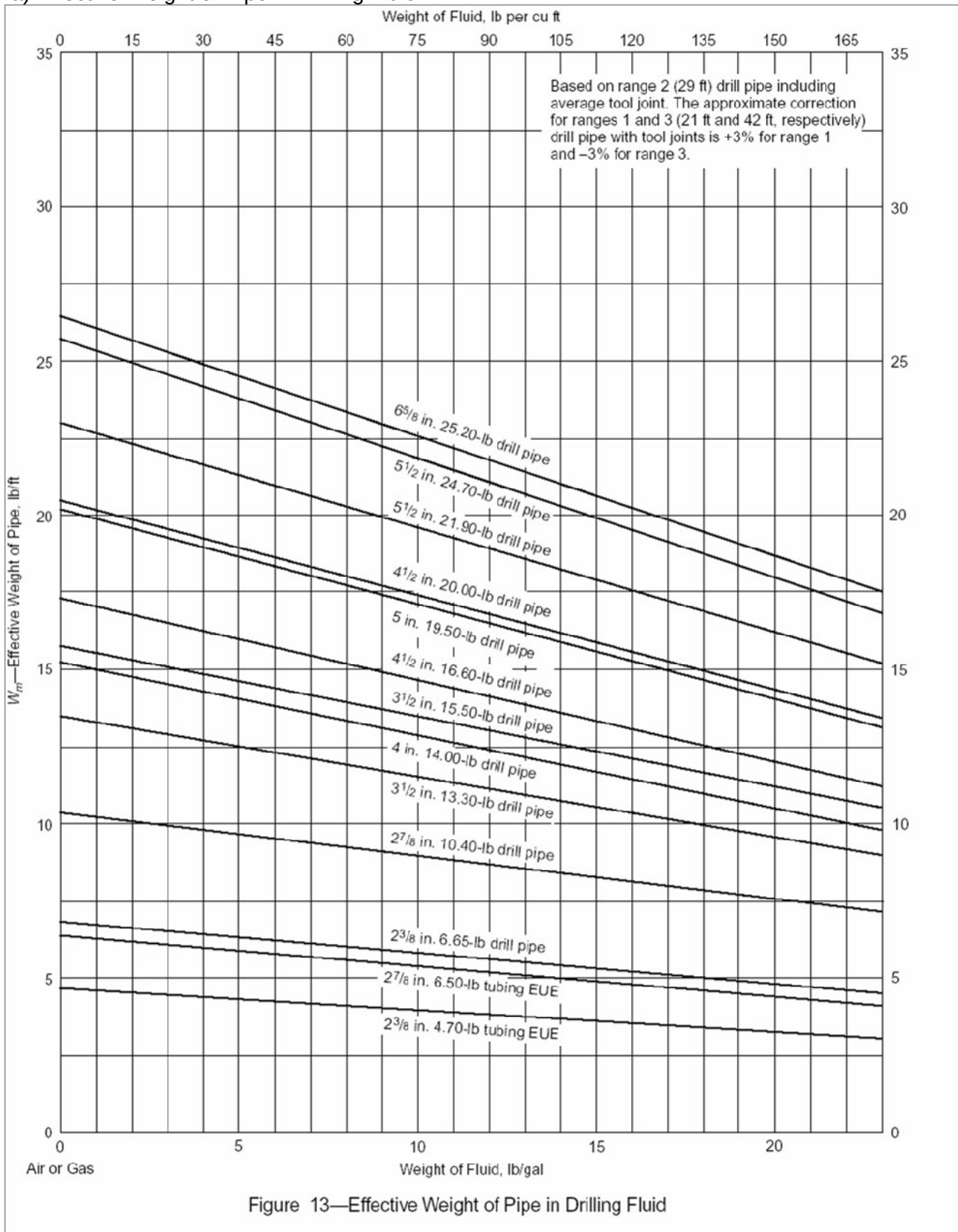
$W_{ca}$  = weight per foot of casing in air, lb,

$B$  = weight of drilling fluid, lb/gal, from Figure 13 or Figure 14.

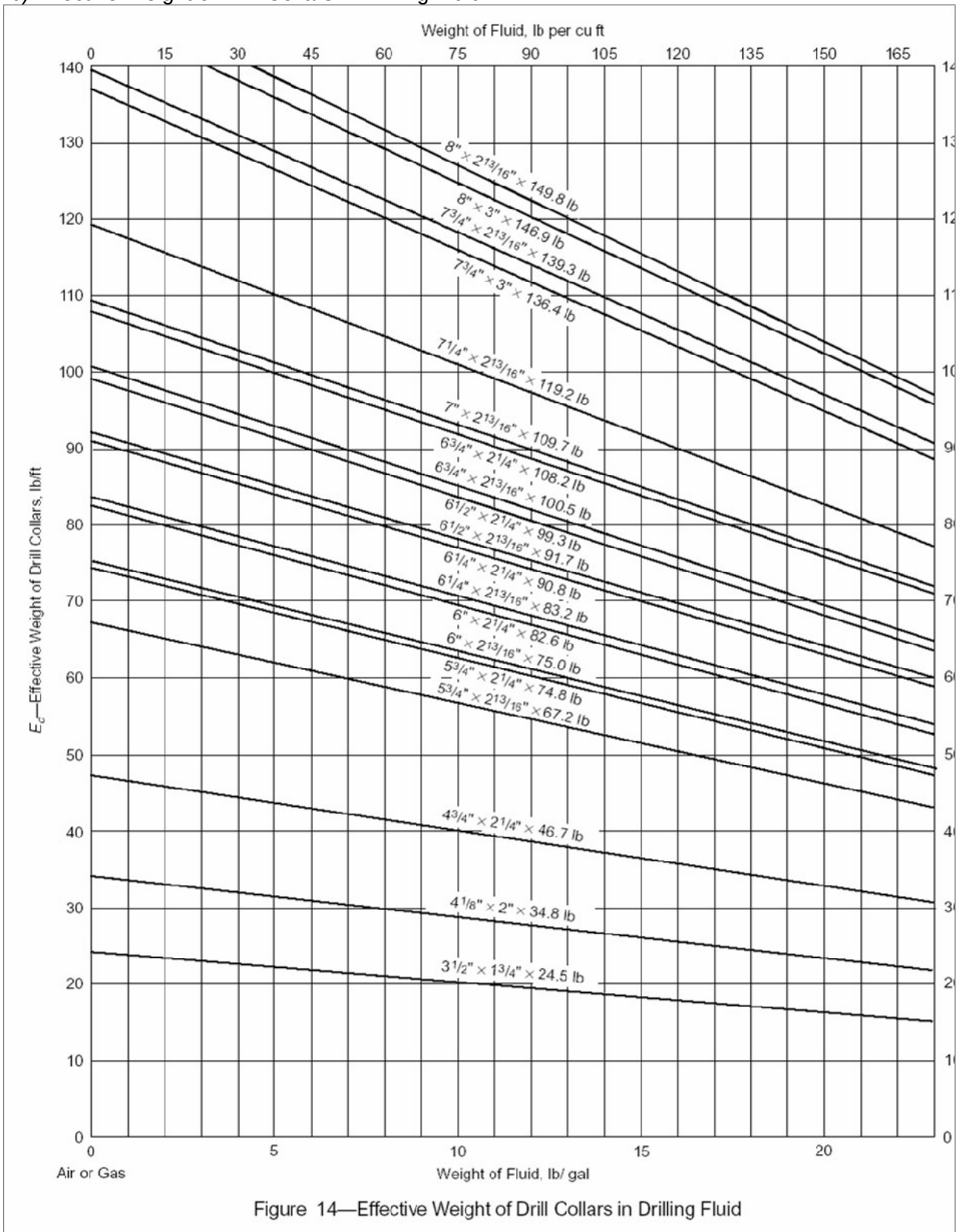
### - CHARTS EXAMPLE

Charts example from which it's possible deduce the unitary weigh of the various tubular of BHA (Bottom Hole Assembly)

a) Effective Weight of Pipe in Drilling Fluid



b) Effective Weight of Drill Collars in Drilling Fluid



## SLIP AND CUT

### - Slip and Cut the drilling line

Every contractor follows a programme, depending on the kind of rig, wire rope, drawwork, etc, to calculate when to slip and cut the drilling line.

| TON-MILE PER FOOT CUT GOAL                  |     |        |        |                         |        |        |
|---------------------------------------------|-----|--------|--------|-------------------------|--------|--------|
| FOR RIGS HAVING NO PAST PERFORMANCE RECORDS |     |        |        |                         |        |        |
| Drum Diameter                               | 1"  | 1-1/8" | 1-1/4" | Rope Diameter<br>1-3/8" | 1-1/2" | 1-5/8" |
| 18"                                         | 6.0 | 9.0    |        |                         |        |        |
| 19"                                         | 6.0 | 9.0    |        |                         |        |        |
| 20"                                         | 7.0 | 9.0    |        |                         |        |        |
| 21"                                         | 7.0 | 10.0   |        |                         |        |        |
| 22"                                         | 7.0 | 10.0   |        |                         |        |        |
| 23"                                         | 8.0 | 10.0   | 13.0   |                         |        |        |
| 24"                                         | 8.0 | 11.0   | 13.0   | 17.0                    |        |        |
| 25"                                         | 8.0 | 11.0   | 14.0   | 17.0                    |        |        |
| 26"                                         | 9.0 | 11.0   | 14.0   | 17.0                    |        |        |
| 27"                                         | 9.0 | 12.0   | 15.0   | 18.0                    |        |        |
| 28"                                         |     | 12.0   | 15.0   | 18.0                    |        |        |
| 29"                                         |     | 12.0   | 15.0   | 18.0                    |        |        |
| 30"                                         |     | 13.0   | 16.0   | 19.0                    |        |        |
| 31"                                         |     |        | 16.0   | 19.0                    |        |        |
| 32"                                         |     |        | 17.0   | 20.0                    |        |        |
| 33"                                         |     |        | 17.0   | 20.0                    |        |        |
| 34"                                         |     |        | 18.0   | 21.0                    | 24.0   |        |
| 35"                                         |     |        |        | 21.0                    | 25.0   |        |
| 36"                                         |     |        |        | 22.0                    | 25.0   | 28.0   |

IADC tool Pusher's manual

### - Recommended Cutoff Lengths

Length of drilling line to be cut following the API RP 9B regulations.

| Table 7—Recommended Cutoff Lengths in Terms of Drum Laps <sup>a</sup><br>See Par. 6.5 |                                |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|---------------------------------------------------------------------------------------|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                                                                                       | 1                              | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  |
|                                                                                       | Drum Diameter, in.             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Derrick or Mast Height, ft                                                            | 11                             | 13  | 14  | 16  | 18  | 20  | 22  | 24  | 26  | 28  | 30  | 32  | 34  | 36  |     |
|                                                                                       | Number of Drum Laps per Cutoff |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 151 Up                                                                                |                                |     |     |     |     |     |     |     |     |     | 15½ | 14½ | 13½ | 12½ | 11½ |
| 141 to 150                                                                            |                                |     |     |     |     |     |     |     | 13½ | 12½ | 11½ | 11½ | 10½ |     |     |
| 133 to 140                                                                            |                                |     |     |     |     | 15½ | 14½ | 12½ | 11½ | 11½ | 10½ | 9½  |     |     |     |
| 120 to 132                                                                            |                                |     |     | 17½ | 15½ | 14½ | 12½ | 12½ | 11½ | 10½ | 9½  | 9½  |     |     |     |
| 91 to 119                                                                             |                                | 19½ | 17½ | 14½ | 12½ | 11½ | 10½ | 9½  | 9½  | 8½  |     |     |     |     |     |
| 73 to 90                                                                              |                                | 17½ | 14½ | 12½ | 11½ |     |     |     |     |     |     |     |     |     |     |
| Up through 72                                                                         | 12½                            | 11½ |     |     |     |     |     |     |     |     |     |     |     |     |     |

<sup>a</sup>To insure a change of the point of crossover on the drum, where wear and crushing are most severe, the laps to be cut off are given in multiples of one-half lap or one quarter lap based on the type of drum grooving.

Table: Recommended Cutoff Lengths



**- Ton miles for 1 " drilling line suggest by IADC**

1. Do not accumulate more than 3700 ton-miles between cuts, even on the first cut of a new line.

2. So long as less than 3700 ton-miles have been accumulated, a cut may be made anytime it is convenient. To determine the length to cut, refer to the above table or calculate so that your "ton-miles per foot cut" is constant (length to cut = T - M since last cut 25.0).

3. This program is based upon a goal of 25.0. Any attempt to improve rope service by increasing the ton-mile goal should not be made until one entire drilling line (requiring no long cuts) has been used following this particular program.

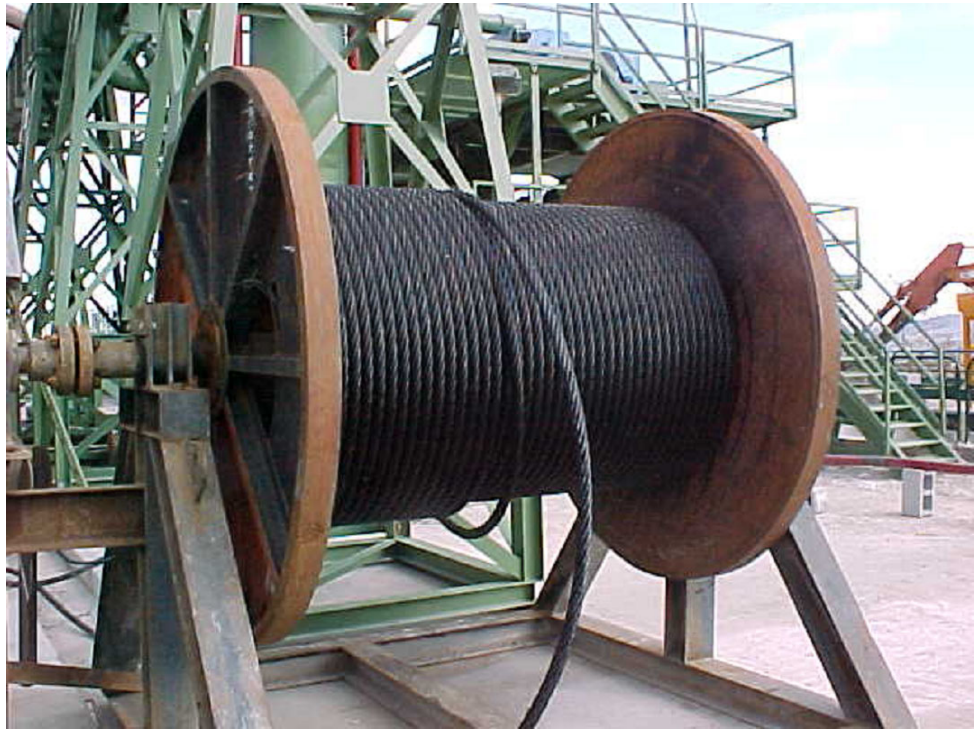
| UNION WIRE ROPE CUT-OFF PROGRAM<br>FOR<br>1-1/2" ROTARY DRILLING LINE                  |                  |                       |                  |
|----------------------------------------------------------------------------------------|------------------|-----------------------|------------------|
| Goal is 25.0 Ton-Miles per Foot Cut<br>Length to Cut = Ton-Miles Since Last Cut ÷ 25.0 |                  |                       |                  |
| T-M Since<br>Last Cut                                                                  | Length<br>To Cut | T-M Since<br>Last Cut | Length<br>To Cut |
| 600                                                                                    | 24               | 2200                  | 88               |
| 700                                                                                    | 28               | 2300                  | 92               |
| 800                                                                                    | 32               | 2400                  | 96               |
| 900                                                                                    | 36               | 2500                  | 100              |
| 1000                                                                                   | 40               | 2600                  | 104              |
| 1100                                                                                   | 44               | 2700                  | 108              |
| 1200                                                                                   | 48               | 2800                  | 112              |
| 1300                                                                                   | 52               | 2900                  | 116              |
| 1400                                                                                   | 56               | 3000                  | 120              |
| 1500                                                                                   | 60               | 3100                  | 124              |
| 1600                                                                                   | 64               | 3200                  | 128              |
| 1700                                                                                   | 68               | 3300                  | 132              |
| 1800                                                                                   | 72               | 3400                  | 136              |
| 1900                                                                                   | 76               | 3500                  | 140              |
| 2000                                                                                   | 80               | 3600                  | 144              |
| 2100                                                                                   | 84               | 3700                  | 148              |

IADC tool Pusher's manual

### **10.7 DRUM**

- Drum size  
Total length of drilling line depends on the drum size.  
Sometimes it's enough to put a new standard drum with the new drilling line.

For some rigs the new drilling line must be passed in the dedicated Rig drum with different dimensions.



## - Service Life

## Relationship Between Rotary-Line Initial Length and Service Life

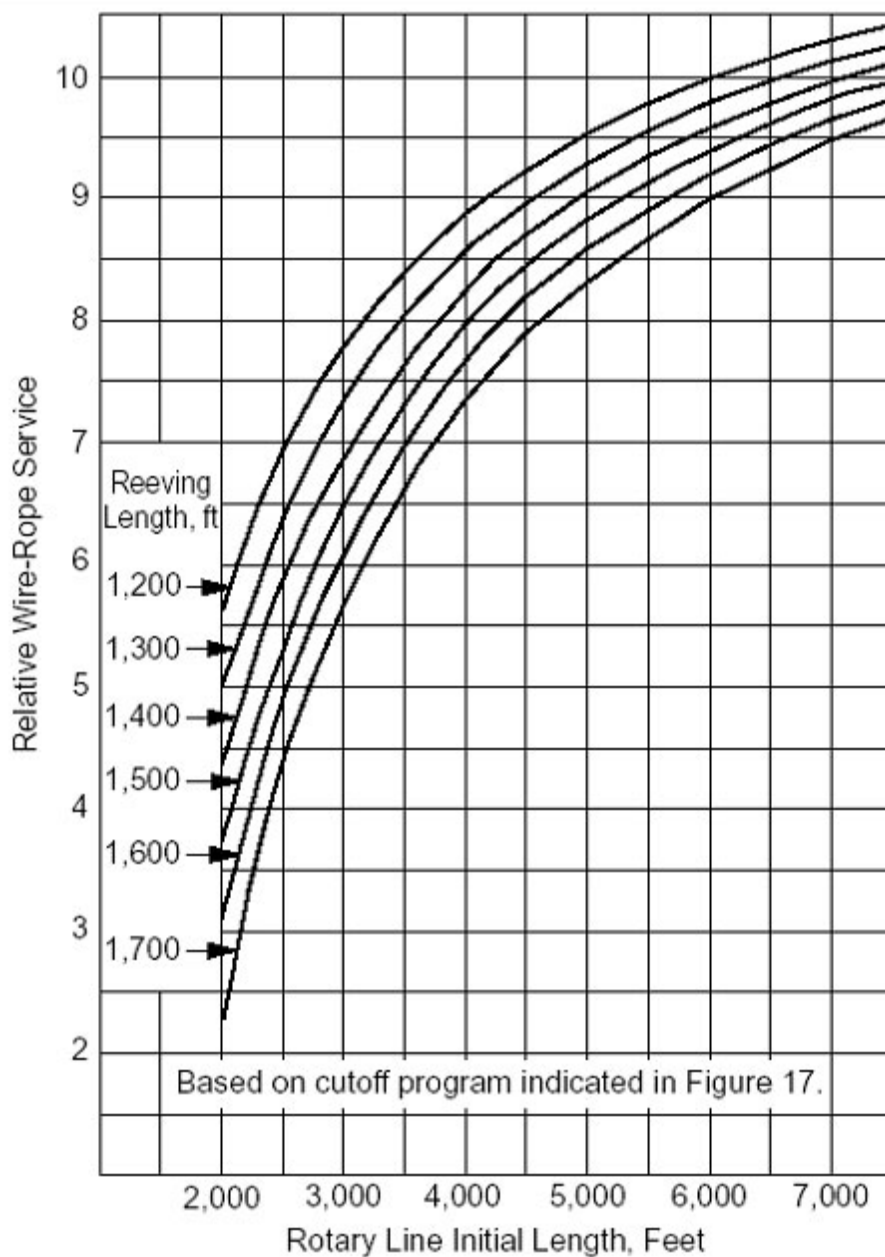


Figure 16—Relationship Between Rotary-Line Initial Length and Service Life<sup>a</sup>

<sup>a</sup>Empirical curves developed from general field experience.

Graph: Rotary-Line Initial Length and Service Life

## 11. POWER GENERATION SYSTEMS

### INDEX

#### 11.1 TYPES OF POWER GENERATORS

- FOR MECHANICAL RIGS
- FOR ELECTRIC RIGS
- ELECTRIC POWER GENERATION
  - DC electric generator
  - AC electric generator
  - Rigs connected to Power Distribution Net

#### 11.1 TYPES OF POWER GENERATORS

- FOR MECHANICAL RIGS
- FOR ELECTRIC RIGS

#### FOR MECHANICAL RIGS

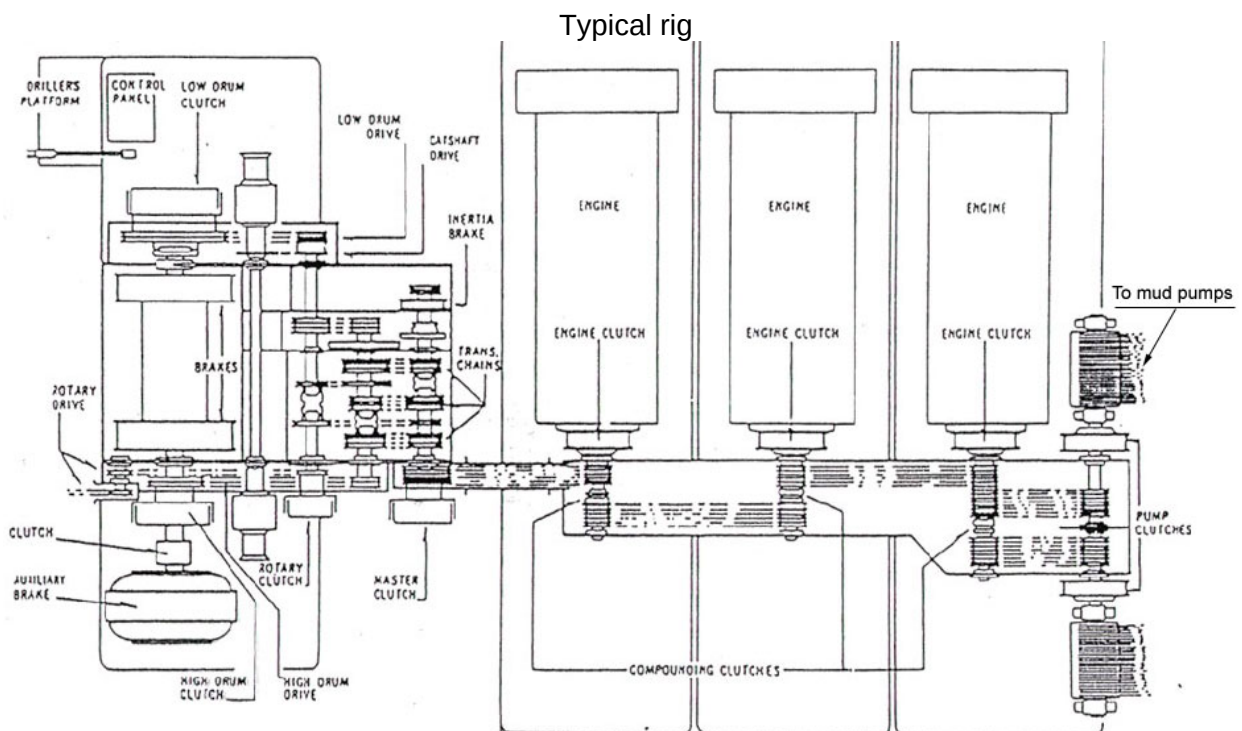
- Diesel engines

Power for mechanical rigs is developed by diesel engines connected directly to the load (drawworks, mud pumps, etc).

Power for the lighting system and small loads (like mud agitators, shakers, etc) comes from a dedicated electric generator.

- Example of a typical rig

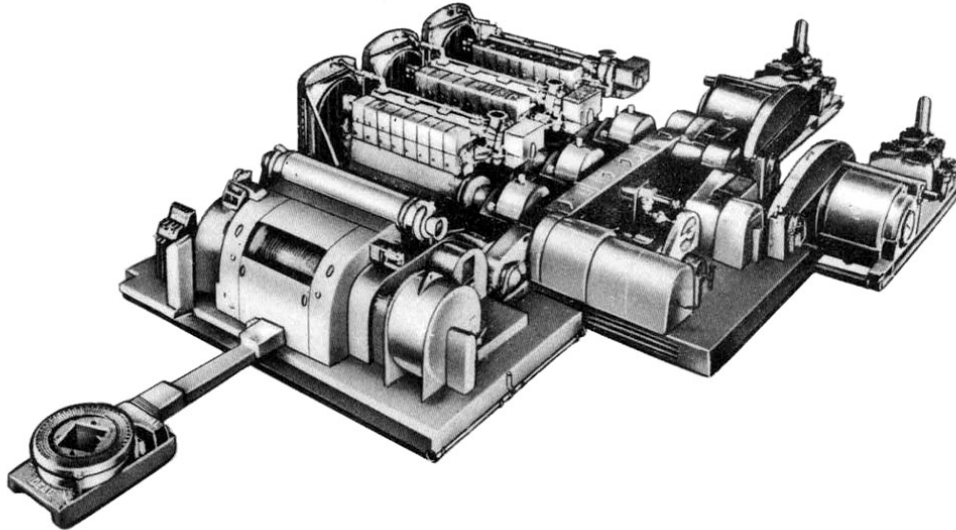
In this example of a typical rig, 3 diesel engines drive the drawworks, pumps and rotary table through a gear transmission system.



- Mechanical rig Lay-Out

Mechanical rig Lay-Out with distribution compound for rotary table, mud pumps and drawworks.

Mechanical Rig Lay Out



- Connection Engine - Drive shaft

There are 2 devices used on a mechanical system to connect the engine and the drive shaft:

- HYDRAULIC COUPLER
- TORQUE CONVERTER

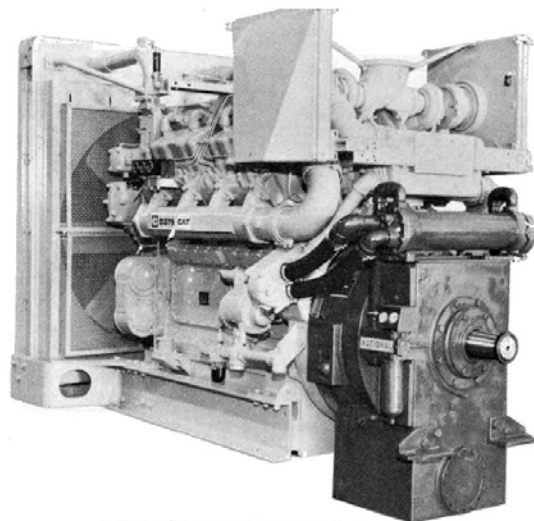
Hydraulic Coupler



Torque Converter

**TYPICAL TORQUE CONVERTER  
ENGINE ARRANGEMENT**

- Engine . . . Cat D379, V8  
(Jacket Water Aftercooling, with Radiator)
- Torque Converter . . . National Series C-245  
(Customer Installed)



The devices are beneficial since they can absorb strains on the system such as those present when starting the engines.

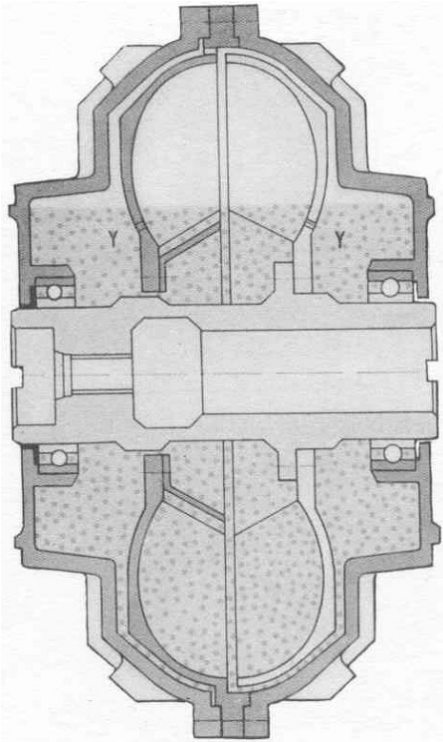
The Hydraulic coupler provides a smooth transfer of power by absorbing mechanical strains.



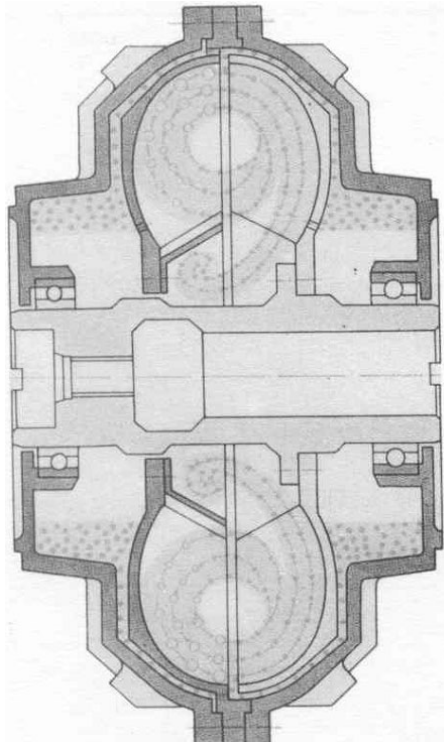
The Torque converter, in addition to functioning as a hydraulic coupler, also operates as a gear shifter by regulating torque variations.

### - Hydraulic Coupler

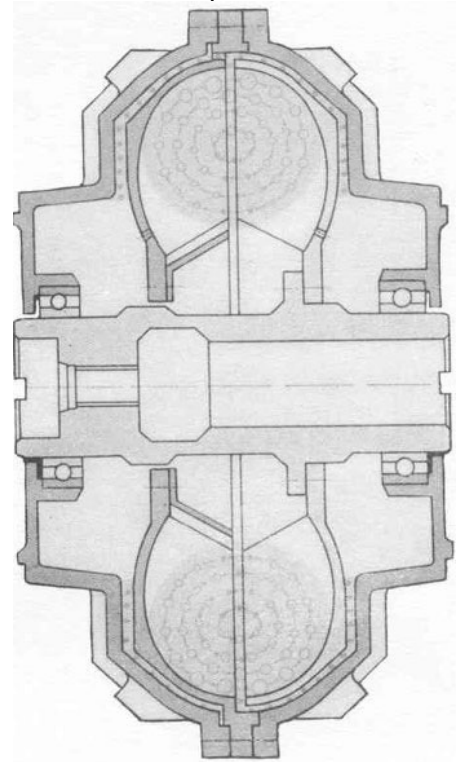
Oil position when the hydraulic coupling has stopped



Oil position when the hydraulic coupling is on starting phase

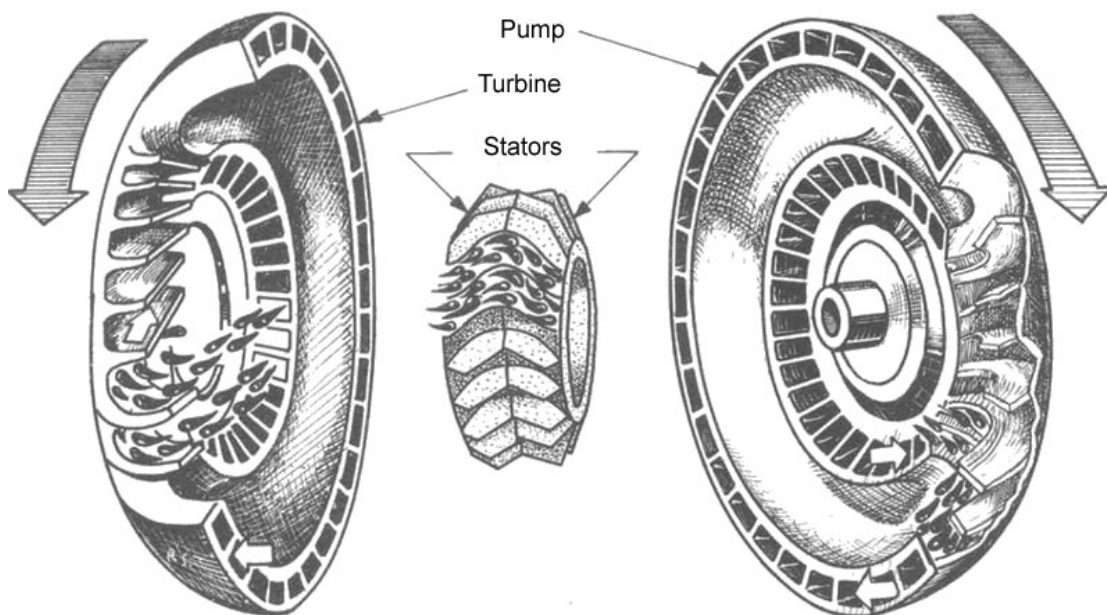


Oil position when the hydraulic coupling has assumed a constant speed

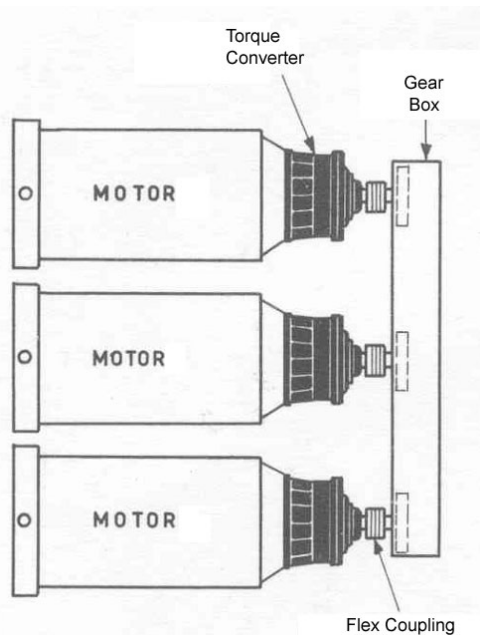


### - Torque Converter

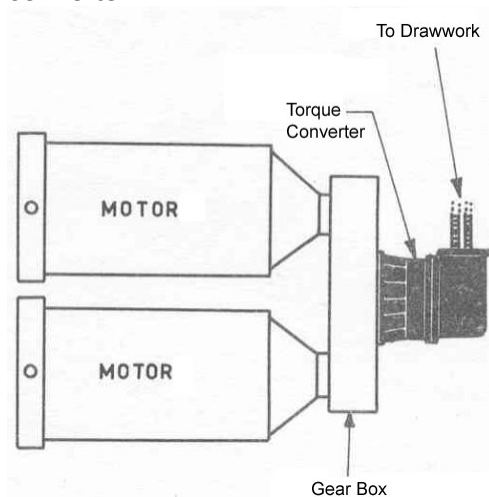
Fluid movement inside the torque converter



Direct connections between motors and torque converter



Indirect connections between motors and torque converter



## FOR ELECTRIC RIGS

### ELECTRIC POWER GENERATION

#### - DC electric generator

##### DC-DC Drives

Ward-Leonard DC-DC drives on drilling rigs usually consist of a diesel engine coupled to a DC generator operating at a constant speed.

The output of the generator is controlled by varying its shunt field excitation.

These systems are dedicated to a single purpose. Any load changes caused by drilling activity are supplied immediately by the motor. The engine and generator rarely interfere with other rig functions.

The engine and DC generator must have adequate capacity to supply full load and accelerating current under all load conditions over the operating speed range.

#### - AC electric generator

##### AC-DC drives

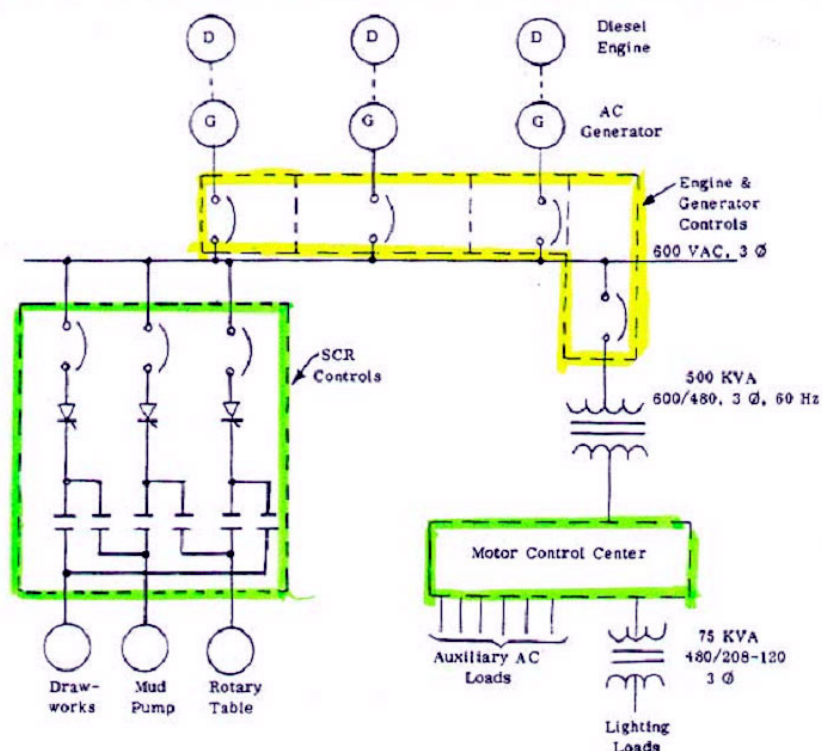
##### - Silicon Controlled Rectifier (SCR)

Ward Leonard DC-DC drives have been replaced lately with a Silicon Controlled Rectifier (SCR) systems. In these systems, AC generator power is converted to DC voltage eliminating the need for a dedicated generator for each drilling function.

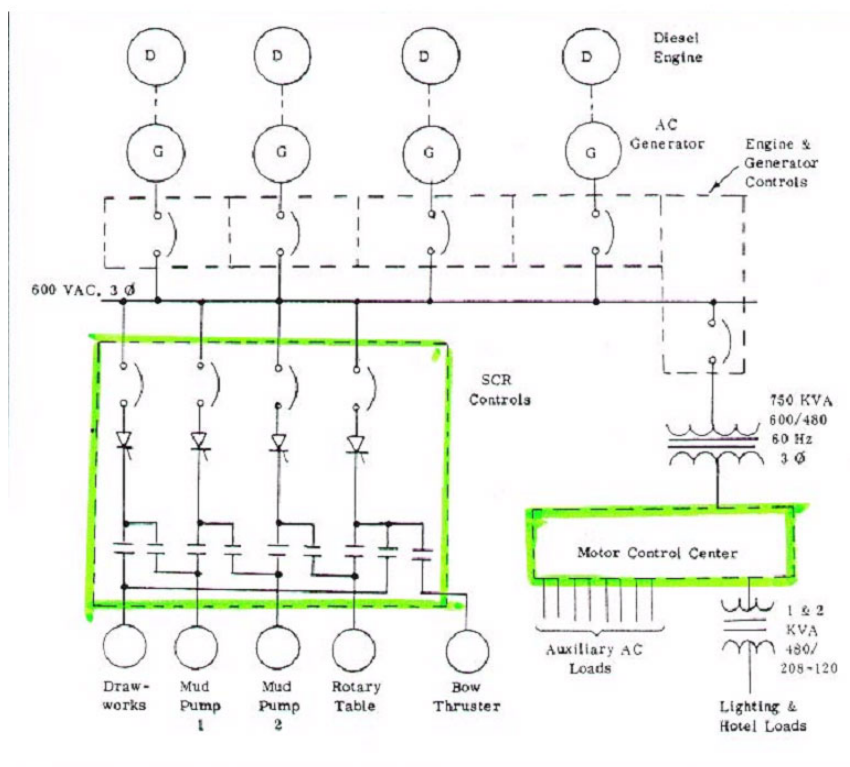
AC loads do not need dedicated generators since they are connected directly to the AC generator.

- Power distribution examples

Typical electrical one-line diagram of a land rig system

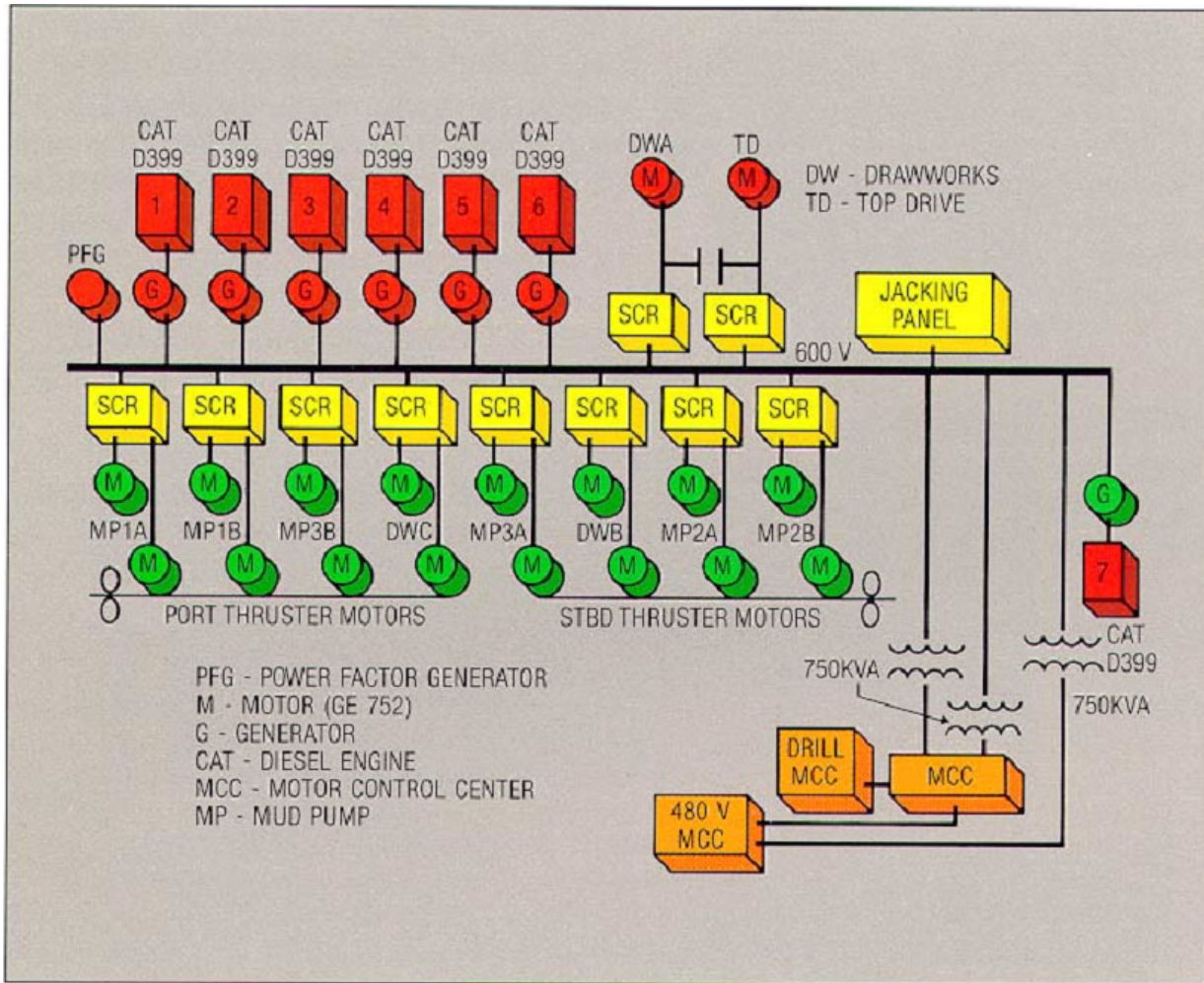


Offshore Rig - Power distribution



Typical electrical one-line diagram of an offshore drilling system.

- Jack Up Power Distribution.



### AC-AC drives

The AC-AC system is the latest generation of power distribution. Generators and all loads (drawwork, pumps, etc) are AC.

- Variable Frequency Drives

Because  $N = f \times 120 / P$

where: f = voltage frequency Hz

P = number of machine poles

N = shaft speed , rpm

Variable Frequency Drives can convert the fixed voltage and frequency into variable voltage and frequency to power AC motors at variable speed.

- Benefits of an AC system

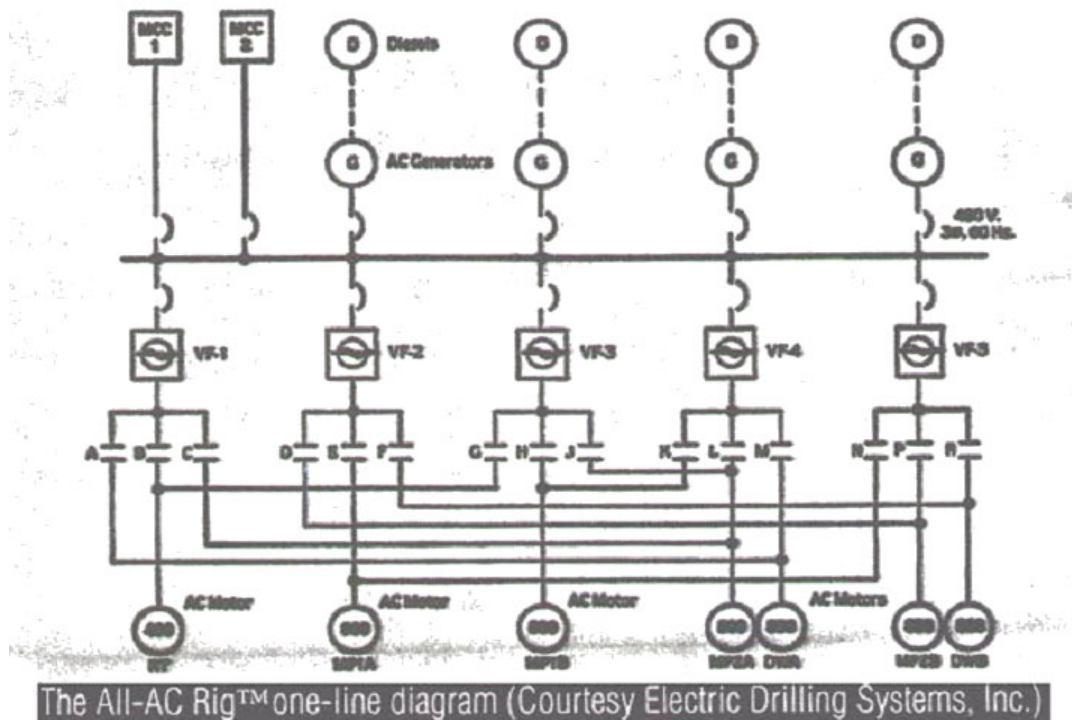
AC motors do not have brushes and therefore create no sparks (beneficial in hazardous areas). Less maintenance.

Can reverse drawworks and rotary table by reversing phase sequence.



Lighter and smaller (GE 752 DC weights 7200 lbs and GEB-AC 6300 lbs).

### AC VARIABLE FREQUENCY DRILLING DRIVE SYSTEM



### - Rigs connected to Power Distribution Net

Power supply at MT for civil and industrial users is 20.000 Volts.

Transformers reduce tension to 600 V.

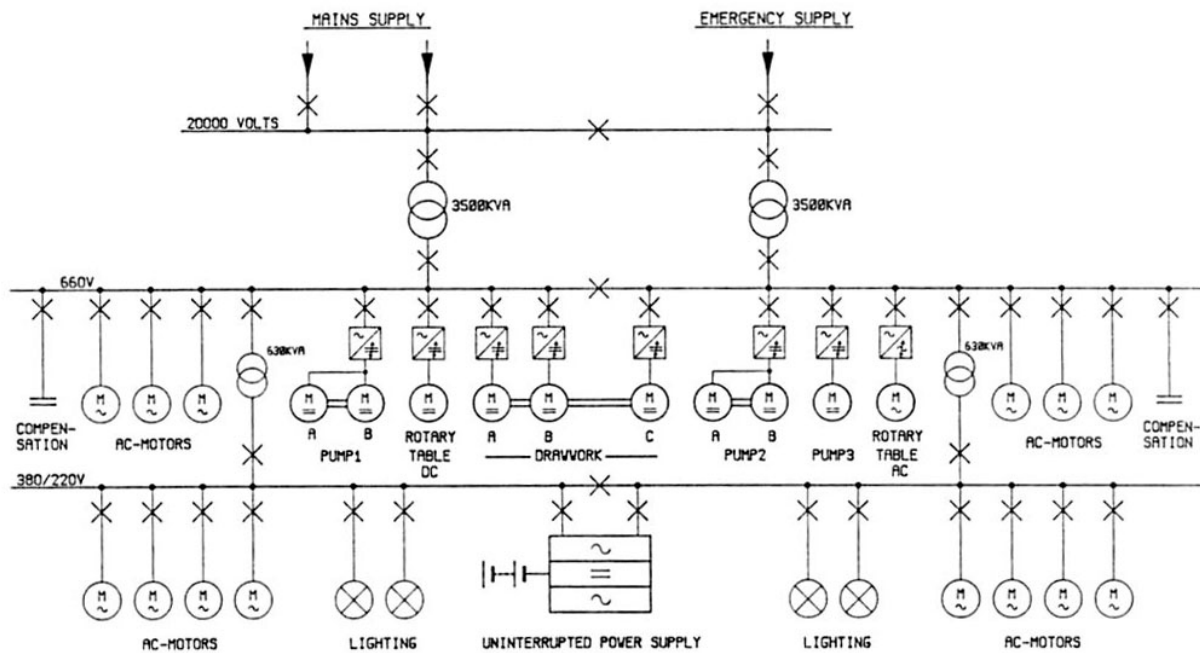
Variable Frequency drivers change frequency from 50Hz to 60Hz if on the rig are installed AC loads manufactured as per American standards.

SCR system supplies DC power to DC loads.

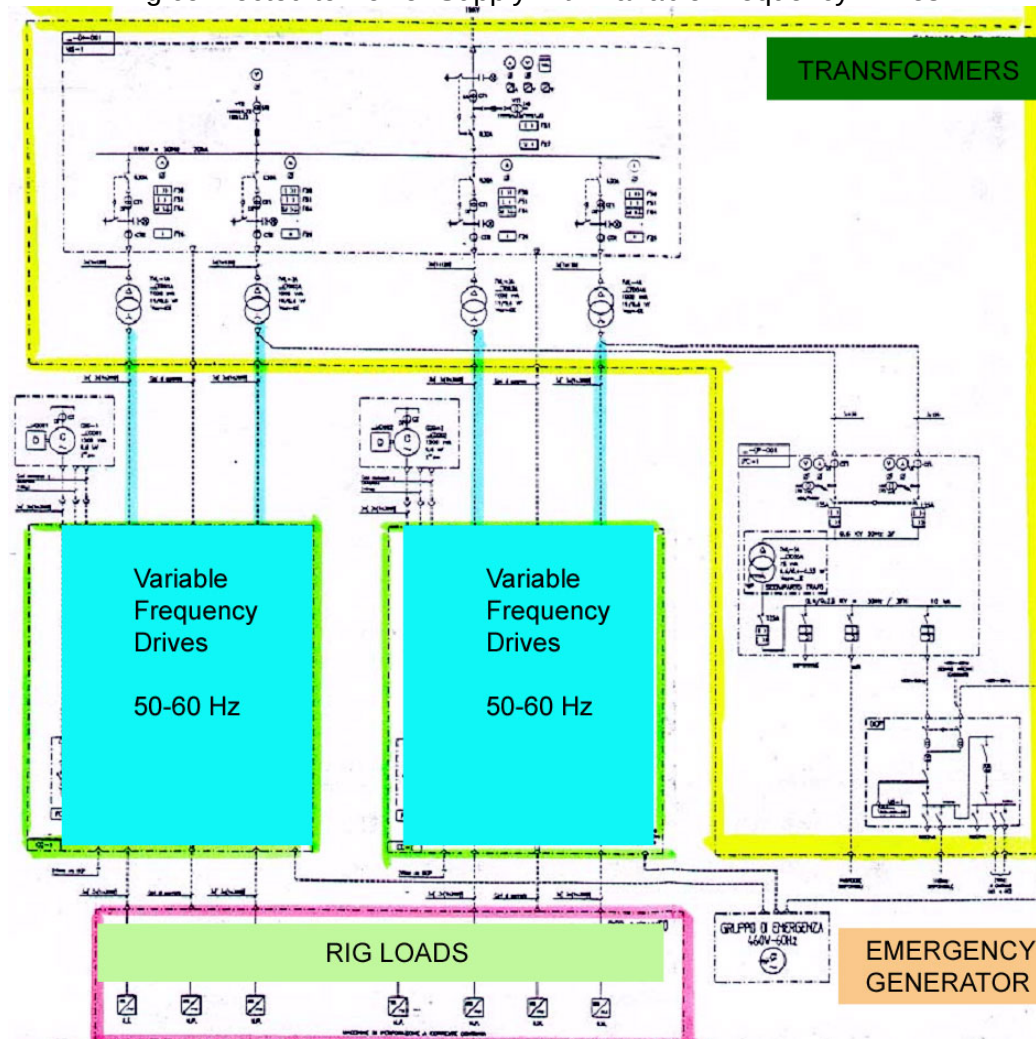
Emergency generator automatically starts in case of Main power supply interruptions



Rig connected to Power Supply



Rig connected to Power Supply with Variable Frequency Drives



- How much electrical power does a rig need ?

#### Classification of Electric Drilling Rigs

| General Classification of Electric Drilling Rigs by Drilling Depth |                     |                                    |                                    |                                       |                              |          |                   |
|--------------------------------------------------------------------|---------------------|------------------------------------|------------------------------------|---------------------------------------|------------------------------|----------|-------------------|
| System type                                                        | Drilling depth (ft) | Drawworks drive HP & total DC mtrs | Mud Pumps drive HP & total DC mtrs | Rotary table drive HP & total DC mtrs | Engine generator system      | SCR bays | Generator control |
| I                                                                  | 0-7500              | 500 HP<br>1 mtr                    | 2-500<br>2 mtrs                    | Mech coupled to DW                    | 2-500 kw                     | 3        | 2                 |
| II                                                                 | 5000-9000           | 700 HP<br>1 mtr                    | 2-500<br>2 mtrs                    | Mech coupled to DW                    | 2-800 kw                     | 3        | 2                 |
| III                                                                | 7000-12,000         | 1000 HP<br>1 mtr                   | 2-1000<br>2 mtrs                   | Mech coupled to DW                    | 3-600 kw<br>or<br>2-1050 kw  | 3        | 2 or 3            |
| IV                                                                 | 10,000-16,000       | 1500 HP<br>2 mtrs                  | 2-1300<br>4 mtrs                   | Mech coupled or 400 HP<br>1 mtr       | 3-1300 kw                    | 4        | 3                 |
| V                                                                  | 12,000-20,000       | 2000 HP<br>2 mtrs                  | 2-1600<br>4 mtrs                   | 400 HP<br>1 mtr                       | 4-1300 kw                    | 4        | 4                 |
| VI                                                                 | 15,000-30,000       | 3000 HP<br>3 mtrs                  | 3-1600<br>6 mtrs                   | 400 HP<br>1 mtr                       | 4-2000 kw<br>or<br>5-1500 kw | 6        | 4 or 5            |

## **12. DIESEL ELECTRIC POWER GENERATION SYSTEM**

### **INDEX**

- 12.1 DIESEL ENGINES
- 12.2 POWER GENERATORS
  - DC GENERATORS
  - AC GENERATORS
- 12.3 DC ENGINES
- 12.4 AC ENGINES
- 12.5 ENGINE CONTROLS
  - Current Control Panel
  - Driller Control Panel
- 12.6 SCR SYSTEM

### **12.1 DIESEL ENGINES**

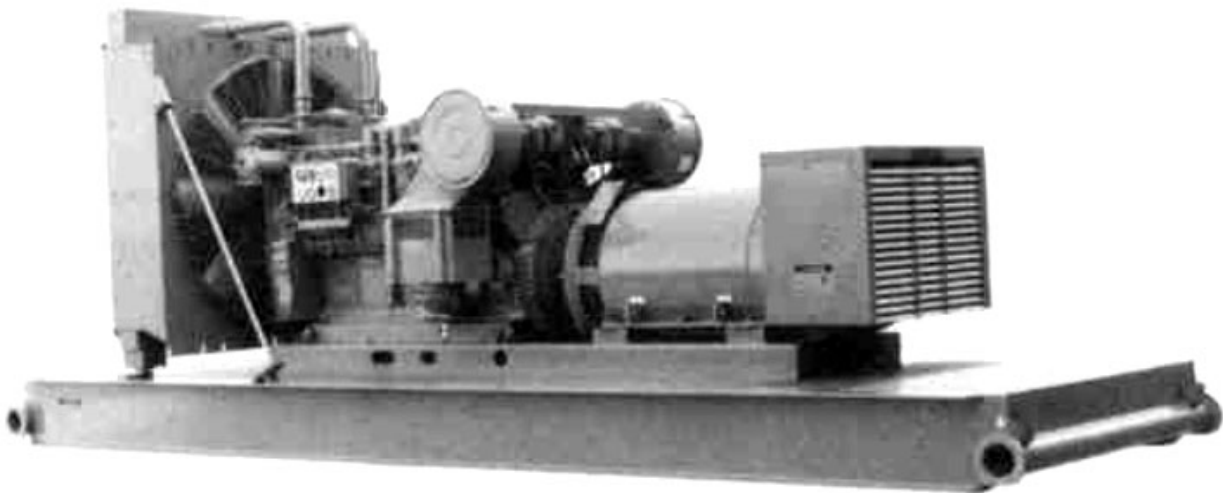
#### **- Characteristics**

Diesel engines are characterized by their low speed of operation, limited speed range, relatively low maintenance and general availability.

The selection of diesel engines to drive electric generators is obvious because their similar operating speeds allow direct coupling, the torque and horsepower of both are compatible, and control of engine-generator speeds allows relatively easy control of generator output power.

Fuel is usually diesel but also methane could be used.

Diesel Engines



#### **- Caterpillar Engines**

Caterpillar engines are the most commonly used engines because of their reliable operation. Some rigs today still use D-399 TA engines, even though they are no longer being produced.

Performance  
COMPARISON TABLE OF DIESEL GENERATORS

SERIE 379 - 398 - 399

SERIE 3500B

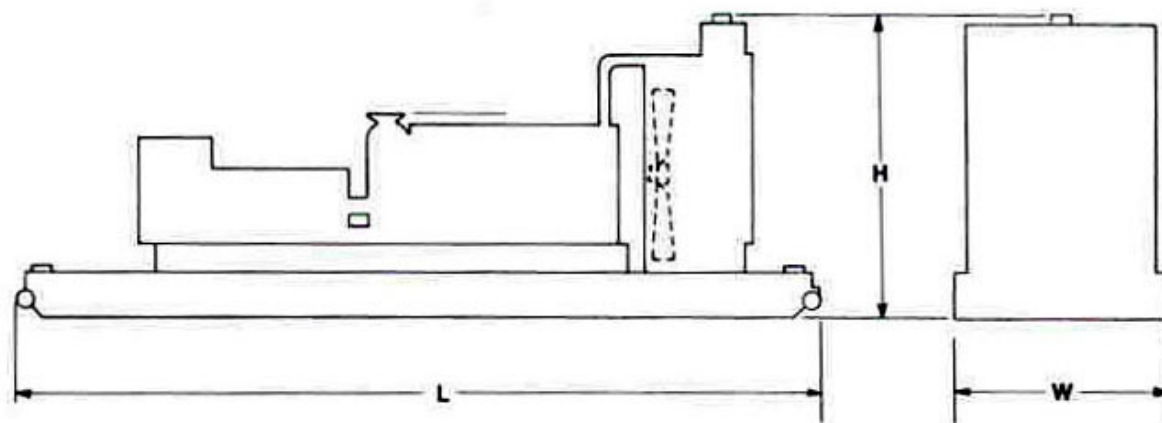
| MODELS                    | N° of Cylinder | Displacement | RPM  | POWER   | Fuel consum. 100% Load | Fuel consum. 75% Load | Fuel consum. 50% Load |
|---------------------------|----------------|--------------|------|---------|------------------------|-----------------------|-----------------------|
| D379 PC TA                | 8 - V          | 32,2 l       | 1200 | 455 kW  | 249 g/bkW*h            | 248 g/bkW*h           | 252 g/bkW*h           |
| 3508B DI TA (Elettronico) | 8 - V          | 34,5 l       | 1200 | 682 kW  | 207 g/bkW*h            | 205 g/bkW*h           | 208 g/bkW*h           |
| D398 PC TA                | 12 - V         | 48,3 l       | 1200 | 680 kW  | 236 g/bkW*h            | 234 g/bkW*h           | 241 g/bkW*h           |
| 3512B DI TA (Elettronico) | 12 - V         | 51,8 l       | 1200 | 1100 kW | 206 g/bkW*h            | 203 g/bkW*h           | 208 g/bkW*h           |
| D399 PC TA                | 16 - V         | 64,4 l       | 1200 | 906 kW  | 234 g/bkW*h            | 229 g/bkW*h           | 240 g/bkW*h           |
| 3516B DI TA (Elettronico) | 16 - V         | 69 l         | 1200 | 1383 kW | 207 g/bkW*h            | 202 g/bkW*h           | 207 g/bkW*h           |

Abbreviations:

PC: Pre Chamber  
DI: Direct Injection  
TA: Turbo Aftercooled

Consumption tolerance + 5%

Dimension Data

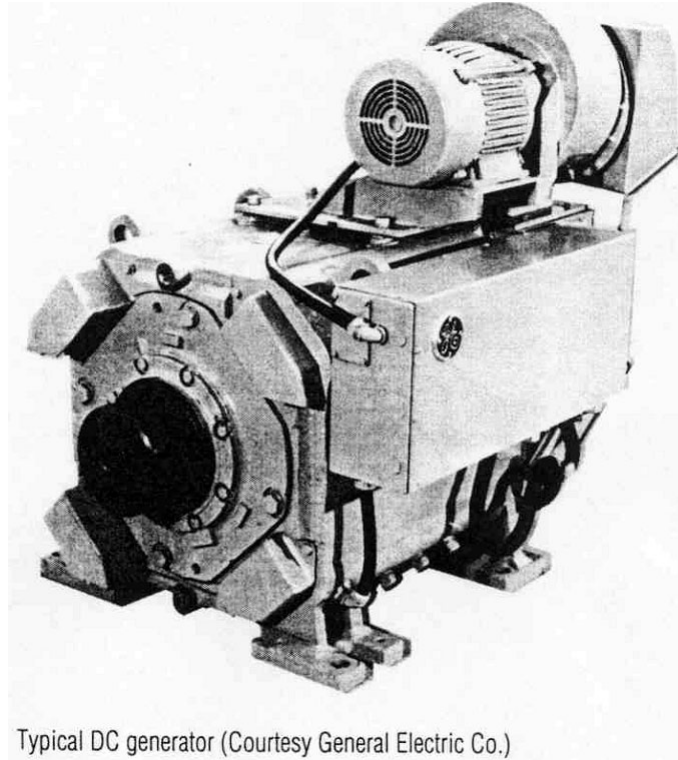


| Model | <b>Bases Available</b> | <b>W</b>  |         | <b>H</b>  |         | <b>Approx. Weight With Base</b> |          |
|-------|------------------------|-----------|---------|-----------|---------|---------------------------------|----------|
|       | 7.85 m<br>25' 9"       | With Base | mm (in) | With Base | mm (in) | kg                              | (lb)     |
| D379* | x                      | 2390      | (94)    | 3048      | (120)   | 12 020                          | (26,500) |
| 3508* | x                      | 2390      | (94)    | 3048      | (120)   | 13 155                          | (29,000) |
| D398* | x                      | 2390      | (94)    | 3048      | (120)   | 14 155                          | (31,210) |
| 3512* | x                      | 2390      | (94)    | 3048      | (120)   | 15 875                          | (35,000) |
| D399* | x                      | 2390      | (94)    | 3048      | (120)   | 16 645                          | (36,700) |
| 3516* | x                      | 2390      | (94)    | 3048      | (120)   | 18 600                          | (41,000) |
| 3606  | 10 m<br>(33')          | 2390      | (94)    | 3250      | (128)   | 33 115                          | (73,000) |

\*9.37 m (30' 9"), 12.4 m (40' 9") bases also available.

## 12.2 POWER GENERATORS

### - DC GENERATORS



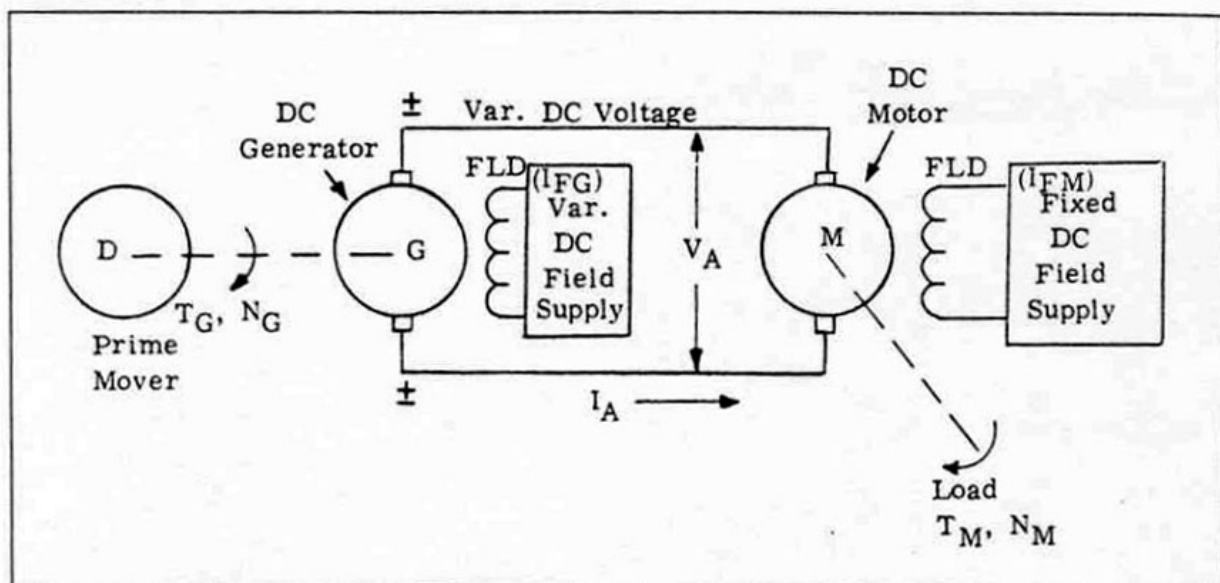
Typical DC generator (Courtesy General Electric Co.)

#### - Characteristics

DC generator are very similar to a DC motor, different only in their winding and commutator.

#### - Speed Control System

Diesel engines coupled to a DC generator work at constant speed. Generator output power is regulated by changing the current field.



DC/DC speed control system (Ward-Leonard System)



- Speed and Torque of DC motor

1. Torque load imposed on the diesel engine shaft by the DC generator

$$T_G = K_G I_{FG} I_A$$

where

$K_G$  = DC Generator machine constant

$I_{FG}$  = DC Generator field current, amperes

$I_A$  = DC Generator/DC motor armature current, amp

2. Armature voltage applied to DC motor terminals

$$V_A = E - I_A R_{AG} - V_{BG} \quad \text{volts DC}$$

where

$E$  = Generated DC voltage

$R_{AG}$  = DC Generator armature resistance, ohms

$V_{BG}$  = DC Generator brush drops, volts

3. Speed of DC motor

$$N_M = \frac{V_A - I_A R_{AM} - V_{BM}}{I_{FM}} K_{M'} \quad \text{rpm}$$

where

$R_{AM}$  = DC motor armature resistance, ohms

$V_{BM}$  = DC motor brush drop, volts

$I_{FM}$  = DC motor field current, amperes

$K_{M'}$  = motor constant

4. Torque developed by DC motor

$$T_M = K_M I_{FM} I_A \quad \text{ft-lb}$$

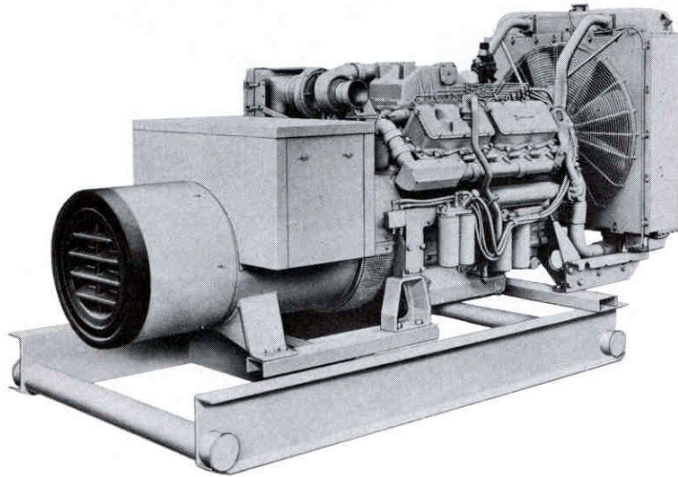
where

$K_M$  = DC motor constant

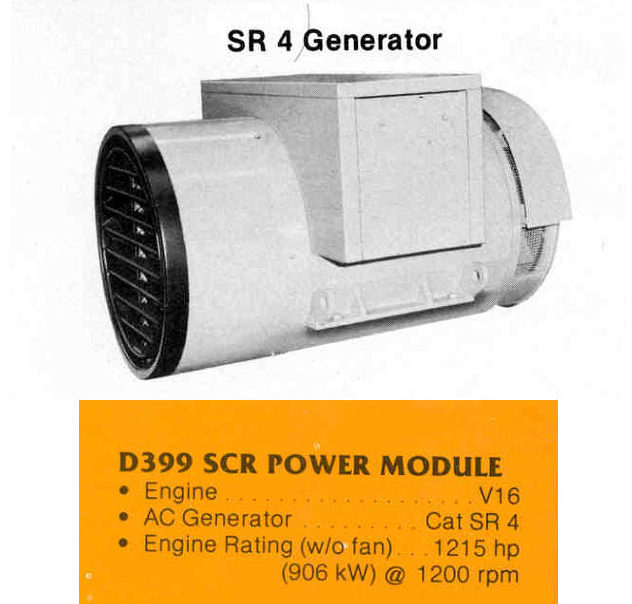
## - AC GENERATORS

Generators used on drilling rigs are generally synchronous three phase 600 V.

Typical DC Generator



- Example (SR4 Generator)



- Example (SR4 Generator)

It is essential to have a properly designed base for diesel electric power modules used on drilling rigs.

Misalignment between engine and generator can cause vibration and shorten the life of couplings and bearings. Caterpillar has designed a base which provides a build-in three-point mounting system.

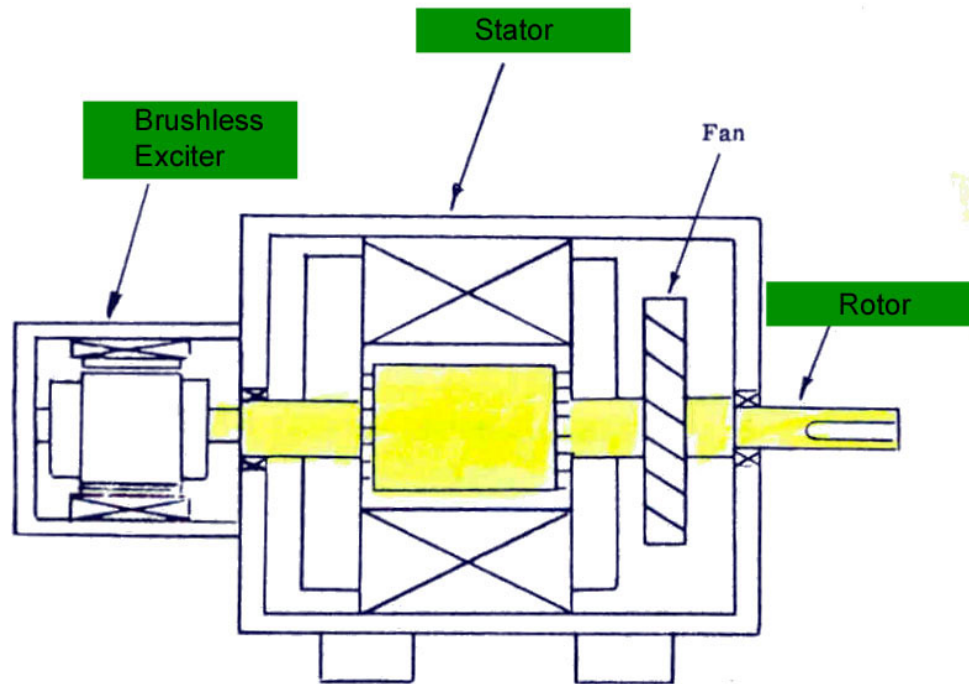
The engine and generator are mounted by Caterpillar on this base and aligned to exacting tolerances at the factory. These power modules will maintain alignment during most rig moves.

- Components

The AC generator consists of:

- Rotor
- Stator
- Field Excitation

The poles are on the rotor.



Sectional view of synchronous generator with brushless exciter

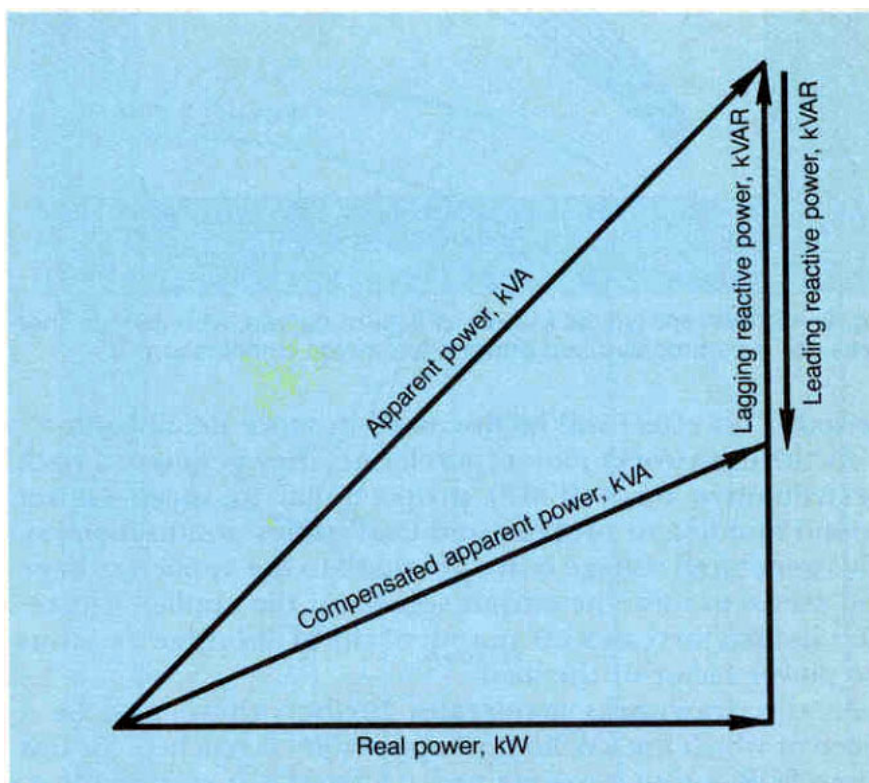
- Frequency
- Frequency (Hz) depends on the number of poles and Rotor speed

$$\text{Hz} = \frac{PN}{120}$$

P = number of poles  
N = rotor speed (rpm)

- Apparent Power and Real power

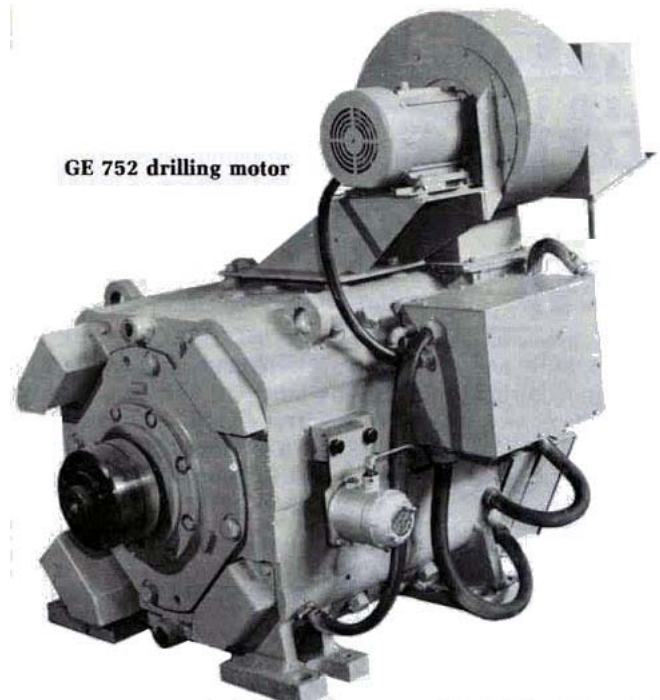
Vector diagram demonstrates the effect of power factor correction. The kVA burden of the generators is lessened by adding leading kVARs, which in turn allows the system to perform up to its full kW potential.



| APPARENT POWER = (Kva):                                    | REACTIVE POWER = (Kvar):                         | REAL POWER = (Kw)                                                              |
|------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------------------|
| $Kva = \frac{V_l \times I_l \times \sqrt{3}}{1000}$        | $Kvar = Kva \times \sin \Phi$                    | $Kw = Kva \times \cos \Phi$                                                    |
| where $V_l$ = line voltage (V)<br>$I_l$ = line current (A) | where $\Phi$ = angle between current and voltage | where $\Phi$ = angle between current and voltage<br>$\cos \Phi$ = power factor |

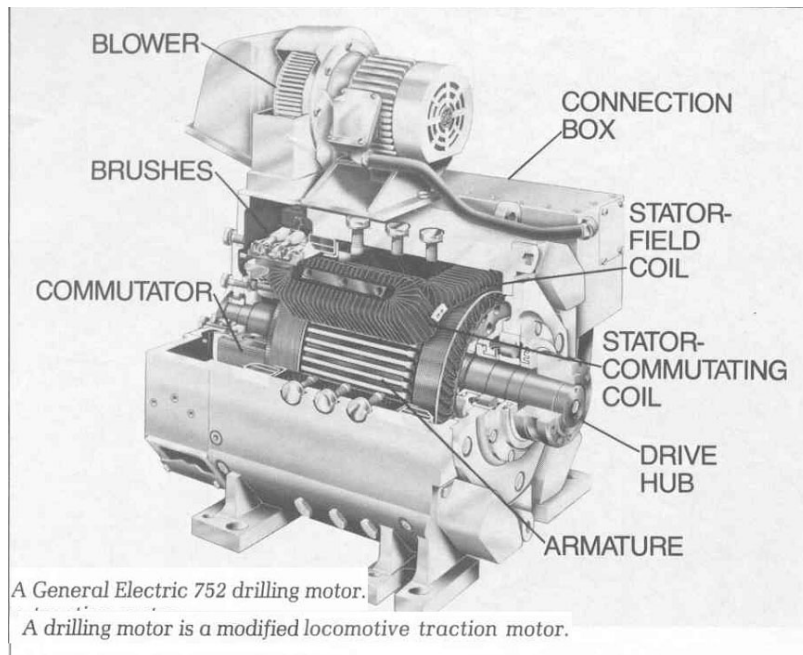
### 12.3 DC ENGINES

DC motors are commonly used in the oilfield because of their flexibility to control RPM and torque.



#### - Components and Models

Manufacturers (mainly GE) produce models at 600, 800, 1000, 1200 HP with maximum speed of 1000 and 1200 RPM.



*Drilling Motor GE-752 components*

#### - Use

Dc motors are mainly used for the:  
DRAWWORK, MUD PUMPS, ROTARY TABLE and TOP DRIVE.

On Offshore rigs they are also used for the:  
PROPELLERS, ANCHOR CHAIN WINCHES, CEMENT UNIT and JACKING CONTROLS.

These motors develop a lot of heat. Cooling is achieved with air coming from a non-hazardous area.



## - Types: SHUNT and SERIES

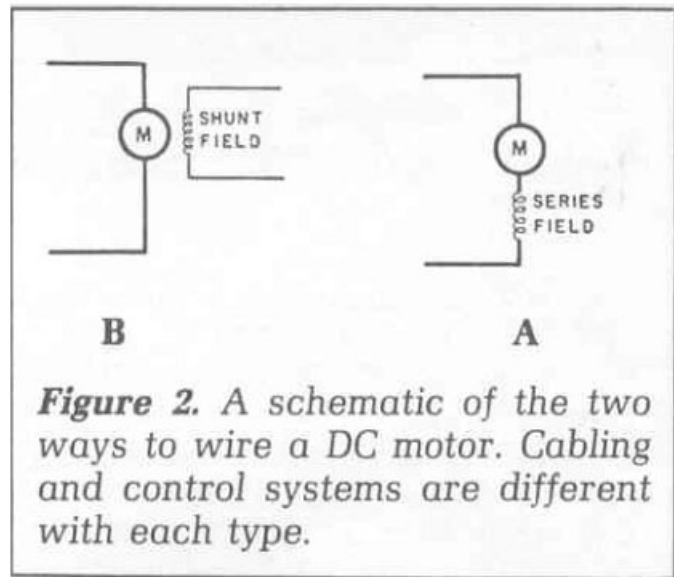
There are 2 main types of DC motors:

SHUNT and SERIES

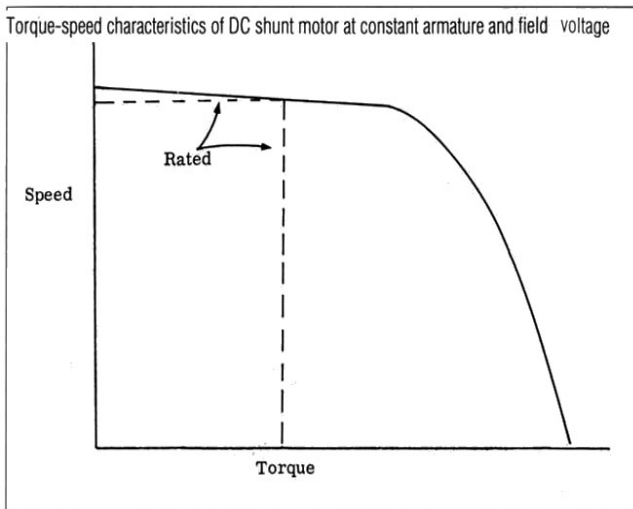
The final selection between them is mainly economical.

- Torque-speed of DC Shunt Motor
- Torque-speed of Series Motor

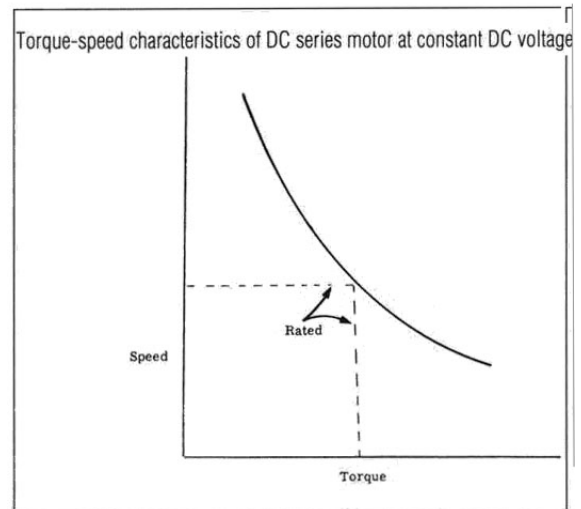
DC motors in series often go into overspeed at light loads.



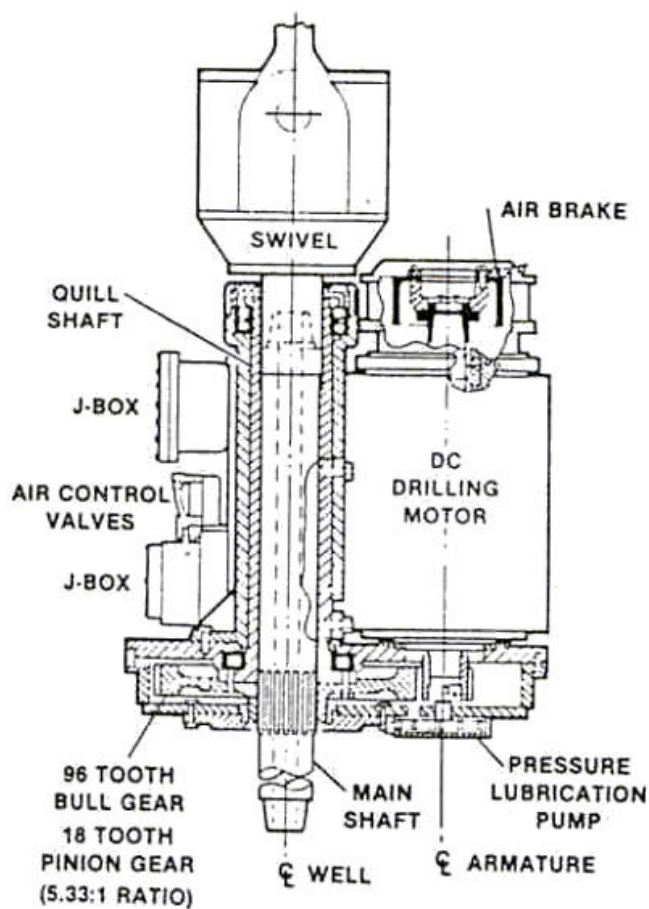
Torque-speed of DC Shunt Motor



Torque-speed of Series Motor



## Example of Top Drive Dc Motors



## Top Drive DC motor Characteristics

### OUTPUT CHARACTERISTICS

MOTOR HORSEPOWER: 1100 HP continuous.

GEAR RATIO: 6.00:1

| <u>CURRENT (AMPS)</u> |            | <u>DRILLING TORQUE</u> | <u>RPM</u> |
|-----------------------|------------|------------------------|------------|
| <u>FIELD</u>          | <u>ARM</u> | <u>(FT-LBS)</u>        |            |
| 57                    | 1450**     | 38,700                 | ----       |
| 57                    | 1250       | 33,700                 | 145        |
| 57                    | 1100       | 29,600                 | 175        |
| 40                    | 890        | 21,200                 | 200        |
| 30                    | 780        | 16,300                 | 230        |

**Part No.**

Complete as above

\* GE 752 Hi Torque Drilling Motors are manufacturer rated at 1100 HP per IEEE standards.

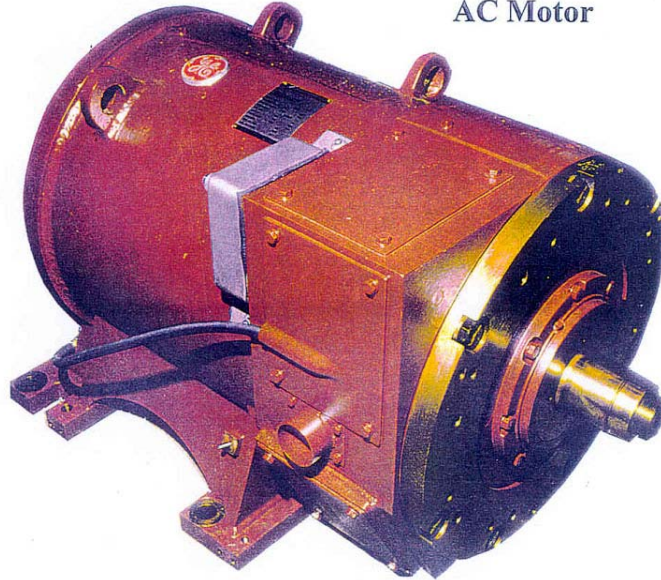
\*\* Intermittent use only. Requires High Capacity DC Contractors in Control System.

## 12.4 AC ENGINES

### - AC motors

AC motors are replacing DC motors due to the Variable Frequency Drives technology.

**GEB-20**  
1,150 Horsepower  
AC Motor

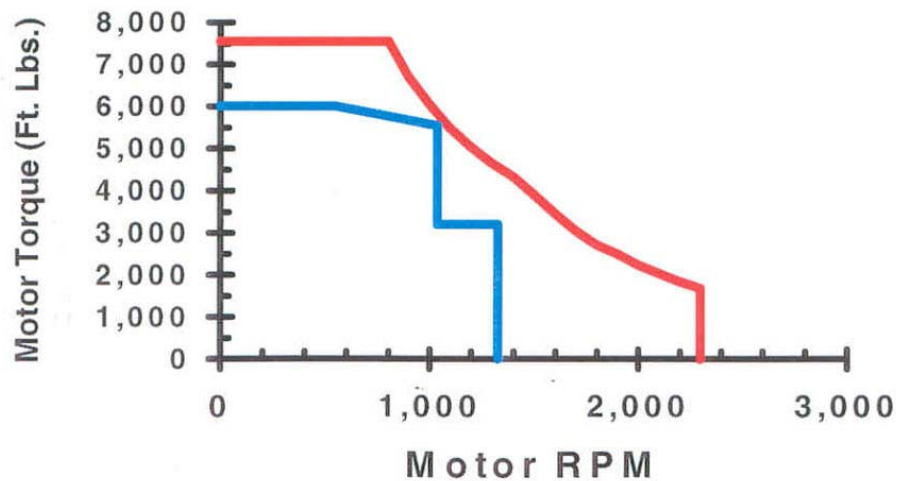


### - Advantages of AC Motors over DC Motors

AC motors:

- do not have any brushes and therefore do not produce sparks (critical in hazardous area)
- require less maintenance
- enable the drawworks and rotary table to be reversed by reversing the phase sequence.
- are lighter and smaller
- can operate at twice the speed

DC Vs. AC Motor Performance



## 12.5 ENGINE CONTROLS

### - Current Control Panel

The functions of the power Control Unit include:

- CONTROL
- PROTECTION
- MEASUREMENT OF ELECTRICAL PARAMETERS

### - Control function

#### Voltage regulator:

Output tension is monitored and regulated. When two or more generators are in parallel, the voltage regulators sense voltage and current to maintain equal voltages and minimize circulating current between generators.

#### Speed regulator:

Regulates engine speed by adjusting the fuel flow. As the load increases, the speed momentarily decreases, creating a speed "error" in the governor. This error causes the fuel rack to adjust for more engine fuel and return to the original speed.

#### Synchronizer :

Allows the generators to work in parallel at the same phase sequence, frequency and voltage.

### - Protection function

#### Circuit Breaker:

Protection against short circuits and overloads.

#### Reverse Power Protection:

Prevents current for circulating between generators.

#### Power Limit:

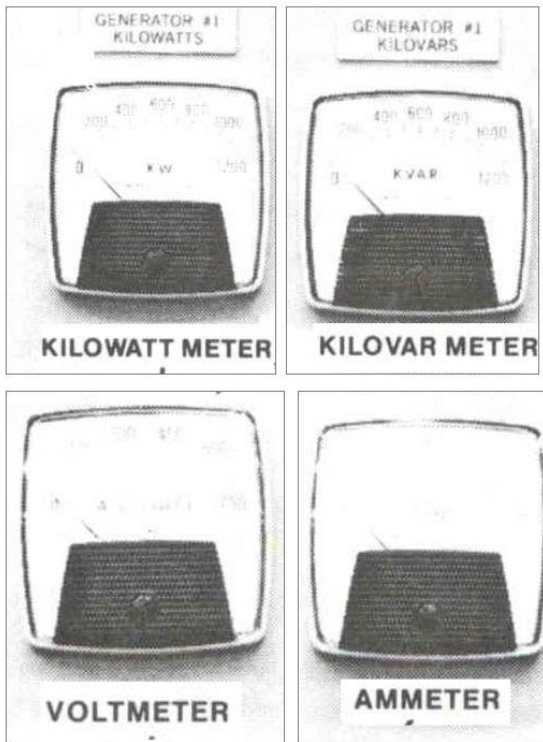
Prevents engine generator overload. Total power delivered from AC bus is monitored electronically and compared to the capacity available.

#### Ground Fault Detection:

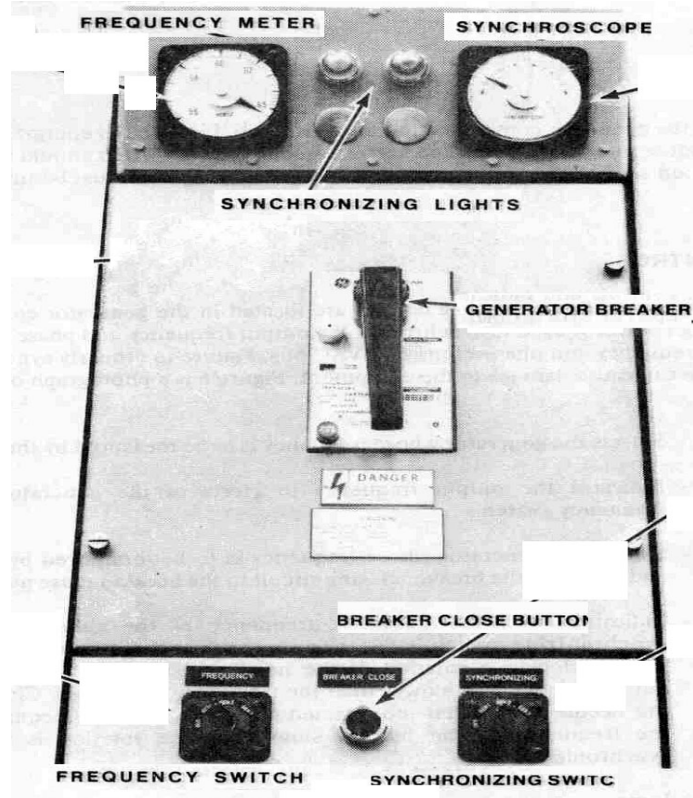
Monitors whether electrical machines and cables are connected to the ground.

- Electric parameters measurements

Panel - Meters

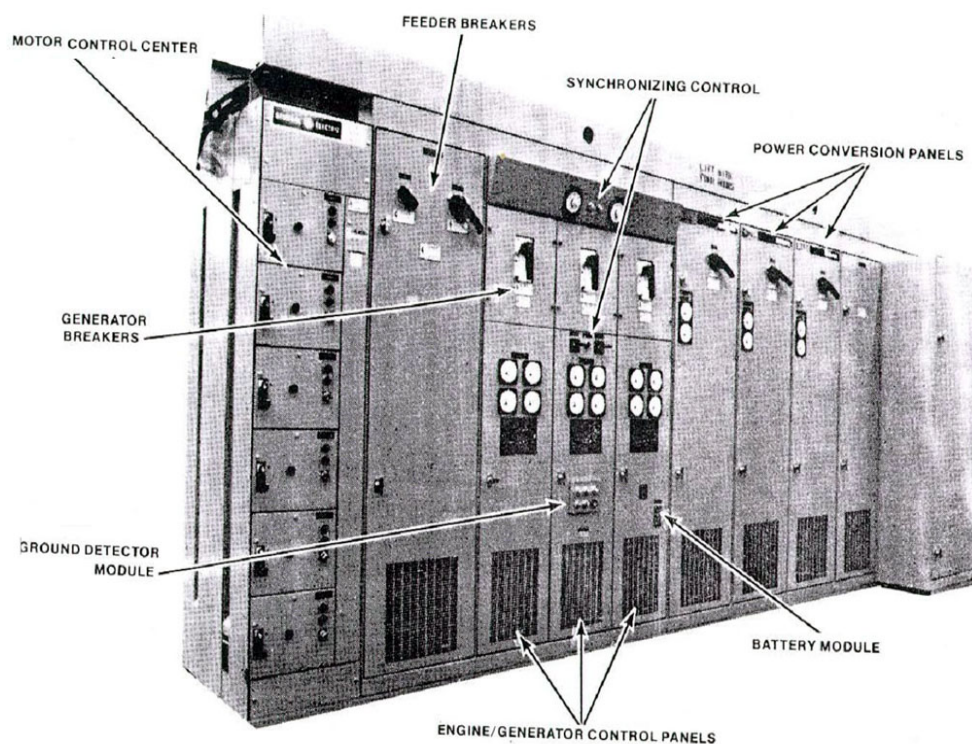


Breakers and Switch



Components

- motor control center
- feeder breakers
- generator breakers
- synchronizing control
- power conversion panels
- engine control panel
- ground detection module



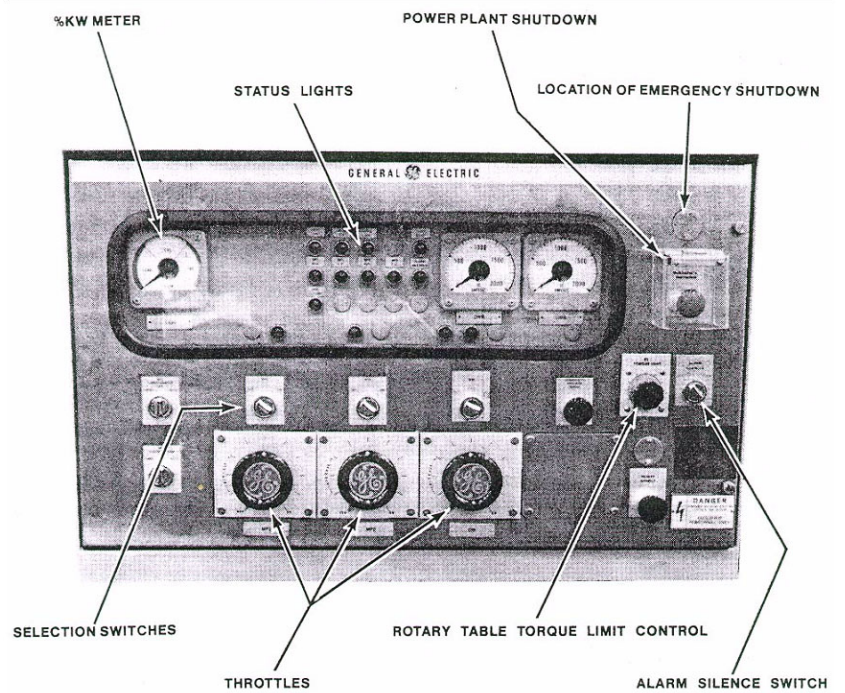


- Driller Control Panel

- Driller Control Panel



- Indicators and Switch

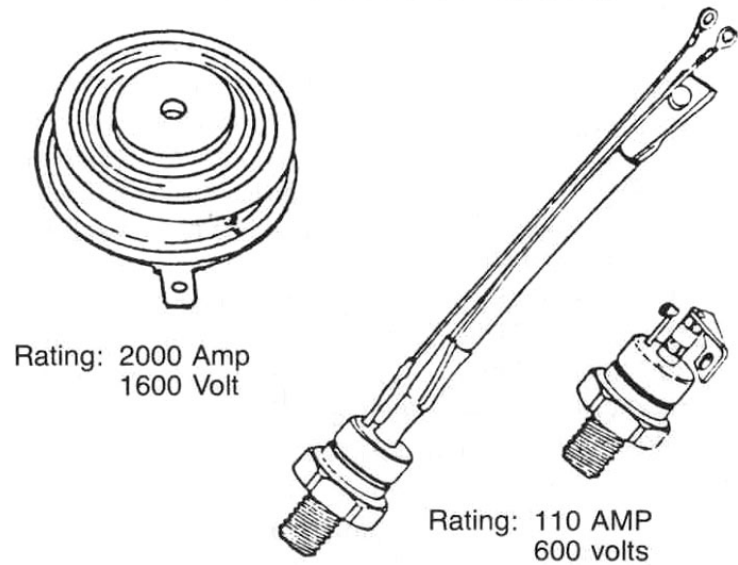


## 12.6 SCR SYSTEM

### - SCR (Silicon-Controlled Rectifier)

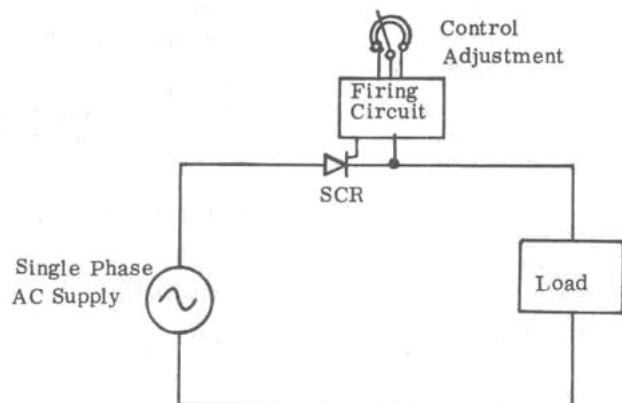
Semiconductors SCR (Silicon-Controlled Rectifier) convert AC power in to DC power.

Power SCRs used in the drilling industry

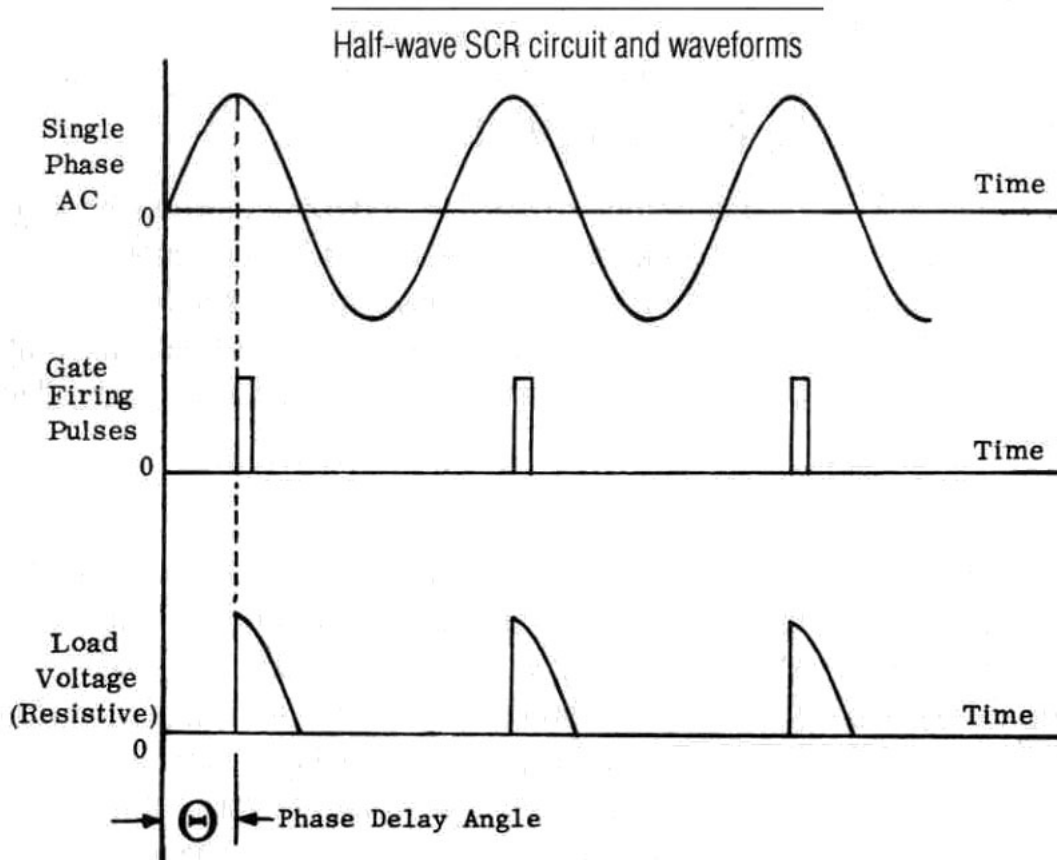


### - SCR Circuit

An SCR is a rectifier, it blocks power in its reverse direction and allows power to conduct in the forward direction.



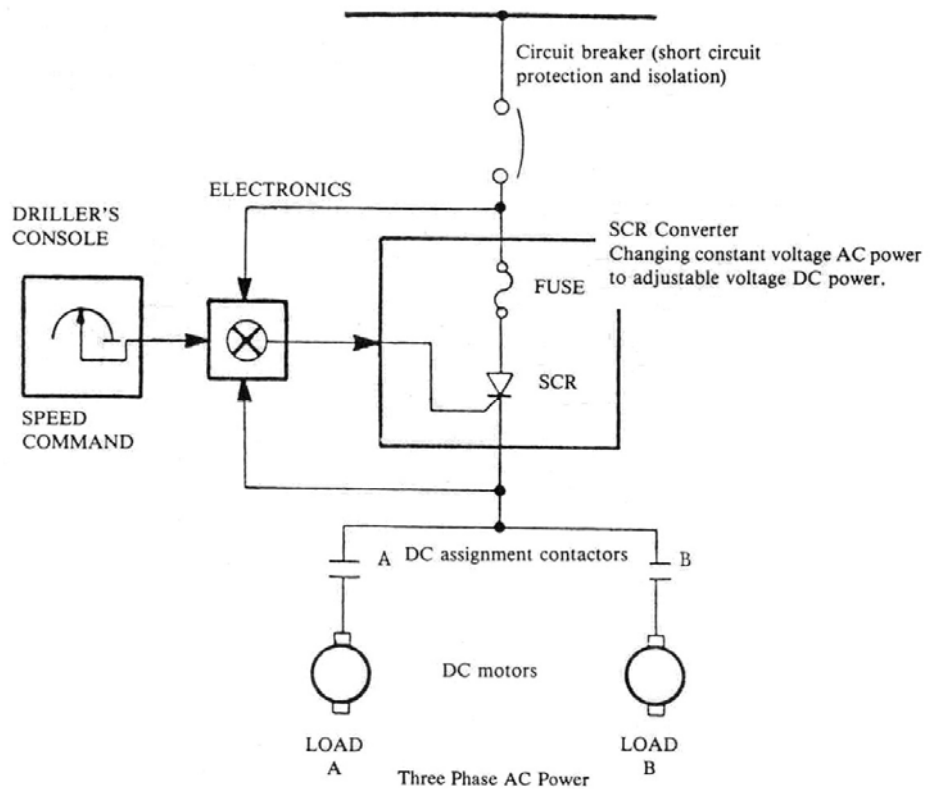
- Waveform



- Speed Command

Once an electrical system is put into service, the driller's primary control is the drilling control console.

Load speed is increased to the desired level by manual adjustment of the throttles.



## **13. PNEUMATIC SYSTEM**

### **INDEX**

- 13.1 FUNCTIONS
- 13.2 CHARACTERISTICS
- 13.3 APPLICATIONS

### **13.1 FUNCTIONS**

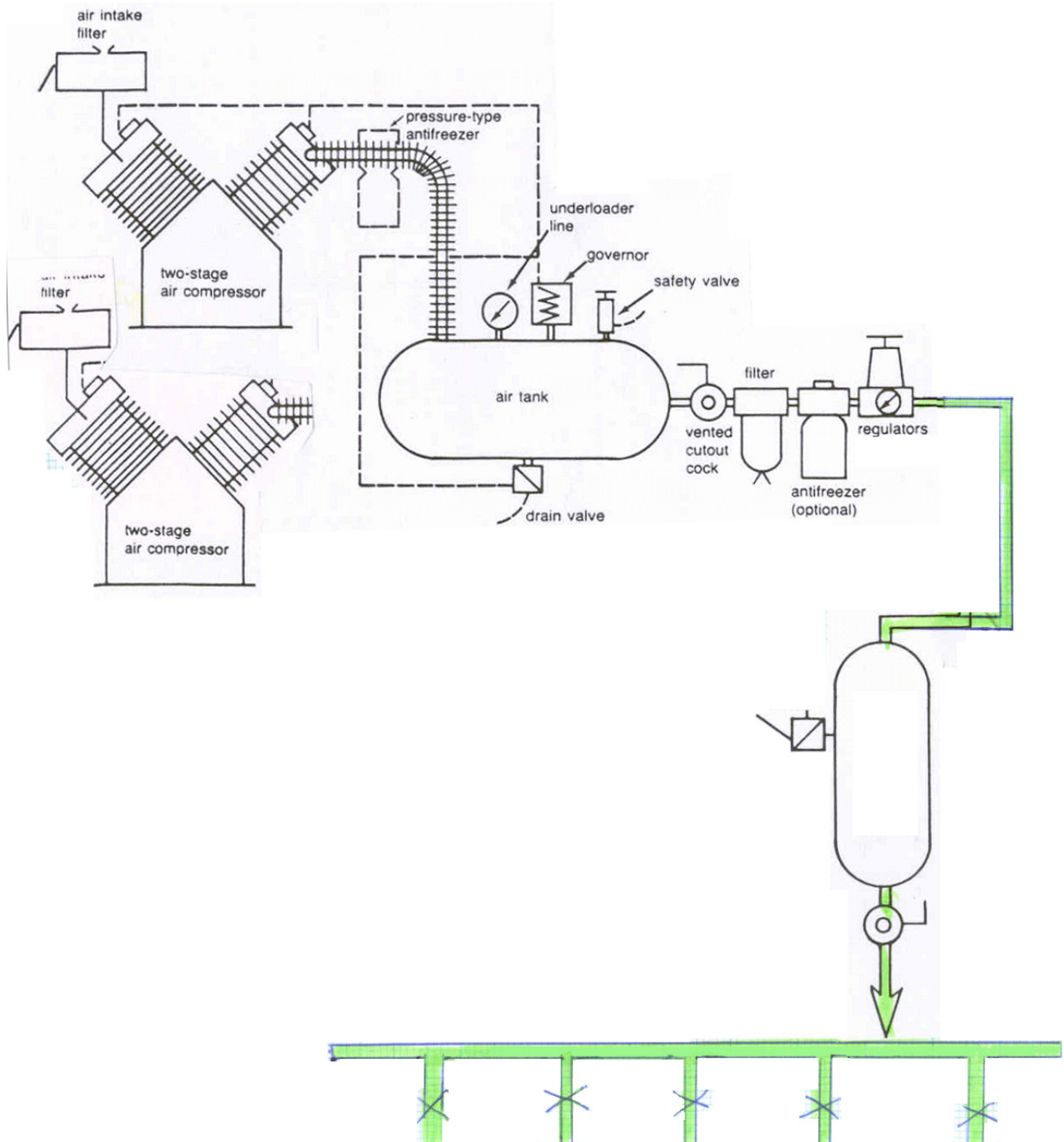
Compressed air is used in many applications on a drilling rig.

- Diesel engine start up
- Drawworks air friction
- Safety device (Crown -O- Matic)
- Instrumentation
- BOP control panel
- Spinning wrench, kelly spinner
- Various servomechanisms (Top drive, valves, etc).

#### **General Plan**

- Two-stage air compressor
  - . Air intake filter
- Air tank
  - . Safety valve
  - . Drain valve
- Regulators
- Manifold

### General Plan





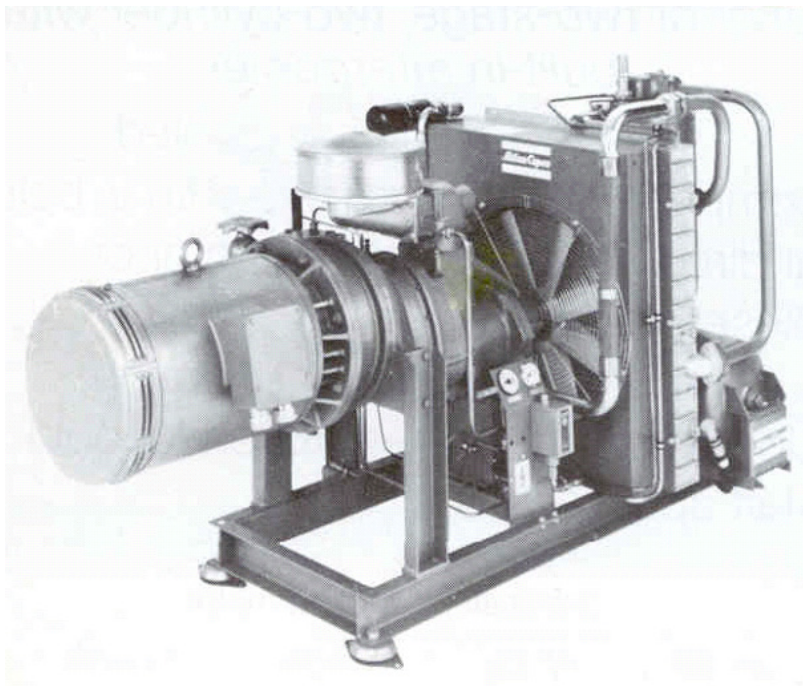
## 13.2 CHARACTERISTICS

### ATLAS COPCO

SERIE GA  
POWER 30- 200  
HP

Max press 125  
psi

Rate 30 m3 for  
min

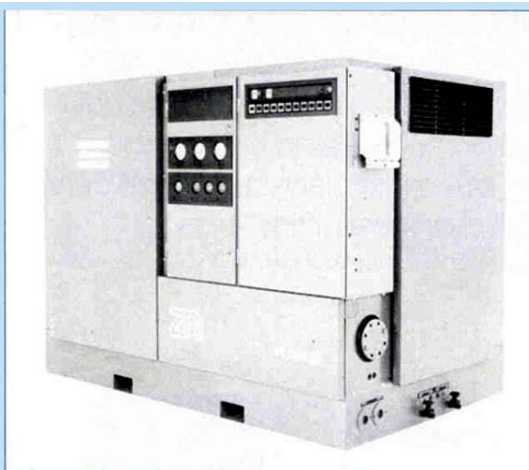


### Z series Rotary Screw

Compressors for 100 %  
oil-free air Vibrationless,  
compact, trouble-free.

Available engineered for  
the oil industry, the Z  
compressor provides  
absolutely clean air with  
vibrationless running,  
compact design, low  
weight an long, trouble-  
free service life.

It has air or water cooling  
and can also be fitted for  
seawater cooling.



| Machine<br>designation | HP      | Max<br>Pressure<br>psig | Capacity<br>a.c.f.m. | Dimensions without motor |             |              |               |
|------------------------|---------|-------------------------|----------------------|--------------------------|-------------|--------------|---------------|
|                        |         |                         |                      | Length<br>in             | Width<br>in | Height<br>in | Weight<br>lbs |
| Z 3                    | 75-200  | 35-150                  | 340- 780 at 100 psi  | 101                      | 57          | 71           | 4012          |
| Z 4                    | 200-300 | 35-150                  | 810-1250 at 100 psi  | 118                      | 68.5        | 76           | 6636          |

The Z has versatility of pressure from low through high. Drive is also versatile - electric motor, turbine or diesel engine.

### 13.3 APPLICATIONS

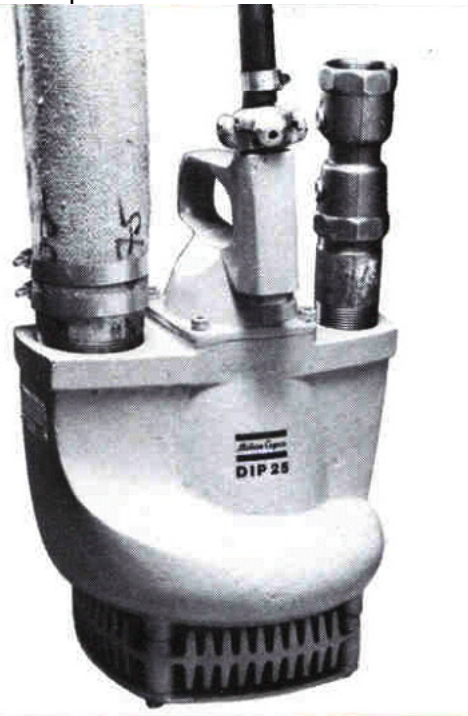
- Air Pressure Testing Pump
- Submersible Pump
- Air Pump
- Air Winch
- Driller's Air Operated Control Panel
- Air Remote Control System
- Crown o Matic
- Pit Level System (air operated)

- Air Pressure Testing Pump

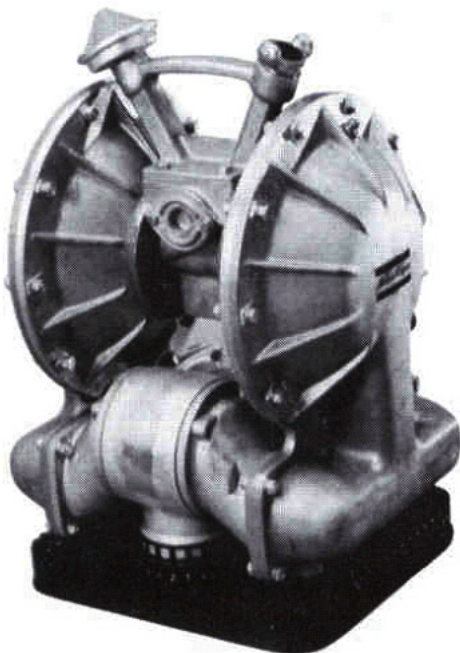
**SUPER SIXTY  
AIR OPERATED HYDRAULIC PUMP**



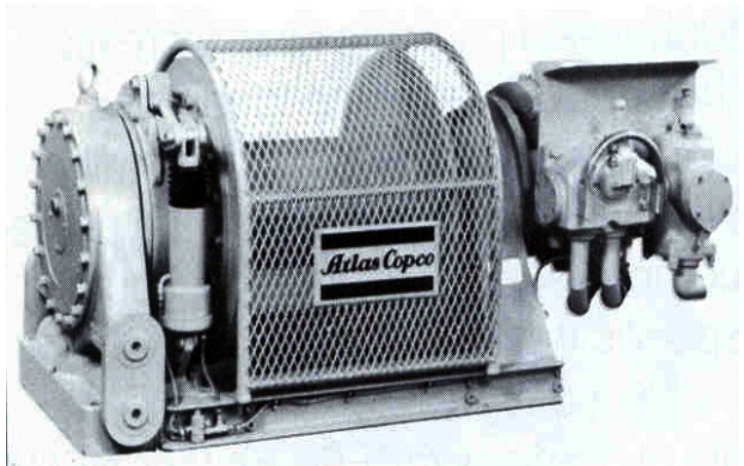
- Submersible Pump



- Air Pump



- Air Winch



## 14. ROTARY TABLE & MASTER BUSHING

### INDEX

- 14.1 FUNCTIONS
- 14.2 DIMENSIONS AND CHARACTERISTICS
- 14.3 TYPES OF ROTARY TABLE
- 14.4 TYPES OF MASTER BUSHINGS
- 14.5 TYPES OF CASING BUSHINGS

### 14.1 FUNCTIONS

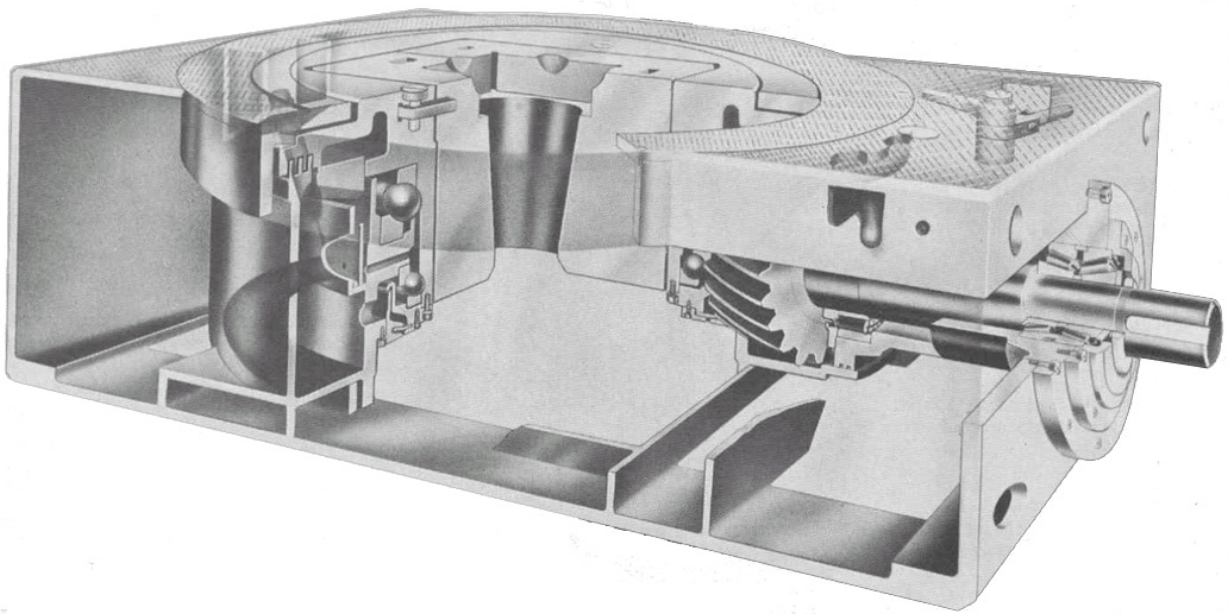
#### - Rotary Table

Before the TOP DRIVE introduction, the rotary table had two main functions:

1. Transmit rotation to the BHA through the Kelly Bushing.
2. Collect and support the weight of all the tools to RIH .

With the invention of the TOP DRIVE, the rotary table is only used for the second function.

*Rotary Table*

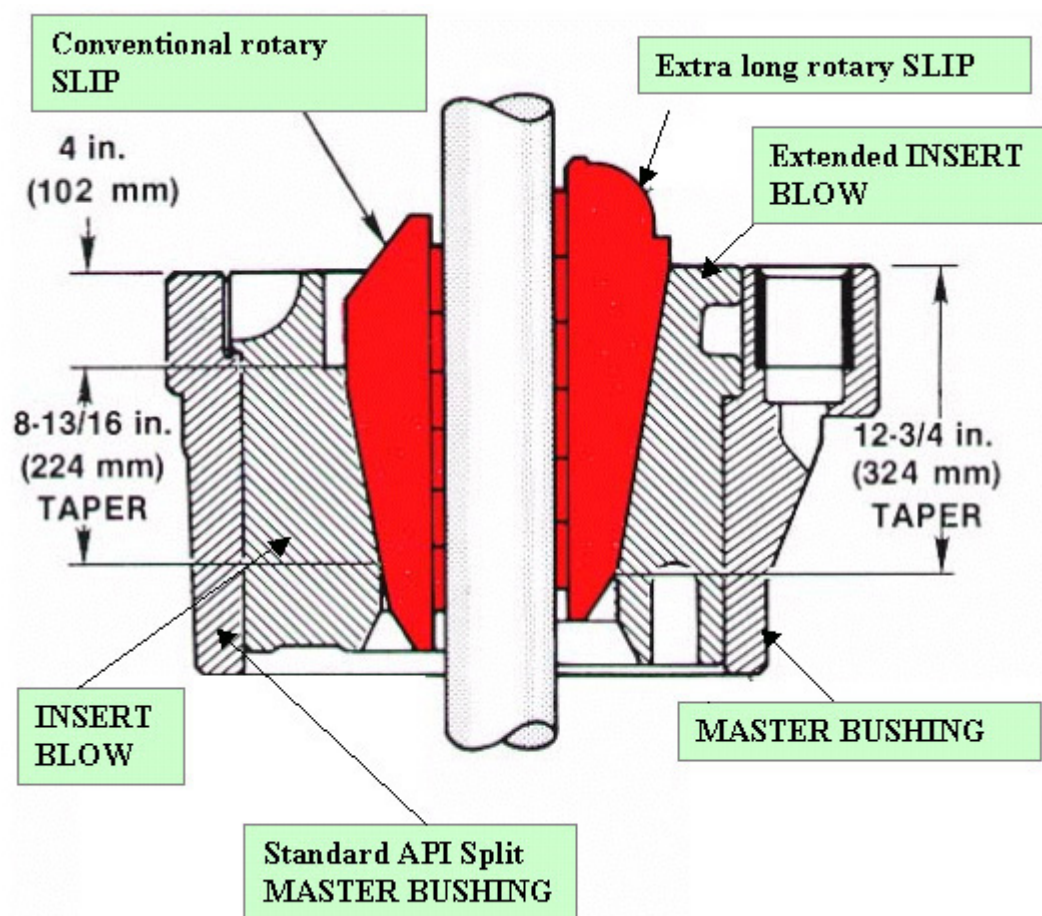


#### - Master Bushings

The **master bushings** and **bushing adaptors** enable the rig to handle all different types and sizes of tubulars (DP, Csg, DC, etc).

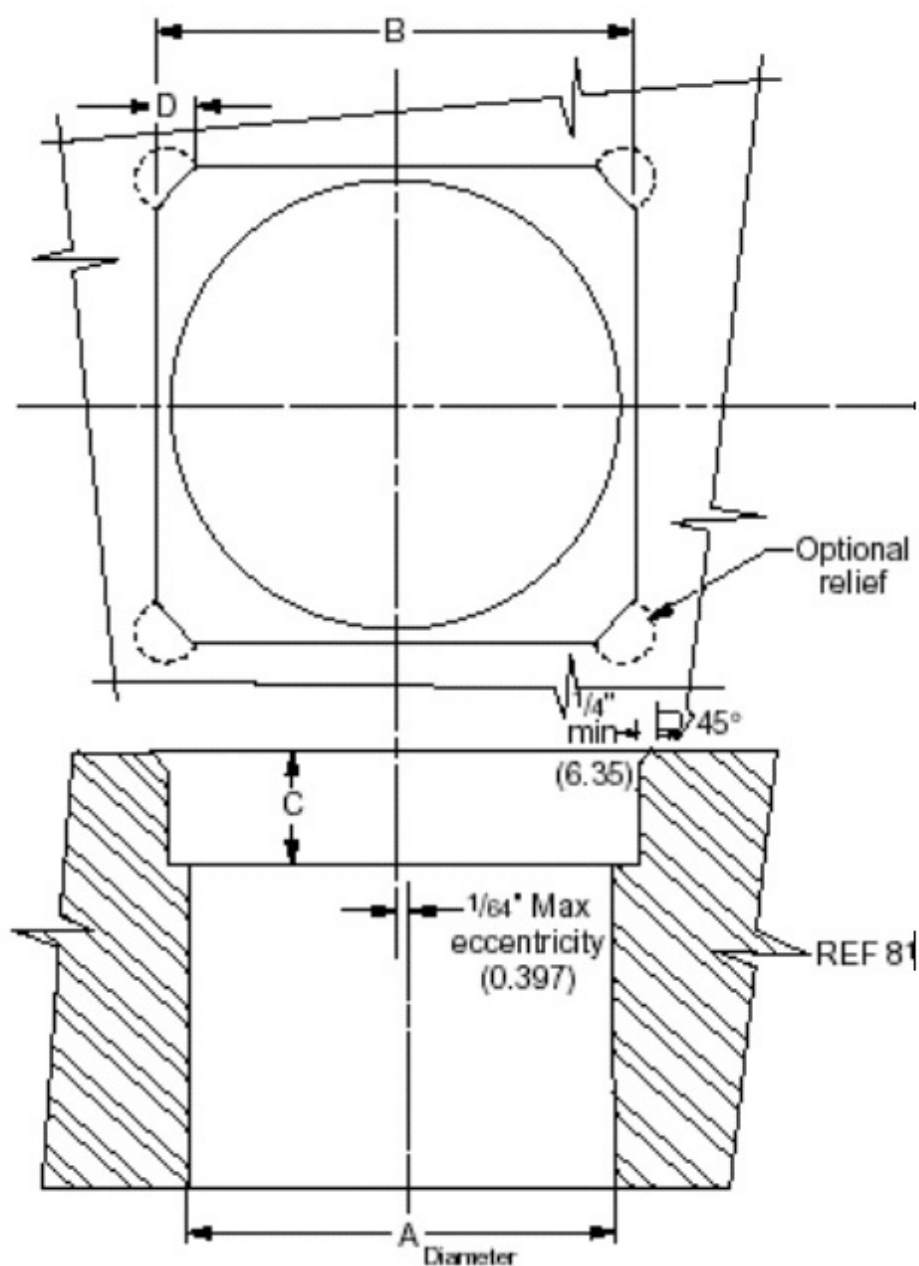


Scheme and Nomenclature



## 14.2 DIMENSIONS AND CHARACTERISTICS

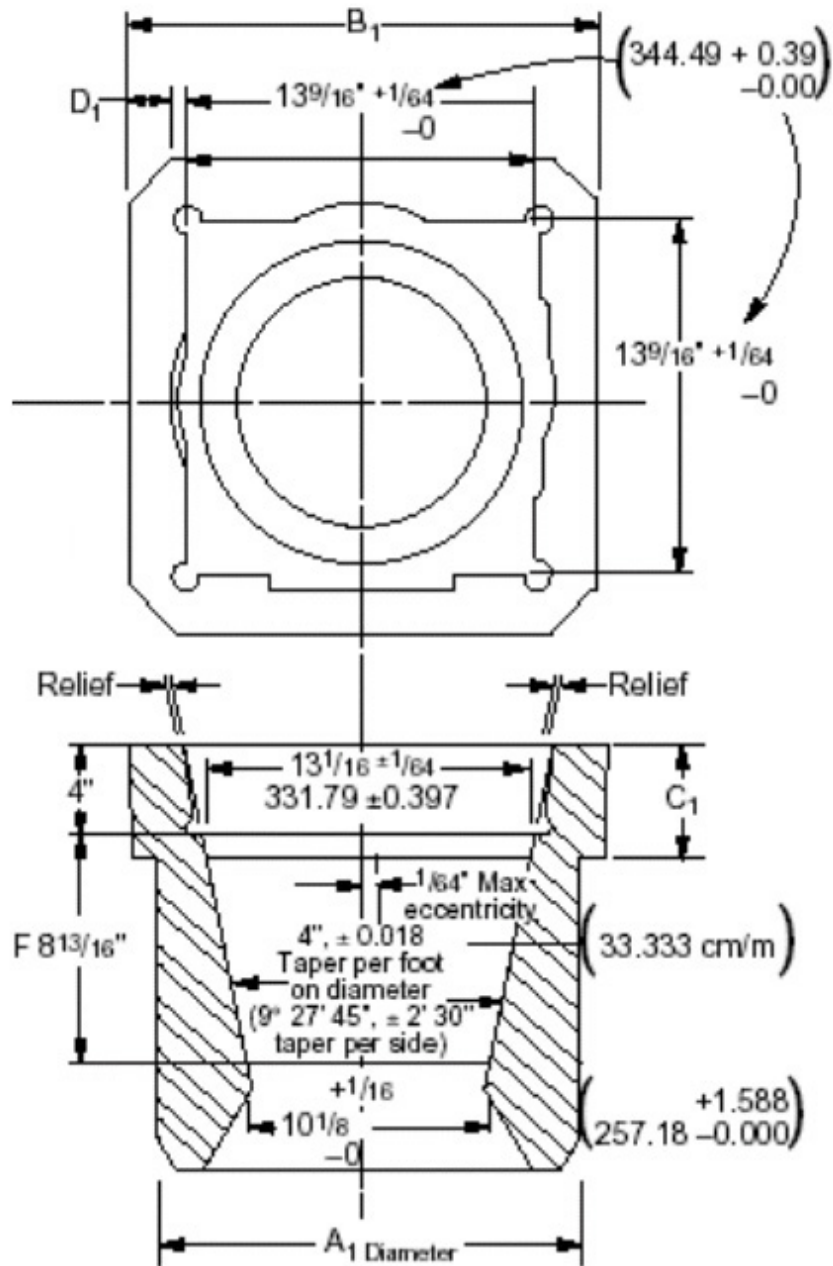
Rotary Table from API 7K



| Nominal<br>Table Size |         | Rotary Table Opening |                  |                  |                  |       |        |       |       |
|-----------------------|---------|----------------------|------------------|------------------|------------------|-------|--------|-------|-------|
|                       |         | A                    |                  | B                |                  | C     |        | D     |       |
|                       |         | +0.015<br>-0.000     | +0.381<br>-0.000 | +0.030<br>-0.000 | +0.762<br>-0.000 |       |        | Max.  | Max.  |
| in.                   | mm      | in.                  | mm               | in.              | mm               | in.   | mm     | in.   | mm    |
| 17 1/2                | 444.50  | 17 1/2               | 444.500          | 18 3/16          | 461.963          | 5 1/4 | 133.35 | 1 3/4 | 44.45 |
| 20 1/2                | 520.70  | 20 1/2               | 520.700          | 21 3/16          | 538.163          | 5 1/4 | 133.35 | 1 3/4 | 44.45 |
| 27 1/2                | 696.50  | 27 1/2               | 696.500          | 28 3/16          | 715.963          | 5 1/4 | 133.35 | 1 3/4 | 44.45 |
| 37 1/2                | 952.50  | 37 1/2               | 952.500          | —                | —                | —     | —      | —     | —     |
| 49 1/2                | 1257.30 | 49 1/2               | 1257.300         | —                | —                | —     | —      | —     | —     |

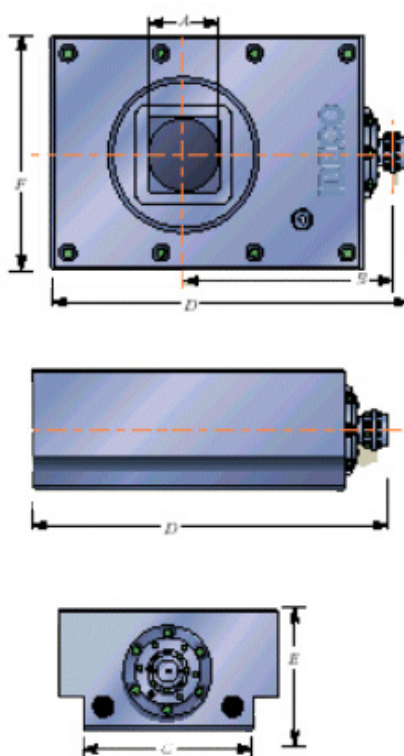


- Master Bushing from API 7K



| Nominal<br>Table Size          |         | Square Drive Master Bushing     |                        |                                 |                        |                               |        |                               |                        |                              |                    |
|--------------------------------|---------|---------------------------------|------------------------|---------------------------------|------------------------|-------------------------------|--------|-------------------------------|------------------------|------------------------------|--------------------|
|                                |         | $A_1$                           |                        | $B_1$                           |                        | $C_1$                         |        | $D_1$                         |                        | Concen-<br>tricity           | Concen-<br>tricity |
| in.                            | mm      | +0.000<br>-0.015<br>in.         | +0.000<br>-0.381<br>mm | +0.000<br>-0.030<br>in.         | +0.000<br>-0.762<br>mm | in.                           | mm     | +0.250<br>-0.000<br>in.       | +6.350<br>-0.000<br>mm | TIR<br>in.                   | TIR<br>mm          |
| 17 <sup>1</sup> / <sub>2</sub> | 444.50  | 17 <sup>7</sup> / <sub>16</sub> | 442.913                | 18 <sup>1</sup> / <sub>8</sub>  | 460.375                | 5 <sup>1</sup> / <sub>4</sub> | 133.35 | 1 <sup>3</sup> / <sub>4</sub> | 44.45                  | <sup>1</sup> / <sub>32</sub> | 0.794              |
| 20 <sup>1</sup> / <sub>2</sub> | 520.70  | 20 <sup>7</sup> / <sub>16</sub> | 519.113                | 21 <sup>1</sup> / <sub>8</sub>  | 536.575                | 5 <sup>1</sup> / <sub>4</sub> | 133.35 | 1 <sup>3</sup> / <sub>4</sub> | 44.45                  | <sup>1</sup> / <sub>32</sub> | 0.794              |
| 27 <sup>1</sup> / <sub>2</sub> | 696.50  | 27 <sup>7</sup> / <sub>16</sub> | 696.913                | 28 <sup>1</sup> / <sub>16</sub> | —                      | 5 <sup>1</sup> / <sub>4</sub> | 133.35 | 1 <sup>3</sup> / <sub>4</sub> | 44.45                  | <sup>1</sup> / <sub>32</sub> | 0.794              |
| 37 <sup>1</sup> / <sub>2</sub> | 952.50  | 37 <sup>7</sup> / <sub>16</sub> | 950.913                | —                               | —                      | —                             | —      | —                             | —                      | —                            | —                  |
| 49 <sup>1</sup> / <sub>2</sub> | 1257.30 | —                               | —                      | —                               | —                      | —                             | —      | —                             | —                      | —                            | —                  |

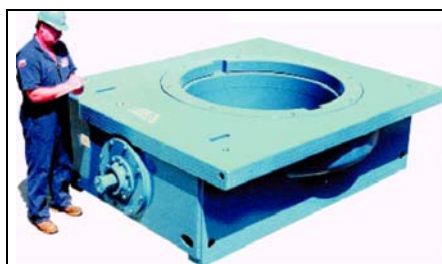
- Rotary Table "IDECO"



| Model                           | RT-17 1/2             | SR-205        | LR-205        | SR-23         | LR-23         | LR275         | RT-27 1/2     | LR-375        |
|---------------------------------|-----------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| A-Table opening in (mm)         | 17 1/2 (445)          | 20 1/2 (521)  | 20 1/2 (521)  | 23 (584)      | 23 (584)      | 27 1/2 (699)  | 27 1/2 (699)  | 37 1/2 (953)  |
| B-Table to sprocket in (mm)     | 44-53 1/4 (1118-1353) | 44 (1118)     | 53 1/4 (1353) | 44 (1118)     | 53 1/4 (1353) | 53 1/4 (1353) | 53 1/4 (1353) | 53 1/4 (1353) |
| C-Overall width of skid in (mm) | 39 (991)              | 44 1/4 (1124) | 44 1/4 (1124) | 45 (1143)     | 45 (1143)     | 48 3/4 (1238) | 50 (1270)     | 58 (1473)     |
| D-Overall Length in (mm)        | 78-87 1/4 (1981-2216) | 79 1/2 (2019) | 88 3/4 (2254) | 81 (2057)     | 90 1/4 (2292) | 94 3/4 (2407) | 92 3/8 (2359) | 95 1/4 (2419) |
| E-Overall Height in (mm)        | 23 (584)              | 22 (559)      | 22 (559)      | 23 1/8 (587)  | 23 1/8 (587)  | 24 3/4 (629)  | 25 1/4 (641)  | 25 3/8 (645)  |
| F-Overall Width in (mm)         | 54 1/4 (1378)         | 54 1/4 (1378) | 54 1/4 (1378) | 59 1/4 (1505) | 59 1/4 (1505) | 63 (1600)     | 63 (1600)     | 73 (1854)     |
| Net Weight lb (kg)              | 7500 (3402)           | 7000 (3175)   | 7200 (3266)   | 8280 (3756)   | 8340 (3783)   | 10,600 (4808) | 12,000 (5443) | 16,600 (7530) |
| Max. Table Speed rpm            | 350                   | 350           | 350           | 350           | 350           | 350           | 350           | 350           |
| Dead Load Cap. t (mt)           | 250 (227)             | 350 (318)     | 350 (318)     | 425 (386)     | 425 (386)     | 500 (454)     | 500 (454)     | 650 (590)     |
| Gear Ratio                      | 3.526:1               | 3.79:1        | 3.79:1        | 3.89:1        | 3.89:1        | 3.95:1        | 3.739:1       | 4.05:1        |

Highlighted areas denote

- Rotary Table "NATIONAL OILWELL"



ROTARY TABLE SPECIFICATIONS.

| Model:                                | C-175-S       | C-175-L       | C-205         | C-275          | D-375          |
|---------------------------------------|---------------|---------------|---------------|----------------|----------------|
| Max table opening diameter, in.(mm)   | 17 1/2 (445)  | 17 1/2 (445)  | 20 1/2 (521)  | 27 1/2 (699)   | 37 1/2 (953)   |
| Static load capacity, tons (tonnes)   | 250 (227)     | 250 (227)     | 350 (318)     | 500 (454)      | 650 (590)      |
| Maximum recommended table speed, rpm  | 500           | 500           | 400           | 400            | 350            |
| Gear ratio                            | 3.16          | 3.16          | 3.14          | 3.16           | 3.60           |
| Oil Capacity gal. (liters)            | 5 (19)        | 6 (23)        | 7 (26)        | 8 (30)         | 8 (30)         |
| Weight, less master bushing, lb. (kg) | 6,602 (2,994) | 6,848 (3,106) | 9,208 (4,176) | 11,230 (5,093) | 13,140 (5,959) |

### 14.3 TYPES OF ROTARY TABLE

The Rotary Table can run off independent motor or can be coupled with the drawworks.

The independent motor can either be

- electrical (most common) or
- hydraulic

Rotary table with electrical motor



Rotary tables with hydraulic motor



Rotary tables with hydraulic motor were designed specifically for a TOP DRIVE.  
They:

- Run at reduced rotary speed.
- Are smaller and cheaper.

Can stay in the locked position with hydraulic pressure.



#### 14.4 TYPES OF MASTER BUSHINGS

##### - MPCH 37 " and 49 "

This MASTER BUSHING has been dimensioned for floating rigs. It can be pulled from Rotary table also when BHA is in the well.



Master Bushing Handling



##### - VARCO MSPC for 20 1/2" to 27 1/2"

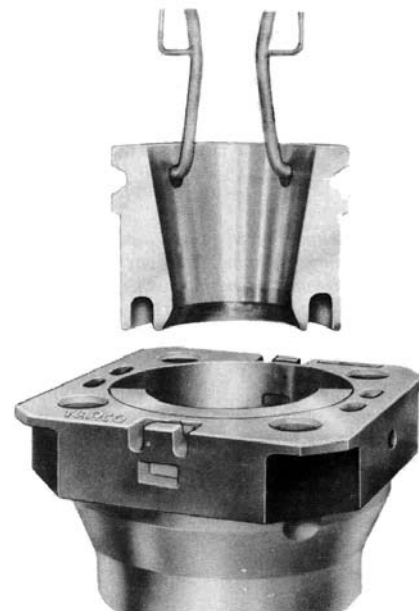


For 20 1/2, 21 and 22 in. Tables—  
Shown less insert bowls.

Uses Varco 20 HDP and 20 4KRP Kelly Bush

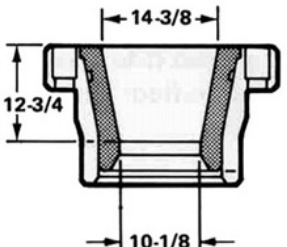
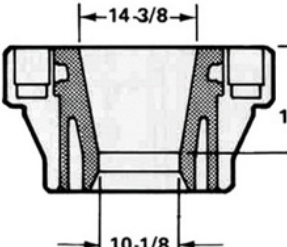
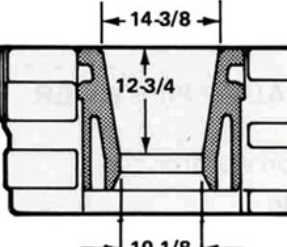
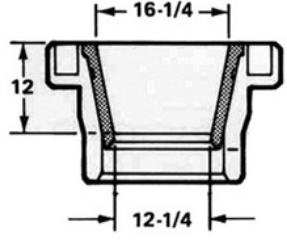
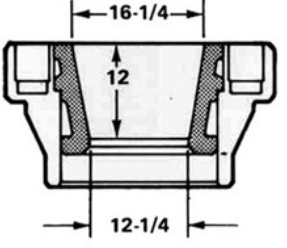
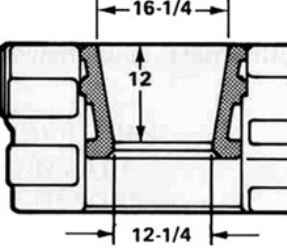
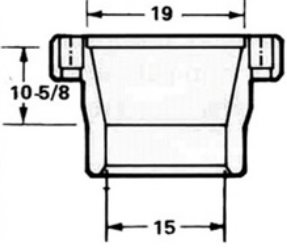
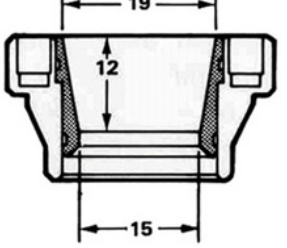
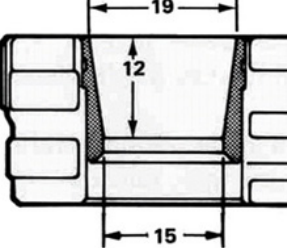
##### - API Insert Bowl

N1 -2 - 3 allow in RT diameters from  
2 3/8" to 13 3/8".



For 23, 26 and 27 1/2 in. Tables—  
Shown with API extended insert bowl no. 3  
Uses Varco 27 HDP or 27 4KRP Kelly Bushings

- INSERT BOWLS (VARCO)

| DRILL PIPE *<br>CASING OR<br>TUBING SIZE | 20-1/2 – 22 MSPC MASTER<br>BUSHING WITH BOWLS                                                                 | 23 – 27-1/2 MSPC MASTER<br>BUSHING WITH BOWLS                                                                | 37-1/2 – 49-1/2 MPCH HINGED<br>MASTER BUSHING WITH BOWLS                                                      |
|------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| 2-3/8 to 8-5/8<br>Use<br>Bowl No. 3      |  <p><b>BOWL 1809</b></p>     |  <p><b>BOWL 1810</b></p>   |  <p><b>BOWL 6608</b></p>   |
| 9-5/8 to 10-3/4<br>Use<br>Bowl No. 2     |  <p><b>BOWL 1902</b></p>    |  <p><b>BOWL 1904</b></p>  |  <p><b>BOWL 6609</b></p>  |
| 11-3/4 to 13-3/8<br>Use<br>Bowl No. 1    |  <p><b>NO BOWL REQ</b></p> |  <p><b>BOWL 1903</b></p> |  <p><b>BOWL 6610</b></p> |
|                                          | USE 20-HDP<br>OR 20-4KRP<br>KELLY BUSHINGS                                                                    | USE 27-HDP<br>OR 27-4KRP<br>KELLY BUSHINGS                                                                   | USE 27-HDP<br>OR 27-4KRP<br>KELLY BUSHINGS                                                                    |



## 14.5 TYPES OF CASING BUSHINGS

### - Casing Bushing

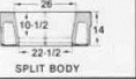
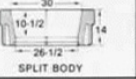
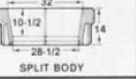
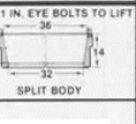
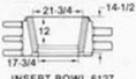
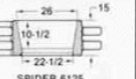
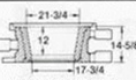
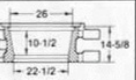
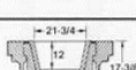
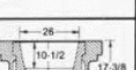
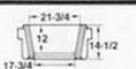
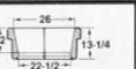
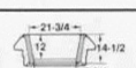
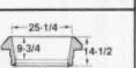
Casing bushing are set inside the Rotary table instead of master bushing for big CSG size.

- CU and CUL models are integrals,
- CB model is split in two.



Casing Bushings

Table: Master Bushing - Casing Bushing

| TUBULAR GOODS<br>OUTSIDE DIAMETER |                                                                                                                                                                                     | 2-3/8 IN. -                                                                                                                                            | 2-3/8 IN. -                                                                                                                                       |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                   |                                                                                                                                                                                     | 16 IN.                                                                                                                                                 | 20 IN. - 18-5/8 IN.                                                                                                                               | 24 IN.                                                                                                                             | 26 IN.                                                                                                                              | 30 IN.                                                                                                                                                |
| ROTARY<br>TABLE<br>SIZE           | BUSHING TYPE                                                                                                                                                                        |                                                                                                                                                        |                                                                                                                                                   |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
| 37-1/2                            | CB<br><br>SPLIT BODY                                                                             | <br>21-3/4<br>12<br>14-1/2<br>17-3/4<br>INSERT BOWL 6127            | <br>26<br>10-1/2<br>14<br>22-1/2<br>SPLIT BODY                 | <br>30<br>10-1/2<br>14<br>26-1/2<br>SPLIT BODY | <br>32<br>10-1/2<br>14<br>28-1/2<br>SPLIT BODY | <br>1 IN. EYE BOLTS TO LIFT<br>36<br>12<br>14<br>32<br>SPLIT BODY |
|                                   | MPCH<br>25-3/4 PIN CIRCLE<br><br>HINGED PIN DRIVE                                                |                                                                                                                                                        |                                                                                                                                                   |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
| ANY                               | 500 TON<br>HCS<br><br>HINGED SPIDER 6125                                                         | <br>21-3/4<br>12<br>14-1/2<br>17-3/4<br>INSERT BOWL 6127            | <br>26<br>10-1/2<br>14<br>22-1/2<br>SPIDER 6125                |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|                                   | 20 IN.<br>200 TON<br>HCS<br><br>36 IN. SQ. BASE<br>HINGED SPIDER 74664                           | <br>21-3/4<br>12<br>14-1/2<br>17-3/4<br>INSERT BOWL 6127            | <br>26<br>10-1/2<br>14-5/8<br>22-1/2<br>SPIDER 74664           |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|                                   | 13-3/8 IN.<br>200 TON<br>HCS<br><br>28 IN. SQ. BASE<br>HINGED SPIDER 74663                       |                                                                                                                                                        |                                                                                                                                                   |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|                                   | 37-1/2<br>SOLID<br>TABLE<br>ADAPT.<br><br>28-3/16 IN. SQ.<br>5-1/4<br>17-3/8<br>27-1/2<br>37-3/8 | <br>21-3/4<br>12<br>17-3/8<br>17-3/4<br>INSERT BOWL 6127 IN CB 6695 | <br>26<br>10-1/2<br>17-3/8<br>22-1/2<br>CB 6695                |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
| 27-1/2                            | CB<br><br>SPLIT A.P.I. BODY 6695                                                                 | <br>21-3/4<br>12<br>14-1/2<br>17-3/4<br>INSERT BOWL 6127            | <br>26<br>10-1/2<br>13-1/4<br>22-1/2<br>SPLIT A.P.I. BODY 6695 |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|                                   | MSP<br><br>SPLIT BODY 5429                                                                       |                                                                                                                                                        |                                                                                                                                                   |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|                                   | CUL<br><br>SOLID BODY 3103                                                                       | <br>21-3/4<br>12<br>14-1/2<br>17-3/4<br>INSERT BOWL 3104            | <br>25-1/4<br>9-3/4<br>14-1/2<br>22<br>BODY 3103               |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|                                   | MSPC<br>25-3/4 PIN CIRCLE<br><br>BODY 1806- 27-1/2 PIN DRIVE                                     |                                                                                                                                                        |                                                                                                                                                   |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|                                   | MSS<br><br>BODY 1010                                                                             |                                                                                                                                                        |                                                                                                                                                   |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |
|                                   |                                                                                                                                                                                     |                                                                                                                                                        |                                                                                                                                                   |                                                                                                                                    |                                                                                                                                     |                                                                                                                                                       |

## 15. KELLY & DRIVE BUSHING

### INDEX

- 15.1 FUNCTION AND TYPES
- 15.2 DIMENSIONS (HEXAGONAL KELLY)
- 15.3 DRIVE BUSHING
- 15.4 OPERATION

### 15.1 FUNCTION AND TYPES

#### - Function

The function of the Kelly is to transmit rotation and torque to the drilling bottom hole assembly.

#### - Types (Hexagonal kelly - Square kelly)

Kellys are manufactured as square or hexagonal.

#### - Square kelly

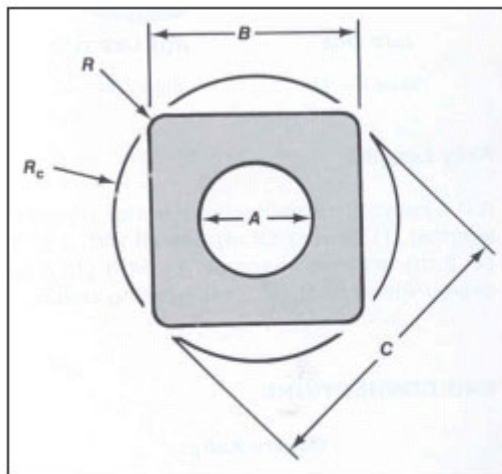
No more utilized

#### - Hexagonal kelly

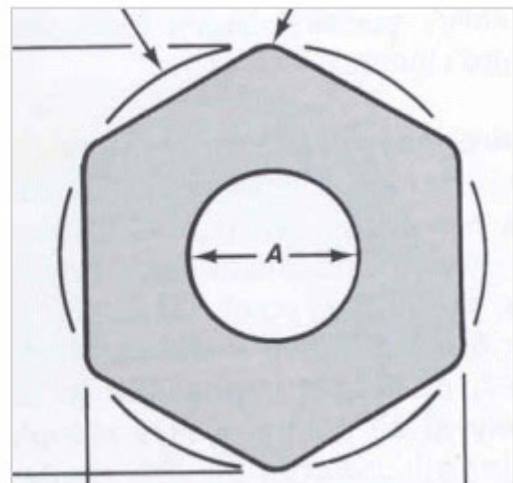
The most common is the hexagonal kelly, which offers maximum surface contact with the Kelly Bushing.

Standard lengths are:

- 40 ft for onshore and
- 54 ft for offshore.



Square Kelly (No more utilized)



hexagonal kelly

## 15.2 DIMENSIONS (HEXAGONAL KELLY)

- Hexagonal kelly data from API 7

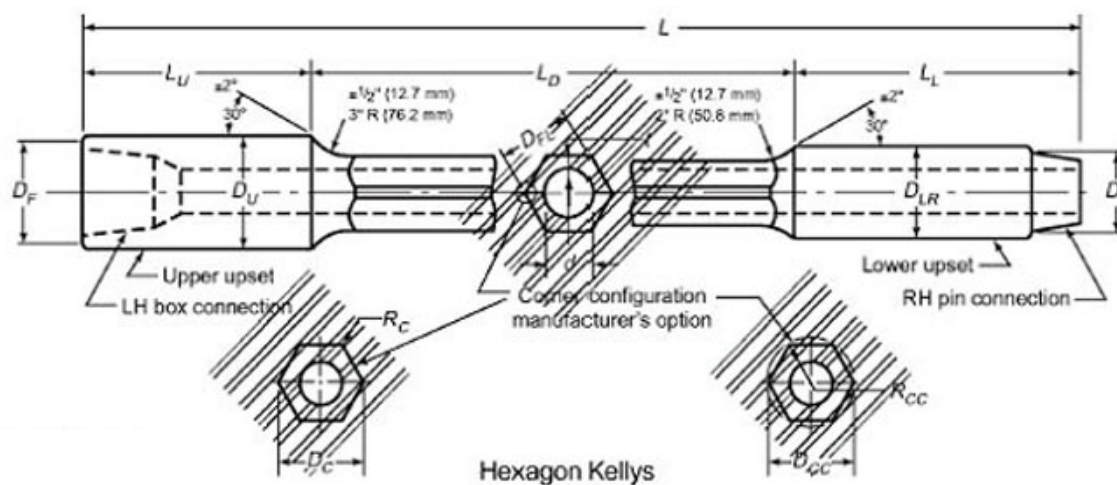


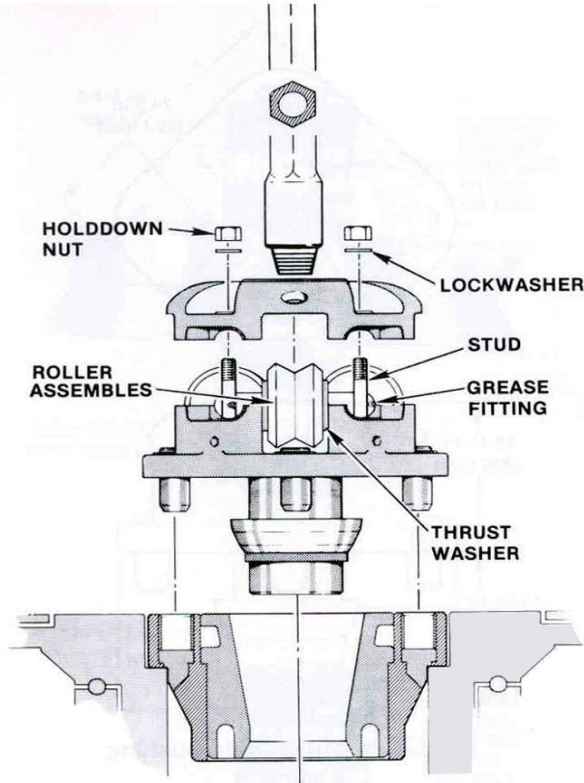
Table 3 Hexagon Kellys

| Upper Box Connection          |          |                     |          |               |                               |                                 |                |        |                                 |                     |                                   |                                   |                               |                               |                |                                 |                                 |                                               |                               |        |                                 |                                            |
|-------------------------------|----------|---------------------|----------|---------------|-------------------------------|---------------------------------|----------------|--------|---------------------------------|---------------------|-----------------------------------|-----------------------------------|-------------------------------|-------------------------------|----------------|---------------------------------|---------------------------------|-----------------------------------------------|-------------------------------|--------|---------------------------------|--------------------------------------------|
| Length of Drive Section feet  |          | Length Overall feet |          | Drive Section |                               |                                 |                |        |                                 |                     | Size and Style LH                 |                                   | Outside Diameter              |                               | Bevel Diameter |                                 | Lower Pin Connection            |                                               |                               |        |                                 |                                            |
| Kelly Size                    | Standard | Optional            | Standard | Optional      | Across Flats                  | Across Corners                  | Across Corners | Radius | Radius                          | Min. Wall Ecc. Bore | Standard                          | Optional                          | Standard                      | Optional                      | Length         | Standard                        | Optional                        | Size and Style                                | Outside Diameter              | Length | Bevel Diameter                  | Inside Diameter                            |
| (a)                           | (b)      | (b)                 | (c)      | (c)           | (d)                           | (e)                             | (f)            | (e)    | (j)                             | t                   | (b)                               | (b)                               | (e)                           | (e)                           | (g)            | (h)                             | (h)                             |                                               | (e)                           | (g)    | (h)                             | (i)                                        |
|                               | $L_D$    | $L_D$               | L        | L             | $D_{FL}$                      | $D_C$                           | $D_{CC}$       | $R_C$  | $R_{CC}$                        |                     |                                   |                                   | $D_U$                         | $D_U$                         | $L_U$          | $D_F$                           | $D_F$                           |                                               | $D_{LR}$                      | $L_L$  | $D_F$                           | d                                          |
| 3                             | 37       | —                   | 40       | —             | 3                             | 3 <sup>3</sup> / <sub>8</sub>   | 3.375          | 1/4    | 1 <sup>11</sup> / <sub>16</sub> | 0.475               | 6 <sup>5</sup> / <sub>8</sub> REG | 4 <sup>1</sup> / <sub>2</sub> REG | 7 <sup>3</sup> / <sub>4</sub> | 5 <sup>3</sup> / <sub>4</sub> | 16             | 7 <sup>21</sup> / <sub>64</sub> | 5 <sup>19</sup> / <sub>64</sub> | NC26                                          | 3 <sup>3</sup> / <sub>8</sub> | 20     | 3 <sup>17</sup> / <sub>64</sub> | 1 <sup>1</sup> / <sub>4</sub>              |
| 3 <sup>1</sup> / <sub>2</sub> | 37       | —                   | 40       | —             | 3 <sup>1</sup> / <sub>2</sub> | 3 <sup>31</sup> / <sub>32</sub> | 3.937          | 1/4    | 1 <sup>31</sup> / <sub>32</sub> | 0.525               | 6 <sup>5</sup> / <sub>8</sub> REG | 4 <sup>1</sup> / <sub>2</sub> REG | 7 <sup>3</sup> / <sub>4</sub> | 5 <sup>3</sup> / <sub>4</sub> | 16             | 7 <sup>21</sup> / <sub>64</sub> | 5 <sup>19</sup> / <sub>64</sub> | NC31                                          | 4 <sup>1</sup> / <sub>8</sub> | 20     | 3 <sup>61</sup> / <sub>64</sub> | 1 <sup>3</sup> / <sub>4</sub>              |
| 4 <sup>1</sup> / <sub>4</sub> | 37       | 51                  | 40       | 54            | 4 <sup>1</sup> / <sub>4</sub> | 4 <sup>13</sup> / <sub>16</sub> | 4.781          | 5/16   | 2 <sup>25</sup> / <sub>64</sub> | 0.625               | 6 <sup>5</sup> / <sub>8</sub> REG | 4 <sup>1</sup> / <sub>2</sub> REG | 7 <sup>3</sup> / <sub>4</sub> | 5 <sup>3</sup> / <sub>4</sub> | 16             | 7 <sup>21</sup> / <sub>64</sub> | 5 <sup>19</sup> / <sub>64</sub> | NC38                                          | 4 <sup>3</sup> / <sub>4</sub> | 20     | 4 <sup>37</sup> / <sub>64</sub> | 2 <sup>1</sup> / <sub>4</sub>              |
| 5 <sup>1</sup> / <sub>4</sub> | 37       | 51                  | 40       | 54            | 5 <sup>1</sup> / <sub>4</sub> | 5 <sup>31</sup> / <sub>32</sub> | 5.900          | 3/8    | 2 <sup>61</sup> / <sub>64</sub> | 0.625               | 6 <sup>5</sup> / <sub>8</sub> REG | —                                 | 7 <sup>3</sup> / <sub>4</sub> | —                             | 16             | 7 <sup>21</sup> / <sub>64</sub> | —                               | NC46 <sup>k</sup>                             | 6 <sup>1</sup> / <sub>4</sub> | 20     | 5 <sup>23</sup> / <sub>32</sub> | 3 <sup>k</sup>                             |
| 6                             | 37       | 51                  | 40       | 54            | 6                             | 6 <sup>13</sup> / <sub>16</sub> | 6.812          | 3/8    | 3 <sup>13</sup> / <sub>32</sub> | 0.625               | 6 <sup>5</sup> / <sub>8</sub> REG | —                                 | 7 <sup>3</sup> / <sub>4</sub> | —                             | 16             | 7 <sup>21</sup> / <sub>64</sub> | —                               | NC50 <sup>k</sup>                             | 6 <sup>3</sup> / <sub>8</sub> | 20     | 6 <sup>1</sup> / <sub>16</sub>  | 3 <sup>1</sup> / <sub>4</sub> <sup>k</sup> |
|                               |          |                     |          |               |                               |                                 |                |        |                                 |                     |                                   |                                   |                               |                               |                |                                 |                                 | 5 <sup>1</sup> / <sub>2</sub> FH <sup>k</sup> | 7                             | 20     | 6 <sup>23</sup> / <sub>32</sub> | 3 <sup>1</sup> / <sub>2</sub>              |
|                               |          |                     |          |               |                               |                                 |                |        |                                 |                     |                                   |                                   |                               |                               |                |                                 |                                 | NC56 <sup>k</sup>                             | 7                             | 20     | 6 <sup>47</sup> / <sub>64</sub> | 3 <sup>1</sup> / <sub>2</sub>              |

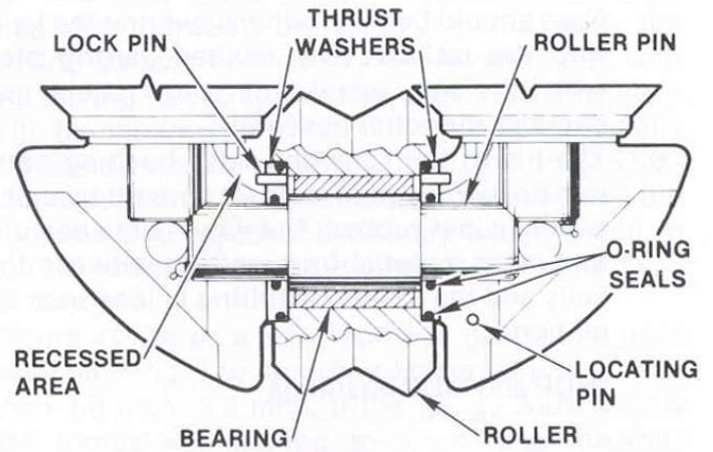
### 15.3 DRIVE BUSHING

#### - Kelly Bushing

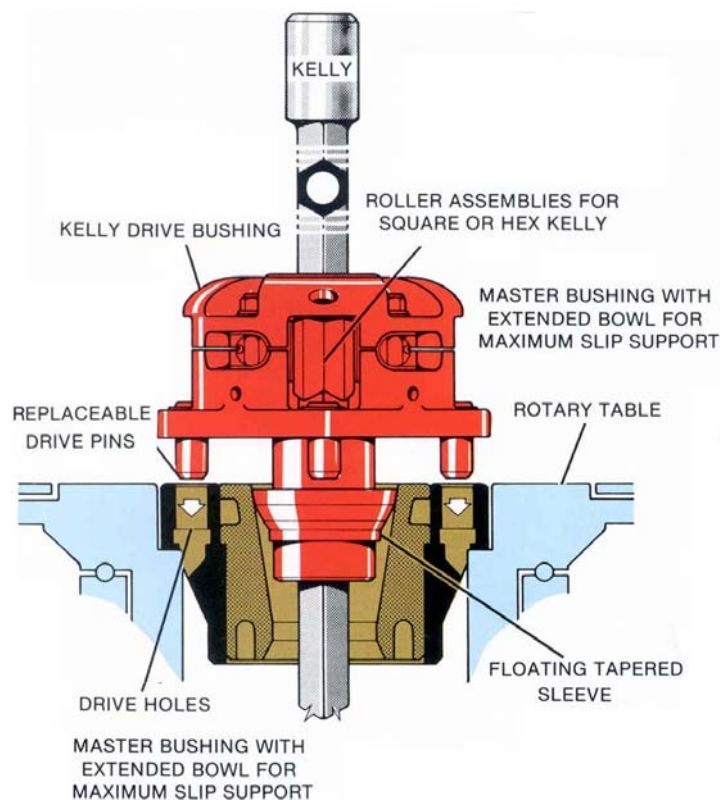
Kelly Bushing Assembly



Kelly Bushing Roller Section



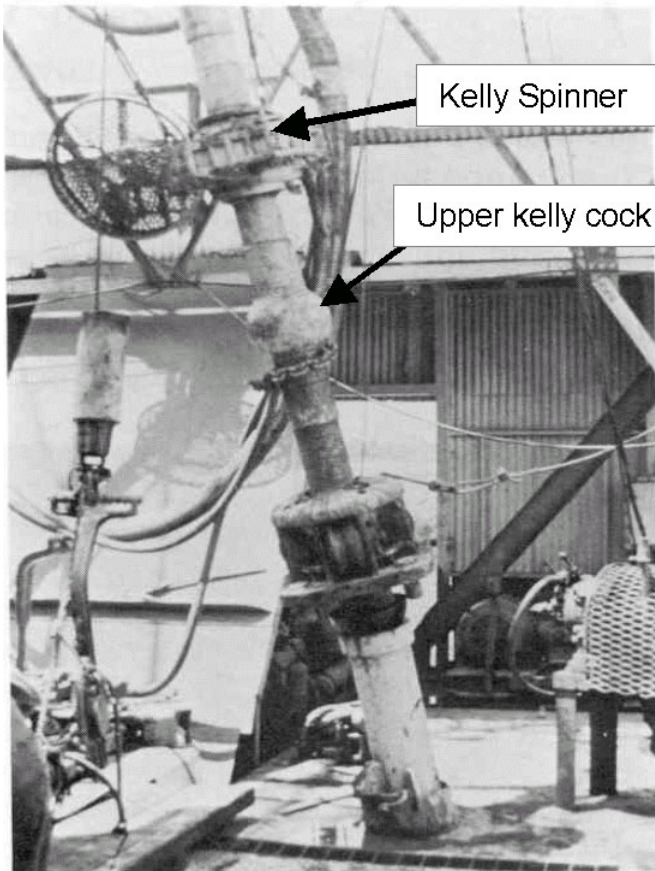
#### - Roller Assembly



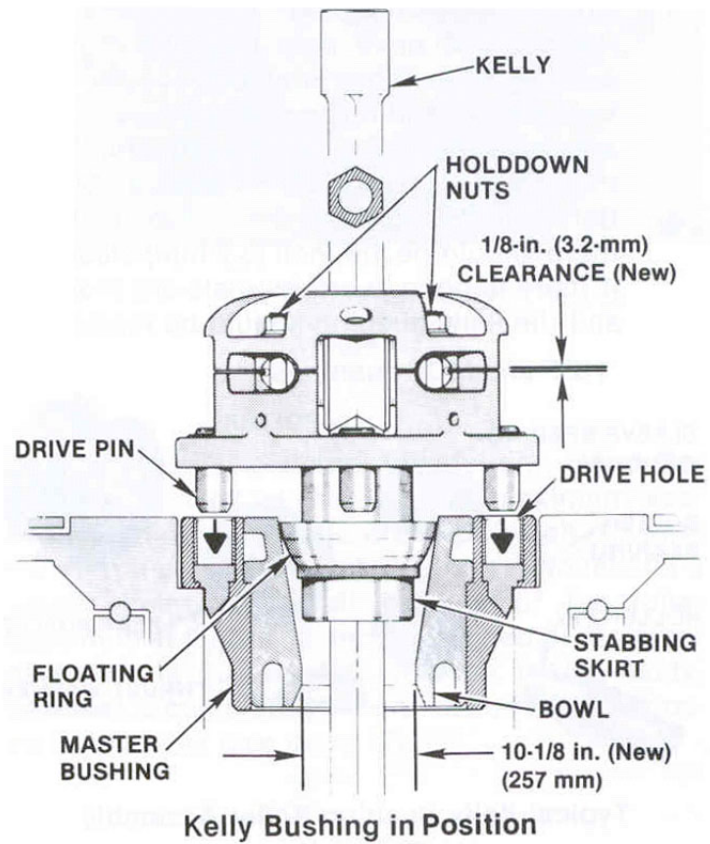


## 15.4 OPERATION

- Kelly & Kelly Bushing Inside Rat hole



- Kelly Bushing in Working Position





## 16. UPPER & LOWER KELLY VALVES

### INDEX

#### 16.1 FUNCTION

#### 16.2 DIMENSIONS

- Upper Kelly Cock
- Lower Kelly Cock

### 16.1 FUNCTION

#### - Kelly valves

Kelly valves are manually operated valves run above and below the kelly to shut off back-flow in the drill stem in the case of a kick.

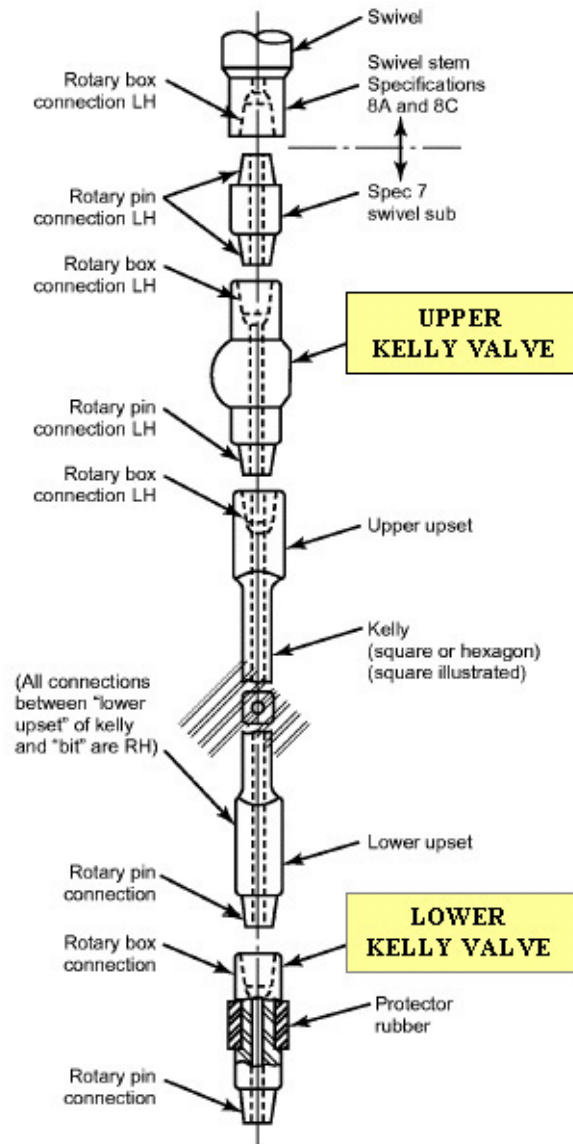
#### - Upper Kelly Cock

#### - Lower Kelly Cock

The valves are manually operated with a dedicated wrench.

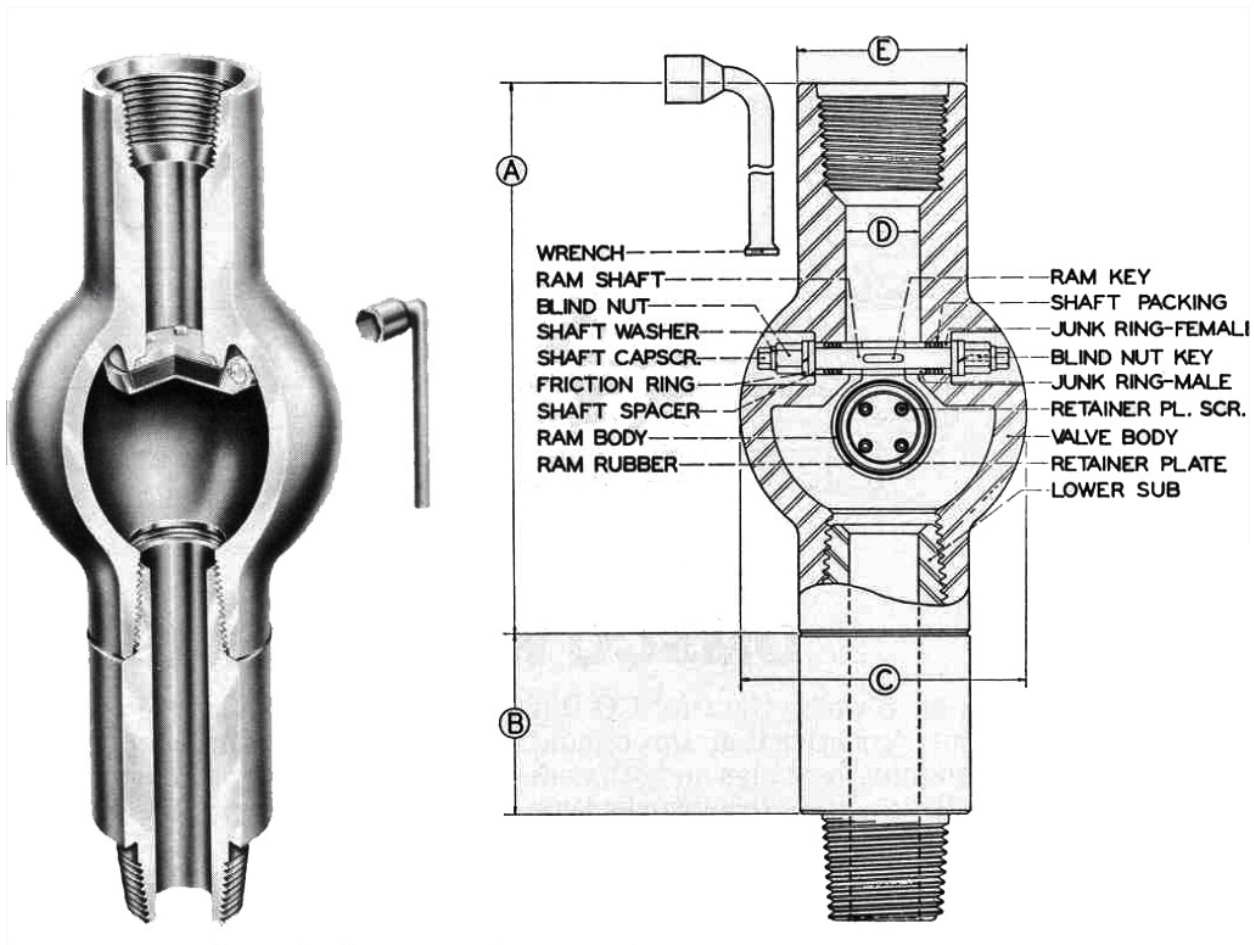
This is a limit for a quick intervention.

The Top drive system has eliminated this with remove control operated valves.



## 16.2 DIMENSIONS

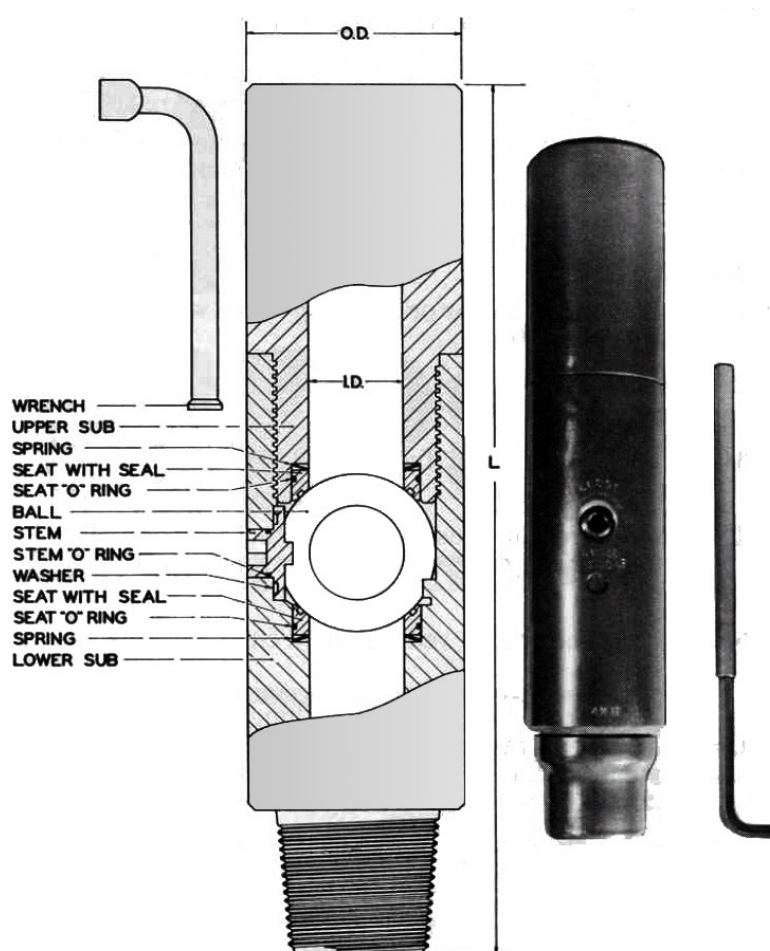
### - Upper Kelly Cock



Upper Kelly Cock - Size Table

| UPPER KELLY COCKS FOR HEXAGON KELLYS                              |           |           |                     | dimensions in inches.    |               |                                                         |               |               |          |                                    |  |
|-------------------------------------------------------------------|-----------|-----------|---------------------|--------------------------|---------------|---------------------------------------------------------|---------------|---------------|----------|------------------------------------|--|
| 1                                                                 | 2         | 3         | 4                   | 5                        | 6             | 7                                                       | 8             | 9             | 10       | 11                                 |  |
| Upper box and<br>Lower Pin Connections<br>Size and Style --<br>LH |           |           |                     | Outside<br>Diameter<br>D |               | Bore d, Minimum,<br>at Maximum Working<br>Pressure, psi |               |               |          | Bevel Diameter<br>D(f)<br>+/- 1/64 |  |
|                                                                   |           |           |                     |                          |               | 5,000                                                   |               | 15,000        |          |                                    |  |
|                                                                   |           |           |                     |                          |               | 10,000                                                  |               |               |          |                                    |  |
|                                                                   |           |           |                     |                          |               |                                                         |               |               |          |                                    |  |
|                                                                   |           |           |                     |                          |               |                                                         |               |               |          |                                    |  |
| Kelly Size                                                        | Standard  | Optional  | Standard<br>+/- 1/4 | Optional<br>+/- 1/52     | Std.<br>Conn. | Opt.<br>Conn.                                           | Std.<br>Conn. | Opt.<br>Conn. | Standard | Optional                           |  |
| 3                                                                 | 6-5/8 REG | 4-1/2 REG | 7-7/8               | 5-3/4                    | 3             | 2                                                       | 2-1/2         | 1-3/4         | 7-21/64  | 5-19/64                            |  |
| 3-1/2                                                             | 6-5/8 REG | 4-1/2 REG | 7-7/8               | 5-3/4                    | 3             | 2                                                       | 2-1/2         | 1-3/4         | 7-21/64  | 5-19/64                            |  |
| 4-1/4                                                             | 6-5/8 REG | 4-1/2 REG | 7-7/8               | 5-3/4                    | 3             | 2                                                       | 2-1/2         | 1-3/4         | 7-21/64  | 5-19/64                            |  |
| 5-1/4                                                             | 6-5/8 REG |           | 7-7/8               |                          | 3             |                                                         | 2-1/2         |               | 7-21/64  |                                    |  |
| 6                                                                 | 6-5/8 REG |           | 7-7/8               |                          | 3             |                                                         | 2-1/2         |               | 7-21/64  |                                    |  |

- Lower Kelly Cock



Lower Kelly Cock - Size Table

|            |                                                          |                 |                                    |
|------------|----------------------------------------------------------|-----------------|------------------------------------|
| e          | NC20                                                     | 3-1/3           | e-41/104                           |
| e          | 2-1/3 BH                                                 | 3-1/3           | e-53/35<br>(2-20/104) <sub>5</sub> |
| 2-1/4      | NC20 (4-1/3 IE)                                          | 3-1/4           | e-1/10                             |
| 2-1/4      | NC40 (4 IE)                                              | 3               | 2-53/35                            |
| 4-1/4      | NC38 (3-1/3 IE)                                          | 3-1/4           | 4-31/104                           |
| 3-1/3      | NC31 (5-1/8 IE)                                          | 1-3/4           | 3-e1/104                           |
| 3          | NC30 (5-3/8 IE)                                          | 1-1/3           | 3-1/104                            |
|            | BH                                                       | q               | D <sup>e</sup>                     |
| Size Kelly | Size and Style<br>for Connections<br>Upper Box and Lower | Minimum<br>Bore | ± 1/16<br>Diameter<br>Bore         |
| 1          | 5                                                        | 3               | 4                                  |

**LOWER KELLY COCKS FOR HEXAGON KELLY**

## 17. SWIVEL HEAD

### INDEX

#### 17.1 FUNCTION

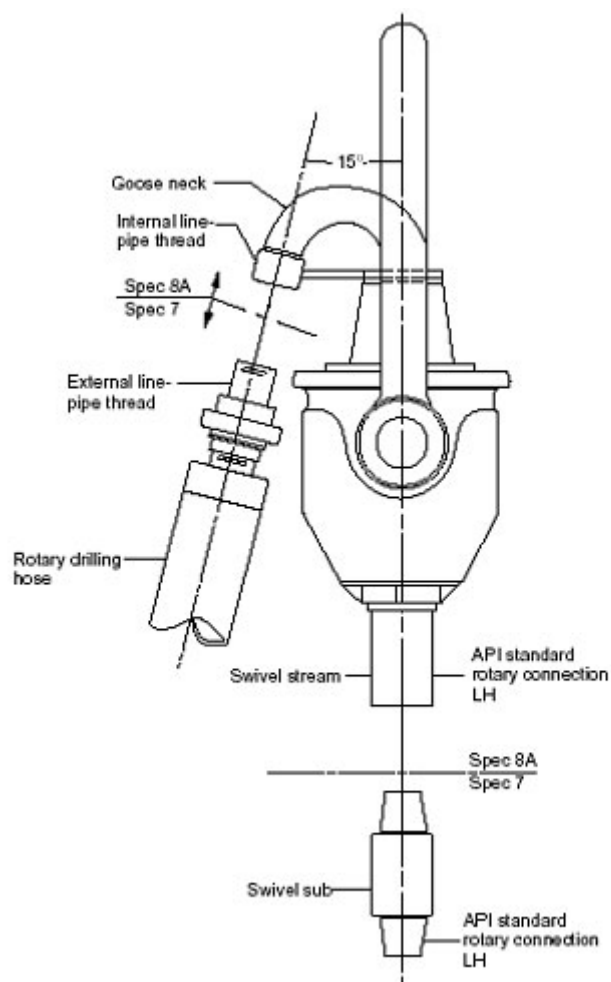
#### 17.2 TYPES AND CHARACTERISTICS

#### 17.3 CONTROLS

### 17.1 FUNCTION

The Swivel head has 3 main functions:

- Bears the string load
- Enables string rotation
- Allows circulation

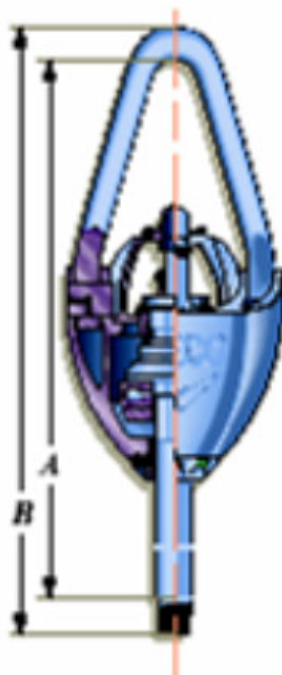


## 17.2 TYPES AND CHARACTERISTICS

- "IDECO" swivel

## Ideco &amp; Cardwell Swivels

| Model              |        | TL120        | S125         | TL200<br>S200   | TL300<br>S300 | TL400<br>S400  | TL500<br>S500         | TL650<br>S650         | TL750      |
|--------------------|--------|--------------|--------------|-----------------|---------------|----------------|-----------------------|-----------------------|------------|
| API Working Load   | t(mt)  | 120(109)     | 144(131)     | 200(181)        | 300(272)      | 400(363)       | 500(454)              | 650(590)              | 750(681)   |
| API Bearing Rating | t      | 78           | 90           | 133             | 193 186       | 258            | 367 327               | 470 426               | 512        |
| @100 rpm           | (mt)   | (71)         | (82)         | (121)           | (175 169)     | (234)          | (333 297)             | (426 386)             | (464)      |
| API Gooseneck      | in(mm) | 2 1/2(64)    | 4(102)       | 4(102)          | 4(102)        | 4(102)         | 4(102)                | 4(102)                | 4(102)     |
| Connection         |        |              |              |                 |               |                |                       |                       |            |
| API Reg Stem Conn. | in(mm) | 4 1/2DP(114) | 4 1/2FH(114) | 4 1/2FH(114)    | 5 1/2(140)    | 6 3/8(168)     | 6 3/8(168) 7 3/8(194) | 6 3/8(168) 7 3/8(194) | 7 3/8(194) |
| Min Fluid Passage  | in(mm) | 2 1/4(57)    | 3(76)        | 3(76)           | 3(76)         | 3(76)          | 3(76)                 | 3(76)                 | 3(76)      |
| A - Working Length | in     | 64 1/2       | 74 13/16     | 81 1/4 76 13/16 | 88 1/2 85 7/8 | 94 1/2 93 9/16 | 101 97 7/8            | 100 7/8 101 3/16      | 114 1 1/16 |
|                    | (mm)   | (1638)       | (1900)       | (2064 1954)     | (2248 2181)   | (2400 2376)    | (2565 2486)           | (2562 2570)           | (2913)     |
| B - Overall Length | in     | 74           | 79 3/16      | 91 90 3/16      | 99 105 1/8    | 106 99 3/16    | 112 104 3/8           | 112 3/8 107 15/16     | 128 3/16   |
|                    | (mm)   | (1880)       | (2015)       | (2311 2291)     | (2515 2670)   | (2692 2904)    | (2845 2645)           | (2867 2742)           | (3256)     |
| Net Weight         | lb     | 970          | 1600         | 2150 2500       | 3300 3220     | 4550 4500      | 5500 6100             | 7200 8070             | 8500       |
|                    | (kg)   | (440)        | (726)        | (975 1134)      | (1497 1460)   | (2063 2041)    | (2494 2766)           | (3266 3660)           | (3855)     |





- "NATIONAL OILWELL" swivel

| Model                                                        | P-200                                                                          | P-300                                                                          | P-400                                                                          | P-500                                                                          | P-650                                                                          | P-750                                                                          |
|--------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Dead load capacity<br>tons (tonnes)                          | 200<br>(181)                                                                   | 300<br>(272)                                                                   | 400<br>(363)                                                                   | 500<br>(454)                                                                   | 650<br>(590)                                                                   | 750<br>(680)                                                                   |
| A.P.I. bearing capacity<br>tons (tonnes)                     | 129<br>(117)                                                                   | 183<br>(166)                                                                   | 268<br>(243)                                                                   | 335<br>(304)                                                                   | 452<br>(410)                                                                   | 619<br>(562)                                                                   |
| Length, overall, less sub<br>ft. in. (mm)                    | 6' 10 <sup>7</sup> / <sub>8</sub> "<br>(2105)                                  | 7' 5 <sup>3</sup> / <sub>4</sub> "<br>(2280)                                   | 7' 8 <sup>1</sup> / <sub>2</sub> "<br>(2350)                                   | 8' 1 <sup>1</sup> / <sub>2</sub> "<br>(2451)                                   | 8' 4 <sup>1</sup> / <sub>4</sub> "<br>(2546)                                   | 10' 3 <sup>5</sup> / <sub>8</sub> "<br>(3140)                                  |
| Width, overall<br>in. (mm)                                   | 34 <sup>1</sup> / <sub>4</sub> "<br>(870)                                      | 35 <sup>1</sup> / <sub>4</sub> "<br>(895)                                      | 39"<br>(991)                                                                   | 42 <sup>1</sup> / <sub>2</sub> "<br>(1080)                                     | 45"<br>(1143)                                                                  | 55 <sup>1</sup> / <sub>4</sub> "<br>(1403)                                     |
| Width inside link rest bracket<br>in. (mm)                   | 31 <sup>1</sup> / <sub>4</sub> "<br>(794)                                      | 31 <sup>1</sup> / <sub>4</sub> "<br>(794)                                      | 31 <sup>1</sup> / <sub>2</sub> "<br>(800)                                      | 31 <sup>1</sup> / <sub>2</sub> "<br>(800)                                      | 32 <sup>1</sup> / <sub>2</sub> "<br>(826)                                      | 45 <sup>3</sup> / <sub>8</sub> "<br>(1153)                                     |
| Clearance between bail and goose-<br>neck, in. (mm)          | 19"<br>(483)                                                                   | 21"<br>(533)                                                                   | 21"<br>(533)                                                                   | 22"<br>(559)                                                                   | 23"<br>(584)                                                                   | 24 <sup>13</sup> / <sub>16</sub> "<br>(630)                                    |
| Stem - fluid passage bore,<br>in. (mm)                       | 3"<br>(76)                                                                     | 3"<br>(76)                                                                     | 3"<br>(76)                                                                     | 3"<br>(76)                                                                     | 3"<br>(76)                                                                     | 4"<br>(102)                                                                    |
| Stem thread, lower end A.P.I. LH<br>box size (REG) in. (mm)  | 4 <sup>1</sup> / <sub>2</sub> F.H.<br>(114.3)                                  | 5 <sup>1</sup> / <sub>2</sub> "<br>(139.7)                                     | 6 <sup>5</sup> / <sub>8</sub> "<br>(168.3)                                     | 7 <sup>5</sup> / <sub>8</sub> "<br>(193.7)                                     | 7 <sup>5</sup> / <sub>8</sub> "<br>(193.7)                                     | 8 <sup>5</sup> / <sub>8</sub> "<br>(219)                                       |
| Gooseneck integral hammer union<br>thread diameter, in. (mm) | 6"<br>(152.4)                                                                  | 6"<br>(152.4)                                                                  | 6"<br>(152.4)                                                                  | 6"<br>(152.4)                                                                  | 6"<br>(152.4)                                                                  | 7"<br>(177.8)                                                                  |
| Gooseneck sleeve Female:<br>A.P.I. line pipe thread Male:    | 4 <sup>1</sup> / <sub>2</sub> " or 3 <sup>1</sup> / <sub>2</sub> "<br>4" or 3" | 4 <sup>1</sup> / <sub>2</sub> " or 3 <sup>1</sup> / <sub>2</sub> "<br>4" or 3" | 4 <sup>1</sup> / <sub>2</sub> " or 3 <sup>1</sup> / <sub>2</sub> "<br>4" or 3" | 4 <sup>1</sup> / <sub>2</sub> " or 3 <sup>1</sup> / <sub>2</sub> "<br>4" or 3" | 4 <sup>1</sup> / <sub>2</sub> " or 3 <sup>1</sup> / <sub>2</sub> "<br>4" or 3" | 4 <sup>1</sup> / <sub>2</sub> " or 3 <sup>1</sup> / <sub>2</sub> "<br>4" or 3" |
| Oil capacity,<br>gal. (liters)                               | 11<br>(42)                                                                     | 15<br>(57)                                                                     | 18<br>(68)                                                                     | 24<br>(91)                                                                     | 31<br>(117)                                                                    | 24<br>(91)                                                                     |
| Weight,<br>lbs. (kg)                                         | 3,005<br>(1363)                                                                | 3,735<br>(1694)                                                                | 4,895<br>(2220)                                                                | 6,000<br>(2722)                                                                | 7,105<br>(3223)                                                                | 11,000<br>(4990)                                                               |



### 17.3 CONTROLS

- Manufacturer and API RP 8A

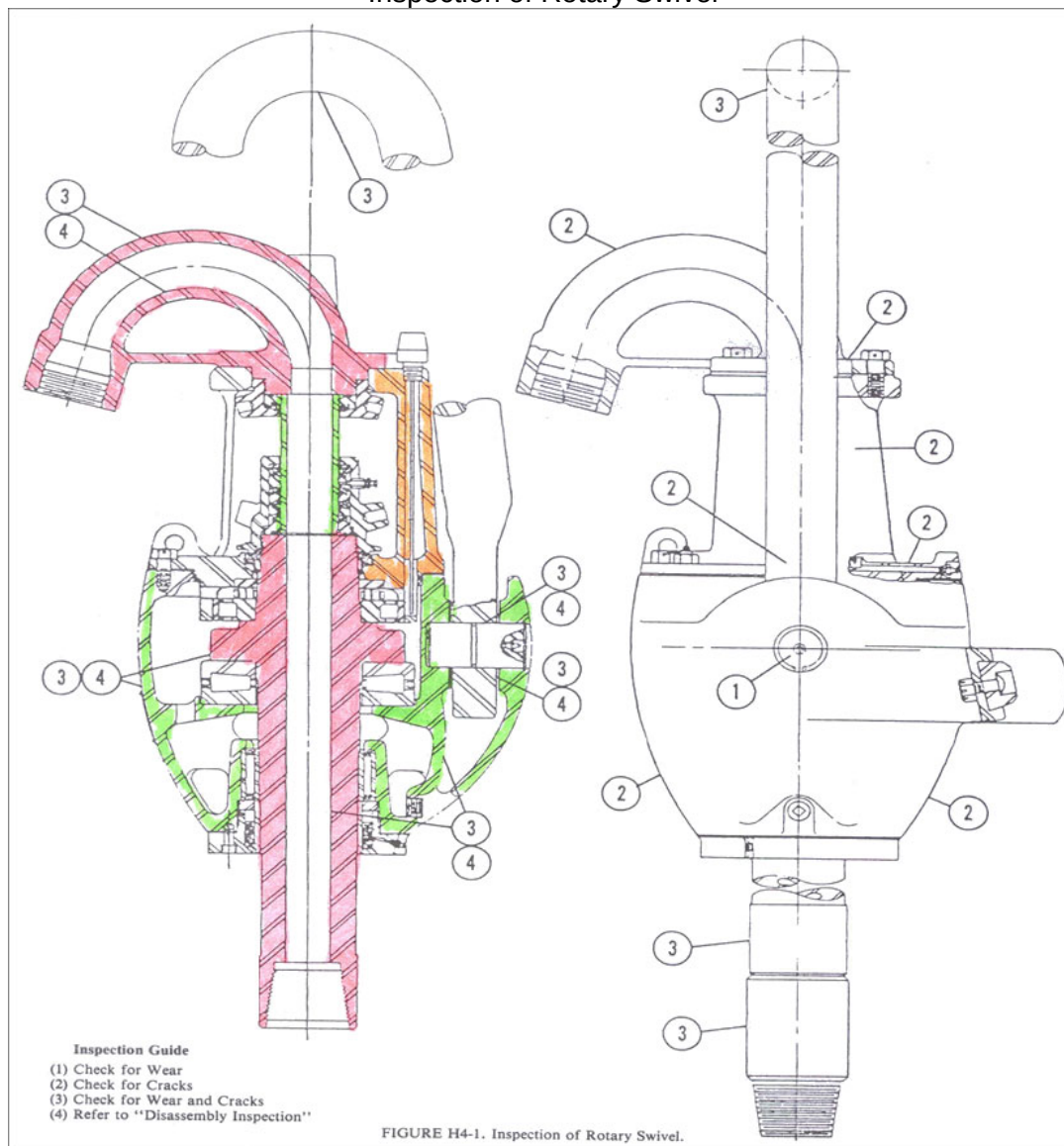
Swivel must be checked and inspected as per the manufacturer's recommendations and API RP 8A.

ENI procedures require a complete re-certification every 5 years.

- Inspection guide

1. Check for Wear
2. Check for Cracks
3. Check for Wear and Cracks
4. Refer to "Disassembly Inspection"

Inspection of Rotary Swivel



## 18. TOP DRIVE

### INDEX

- 18.1 FUNCTION
- 18.2 TYPES AND CHARACTERISTICS
- 18.3 TOP DRIVE COMPONENTS
- 18.4 INSPECTIONS

### 18.1 FUNCTION

#### - Introduction

Oil well drilling with a rotary table, kelly drive bushing and 45 ft of kelly was the industry standard for years.

TOP DRIVE has been one of the better innovations in the oil field in the last few years

#### - Main functions and advantages

Top drive system has 3 main functions:

1. Perform all normal hoisting requirements
2. Rotate the drill string
3. Enable circulation through the drill string

Most rigs today are equipped with top drive.



#### Advantages:

- Possibility to drill stands of pipe rather than single

- Ability to back-ream while pooh

- Contains remote-controlled Inside BOP , that can be operated at distance from the rig floor

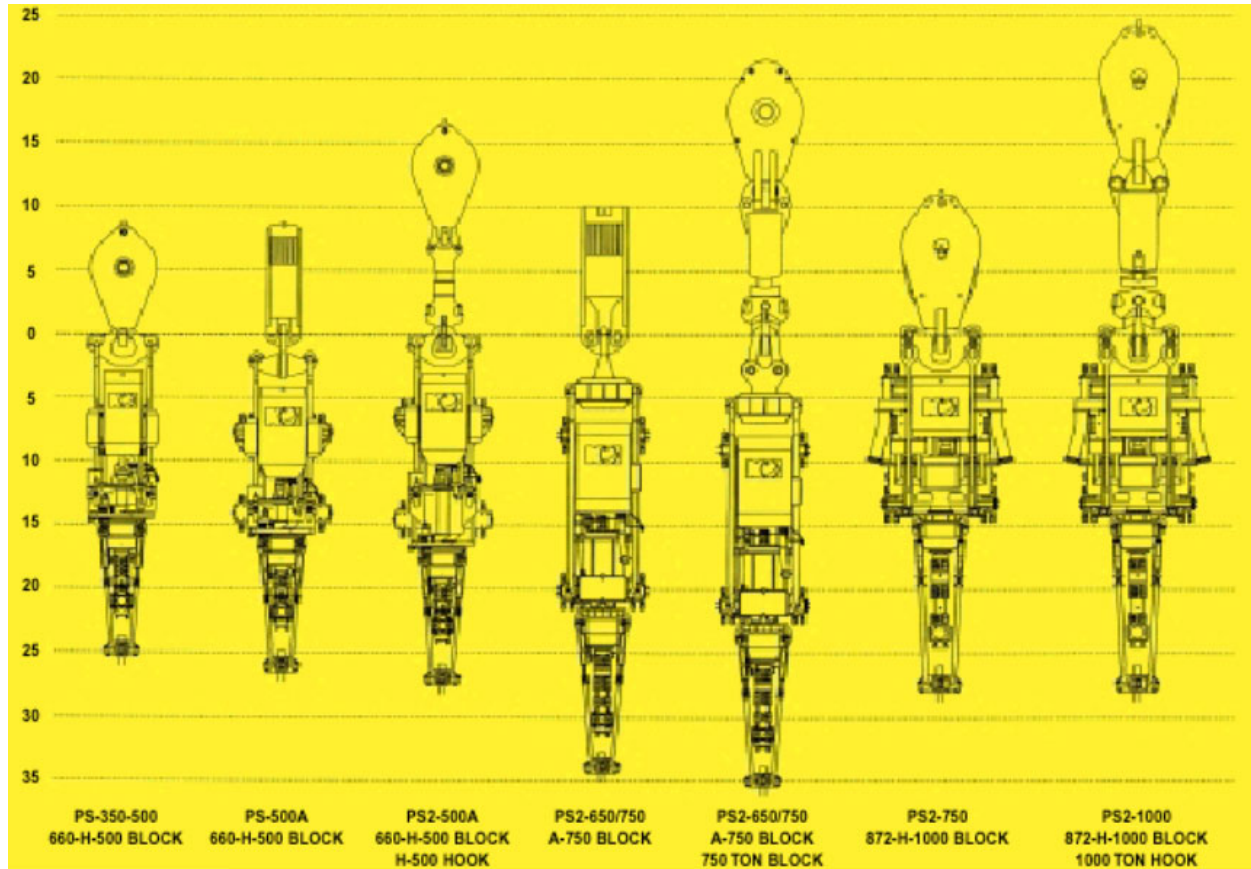
#### - Manufacture specifications

Top Drive is built in accordance with API Spec. 8A and 8C.

The reference standards adopted by ENI is: ISO 13535

## 18.2 TYPES AND CHARACTERISTICS

### - Top Drive National Oilwell





## - Top Drive VARCO

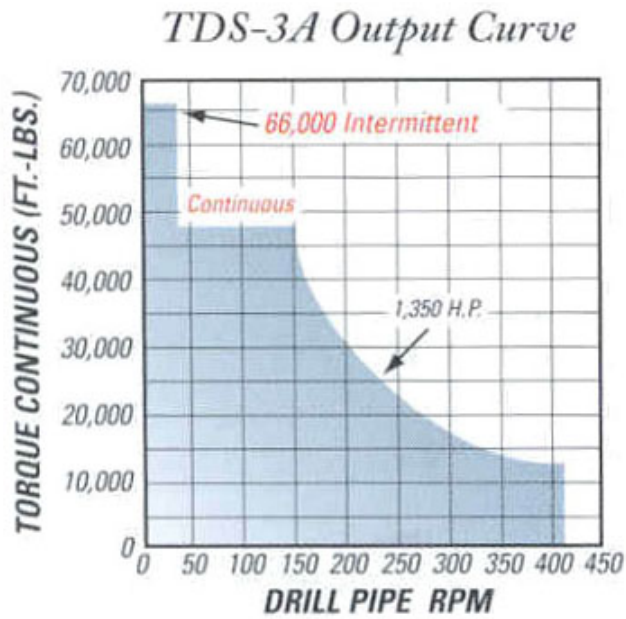


### - Characteristics of Top Drive VARCO

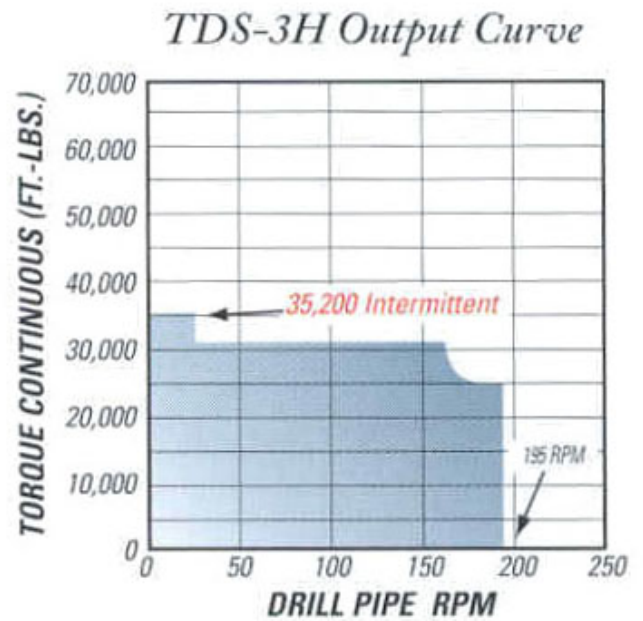
| Top Drive Model  | API Hoisting Capacity | Horsepower | Continuous Torque | Intermittent Torque | Pipe Handler | Drill Pipe Sizes |
|------------------|-----------------------|------------|-------------------|---------------------|--------------|------------------|
| TDS-3A           | 500 Ton               | 1350       | 47,000            | 66,000              | 60d          | 3-1/2" to 5"     |
| TDS-3H           | 500 Ton               | 1150       | 31,000            | 35,200              | 60d          | 3-1/2" to 5"     |
| TDS-4H           | 500 Ton               | 1150       | 46,380            | 61,800              | 60d          | 3-1/2" to 5"     |
| TDS-5            | 500 Ton               | 1150       | 33,000            | 38,700              | 60d          | 3-1/2" to 5"     |
| TDS-5H           | 500 Ton               | 1150       | 38,700            | 43,900              | 60d          | 3-1/2" to 5"     |
| TDS-5H (650 Ton) | 650 Ton               | 1150       | 38,700            | 43,900              | 85           | 3-1/2" to 6-5/8" |



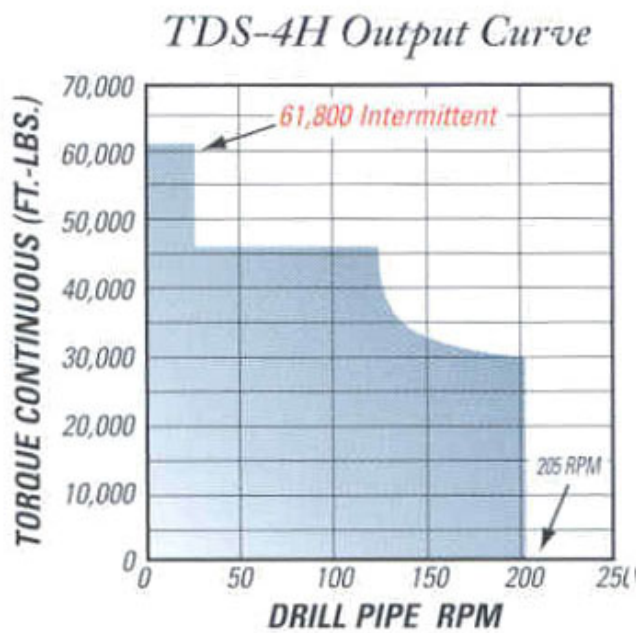
- TDS-3A Output Curves



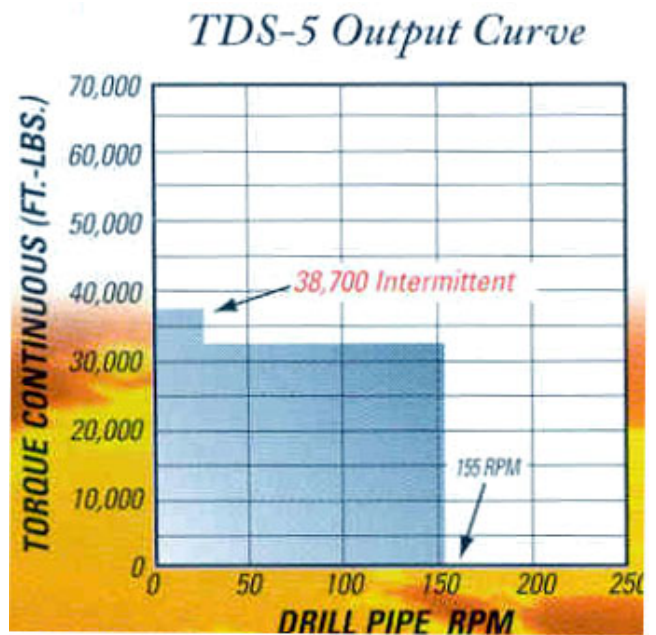
- TDS-3H Output Curves



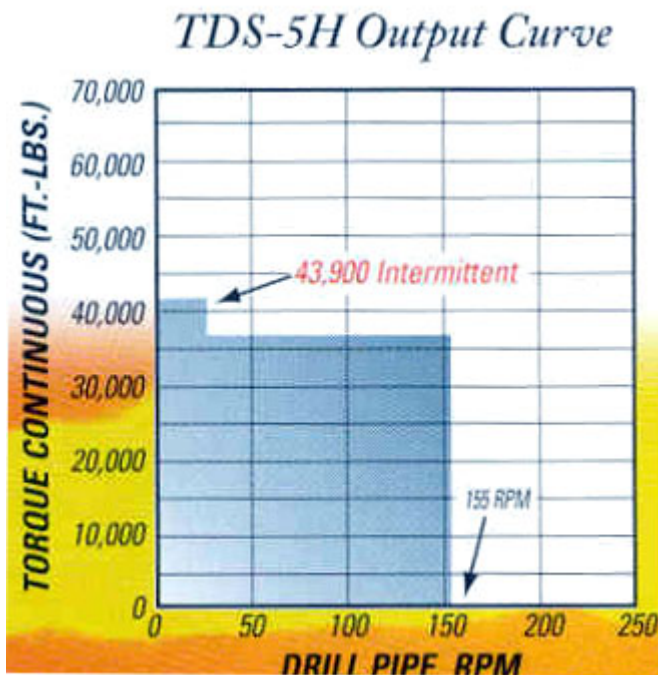
- TDS-4H Output Curves



- TDS-5 Output Curves



- TDS-5H Output Curves



Features of Top Drive VARCO

- Features IDS-1 TDS-4H TDS-4S TDS-6S

| Features                              | IDS-1                                        | TDS-4H, TDS-4S                                       |                                                    | TDS-6S                                               |        |        |
|---------------------------------------|----------------------------------------------|------------------------------------------------------|----------------------------------------------------|------------------------------------------------------|--------|--------|
| Application:                          | ■ Jack-ups, Platforms, Barges and Land Rigs  | ■ All offshore Rigs, Barges and Large Land Rigs      |                                                    | ■ Large Offshore Rigs                                |        |        |
| Motor:                                | GE 752 Shunt Hi-Torque DC Motor, 1100 HP     |                                                      | GE 752 Series or Shunt Hi-Torque DC Motor, 1130 HP |                                                      |        |        |
| API Hoisting Capacity:                | 500 ton                                      | 500, 650 or 750 ton                                  |                                                    | 750 ton                                              |        |        |
| Dolly Sizing:<br>(setback x spacing)* | Guide track setback<br>33-3/4" or 41"        | Swing /<br>Non-Swing                                 | Retract /<br>Non-Retract                           | 101" x 108" Retract or<br>Non-Retract                |        |        |
|                                       |                                              | 30 x 72<br>32 x 72<br>39 x 66<br>48 x 62             | 91 x 108                                           |                                                      |        |        |
| Pipe Handler:                         | PH-60d<br>(60,000 lb. ft. torque)            |                                                      | PH-85 (85,000 lb. ft. torque)                      |                                                      |        |        |
| Drill Pipe Sizes:                     | 3-1/2" to 5"<br>(4" to 6-5/8" OD Tool Joint) | 3-1/2" to 6-5/8"<br>(4-5/8" to 8-1/4" OD Tool Joint) |                                                    | 3-1/2" to 6-5/8"<br>(4-5/8" to 8-1/4" OD Tool Joint) |        |        |
| Stack Up Height:                      | 22.8 ft. (6.9M)                              | TDS-4H:<br>26.2 ft. (7.9 M)**                        | TDS-4S:<br>20.8 ft. (6.3 M)                        | 23.0 ft. (7.0 M)                                     |        |        |
| System Output:<br>Torque (lb. ft.)    | Shunt                                        | Series                  Shunt                        |                                                    | Shunt                                                |        |        |
|                                       |                                              | Hi                                                   | Lo                                                 | Hi                                                   | Lo     |        |
| Continuous                            | 34,900                                       | 32,500                                               | 50,900                                             | 29,640                                               | 46,380 | 60,000 |
| Intermittent                          | 38,800                                       | 43,400                                               | 67,800                                             | 39,500                                               | 61,800 | 84,200 |
| Maximum RPM @ Full Power              | 173                                          | 190                                                  | 120                                                | 205                                                  | 130    | 195    |



- Features TDS-10SA TDS-11SA

| Features                                     | TDS-10SA                                                 | TDS-11SA                                       |
|----------------------------------------------|----------------------------------------------------------|------------------------------------------------|
| <b>Application:</b>                          | ■ Medium and Small Land Rigs,<br>Platform Rigs, Jack-Ups |                                                |
| <b>Motor:</b>                                | Reliance Electric<br>AC Motor, 350 HP                    | Reliance Electric Dual AC Motor,<br>2 x 400 HP |
| <b>API Hoisting<br/>Capacity:</b>            | 250 ton                                                  | 500 ton                                        |
| <b>Dolly Sizing:</b><br>(setback x spacing)* | 21.5" Guide Track Setback                                | 30" or 33-3/4"<br>Guide Track Setback          |
| <b>Pipe Handler:</b>                         | PH-50 (55,000 lb. ft. torque)                            |                                                |
| <b>Drill Pipe Sizes:</b>                     | 2-7/8" to 5"<br>(4" to 6-5/8" OD Tool Joint)             | 3-1/2" to 5"<br>(4" to 6-5/8" OD Tool Joint)   |
| <b>Stack Up Height:</b>                      | 15.3 ft. (4.7 M)                                         | 18 ft. (5.4 M)                                 |
| <b>System Output:<br/>Torque (lb. ft.)</b>   | Standard      High Speed                                 | Standard                                       |
| <b>Continuous</b>                            | 20,000      7,400                                        | 37,500                                         |
| <b>Intermittent</b>                          | 36,500      13,390                                       | 55,000                                         |
| <b>Maximum RPM @ Full Power</b>              | 182      240                                             | 228                                            |

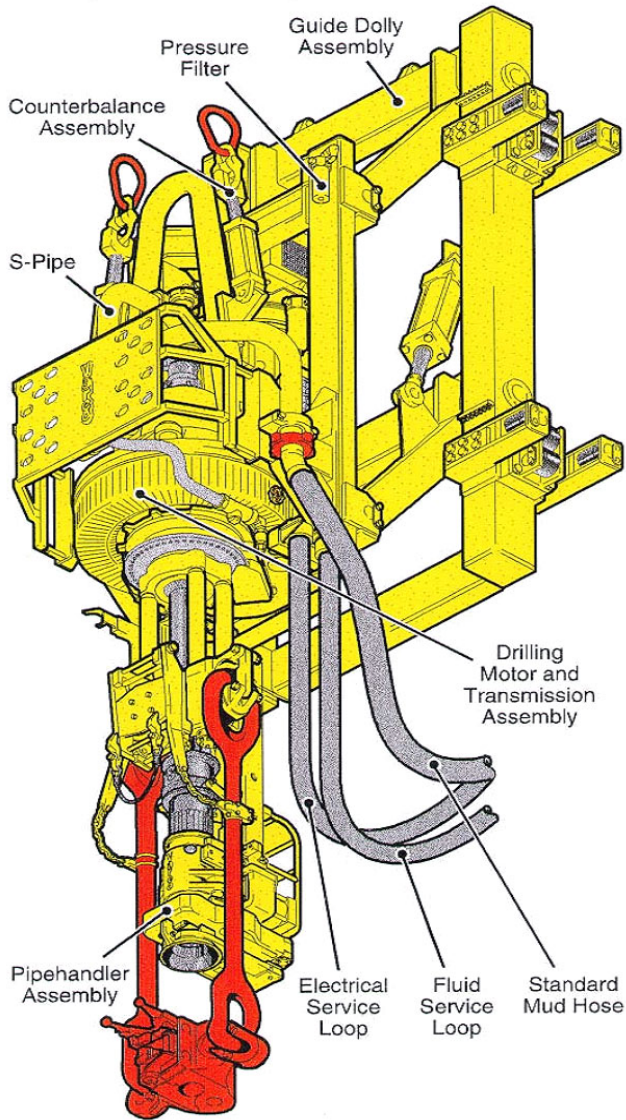
- Features TDS-8SA

| <b>Features</b>                              |  | <b>TDS-8SA</b>                                                                         |                       |
|----------------------------------------------|--|----------------------------------------------------------------------------------------|-----------------------|
| <b>Application:</b>                          |  | <ul style="list-style-type: none"> <li>■ All Offshore Rigs, Large Land Rigs</li> </ul> |                       |
| <b>Motor:</b>                                |  | GE GEB-20A1 AC Motor, 1150 HP                                                          |                       |
| <b>API Hoisting Capacity:</b>                |  | 750 ton                                                                                |                       |
| <b>Dolly Sizing:</b><br>(setback x spacing)* |  | Swing / Non-Swing                                                                      | Retract / Non-Retract |
|                                              |  | 30 x 72                                                                                | 91 x 108              |
|                                              |  | 32 x 72                                                                                |                       |
|                                              |  | 39 x 66                                                                                |                       |
|                                              |  | 48 x 62                                                                                |                       |
| <b>Pipe Handler:</b>                         |  | PH-100<br>(100,000 lb. ft. torque)                                                     |                       |
| <b>Drill Pipe Sizes:</b>                     |  | 3-1/2" to 6-5/8"<br>(4" to 8-5/8" OD Tool Joint)                                       |                       |
| <b>Stack Up Height:</b>                      |  | 20.8 ft. (6.3 M)                                                                       |                       |
| <b>System Output:</b>                        |  |                                                                                        |                       |
| <b>Torque (lb. ft.)</b>                      |  |                                                                                        |                       |
| <b>Continuous</b>                            |  | 63,000                                                                                 |                       |
| <b>Intermittent</b>                          |  | 94,000                                                                                 |                       |
| <b>Maximum RPM @ Full Power</b>              |  | 188                                                                                    |                       |

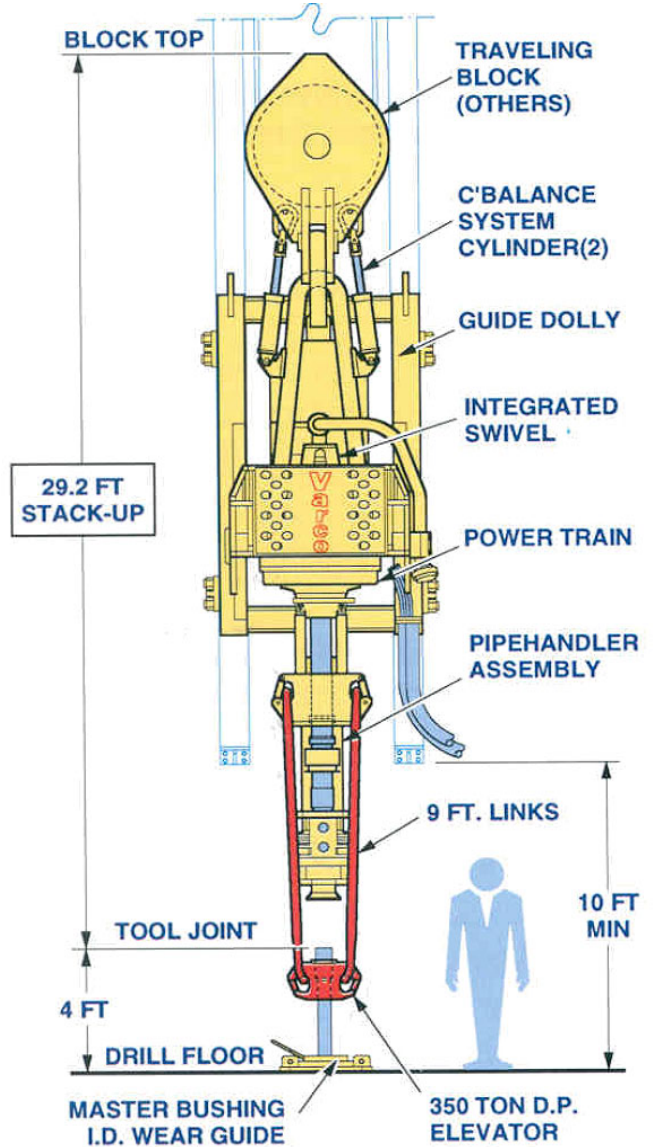


### 18.3 TOP DRIVE COMPONENTS

#### - Top Drive Components



#### - Nomenclature



#### Top Drive Components

1. Counterbalance System
2. Guide Dolly Assembly
3. Motor Housing & Swivel Assembly
4. Pipe Handler
5. Top Drive Control System
6. Top Drive Auxiliary Tools



## 1. Counterbalance System

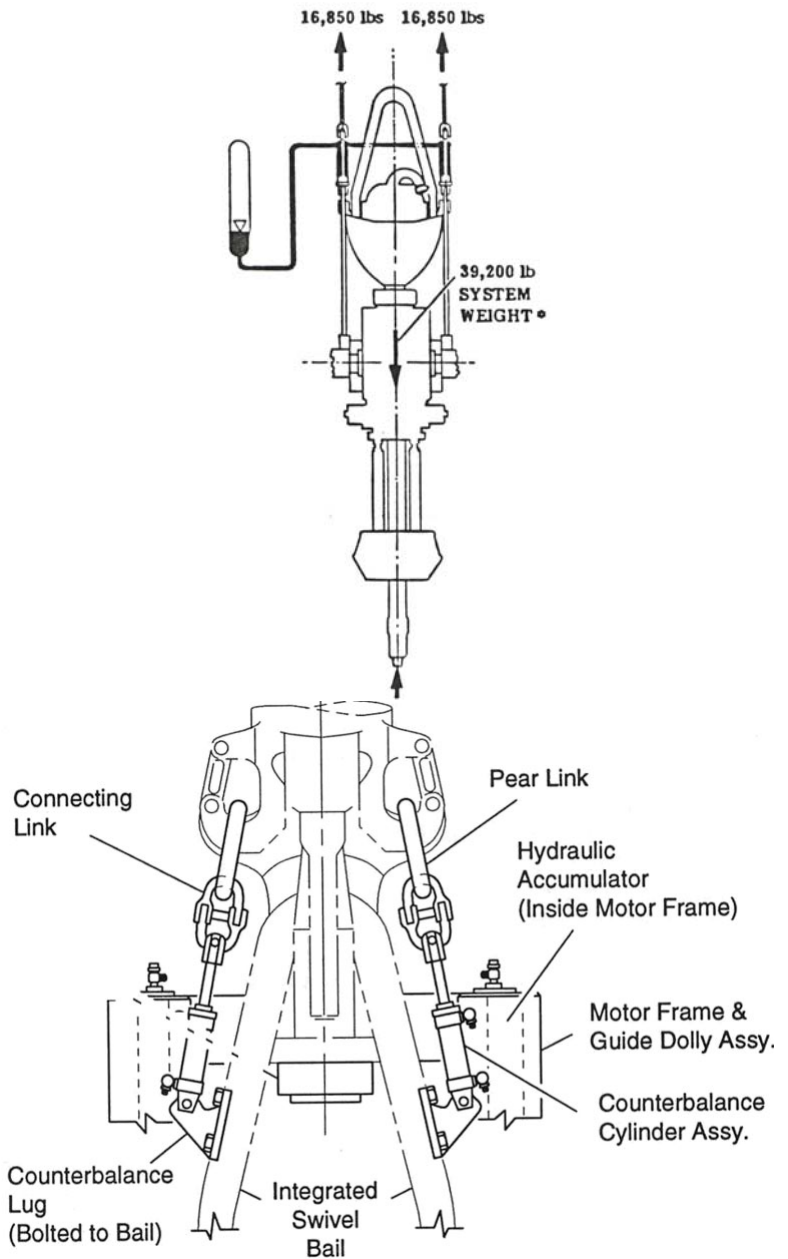
A Counterbalance system offsets the weight of the TDS and provides a soft landing when TDS stabs into or out of the joint when making a connection.

This prevents damage to the tool joint threads.

To do this, Hydraulic cylinder connect the Swivel Bail and the elevator ear portion of the hook body.

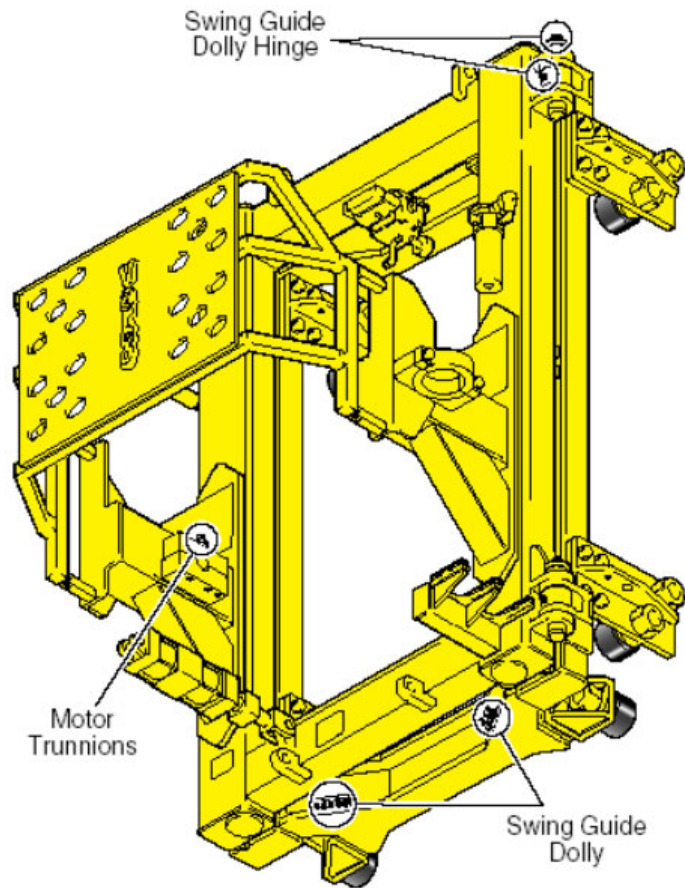
### - Components

2. Guide Dolly Assembly
3. Motor Housing & Swivel Assembly
4. Pipe Handler
5. Top Drive Control System
6. Top Drive Auxiliary Tools



## 2. Guide Dolly Assembly

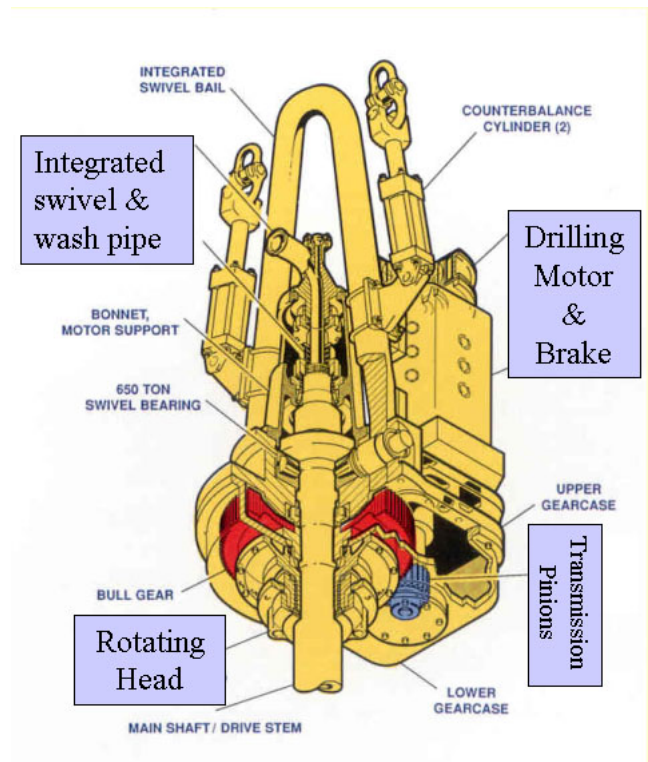
The Guide Dolly assembly transmits the drilling torque reaction to the Guide Rails and can provide a method for setting the entire unit aside for maintenance or to allow rig operation without the TDS if necessary.



## 3. Motor Housing & Swivel Assembly

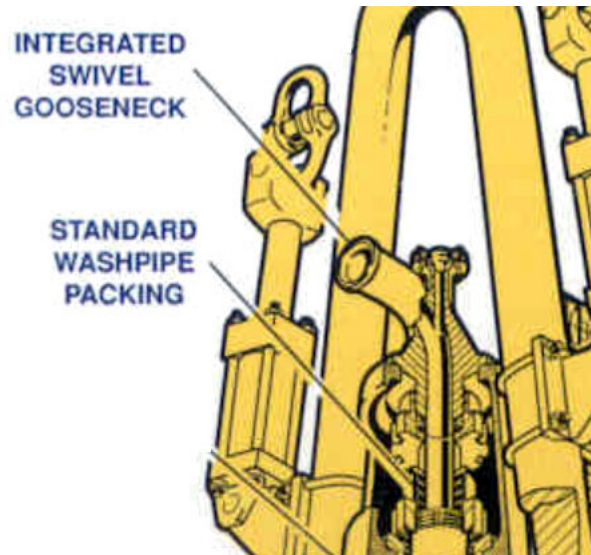
Consists of:

- Integrated swivel & wash pipe
- Drilling Motor & Brake
- Transmission Pinions
- Rotating Head



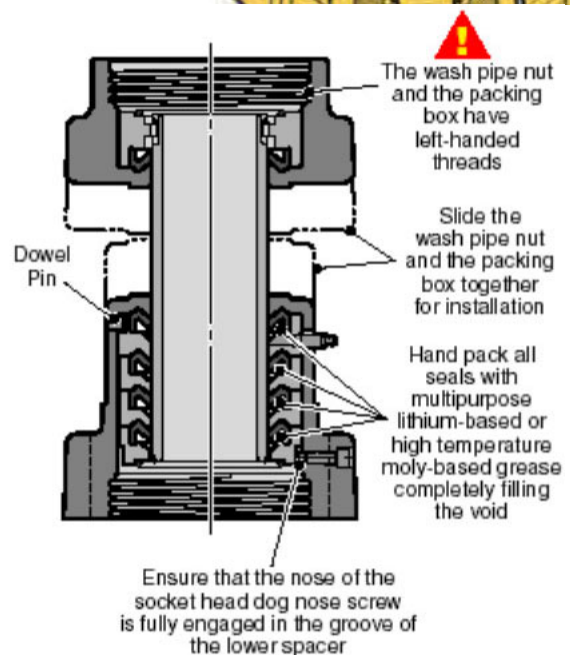
### a. Integrated Swivel & Wash Pipe

The Integrated Swivel is a bearing assembly that allows transfer of the rotating load to the lifting components.



- The Swivel Wash pipe is a rotating seal that allows mud to flow to the rotating drill string.

Working pressure is usually 5000 or 7500 psi.



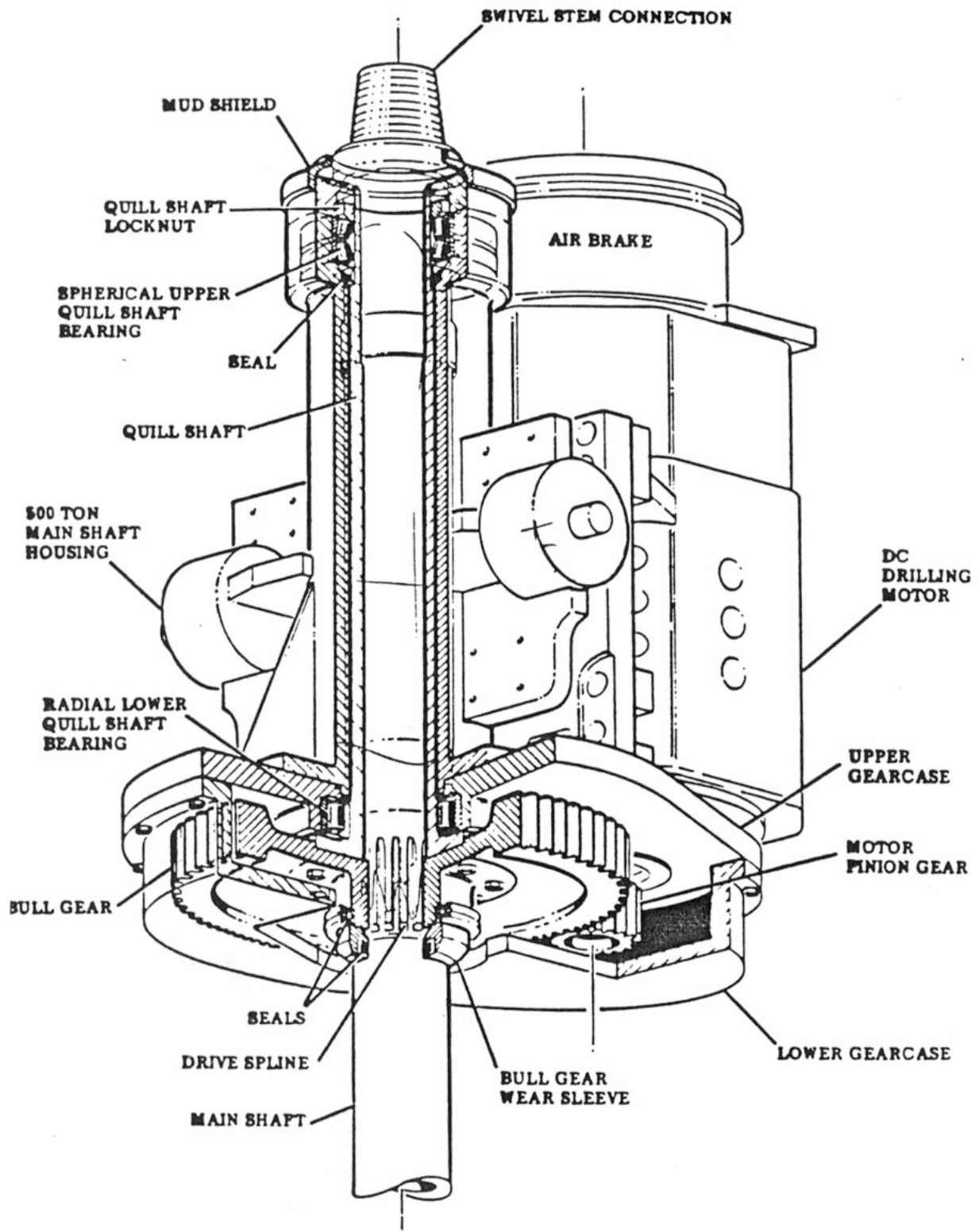
### b. Drilling Motor & Brake

DC drilling motor used is essentially the same as those used elsewhere on a drilling rig to power the drawworks, mud pumps and rotary table, with same modifications:

1. A double ended armature shaft is provided to permit the attachment of an air brake.
2. Special bearings are installed to allow the motor to operate in a vertical orientation.

The shaft extension on the commutator end of the motor is used to attach an Airflex 16VC600 air brake that with 90 psi air pressure gives 35.000 ftlbs brake torque.

Drilling Motor & Brake



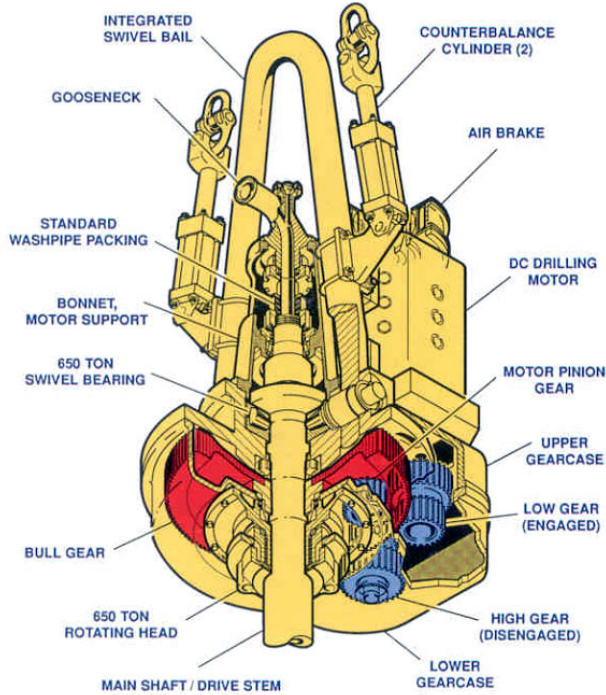


### c. Transmission Gear

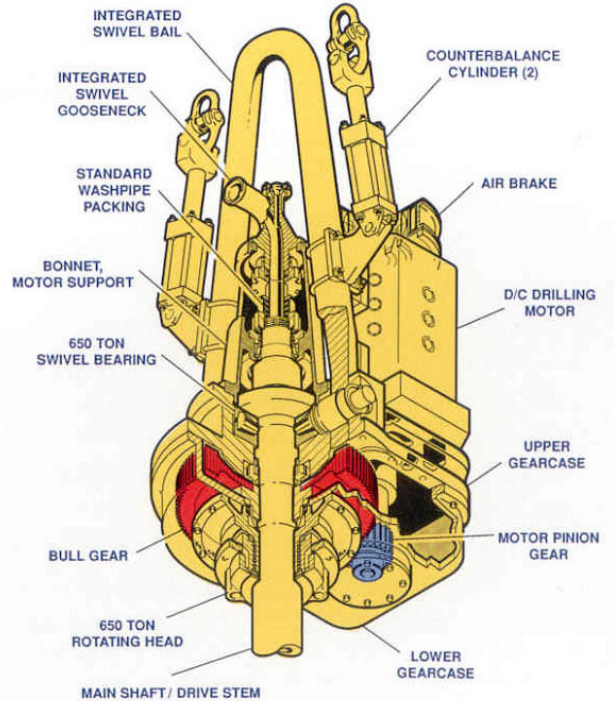
Depends on the model of TDS

- Transmission Gear: Two speeds
- Transmission Gear: One speed

- Transmission Gear: Two speeds

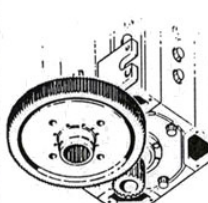
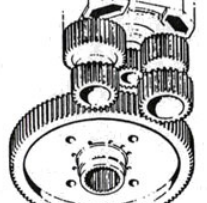


- Transmission Gear: One speed



- Example of Torque data of Varco Top Drive

### MAXIMUM CONTINUOUS TORQUE (FT-LB)

| TDS MODEL<br>(GEAR RATIO)   | TDS-3<br>(5.33:1)                                                                    |  | TDS-4<br>(HI-5.08:1) (LO-7.95:1)                                                      |        |
|-----------------------------|--------------------------------------------------------------------------------------|--|---------------------------------------------------------------------------------------|--------|
|                             |  |  |  |        |
| MOTOR TYPE                  |                                                                                      |  |                                                                                       |        |
| GE 752 UP SHUNT WOUND       | 26,400                                                                               |  | 24,800                                                                                | 38,700 |
| GE 752 US HI-TORQUE SHUNT   | 31,000                                                                               |  | 29,100                                                                                | 45,500 |
| GE 752 AUP SERIES WOUND     | 27,800                                                                               |  | 26,100                                                                                | 40,900 |
| GE 752 AUT HI-TORQUE SERIES | 34,700                                                                               |  | 32,500                                                                                | 50,900 |
| EMD M89-VTS SERIES WOUND    | 30,200                                                                               |  | 28,300                                                                                | 44,300 |

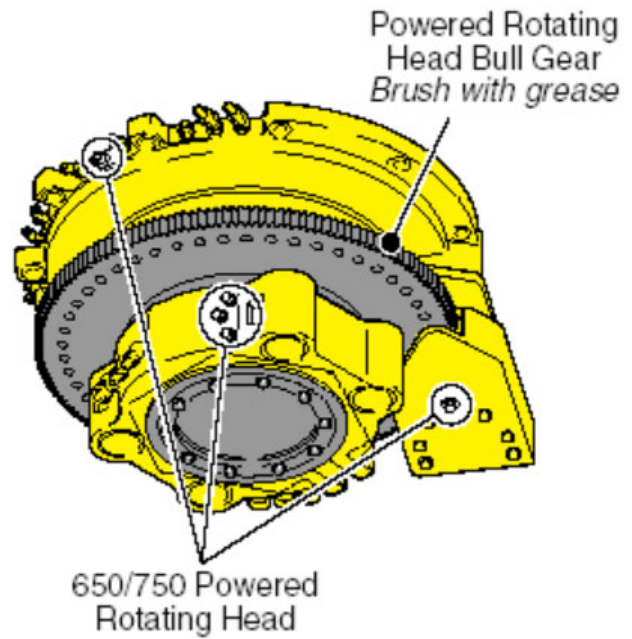


#### d. Rotating head

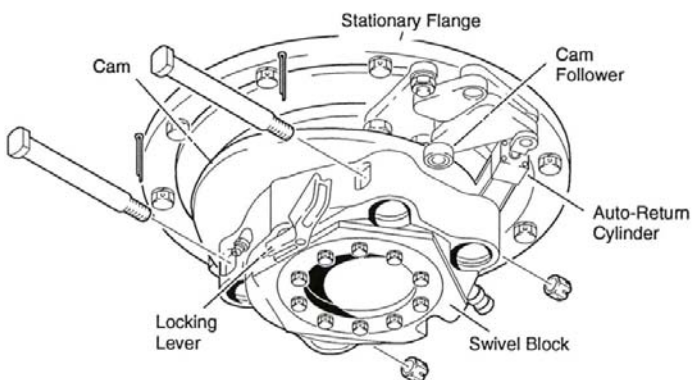
The rotating head allows the pipe handler to rotate on the Top Drive.

It can be locked in 2 positions:  
180° and 360°.

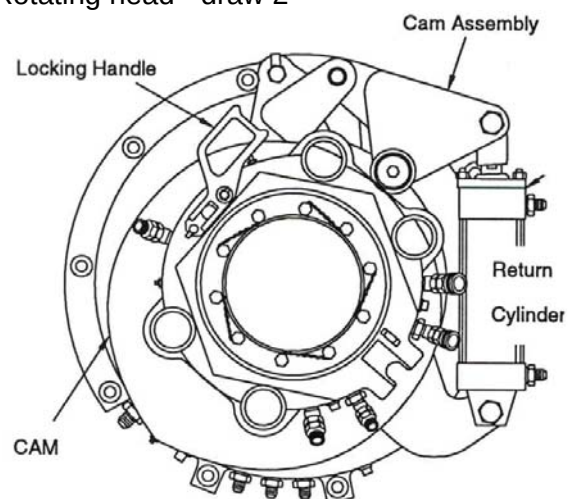
- Rotating head - draw 1
- Rotating head - draw 2



Rotating head - draw 1



Rotating head - draw 2



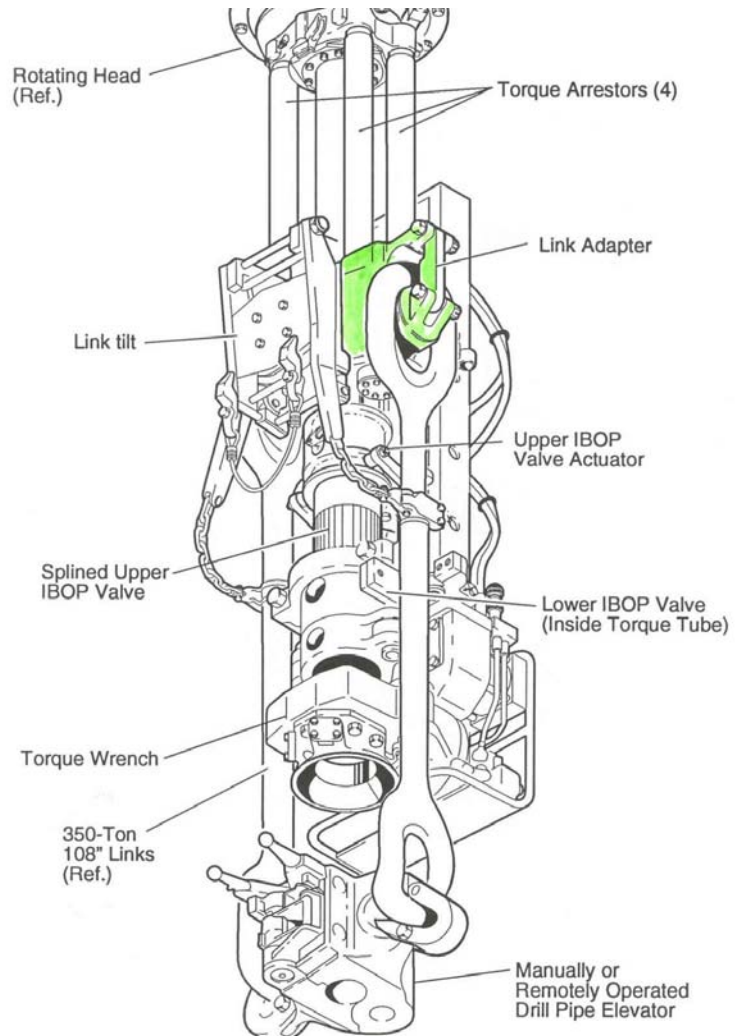
#### 4. Pipe Handler

The pipe handler has 2 main function:

- Tripping 93 foot stands
- Providing torque for make up and break out of connections (at any height in the derrick)

The main components are:

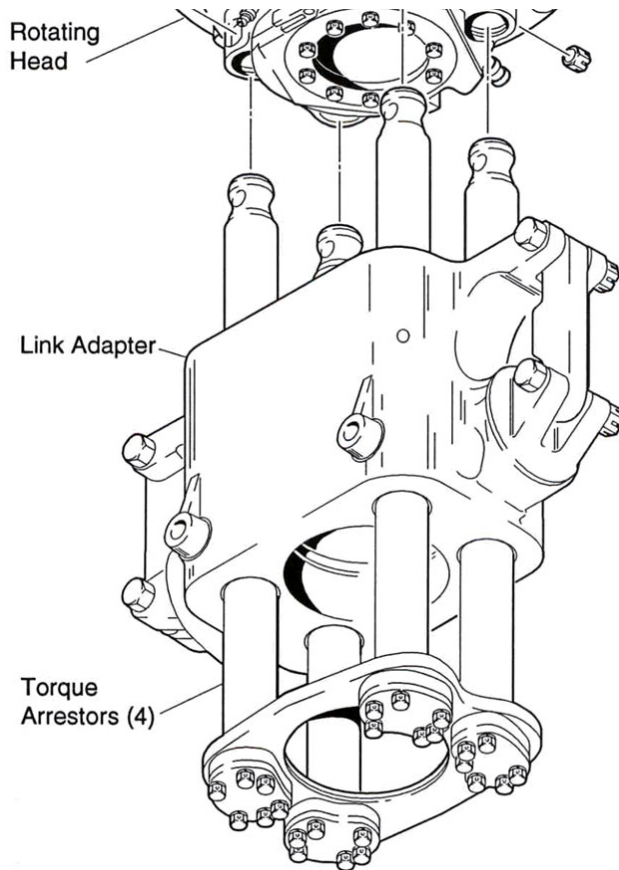
- a. Link Adapter
- b. Safety valves and Actuator
- c. Torque Wrench
- d. Link Tilt
5. Top Drive Control System
6. Top Drive Auxiliary Tools



### a. Link Adapter

The link adapter transfers the hoisting loads to the drive stem.

The 4 torque arrestors avoid the elevator rotation and shift 2 ft when the elevators touch the rig floor.

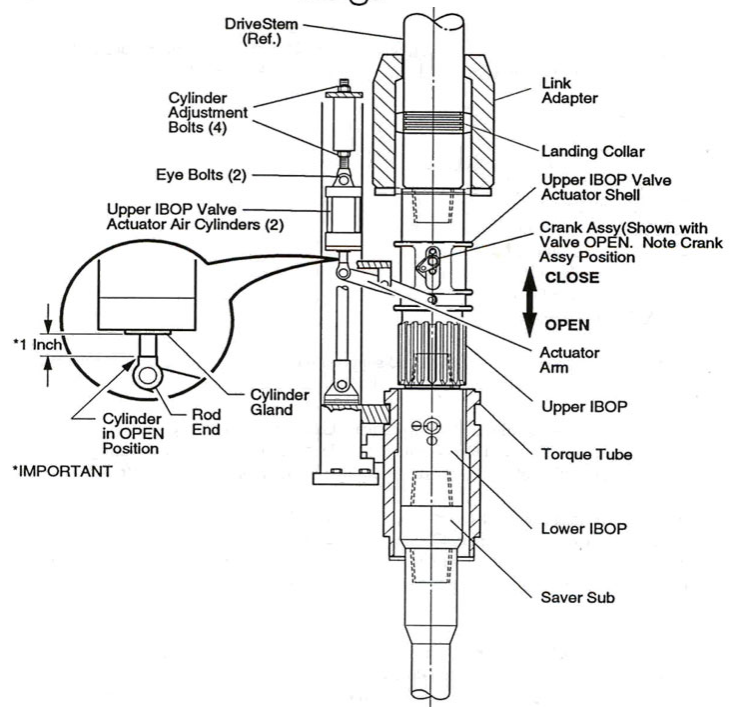


### b. Safety valves & Actuator

There are 2 safety valves on a TDS:

One manual and one remote controlled.

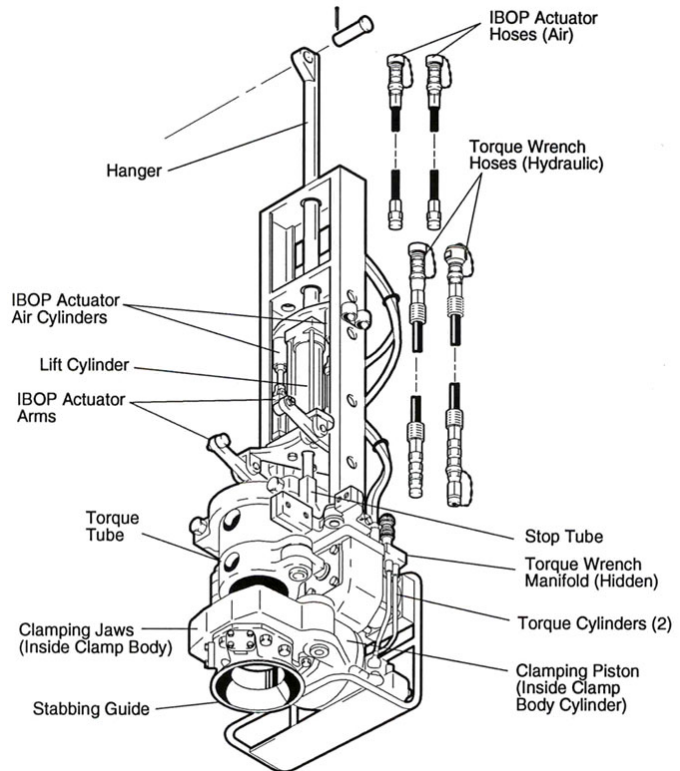
- VARCO remote operated safety valve
- HYDRIL remote operated safety valve
- Kellyguard Valve actuator



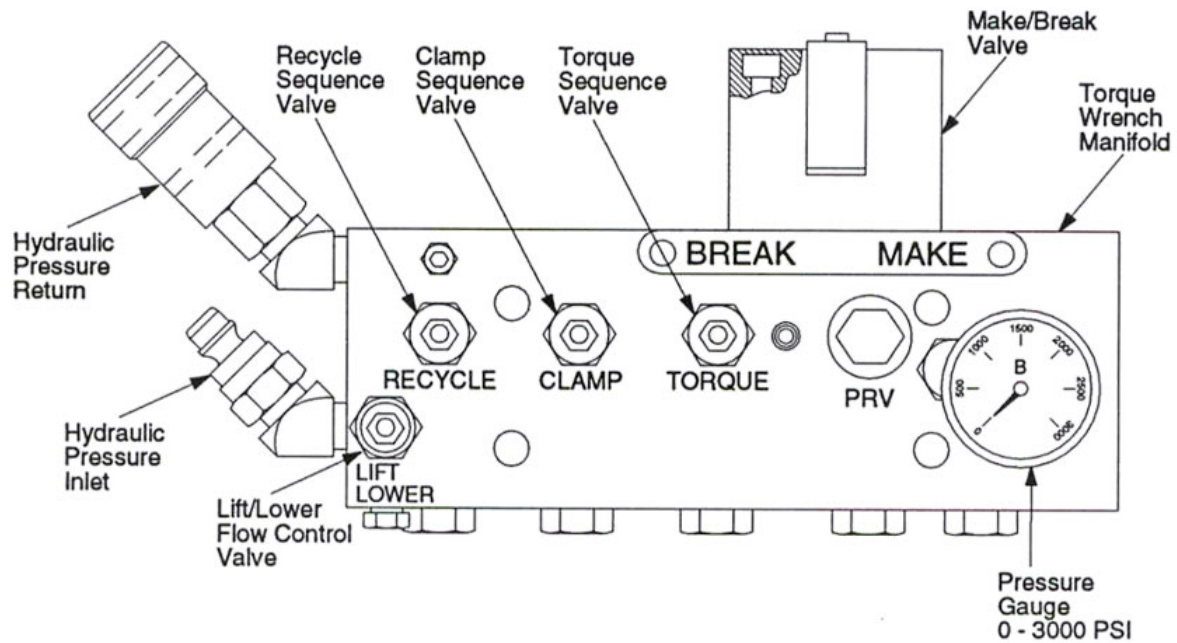
### c. Torque Wrench

The torque wrench has a clamping Jaw for standard tool joints from 5 " to 7 3/8". Different size can also be handled.

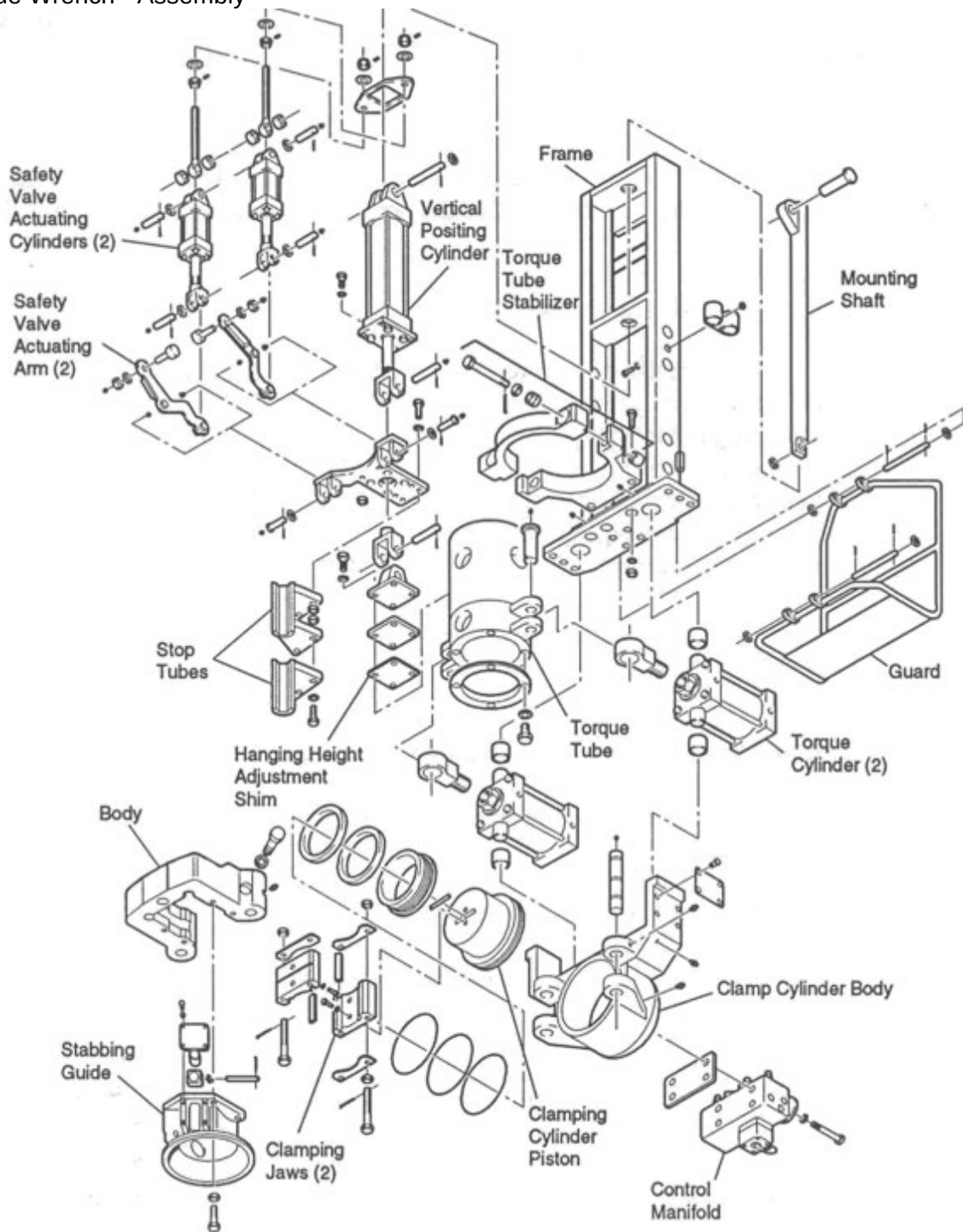
#### - Torque Wrench Assembly



#### - Torque Wrench Control manifold



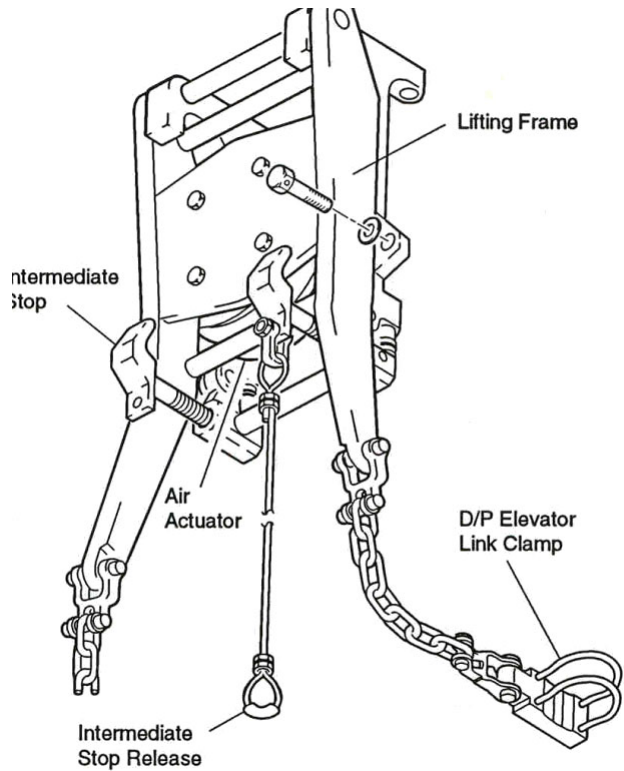
# Torque Wrench - Assembly





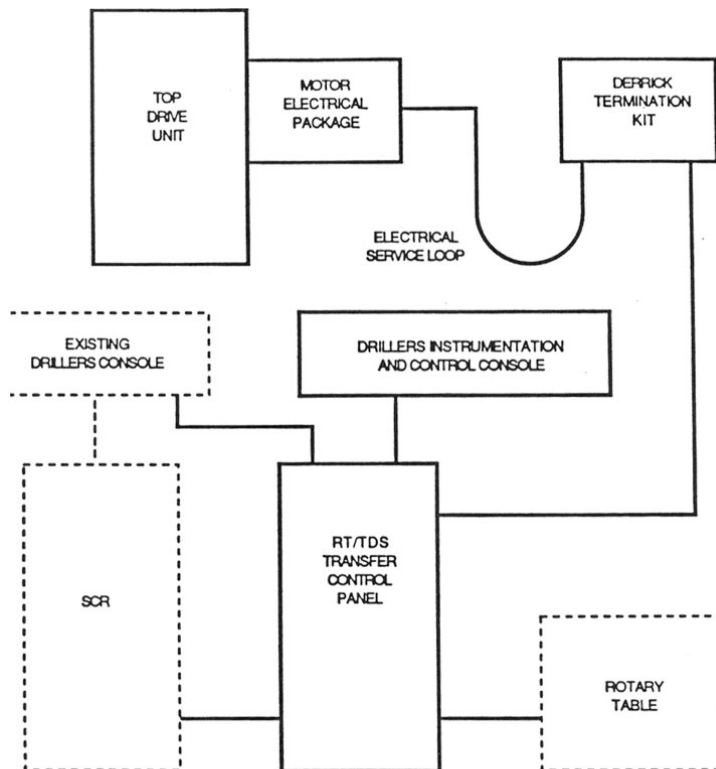
#### d. Link Tilt

The link tilt allows the elevators to move off of well center to pick up a joint from the mousehole. It also helps the derrickman to handle pipe more easily

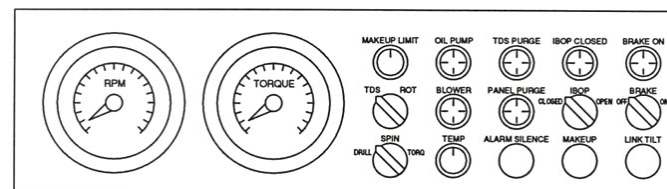


#### 5. Top Drive Control System

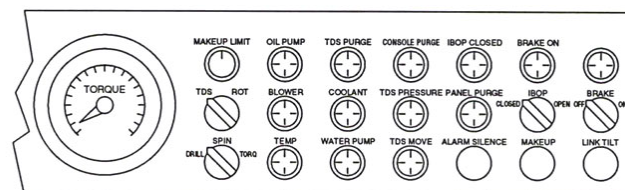
- Scheme: Top Drive Control system



- Control panel

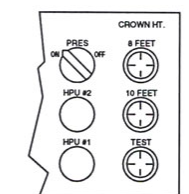


STANDARD CONTROL CONSOLE



CLOSED LOOP COOLING CONTROL CONSOLE

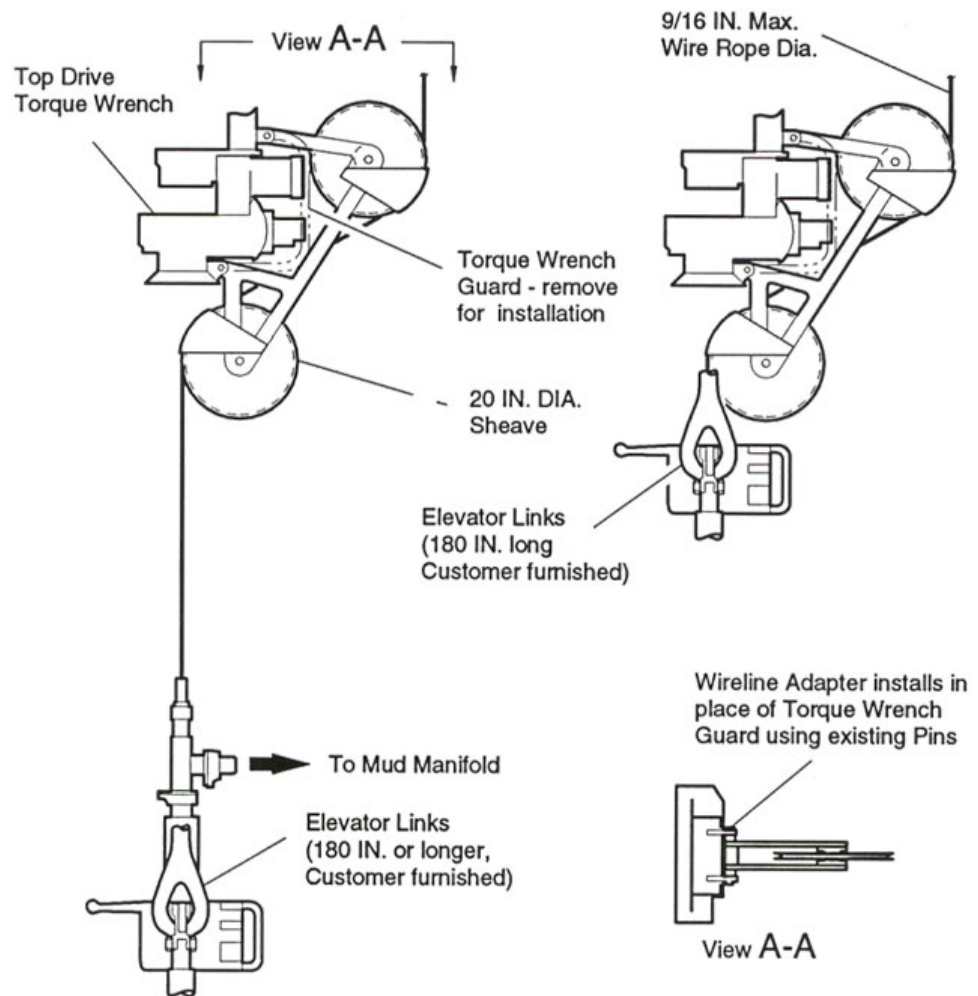
- POTENTIOMETER
- INDICATOR LIGHT
- SELECTOR SWITCH
- PUSH BUTTON SWITCH



OPTIONAL CONTROL CONSOLE

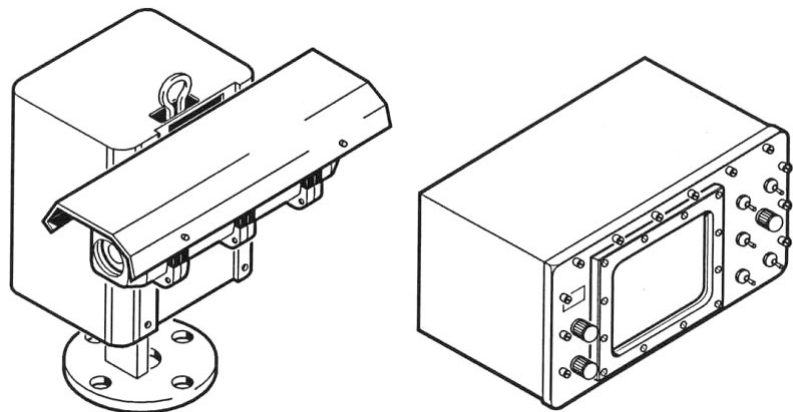
## 6. Top Drive Auxiliary Tools

### - Wireline Adapter tool



### - TV camera system

It's a system with one or more cameras installed at different level of Derrick to allow the driller to monitor the operations .



## 18.4 INSPECTIONS

TOP DRIVE system, as with traditional hoisting equipment, must be checked and inspected periodically as per the manufacturer's recommendations and API RP 8B or related ISO (International Organization for Standardization) 13534.  
ENI policy requires the Category IV inspection (as per API RP 8B and ISO 13534) every 5 years.

## 19. RIG FLOOR MUD MANIFOLD

### INDEX

#### 19.1 FUNCTION

#### 19.2 TYPES

#### 19.3 COMPONENTS

- Rotary Hose and Vibrator Hose
- Mud Valve
- Quick Unions
- Pressure Readings

### 19.1 FUNCTION

#### - Description

The mud manifold is composed of pipes and valves. It connects the high pressure mud pumps to the injection head in order to circulate the drilling mud down the DP.

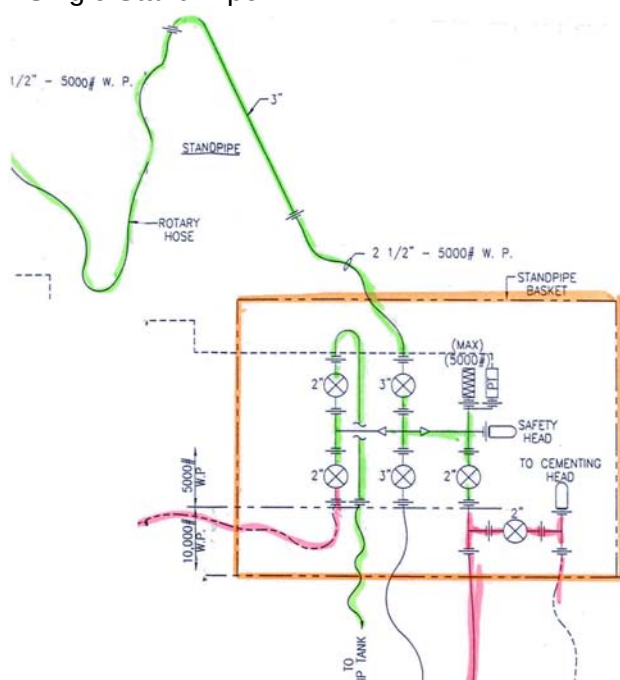
There are several outlets on the mud manifold to connect pressure transducer.

This allow the crew to monitor the "stand pipe pressure"

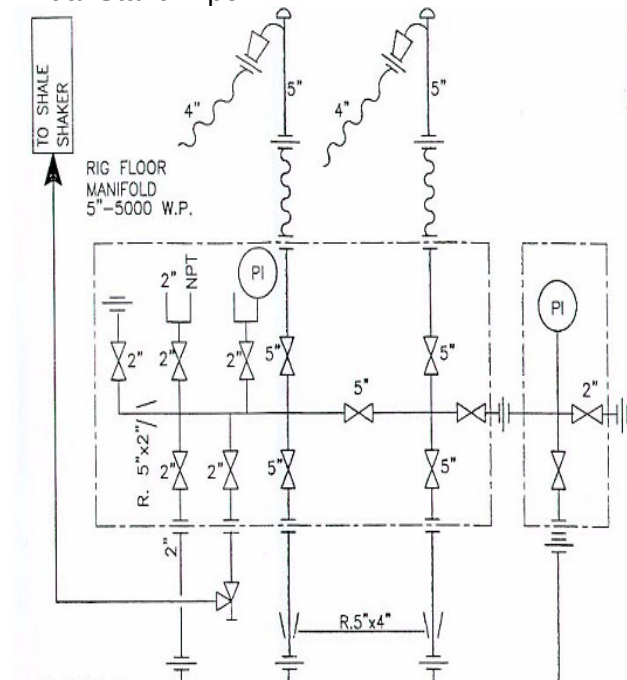


### 19.2 TYPES

#### - Single Stand Pipe

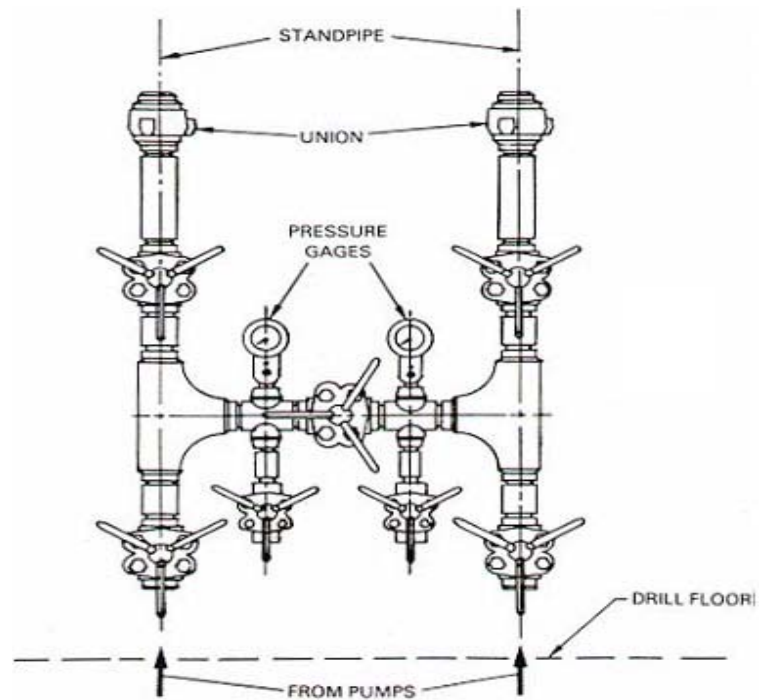


#### - Dual Stand Pipe

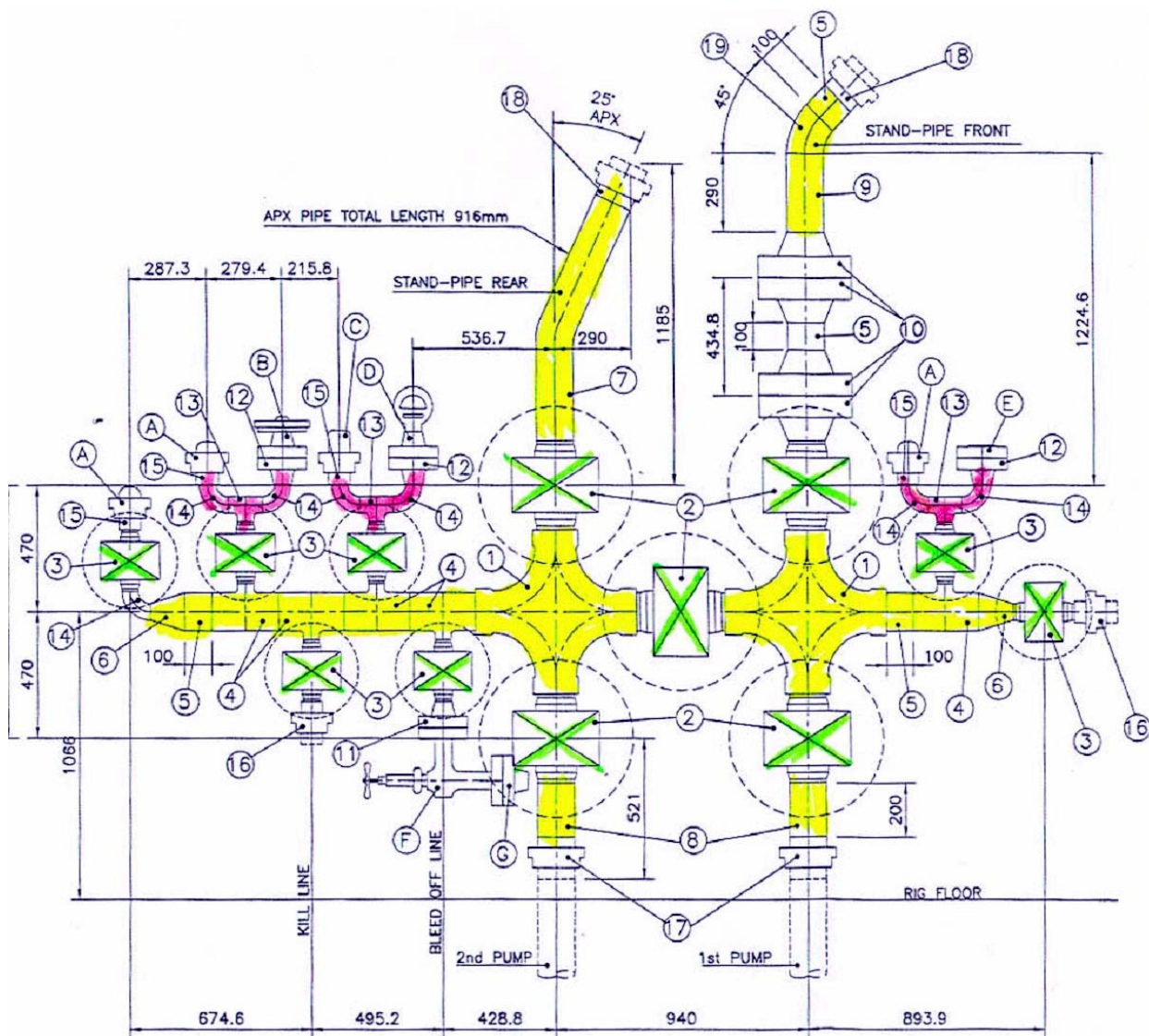




- Dual Stand Pipe  
5000 psi w.p. for  
Land Rig



- Dual Stand Pipe 7500 psi w.p. for Land Rig



### 19.3 COMPONENTS

1. Rotary Hose and Vibrator Hose
2. Mud Valve
3. Quick Unions
4. Pressure Readings

#### 1. Rotary Hose and Vibrator Hose

##### Definitions (API 7K)

- Rotary drilling hose

Rotary drilling hose is used as the flexible connector between the top of the standpipe and the swivel that allows for vertical travel.

It is usually used in lengths of 45 ft (13.7 m) and over.



- Rotary vibrator hoses

Rotary vibrator hoses are used as flexible connectors between the mud pump manifold and the standpipe manifold to accommodate alignment and isolate vibration.

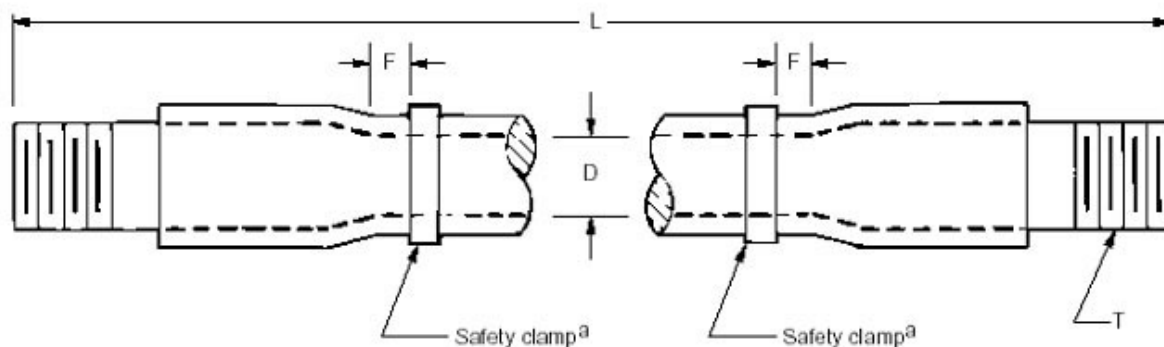
They are usually used in lengths of 30 ft (9.2 m) or less.





## Rotary Vibrator and Drilling Hose

### Dimensions and Pressures



| Size<br>Inside<br>Diam, in. D | Standard<br>Length, ft<br>L | Threads<br>(Line Pipe<br>Size, in.) | Working Pressure, psi |            |            |
|-------------------------------|-----------------------------|-------------------------------------|-----------------------|------------|------------|
|                               |                             |                                     | Grade<br>C            | Grade<br>D | Grade<br>E |
| 3<br>and<br>3 1/2             | 30                          | 4                                   | 4000                  | 5000       | 7500       |
|                               | 55                          | 4                                   | 4000                  | 5000       | 7500       |
|                               | 60                          | 4                                   | 4000                  | 5000       | 7500       |
|                               | 70                          | 4                                   | 4000                  | 5000       | 7500       |
|                               | 75                          | 4                                   | 4000                  | 5000       | 7500       |
| 4                             | 30                          | 5                                   |                       |            |            |
|                               | 55                          | 5                                   | 4000                  | 5000       | —          |
|                               | 60                          | 5                                   | 4000                  | 5000       | —          |
|                               | 70                          | 5                                   | 4000                  | 5000       | —          |
|                               | 75                          | 5                                   | 4000                  | 5000       | —          |

## 2. Mud Valve

### - Features

A gate valve uses a closing mechanism different than a ball valve. In the gate valve a blank plate is positioned across the flow path to halt fluid flow.

When the valve is opened, the plate is moved in a manner such that a section of the plate containing an orifice is positioned across the flow path which thus allows fluid movement through the orifice.

Gate and seat are easy changeable for re-dressing.



- Use and Connections Type

Valve dimension should be proportional to the flux speed. 20 ft/s (6 m/s) to limitate the wear.

Valves connections could be flanged, welded or threaded.

API rules are against threaded connections since 2" 5000 psi w.p.

ENI policy is against threaded connections on the mud manifold.

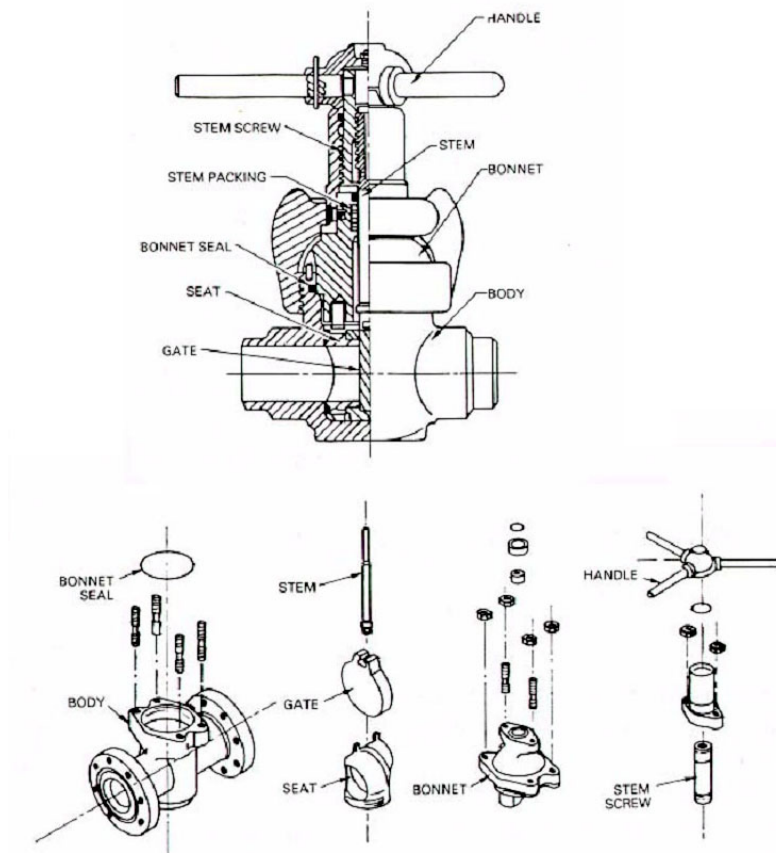
- Drawing, working pressure, dimensions

Nominal dimensions are referred to the nominal gauge of the line connected to the valve.

Most commons size are : 2 -3- 4- 5 -6 inch.

Working pressures are: 1.000, 2.000, 3.000, 5.000, 7.500 psi.

-Example of Valve component and assembly



### 3. Quick Unions

#### - Red Nut Blue Sub

These unions are available in 1 thru 4 inch 10,000-psi and 5 and 6 inch 7,500-psi NSCWP. These unions also have a resilient nitrile seal ring (5-inch and 6-inch have nitrile o-ring).

They are made from alloy steel and are used primarily by service companies in applications such as cementing, fracturing and acidizing.

Designed for high-pressure systems, including truck-mounted systems, Fig 1002 unions also are available as non-pressure seal unions, and in butt-weld.

Sch. 160 or XXH, or prepped for sour gas service.

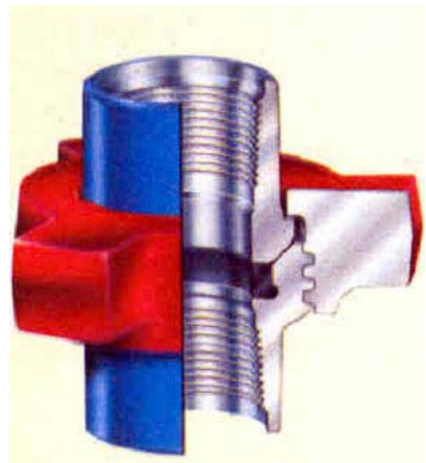
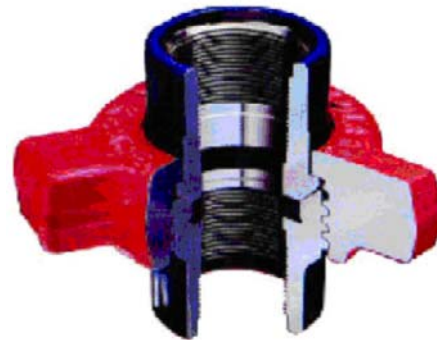
#### - **Figure 1002**; WP Use and Features

10,000 psi (960 bar) cold working pressure  
5- and 6-inch sizes butt weld only

Recommended service: Cementing, fracturing, acidizing, testing, and choke-and-kill lines

##### Features

- Replaceable, lip-type seal provides primary seal, protectors secondary metal-to-metal seal, minimizes flow turbulence.
- O-ring seal on 5- and 6-inch sizes
- Available for sour gas service: 7,500 psi (517 bar) cold working pressure



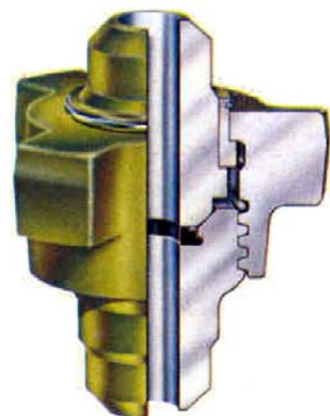
#### - **Figure 1202**: WP Use and Features

15,000 psi (10034 bar) cold working pressure

Recommended service: Especially designed for sour gas service

##### Features

- Meets National Association of Corrosion Engineers Standard MR-01-75 and American Petroleum Institute RP-14E.
- Heat-treated components 100 percent tested for hardness
- Fluoroelastomer seal rings

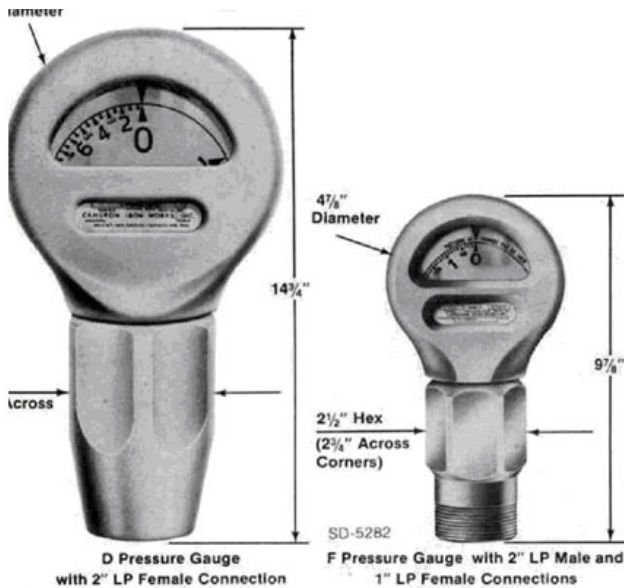


#### - Pipes

- Quick Unions Pipes
- Quick Unions Pipes Use
- Quick Unions Pipes Fittings

#### 4. Pressure Readings

##### - Pressure gauge



D PRESSURE GAUGE PART NUMBERS

| Pressure Range           | Standard Service | Salt Water Service | Corrosive Fluid |
|--------------------------|------------------|--------------------|-----------------|
| 0-1000 psi               | 2559-01          | 19965-01           | 19990-01        |
| 0-3000 psi               | 2559-03          | 19965-03           | 19990-03        |
| 0-5000 psi               | 2559-05          | 19965-05           | 19990-05        |
| 0-6000 psi               | 2559-06          | 19965-06           | 19990-06        |
| 0-70 kg/cm <sub>2</sub>  | 2559-02          | 19965-02           | 19990-02        |
| 0-150 kg/cm <sub>2</sub> | 2559-11          | 19965-11           | 19990-11        |
| 0-210 kg/cm <sub>2</sub> | 2559-04          | 19965-04           | 19990-04        |
| 0-350 kg/cm <sub>2</sub> | 2559-07          | 19965-07           | 19990-07        |
| 0-70 atm                 | 2559-10          | 19965-10           | 19990-10        |
| 0-150 atm                | 2559-08          | 19965-08           | 19990-08        |
| 0-210 atm                | 2559-09          | 19965-09           | 19990-09        |
| 0-350 atm                | 2559-12          | 19965-12           | 19990-12        |
| Shipping Wt              | 24 lb            | 48 lb              | 48 lb           |

##### - Pressure transducers

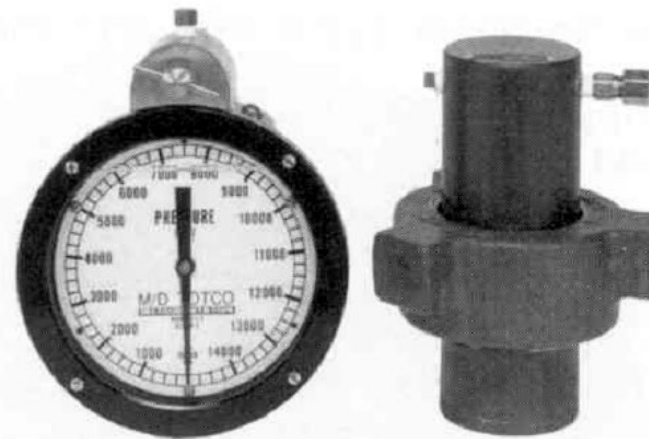
- Provides quick, accurate check on mud pump operation; helps detect washed out drill pipe or bit nozzle problems
- Indicator gauges can be mounted in the weight indicator box, driller's console, or locally on the mud pump
- Full 360 dial calibration for maximum pointer movement; shows the smallest pressure changes.
- Fluid filled gauge has large easy-to-read 6" dial face and high pressure damper adjust.
- Rugged E17-152 Diaphragm Protector mounts with 2" NPT sb
- Hose lengths to 50 feet are standard; longer lengths available in some pressure ranges.

Standard Capacity include:

3,000 5,000 6,000 10,000 and 15,000 psi

210 350 420 700 and 1,000 kg/cm<sub>2</sub>

21 35 42 70 100 MPa





## 20. MUD PUMPS

### INDEX

#### HIGH PRESSURE MUD PUMPS

##### 20.1 PRINCIPLES

##### 20.2 NOMENCLATURE

##### 20.3 TYPES AND CHARACTERISTICS

##### 20.4 ACCESSORIES

##### 20.5 FLOW RATE AND EFFICIENCY CALCULATION

##### 20.6 POWER AND EFFICIENCY CALCULATION

#### LOW PRESSURE MUD PUMPS (Centrifugal Pump)

##### 20.7 FUNCTION

##### 20.8 NOMENCLATURE

##### 20.9 PUMP PERFORMANCE CURVES

### HIGH PRESSURE MUD PUMPS

#### 20.1 PRINCIPLES

##### - Duplex Pump / Triplex pump

Hi-pressure mud pumps:

In a **Duplex Pump** the piston discharges mud on one side of the piston and at the same time takes mud in on other side.

In a **Triplex pump** the piston discharges mud only when it moves forward in the liner.

In the Oilfield, duplex pumps have been replaced by triplex pumps.

Triplex pumps of the same power, are smaller and lighter than duplex pumps.

They also provide an uniform flow.





## 20.2 NOMENCLATURE

Pistons are moved with a shaft by an **electrical engine** or a **diesel engine**.

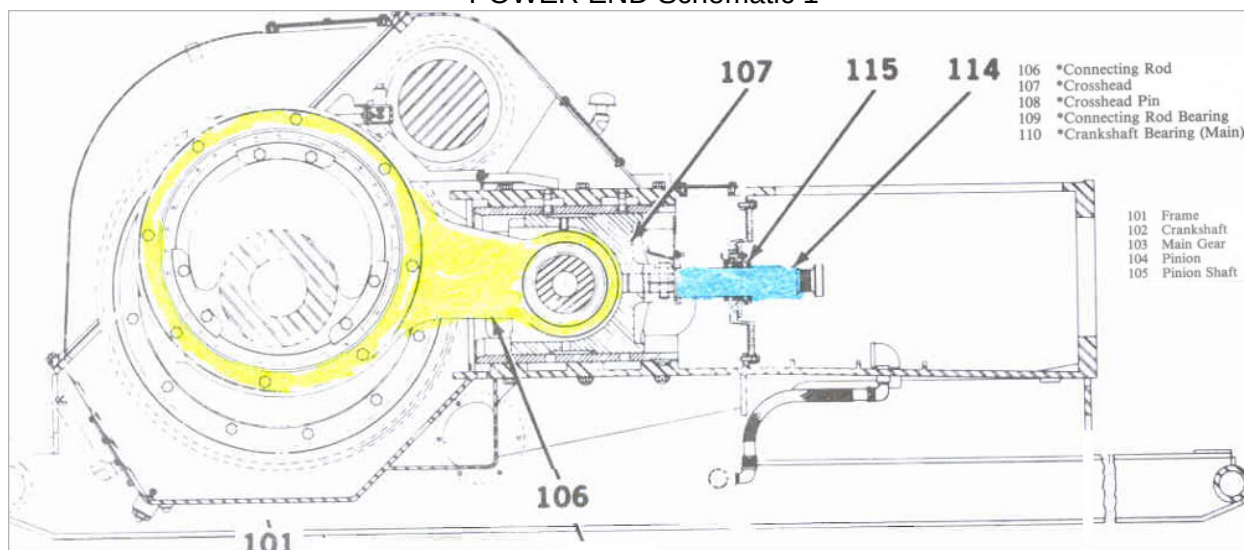
The **pump** is divided in 2 parts:

- POWER END
- FLUID END

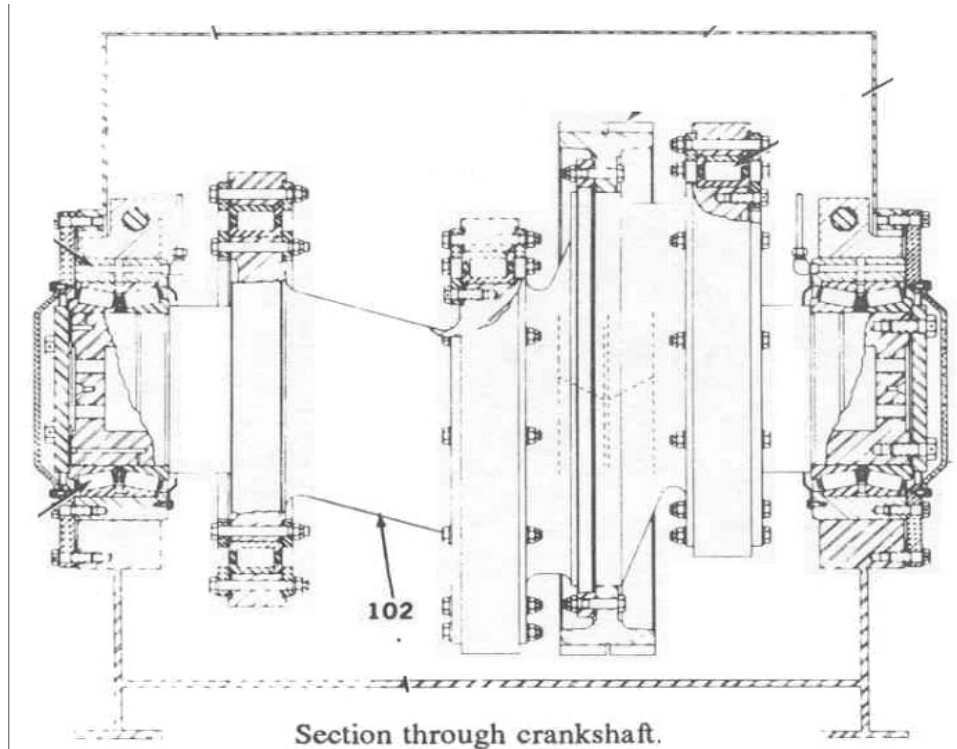


### POWER END

- POWER END Schematic 1



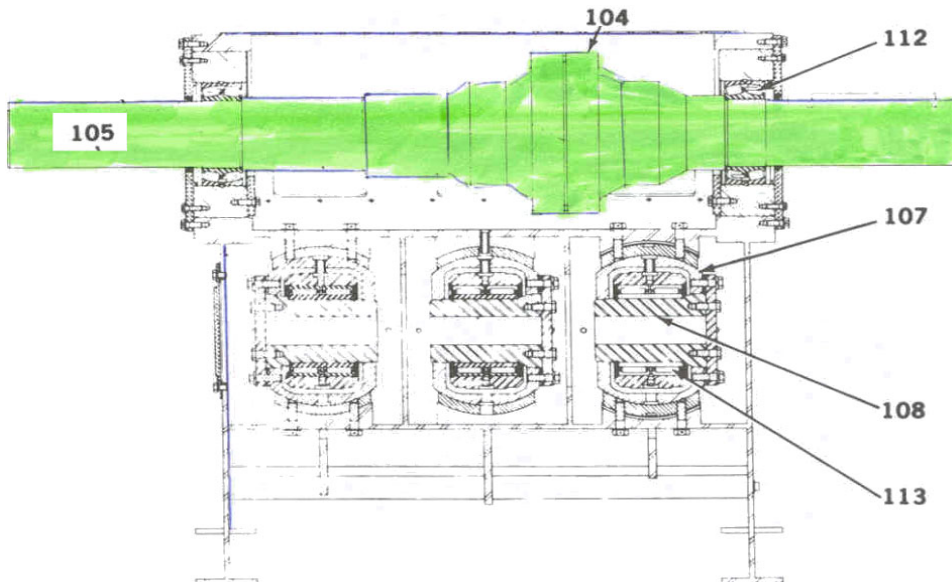
- POWER END Schematic 2



- 106 \*Connecting Rod
- 107 \*Crosshead
- 108 \*Crosshead Pin
- 109 \*Connecting Rod Bearing
- 110 \*Crankshaft Bearing (Main)

- 111 \*Crankshaft Bearing Housing
- 112 \*Pinion Shaft Bearing
- 113 \*Crosshead Pin Bearing
- 114 \*Crosshead Extension Rod (Pony)
- 115 \*Crosshead Extension Rod Wiper

- POWER END Schematic 3



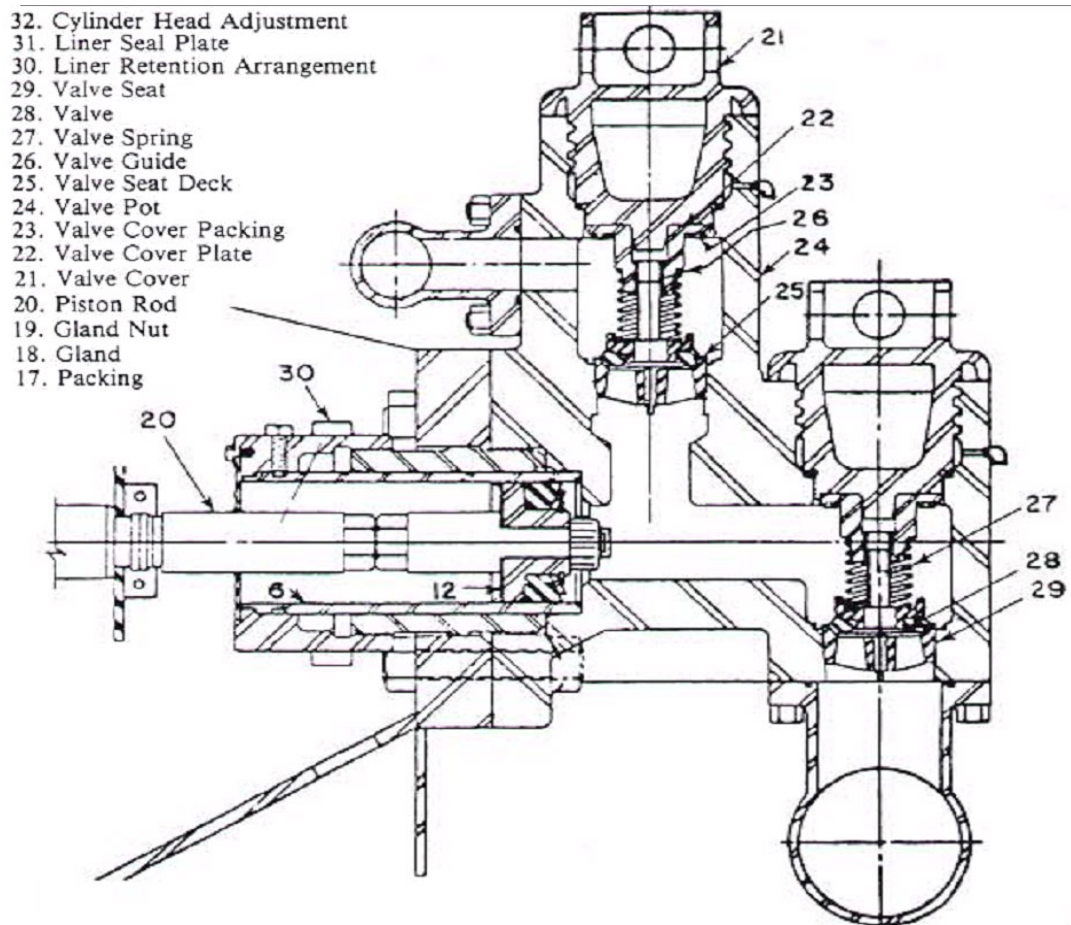
- 101 Frame
- 102 Crankshaft
- 103 Main Gear
- 104 Pinion
- 105 Pinion Shaft

- 106 \*Connecting Rod
- 107 \*Crosshead
- 108 \*Crosshead Pin
- 109 \*Connecting Rod Bearing
- 110 \*Crankshaft Bearing (Main)

- 111 \*Crankshaft Bearing Housing
- 112 \*Pinion Shaft Bearing
- 113 \*Crosshead Pin Bearing
- 114 \*Crosshead Extension Rod (Pony)
- 115 \*Crosshead Extension Rod Wiper

## FLUID END

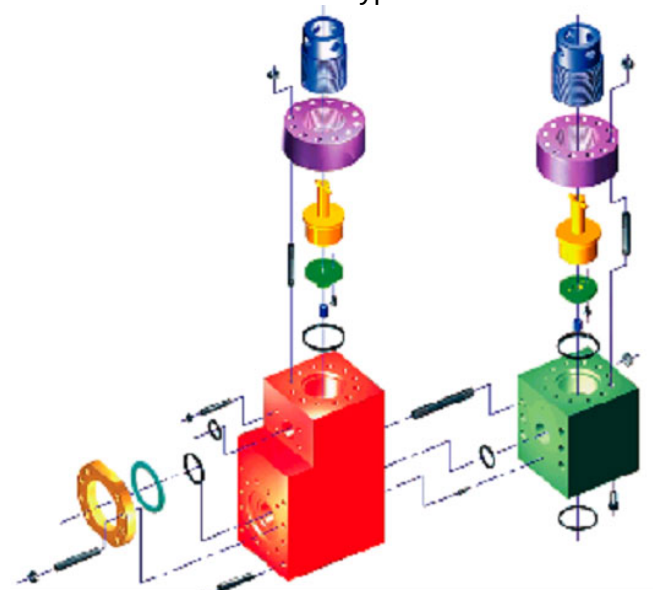
- FLUID END Schematic 1



- FLUID END Schematic 2



- Fluid end type "L"

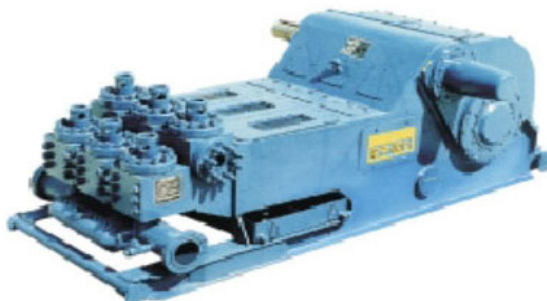




## 20.3 TYPES AND CHARACTERISTICS

### Performance Data

#### - NATIONAL OILWELL 10-P-130



#### 10-P-130 PERFORMANCE DATA

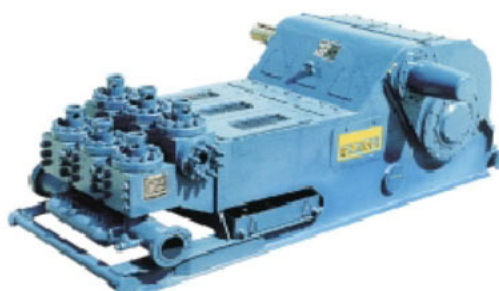
Stroke, in.(mm): 10 (254.0) ... Gear ratio: 2.853 ... Rated input: 1300 hp @ 140 spm (969 kw @ 140 spm)

| Liner size, in.(mm)                                    |                 | 6 1/4<br>(171.5)  | 6 1/2<br>(165.1)                           | 6 3/4<br>(158.8)  | 6<br>(152.4)      | 5 1/2<br>(139.7)  | 5<br>(127.0)     | 4 1/2<br>(114.3) | 4<br>(101.6)     |
|--------------------------------------------------------|-----------------|-------------------|--------------------------------------------|-------------------|-------------------|-------------------|------------------|------------------|------------------|
| Maximum discharge pressure - psi (kg/cm <sup>2</sup> ) |                 | 3085<br>(216.9)   | 3325<br>(233.8)                            | 3595<br>(252.8)   | 3900<br>(274.2)   | 4645<br>(326.6)   | 5000<br>(351.5)  | 5000<br>(351.5)  | 5000<br>(351.5)  |
| Volume/stroke gal/rev (liters/rev)                     |                 | 4.647<br>(17.592) | 4.309<br>(16.313)                          | 3.984<br>(15.082) | 3.672<br>(13.900) | 3.085<br>(11.679) | 2.550<br>(9.652) | 2.065<br>(7.816) | 1.632<br>(6.177) |
| Pump speed (spm)                                       | Max. input (hp) | Hydraulic (hp)    | Gallons per minute** (Liters per minute**) |                   |                   |                   |                  |                  |                  |
| 140*                                                   | 1300*           | 1170              | 651<br>(2463)                              | 603<br>(2284)     | 558<br>(2111)     | 514<br>(1946)     | 432<br>(1635)    | 357<br>(1351)    | 289<br>(1093)    |
| 120                                                    | 1114            | 1003              | 558<br>(2111)                              | 517<br>(1958)     | 478<br>(1810)     | 441<br>(1668)     | 370<br>(1401)    | 306<br>(1158)    | 248<br>(939)     |
| 100                                                    | 929             | 836               | 465<br>(1759)                              | 431<br>(1631)     | 398<br>(1508)     | 367<br>(1390)     | 309<br>(1168)    | 255<br>(965)     | 207<br>(784)     |
| 80                                                     | 743             | 669               | 372<br>(1407)                              | 345<br>(1305)     | 319<br>(1207)     | 294<br>(1112)     | 247<br>(934)     | 204<br>(772)     | 165<br>(625)     |
| 60                                                     | 557             | 501               | 279<br>(1056)                              | 259<br>(979)      | 239<br>(905)      | 220<br>(834)      | 185<br>(701)     | 153<br>(579)     | 124<br>(469)     |
|                                                        |                 |                   |                                            |                   |                   |                   |                  |                  | 98<br>(371)      |

\*Rated maximum input horsepower and speed.

\*\*Based on 90% mechanical efficiency and 100% volumetric efficiency.

#### - NATIONAL OILWELL 12-P-160

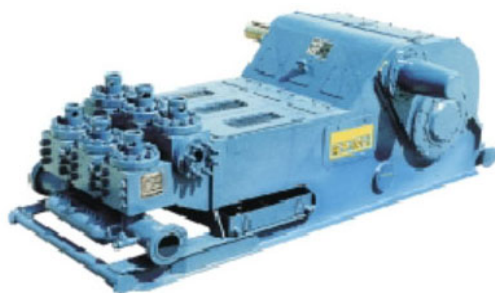


#### 12-P-160 PERFORMANCE DATA

Stroke, in.(mm): 12 (304.8) ... Gear ratio: 3.439 ... Rated input: 1600 hp @ 120 spm (1193 kw @ 120 spm)

| Liner size, in.(mm)                                    |                 | 7 1/4<br>(184.2)  | 7<br>(177.8)                               | 6 3/4<br>(171.5)  | 6 1/2<br>(165.1)  | 6 1/4<br>(158.8)  | 6<br>(152.4)      | 5 1/2<br>(139.7)  | 5<br>(127.0)     | 4 1/2<br>(114.3) | 4<br>(101.6)     |
|--------------------------------------------------------|-----------------|-------------------|--------------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|------------------|------------------|
| Maximum discharge pressure - psi (kg/cm <sup>2</sup> ) |                 | 3200<br>(225.0)   | 3430<br>(241.1)                            | 3690<br>(259.4)   | 3980<br>(279.8)   | 4305<br>(302.7)   | 4670<br>(328.3)   | 5000<br>(351.5)   | 5000<br>(351.5)  | 5000<br>(351.5)  | 5000<br>(351.5)  |
| Volume/stroke gal/rev (liters/rev)                     |                 | 6.433<br>(24.454) | 5.997<br>(22.703)                          | 5.576<br>(21.110) | 5.171<br>(19.575) | 4.781<br>(18.098) | 4.406<br>(16.680) | 3.702<br>(14.015) | 3.060<br>(11.58) | 2.479<br>(9.384) | 1.958<br>(7.412) |
| Pump speed (spm)                                       | Max. input (hp) | Hydraulic (hp)    | Gallons per minute** (Liters per minute**) |                   |                   |                   |                   |                   |                  |                  |                  |
| 120*                                                   | 1600*           | 1440              | 772<br>(2922)                              | 720<br>(2724)     | 669<br>(2533)     | 621<br>(2349)     | 574<br>(2172)     | 529<br>(2002)     | 444<br>(1682)    | 367<br>(1389)    | 297<br>(1124)    |
| 100                                                    | 1333            | 1200              | 643<br>(2435)                              | 600<br>(2270)     | 558<br>(2111)     | 517<br>(1958)     | 478<br>(1810)     | 441<br>(1668)     | 370<br>(1402)    | 306<br>(1158)    | 248<br>(938)     |
| 80                                                     | 1067            | 960               | 515<br>(1948)                              | 480<br>(1816)     | 446<br>(1689)     | 414<br>(1566)     | 383<br>(1448)     | 353<br>(1334)     | 296<br>(1121)    | 245<br>(927)     | 198<br>(750)     |
| 60                                                     | 800             | 720               | 386<br>(1461)                              | 360<br>(1362)     | 335<br>(1267)     | 310<br>(1175)     | 287<br>(1086)     | 264<br>(1001)     | 222<br>(841)     | 184<br>(697)     | 149<br>(564)     |
| 40                                                     | 533             | 480               | 257<br>(974)                               | 240<br>(908)      | 223<br>(844)      | 207<br>(783)      | 191<br>(724)      | 176<br>(667)      | 148<br>(561)     | 122<br>(462)     | 99<br>(375)      |
|                                                        |                 |                   |                                            |                   |                   |                   |                   |                   |                  |                  | 78<br>(295)      |

- NATIONAL OILWELL 14-P-220



14-P-220 PERFORMANCE DATA

Stroke, in.(mm): 14 (356) ... Gear ratio: 3.969 ... Rated input: 2200 hp @ 105 spm (1642 kw @ 105 spm)

| Liner size, in.(mm)                       |                | 9†<br>(228.6)     | 8<br>(203.2)                               | 7½<br>(190.5)    | 7<br>(177.8)     | 6½<br>(165.1)    | 6†<br>(152.4)    | 5½†<br>(139.7)   | 5†<br>(127.0)    |               |
|-------------------------------------------|----------------|-------------------|--------------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|---------------|
| Maximum discharge pressure - psi (kg/cm²) |                | 2795<br>(196.5)   | 3535<br>(248.5)                            | 4025<br>(283.0)  | 4615<br>(324.5)  | 5360<br>(376.8)  | 6285<br>(441.9)  | 7475<br>(525.5)  | 7500<br>(527.3)  |               |
| Volume/stroke gal/rev (liters/rev)        |                | 11.57<br>(43.797) | 9.14<br>(34.598)                           | 8.03<br>(30.397) | 7.00<br>(26.498) | 6.03<br>(22.826) | 5.14<br>(19.457) | 4.32<br>(16.353) | 3.57<br>(13.514) |               |
| Pump speed (spm)                          | Max input (hp) | Hydraulic (hp)    | Gallons per minute** (Liters per minute**) |                  |                  |                  |                  |                  |                  |               |
| 105*                                      | 2200*          | 1980              | 1215<br>(4600)                             | 960<br>(3634)    | 843<br>(3191)    | 735<br>(2782)    | 633<br>(2396)    | 540<br>(2044)    | 454<br>(1718)    | 375<br>(1419) |
| 80                                        | 1676           | 1509              | 925<br>(3501)                              | 731<br>(2767)    | 643<br>(2434)    | 560<br>(2120)    | 483<br>(1828)    | 411<br>(1556)    | 346<br>(1309)    | 286<br>(1082) |
| 60                                        | 1257           | 1131              | 694<br>(2627)                              | 548<br>(2074)    | 482<br>(1824)    | 420<br>(1590)    | 362<br>(1370)    | 308<br>(1166)    | 259<br>(980)     | 214<br>(810)  |
| 40                                        | 838            | 754               | 462<br>(1748)                              | 366<br>(1385)    | 321<br>(1215)    | 280<br>(1060)    | 241<br>(912)     | 206<br>(780)     | 173<br>(654)     | 143<br>(541)  |

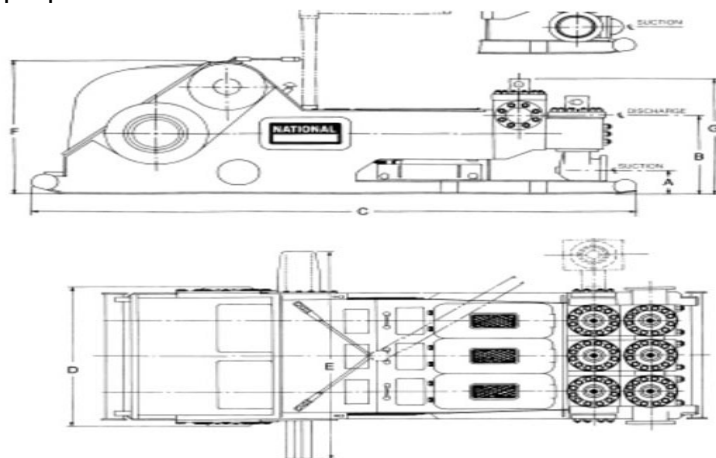
\*Rated maximum input horsepower and speed.

\*\*Based on 90% mechanical efficiency and 100% volumetric efficiency.

†9-inch liner requires special liner bushing and liner clamp.

‡Plungers and packing recommended over 6000 psi. Premium modules required over 8000 psi.

- Type P Mud Pump Specification and Dimensions



Type P Mud Pump specifications and dimensions.

| Model:                                                              | 7-P-50        | 8-P-80          | 9-P-100         | 10-P-130        | 12-P-160        | 14-P-220        |
|---------------------------------------------------------------------|---------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| <b>A</b> Height, floor to center of front inlet suction, in.(mm)    | 10½ (270)     | 10¾ (273)       | 13¼ (337)       | 13¾ (337)       | 16½ (419)       | 19½ (505)       |
| <b>B</b> Height, floor to center of discharge, in.(mm)              | 33½ (851)     | 35¼ (895)       | 38¾ (972)       | 39¾ (997)       | 45¼ (1149)      | 49¼ (1251)      |
| <b>C</b> Overall length over skids, in.(mm)                         | 142¼ (3613)   | 161¼ (4105)     | 176¼ (4477)     | 186¼ (4740)     | 209 (5309)      | 218¼ (5544)     |
| <b>D</b> Width over frame                                           | 54¼ (1384)    | 62¼ (1589)      | 67¼ (1705)      | 71¼ (1813)      | 78¼ (1997)      | 91 (2311)       |
| <b>E</b> Width over pinion shaft, in.(mm)                           | 81¼ (2069)    | 93¼ (2384)      | 101¼ (2572)     | 107¼ (2724)     | 113¼ (2889)     | 125¼ (3194)     |
| <b>F</b> Height, floor to top of gear case, in.(mm)                 | 54¼ (1384)    | 60 (1524)       | 64 (1626)       | 67 (1702)       | 75 (1905)       | 84¼ (2139)      |
| <b>G</b> Height over fluid cylinders, in.(mm)                       | 48¾ (1241)    | 51¼ (1318)      | 54¼ (1394)      | 55¼ (1419)      | 62¼ (1599)      | 69¼ (1756)      |
| Max. input horsepower (kw)                                          | 500 (373)     | 800 (597)       | 1000 (746)      | 1300 (969)      | 1600 (1193)     | 2200 (1491)     |
| Rated pump speed, spm                                               | 165           | 160             | 150             | 140             | 120             | 105             |
| Max. fluid cylinder liner bore, in.(mm)                             | 6¼ (158.8)    | 6¼ (158.8)      | 6¼ (171.5)      | 6¼ (171.5)      | 7¼ (184.2)      | 9 (228.6)       |
| Stroke, in (mm)                                                     | 7¼ (196.9)    | 8½ (215.9)      | 9¼ (235.0)      | 10 (254.0)      | 12 (304.8)      | 14 (355.6)      |
| Hydrostatic test pressure of standard fluid cylinders, psi (kg/cm²) | 10,000 (703)  | 10,000 (703)    | 10,000 (703)    | 10,000 (703)    | 10,000 (703)    | 11,250 (791)    |
| Ratio of gears                                                      | 2.742         | 2.463           | 2.658           | 2.853           | 3.439           | 3.969           |
| Suction connection<br>ASA-150 lb. R.J. flange, inches               | 8             | 8               | 8               | 8               | 10              | 10              |
| Discharge connection cross<br>w/ API-5000-lb. R.J. flange, inches   | 4             | 4               | 5               | 5               | 6               | 6               |
| Valve pot, API number                                               | MOD 5.5       | MOD. 6          | MOD.6           | MOD. 6          | MOD. 7          | MOD. 8          |
| Weight - complete, less sheave, lbs.(kg)                            | 16,750 (7600) | 26,970 (12,235) | 33,200 (15,060) | 42,550 (19,300) | 54,700 (24,810) | 82,000 (37,195) |



## 20.4 ACCESSORIES

- Pulsation Dampeners
- Pressure Relief Valve (Safety Valve)
- Pump Stroke Counter



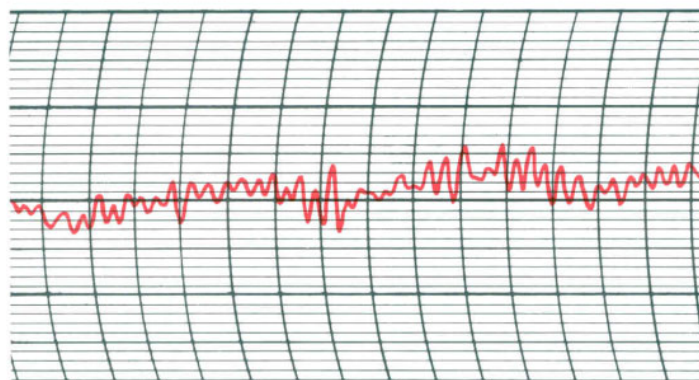
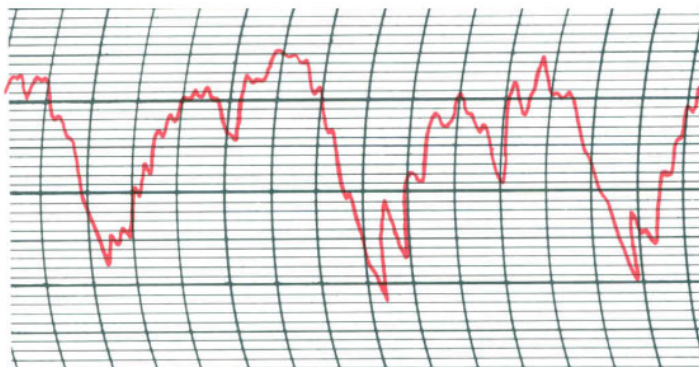
Accessories

### Pulsation Dampeners

#### - Function

Alternating movement of the pistons produces an irregular flux (See right).

Pulsation dampener reduces vibrations of pumps and lines (See right).

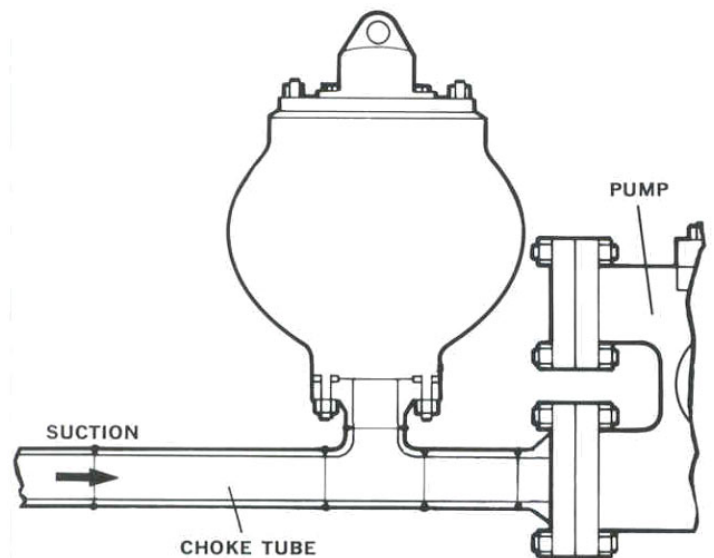
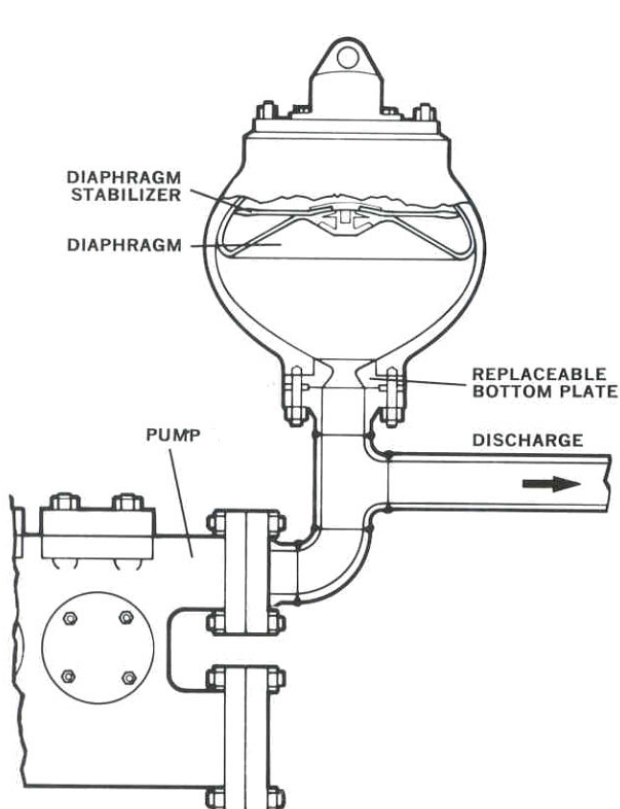


- Installation examples



- Pulsation dampener on discharge line

- Pulsation dampener on suction line



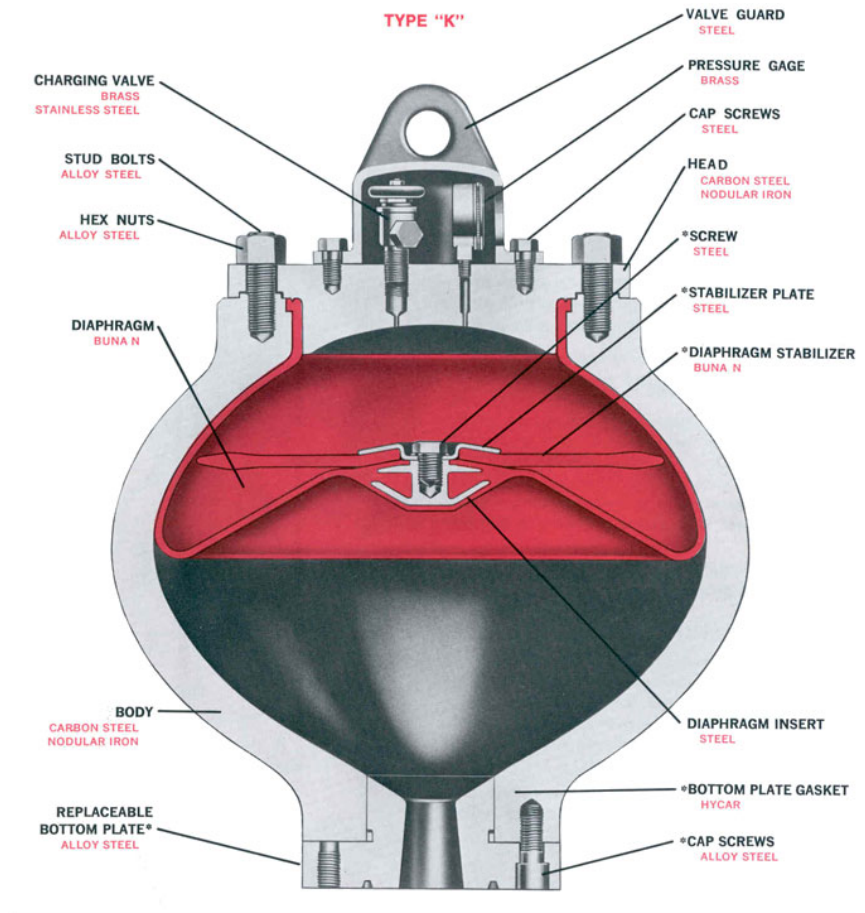
## - PULSATION DAMPENER HYDRIL TYPE K

### - Characteristics

Pulsation Dampeners are usually installed on discharge line.

It is a bottle with a diaphragm inside and pre-charged with Nitrogen at **maximum 1000 psi**.

It absorbs pressure variations, reduces peak pressures, permits slightly higher pump output and increases discharge line life.



### - Movement and Components

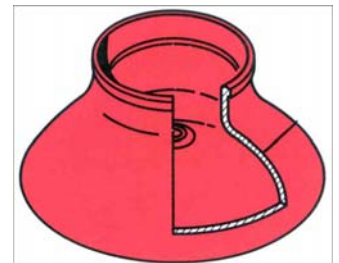
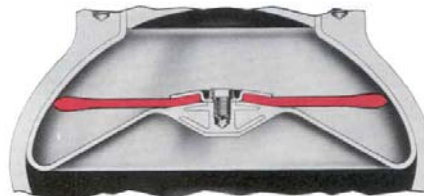
- Diaphragm movement during operation

- Diaphragm section

- Diaphragm



Shows the "breathing" action of the Hydriil Non-Wrinkling Diaphragm.



### - Pressure Relief Valve



- Installation and Primary Purpose

A **pressure relief valve** must be installed in the discharge line immediately beyond the pump.

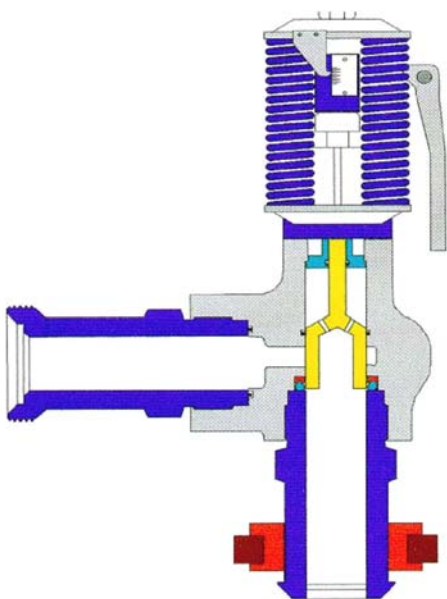
Its purpose is primarily to protect the pump and discharge line against extreme pressures that might occur when a bit becomes plugged.



Pressure Relief Valve - Installation

- Use of the Relief Valve

The relief valve should be used to **limit the pressure** in accordance with the pump manufacturer's rating for a given liner size.



Pressure Relief Valve  
- Scheme



Safety Valves

## 20.5 FLOW RATE AND EFFICIENCY CALCULATION

### - Theoretical Flowrate

$$V_{liq} = 3 \times \frac{3.14 \times D^2 \times L}{4 \times 10^6}$$

where

**P<sub>t</sub>** = theoretical flow rate (l/min)

**D** = Liner diameter in mm

**L** = Length of stroke in mm

**V<sub>liq</sub>** = Output volume per stroke

**SPM** = strokes per minute

$$P_t = V_{liq} \times SPM$$

### - Efficiency

Real flow rate must be calculated with the pump efficiency, which varies according to the state of the valves, the supercharging and the type of fluid.

In the best case it is **0.98** for a supercharged triplex pump.

Usually a normal average is between **0.95 - 0.97**

## 20.6 POWER AND EFFICIENCY CALCULATION

### - Hydraulic Power Calculation

$$HHP = \frac{P \times P_t}{450}$$

where

**P<sub>t</sub>** = Real Flow rate (theoretical flow rate x efficiency)

**HHP** = Hydraulic power in HP

**P** = output pressure in kg/cm<sup>2</sup>

### - Mechanical Horse Power :

$$HP = \frac{HHP}{E}$$

### - Efficiency

Real flow rate must be calculated with the pump efficiency.  
Usually efficiency is between **E = 0.95 - 0.97**



## **LOW PRESSURE MUD PUMPS (Centrifugal Pump)**

### **20.7 FUNCTION**

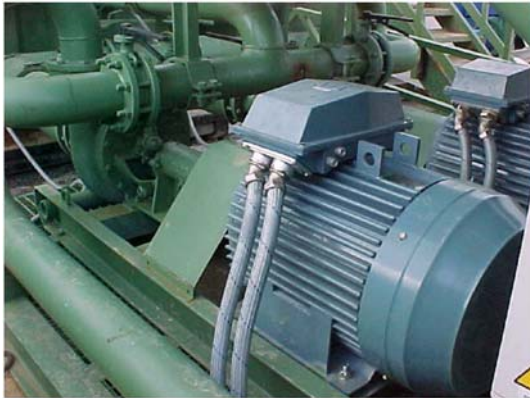
#### - Centrifugal pumps

Centrifugal pumps have an important role on drilling rigs.

They are used to:

- **Feed the degasser, desander desilter, mud cleaner, trip tank**
- Supercharge mud pumps
- Mix mud
- Transfer mud

- Mix mud



- Transfer mud



#### - Primary purpose

The primary purpose of the centrifugal precharge pump is to keep the mud pump from being starved by maintaining a positive pressure in the suction line.

Total head doesn't change depending by type and weight fluid.

It changes only the final pressure.

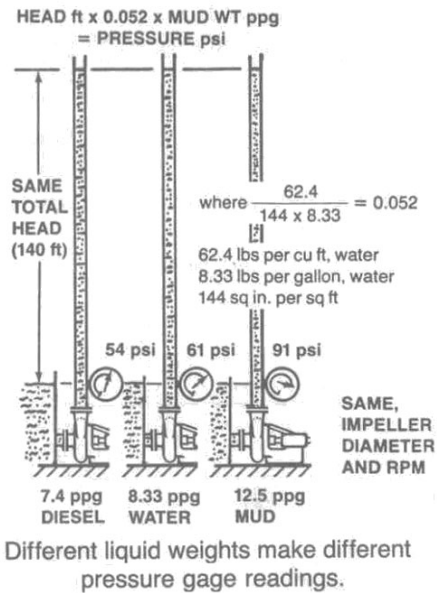


Mud Pumps

## - Total head and Output pressure

Total head stays the same. Output pressure changes

### - Pressure gage readings



### - Pressure gage and Mud weight

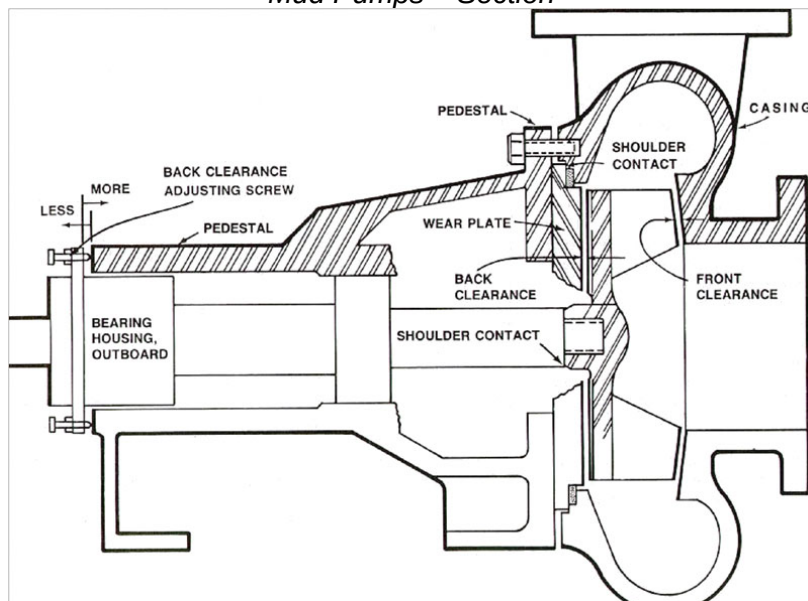
Pressure Gage Reading and Mud Weight Changed to Head Ft

| Head Feet                  | MUD WEIGHT POUNDS PER GALLON |     |     |     |     |     |      |      |      |      |      |      |      |      |      |
|----------------------------|------------------------------|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|
|                            | 8.33                         | 8.7 | 9.0 | 9.3 | 9.6 | 9.9 | 10.2 | 10.5 | 10.8 | 11.1 | 11.4 | 11.7 | 12.0 | 12.3 | 12.6 |
| Pressure Gage Readings PSI |                              |     |     |     |     |     |      |      |      |      |      |      |      |      |      |
| 52                         | 23                           | 24  | 24  | 25  | 26  | 27  | 28   | 28   | 29   | 30   | 31   | 32   | 32   | 33   | 34   |
| 54                         | 23                           | 24  | 25  | 26  | 27  | 28  | 29   | 29   | 30   | 31   | 32   | 33   | 34   | 35   | 35   |
| 56                         | 24                           | 25  | 26  | 27  | 28  | 29  | 30   | 31   | 31   | 32   | 33   | 34   | 35   | 36   | 37   |
| 58                         | 25                           | 26  | 27  | 28  | 29  | 30  | 31   | 32   | 33   | 33   | 34   | 35   | 36   | 37   | 38   |
| 60                         | 26                           | 27  | 28  | 29  | 30  | 31  | 32   | 33   | 34   | 35   | 36   | 36   | 37   | 38   | 39   |
| 62                         | 27                           | 28  | 29  | 30  | 31  | 32  | 33   | 34   | 35   | 36   | 37   | 38   | 39   | 40   | 41   |
| 64                         | 28                           | 29  | 30  | 31  | 32  | 33  | 34   | 35   | 36   | 37   | 38   | 39   | 40   | 41   | 42   |
| 66                         | 29                           | 30  | 31  | 32  | 33  | 34  | 35   | 36   | 37   | 38   | 39   | 40   | 41   | 42   | 43   |
| 68                         | 29                           | 31  | 32  | 33  | 34  | 35  | 36   | 37   | 38   | 39   | 40   | 41   | 42   | 43   | 45   |
| 70                         | 30                           | 32  | 33  | 34  | 35  | 36  | 37   | 38   | 39   | 40   | 41   | 43   | 44   | 45   | 46   |
| 72                         | 31                           | 33  | 34  | 35  | 36  | 37  | 38   | 39   | 40   | 42   | 43   | 44   | 45   | 46   | 47   |
| 74                         | 32                           | 33  | 35  | 36  | 37  | 38  | 39   | 40   | 42   | 43   | 44   | 45   | 46   | 47   | 48   |
| 76                         | 33                           | 34  | 36  | 37  | 38  | 39  | 40   | 41   | 43   | 44   | 45   | 46   | 47   | 49   | 50   |
| 78                         | 34                           | 35  | 36  | 38  | 39  | 40  | 41   | 43   | 44   | 45   | 46   | 47   | 49   | 50   | 51   |
| 80                         | 35                           | 36  | 37  | 39  | 40  | 41  | 42   | 44   | 45   | 46   | 47   | 49   | 50   | 51   | 52   |
| 82                         | 35                           | 37  | 38  | 40  | 41  | 42  | 43   | 45   | 46   | 47   | 49   | 50   | 51   | 52   | 54   |
| 84                         | 36                           | 38  | 39  | 41  | 42  | 43  | 45   | 46   | 47   | 48   | 50   | 51   | 52   | 54   | 55   |
| 86                         | 37                           | 39  | 40  | 42  | 43  | 44  | 46   | 47   | 48   | 50   | 51   | 52   | 54   | 55   | 56   |
| 88                         | 38                           | 40  | 41  | 43  | 44  | 45  | 47   | 48   | 49   | 51   | 52   | 53   | 55   | 56   | 58   |
| 90                         | 39                           | 41  | 42  | 43  | 45  | 46  | 48   | 49   | 50   | 52   | 53   | 55   | 56   | 58   | 59   |
| 92                         | 40                           | 42  | 43  | 44  | 46  | 47  | 49   | 50   | 52   | 53   | 54   | 56   | 57   | 59   | 60   |
| 94                         | 41                           | 42  | 44  | 45  | 47  | 48  | 50   | 51   | 53   | 54   | 56   | 57   | 59   | 60   | 62   |
| 96                         | 42                           | 43  | 45  | 46  | 48  | 49  | 51   | 52   | 54   | 55   | 57   | 58   | 60   | 61   | 63   |
| 98                         | 42                           | 44  | 46  | 47  | 49  | 50  | 52   | 53   | 55   | 57   | 58   | 60   | 61   | 63   | 64   |
| 100                        | 43                           | 45  | 47  | 48  | 50  | 51  | 53   | 55   | 56   | 58   | 59   | 61   | 62   | 64   | 65   |
| 102                        | 44                           | 46  | 48  | 49  | 51  | 52  | 54   | 56   | 57   | 59   | 60   | 62   | 64   | 65   | 67   |
| 104                        | 45                           | 47  | 49  | 50  | 52  | 53  | 55   | 57   | 58   | 60   | 62   | 63   | 65   | 66   | 68   |
| 106                        | 46                           | 48  | 50  | 51  | 53  | 55  | 56   | 58   | 59   | 61   | 63   | 64   | 66   | 68   | 69   |
| 108                        | 47                           | 49  | 50  | 52  | 54  | 56  | 57   | 59   | 61   | 62   | 64   | 66   | 67   | 69   | 71   |
| 110                        | 48                           | 50  | 51  | 53  | 55  | 57  | 58   | 60   | 62   | 63   | 65   | 67   | 69   | 70   | 72   |
| 112                        | 48                           | 51  | 52  | 54  | 56  | 58  | 59   | 61   | 63   | 65   | 66   | 68   | 70   | 72   | 73   |
| 114                        | 49                           | 52  | 53  | 55  | 57  | 59  | 60   | 62   | 64   | 66   | 68   | 69   | 71   | 73   | 75   |
| 116                        | 50                           | 52  | 54  | 56  | 58  | 60  | 61   | 63   | 65   | 67   | 69   | 71   | 72   | 74   | 76   |
| 118                        | 51                           | 53  | 55  | 57  | 59  | 61  | 63   | 64   | 66   | 68   | 70   | 72   | 74   | 75   | 77   |
| 120                        | 52                           | 54  | 56  | 58  | 60  | 62  | 64   | 65   | 67   | 69   | 71   | 73   | 75   | 77   | 79   |

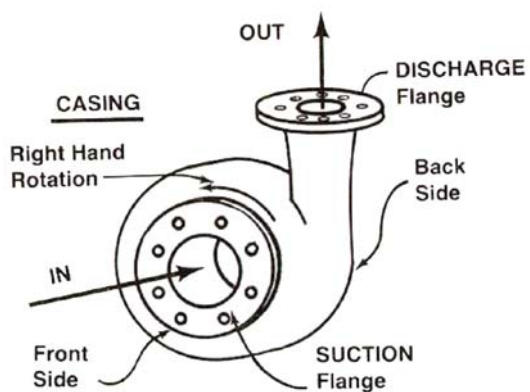
Head pressure = Mud weight x (0.433/8.33) x Head

## 20.8 NOMENCLATURE

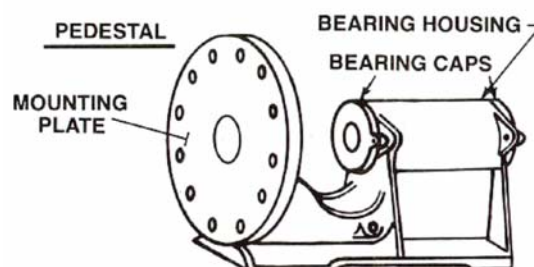
*Mud Pumps – Section*



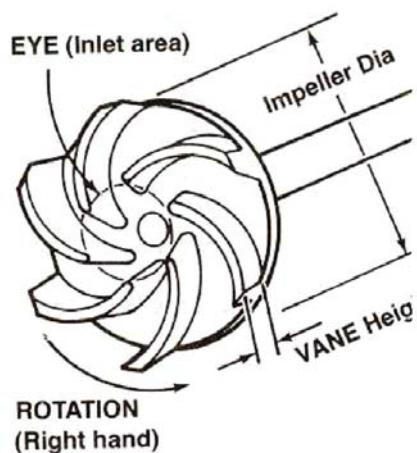
*Casing*



*Pedestal*

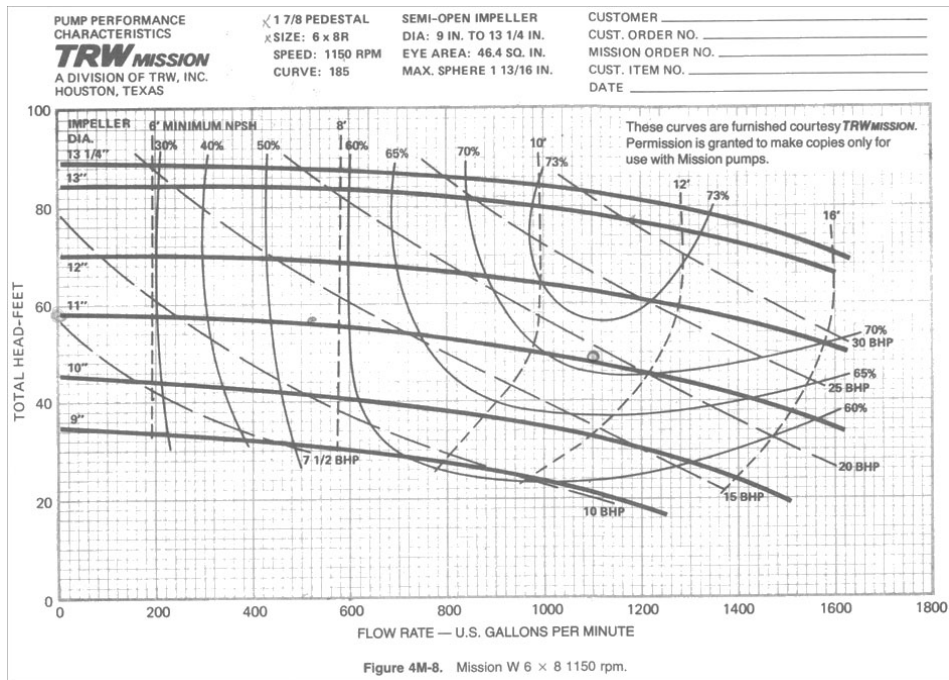


*Rotation*

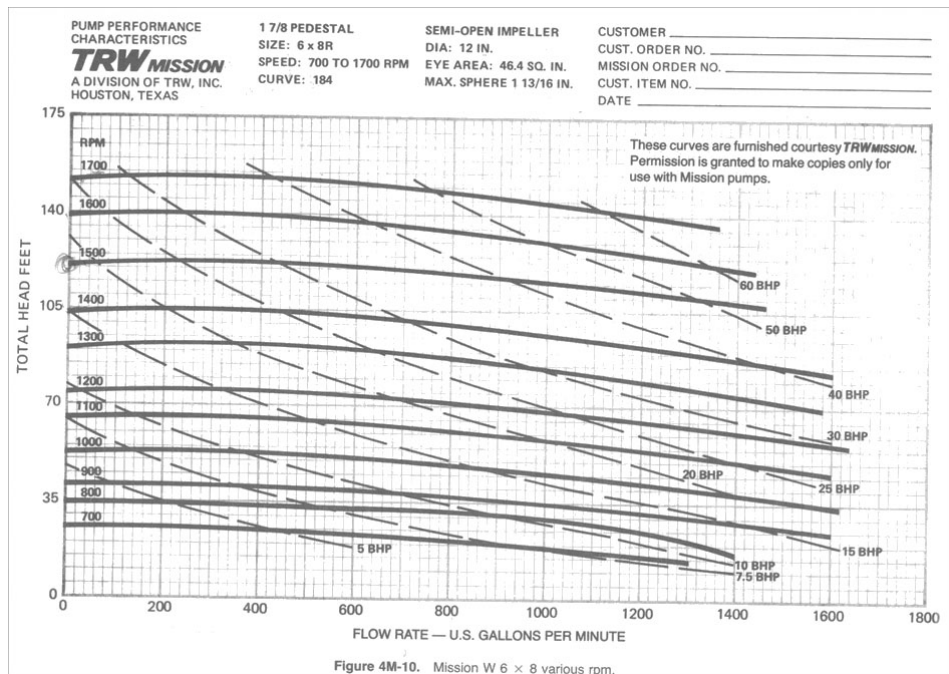


## 20.9 PUMP PERFORMANCE CURVES

### - Performance Curve 1

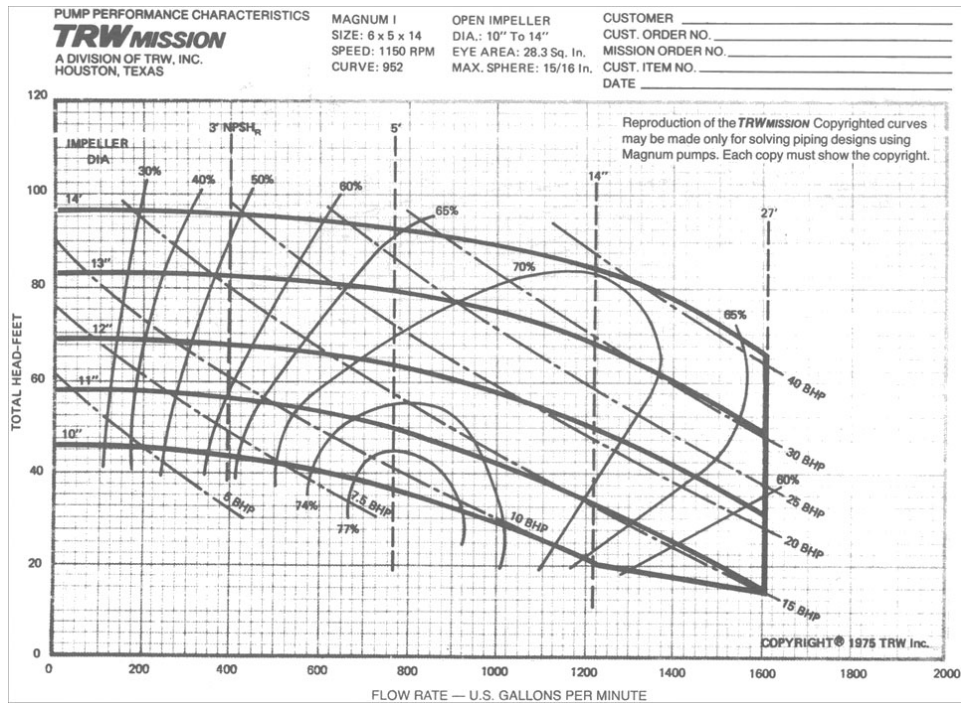


### - Performance Curve 2





- Performance Curve 3



## 21. MUD MIXING SYSTEM

### INDEX

- 21.1 FUNCTION
- 21.2 MIXING EQUIPMENT
- 21.3 BULK STOCK SYSTEM
  - SILOS
  - SURGE TANK

### 21.1 FUNCTION

- Use of Mud Mixing Equipment

The mud mixing equipment is used to accomplish the following:

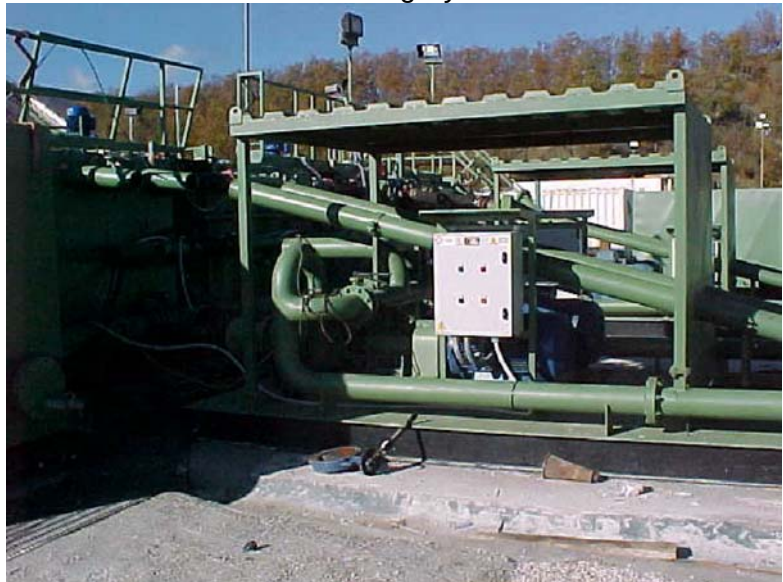
- **Prepare and mix mud**
- **Maintain mud weight and properties while drilling the well.**

Mud mixing must be done at the highest pump rate, to avoid decantation and grumes of the solid part (barite, bentonite, polymers, etc).

#### **NOTE: event of a kick**

The mud mixing system must enable personnel to mix as much mud as required, as fast as possible, in the event of a kick.

Mud Mixing System



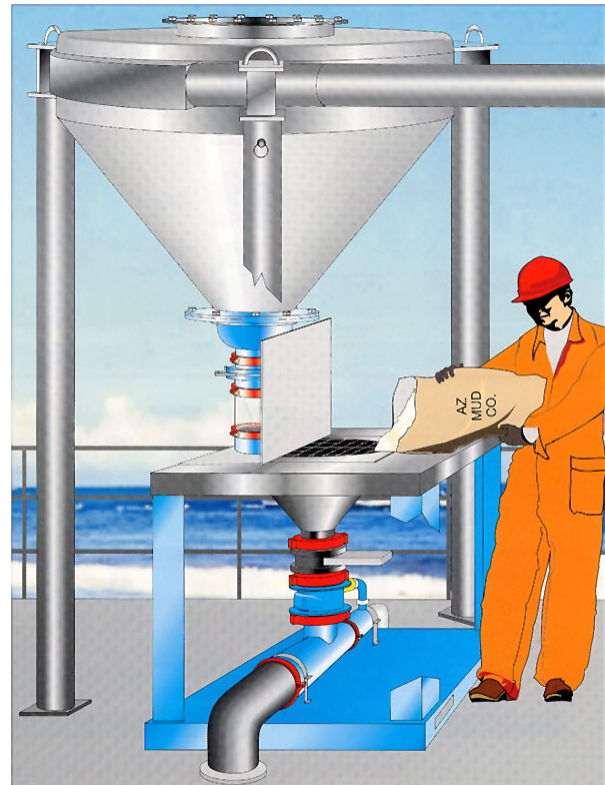
## 21.2 MIXING EQUIPMENT

Mud mixing system includes:

- Centrifugal pumps
- Funnel with nozzle and Venturi pipe
- Charging hopper

**Centrifugal pump** must have:

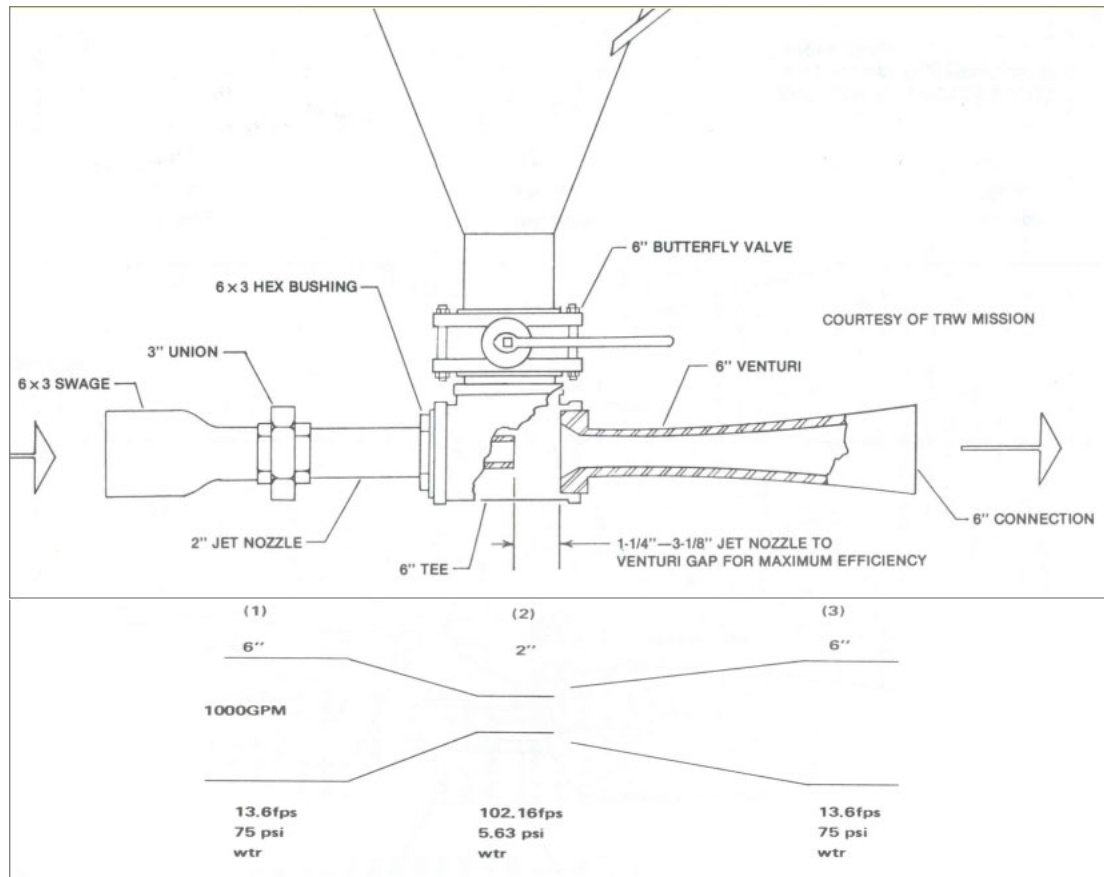
- a **flow rate** of about 3000-3200 liters/min and
- a **total head** of 70 - 75 ft.



Mixing Equipment

### Funnel with Venturi Pipe





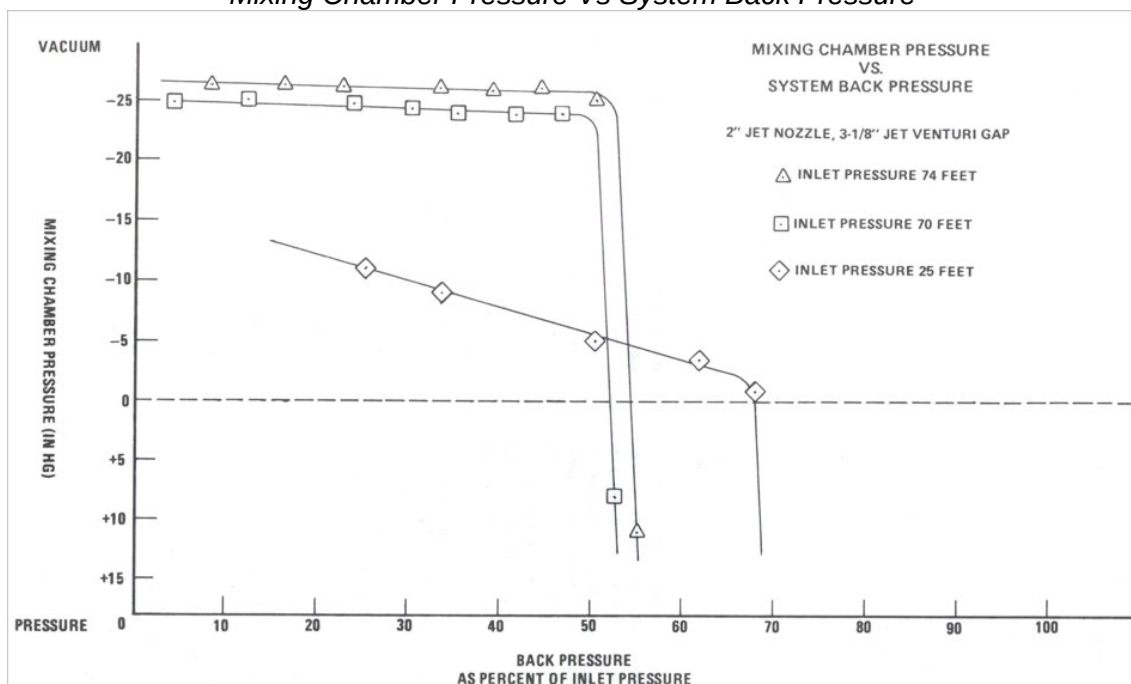
Pressure and speed profile

### - Pressure losses in downstream pipes

Pressure losses in downstream pipes must be less than 50% of the total pressure.

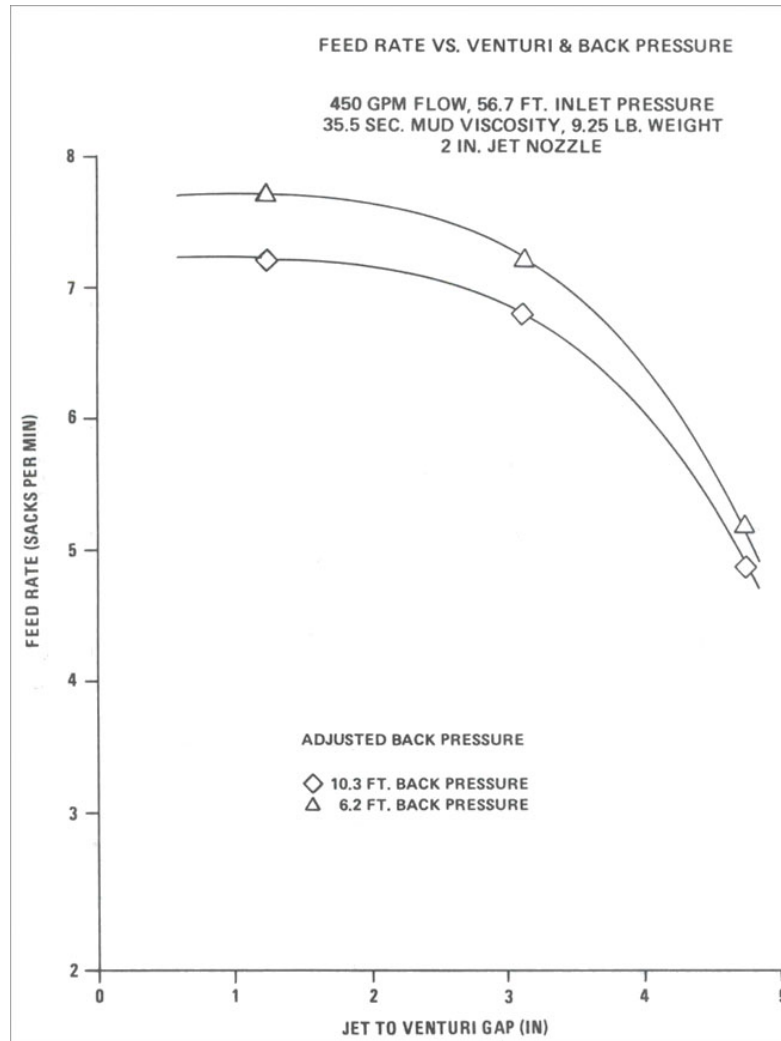
- Mixing Chamber Pressure Vs System Back Pressure
- Feed Rate Vs Venturi Back Pressure
- Discharge pressure Vs Sacks per Minute Barite

### Mixing Chamber Pressure Vs System Back Pressure

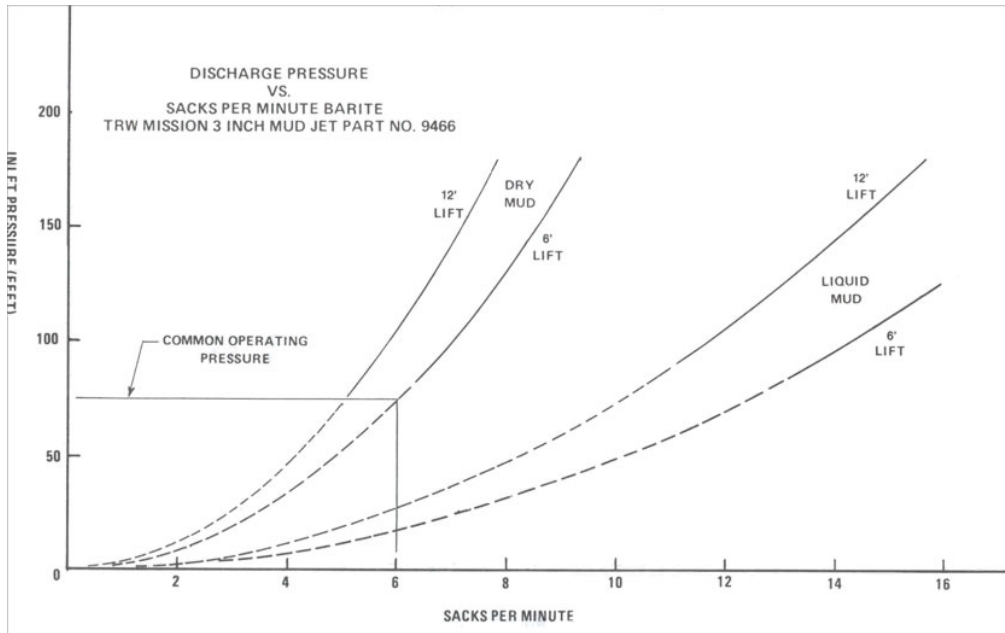




Feed Rate Vs Venturi Back Pressure



Discharge pressure Vs Sacks per Minute Barite



### - Suction and discharge lines

Try to keep the difference of height between the suction and discharge lines of the centrifugal pump as short as possible.

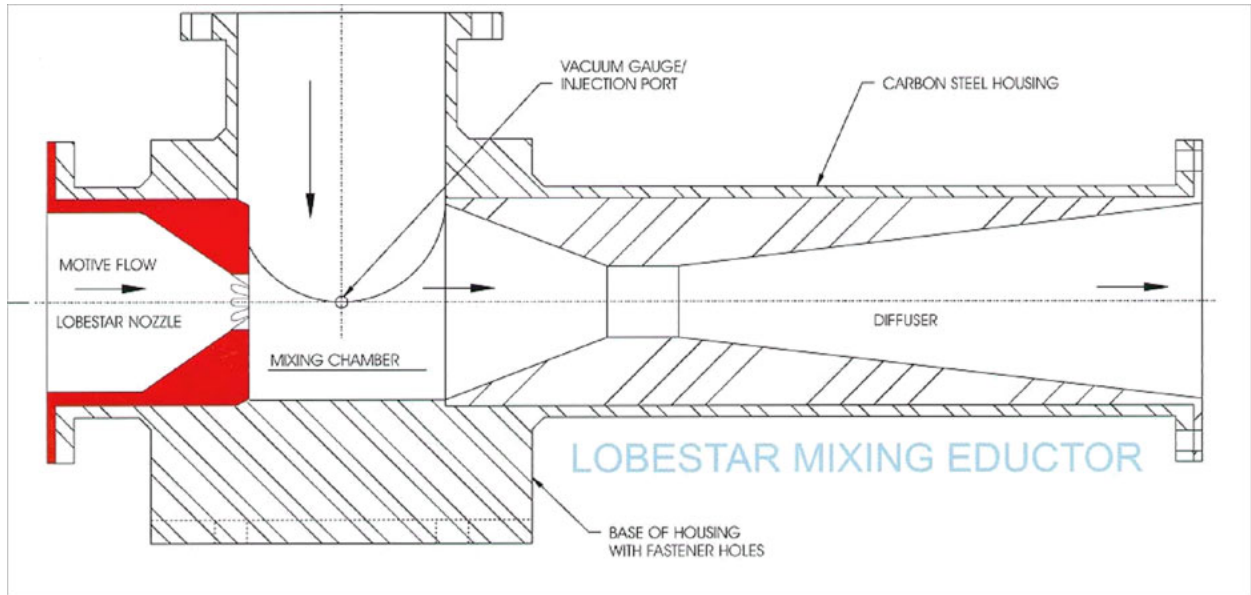
### High Efficiency Funnels

#### Vortex Ventures Unit

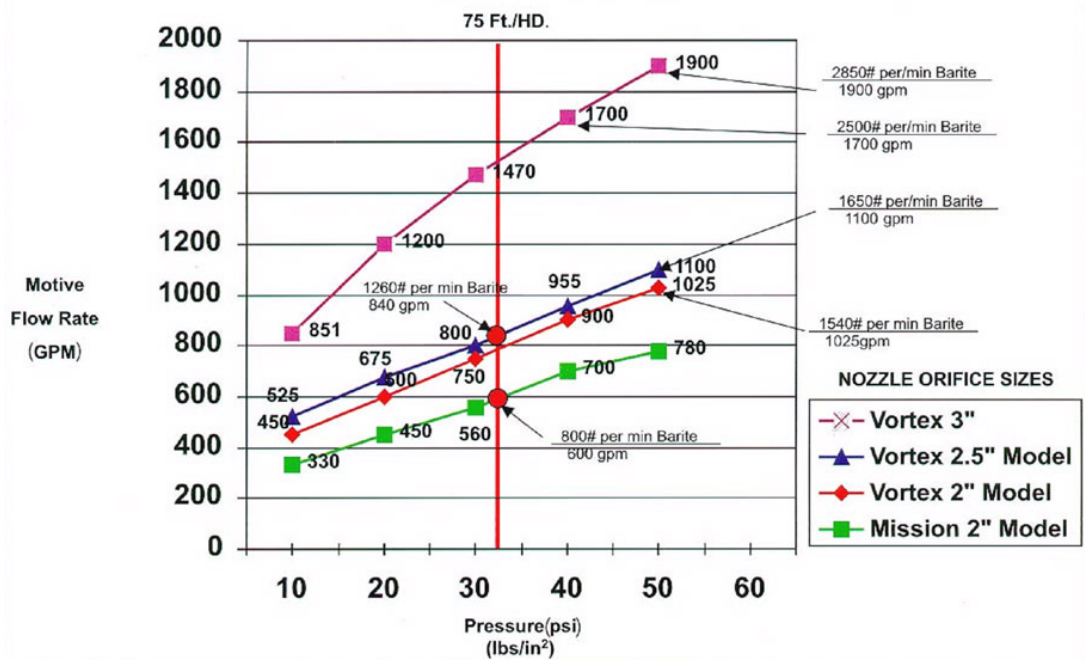
- VORTEX VENTURES
- SPEED MIXING BARITE



#### High Efficiency Funnels

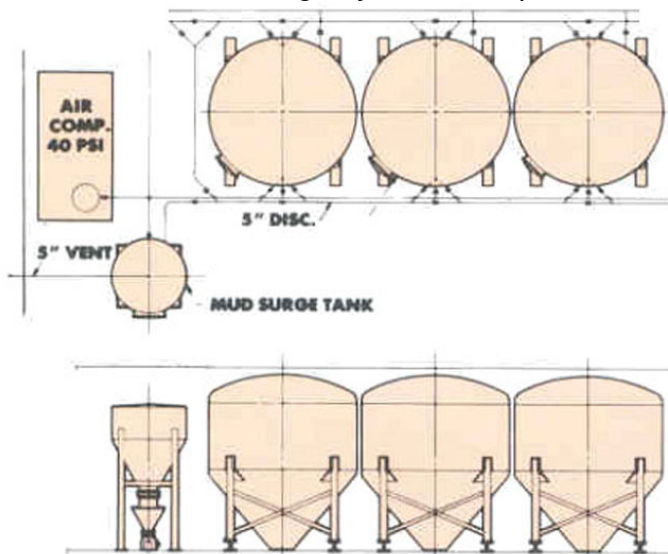


### EMPIRICAL PERFORMANCE CHART SPEED MIXING BARITE



## 21.3 BULK STOCK SYSTEM

Bulk Storage System Example



|                    | Aerated   |          | Packed    |    |
|--------------------|-----------|----------|-----------|----|
|                    | Lbs/Cu Ft | Cu Ft/Sk | Lbs/Cu Ft | Cu |
| Barite             | 111       | 0.90     | 150       | 0  |
| Bentonite (gel)    | 50        | 2.00     | 65        | 1  |
| Cal Seal           | 58        | 1.72     | 86        | 1  |
| Cement API Class H | 74        | 1.27     | 106       | 0  |
| Diacel D           | 10        | 5.00     | 16        | 3  |
| Gilsonite          | 38        | 1.33     | 43        | 1  |
| Hi-Dense®          | 150       | 0.67     | 190       | 0  |
| Pozmix™ A          | 67        | 1.10     | 86        | 0  |
| Sand, 20-40        | 98        | 1.02     | 105       | 0  |
| Silica Flour       | 60        | 1.66     | 84        | 1  |
| Coarse Silica      | 96        | 1.04     | 111       | 0  |

Horizontal Silos



Vertical Silos



Gravity Surge Tank



### - SILOS

Most rigs have a system to stock bulk barite.

The number of silos required depends on the kind of well, depth, overpressures and distance to the logistic base.

The entire storage system has an **air compressor**, **one or more silos**, and a **surge tank**.

- Air Compressor for Silos with Electric Motor

#### COMPRESSOR:

Gardner-Denver WAQ-Single Stage-300 SCFM @ 40 PSI-Water Cooled - With Radiator and Air-to-Air Aftercooler-6 Cylinder

#### ELECTRIC MOTOR

50 HP-230/460 Volt - 3 Ph-60 Hertz

- 1750 RPM-Open

- T.E.F.C. (Totally Enclosed, Fan Cooled), or Explosion Proof Enclosure

Air Compressor with Electric Motor



- Air Compressor for Silos with Diesel Engine

#### Model H-05

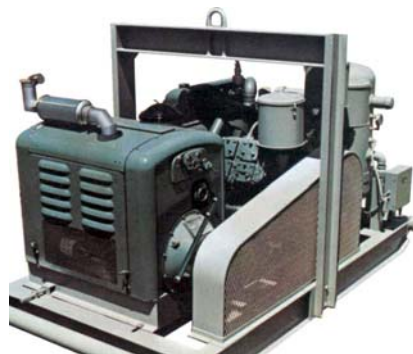
Air Compressor with Diesel Engine

Specifications:

Size: 11'4" L x 6'3" W x 6'10" H

Weight: 760 lbs

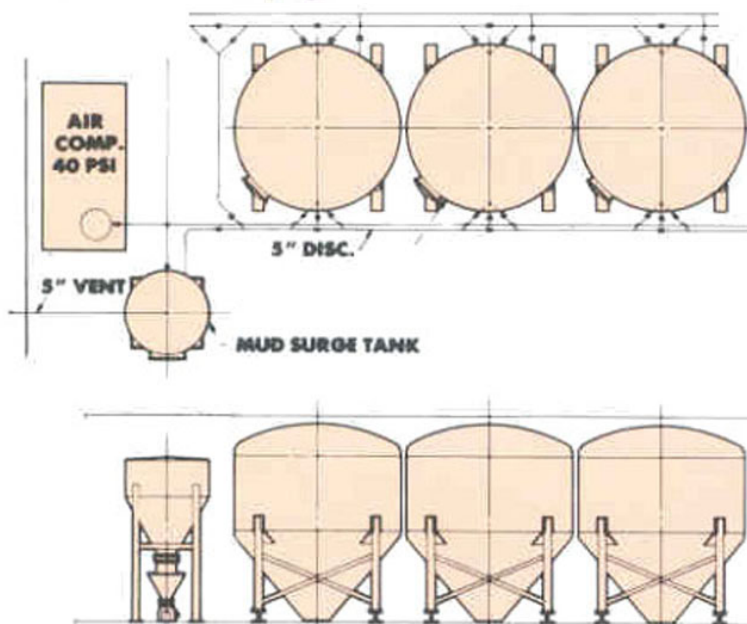
Compressor: Gardner-Denver WAQ-Single Stage-300 SCFM  
@40 PSI-Water Cooled- With Radiator and Air-to-Air  
Aftercooler-6 Cylinder



### - Horizontal Silos



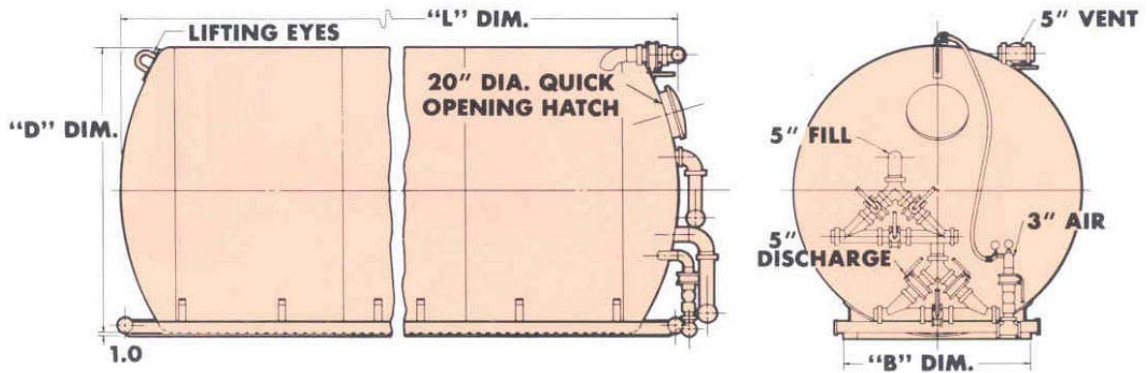
### - Silos - Specifications



|                    | Aerated   |          | Packed    |    |
|--------------------|-----------|----------|-----------|----|
|                    | Lbs/Cu Ft | Cu Ft/Sk | Lbs/Cu Ft | Cu |
| Barite             | 111       | 0.90     | 150       | 0  |
| Bentonite (gel)    | 50        | 2.00     | 65        | 1. |
| Cal Seal           | 58        | 1.72     | 86        | 1  |
| Cement API Class H | 74        | 1.27     | 106       | 0. |
| Diacel D           | 10        | 5.00     | 16        | 3  |
| Gilsonite          | 38        | 1.33     | 43        | 1. |
| Hi-Dense®          | 150       | 0.67     | 190       | 0. |
| Pozmix™ A          | 67        | 1.10     | 86        | 0  |
| Sand, 20-40        | 98        | 1.02     | 105       | 0. |
| Silica Flour       | 60        | 1.66     | 84        | 1. |
| Coarse Silica      | 96        | 1.04     | 111       | 0. |



## Horizontal Silos – Specifications



"D" DIM-11'-0"

| "L" DIM. | "B" DIM. | VOLUME       | APPROX. EMPTY WT. | MATERIAL CEMENT | WT. BARITE |
|----------|----------|--------------|-------------------|-----------------|------------|
| 20'-0"   | 7'-6"    | 1,350 CU.FT. | 17,200#           | 1,100 SK        | 1,755 SK   |
|          |          |              |                   | 103,400#        | 175,500#   |
| 24'-0"   | 7'-6"    | 1,600 CU.FT. | 19,000#           | 1,300 SK        | 2,080 SK   |
|          |          |              |                   | 122,200#        | 208,000#   |
| 30'-6"   | 7'-6"    | 2,000 CU.FT. | 21,900#           | 1,630 SK        | 2,600 SK   |
|          |          |              |                   | 153,220#        | 260,000#   |

"D" DIM-12'-0"

|        |        |              |         |          |          |
|--------|--------|--------------|---------|----------|----------|
| 20'-0" | 8'-10" | 1,600 CU.FT. | 21,000# | 1,300 SK | 2,080 SK |
|        |        |              |         | 122,200# | 208,000# |
| 24'-0" | 8'-10" | 1,920 CU.FT. | 23,000# | 1,560 SK | 2,500 SK |
|        |        |              |         | 146,640# | 250,000# |
| 25'-0" | 8'-10" | 2,000 CU.FT. | 23,500# | 1,620 SK | 2,600 SK |
|        |        |              |         | 152,000# | 260,000# |
| 34'-8" | 8'-10" | 2,750 CU.FT. | 31,000# | 2,230 SK | 3,600 SK |
|        |        |              |         | 210,000# | 360,000# |
| 37'-2" | 8'-10" | 3,000 CU.FT. | 34,000# | 2,430 SK | 3,900 SK |
|        |        |              |         | 228,000# | 390,000# |

## - Vertical Silos

Vertical silos

Specifications



| DIAMETER | HEIGHT  | VOLUME (CU/FT) | APPROXIMATE EMPTY WEIGHT (LB) |
|----------|---------|----------------|-------------------------------|
| 10'-0"   | 7'-6"   | 280            | 5700                          |
| 10'-0"   | 9'-0"   | 395            | 6125                          |
| 10'-0"   | 10'-0"  | 475            | 6400                          |
| 10'-0"   | 10'-4"  | 500            | 6500                          |
| 10'-0"   | 10'-8"  | 530            | 6575                          |
| 10'-0"   | 11'-3"  | 575            | 6700                          |
| 10'-0"   | 11'-4"  | 580            | 6725                          |
| 10'-0"   | 11'-7"  | 600            | 6800                          |
| 10'-0"   | 11'-10" | 620            | 6875                          |
| 10'-0"   | 12'-0"  | 630            | 6875                          |
| 10'-0"   | 12'-4"  | 650            | 6950                          |
| 10'-0"   | 12'-10" | 700            | 7125                          |
| 10'-0"   | 13'-0"  | 720            | 7150                          |
| 10'-0"   | 13'-4"  | 750            | 7250                          |
| 10'-0"   | 14'-0"  | 800            | 7425                          |
| 10'-0"   | 14'-3"  | 820            | 7500                          |
| 10'-0"   | 15'-0"  | 860            | 7725                          |
| 10'-0"   | 15'-9"  | 920            | 7825                          |
| 10'-0"   | 16'-0"  | 940            | 7900                          |
| 10'-0"   | 16'-8"  | 1000           | 7950                          |
| 10'-0"   | 17'-0"  | 1020           | 8150                          |
| 10'-0"   | 17'-2"  | 1040           | 8200                          |
| 10'-0"   | 17'-3"  | 1045           | 8225                          |
| 10'-0"   | 17'-4"  | 1050           | 8250                          |
| 10'-0"   | 17'-6"  | 1060           | 8300                          |
| 10'-0"   | 19'-4"  | 1200           | 8750                          |
| 10'-0"   | 20'-0"  | 1250           | 8900                          |
| 10'-0"   | 21'-0"  | 1350           | 9150                          |
| 10'-0"   | 22'-0"  | 1400           | 9400                          |
| 10'-0"   | 23'-0"  | 1500           | 9700                          |
| 10'-0"   | 24'-0"  | 1600           | 9900                          |
| 10'-0"   | 25'-0"  | 1650           | 10,300                        |
| 10'-0"   | 26'-0"  | 1725           | 10,600                        |
| 10'-0"   | 27'-0"  | 1800           | 10,900                        |
| 10'-0"   | 28'-0"  | 1875           | 11,200                        |
| 10'-0"   | 28'-6"  | 1925           | 11,350                        |
| 10'-0"   | 29'-0"  | 1960           | 11,500                        |
| 10'-6"   | 13'-0"  | 760            | 7500                          |
| 10'-6"   | 17'-2"  | 1130           | 8550                          |

## - SURGE TANK

### - Gravity Type Surge Tank

Shown is a 70 cu ft non-pressurized surge tank.

This economical unit is provided with sight glasses for level indication but high and low level indicators may be specified



### - Pressurized Surge Tank

Shown is a 220 cu ft pressurized surge tank.

It may be specified with or without weighing device.

High and low level indicators are also optional.

Where weight is critical, tanks may be constructed from alluminium alloys. Choice of alloys will depend on climatic conditions.



### Aerated / packed Powder Density Table

|                    | Aerated   |          | Packed    |    |
|--------------------|-----------|----------|-----------|----|
|                    | Lbs/Cu Ft | Cu Ft/Sk | Lbs/Cu Ft | Cu |
| Barite             | 111       | 0.90     | 150       | 0  |
| Bentonite (gel)    | 50        | 2.00     | 65        | 1  |
| Cal Seal           | 58        | 1.72     | 86        | 1  |
| Cement API Class H | 74        | 1.27     | 106       | 0  |
| Diacel D           | 10        | 5.00     | 16        | 3  |
| Gilsonite          | 38        | 1.33     | 43        | 1  |
| Hi-Dense®          | 150       | 0.67     | 190       | 0  |
| Pozmix™ A          | 67        | 1.10     | 86        | 0  |
| Sand, 20-40        | 98        | 1.02     | 105       | 0  |
| Silica Flour       | 60        | 1.66     | 84        | 1  |
| Coarse Silica      | 96        | 1.04     | 111       | 0  |

API Class H Cement + Barite

## 22. MUD PITS

### INDEX

#### 22.1 GENERAL

#### 22.2 TYPES

#### 22.3 ACCESSORIES

- a. Valves (suction, butterfly, dump, equalizing)
- b. Agitators (hydraulic, mechanical)

### 22.1 GENERAL

#### - Mud Pits Overview

The Mud Pit enable the rig crew to:

- Contain the drilling mud in a close system
- Monitor the physical and reological characteristics of the mud
- Monitor the well lost circulation
- Control kicks

Mud Pit Features



#### - Mud Pits Capability

The capability of the mud pits depends on:

- Formations and characteristics
- Applicable laws at the operation zones
- Well's depth
- Logistic positioning and well site.

Mud Pit Capability





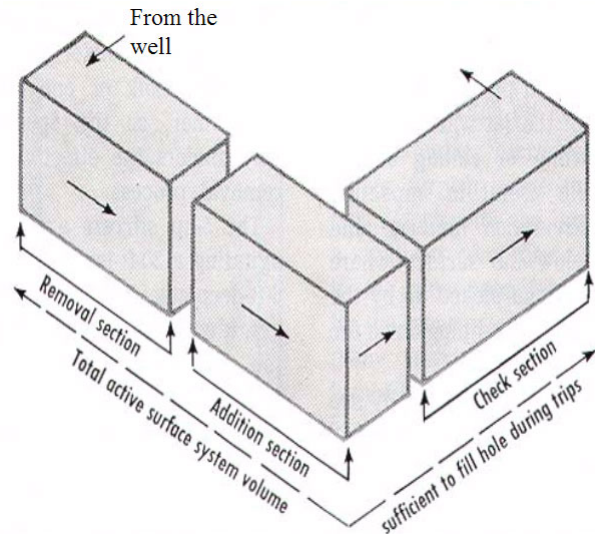
There are 2 category of mud pits:

- Active Mud Pit System
- Supply Mud Pit System

### - Active Mud Pit System

The active system has 3 compartments:

- Solids removal compartment
- Control / Modification of mud characteristics compartment
- Suction compartment.

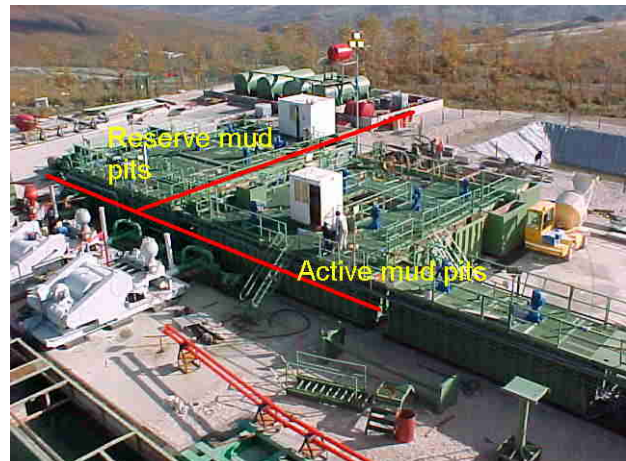


### - Supply Mud Pit System

The supply system is used to prepare mud for emergency response or for next drilling phase.

The capacity of the supply system is a compromise between economic and technical / operative necessities.

Reserve-Active Mud Pits



## 22.2 TYPES

### - Parallelepiped Shape

Dimensions are usually choose on the basis of transportation needs.

These are the most common pits.



### - Cylindrical Shape with Truncated Cone Base

They are engineered to reduce at the minimum the decabontation phenomenon.

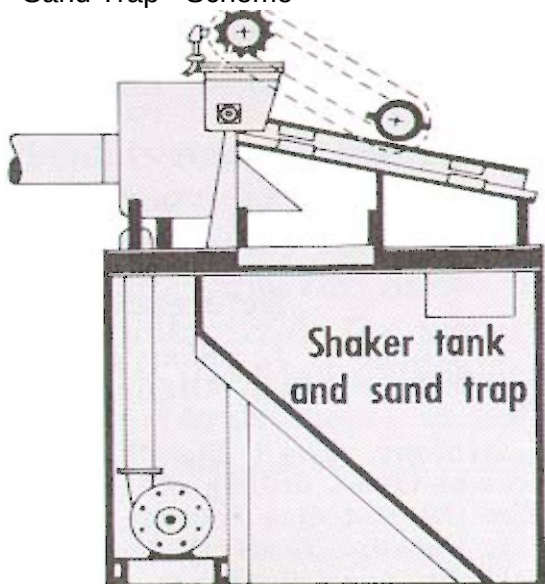
It's an innovative type, not so much used so far.



### - Sand Trap

The bottom of the mud pit shall have the right shape to facilitate good solids extraction. The following is an example of the sand trap below the shale shaker.

- Sand Trap - Scheme





## 22.3 ACCESSORIES

- a. Valves (suction, butterfly, dump, equalizing)
- b. Agitators (hydraulic, mechanical)

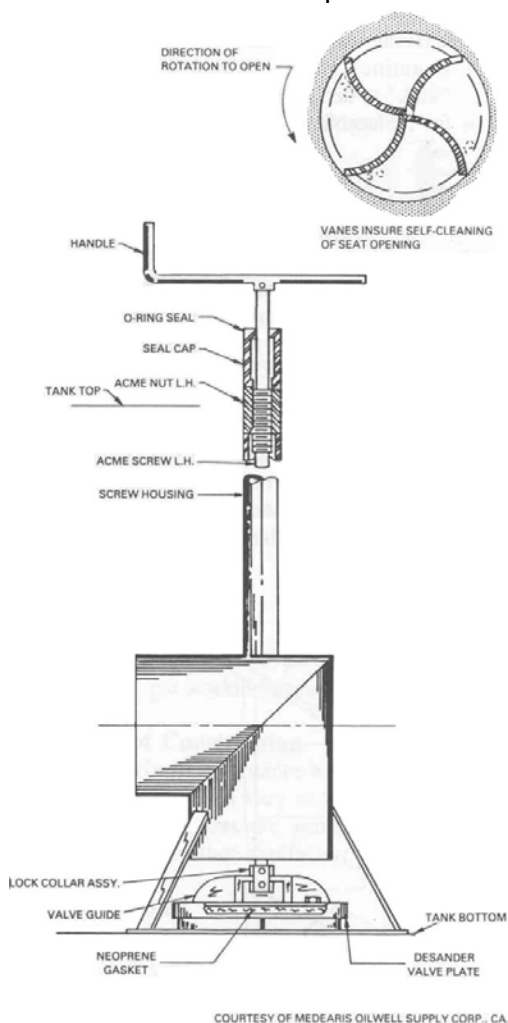
### a. Valves (suction, butterfly, dump, equalizing)

*Weco Butterfly Valve Quick Reference Chart*

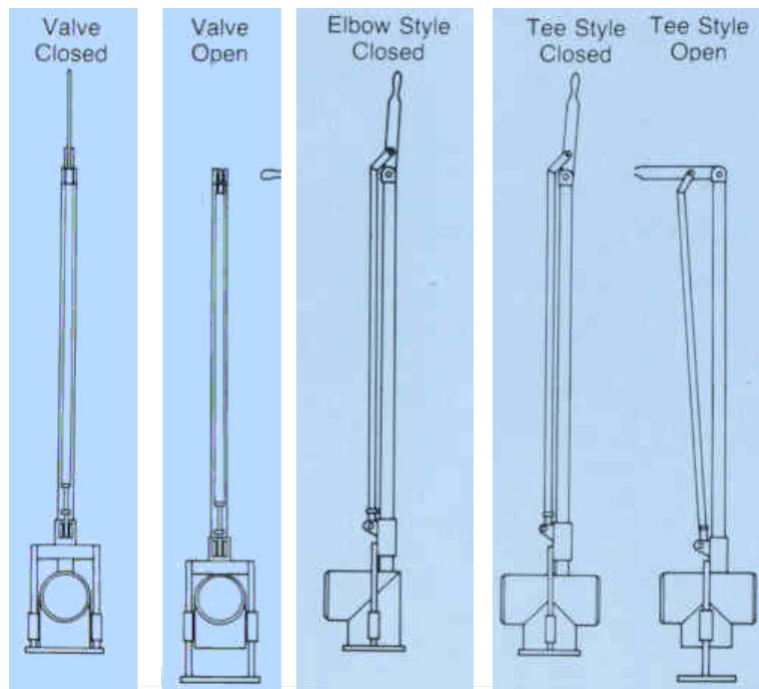
|           | Pressure Rating  | Body Style | Neck Length | Sizes, in. |    |   |   |   |   |   |    |    |    |    |    |    |    | Notes   |
|-----------|------------------|------------|-------------|------------|----|---|---|---|---|---|----|----|----|----|----|----|----|---------|
|           |                  |            |             | 2          | 2½ | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 24 |         |
| Model 12  | 175 psi (12 bar) | Wafer      | Short       |            |    |   |   |   |   |   |    |    |    |    |    |    |    | 1,2,3,4 |
| Model 12N | 175 psi (12 bar) | Notched    | Short       |            |    |   |   |   |   |   |    |    |    |    |    |    |    |         |
| Model 22  | 175 psi (12 bar) | Wafer      | Long        |            |    |   |   |   |   |   |    |    |    |    |    |    |    | 1       |
| Model 22L | 175 psi (12 bar) | Lug        | Long        |            |    |   |   |   |   |   |    |    |    |    |    |    |    | 1,3     |

#### - Suction valves

These valves are installed on the suction line at the bottom of the pit.



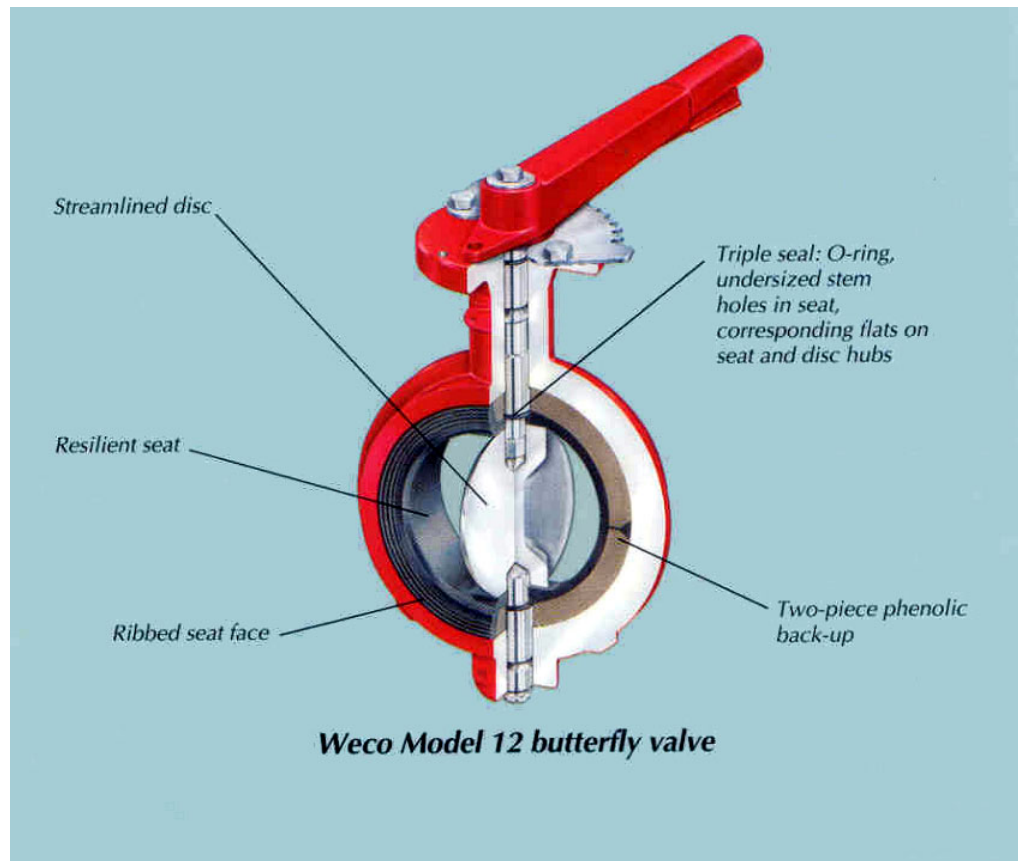
- Some of most common types



Common Types Suction Valves

## - Butterfly valves

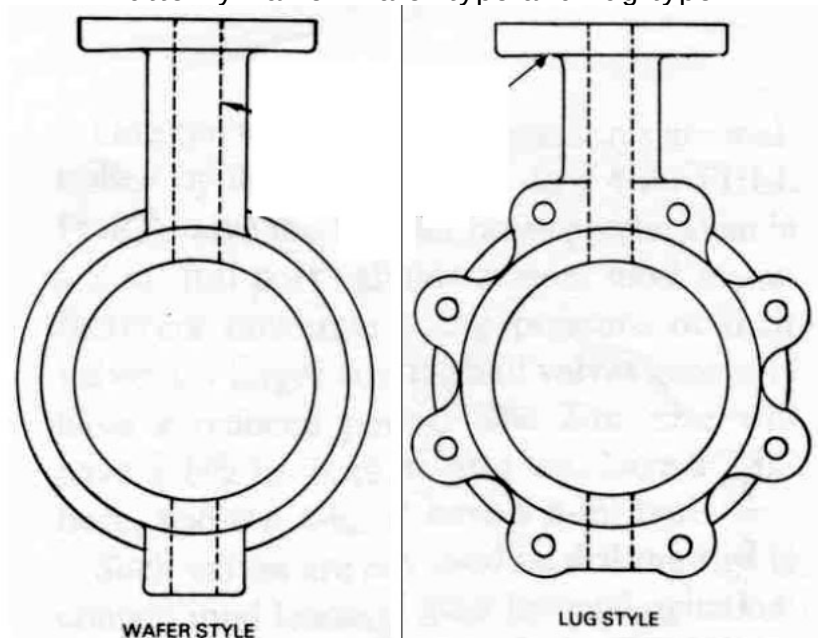
This is the easiest valve to operate and is the most commonly used valve on low pressure lines.



The valve's body can be

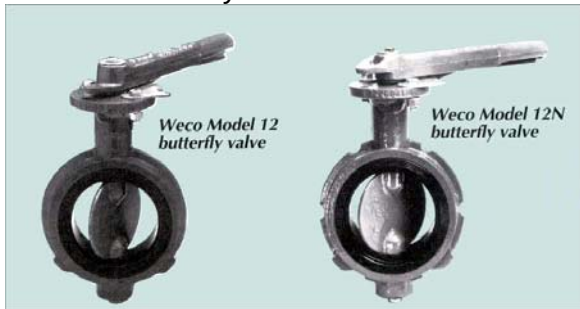
- without flange (wafer type), or
- with flange (lug type).

Butterfly Valve: Wafer type and Lug type



- Butterfly valve FMC: Size and Types
- Model 12
- Model 22
- Size

Weco Butterfly Valves Model 12



Weco Butterfly Valves Model 22



Weco Butterfly Valves Size

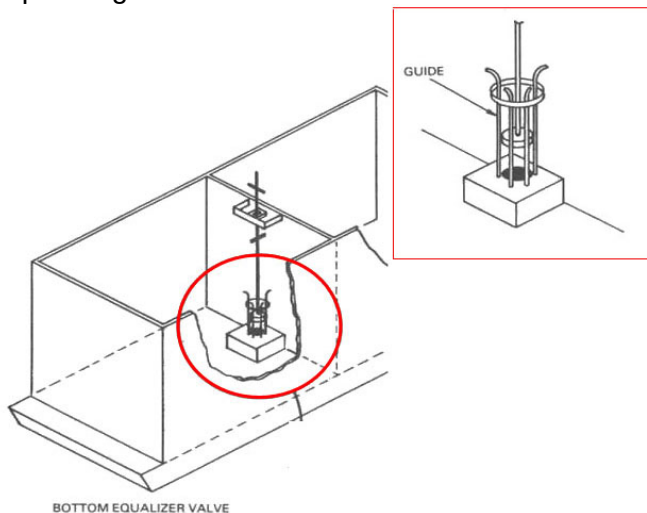
Weco Butterfly Valve Quick Reference Chart

|           | Pressure Rating  | Body Style | Neck Length | Sizes, in. |    |   |   |   |   |   |    |    |    |    |    |    |         | Notes |
|-----------|------------------|------------|-------------|------------|----|---|---|---|---|---|----|----|----|----|----|----|---------|-------|
|           |                  |            |             | 2          | 2½ | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 24      |       |
| Model 12  | 175 psi (12 bar) | Wafer      | Short       |            |    |   |   |   |   |   |    |    |    |    |    |    | 1,2,3,4 |       |
| Model 12N | 175 psi (12 bar) | Notched    | Short       |            |    |   |   |   |   |   |    |    |    |    |    |    |         |       |
| Model 22  | 175 psi (12 bar) | Wafer      | Long        |            |    |   |   |   |   |   |    |    |    |    |    |    | 1       |       |
| Model 22L | 175 psi (12 bar) | Lug        | Long        |            |    |   |   |   |   |   |    |    |    |    |    |    | 1,3     |       |

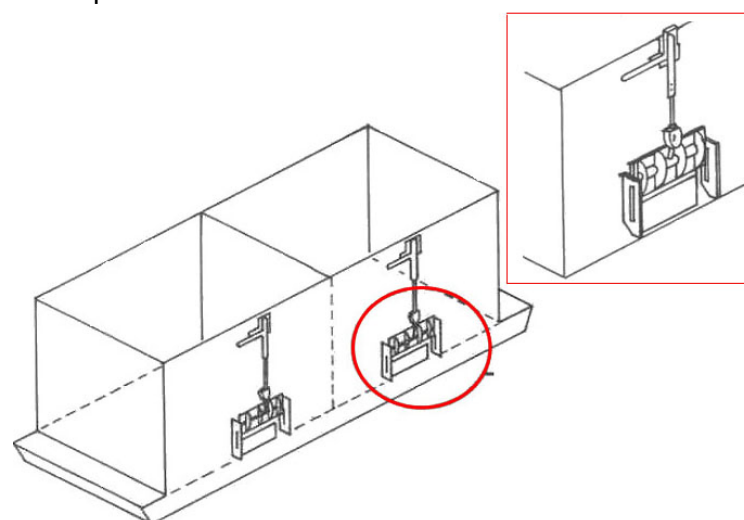
## - Equalizing Valve and Dump valves

- Equalizing valve
- Dump valve

Equalizing Valve



- Dump valve

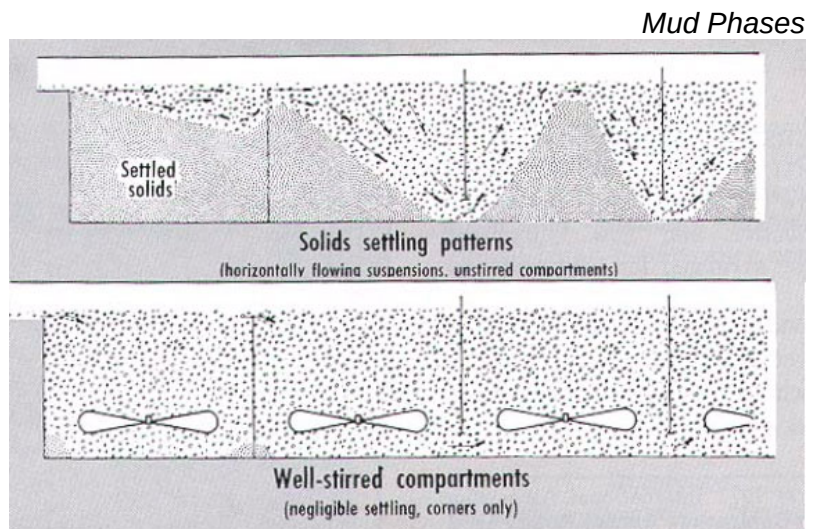


## b. Agitators (hydraulic, mechanical)

- Mud agitations in a pits

Mud consist of a liquid phase and a solid phase.

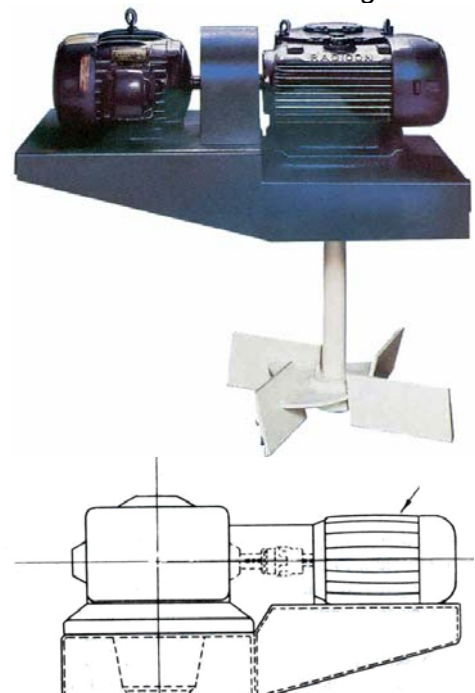
In order to avoid the separation of these two phases, it's necessary to keep the mud moving at all times.



### Mechanical agitators

- Scheme Mechanical agitators
- Flow types
- Agitator Design Based on Pit Dimensions
- Agitation Time
- Hydraulic agitators

### *Mechanical agitators*



- Scheme Mechanical agitators

These are moved by electric motors through a gear reducer.

- Home made Agitator 1
- Home made Agitator 2



Home made Agitator 1



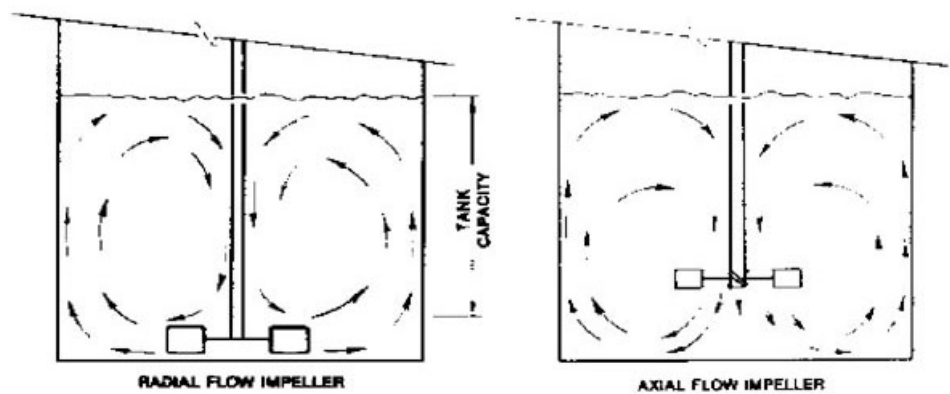
Home made Agitator 2



#### - Flow types

Based on the impeller's configuration they can create:

- Radial flow; the most commonly used
- Axial flow



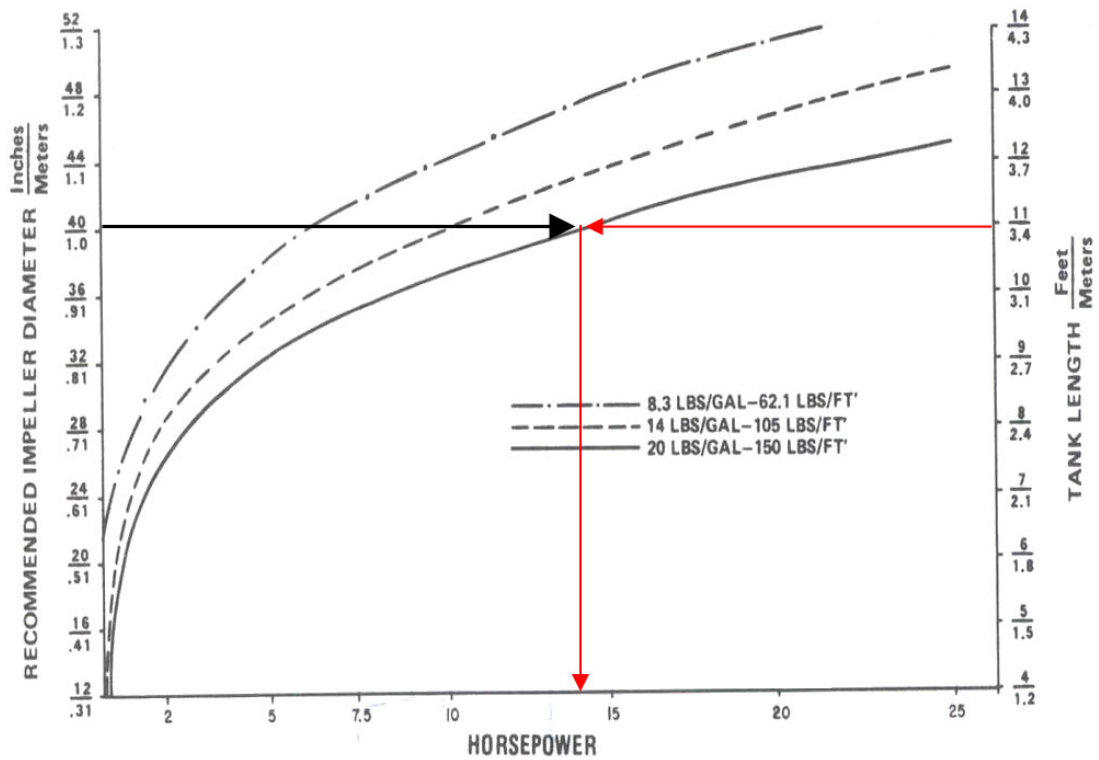
- Agitator Design Based on Pit Dimensions

Common practice is to install one agitator each compartment with length of 1.3 and a width 1.5.

Once the compartment has been established the maximum weight of mud to be agitated is determinate, use the diagram to find the correct impeller diameter and motor.

Use the volume of mud in the compartment and the pumping rate to determine the agitation time. The optimum value shall be below of 35 seconds.

Agitator Design



- Agitation Time

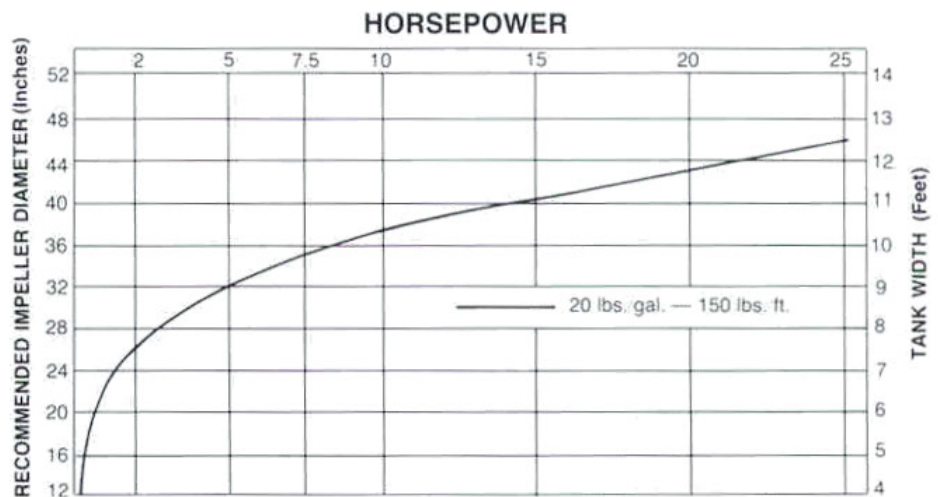
The rate between pit compartment volume and the agitated mud allows to calculate the agitation time. The **optimum value** shall be below of **35 seconds**

$$\text{TOR} = \frac{\text{TANK VOLUME}}{\text{DISPLACEMENT}} \times 60$$

- Table Displacement

| Table: Calculated Displacement                                                                                                                                       |                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| <p>Table 1.</p> <p>Calculated displacement for four 60° canted blade impeller. Displacement is based on the projected area of the blade.</p> <p>57.5 rpm: (60hz)</p> | <p>Table 2.</p> <p>Calculated displacement for four flat blade impeller.</p> <p>57.5 rpm: (60hz)</p> |
| 20 in. dia. – 909 gpm                                                                                                                                                | 20 in. dia. – 1,051 gpm                                                                              |
| 24 in. dia. – 1,645 gpm                                                                                                                                              | 24 in. dia. – 1,941 gpm                                                                              |
| 28 in. dia. – 2,468 gpm                                                                                                                                              | 28 in. dia. – 2,839 gpm                                                                              |
| 32 in. dia. – 3,764 gpm                                                                                                                                              | 32 in. dia. – 4,365 gpm                                                                              |
| 36 in. dia. – 5,402 gpm                                                                                                                                              | 36 in. dia. – 6,273 gpm                                                                              |
| 40 in. dia. – 7,284 gpm                                                                                                                                              | 40 in. dia. – 8,411 gpm                                                                              |
| 44 in. dia. – 9,928 gpm                                                                                                                                              | 44 in. dia. – 11,300 gpm                                                                             |
| 48 in. dia. – 12,512 gpm                                                                                                                                             | 48 in. dia. – 14,401 gpm                                                                             |

- Horse Power



NOTE: Horsepower is based on 58 rpm and a four bladed impeller. Maximum impeller size for given horsepower shown by heavy line.

## Hydraulic agitators



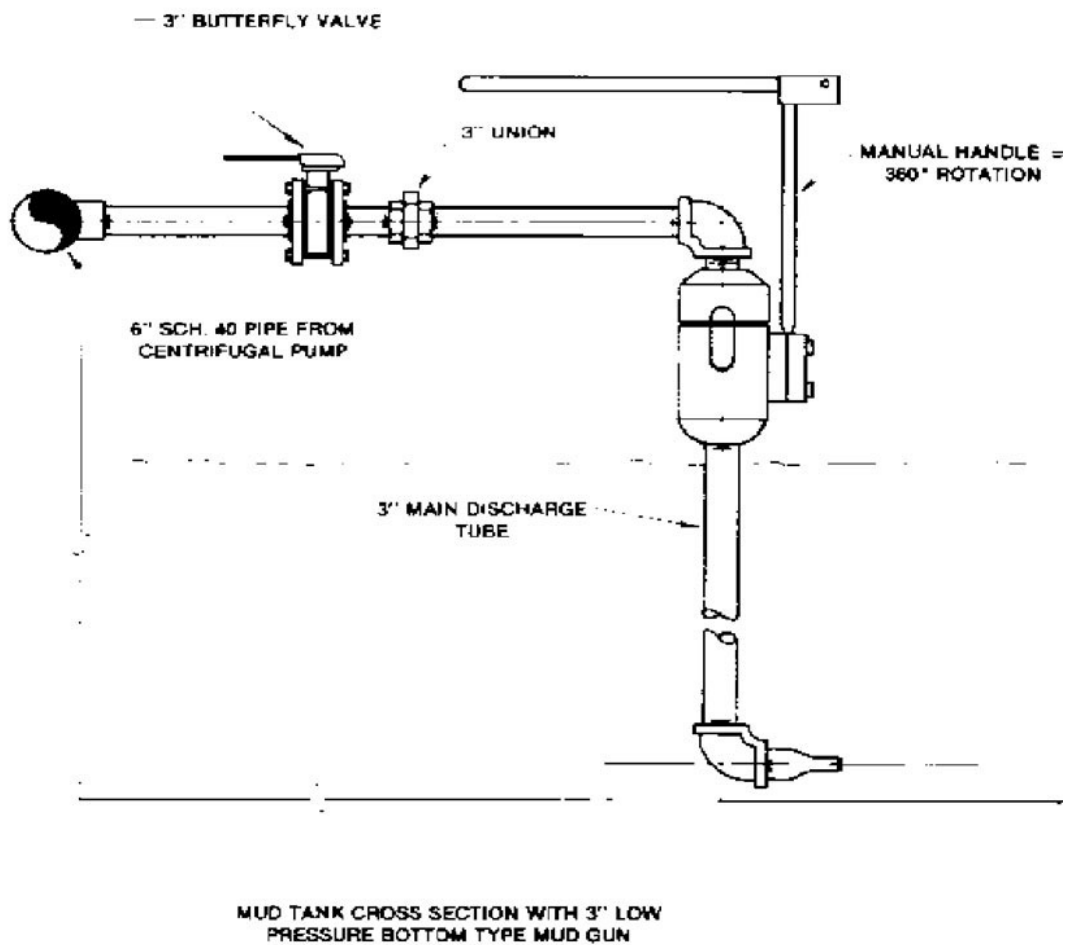
*Hydraulic Agitator - Home made*

### - Scheme Hydraulic Agitator

The high pressure type is not more used.

The low pressure agitators (guns) need a service centrifuge with a good prevalence (75 ft at least)

*Hydraulic Agitator - Scheme*





## 23. PIPE SIZING

### INDEX

#### 23.1 INTRUCTION

#### 23.2 FRICTION LOSSES

- Friction Losses for Different Pipe Size
- Friction Losses for Valves and Connections

### 23.1 INTRUCTION

There are several lines on surface in a drilling rig.  
They can be for high pressure, low pressure or discharge lines.

Everyone of these lines has to be dimensioned depending by the use, the kind of fluid, the general conditions (Flow rate, pressure, temperature, etc).

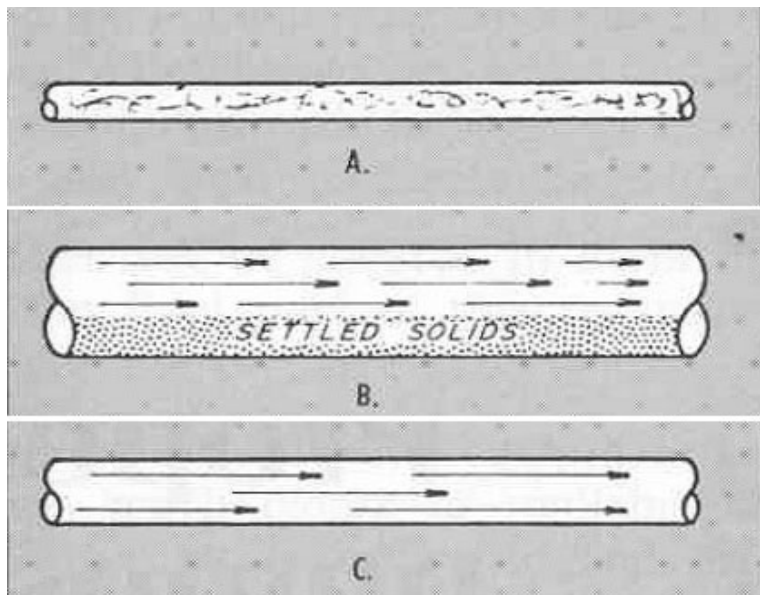
For very long lines we have also to consider the pressure losses, for example in the kill and choke lines of a semisub or even for the stand pipe manifold with the rig pumps far from the rig floor.

- Results of pipe sizing

**A. Pipes with an I.D. that is too small** cause high flow velocities and turbulence. This results in high friction losses, power wastege, and high maintenance costs.

**B. In pipes with an I.D. that is too large**, solids tend to settle on the pipe bottom and restrict size. These also cost more initially.

**C. Whit the correct pipe I.D.**, the flow velocity is optimum and the lines remain clean. Investment and maintenance costs are optimum.



Pipe Sizing

- **Table1:** Maximum flow rate and velocity according to pipe size

| Table 1                           | NOMINAL PIPE DIAMETER SCHEDULE 40 |     |       |       |     |       |     |       |     |     |      |
|-----------------------------------|-----------------------------------|-----|-------|-------|-----|-------|-----|-------|-----|-----|------|
|                                   | 3/4                               | 1   | 1 1/4 | 1 1/2 | 2   | 2 1/2 | 3   | 3 1/2 | 4   | 5   | 6    |
| Maximum Recommended Flow Rate GPM | 7                                 | 14  | 28    | 42    | 81  | 130   | 235 | 340   | 480 | 870 | 1400 |
| Velocity fps                      | 4.2                               | 5.2 | 6     | 6.3   | 7.7 | 8.7   | 10  | 11    | 12  | 14  | 15.5 |

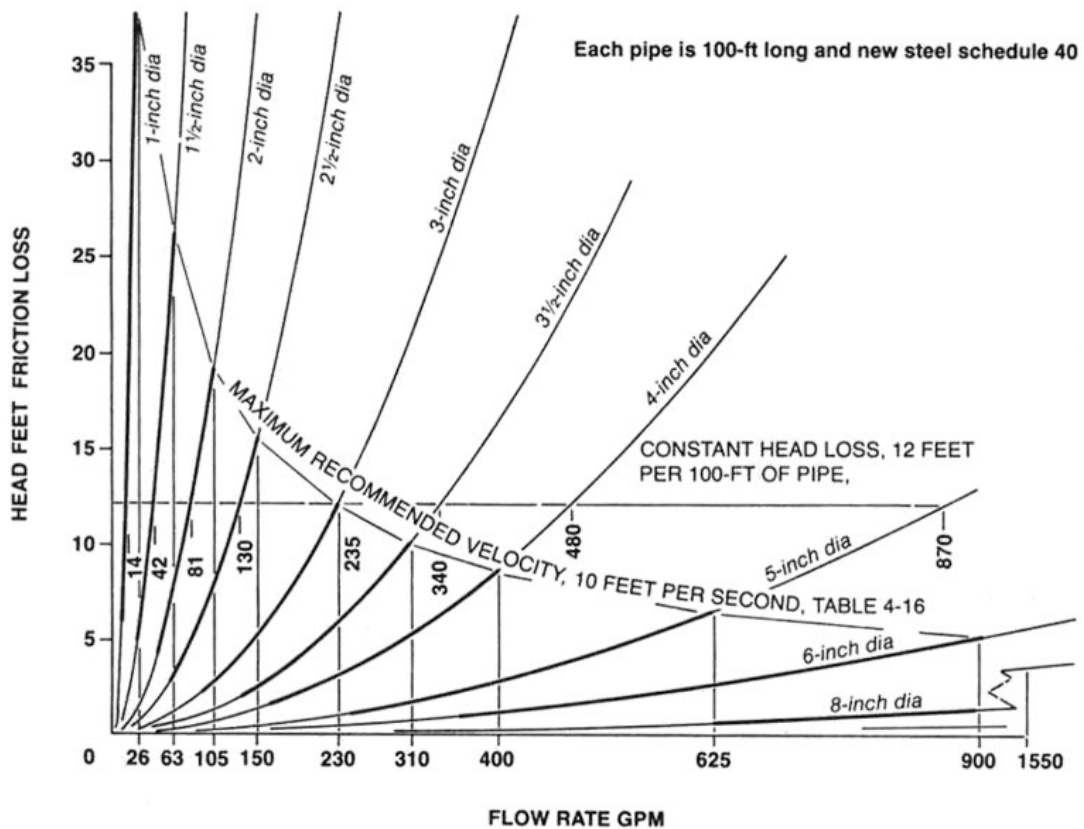
- **Table 2** : Optimum flow rate with maximum ( 10 ft/sec) and minimum (4 ft/sec) recommended velocities for different pipe size

| Table 2              | NOMINAL PIPE DIAMETER SCHEDULE 40 |    |       |       |     |       |     |       |     |     |     |      |      |      |
|----------------------|-----------------------------------|----|-------|-------|-----|-------|-----|-------|-----|-----|-----|------|------|------|
|                      | 3/4                               | 1  | 1 1/4 | 1 1/2 | 2   | 2 1/2 | 3   | 3 1/2 | 4   | 5   | 6   | 8    | 10   | 12   |
| Recommended Velocity | GALLONS PER MINUTE                |    |       |       |     |       |     |       |     |     |     |      |      |      |
| MAXIMUM 10 fps       | 16                                | 26 | 47    | 63    | 105 | 150   | 230 | 310   | 400 | 625 | 900 | 1550 | 2550 | 3500 |
| MINIMUM in mud 4 fps | 7                                 | 12 | 20    | 26    | 45  | 60    | 95  | 130   | 160 | 260 | 360 | 650  | 1000 | 1400 |

## 23.2 FRICTION LOSSES

- Friction Losses for Different Pipe Size
- Friction Losses for Valves and Connections

### - Friction Losses for Different Pipe Size



- Friction Losses: 4" Nominal & 5" Nominal

**FRICITION LOSS FOR WATER IN FEET HEAD PER 100 FEET OF PIPE LENGTH**

| 4 INCH<br>NOMINAL   | STEEL SCHEDULE 40<br>ID - 4.026 INCHES<br>$\epsilon/D - 0.000447$ |                  |                                                           | 5 INCH<br>NOMINAL   | STEEL SCHEDULE 40<br>ID - 5.047 INCHES<br>$\epsilon/D - 0.000357$ |                  |                                                           |
|---------------------|-------------------------------------------------------------------|------------------|-----------------------------------------------------------|---------------------|-------------------------------------------------------------------|------------------|-----------------------------------------------------------|
| FLOW<br>RATE<br>GPM | V<br>ft/sec                                                       | $V^2/2g$<br>feet | Friction<br>Loss in<br>Feet Head<br>Per 100 ft<br>of pipe | FLOW<br>RATE<br>GPM | V<br>ft/sec                                                       | $V^2/2g$<br>feet | Friction<br>Loss in<br>Feet Head<br>Per 100 ft<br>of pipe |
| 100                 | 2.52                                                              | 0.10             | 0.62                                                      | 160                 | 2.57                                                              | 0.10             | 0.49                                                      |
| 110                 | 2.77                                                              | 0.12             | 0.74                                                      | 180                 | 2.89                                                              | 0.13             | 0.61                                                      |
| 120                 | 3.02                                                              | 0.14             | 0.88                                                      | 200                 | 3.21                                                              | 0.16             | 0.74                                                      |
| 130                 | 3.28                                                              | 0.17             | 1.02                                                      | 220                 | 3.53                                                              | 0.19             | 0.88                                                      |
| 140                 | 3.53                                                              | 0.19             | 1.17                                                      | 240                 | 3.85                                                              | 0.23             | 1.04                                                      |
| 150                 | 3.78                                                              | 0.22             | 1.32                                                      | 260                 | 4.17                                                              | 0.27             | 1.20                                                      |
| 160                 | 4.03                                                              | 0.25             | 1.49                                                      | 280                 | 4.49                                                              | 0.31             | 1.38                                                      |
| 170                 | 4.28                                                              | 0.29             | 1.67                                                      | 300                 | 4.81                                                              | 0.36             | 1.58                                                      |
| 180                 | 4.54                                                              | 0.32             | 1.86                                                      | 320                 | 5.13                                                              | 0.41             | 1.78                                                      |
| 190                 | 4.79                                                              | 0.36             | 2.06                                                      | 340                 | 5.45                                                              | 0.46             | 2.00                                                      |
| 200                 | 5.04                                                              | 0.40             | 2.27                                                      | 360                 | 5.77                                                              | 0.52             | 2.22                                                      |
| 220                 | 5.54                                                              | 0.48             | 2.72                                                      | 380                 | 6.09                                                              | 0.58             | 2.46                                                      |
| 240                 | 6.05                                                              | 0.57             | 3.21                                                      | 400                 | 6.41                                                              | 0.64             | 2.72                                                      |
| 260                 | 6.55                                                              | 0.67             | 3.74                                                      | 420                 | 6.74                                                              | 0.71             | 2.98                                                      |
| 280                 | 7.06                                                              | 0.77             | 4.30                                                      | 440                 | 7.06                                                              | 0.77             | 3.26                                                      |
| 300                 | 7.56                                                              | 0.89             | 4.89                                                      | 460                 | 7.38                                                              | 0.85             | 3.55                                                      |
| 320                 | 8.06                                                              | 1.01             | 5.51                                                      | 480                 | 7.70                                                              | 0.92             | 3.85                                                      |
| 340                 | 8.57                                                              | 1.14             | 6.19                                                      | 500                 | 8.02                                                              | 1.00             | 4.16                                                      |
| 360                 | 9.07                                                              | 1.28             | 6.92                                                      | 550                 | 8.82                                                              | 1.21             | 4.98                                                      |
| 380                 | 9.58                                                              | 1.43             | 7.68                                                      | 600                 | 9.62                                                              | 1.44             | 5.88                                                      |
| 400                 | 10.10                                                             | 1.58             | 8.47                                                      | 650                 | 10.4                                                              | 1.69             | 6.87                                                      |
| 420                 | 10.6                                                              | 1.74             | 9.30                                                      | 700                 | 11.2                                                              | 1.96             | 7.93                                                      |
| 440                 | 11.1                                                              | 1.91             | 10.2                                                      | 750                 | 12.0                                                              | 2.25             | 9.05                                                      |
| 460                 | 11.6                                                              | 2.09             | 11.1                                                      | 800                 | 12.8                                                              | 2.56             | 10.22                                                     |

- Friction Losses: 6" Nominal & 8" Nominal

**FRICITION LOSS FOR WATER IN FEET HEAD PER 100 FEET OF PIPE LENGTH**

| 6 INCH<br>NOMINAL   | STEEL SCHEDULE 40<br>ID - 6.065 INCHES<br>$\epsilon/D - 0.000293$ |                            |                                                           | 8 INCH<br>NOMINAL   | STEEL SCHEDULE 40<br>ID - 7.981 INCHES<br>$\epsilon/D - 0.000226$ |                            |                                                           |
|---------------------|-------------------------------------------------------------------|----------------------------|-----------------------------------------------------------|---------------------|-------------------------------------------------------------------|----------------------------|-----------------------------------------------------------|
| FLOW<br>RATE<br>GPM | V<br>ft/sec                                                       | V <sup>2</sup> /2g<br>feet | Friction<br>Loss in<br>Feet Head<br>Per 100 ft<br>of pipe | FLOW<br>RATE<br>GPM | V<br>ft/sec                                                       | V <sup>2</sup> /2g<br>feet | Friction<br>Loss in<br>Feet Head<br>Per 100 ft<br>of pipe |
| 300                 | 3.33                                                              | 0.17                       | 0.64                                                      | 360                 | 2.31                                                              | 0.08                       | 0.23                                                      |
| 320                 | 3.55                                                              | 0.20                       | 0.72                                                      | 380                 | 2.44                                                              | 0.09                       | 0.25                                                      |
| 340                 | 3.78                                                              | 0.22                       | 0.81                                                      | 400                 | 2.57                                                              | 0.10                       | 0.28                                                      |
| 360                 | 4.00                                                              | 0.24                       | 0.90                                                      | 450                 | 2.89                                                              | 0.13                       | 0.35                                                      |
| 380                 | 4.22                                                              | 0.28                       | 1.00                                                      | 500                 | 3.21                                                              | 0.16                       | 0.42                                                      |
| 400                 | 4.44                                                              | 0.31                       | 1.10                                                      | 550                 | 3.53                                                              | 0.19                       | 0.51                                                      |
| 420                 | 4.66                                                              | 0.34                       | 1.20                                                      | 600                 | 3.85                                                              | 0.23                       | 0.60                                                      |
| 440                 | 4.89                                                              | 0.37                       | 1.31                                                      | 650                 | 4.17                                                              | 0.27                       | 0.70                                                      |
| 460                 | 5.11                                                              | 0.41                       | 1.42                                                      | 700                 | 4.49                                                              | 0.31                       | 0.80                                                      |
| 480                 | 5.33                                                              | 0.44                       | 1.54                                                      | 750                 | 4.81                                                              | 0.36                       | 0.91                                                      |
| 500                 | 5.55                                                              | 0.48                       | 1.66                                                      | 800                 | 5.13                                                              | 0.41                       | 1.02                                                      |
| 550                 | 6.11                                                              | 0.58                       | 1.99                                                      | 850                 | 5.45                                                              | 0.46                       | 1.15                                                      |
| 600                 | 6.66                                                              | 0.69                       | 2.34                                                      | 900                 | 5.77                                                              | 0.52                       | 1.27                                                      |
| 650                 | 7.22                                                              | 0.81                       | 2.73                                                      | 950                 | 6.09                                                              | 0.58                       | 1.41                                                      |
| 700                 | 7.77                                                              | 0.94                       | 3.13                                                      | 1000                | 6.41                                                              | 0.64                       | 1.56                                                      |
| 750                 | 8.33                                                              | 1.08                       | 3.57                                                      | 1100                | 7.05                                                              | 0.77                       | 1.87                                                      |
| 800                 | 8.88                                                              | 1.23                       | 4.03                                                      | 1200                | 7.70                                                              | 0.92                       | 2.20                                                      |
| 850                 | 9.44                                                              | 1.38                       | 4.53                                                      | 1300                | 8.34                                                              | 1.08                       | 2.56                                                      |
| 900                 | 9.99                                                              | 1.55                       | 5.05                                                      | 1400                | 8.98                                                              | 1.25                       | 2.95                                                      |
| 950                 | 10.5                                                              | 1.73                       | 5.60                                                      | 1500                | 9.62                                                              | 1.44                       | 3.37                                                      |
| 1000                | 11.1                                                              | 1.92                       | 6.17                                                      | 1600                | 10.3                                                              | 1.64                       | 3.82                                                      |
| 1100                | 12.2                                                              | 2.32                       | 7.41                                                      | 1700                | 10.9                                                              | 1.85                       | 4.29                                                      |
| 1200                | 13.3                                                              | 2.76                       | 8.76                                                      | 1800                | 11.5                                                              | 2.07                       | 4.79                                                      |
| 1300                | 14.4                                                              | 3.24                       | 10.2                                                      | 1900                | 12.2                                                              | 2.31                       | 5.31                                                      |
| 1400                | 15.5                                                              | 3.76                       | 11.8                                                      | 2000                | 12.8                                                              | 2.56                       | 5.86                                                      |



- Friction Losses: 10" Nominal & 12" Nominal

**FRICITION LOSS FOR WATER IN FEET HEAD PER 100 FEET OF PIPE LENGTH**

| 10 INCH<br>NOMINAL  | STEEL SCHEDULE 40<br>ID - 10.020 INCHES<br>$\epsilon/D - 0.000180$ |                  |                                                           | 12 INCH<br>NOMINAL  | STEEL SCHEDULE 40<br>ID - 11.938 INCHES<br>$\epsilon/D - 0.000151$ |                  |                                                           |
|---------------------|--------------------------------------------------------------------|------------------|-----------------------------------------------------------|---------------------|--------------------------------------------------------------------|------------------|-----------------------------------------------------------|
| FLOW<br>RATE<br>GPM | V<br>ft/sec                                                        | $V^2/2g$<br>feet | Friction<br>Loss in<br>Feet Head<br>Per 100 ft<br>of pipe | FLOW<br>RATE<br>GPM | V<br>ft/sec                                                        | $V^2/2g$<br>feet | Friction<br>Loss in<br>Feet Head<br>Per 100 ft<br>of pipe |
| 500                 | 2.03                                                               | 0.06             | 0.14                                                      | 700                 | 2.01                                                               | 0.06             | 0.11                                                      |
| 550                 | 2.24                                                               | 0.08             | 0.16                                                      | 750                 | 2.15                                                               | 0.07             | 0.12                                                      |
| 600                 | 2.44                                                               | 0.09             | 0.19                                                      | 800                 | 2.29                                                               | 0.08             | 0.14                                                      |
| 650                 | 2.64                                                               | 0.11             | 0.22                                                      | 850                 | 2.44                                                               | 0.09             | 0.16                                                      |
| 700                 | 2.85                                                               | 0.13             | 0.26                                                      | 900                 | 2.58                                                               | 0.10             | 0.17                                                      |
| 750                 | 3.05                                                               | 0.15             | 0.30                                                      | 950                 | 2.72                                                               | 0.12             | 0.19                                                      |
| 800                 | 3.25                                                               | 0.17             | 0.33                                                      | 1000                | 2.87                                                               | 0.13             | 0.21                                                      |
| 850                 | 3.46                                                               | 0.19             | 0.37                                                      | 1100                | 3.15                                                               | 0.15             | 0.25                                                      |
| 900                 | 3.66                                                               | 0.21             | 0.41                                                      | 1200                | 3.44                                                               | 0.18             | 0.30                                                      |
| 950                 | 3.87                                                               | 0.23             | 0.46                                                      | 1300                | 3.73                                                               | 0.22             | 0.34                                                      |
| 1000                | 4.07                                                               | 0.26             | 0.50                                                      | 1400                | 4.01                                                               | 0.25             | 0.40                                                      |
| 1100                | 4.48                                                               | 0.31             | 0.60                                                      | 1500                | 4.30                                                               | 0.29             | 0.45                                                      |
| 1200                | 4.88                                                               | 0.37             | 0.70                                                      | 1600                | 4.59                                                               | 0.33             | 0.51                                                      |
| 1300                | 5.29                                                               | 0.44             | 0.82                                                      | 1700                | 4.87                                                               | 0.37             | 0.57                                                      |
| 1400                | 5.70                                                               | 0.50             | 0.94                                                      | 1800                | 5.16                                                               | 0.41             | 0.64                                                      |
| 1500                | 6.10                                                               | 0.58             | 1.07                                                      | 1900                | 5.45                                                               | 0.46             | 0.70                                                      |
| 1600                | 6.51                                                               | 0.66             | 1.21                                                      | 2000                | 5.73                                                               | 0.51             | 0.78                                                      |
| 1700                | 6.92                                                               | 0.74             | 1.36                                                      | 2200                | 6.31                                                               | 0.62             | 0.93                                                      |
| 1800                | 7.32                                                               | 0.83             | 1.52                                                      | 2400                | 6.88                                                               | 0.74             | 1.10                                                      |
| 1900                | 7.73                                                               | 0.93             | 1.68                                                      | 2600                | 7.45                                                               | 0.86             | 1.28                                                      |
| 2000                | 8.14                                                               | 1.03             | 1.86                                                      | 2800                | 8.03                                                               | 1.00             | 1.47                                                      |
| 2200                | 8.95                                                               | 1.25             | 2.23                                                      | 3000                | 8.60                                                               | 1.15             | 1.68                                                      |
| 2400                | 9.76                                                               | 1.48             | 2.64                                                      | 3200                | 9.17                                                               | 1.31             | 1.90                                                      |
| 2600                | 10.6                                                               | 1.74             | 3.08                                                      | 3400                | 9.75                                                               | 1.48             | 2.13                                                      |
| 2800                | 11.4                                                               | 2.02             | 3.56                                                      | 3600                | 10.3                                                               | 1.65             | 2.37                                                      |
| 3000                | 12.2                                                               | 2.32             | 4.06                                                      | 3800                | 10.9                                                               | 1.84             | 2.63                                                      |
| 3200                | 13.0                                                               | 2.63             | 4.59                                                      | 4000                | 11.5                                                               | 2.04             | 2.92                                                      |
| 3400                | 13.8                                                               | 2.97             | 5.16                                                      | 4500                | 12.9                                                               | 2.59             | 3.65                                                      |

- Friction Losses for Valves and Connections

Friction Loss in Pipe Fittings in Equivalent Feet of Straight Pipe

USE FOR ANY LIQUID

| Nominal<br>Pipe<br>Size | Actual<br>Inside<br>Dia<br>Inches<br><br>Std Wt | <br>Gate<br>Valve<br>FULLY<br>OPEN | <br>Long Ell<br>Threading<br>or<br>45° Ell<br>Threading<br><br>$\begin{matrix} \text{---} d \text{---} \\ \text{---} 2d \text{---} \end{matrix}$<br>Cone<br>Entrance | <br>Std Tee<br>Threading<br><br><br>Square<br>Entrance | <br>90° Ell<br>Threading<br><br><br>Reduced<br>Tee<br>Threading<br><br><br>Extended<br>Entrance | <br>Square Ell<br><br><br>Std Tee<br>Threading | <br>Butterfly<br>Valve<br>FULLY<br>OPEN | <br>Swing<br>Check<br>Valve<br>FULLY<br>OPEN | <br>Globe<br>Valve<br>FULLY<br>OPEN | Std Wt<br>Welding Ell 90°                                                                                         |                                                                                                                    |
|-------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
|                         |                                                 |                                                                                                                     |                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                  |                                                                                                                          |                                                                                                                                |                                                                                                                        | Short<br><br>$\frac{R}{D} = 1$ | Long<br><br>$\frac{R}{D} = 1.5$ |
|                         |                                                 |                                                                                                                     |                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                  |                                                                                                                          |                                                                                                                                |                                                                                                                        | For 45° Ells<br>Use 65% of<br>Values Given<br>Below                                                               |                                                                                                                    |
| 1/2                     | .622                                            | .4                                                                                                                  | .8                                                                                                                                                                                                                                                    | 1.1                                                                                                                                                                                                                      | 1.7                                                                                                                                                                                                                                                                                                                                                | 3.3                                                                                                                                                                                                              | —                                                                                                                        | 5                                                                                                                              | 19                                                                                                                     | —                                                                                                                 | —                                                                                                                  |
| 3/4                     | .824                                            | .4                                                                                                                  | 1.0                                                                                                                                                                                                                                                   | 1.4                                                                                                                                                                                                                      | 2.1                                                                                                                                                                                                                                                                                                                                                | 4.2                                                                                                                                                                                                              | —                                                                                                                        | 7                                                                                                                              | 23                                                                                                                     | —                                                                                                                 | .9                                                                                                                 |
| 1                       | 1.049                                           | .6                                                                                                                  | 1.4                                                                                                                                                                                                                                                   | 1.8                                                                                                                                                                                                                      | 2.6                                                                                                                                                                                                                                                                                                                                                | 5.3                                                                                                                                                                                                              | —                                                                                                                        | 8                                                                                                                              | 29                                                                                                                     | —                                                                                                                 | —                                                                                                                  |
| 1 1/4                   | 1.380                                           | .7                                                                                                                  | 1.8                                                                                                                                                                                                                                                   | 2.3                                                                                                                                                                                                                      | 3.5                                                                                                                                                                                                                                                                                                                                                | 7.0                                                                                                                                                                                                              | —                                                                                                                        | 11                                                                                                                             | 39                                                                                                                     | —                                                                                                                 | —                                                                                                                  |
| 1 1/2                   | 1.610                                           | .9                                                                                                                  | 2.2                                                                                                                                                                                                                                                   | 2.7                                                                                                                                                                                                                      | 4.1                                                                                                                                                                                                                                                                                                                                                | 8.1                                                                                                                                                                                                              | —                                                                                                                        | 13                                                                                                                             | 45                                                                                                                     | —                                                                                                                 | —                                                                                                                  |
| 2                       | 2.067                                           | 1.                                                                                                                  | 3.                                                                                                                                                                                                                                                    | 4.                                                                                                                                                                                                                       | 5.                                                                                                                                                                                                                                                                                                                                                 | 10.                                                                                                                                                                                                              | 11                                                                                                                       | 15                                                                                                                             | 58                                                                                                                     | 3                                                                                                                 | 2.                                                                                                                 |
| 2 1/2                   | 2.467                                           | 1.                                                                                                                  | 3.                                                                                                                                                                                                                                                    | 4.                                                                                                                                                                                                                       | 6.                                                                                                                                                                                                                                                                                                                                                 | 12.                                                                                                                                                                                                              | 11                                                                                                                       | 19                                                                                                                             | 69                                                                                                                     | 4                                                                                                                 | 3.                                                                                                                 |
| 3                       | 3.068                                           | 2.                                                                                                                  | 4.                                                                                                                                                                                                                                                    | 5.                                                                                                                                                                                                                       | 8.                                                                                                                                                                                                                                                                                                                                                 | 15.                                                                                                                                                                                                              | 8                                                                                                                        | 23                                                                                                                             | 86                                                                                                                     | 5                                                                                                                 | 3.                                                                                                                 |
| 4                       | 4.026                                           | 2.                                                                                                                  | 5.                                                                                                                                                                                                                                                    | 7.                                                                                                                                                                                                                       | 10.                                                                                                                                                                                                                                                                                                                                                | 20.                                                                                                                                                                                                              | 9                                                                                                                        | 32                                                                                                                             | 113                                                                                                                    | 7                                                                                                                 | 4.                                                                                                                 |
| 5                       | 5.047                                           | 3.                                                                                                                  | 7.                                                                                                                                                                                                                                                    | 8.                                                                                                                                                                                                                       | 13.                                                                                                                                                                                                                                                                                                                                                | 25.                                                                                                                                                                                                              | 7                                                                                                                        | 40                                                                                                                             | 142                                                                                                                    | 8                                                                                                                 | 5                                                                                                                  |
| 6                       | 6.065                                           | 3.                                                                                                                  | 8.                                                                                                                                                                                                                                                    | 10.                                                                                                                                                                                                                      | 15.                                                                                                                                                                                                                                                                                                                                                | 30.                                                                                                                                                                                                              | 11                                                                                                                       | 48                                                                                                                             | 170                                                                                                                    | 10                                                                                                                | 6.                                                                                                                 |
| 8                       | 7.981                                           | 4.                                                                                                                  | 11.                                                                                                                                                                                                                                                   | 13.                                                                                                                                                                                                                      | 20.                                                                                                                                                                                                                                                                                                                                                | 40.                                                                                                                                                                                                              | 13                                                                                                                       | 33                                                                                                                             | 224                                                                                                                    | 13                                                                                                                | 8.                                                                                                                 |
| 10                      | 10.020                                          | 5.                                                                                                                  | 13.                                                                                                                                                                                                                                                   | 17.                                                                                                                                                                                                                      | 25.                                                                                                                                                                                                                                                                                                                                                | 50.                                                                                                                                                                                                              | 16                                                                                                                       | 42                                                                                                                             | 281                                                                                                                    | 17                                                                                                                | 10.                                                                                                                |
| 12                      | 12.000                                          | 6.                                                                                                                  | 16.                                                                                                                                                                                                                                                   | 20.                                                                                                                                                                                                                      | 30.                                                                                                                                                                                                                                                                                                                                                | 60.                                                                                                                                                                                                              | 22                                                                                                                       | 50                                                                                                                             | 336                                                                                                                    | 20                                                                                                                | 12.                                                                                                                |

## 24. TRIP TANK

### INDEX

- 24.1 DESCRIPTION
- 24.2 DIMENSIONS
- 24.3 CONFIGURATION

### 24.1 DESCRIPTION

#### - Monitoring of the mud

It is necessary to monitor the amount of mud that exits or enters the hole as the drilling string is run in or out.

The **monitoring**, or **measurement**, can be done either by using the rig pumps and calculating the number of strokes required to fill the hole, or by using a trip tank.

*Trip Tank*

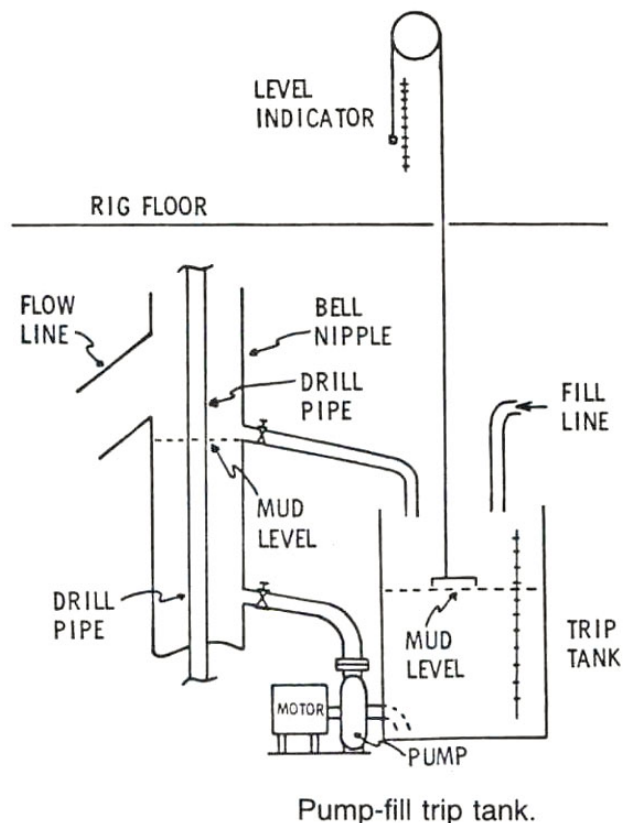


#### - Function

A TRIP TANK is any pit or tank in which the mud volume can be measured accurately to within  $\pm 1.0$  bbls. As the pipe is pulled from the hole, the mud from the tank is allowed to fill the hole as needed, which at the same time denotes the amount of mud being used.

The mud fills the hole by a pump with a return line from the bell nipple to the tank. A continuous fill up device doesn't require as much of the driller's attention.

*Trip Tank - Components*



#### - Components

Trip tank used on every rig has: pit/ centrifugal pump/ pit level.

## 24.2 DIMENSIONS

### - Trip tank dimensions

Trip tank dimensions are a compromise between reading 100 liters variations and having to fill the tank too often.

Usually, they are dimensioned to achieve a 3 inches height variation for a 5 DP stand.

The **Centrifugal pump** must have a sufficient flow rate to empty the tank in a few minutes.

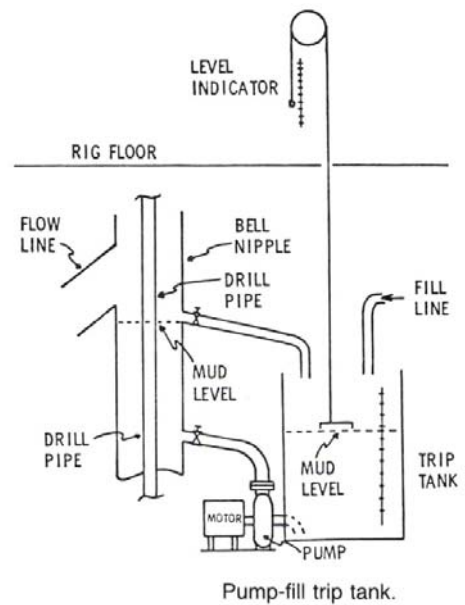
ENI Well Control police stipulates that the minimum capacity of trip tank should be 5 m<sup>3</sup> (30bbls).



### - Level indicator

The Level indicator is a float connected to a graduated gauge stick positioned on the rig floor and visible to the driller.

- Modern systems have the float connected to an electronic gauge or ultrasonic device.



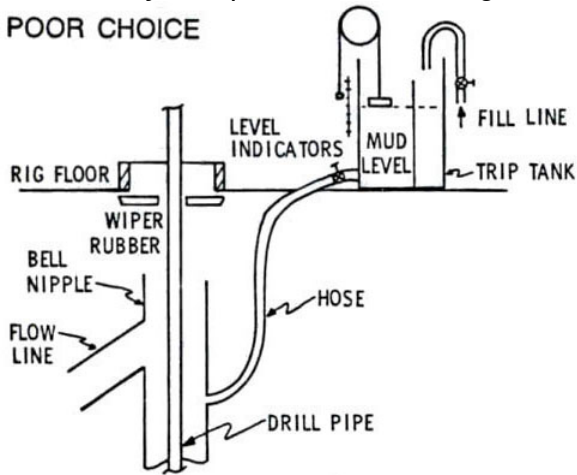


### 24.3 CONFIGURATION

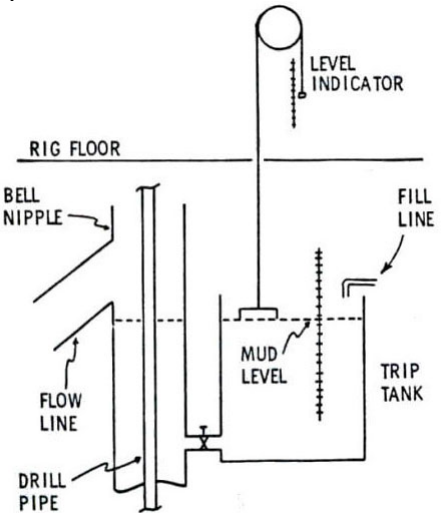
#### - Gravity Trip Tank

*Gravity-fill trip tank located on rig floor*

POOR CHOICE

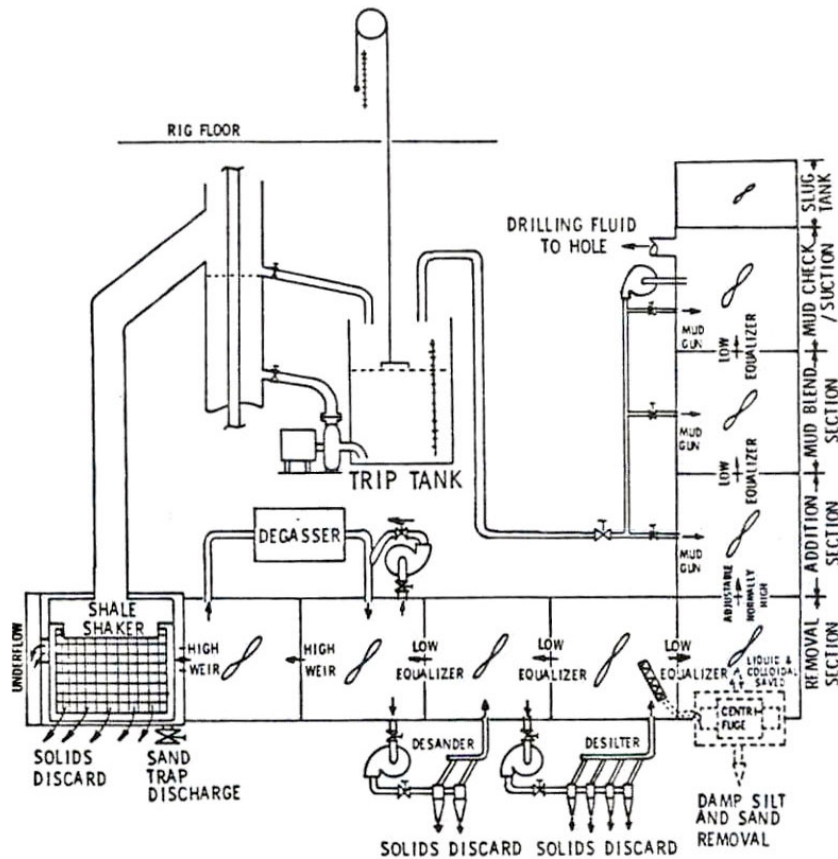


*Gravity-fill trip tank located at annulus level*



#### - Trip tank with centrifugal pump

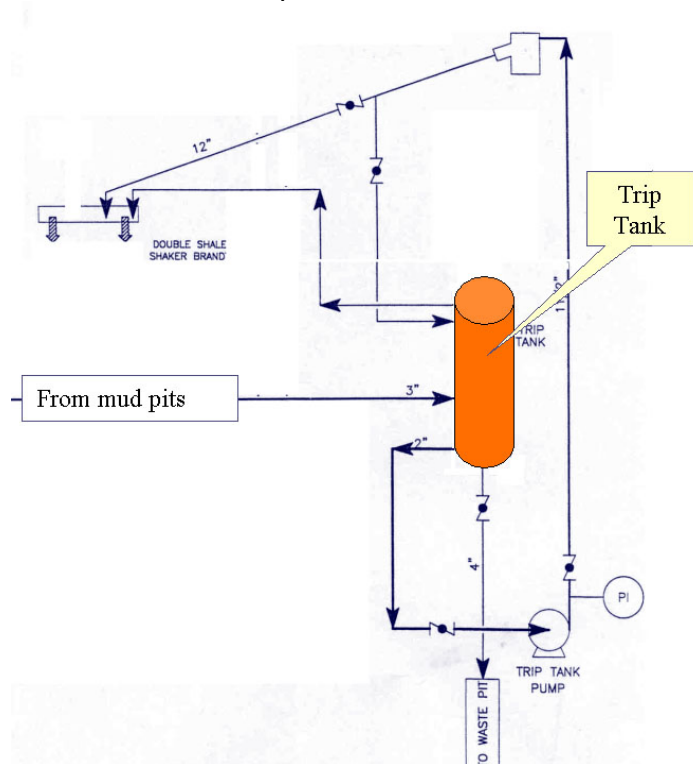
*System arrangement with pump-fill trip tank*



Trip Tank on Land Rig



Trip Tank Scheme



## 25. SOLIDS REMOVAL SYSTEM

### INDEX

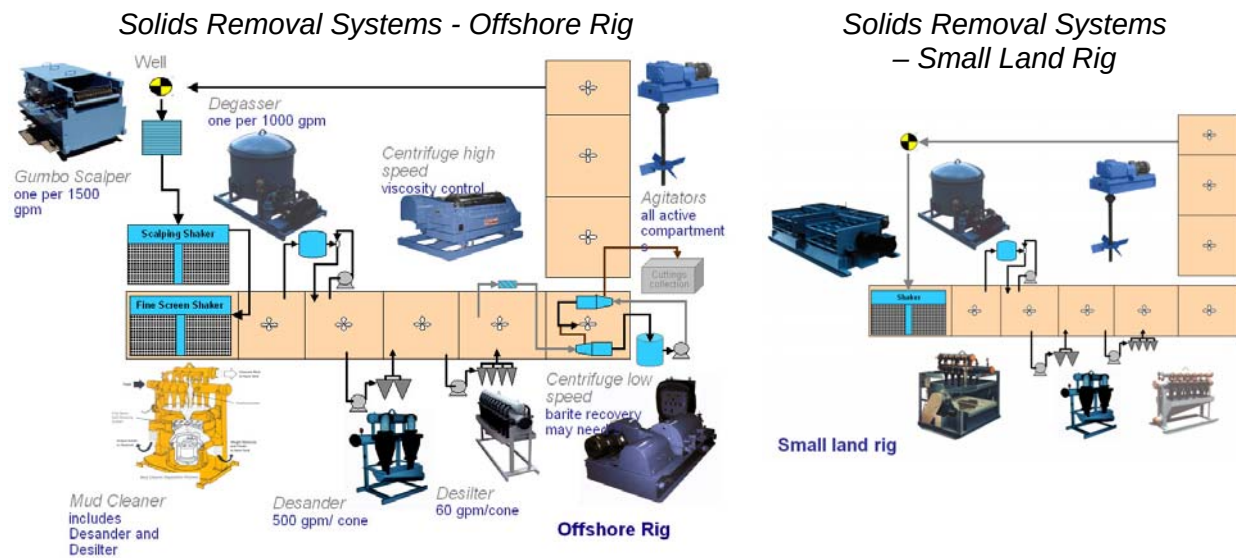
- 25.1 BENEFITS OF SOLIDS REMOVAL
- 25.2 DRILLED SOLIDS
- 25.3 EQUIPMENT
- 25.4 SHALE SHAKER
  - Deck and Screens
  - Vibration Motion
  - Most common models
  - Screen
  - Dimensions of Solids Removed
- 25.5 DESANDER & DESILTER
- 25.6 MUD CLEANER
- 25.7 DECANTATION CENTRIFUGE

### 25.1 BENEFITS OF SOLIDS REMOVAL

- Solid Removal

A large quantity of solids in the mud can cause many problems during drilling. It also results in high mud treatment costs trying to maintain the shape of the mud.

The **purpose of solid removal** equipment is to contain the percentage of solid in the mud at an acceptable level.



### - Benefits

Benefits of a low solids content are:

- Higher rate of penetration during drilling
- Increased bit life
- Reduced mud control costs
- Reduced mud pump maintenance costs
- Reduced possibility of stuck pipe
- More regular hole geometry
- Reduced need for mud dilution
- Increased cement efficiency
- Reduced BHA torque

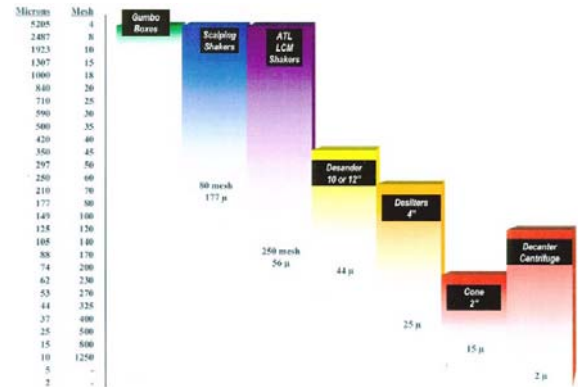
## 25.2 DRILLED SOLIDS

Drilling mud contains two kinds of solids:

- Commercial solids
- Drilled solids
- Solids Removal by Type of System



Solids Removal Systems

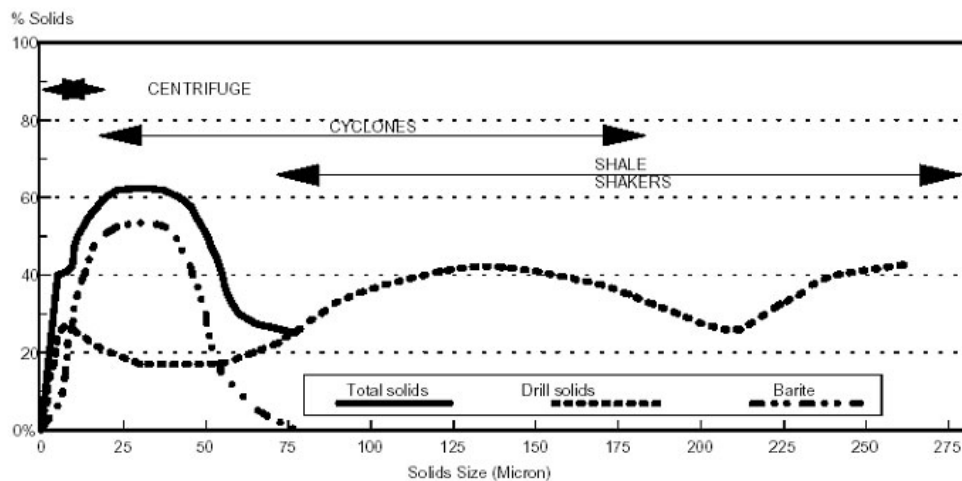


Solids Removal by Type of System

- Commercial solids

Commercial solids (with the exception of barite and lost circulation material), have dimension below of 1 micron.

Distribution of Solids in the Mud



- Drilled solids

Drilled solids have varying dimensions, depending on bit and used mud transportation.

They can be between 1 and 2000 micron, classified as follows:

|                          |                   |
|--------------------------|-------------------|
| $\leq 440 \mu$           | big size cuttings |
| between 74 and $440 \mu$ | sand              |
| between 2 and $74 \mu$   | silt              |
| between 0.5 and $74 \mu$ | clay              |



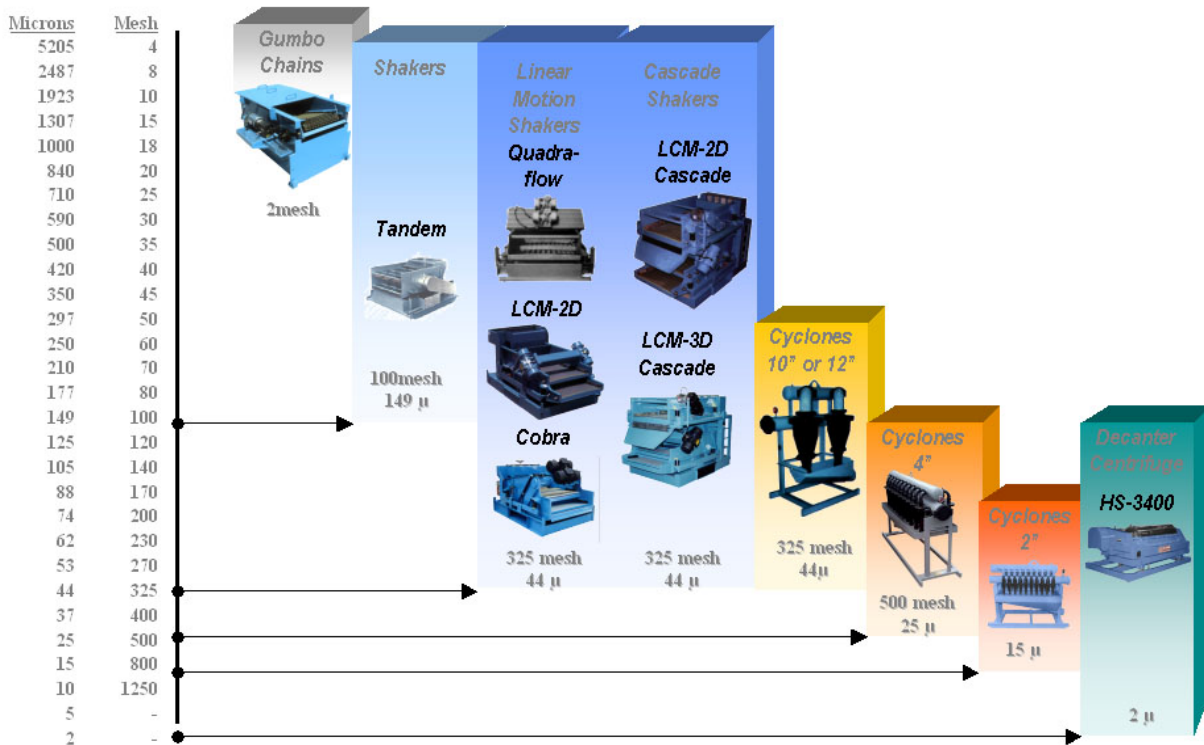
## 25.3 EQUIPMENT

- Mechanical removal
- Solids control equipment
- Equipment Lay out

### - Mechanical removal

Mechanical removal of solids is achieved by 2 forces:

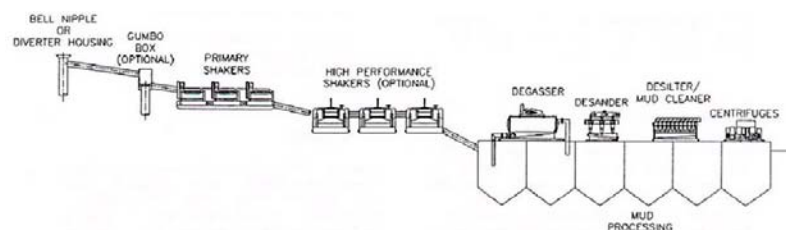
- Vibration
- Centrifugal force



### - Solids control equipment

Solids control equipment used on a Drilling Rigs includes:

- SHALE SHAKER
- DESANDER
- DESILTER
- MUD CLEANER
- DECANTER CENTRIFUGE

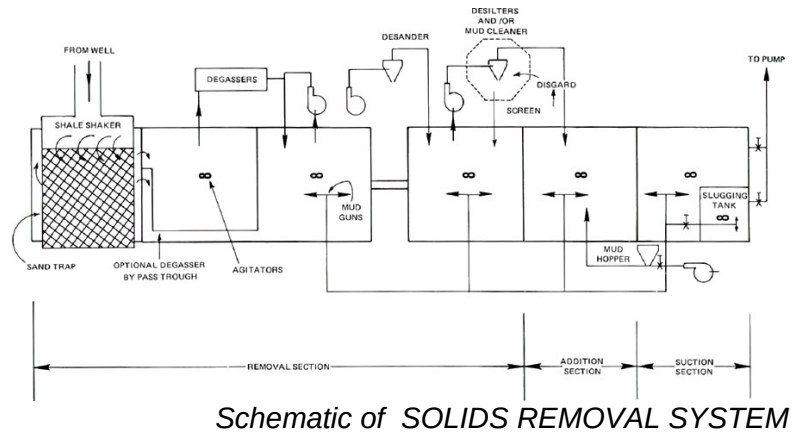


Scheme of a MODERN SYSTEM of SOLIDS REMOVAL

## - Equipment Lay out

This equipment is used in succession because each of them is engineered to remove solids of a progressively smaller size.

At the moment the trend is to equip new rigs with shale shakers that are more efficient and also function as a desander, desilter and sometimes as a mud cleaner.

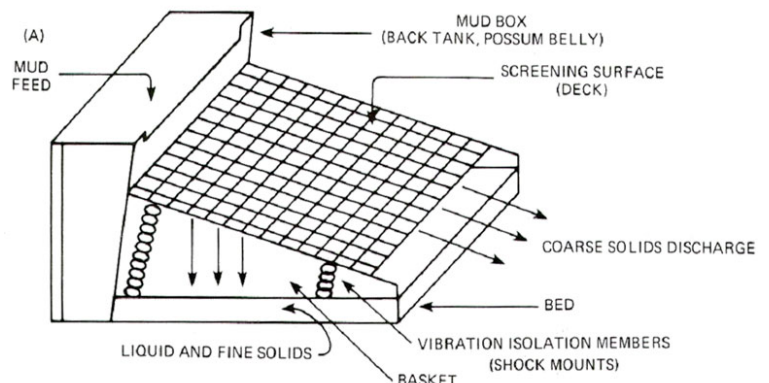


## 25.4 SHALE SHAKER

The Shale shaker is the first stage of solids removal as the mud comes from the well. Its treatment capability is determined by the size of screen and to the mud characteristics.



Shale Shaker



Nomenclature API Standard

## - Cascade system

Drilling Rigs have more than one shale shakers installed in parallel in order to better distribute the mud flow coming from the well.

Shale shakers can also be installed in succession (cascade system) in order to get a first cuttings removal (bigger sizes) on the primary and a following one of smaller cuttings on the secondary.

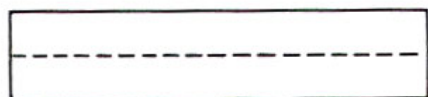


Cascade system

## Deck and Screens

- HORIZONTAL BASKET
- SLOPING BASKET

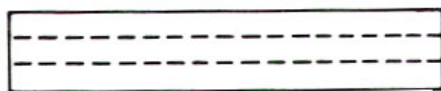
### Horizontal Basket



SINGLE DECK SINGLE SCREEN

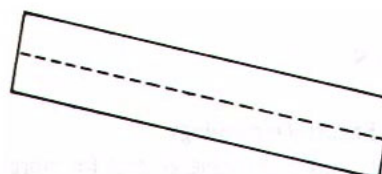


SINGLE DECK DOUBLE SCREEN

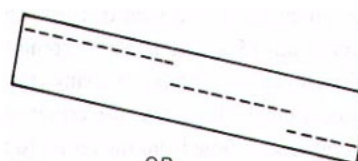


DOUBLE DECK DOUBLE SCREEN

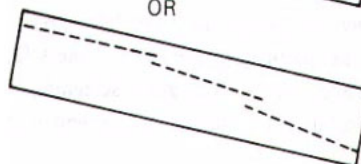
### Sloping Basket



SINGLE DECK SINGLE SCREEN



OR



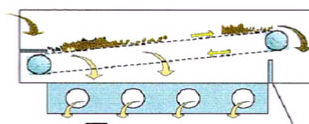
SINGLE DECK  
TRIPLE  
SCREEN  
(CASCADE;  
PARALLEL  
FLOW)

## - Vibration Motion

### - Sequence

- Linear Motion
- Circular Motion
- Elliptical & Circular
- Steps Motion

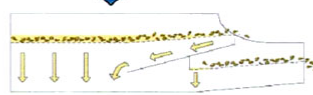
#### Step 1 Gumbo Chain



#### Step 2 Circular Motion Scalper

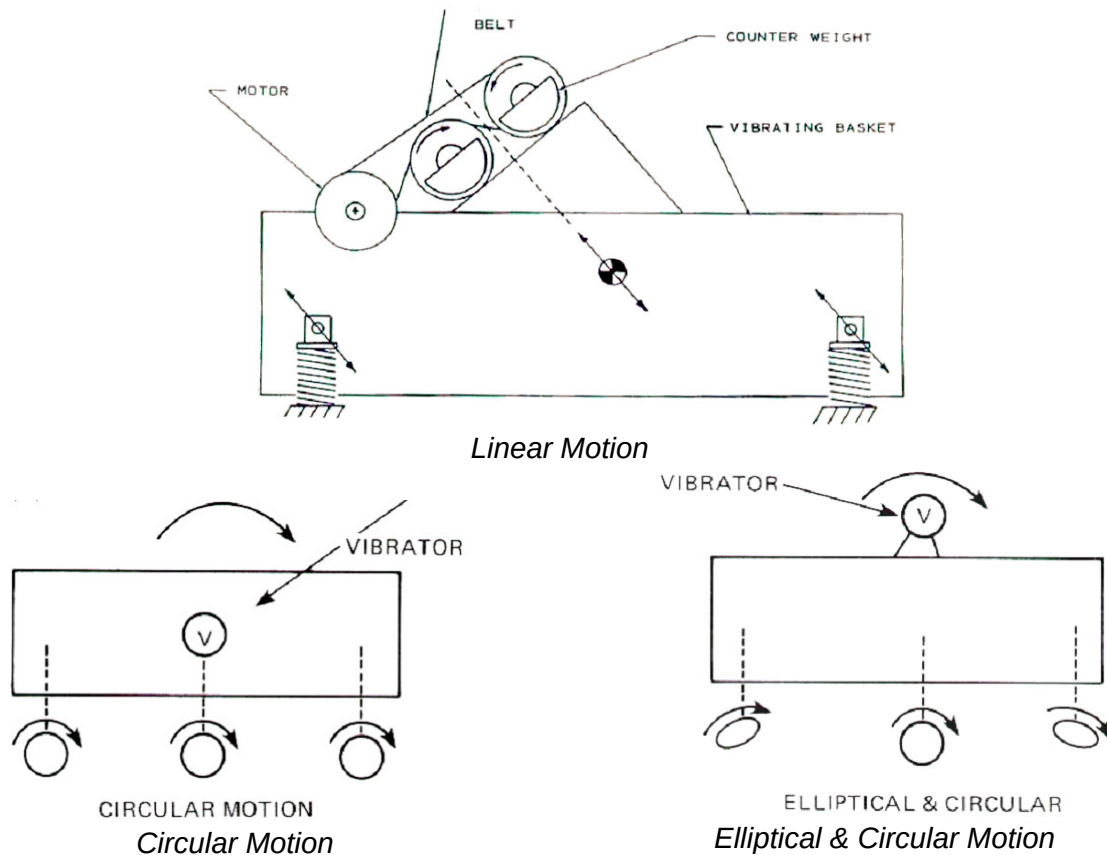


#### Step 3 Linear Motion Shakers



| Microns | Mesh |
|---------|------|
|         | 1/2  |
|         | 1    |
|         | 2    |
| 5205    | 4    |
| 2487    | 8    |
| 1923    | 10   |
| 1307    | 15   |
| 1000    | 18   |
| 840     | 20   |
| 710     | 25   |
| 590     | 30   |
| 500     | 35   |
| 420     | 40   |
| 350     | 45   |
| 297     | 50   |
| 250     | 60   |
| 210     | 70   |
| 177     | 80   |
| 149     | 100  |
| 125     | 120  |
| 105     | 140  |
| 88      | 170  |
| 74      | 200  |
| 62      | 230  |
| 56      | 250  |

### Steps Motion



### - "G" Factor

Shale shaker differentiates also by their vibration capability that is due to engine the Round Per Minute and therefore, of rack's speed; more high it is, more is the mud thrown force on the shale shaker screens.

Empirically, this force is identified by g factor that is calculated as follows:

|                                                                                   |
|-----------------------------------------------------------------------------------|
| $\text{"g" factor} = \frac{\text{Run of vibration motion (inc x RPM } 2)}{70400}$ |
|-----------------------------------------------------------------------------------|



### Most common models

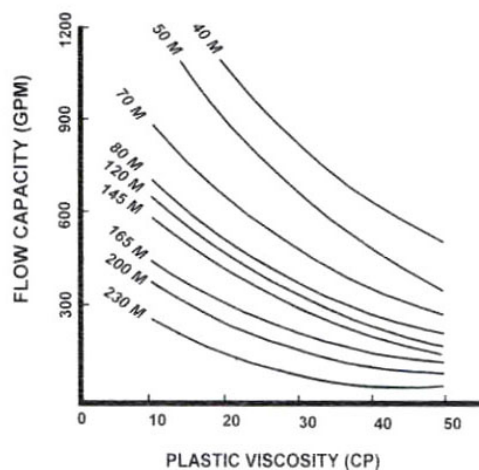
- BRANDT RIGTECH LCM Model
- BRANDT RIGTECH ATL Models
- DERRICK Models
- SWACO

#### - BRANDT RIGTECH LCM Model

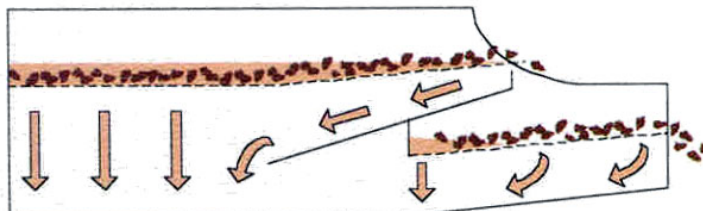
*LCM-2D(sm) Cascade Screen Separator*



*Flow Rates for the LCM-2D (sm) Cascade*



*Contour Plus m(sm)*



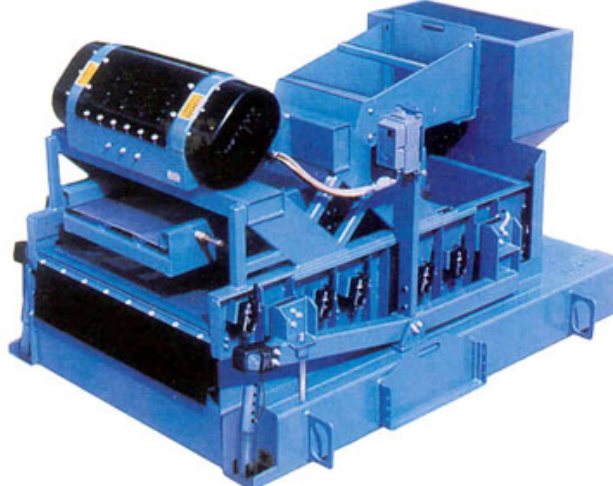
*ContourPlus<sup>SM</sup> deck design improves cuttings conveyance*

#### - BRANDT RIGTECH ATL Models

- ATL-CS (sm) Cascade Screen Separator

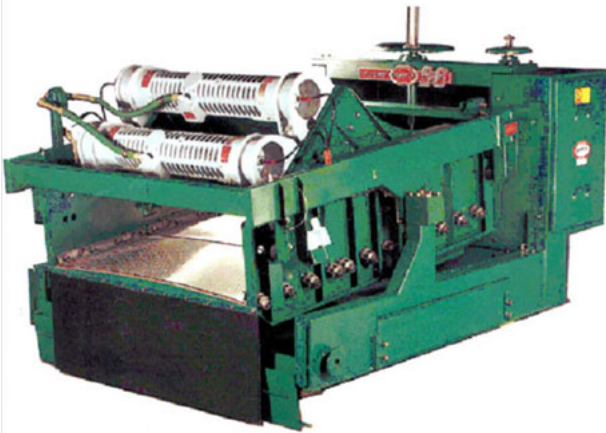


- ATL-1000 (sm) Cascade Screen Separator

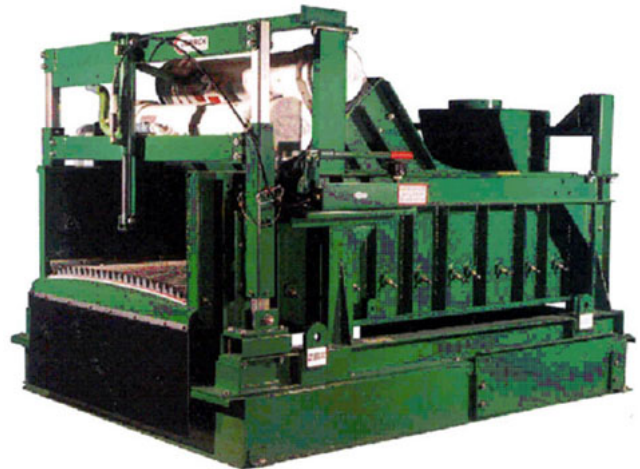


- **DERRICK Models**

- Model 58 Flo-Line Cleaner Plus



Model FLC 2000 3-panel



- Model FLC 513

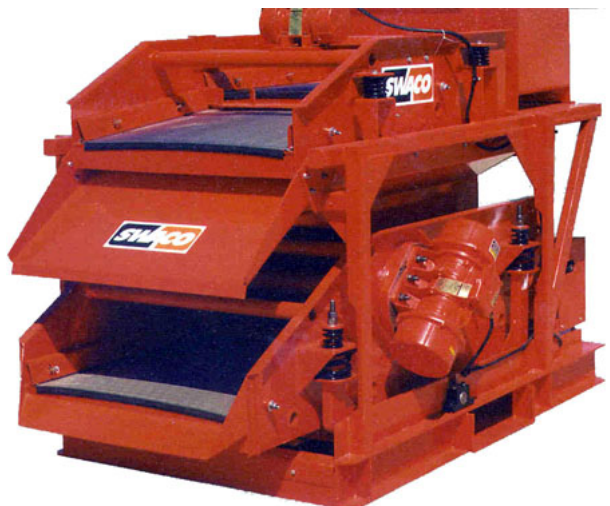


- **SWACO**

- Swaco <sup>TM</sup> Adjustable Line Shaker



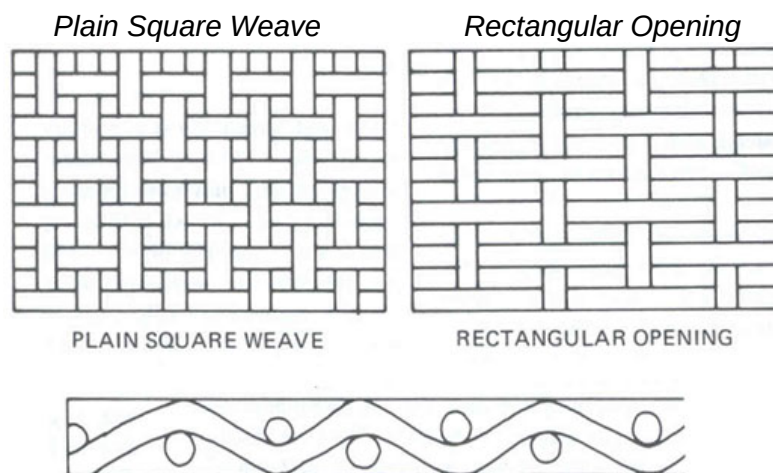
- Swaco <sup>TM</sup> Adjustable Cascade System



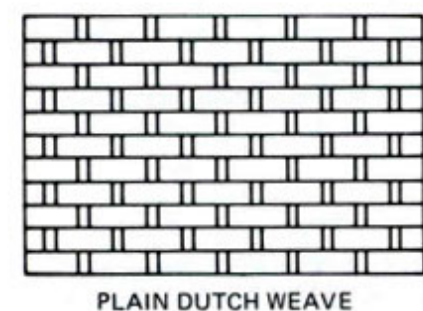


## Screen

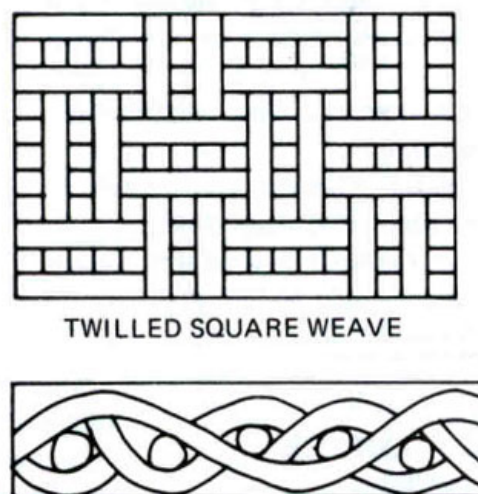
### - Screen weaves



### - Plain Dutch Weave



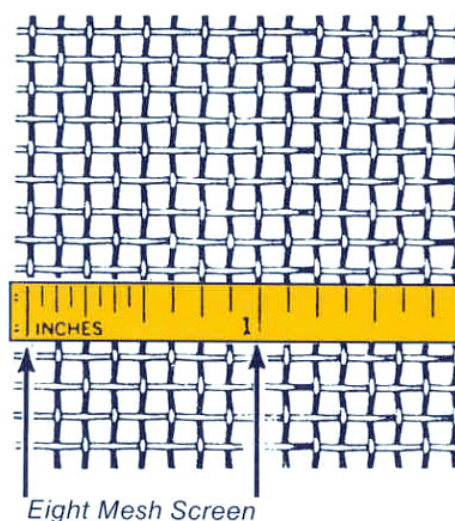
### - Twilled Square Weave



### - Screen mesh

Screen mesh is the number of meshes per inch; that correspond to number of mesh per inch. API Specification has standardizide a different way to identify the shale shaker's screens.

For instance, 80 x 80 (178 x 178, 31,4) means that the screen has 80 mesh of square shape with a square light of 178 micron and a passing light of 31,4% on the total area.



## - Screen types

### DERRICK PIRAMIDAL SCREENS

- Pyramid Screen 0.8" Corrugation height
- Pyramid Plus Screen 1.5" Corrugation height

### CHARACTERISTICS

- Increase Surface area
- Enhanced Permeability

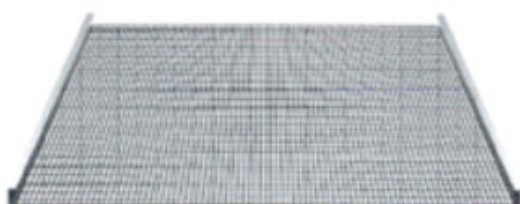


**PYRAMID® SCREEN**  
0.8" corrugation height



**PYRAMID PLUS™ SCREEN**  
1.5" corrugation height

## **40% Increase In Actual Surface Area**



Conventional Screen  
48 x 30 (PWP) Panel

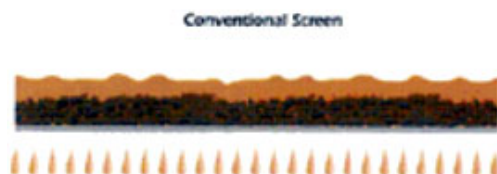
5.3 sq. ft. of screen area



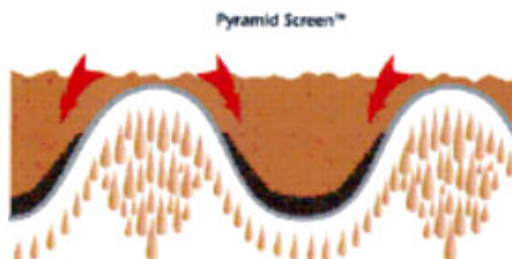
Pyramid Screen™  
48 x 30 (PMD) Panel

**7.6 sq. ft. of screen area**

## **Enhanced Permeability**



Solids Form Continuous Bed  
Impeding Fluid Throughput



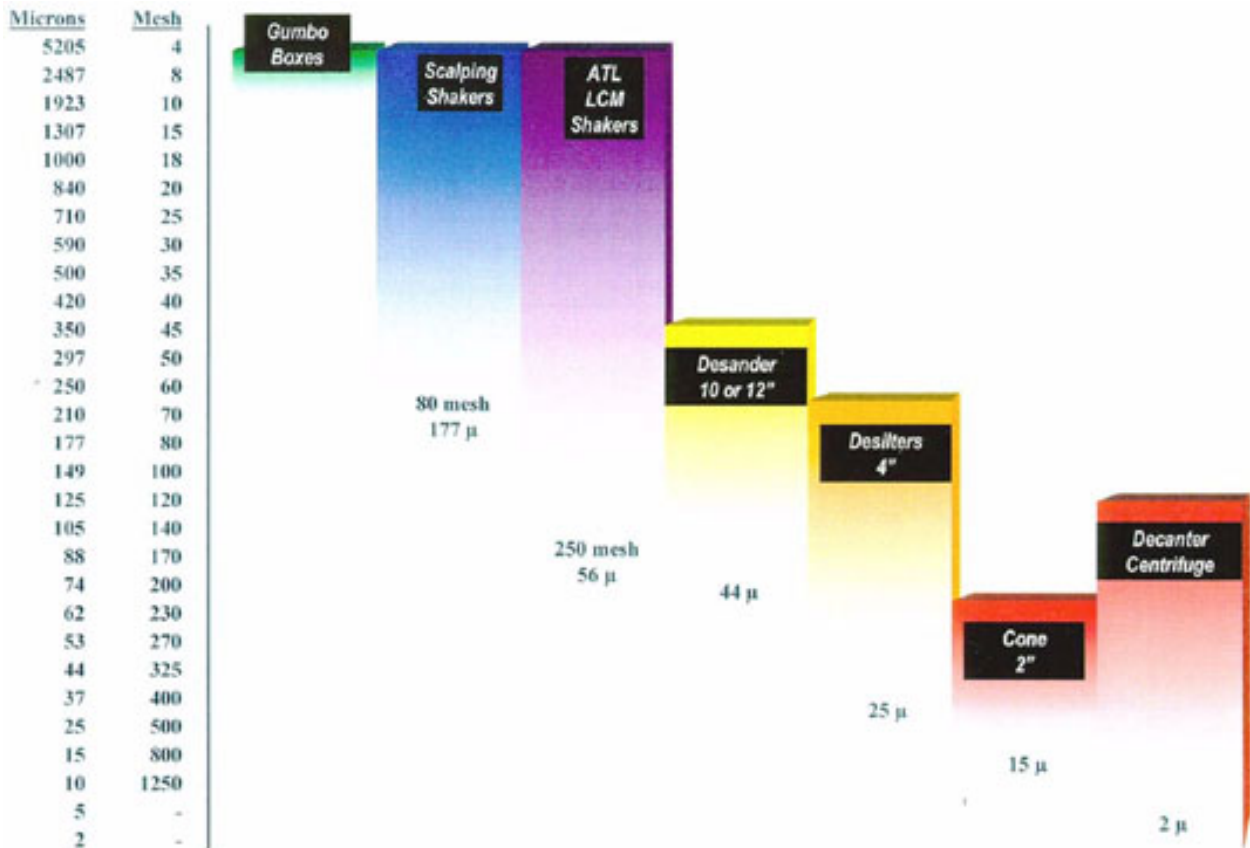
**Gravity Forces Solids Into Troughs**



## Dimensions of Solids Removed

- Comparison of field applications

Dimensions of Solids Removed By Each System (Brandt)

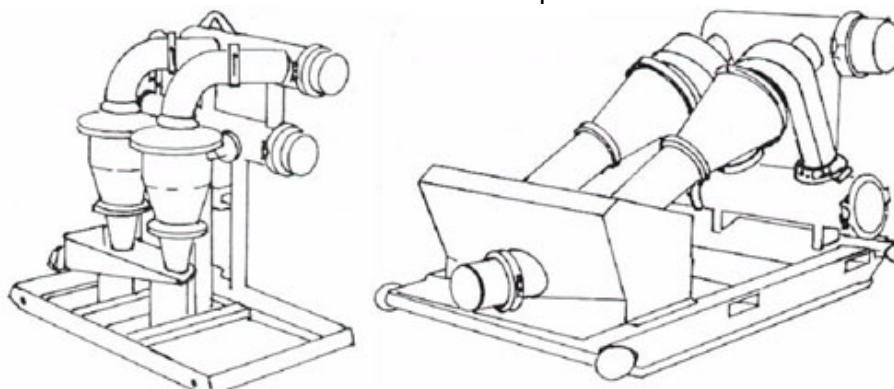


## 25.5 DESANDER & DESILTER

A battery (bank) of hydro-cyclones is able to remove solids from mud not weighted with barite as follows:

- DESANDER Above 74 microns (sand)
- DESILTER Fine solids (silt)

Desander Examples



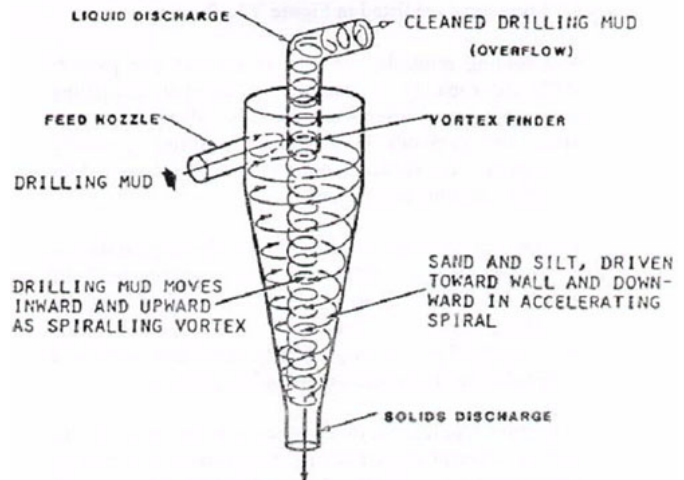
## - Cyclone

Mud is sent to a cyclone through a dedicated centrifuge engineered specifically for this purpose.

The drilling mud must enter the cyclone tangentially with high flow and pressure.

Here it acquires high velocity.

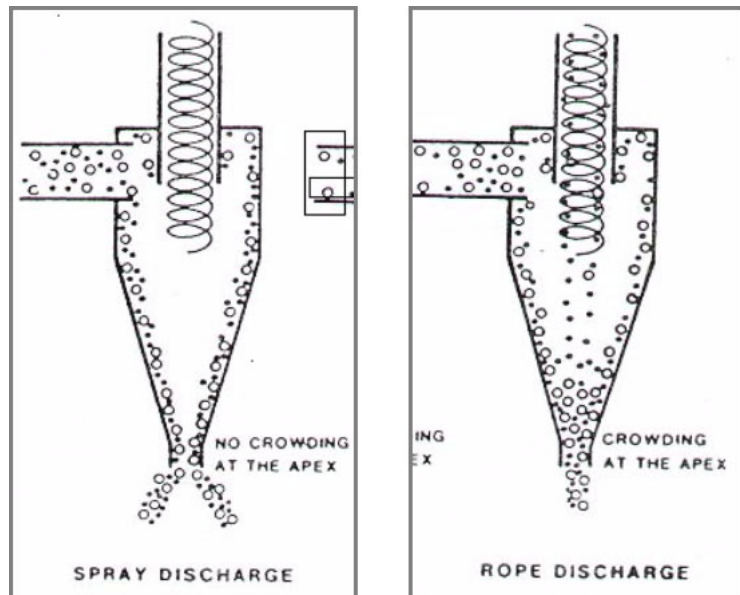
Centrifugal force separates the solid phase from the liquid phase, sending the solids to the lower exit (Underflow) and the liquids to the upper exit (Overflow).



## - Underflow discharge

Underflow discharge is a good indicator of current operation of the system:

- Spray discharge: proper operation
- Rope discharge: improper operation



## - Cone Size and Use

The wide part of a cone can vary between 4 to 12 inches. Cones are usually installed in parallel to adequately treat the mud.

| CONE SIZE (I.D.)    | 4"     | 5"     | 6"      | 8"      | 10"     | 12"     |
|---------------------|--------|--------|---------|---------|---------|---------|
| CAPACITY (GPM)      | 50-75  | 70-80  | 100-150 | 150-250 | 400-500 | 400-500 |
| FEED PRESSURE (PSI) | 30-40  | 30-40  | 30-40   | 25-35   | 20-30   | 20-30   |
| CUT POINT (MICRONS) | 15-20μ | 20-25μ | 25-30μ  | 30-40μ  | 30-40μ  | 40-60μ  |

## - DESANDER

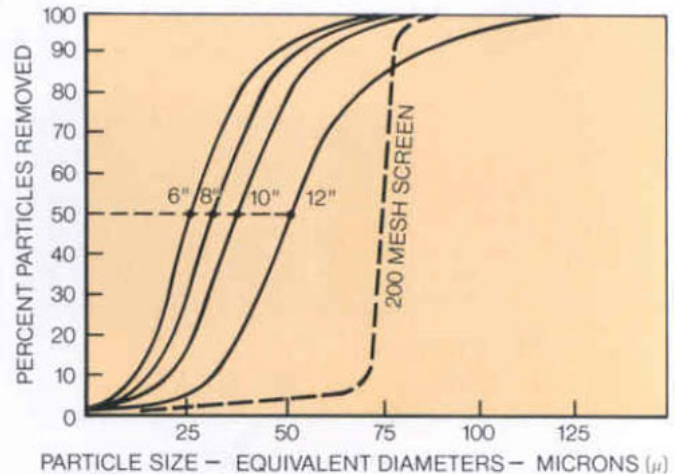
### - Desander cones

A desander uses cones with a diameter of 8 to 12 inches.

The bigger the cone the larger the solids discharged.

### - Particle Removal

Desilter remove particles in the range of 15 micron.



Desander: Particle Removal

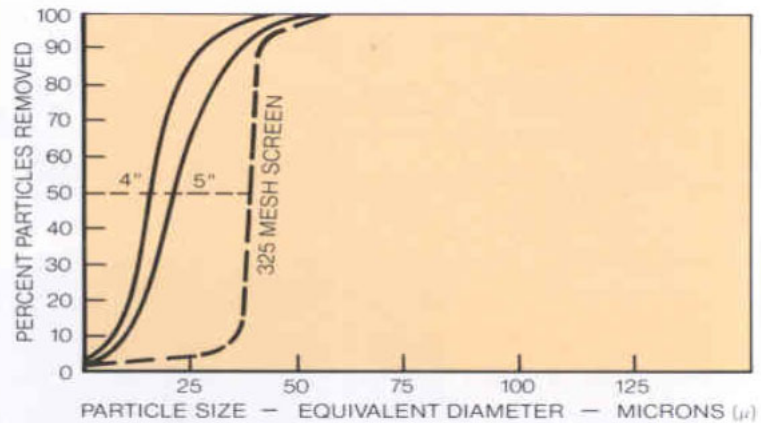
## - DESILTER

### - Desilter cones

A desilter uses cones with a diameter of 4 to 5 inches, and can use from 8 to 20 depending on the volume of mud flow to be treated.

### - Particle Removal

Desilter remove particles in the range of 15 micron.

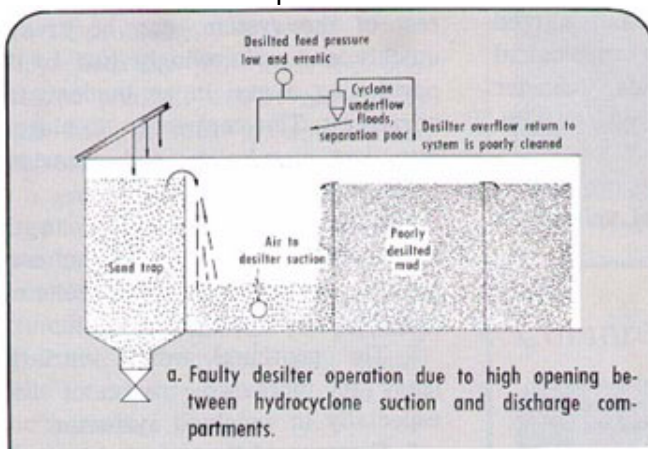


Desilter: Particle Removal

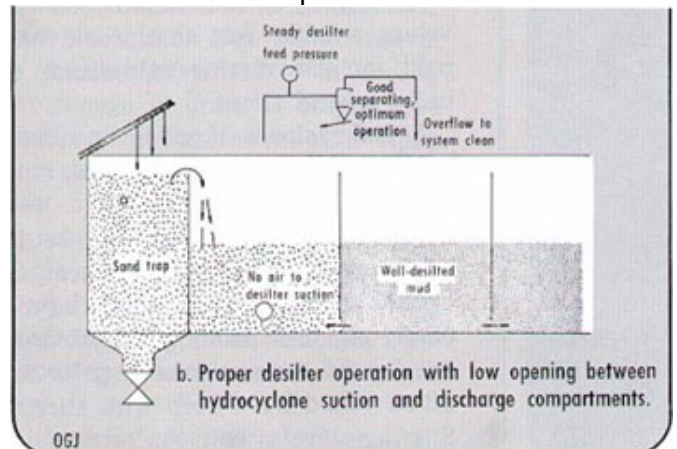
## - Desilter Operation

Proper fluid balance between pit compartments is very important.

### Desilter Operation: WRONG



### Desilter Operation: RIGHT





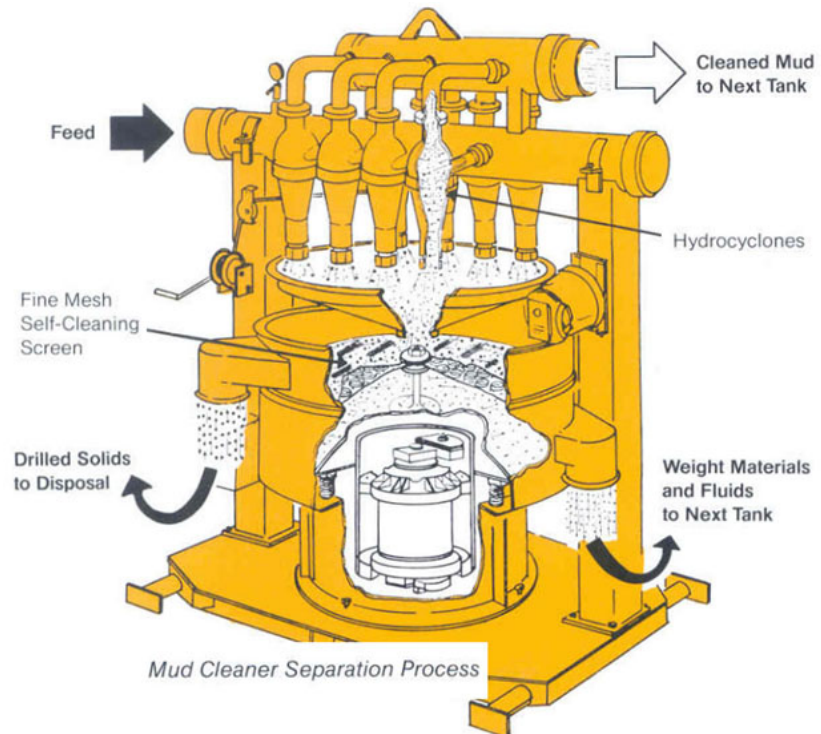
## 25.6 MUD CLEANER

### - Functionality

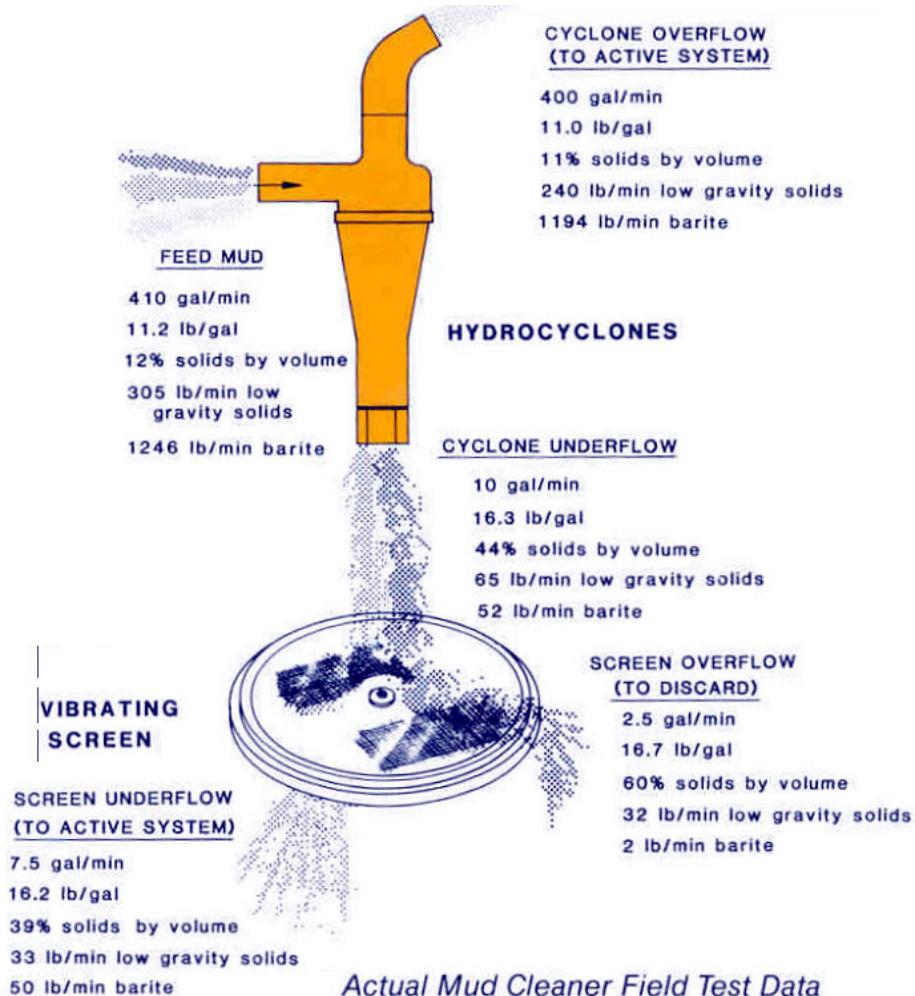
The mud cleaner is a combination shaleshaker/desilter that was introduced in the early '70s.

It was invented out of the necessity to reduce the volume of weighted solids (barite) discharged from the mud.

A 200 Mesh screen removes drilled solids but returns mud additives and liquids back into the circulating system.

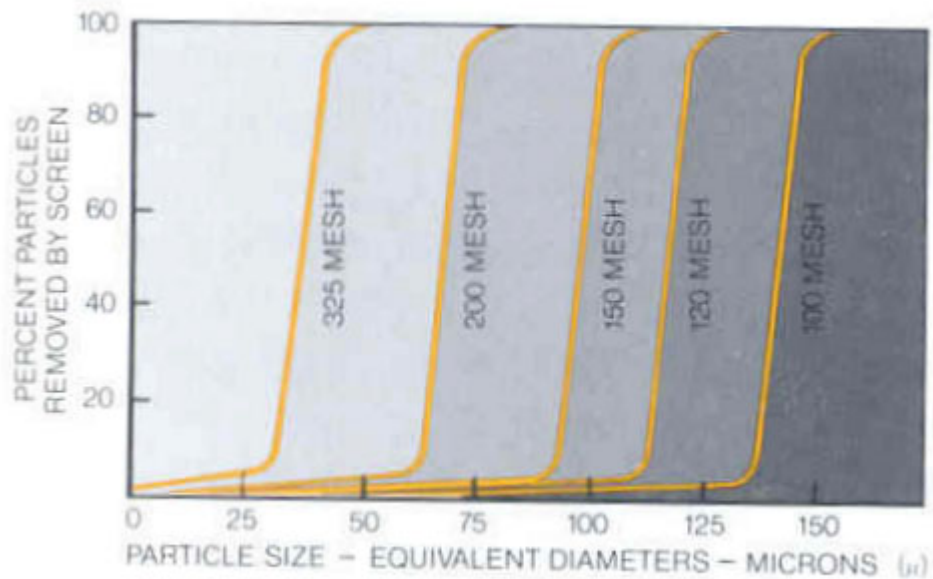


### - Hydrocyclones





- Screen particle removal



*Particle Removal*

## 25.7 DECANTATION CENTRIFUGE



### - Functioning principles

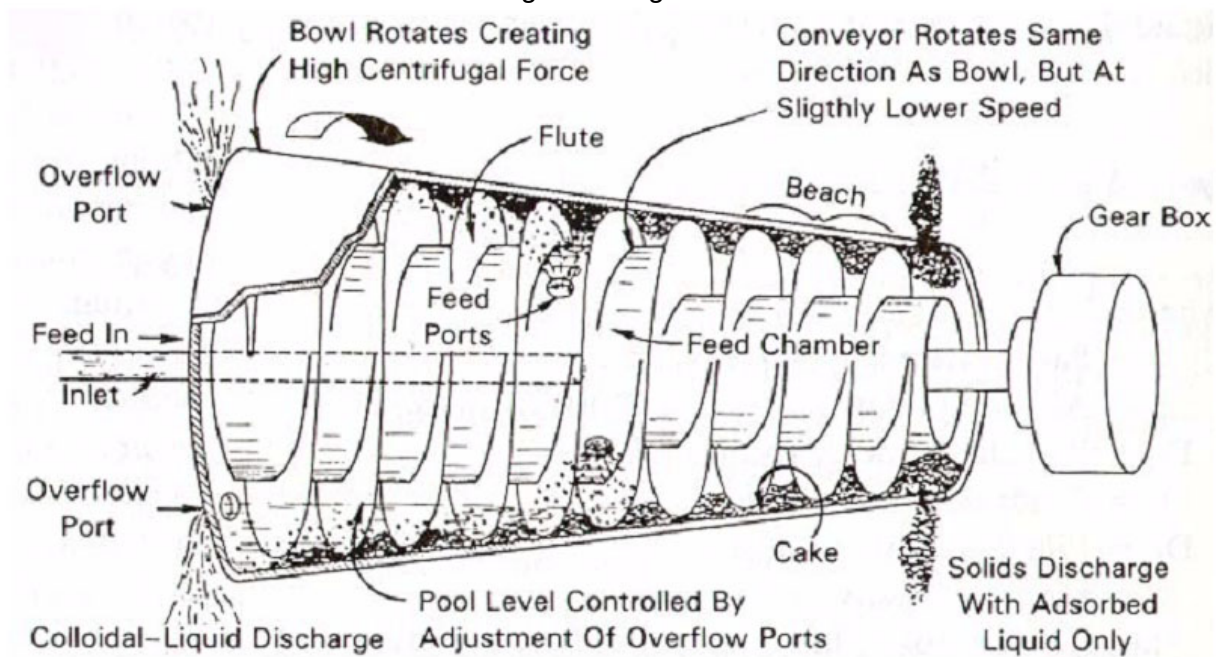
The centrifuge consists of a conical body (BOWL) and a channel with helicoidally shape (CONVEYOR)

They both rotate coaxially in the same direction, but the conveyor rotates a slightly lower angular speed than the bowl.

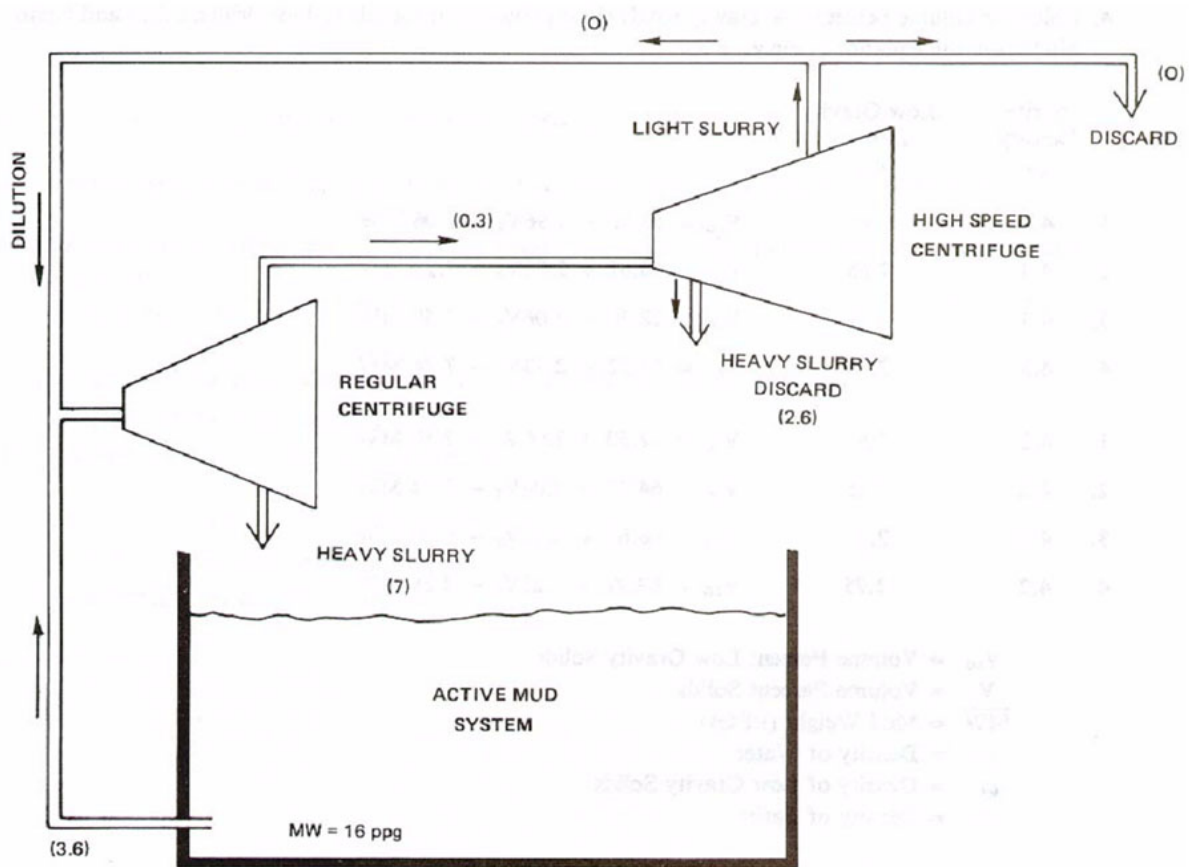
Mud to be treated is introduced into the centrifuge through a mono type pump.

The rotation in the bowl separates the solids from the liquids by centrifugal force. The conveyor transports the solids discharged while the liquids go back in the mud circulating system through the colloidal liquid discharge.

Decanting Centrifuges Scheme



Scheme of Succession Centrifuges



## 26. DEGASSER

### INDEX

- 26.1 FUNCTIONS
- 26.2 PRINCIPLES
- 26.3 DEGASSER TYPES
  - BURGESS
  - SWACO
  - WELLCO & BRANDT
  - DEGASSER SYSTEM for H<sub>2</sub>S PRESENCE
- 26.4 INSTALLATION CRITERIA

### 26.1 FUNCTIONS

The purpose of degassers is to remove air or gas entrained in the mud system in order to insure that the proper density mud is recirculated down the drill pipe.

If the gas or air is not removed, the mud weight measured in the pits may be misleading. This will result in the addition of unnecessary amounts of weight material thereby giving true mud densities down the hole that are more than desired.

Gas contamination could result from:

- |                   |                     |
|-------------------|---------------------|
| - 1. Drilling Gas | - 3. Connection Gas |
| - 2. Trip Gas     | - 4. Well testing   |



### 26.2 PRINCIPLES

All degasser types operate on: turbulence and vacuum.

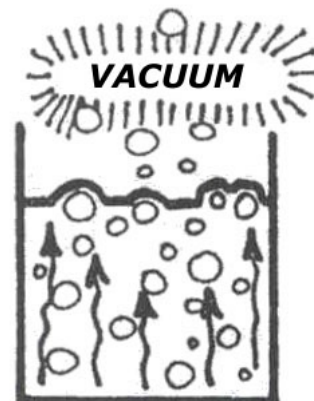
#### - TURBULENCE

Mud flows in thin sheets over a series of baffles arranged inside a vertical tank. The resulting turbulent flow breaks out large gas bubbles which then rise through a vent line.



#### - VACUUM

Vacuum increases gas speed through the vertical vent line.



## 26.3 DEGASSER TYPES

### - MANUFACTURERS

The most common oil field degasser manufacturers are:

- BURGESS
- SWACO
- WELLCO & BRANDT

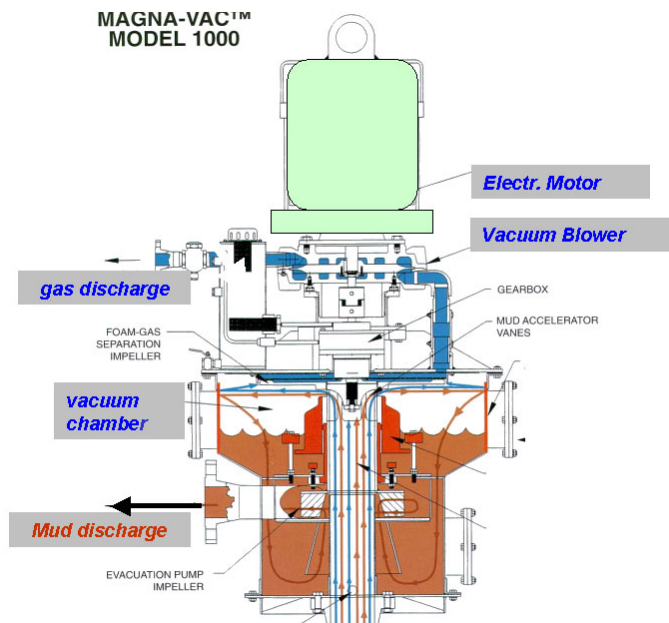
### - BURGESS

Gas-cut mud is drawn into the rotor body by vacuum, then sprayed radially and impacted against a urethane ring, creating adequate turbulence for air and other gas removal.

Gasses are removed by a vacuum blower.

The degasser mud is evacuated by a center vented centrifugal pump which prohibits gas locking.

The mud is pumped to the degasser mud tank through a reinforced hose.



*Burgess Degasser - Scheme*

### - SWACO

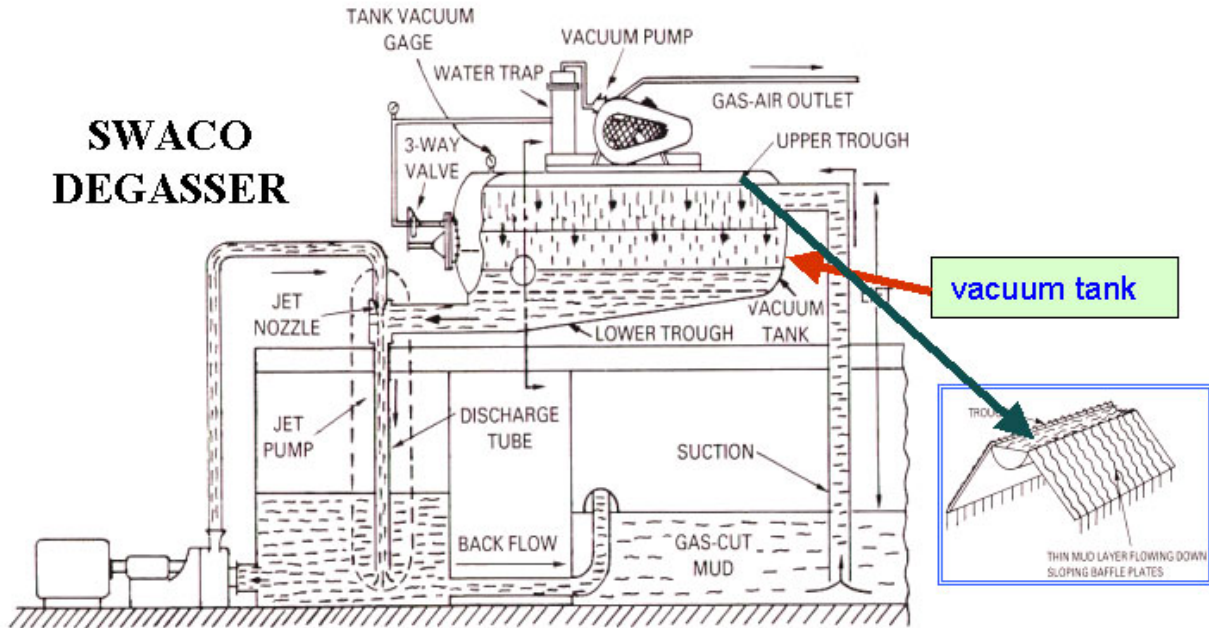
This degasser is a horizontal tank with long downward sloping baffles inside. Mud flows down these baffles in a thin layer, releasing the gas bubbles.

A vacuum pump is used to remove the gas from the tank and dispose it a safe distance from the rig.

The vacuum tank also reduces the internal tank pressure, drawing fluid into the tank and increasing the gas bubble size, improving removal efficiency.

The jet pump discharges the degassed mud from the tank and returns it to the next downstream compartment. There is no re-mixing of released gas and fluid.





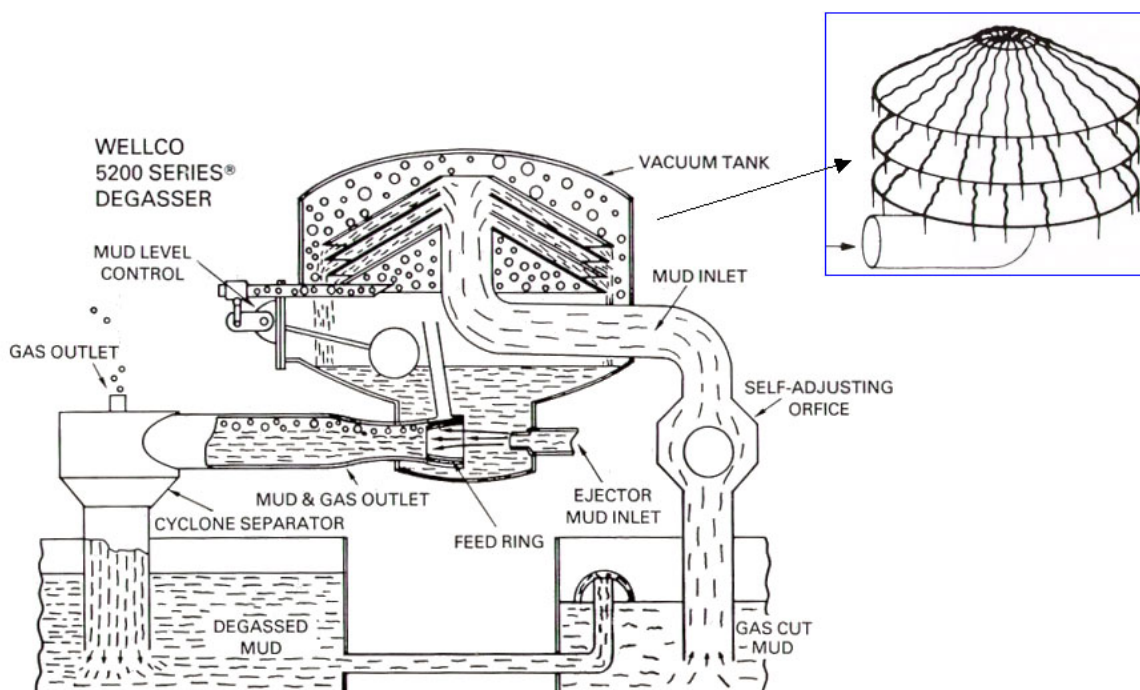
#### - WELLCO & BRANDT

Vacuum degassers (Wellco & Brandt) consist of a vacuum generating tank which, in effect, pulls the gas out of the mud due to gravity segregation.

Some degassers have a small pump to create a vacuum while others (see picture) use the centrifugal mixing pumps to create a vacuum.

It's important to note that most degassers, regardless of type, have a minimum required mud throughput for efficient operation.

#### Wellco-Brandt Degasser



## - DEGASSER SYSTEM for H<sub>2</sub>S PRESENCE

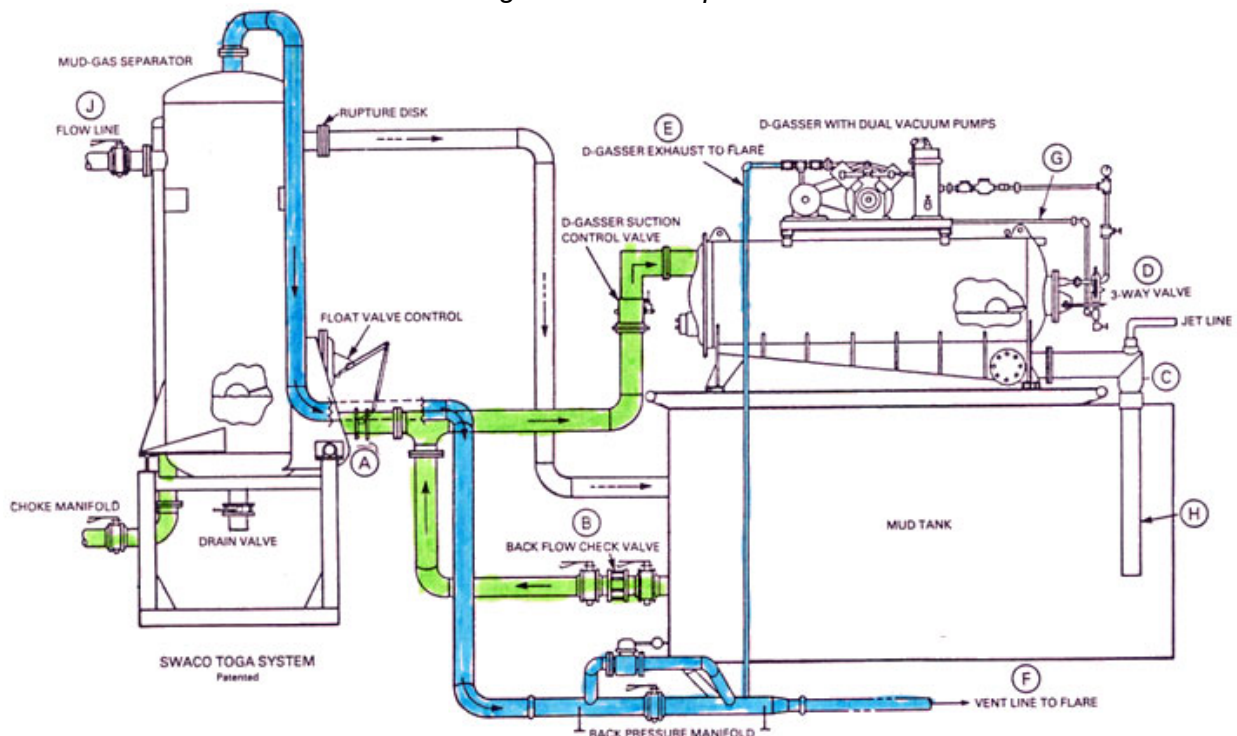
This is a mix between a Swaco degasser and a mud gas separator working in series. It's used to control a kick in the presence of H<sub>2</sub>S.

The mud gas separator receives the flow of mud and gas heads from the choke manifold. The free gas is routed to the flare line.

The remaining entrained gas and mud is discharged from the bottom of the separator to a modified degasser.

The check valve ensures that no mud from the separator can bypass the degasser and flow into the active mud system.

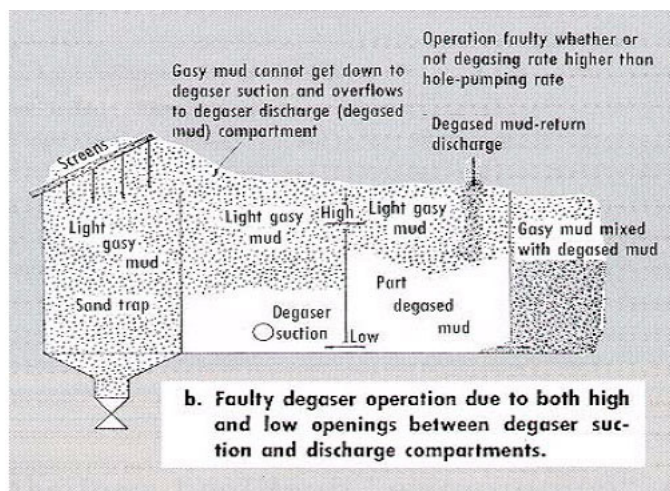
*Degasser for H<sub>2</sub>S presence*



## 26.4 INSTALLATION CRITERIA

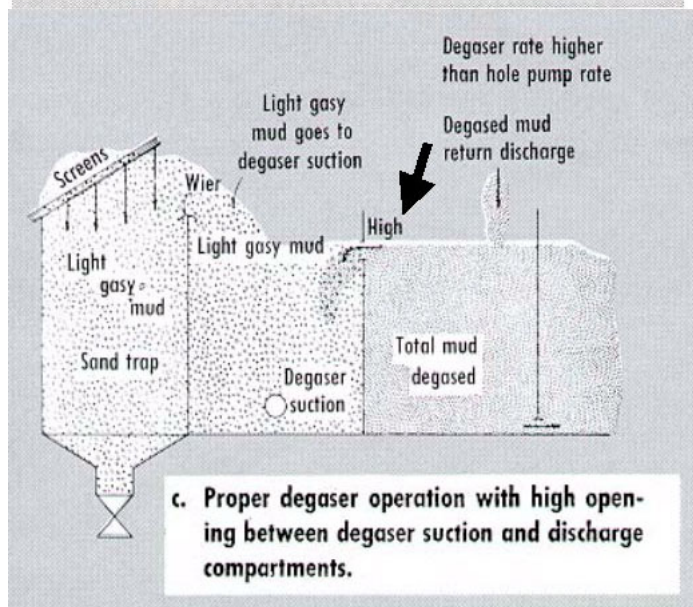
### - Incorrect Example

Faulty degasser operation due to both high and low opening between degaser suction and discharge compartments.



### - Correct Example

Proper degasser operation with high opening between degaser suction and discharge compartments.



## 27. DRILL PIPE

### INDEX

- 27.1 PHYSICAL DATA FOR STEEL DRILL PIPE
- 27.2 DRILL STEM DESIGN CALCULATIONS
  - BODY STRESS
  - TOOL JOINT STRESS
- 27.3 DRILL PIPE CODE IDENTIFICATION
- 27.4 DRILL PIPE INSPECTIONS
- 27.5 DRILL PIPE BRITTLE FOR H<sub>2</sub>S

### 27.1 PHYSICAL DATA FOR STEEL DRILL PIPE

#### DRILL PIPE

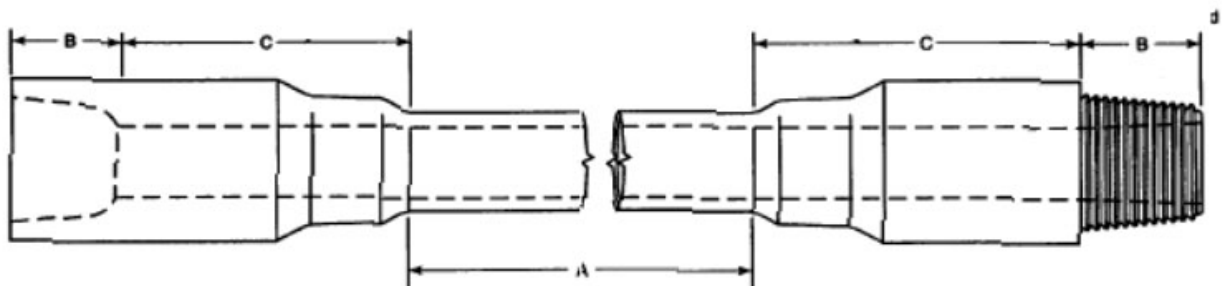
A joint of drill pipe is composed of 2 parts: the body and the tool joint.

Body: central part

Tool Joint: connections welded to each end of the pipe body and threaded - one box thread and one pin thread.

API 5D specifies the dimensions and characteristics of the body.  
 API 7 specifies the dimensions and characteristics of the tool joint  
 The ISO reference is the draft 11961.  
 ENI requirements are defined by internal specification.

*Drill Pipe - Scheme*



#### - Transition between the pipe body and tool joint

The transition between the pipe body and tool joint can be:

- INTERNAL UPSET
- EXTERNAL UPSET
- INTERNAL-EXTERNAL - UPSET

DP usually has:

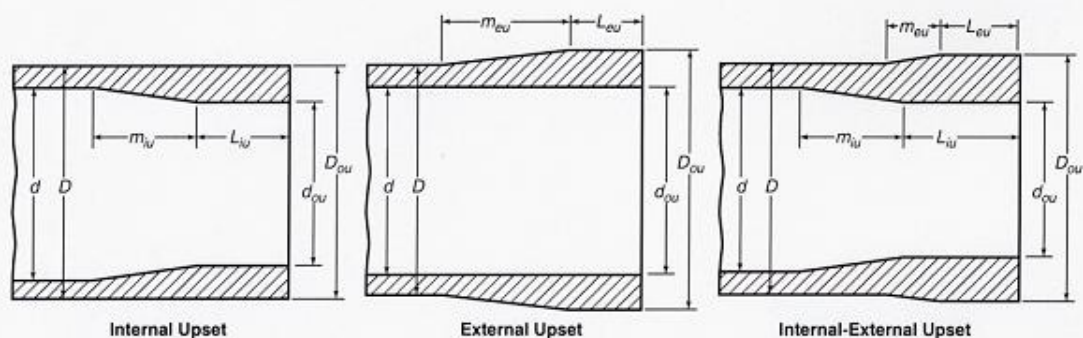
INTERNAL EXTERNAL UPSET



# API - Upset Drill Pipe

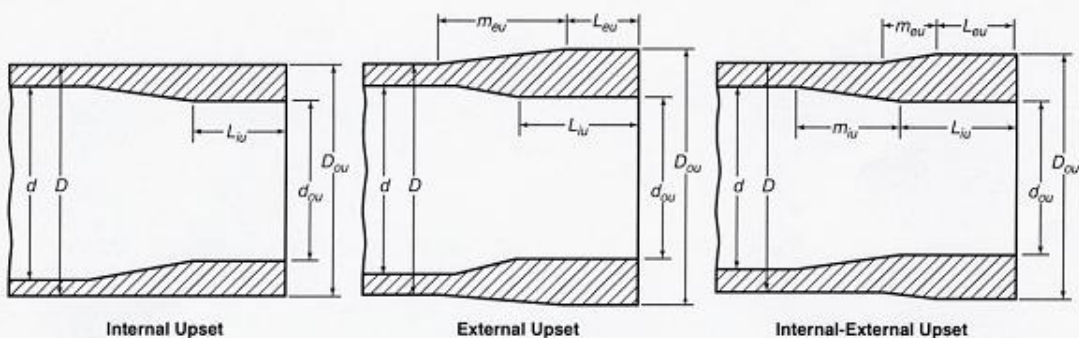
12

API SPECIFICATION 5D



Note: See Table 7 for drill pipe dimensions.

Figure 3—Upset Drill Pipe for Weld-on Tool Joints (Group 1)



Notes: □

a. See Table 8 for drill pipe dimensions.□

b. Permissible internal taper within length  $L_{iu}$  shall not exceed  $1/4$  in./ft (21 mm/m) on diameter.

Figure 4—Upset Drill Pipe for Weld-on Tool Joints (Group 3)

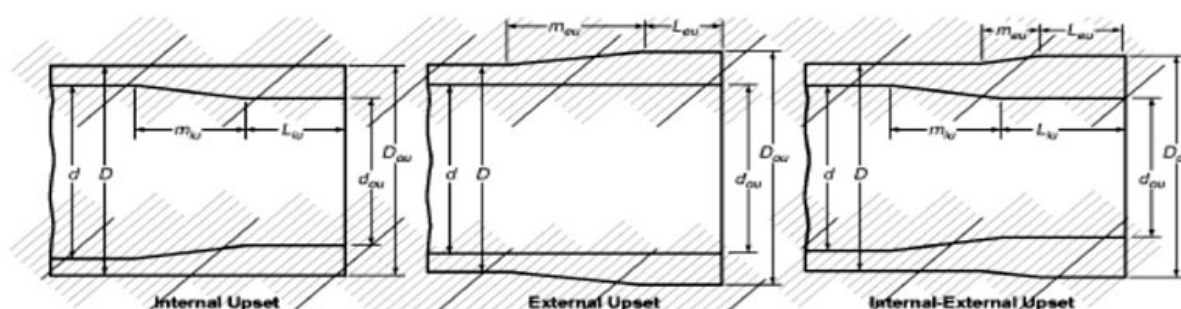
## DRILL PIPE BODY

API 5D covers Group 1 and Group 3 DP.

Group 1 - Grade E drill pipe.

Group 3 - All high strength grades of drill pipe.  
(Grades X-95, G-105, and S-135)

- Upset Drill Pipe Body (Group 1)



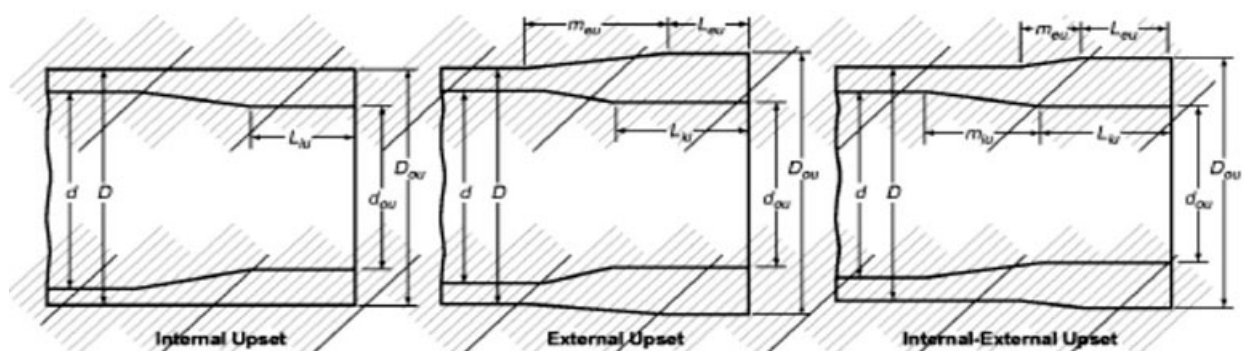
Note: See Table 7 for drill pipe dimensions.

Figure 3—Upset Drill Pipe for Weld-on Tool Joints (Group 1)

Table 7—Upset Drill Pipe for Weld-on Tool Joints  
Dimensions and Weights (Group 1)

| 1                                  |        | 2                | 3                  | 4                   | 5                     | 6                     | 7                                                                                            | 8                                                                           | 9                                           | 10                             | 11                            | 12                    | 13                                        |                               |
|------------------------------------|--------|------------------|--------------------|---------------------|-----------------------|-----------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------|--------------------------------|-------------------------------|-----------------------|-------------------------------------------|-------------------------------|
| Calculated Weight                  |        |                  |                    |                     |                       |                       | Upset Dimensions, in. <sup>5f</sup>                                                          |                                                                             |                                             |                                |                               |                       |                                           |                               |
| Designations <sup>a</sup>          |        | Outside Diameter | Wall Thickness in. | Inside Diameter in. | Plain End lb/ft       | Upset <sup>d</sup> lb | Length                                                                                       |                                                                             | Length of Internal Taper, <sup>g</sup> Min. | Length of External Upset, Min. | Length of External Taper      |                       | Length End of Pipe to Taper Fadeout, Max. |                               |
|                                    |        |                  |                    |                     |                       |                       | Outside Diameter <sup>2</sup> + <sup>1</sup> / <sub>8</sub> , - <sup>1</sup> / <sub>32</sub> | Inside Diameter at End of Pipe, <sup>c</sup> ± <sup>1</sup> / <sub>16</sub> |                                             |                                | Min.                          | Max.                  |                                           |                               |
| Size                               | Weight | <i>D</i>         | <i>t</i>           | <i>d</i>            | <i>w<sub>pe</sub></i> | <i>e<sub>w</sub></i>  | <i>D<sub>ou</sub></i>                                                                        | <i>d<sub>ou</sub></i>                                                       | <i>L<sub>iu</sub></i>                       | <i>m<sub>iu</sub></i>          | <i>L<sub>eu</sub></i>         | <i>m<sub>eu</sub></i> | <i>L<sub>eu</sub> + m<sub>eu</sub></i>    |                               |
| Internal-External Upset Drill Pipe |        |                  |                    |                     |                       |                       |                                                                                              |                                                                             |                                             |                                |                               |                       |                                           |                               |
| 4 <sup>1</sup> / <sub>2</sub>      | 16.60  | 4.500            | 0.337              | 3.826               | 15.00                 | 8.11                  | 4.750                                                                                        | 3 <sup>5</sup> / <sub>32</sub>                                              | 2 <sup>1</sup> / <sub>2</sub>               | 2                              | 1 <sup>1</sup> / <sub>2</sub> | 1                     | 1 <sup>1</sup> / <sub>2</sub>             | —                             |
| 4 <sup>1</sup> / <sub>2</sub>      | 20.00  | 4.500            | 0.430              | 3.640               | 18.71                 | 8.61                  | 4.781                                                                                        | 3                                                                           | 2 <sup>1</sup> / <sub>4</sub>               | 2                              | 1 <sup>1</sup> / <sub>2</sub> | 1                     | 1 <sup>1</sup> / <sub>2</sub>             | —                             |
| 5                                  | 19.50  | 5.000            | 0.362              | 4.276               | 17.95                 | 8.61                  | 5.188                                                                                        | 3 <sup>11</sup> / <sub>16</sub>                                             | 2 <sup>1</sup> / <sub>4</sub>               | 2                              | 1 <sup>1</sup> / <sub>2</sub> | 1                     | 1 <sup>1</sup> / <sub>2</sub>             | —                             |
| 5                                  | 25.60  | 5.000            | 0.500              | 4.000               | 24.05                 | 7.81                  | 5.188                                                                                        | 3 <sup>7</sup> / <sub>16</sub>                                              | 2 <sup>1</sup> / <sub>4</sub>               | 2                              | 1 <sup>1</sup> / <sub>2</sub> | 1                     | 1 <sup>1</sup> / <sub>2</sub>             | —                             |
| 5 <sup>1</sup> / <sub>2</sub>      | 21.90  | 5.500            | 0.361              | 4.778               | 19.83                 | 10.61                 | 5.750                                                                                        | 4                                                                           | 2 <sup>1</sup> / <sub>4</sub>               | 2                              | 1 <sup>1</sup> / <sub>2</sub> | 1                     | 1 <sup>1</sup> / <sub>2</sub>             | —                             |
| 5 <sup>1</sup> / <sub>2</sub>      | 24.70  | 5.500            | 0.415              | 4.670               | 22.56                 | 9.01                  | 5.750                                                                                        | 4                                                                           | 2 <sup>1</sup> / <sub>4</sub>               | 2                              | 1 <sup>1</sup> / <sub>2</sub> | 1                     | 1 <sup>1</sup> / <sub>2</sub>             | —                             |
| 6 <sup>3</sup> / <sub>8</sub>      | 25.20  | 6.625            | 0.330              | 5.965               | 22.21                 | 25.90                 | 7.000                                                                                        | 5.315                                                                       | 4 <sup>1</sup> / <sub>2</sub>               | 2                              | 3                             | —                     | —                                         | 5 <sup>1</sup> / <sub>2</sub> |
| 6 <sup>3</sup> / <sub>8</sub>      | 27.70  | 6.625            | 0.362              | 5.901               | 24.24                 | 24.03                 | 7.000                                                                                        | 5.315                                                                       | 4 <sup>1</sup> / <sub>2</sub>               | 2                              | 3                             | —                     | —                                         | 5 <sup>1</sup> / <sub>2</sub> |

- Upset Drill Pipe Body (Group 3)



Notes: □

a. See Table 8 for drill pipe dimensions. □

b. Permissible internal taper within length  $L_{iu}$  shall not exceed  $1/4$  in./ft (21 mm/m) on diameter.

Figure 4—Upset Drill Pipe for Weld-on Tool Joints (Group 3)

Dimensions and Weights (Group 3)

|                                    |        | 1                 | 2                  | 3                   | 4               | 5                     | 6                                                                                            | 7                                                                           | 8                                                                             | 9                              | 10                             | 11                                                      | 12 |
|------------------------------------|--------|-------------------|--------------------|---------------------|-----------------|-----------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------|--------------------------------|---------------------------------------------------------|----|
|                                    |        | Calculated Weight |                    |                     |                 |                       |                                                                                              | Upset Dimensions, in. <sup>5,6</sup>                                        |                                                                               |                                |                                |                                                         |    |
| Designations <sup>a</sup>          |        | Outside Diameter  | Wall Thickness in. | Inside Diameter in. | Plain End lb/ft | Upset <sup>d</sup> lb | Outside Diameter <sup>b</sup> + <sup>1</sup> / <sub>8</sub> , - <sup>1</sup> / <sub>32</sub> | Inside Diameter at End of Pipe, <sup>c</sup> ± <sup>1</sup> / <sub>16</sub> | Length of Upset + <sup>1</sup> / <sub>2</sub> , - <sup>1</sup> / <sub>2</sub> | Length of Internal Taper, Min. | Length of External Upset, Min. | Length of End of Pipe to Taper Fadeout, Ext. Upset Max. |    |
| Size                               | Weight | D                 | t                  | d                   | w <sub>pe</sub> | e <sub>w</sub>        | D <sub>ou</sub>                                                                              | d <sub>ou</sub>                                                             | L <sub>tu</sub>                                                               | m <sub>tu</sub>                | L <sub>ew</sub>                | L <sub>eu</sub> + m <sub>eu</sub>                       |    |
| Internal-External-Upset Drill Pipe |        |                   |                    |                     |                 |                       |                                                                                              |                                                                             |                                                                               |                                |                                |                                                         |    |
| 3½                                 | 15.50  | 3.500             | 0.449              | 2.602               | 14.64           | 11.01                 | 3.781                                                                                        | 1 <sup>15</sup> / <sub>16</sub>                                             | 4 <sup>1</sup> / <sub>4</sub>                                                 | —                              | 3                              | 5½                                                      |    |
| 4½                                 | 16.60  | 4.500             | 0.337              | 3.826               | 15.00           | 8.71                  | 4.750                                                                                        | 2 <sup>7</sup> / <sub>8</sub>                                               | 2½                                                                            | 3                              | 1½                             | 3                                                       |    |
| 4½                                 | 20.00  | 4.500             | 0.430              | 3.640               | 18.71           | 17.62                 | 4.781                                                                                        | 2 <sup>13</sup> / <sub>16</sub>                                             | 4 <sup>1</sup> / <sub>4</sub>                                                 | 3                              | 3                              | 5½                                                      |    |
| 5                                  | 19.50  | 5.000             | 0.362              | 4.276               | 17.95           | 16.82                 | 5.188                                                                                        | 3 <sup>9</sup> / <sub>16</sub>                                              | 4 <sup>1</sup> / <sub>4</sub>                                                 | 3                              | 3                              | 5½                                                      |    |
| 5                                  | 25.60  | 5.000             | 0.500              | 4.000               | 24.05           | 15.42                 | 5.188                                                                                        | 3 <sup>5</sup> / <sub>16</sub>                                              | 4 <sup>1</sup> / <sub>4</sub>                                                 | 3                              | 3                              | 5½                                                      |    |
| 5½                                 | 21.90  | 5.500             | 0.361              | 4.778               | 19.83           | 21.02                 | 5.750                                                                                        | 3 <sup>13</sup> / <sub>16</sub>                                             | 4 <sup>1</sup> / <sub>4</sub>                                                 | 3                              | 3                              | 5½                                                      |    |
| 5½                                 | 24.70  | 5.500             | 0.415              | 4.670               | 22.56           | 18.42                 | 5.750                                                                                        | 3 <sup>13</sup> / <sub>16</sub>                                             | 4 <sup>1</sup> / <sub>4</sub>                                                 | 3                              | 3                              | 5½                                                      |    |
| 6 <sup>5</sup> / <sub>8</sub>      | 25.20  | 6.625             | 0.330              | 5.965               | 22.21           | 25.90                 | 7.000                                                                                        | 5.315                                                                       | 4½                                                                            | 3                              | 3                              | 5½                                                      |    |
| 6 <sup>5</sup> / <sub>8</sub>      | 27.70  | 6.625             | 0.362              | 5.901               | 24.24           | 24.03                 | 7.000                                                                                        | 5.315                                                                       | 4½                                                                            | 3                              | 3                              | 5½                                                      |    |





## - Mechanical Properties

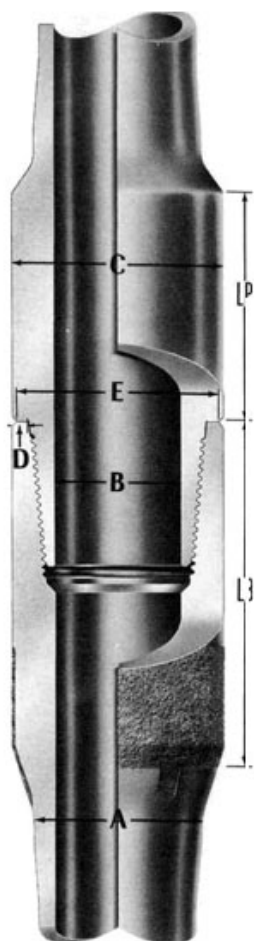


Table 6—Mechanical Properties of New Tool Joints at Locations Shown in Figure 5 (All Sizes)

| Minimum Yield Strength |                   | Minimum Tensile Strength |                   | Minimum Elongation Percent | Box Minimum Brinell Hardness |
|------------------------|-------------------|--------------------------|-------------------|----------------------------|------------------------------|
| psi                    | N/mm <sup>2</sup> | psi                      | N/mm <sup>2</sup> |                            |                              |
| 120,000                | 827.4             | 140,000                  | 965.3             | 13                         | 285                          |

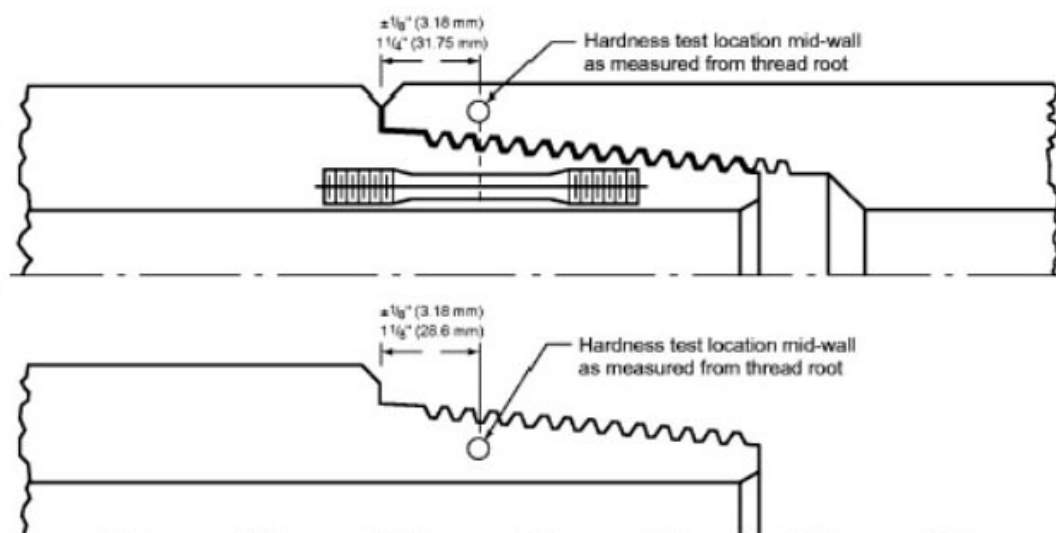


Figure 5—Tensile Specimen and Hardness Test Location

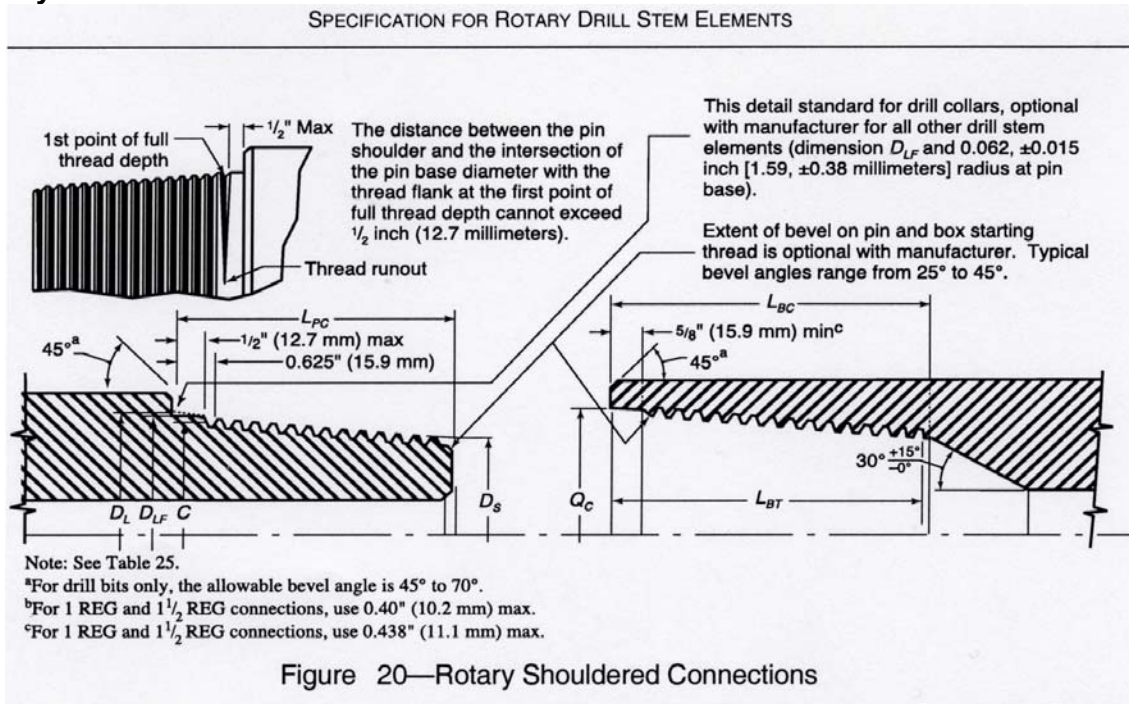
## - DP Tool Joint Threads

The number connections and their equivalent connections are as follows

### Equivalent Connections

| Number Connection | Equivalent Connection |
|-------------------|-----------------------|
| NC26              | 2 3/8 IF              |
| NC31              | 2 7/8 IF              |
| NC38              | 3 1/2 IF              |
| NC40              | 4 FH                  |
| NC46              | 4 IF                  |
| NC50              | 4 1/2 IF              |

## - Rotary Shouldered Connections



## - API Threads type

Table 26—Product Thread Dimensions Rotary Shouldered Connections

| 1             | 2         | 3             | 4                                          | 5                                              | 6                                                                | 7                                            | 8                       | 9                      | 10                            | 11                                            |
|---------------|-----------|---------------|--------------------------------------------|------------------------------------------------|------------------------------------------------------------------|----------------------------------------------|-------------------------|------------------------|-------------------------------|-----------------------------------------------|
| Width of Flat |           |               |                                            |                                                |                                                                  |                                              |                         |                        |                               |                                               |
| Thread Form   | Pitch $p$ | Taper in./ft. | Reference Thread Height, Not Truncated $H$ | Reference Thread Height, Truncated $h_n = h_s$ | Reference Root Truncation $s_{rn} = s_{rs}$<br>$f_{rn} = f_{rs}$ | Reference Crest Truncation $f_{cn} = f_{cs}$ | Crest $F_{cn} = F_{cs}$ | Root $F_{rn} = F_{rs}$ | Root Radius $r_{rn} = r_{rs}$ | Radius at Thread Corners Form $r$ $\pm 0.008$ |
| V-0.038R      | 0.250000  | 2             | 0.216005                                   | 0.121844                                       | 0.038000                                                         | 0.056161                                     | 0.065                   | —                      | 0.038                         | 0.015                                         |
| V-0.038R      | 0.250000  | 3             | 0.215379                                   | 0.121381                                       | 0.038000                                                         | 0.055998                                     | 0.065                   | —                      | 0.038                         | 0.015                                         |
| V-0.040       | 0.200000  | 3             | 0.172303                                   | 0.117842                                       | 0.020000                                                         | 0.034461                                     | 0.040                   | —                      | 0.020                         | 0.015                                         |
| V-0.050       | 0.250000  | 3             | 0.215379                                   | 0.147303                                       | 0.025000                                                         | 0.043076                                     | 0.050                   | —                      | 0.025                         | 0.015                                         |
| V-0.050       | 0.250000  | 2             | 0.216005                                   | 0.147804                                       | 0.025000                                                         | 0.043201                                     | 0.050                   | —                      | 0.025                         | 0.015                                         |
| V-0.055       | 0.166667  | 1.50          | 0.144200                                   | 0.055900                                       | 0.040600                                                         | 0.047600                                     | 0.055                   | 0.047                  | —                             | 0.015                                         |

Notes:

1. See Figures 21 and 22 and 22a.

2. All dimensions are in inches unless otherwise specified. See Appendix M for metric table.

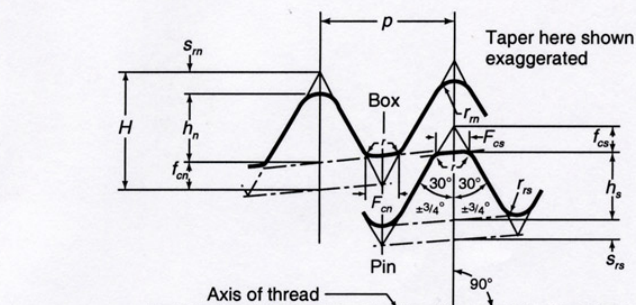


Figure 21—V-0.038 Product Thread Form

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## Tool Joint Hardfacing

To reduce the wear on the tool joint, some contractors weld a hard-facing material on the wear area of the tool joint.

In some deviated wells the hardfacing has been dangerous because it was damaging the casing with rotation.

Recently technology has developed hardfacing materials producing a minimum wear on the tool joint and on the casing.

ENI policy stipulates the using of "Casing friendly Hardfacing".

### - DEA comparison table

As shown in DEA comparison table (see following table) sometimes the hardfacing has better performances than the DP without it.

ENI accepts a maximum csg wear of 7%.

#### HARDFACE FOR TOOLJOINT

Table of comparisons of casing wear with 12 different hardmetal tested in DEA-42 project.  
(N-80 3000 lb/ft load and WB-mud)

| Tool Joint              | Tool Joint wear (open hole) (inch) | Casing wear (%) | Wear Factor | Friction Factor | Remarks                              |
|-------------------------|------------------------------------|-----------------|-------------|-----------------|--------------------------------------|
| Steel Smooth            | 0.043                              | 18.2            | 5.6         | 0.21            | Steel 4145                           |
| Rough-Tungsten Carbide  | -                                  | 75              | 1417        | 0.29            | Mesh Size 14/24(20 minute test)      |
| Smooth-Tungsten Carbide | 0.014                              | 27.8            | 10.8        | 0.20            | Mesh Size 14/24(field-worn surface)  |
| Hughes Smooth-X         | -                                  | 21.8            | 7.6         | 0.15            | Tungsten Carbide(spherical granules) |
| Drilco Sphere           | -                                  | 7.6             | 1.95        | 0.21            | Tungsten Carbide (spherical)         |
| AGIP Tungsten Carbide   | -                                  | 17.2            | 5.5         | 0.19            | Low Vibration                        |
| AGIP Austenite          | -                                  | 14.6            | 4.3         | 0.18            | Low Vibration                        |
| Aluminium Bronze        | -                                  | 9.5             | 2.3         | 0.32            | High Friction                        |
| ARMACOR-M               | 0.027                              | 5.9             | 1.1         | 0.15            | Amorphous Material                   |
| ARNCO-200X              | 0.018                              | 7.0             | 1.43        | 0.14            | Chromium Carbide                     |
| Colmonoy 5              | 0.016                              | 5.9             | 1.06        | 0.15            | Nickel Base                          |
| Triboloy-800            | 0.020                              | 4.2             | 0.65        | 0.12            | Cobalt Molybdenum                    |
| Duocor                  | -                                  | 9.7             | 2.24        | 0.24            | Titanium Carbide                     |
| Stellite 6              | -                                  | 9.7             | 2.19        | 0.17            | Cobalt Base                          |
| Polished Chrome         | -                                  | 6.6             | 1.27        | 0.15            | Sensitive in Salt Mud                |
| BP-1                    | -                                  | 10.2            | 2.53        | 0.19            | Steel Machine Ground Smooth          |
| BP-2                    | -                                  | 18.6            | 6.74        | 0.21            | Steel Hand Ground Smooth             |

- Types examples
  - SmoothX
  - SuperSmoothX

### SMOOTHX®

Spherical Carbide Granules in a  
Mild Steel Matrix

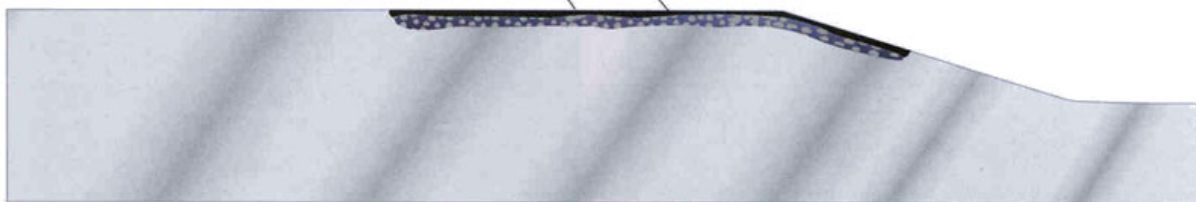


*The patented SMOOTHX process submerges spherical shaped carbide granules in a mild steel matrix leaving a smooth surface with little or no exposed carbide.*

### SUPERSMOOTHX®

Mild Steel Overlay Machined to Tool Joint OD

Spherical Carbide Granules in a  
Mild Steel Matrix



*SUPERSMOOTHX has an additional layer of mild steel applied, then machined to the same OD as the tool joint.*



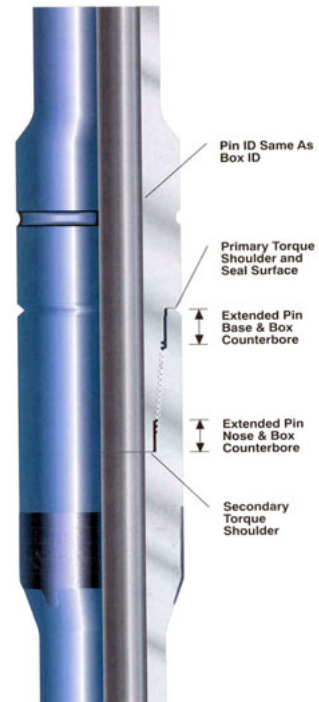
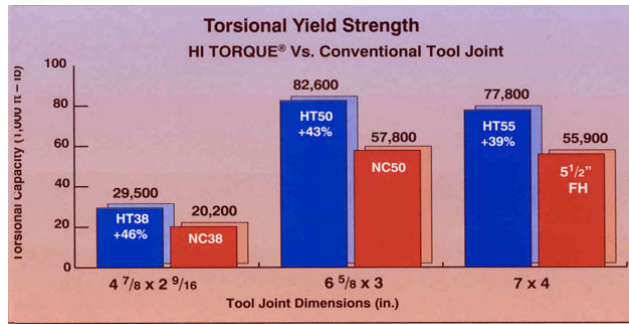
## High Torque Tool Joint

Extended reach well create very high torque during drilling.

Because API tool joints cannot tolerate these high torques values, a special high-torque tool joint has been developed for these applications.

### - GRANT\_PRIDECO H-T Tool Joint

- Tool Joint
- Graph



### - NKK High-Torque Tool Joint

- Tool Joint
- Torque Curve

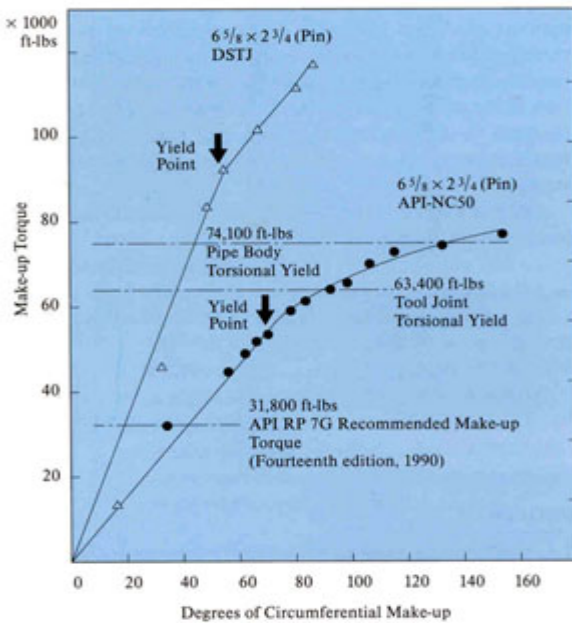


FIG. 2 Tool Joint Make-up Torque Curve

### SPECIAL TOOL JOINT DSTJ (Double Shoulder Tool Joint)

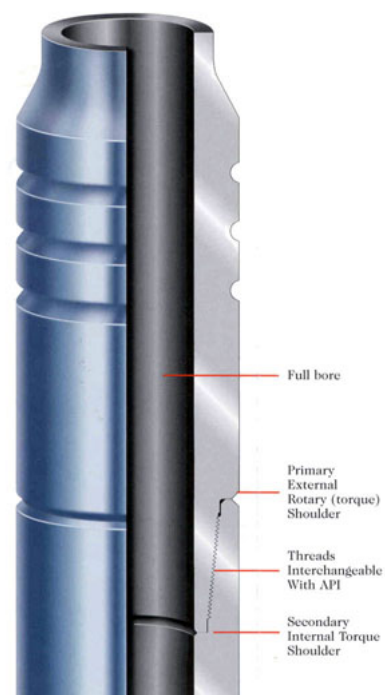
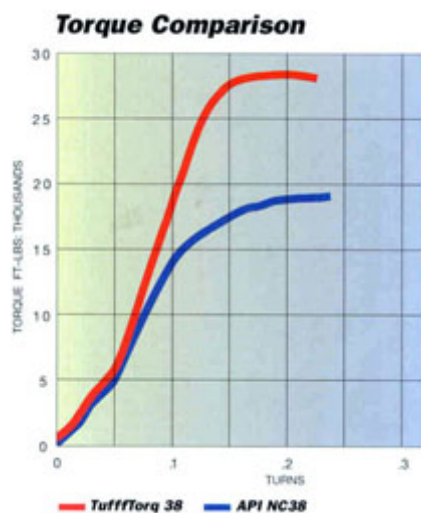


FIG. 1 NKK DSTJ

### - OMSCO TuffTorq Tool Joint

Possible to connect to API connection

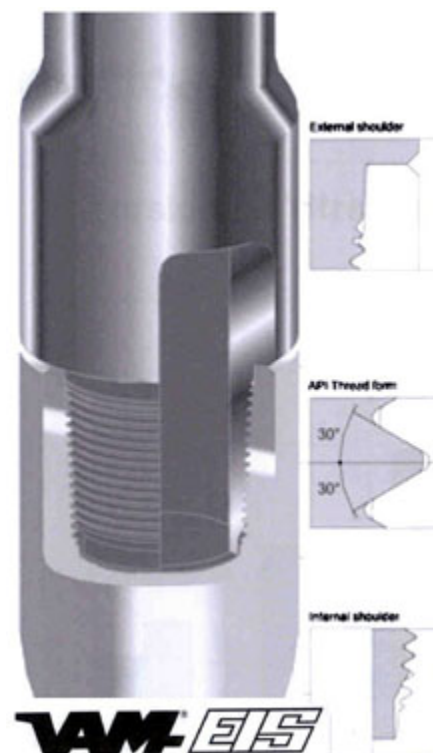
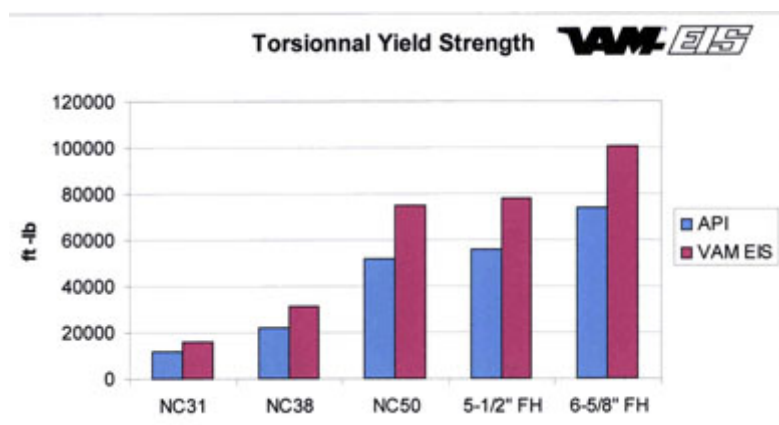
- Tool Joint
- Torque Comparison



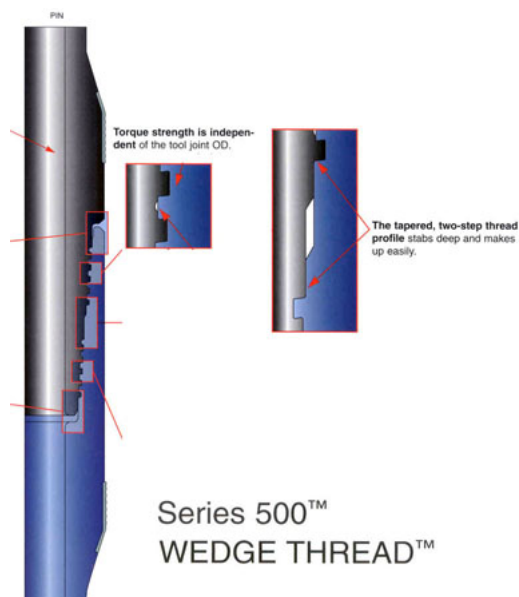
### - VAM EIS Tool Joint

Possible to connect to API connection

- Tool Joint
- Torsionnal Yield Strength



## - HYDRIL High-Torque Tool Joint



## High torque connections table comparison

POSSIBLE CONNECTIONS FOR 5 1/2" DRILL STRING WITH S135 x 21,9lb/ft DRILL PIPES

| CONNECTION STYLE | SOURCE        | TYPE            | OD TOOL JOIN<br>inch | ID TOOL JOIN<br>inch | MAKE UP TORQUE<br>ft-lbs | TORSIONAL YIELD<br>ft-lbs | TENSILE YIELD<br>lbs |
|------------------|---------------|-----------------|----------------------|----------------------|--------------------------|---------------------------|----------------------|
| 5 1/2 FH         | API           | SINGLE SHOULDER | 7"                   | 4"                   | 33500                    | 55900                     | 1265800              |
| 5 1/2 FH DSTJ    | NKK           | DOUBLE SHOULDER | 7"                   | 4"                   | 41500                    | 69140                     | 1265800              |
| HT 55            | GRANT PRIDECO | DOUBLE SHOULDER | 7"                   | 4"                   | 46700                    | 77900                     | 1265800              |
| XT 55            | GRANT PRIDECO | DOUBLE SHOULDER | 7"                   | 4"                   | 59000                    | 82400                     | 1272600              |
| WT 50            | HYDRILL       | WEDGE TYPE      | 7"                   | 4"                   | 57000                    | 109000                    | 1440000              |
| 5 1/2 FH VAM EIS | VMOG          | DOUBLE SHOULDER | 7"                   | 4"                   | 40800                    | 68000                     | 1266037              |
| VAM TAURUS VT 59 | VMOG          | DOUBLE SHOULDER | 7"                   | 4"                   | 79690                    | 92560                     | 1391000              |

## 27.2 DRILL STEM DESIGN CALCULATIONS

Areas to analyze for working stress on a DP are the:

- BODY
- TOOL JOINT

### BODY STRESS

- Stresses on the DP body
- DP operational limits( API RP)
- Maximum Tension Load and Torque
- Biaxial Loading
- Fatigue Stress

## - Stresses on the DP body

Stresses on the DP body include:

- TENSION LOADING
- TORSIONAL STRENGTH
- INTERNAL PRESSURE
- COLLAPSE

## - TENSION LOADING

### A.7 Tension

$$P = Y_m A$$

where

P = minimum tensile strength, lbs,

$Y_m$  = material minimum yield strength, psi.

A = cross-section area sq.in. (Table 1, Column 6, for drill pipe)

Table 1—New Drill Pipe Dimensional Data

| (1)                           | (2)                                                  | (3)                                       | (4)                      | (5)                   | (6)                                                              | (7)                                                            |
|-------------------------------|------------------------------------------------------|-------------------------------------------|--------------------------|-----------------------|------------------------------------------------------------------|----------------------------------------------------------------|
| Size<br>OD<br>in.<br><i>D</i> | Nominal Weight<br>Threads and<br>Couplings,<br>lb/ft | Plain End<br>Weight <sup>1</sup><br>lb/ft | Wall<br>Thickness<br>in. | ID<br>in.<br><i>d</i> | Section Area<br>Body of Pipe <sup>2</sup><br>sq. in.<br><i>A</i> | Polar Sectional<br>Modulus <sup>3</sup><br>cu. in.<br><i>Z</i> |
| 3 1/2                         | 9.50                                                 | 8.81                                      | .254                     | 2.992                 | 2.5902                                                           | 3.923                                                          |
|                               | 13.30                                                | 12.31                                     | .368                     | 2.764                 | 3.6209                                                           | 5.144                                                          |
|                               | 15.50                                                | 14.63                                     | .449                     | 2.602                 | 4.3037                                                           | 5.847                                                          |
| 4                             | 11.85                                                | 10.46                                     | .262                     | 3.476                 | 3.0767                                                           | 5.400                                                          |
|                               | 14.00                                                | 12.93                                     | .330                     | 3.340                 | 3.8048                                                           | 6.458                                                          |
|                               | 15.70                                                | 14.69                                     | .380                     | 3.240                 | 4.3216                                                           | 7.157                                                          |
| 4 1/2                         | 13.75                                                | 12.24                                     | .271                     | 3.958                 | 3.6004                                                           | 7.184                                                          |
|                               | 16.60                                                | 14.98                                     | .337                     | 3.826                 | 4.4074                                                           | 8.543                                                          |
|                               | 20.00                                                | 18.69                                     | .430                     | 3.640                 | 5.4981                                                           | 10.232                                                         |
| 5                             | 22.82                                                | 21.36                                     | .500                     | 3.500                 | 6.2832                                                           | 11.345                                                         |
|                               | 16.25                                                | 14.87                                     | .296                     | 4.408                 | 4.3743                                                           | 9.718                                                          |
|                               | 19.50                                                | 17.93                                     | .362                     | 4.276                 | 5.2746                                                           | 11.415                                                         |
|                               | 25.60                                                | 24.03                                     | .500                     | 4.000                 | 7.0686                                                           | 14.491                                                         |
| 5 1/2                         | 19.20                                                | 16.87                                     | .304                     | 4.892                 | 4.9624                                                           | 12.221                                                         |
|                               | 21.90                                                | 19.81                                     | .361                     | 4.778                 | 5.8282                                                           | 14.062                                                         |
|                               | 24.70                                                | 22.54                                     | .415                     | 4.670                 | 6.6296                                                           | 15.688                                                         |
| 6 5/8                         | 25.20                                                | 22.19                                     | .330                     | 5.965                 | 6.5262                                                           | 19.572                                                         |
|                               | 27.70                                                | 24.22                                     | .362                     | 5.901                 | 7.1227                                                           | 21.156                                                         |

<sup>1</sup>lb/ft = 3.3996 × A (col. 6)

<sup>2</sup>A = 0.7854 (D<sup>2</sup> - d<sup>2</sup>)

<sup>3</sup>Z = 0.19635  $\left( \frac{D^4 - d^4}{D} \right)$

## - TORSIONAL STRENGTH

### A.9 Drill Pipe Torsional Yield Strength

#### A.9.1 PURE TORSIONAL ONLY

$$Q = \frac{0.096167 J Y_m}{D} \quad (A.15)$$

where

Q = minimum torsional yield strength, ft-lb

$Y_m$  = material minimum yield strength, psi.

J = polar moment of inertia

$$= \frac{\pi (D^4 - d^4)}{32} \quad \text{for tubes}$$

$$= 0.098175 (D^4 - d^4)$$

D = outside diameter, in

d = inside diameter, in



**- INTERNAL PRESSURE**

**A.5 Internal Pressure  
A.5.1 DRILL PIPE**

$$P_i = \frac{2 Y_m t}{D} \quad (A.8)$$

where

- P<sub>i</sub>** = internal pressure psi  
**Y<sub>m</sub>** = material minimum yield strength, psi.  
**t** = remaining wall thickness of tube, in.  
**D** = nominal outside diameter of tube, in.

**Notes:**

1. Internal pressure for new drill pipe in table 3 were determined by using the nominal wall thickness for t in the above equation and multiplying by the factor 0.875 due to permissible wall thickness tolerance of minus 12 ½ percent.
2. Internal pressure for used drill pipe were determined by adjusting the nominal wall thickness according to footnotes below Table 5 and 7 and using the nominal outside diameter, in the above Equation A.8

**- COLLAPSE**

**A.3 Collapse Pressure for Drill Pipe**

Note: See API Bulletins 5C3 for derivation of equations in A.3

The minimum collapse pressures given in Tables 3, 5 and 7 are calculated values determined from equations in API Bulletin 5C3. Equations A.2 through A.5 are simplified equations that yield similar results. The D/t ratio determines the applicable formula, since each formula is based on a specific D/t ratio range.

For minimum collapse failure in the plastic range with minimum yield stress limitations: the external pressure that generates minimum yield stress on the inside wall of a tube.

$$P_c = 2Y_m \left[ \frac{(D/t) - 1}{(D/t)^2} \right] \quad (A.2)$$

Applicable D/t for application of Equation A.2 are as follows:

| Grade | D/T Ratio      |
|-------|----------------|
| E75   | 13.60 and less |
| X95   | 12.85 and less |
| G105  | 12.57 and less |
| S135  | 11.92 and less |

## - DP operational limits( API RP)

API RP 7G classifies DP operational limits based on wear:

- NEW
- PREMIUM CLASS (wall thickness 80% of new joint)
- CLASS II (wall thickness 70% of new joint)

## Biaxial Loading

### - Example Calculation of Biaxial Loading

An example of the calculation of drill pipe collapse resistance, corrected for the effect of tensile load is as follows:

Given: string of 5-inch OD, 19.50 lb per ft, Grade E Premium Class drill pipe.

Required: Determine the collapse resistance corrected for tension loading during drill stem test, with drill pipe empty and 15 lb per gal. mud behind the drill pipe. Tension of 50,000 lb on the joint above the packer.

Solution: Find reduced cross section area of Premium Class drill pipe as follows:

a. Nominal OD = 5 inches, nominal wall thickness = 0.362 inches.

b. Nominal ID = 4.276 inches.

c. Reduced wall thickness for premium.

d. Class =  $(0.8)(0.362) = 0.2896$  inches.

e. Reduced OD for premium class = 4.8552 inches.

f. Cross-sectional area for premium.

g. Class = reduced OD area – nominal ID area  
 $= 18.5141 - 14.3603 = 4.1538$  sq. inches.

h. Tension load on bottom joint =  $50,000 \div 4.1538 = 12037$  psi.

i. Average yield strength for Grade E drill pipe = 85,000 psi.

j. Percent tensile stress to average yield strength

$$= \frac{12,037}{85,000} \times 100 = 14.16 \text{ percent}$$

k. Enter Figure 81 at 14.16 percent on upper right horizontal scale and drop vertically to intersect right-hand portion of the ellipse. Proceed horizontally to the left and intersect Nominal Collapse Resistance (center vertical scale) at 92 percent.

l. Minimum collapse resistance for premium class (Table 5) = 7041 psi.

m. Corrected collapse resistance for effect of tension  
 $= (7041)(.92) = 6478$  psi.

**CAUTION:** No safety factors are included in this example calculation.

Note: Use reduced values for cross sectional area, tension and collapse rating for the appropriate class (Premium, Class 2) of used drill pipe being considered.

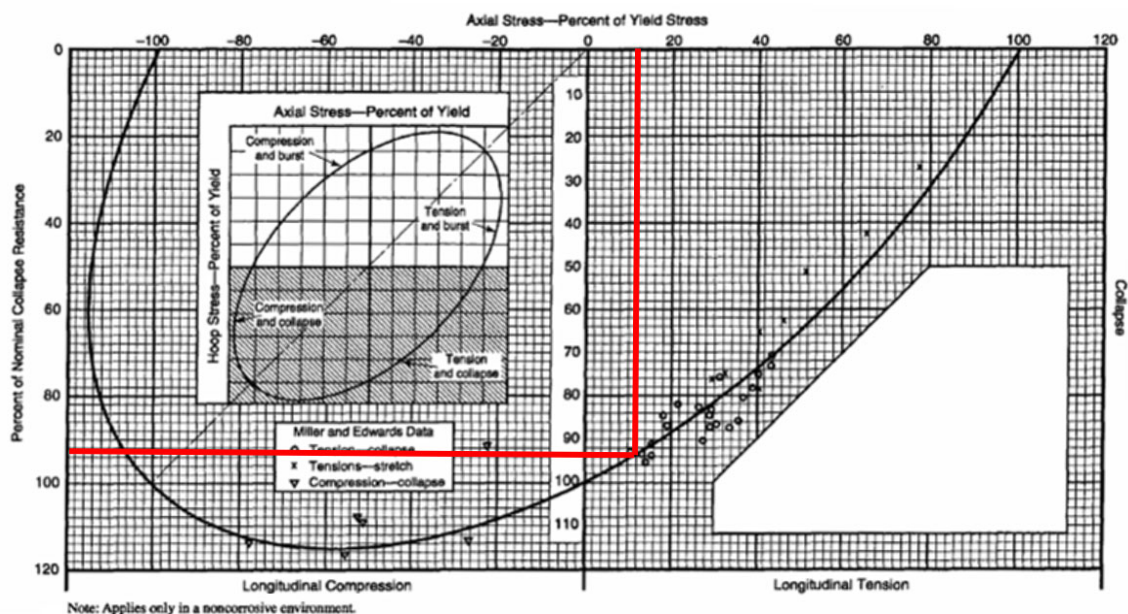


Figure 81—Ellipse of Biaxial Yield Stress<sup>12</sup> or Maximum Shear-Strain Energy Diagram  
 After Holmquist and Nadai, Collapse of Deep Well Casing, API Drilling and Production Practice (1939)

*Ellipse of Biaxial Yield Stress*

## Fatigue stress

Drill pipe is subjected to cyclic stresses in tension, compression, torsion and bending. Drill pipe will suffer fatigue when it is rotated in a section of hole in which there is a change of hole angle and/or direction, commonly called a dogleg.

### - LUBINSKI method's

LUBINSKI has developed a method for estimating the cumulative fatigue damage to pipe which has been rotated through severe doglegs.

| - Maximum permissible dogleg severity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | - Maximum permissible bending stress                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $c = \frac{432,000}{\pi} \frac{\delta_b}{ED} \frac{\tanh KL}{KL} \quad (15)$ $K = \sqrt{\frac{T}{EI}} \quad (16)$ <p>where</p> <p><math>c</math> = maximum permissible dogleg severity (hole curvature), degrees per 100 feet,</p> <p><math>E</math> = Young's modulus, psi,<br/>= 30 x 10<sup>6</sup> psi, for steel,<br/>= 10.5 x 10<sup>6</sup> psi, for aluminum,</p> <p><math>D</math> = drill pipe OD, inches,</p> <p><math>L</math> = half the distance between tool joints, inches,<br/>= 180 inches, for Range 2.</p> <p>Note: Equation 15 does not hold true for Range 3.<sup>14</sup></p> <p><math>T</math> = buoyant weight (including tool joints) suspended below the dogleg, pounds,</p> <p><math>\delta_b</math> = maximum permissible bending stress, psi,</p> <p><math>I</math> = drill pipe moment of inertia with respect to its diameter, in.<sup>4</sup>, calculated by Equation 17.</p> $I = \frac{\pi}{64} (D^4 - d^4), \quad (17)$ <p>where</p> <p><math>D</math> = drill pipe OD, inches,</p> <p><math>d</math> = drill pipe ID, inches.</p> | <p>The maximum permissible bending stress, <math>\delta_b</math>, is calculated from the buoyant tensile stress, <math>\delta_t</math> (psi), in the dogleg with Equations 19 and 20 below. <math>\delta_t</math> is calculated with Equation 18:</p> $\delta_t = \frac{T}{A} \quad (18)$ <p>where</p> <p><math>A</math> = cross sectional area of drill pipe body, square inches.</p> <p>For Grade E:<sup>14</sup></p> $\delta_b = 19,500 - \frac{10}{67} \delta_t - \frac{0.6}{(670)^2} (\delta_t - 33,500)^2 \quad (19)$ <p>Equation 19 holds true for values of <math>\delta_t</math> up to 67,000 psi.<br/>For Grade S-135:<sup>2</sup></p> $\sigma_b = 2000 \left( 1 - \frac{\sigma_t}{145,000} \right) \quad (20)$ <p>Equation 20 holds true for values of up to 133,400 psi.<br/>The following equation may be used instead of Figure 38:</p> $c = \frac{108,000}{\pi L} \frac{F}{T} \quad (21)$ <p>in which <math>F</math> is the lateral force on tool joint (1000, 2000, or 3000 pounds in Figure 38), and the meaning of the other symbols is the same as previously.</p> |

### Dogleg Severity Limits for Fatigue

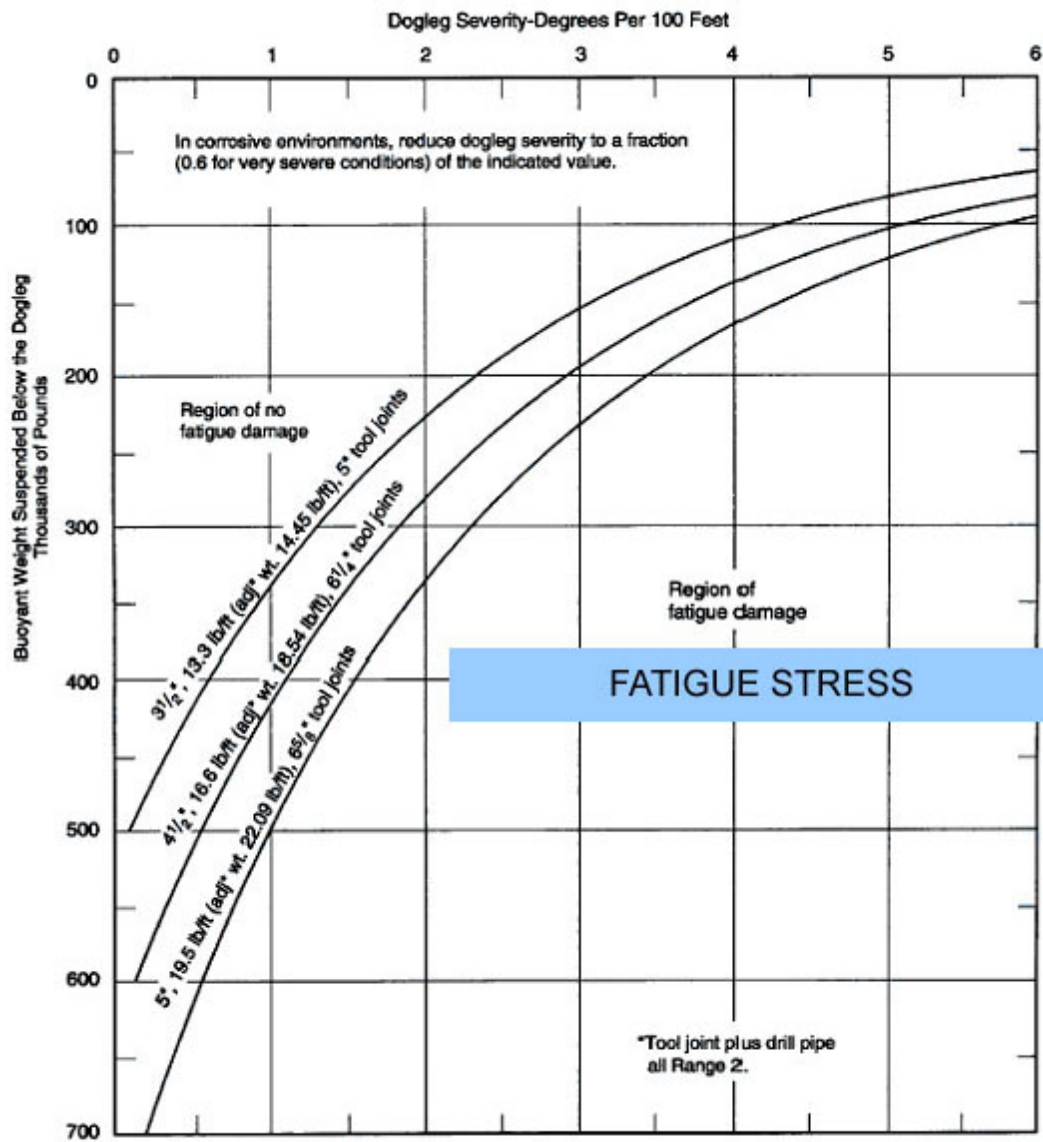


Figure 37—Dogleg Severity Limits for Fatigue of S-135 Drill Pipe



## TOOL JOINT STRESS

- Tension
- Torque
- Combined Stresses

### Tension

- Calculations

Calculations are the same as DP body.

120,000 is the minimum Yield.

The critical area is 5/8 from tool joint shoulder

### A.7 Tension

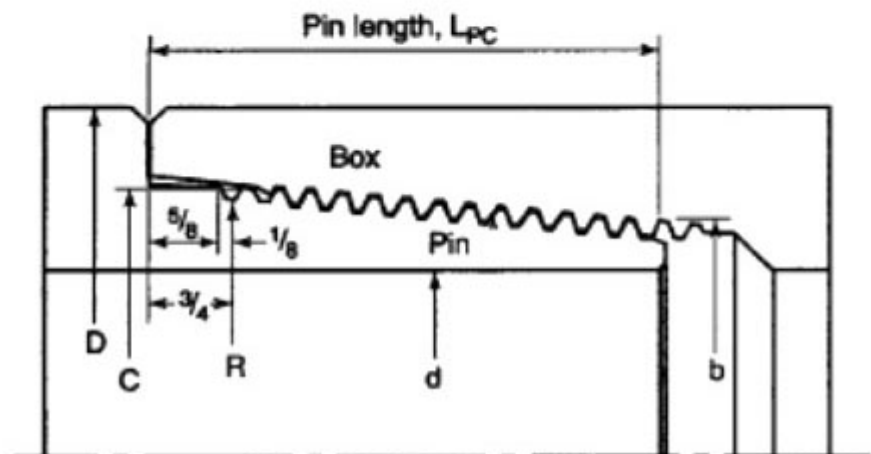
$$P = Y_m A, \quad (A.13)$$

where

$P$  = minimum tensile strength, lbs.,

$Y_m$  = material minimum yield strength, psi,

$A$  = cross-section area, sq. in. (Table 1, Column 6, for drill pipe).



## Torque

### - Calculation

#### A.8.1 TORQUE TO YIELD A ROTARY SHOULDERED CONNECTION

$$T_y = \frac{Y_m A}{12} \left( \frac{p}{2\pi} + \frac{R_t f}{\cos \theta} + R_s f \right),$$

where

$T_y$  = turning moment or torque required to yield, ft-lbs.,

$Y_m$  = material minimum yield strength, psi,

$p$  = lead of thread, in.,

$f$  = coefficient of friction on mating surfaces, threads and shoulders, assumed 0.08 for thread compounds containing 40 to 60 percent by weight of finely powdered metallic zinc. (Reference the caution regarding the use of hazardous materials in Appendix G of Specification 7.),

$q$  =  $1/2$  included angle of thread (Figures 21 or 22, Specification 7), degrees,

$$R_t = \frac{C + [C - (L_{pc} - .625) \times tpr \times 1/12]}{4},$$

$L_{pc}$  = length of pin (Specification 7, Table 25, Column 9), in.,

$R_s = 1/4 (OD + Q_c)$ , in.

The maximum value of  $R_s$  is limited to the value obtained from the calculated OD where  $A_p = A_s$ ,

$A$  = cross-section area  $A_s$  or  $A_p$  whichever is smaller, sq. in.

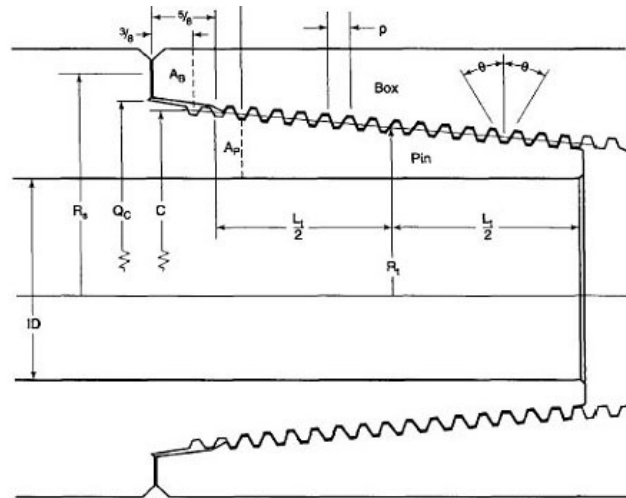


Figure A-2—Rotary Shouldered Connection

$$A_p = \frac{\pi}{4} [(D_{RG}^2 - ID^2)] \text{ with relief grooves,}$$

where

$D_{RG}$  = diameter of relief groove (Specification 7, Table 16, Column 5), in.,

$C$  = pitch diameter of thread at gauge point (Specification 7, Table 25, Column 5), in.,

$ID$  = inside diameter, in.,

$$B = 2 \left( \frac{H}{2} - S_r \right) + tpr \times 1/4 \times 1/12,$$

$H$  = thread height not truncated (Specification 7, Table 26, Column 3), in.,

$S_r$  = root truncation (Specification 7, Table 26, Column 5), in.,

$tpr$  = taper (Specification 7, Table 25, Column 4), in./ft.,

$$A_s = \frac{\pi}{4} [OD^2 - (Q_c - E)^2],$$

## - Combined Stresses

The end points for the limits lines are defined by five equations:

$$P1 = \left( \frac{Y_m}{1.1} \right) A_p$$

$$T1 = \left( \frac{Y_m}{1.1 \times 12} \right) A_b \left( \frac{p}{2\pi} + \frac{R_t f}{\cos \theta} + R_t f \right)$$

$$T2 = \left( \frac{Y_m}{1.1 \times 12} \right) A_p \left( \frac{p}{2\pi} + \frac{R_t f}{\cos \theta} + R_t f \right)$$

$$T3 = \left( \frac{Y_m}{1.1 \times 12} \right) A_p \left( \frac{p}{2\pi} + \frac{R_t f}{\cos \theta} \right)$$

$$T4 = \left( \frac{Y_m}{1.1 \times 12} \right) \left( \frac{A_p A_b}{A_p + A_b} \right) \left( \frac{p}{2\pi} + \frac{R_t f}{\cos \theta} + R_t f \right)$$

Depending on the connection geometry,  $T3$  may be greater or smaller than  $T4$ . The same is true for  $T1$  and  $T2$ .

The line (0,0) to ( $T4$ ,  $P1$ ) represents shoulder separation for low makeup torque. The line ( $T2$ , 0) to ( $T3$ ,  $P1$ ) represents pin yield under the combination of torque and tension. The line ( $T1$ , 0) to ( $T1$ ,  $P1$ ) represents box yield due to torsion. The horizontal line from  $P1$  represents maximum tension load on the pin.

### Calculations

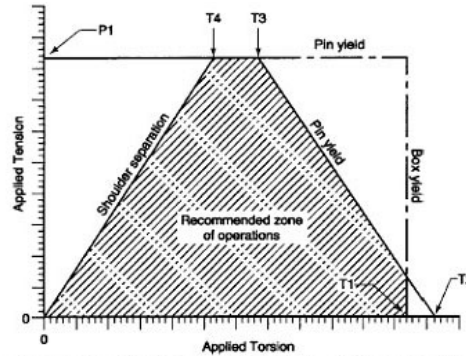


Figure A-3—Limits for Combined Torsion and Tension for a Rotary Shouldered Connection

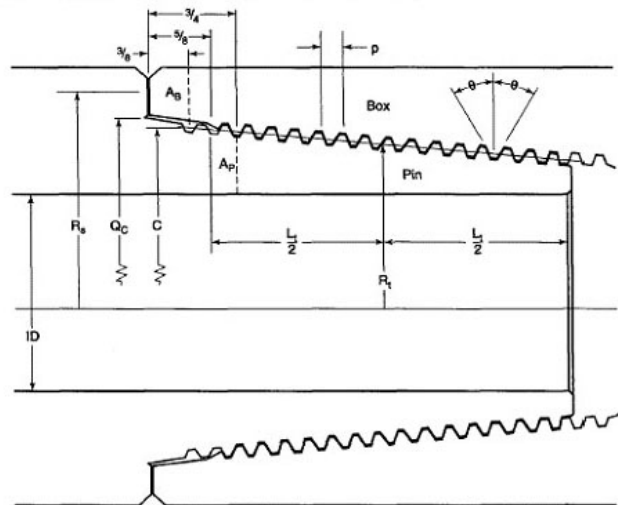


Figure A-2—Rotary Shouldered Connection

### 27.3 DRILL PIPE CODE IDENTIFICATION

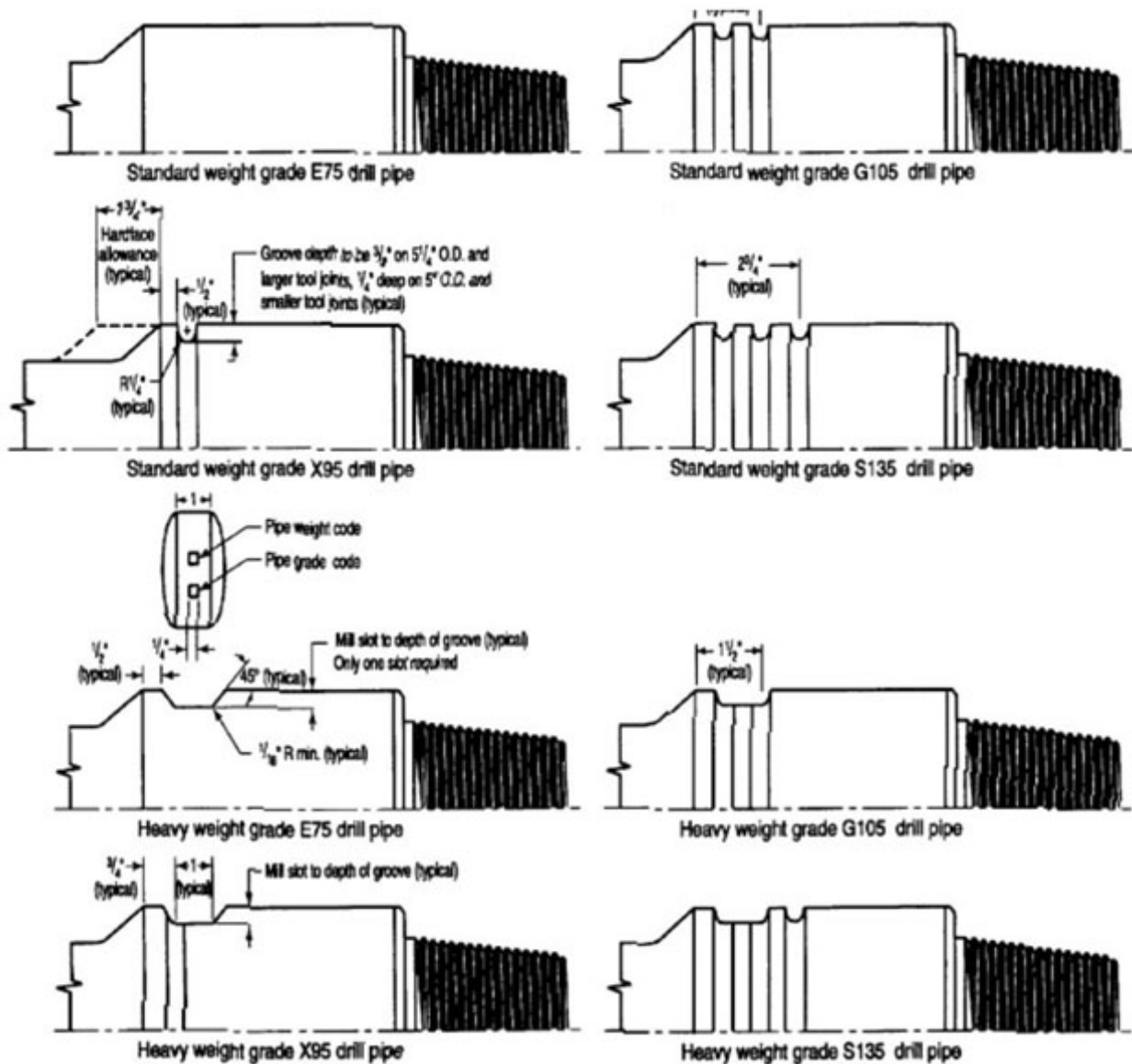
- Marking as per API 7 Spec



| Sample markings at base of pin |   |    |   |   |
|--------------------------------|---|----|---|---|
| 1                              | 2 | 3  | 4 | 5 |
| ZZ                             | 6 | 70 | N | E |

- 1 Tool Joint Manufacturer's Symbol:  
ZZ Company (fictional for example only)
- 2 Month Welded:  
6—June
- 3 Year Welded:  
70—1970
- 4 Pipe Manufacturer's Symbol:  
N—United States Steel Company
- 5 Drill Pipe Grade:  
E—Grade E75 drill pipe

- API RP 7G Drill Pipe Identification





## 27.4 DRILL PIPE INSPECTIONS

### - Periodical inspections

Drill pipes shall be inspected according to API RP 7G and API RP 5A5.

The relevant ISO standard is the 10407 Spec.

ENI requirements are defined by internal specification.

DS1 and NS2 are new standardization issued by independent body.

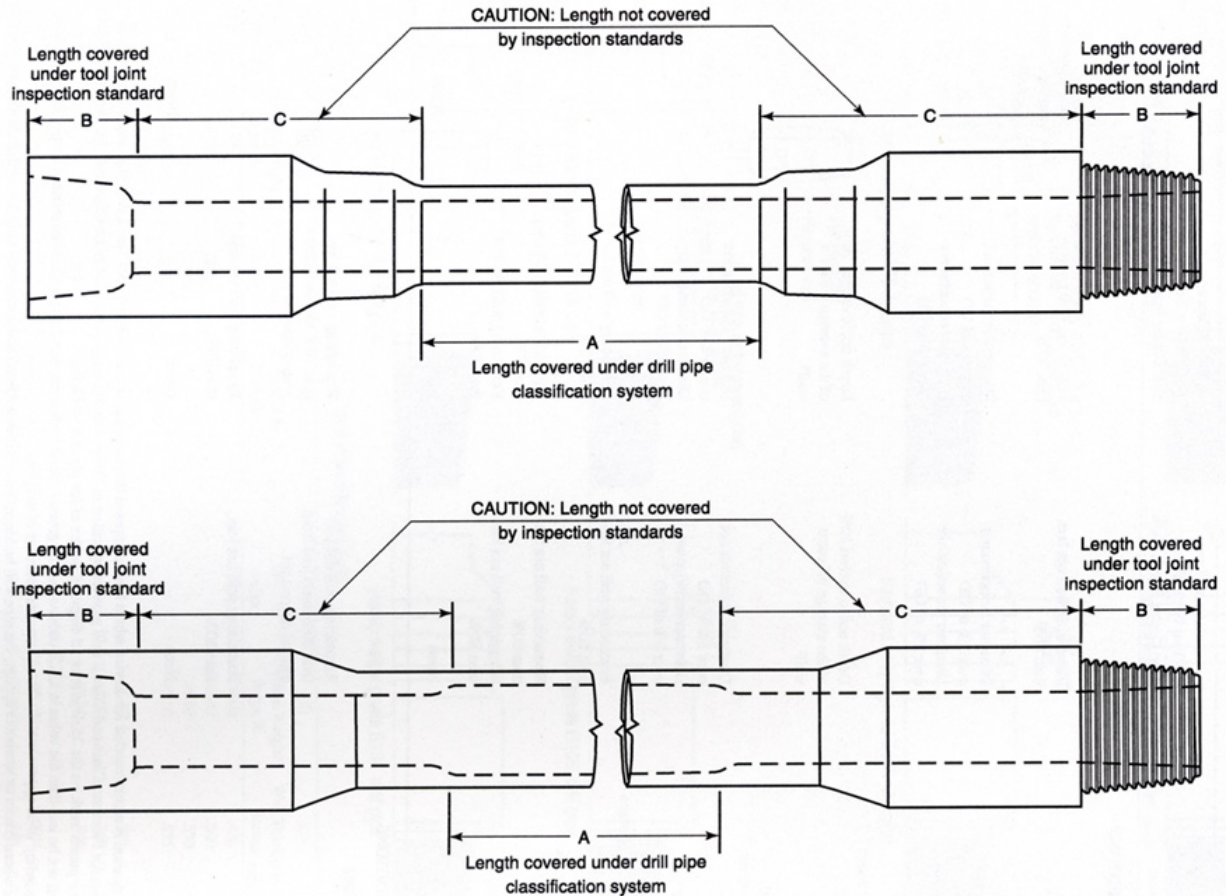


Figure 84—Identification of Lengths Covered by Inspection Standards

### - Classifications of used Drill pipe (API RP 7G)

- Exterior Conditions
- Interior Conditions

## 27.5 DRILL PIPE BRITTLE FOR H<sub>2</sub>S

### - Sulphide Stress Cracking SSC

In the presence of hydrogen sulfide (H<sub>2</sub>S) tensile-loaded drill stem components may suddenly fail in a brittle manner at a fraction of their nominal load-carrying capability after performing satisfactorily for extended periods of time.

Failure may occur even in the apparent absence of corrosion, but is more likely if active corrosion exists (Sulphide Stress Cracking SSC).

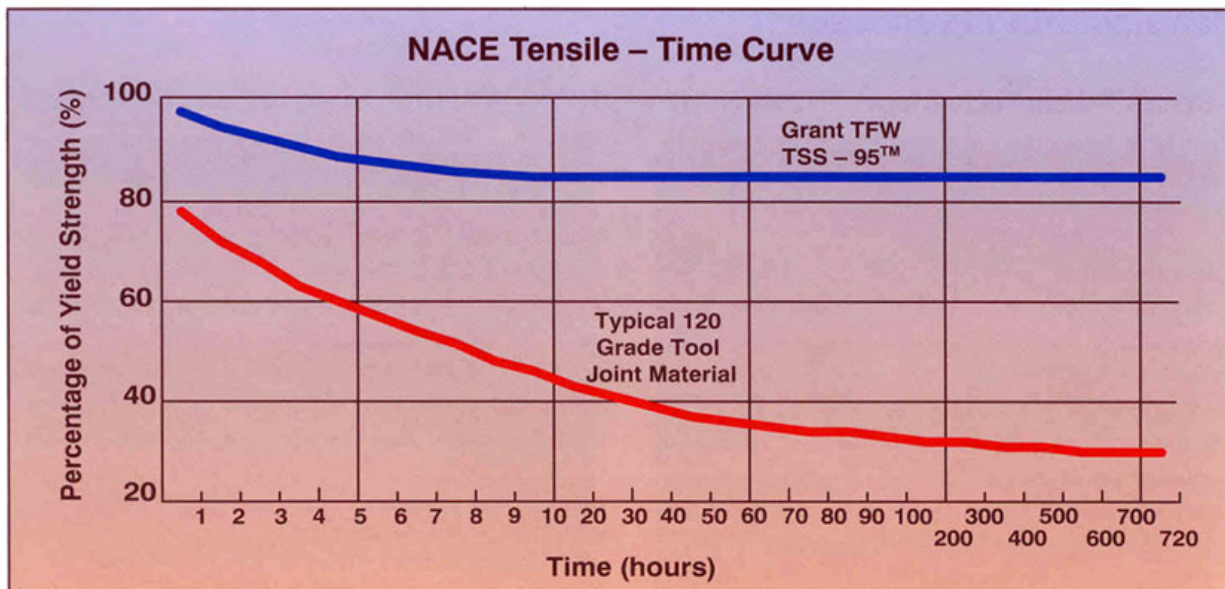
With H<sub>2</sub>S, Strength of steel between 22 and 26 HRC is suggested.

### - Minimize H<sub>2</sub>S attack

H<sub>2</sub>S attack can be minimized by keeping the following properties:

- Temperature > 57 C
- Oil base mud
- Mud with pH > 10
- Reduce contact time

*Steel grade example comparison in H<sub>2</sub>S environment*



With A NACE threshold of 85% of the yield strength, TSS-95 provides optimum fracture toughness, controlled yield strength, and restricted hardness for service in H<sub>2</sub>S environments.

## 28. HEAVY WALL DP & DRILL COLLARS

### INDEX

- 28.1 HEAVY WALL DRILL PIPE
- 28.2 DRILL COLLARS
  - DRILL COLLAR TYPES
  - DRILL COLLAR CHARACTERISTICS
  - BENDING STRENGTH RATIO CALCULATION
  - DRILL COLLAR THREADS FEATURES
- 28.3 DRILL STEM SUBS
- 28.4 LIFT SUBS
- 28.5 INSPECTIONS

### 28.1 HEAVY WALL DRILL PIPE

#### - Functions

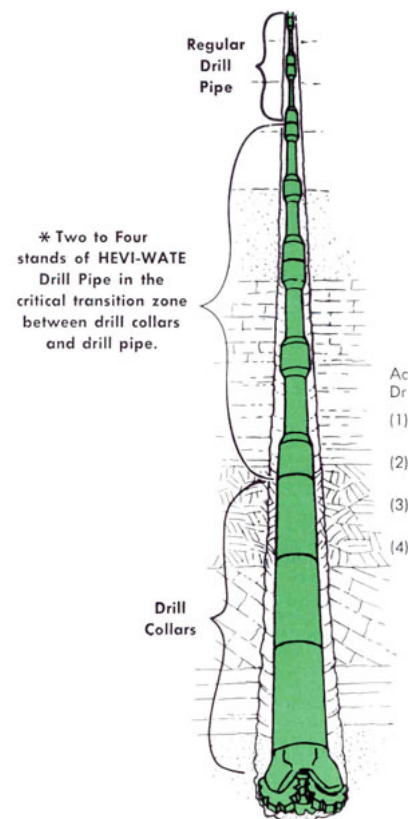
Part of the Drilling String, Heavy Drill pipe has a unit weight in between Drill Pipe and Drill Collars.

They are run between Drill Collars and Drill Pipes to:

1. Create a gradual reduction of BHA rigidity between the two.
2. Reduce fatigue stress on the DP just above the DCs.
3. Reduce wall friction in vertical deep wells with high RPM.

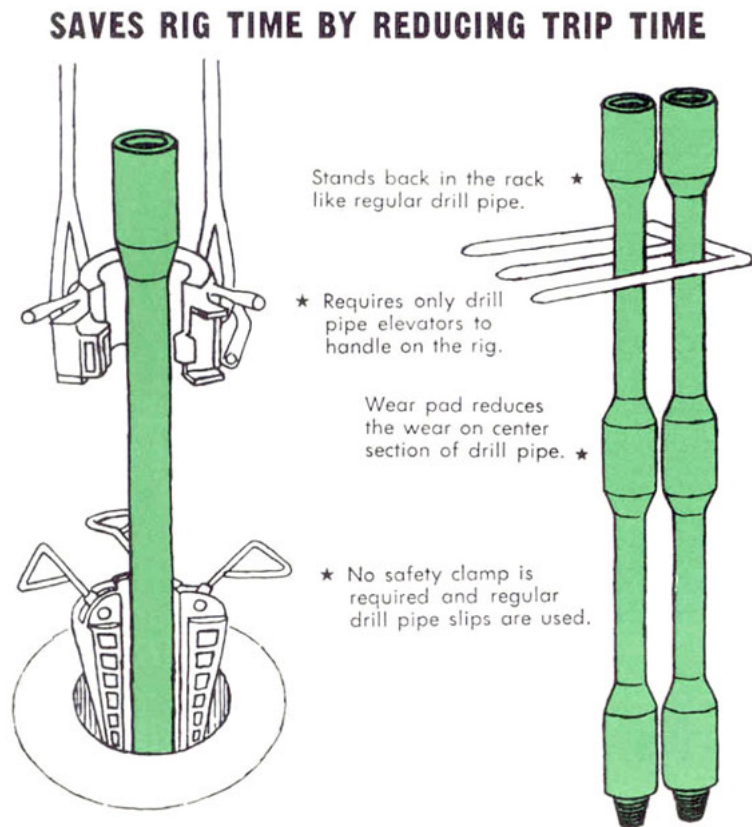
HW DP dimensions are standardized by API 7 Specifications.

The relevant ISO standard is the 10407 Spec.  
ENI requirements are defined by internal specification.



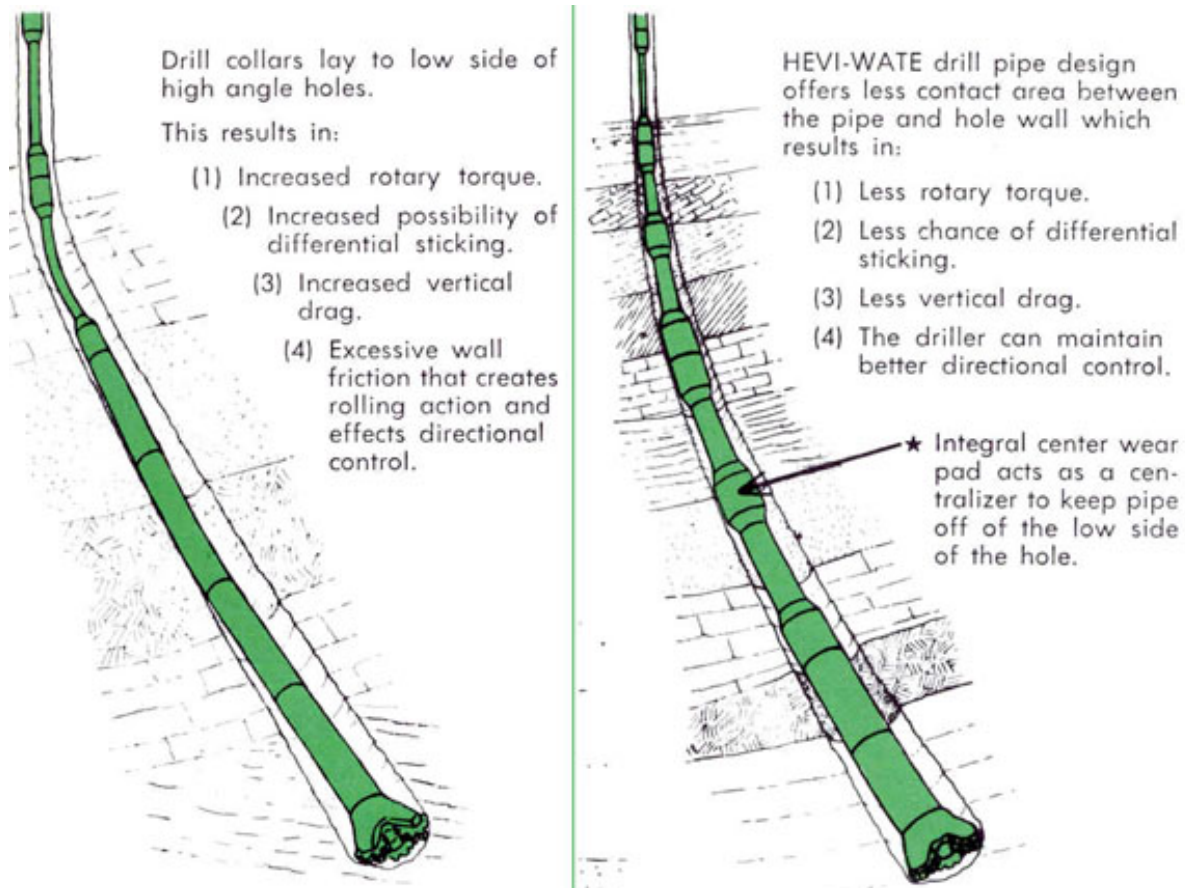
- HW Saves Rig Time by Reducing Trip Time

HWs stand back in the rack like regular Drill Pipe



- Reducing wall friction In Deviated Well

Reducing wall friction in deviated wells, heavy wall DP gives better direction control in deviated wells.





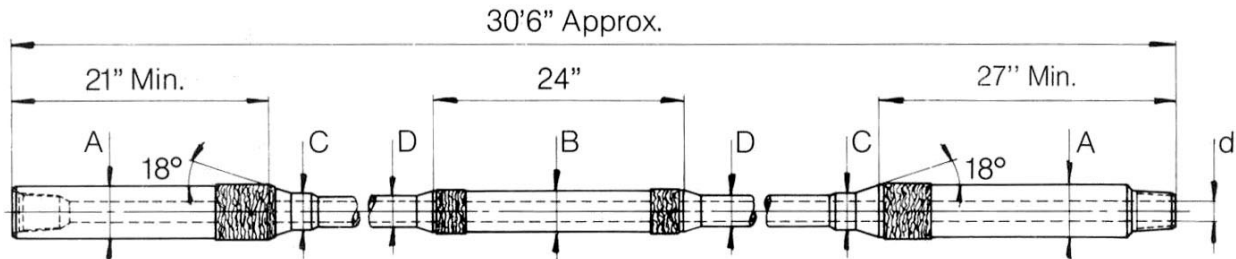
## - Dimensions

ENI requires that all HWDP connections must have appropriate bore back boxes features.

External Tool Joint diameter = same as regular Drill Pipe;

Tool Joint length > regular Drill Pipe;

Body thickness > regular Drill Pipe;

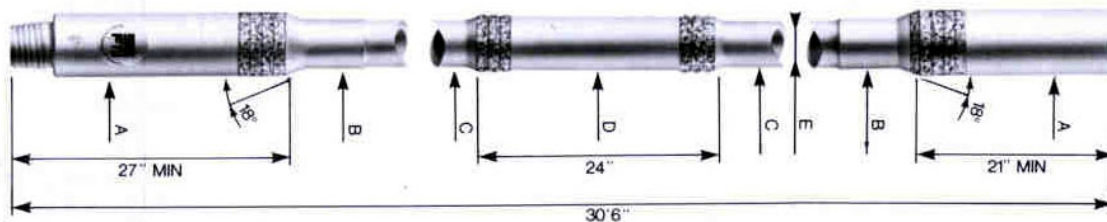


Dimensions

| Nominal Size<br>D in. | Bore<br>d in. | Wall Thickness<br>in. | Area<br>in. <sup>2</sup> | Upsets          |               | Tool Joint OD<br>A in. | Connection | Approx. Weight |      |
|-----------------------|---------------|-----------------------|--------------------------|-----------------|---------------|------------------------|------------|----------------|------|
|                       |               |                       |                          | Center<br>B in. | Ends<br>C in. |                        |            | kg             | lbm  |
| 3½                    | 2⅞            | 0.719                 | 6.28                     | 4               | 3⅝            | 4¾                     | NC 38      | 370            | 815  |
| 4                     | 2⅞            | 0.719                 | 7.41                     | 4½              | 4⅞            | 5¼                     | NC 40      | 410            | 905  |
| 4½                    | 2⅞            | 0.844                 | 9.69                     | 5               | 4⅞            | 6¼                     | NC 46      | 580            | 1280 |
| 5                     | 3             | 1.000                 | 12.57                    | 5½              | 5⅞            | 6½                     | NC 50      | 710            | 1565 |

Heavy Wall Drill Pipe - Dimensions

## - Heavy Wall Drill Pipe by SMF



| Range 2 - 30'6"        |                         |         |                 |                     |                            |        |    |           |                     |                            |                     |                           |
|------------------------|-------------------------|---------|-----------------|---------------------|----------------------------|--------|----|-----------|---------------------|----------------------------|---------------------|---------------------------|
| Nominal size<br>C (in) | Tool Joint              |         |                 |                     |                            | Tube   |    |           |                     |                            | Approx. Weight (kg) | Make-up torque (ft x lbs) |
|                        | Tool Joint OD<br>A (in) | ID (in) | Connection size | Tensile Yield (lbs) | Torsional Yield (ft x lbs) | Upsets |    | ID E (in) | Tensile Yield (lbs) | Torsional Yield (ft x lbs) |                     |                           |
| 6⅝                     | 8⅞                      | 4       | 6⅝ FH           | 2 248 700           | 116 700                    | 7      | 6⅝ | 5         | 1 112 700           | 139 000                    | 940                 | 60 800                    |
| 5½                     | 7                       | 3⅝      | 5½ FH           | 1 399 600           | 59 100                     | 6      | 5⅞ | 3⅝        | 1 007 800           | 95 500                     | 720                 | 30 800                    |
| 5                      | 6½                      | 3       | NC 50 (4½ IF)   | 1 384 200           | 56 900                     | 5½     | 5⅞ | 3         | 942 400             | 77 000                     | 680                 | 29 700                    |
| 4½                     | 6¼                      | 2⅞      | NC 46 (4 IF)    | 1 133 500           | 54 600                     | 5      | 4⅞ | 2⅞        | 726 800             | 54 600                     | 555                 | 22 700                    |
| 4                      | 5¾                      | 2½      | NC 40 (4 FH)    | 852 600             | 38 400                     | 4½     | 4⅞ | 2½        | 574 300             | 38 400                     | 425                 | 15 000                    |
| 3½                     | 4¾                      | 2⅞      | NC 38 (3½ IF)   | 606 600             | 26 600                     | 4      | 3⅞ | 2⅞        | 471 000             | 26 600                     | 350                 | 10 000                    |

Heavy Wall Drill Pipe by SMF - Dimension

## 28.2 DRILL COLLARS

Drill collars are the components of the drill string that provide the weight on bit when drilling.

They are thick-walled, hollow tubulars machined from solid bars of steel (usually plain carbon) or non-magnetic nickel-copper alloy or other non-magnetic premium alloys.

The outside diameter may be machined with helical grooves (spiral) to reduce the potential contact surface for differential sticking prevention.

ENI requirements are defined by internal specification.

Drill Collars dimensions are standardized by API 7 Specifications.

The ISO 10407 Spec. is actually a draft.

### - DRILL COLLAR TYPES

- Smooth
- Spiral

"Eni Best Practices" policy requires to use only "Spiral Drill Collars" instead of the "Smooth" type".



*Drill collar types: Smooth*

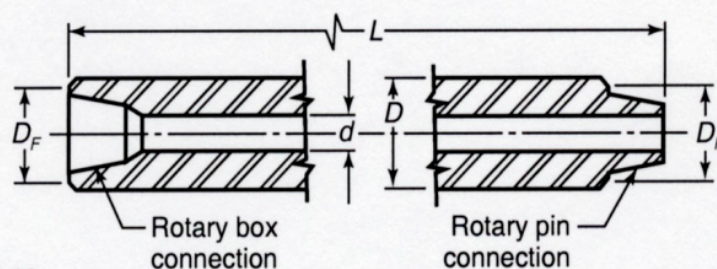
*Spiral DC with elevator groove and slip recess*

## - DRILL COLLAR CHARACTERISTICS

- Sizes and Dimensions (API 7)
- D.C. Connection Dimensions
- Mechanical characteristics

## - Sizes and Dimensions (API 7)

Drill Collars are furnished in the sizes and dimensions shown in table .



Note: See Table 13.

Table 13—Drill Collars

| 1                                | 2                         | 3                        | 4                                | 5                                   | 6                                                |
|----------------------------------|---------------------------|--------------------------|----------------------------------|-------------------------------------|--------------------------------------------------|
| Drill Collar Number <sup>a</sup> | Outside Diameter<br>$D^b$ | Bore, $+1/16 - 0$<br>$d$ | Length, ft. $\pm 6$ in.<br>$L^d$ | Bevel Diameter, $\pm 1/64$<br>$D_F$ | Reference Bending Strength<br>Ratio <sup>e</sup> |
| NC23-31                          | 3 1/8                     | 1 1/4                    | 30                               | 3                                   | 2.57:1                                           |
| NC26-35                          | 3 1/2                     | 1 1/2                    | 30                               | 3 17/64                             | 2.42:1                                           |
| NC31-41                          | 4 1/8                     | 2                        | 30 or 31                         | 3 61/64                             | 2.43:1                                           |
| NC35-47                          | 4 3/4                     | 2                        | 30 or 31                         | 4 33/64                             | 2.58:1                                           |
| NC38-50                          | 5                         | 2 1/4                    | 30 or 31                         | 4 49/64                             | 2.38:1                                           |
| NC44-60                          | 6                         | 2 1/4                    | 30 or 31                         | 5 11/16                             | 2.49:1                                           |
| NC44-60                          | 6                         | 2 13/16                  | 30 or 31                         | 5 11/16                             | 2.84:1                                           |
| NC44-62                          | 6 1/4                     | 2 1/4                    | 30 or 31                         | 5 7/8                               | 2.91:1                                           |
| NC46-62                          | 6 1/4                     | 2 13/16                  | 30 or 31                         | 5 29/32                             | 2.63:1                                           |
| NC46-65                          | 6 1/2                     | 2 1/4                    | 30 or 31                         | 6 3/32                              | 2.76:1                                           |
| NC46-65                          | 6 1/2                     | 2 13/16                  | 30 or 31                         | 6 3/32                              | 3.05:1                                           |
| NC46-67                          | 6 3/4                     | 2 1/4                    | 30 or 31                         | 6 9/32                              | 3.18:1                                           |
| NC50-70                          | 7                         | 2 1/4                    | 30 or 31                         | 6 31/64                             | 2.54:1                                           |
| NC50-70                          | 7                         | 2 13/16                  | 30 or 31                         | 6 31/64                             | 2.73:1                                           |
| NC50-72                          | 7 1/4                     | 2 13/16                  | 30 or 31                         | 6 43/64                             | 3.12:1                                           |
| NC56-77                          | 7 3/4                     | 2 13/16                  | 30 or 31                         | 7 19/64                             | 2.70:1                                           |
| NC56-80                          | 8                         | 2 13/16                  | 30 or 31                         | 7 31/64                             | 3.02:1                                           |
| 6 5/8 REG                        | 8 1/4                     | 2 13/16                  | 30 or 31                         | 7 45/64                             | 2.93:1                                           |
| NC61-90                          | 9                         | 2 13/16                  | 30 or 31                         | 8 3/8                               | 3.17:1                                           |
| 7 5/8 REG                        | 9 1/2                     | 3                        | 30 or 31                         | 8 13/16                             | 2.81:1                                           |
| NC70-97                          | 9 3/4                     | 3                        | 30 or 31                         | 9 5/32                              | 2.57:1                                           |
| NC70-100                         | 10                        | 3                        | 30 or 31                         | 9 11/32                             | 2.81:1                                           |
| 8 5/8 REG <sup>c</sup>           | 11                        | 3                        | 30 or 31                         | 10 1/2                              | 2.84:1                                           |



## - D.C. Connection Dimensions

All drill collars connections must have stress relieve/bore back features in conformance with API 7.

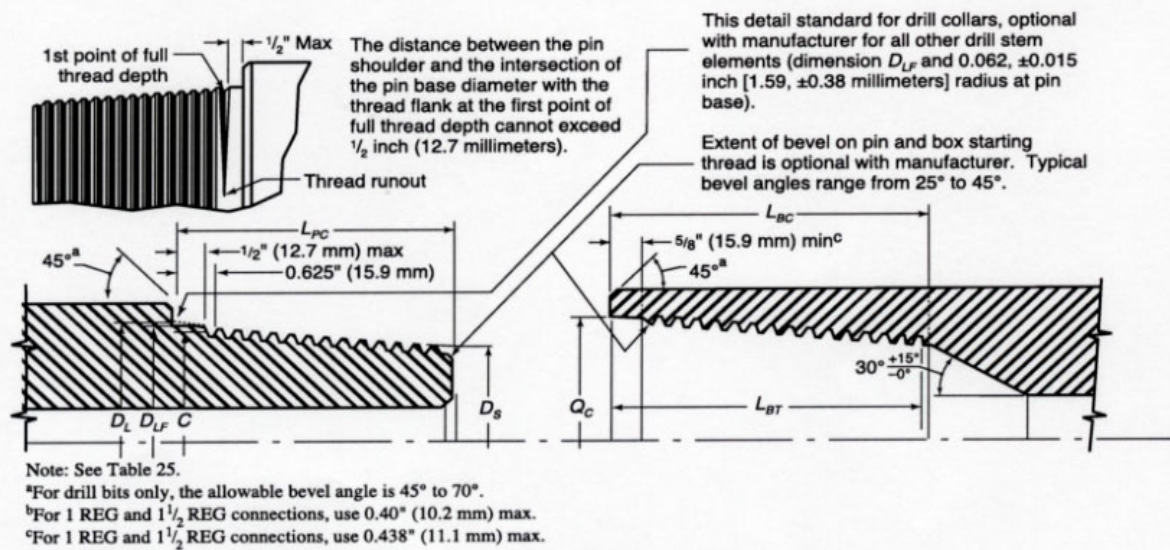


Table 25—Product Dimensions Rotary Shouldered Connections

| 1                         | 2           | 3                | 4                                  | 5                                         | 6                           | 7                                           | 8                           | 9                                   | 10                                                  | 11                               | 12                                    |
|---------------------------|-------------|------------------|------------------------------------|-------------------------------------------|-----------------------------|---------------------------------------------|-----------------------------|-------------------------------------|-----------------------------------------------------|----------------------------------|---------------------------------------|
| Connection Number or Size | Thread Form | Threads Per Inch | Taper, Inches Per Foot on Diameter | Pitch Diameter of Thread at Gauge Point C | Large Diameter of Pin $D_L$ | Diameter of Flat on Pin $\pm 1/64$ $D_{LF}$ | Small Diameter of Pin $D_S$ | Length of pin <sup>a</sup> $L_{PC}$ | Minimum Length of Box Threads <sup>b</sup> $L_{BT}$ | Depth of Box $+3/8 - 0$ $L_{BC}$ | Box Counter-bore $+1/32 - 1/64$ $Q_C$ |
| Number (NC) Style         |             |                  |                                    |                                           |                             |                                             |                             |                                     |                                                     |                                  |                                       |
| NC23                      | V-0.038R    | 4                | 2                                  | 2.35500                                   | 2.563                       | 2.437                                       | 2.063                       | 3                                   | 3 1/8                                               | 3 5/8                            | 2 5/8                                 |
| NC26                      | V-0.038R    | 4                | 2                                  | 2.66800                                   | 2.876                       | 2.750                                       | 2.376                       | 3                                   | 3 1/8                                               | 3 5/8                            | 2 15/16                               |
| NC31                      | V-0.038R    | 4                | 2                                  | 3.18300                                   | 3.391                       | 3.266                                       | 2.808                       | 3 1/2                               | 3 5/8                                               | 4 1/8                            | 3 29/64                               |
| NC35                      | V-0.038R    | 4                | 2                                  | 3.53100                                   | 3.739                       | 3.625                                       | 3.114                       | 3 3/4                               | 3 7/8                                               | 4 3/8                            | 3 13/16                               |
| NC38                      | V-0.038R    | 4                | 2                                  | 3.80800                                   | 4.016                       | 3.891                                       | 3.349                       | 4                                   | 4 1/8                                               | 4 5/8                            | 4 5/64                                |
| NC40                      | V-0.038R    | 4                | 2                                  | 4.07200                                   | 4.280                       | 4.156                                       | 3.530                       | 4 1/2                               | 4 5/8                                               | 5 1/8                            | 4 11/32                               |
| NC44                      | V-0.038R    | 4                | 2                                  | 4.41700                                   | 4.625                       | 4.499                                       | 3.875                       | 4 1/2                               | 4 5/8                                               | 5 1/8                            | 4 11/16                               |
| NC46                      | V-0.038R    | 4                | 2                                  | 4.62600                                   | 4.834                       | 4.709                                       | 4.084                       | 4 1/2                               | 4 5/8                                               | 5 1/8                            | 4 29/32                               |
| NC50                      | V-0.038R    | 4                | 2                                  | 5.04170                                   | 5.250                       | 5.135                                       | 4.500                       | 4 1/2                               | 4 5/8                                               | 5 1/8                            | 5 5/16                                |
| NC56                      | V-0.038R    | 4                | 3                                  | 5.61600                                   | 5.876                       | 5.703                                       | 4.626                       | 5                                   | 5 1/8                                               | 5 5/8                            | 5 15/16                               |
| NC61                      | V-0.038R    | 4                | 3                                  | 6.17800                                   | 6.438                       | 6.266                                       | 5.063                       | 5 1/2                               | 5 5/8                                               | 6 1/8                            | 6 1/2                                 |
| NC70                      | V-0.038R    | 4                | 3                                  | 7.05300                                   | 7.313                       | 7.141                                       | 5.813                       | 6                                   | 6 1/8                                               | 6 5/8                            | 7 3/8                                 |
| NC77                      | V-0.038R    | 4                | 3                                  | 7.74100                                   | 8.000                       | 7.828                                       | 6.376                       | 6 1/2                               | 6 5/8                                               | 7 1/8                            | 8 1/16                                |
| Regular (REG) Style       |             |                  |                                    |                                           |                             |                                             |                             |                                     |                                                     |                                  |                                       |
| 1 REG                     | V-0.055     | 6                | 1.5                                | 1.15400                                   | 1.281                       | 1.233                                       | 1.094                       | 1.50                                | 2.00                                                | 2.13                             | 1.301                                 |
| 1 1/2 REG                 | V-0.055     | 6                | 1.5                                | 1.54100                                   | 1.668                       | 1.621                                       | 1.418                       | 2.00                                | 2.125                                               | 2.63                             | 1.688                                 |
| 2 3/8 REG                 | V-0.040     | 5                | 3                                  | 2.36537                                   | 2.625                       | 2.515                                       | 1.875                       | 3                                   | 3 1/8                                               | 3 5/8                            | 2 11/16                               |
| 2 7/8 REG                 | V-0.040     | 5                | 3                                  | 2.74037                                   | 3.000                       | 2.890                                       | 2.125                       | 3 1/2                               | 3 5/8                                               | 4 1/8                            | 3 1/16                                |
| 3 1/2 REG                 | V-0.040     | 5                | 3                                  | 3.23987                                   | 3.500                       | 3.390                                       | 2.562                       | 3 3/4                               | 3 7/8                                               | 4 3/8                            | 3 9/16                                |
| 4 1/2 REG                 | V-0.040     | 5                | 3                                  | 4.36487                                   | 4.625                       | 4.515                                       | 3.562                       | 4 1/4                               | 4 3/8                                               | 4 7/8                            | 4 11/16                               |
| 5 1/2 REG                 | V-0.050     | 4                | 3                                  | 5.23402                                   | 5.520                       | 5.410                                       | 4.333                       | 4 3/4                               | 4 7/8                                               | 5 3/8                            | 5 37/64                               |
| 6 5/8 REG                 | V-0.050     | 4                | 2                                  | 5.75780                                   | 5.992                       | 5.882                                       | 5.159                       | 5                                   | 5 1/8                                               | 5 5/8                            | 6 1/16                                |
| 7 5/8 REG                 | V-0.050     | 4                | 3                                  | 6.71453                                   | 7.000                       | 6.890                                       | 5.688                       | 5 1/4                               | 5 3/8                                               | 5 7/8                            | 7 3/32                                |
| 8 5/8 REG                 | V-0.050     | 4                | 3                                  | 7.66658                                   | 7.952                       | 7.840                                       | 6.608                       | 5 3/8                               | 5 1/2                                               | 6                                | 8 3/64                                |
| Full-Hole (FH) Style      |             |                  |                                    |                                           |                             |                                             |                             |                                     |                                                     |                                  |                                       |
| 5 1/2 FH                  | V-0.050     | 4                | 2                                  | 5.59100                                   | 5.825                       | —                                           | 4.992                       | 5                                   | 5 1/8                                               | 5 5/8                            | 5 29/32                               |
| 6 5/8 FH                  | V-0.050     | 4                | 2                                  | 6.51960                                   | 6.753                       | —                                           | 5.920                       | 5                                   | 5 1/8                                               | 5 5/8                            | 6 27/32                               |

Notes:

1. See Figure 20.

2. All dimensions are in inches unless otherwise specified. See Appendix M for metric table.

<sup>a</sup>For rolling cone drill bits only, the tolerance is  $+0, -3/16$ .

<sup>b</sup> $L_{BT}$  is the length of threads in the box measured from the make-up shoulder to the intersection of the non-pressure flank and crest of the last thread with full thread depth.



## - Mechanical characteristics

Table 17—Mechanical Properties and Tests New Standard Steel Drill Collars

| 1<br>Drill Collar<br>OD Range<br>inches | 2<br>Minimum Yield Strength |                   | 3<br>Minimum Tensile Strength |                   | 4<br>Elongation, Minimum, With Gauge<br>Length Four Times Diameter,<br>percent | 5<br>Minimum<br>Brinell<br>Hardness |
|-----------------------------------------|-----------------------------|-------------------|-------------------------------|-------------------|--------------------------------------------------------------------------------|-------------------------------------|
|                                         | psi                         | N/mm <sup>2</sup> | psi                           | N/mm <sup>2</sup> |                                                                                |                                     |
| 3 1/8 through 6 7/8                     | 110,000                     | 758               | 140,000                       | 965               | 13                                                                             | 285                                 |
| 7 through 11                            | 100,000                     | 689               | 135,000                       | 931               | 13                                                                             | 285                                 |

### Notes:

1. Tensile properties shall be determined by tests on cylindrical specimens conforming to the requirements of the current ASTM A370, 0.2 percent offset method.
2. Tensile specimens from drill collars shall be taken within 3 feet (0.9 meters) of the end of the drill collar in a longitudinal direction, having the centerline of the tensile specimen 1 inch (25 millimeters) from the outside surface or midwall, whichever is closer to the outside surface.
3. Hardness test shall be on OD of drill collar using Brinell Hardness (Rockwell-C acceptable alternative) test methods in compliance with current ASTM A370 requirements.

## - BENDING STRENGTH RATIO CALCULATION

### - Calculation

#### A.10 Drill Collar Bending Strength Ratio

The bending strength ratios in Figures 26 through 32 were determined by application of Equation A.17. The effect of stress-relief features was disregarded.

$$\begin{aligned}
 BSR &= \frac{Z_B}{Z_P} \\
 &= \frac{0.098 \frac{(D^4 - b^4)}{D}}{0.098 \frac{(R^4 - d^4)}{R}} \quad (A.17) \\
 &= \frac{\frac{D^4 - b^4}{D}}{\frac{R^4 - d^4}{R}}
 \end{aligned}$$

where

- $BSR$  = bending strength ratio,  
 $Z_B$  = box section modulus, cu. in.,  
 $Z_P$  = pin section modulus, cu. in.,  
 $D$  = outside diameter of pin and box (Figure A-4), in.,  
 $d$  = inside diameter or bore (Figure A-4), in.,  
 $b$  = thread root diameter of box threads at end of pin (Figure A-4), in.,  
 $R$  = thread root diameter of pin threads 3/4 inch from shoulder of pin (Figure A-4), in.

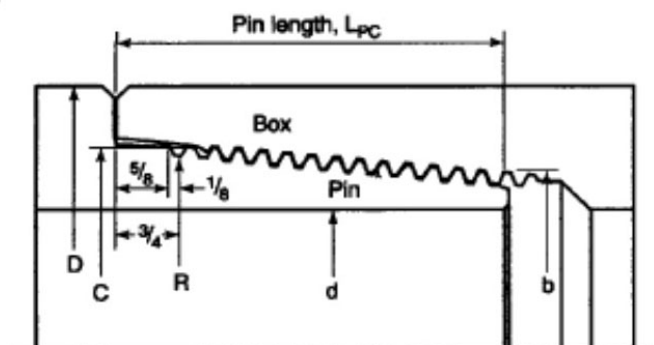


Figure A-4—Rotary Shouldered Connection Location of Dimensions for Bending Strength Ratio Calculations

- Optimal Bending Strength Ratio

Bending ratio is calculated knowing the type of thread and measuring, at a specific point shown in the picture, the ID and OD.

For every table of determined ID, with OD we can cross the thread line and see the strength ratio on the horizontal axis.

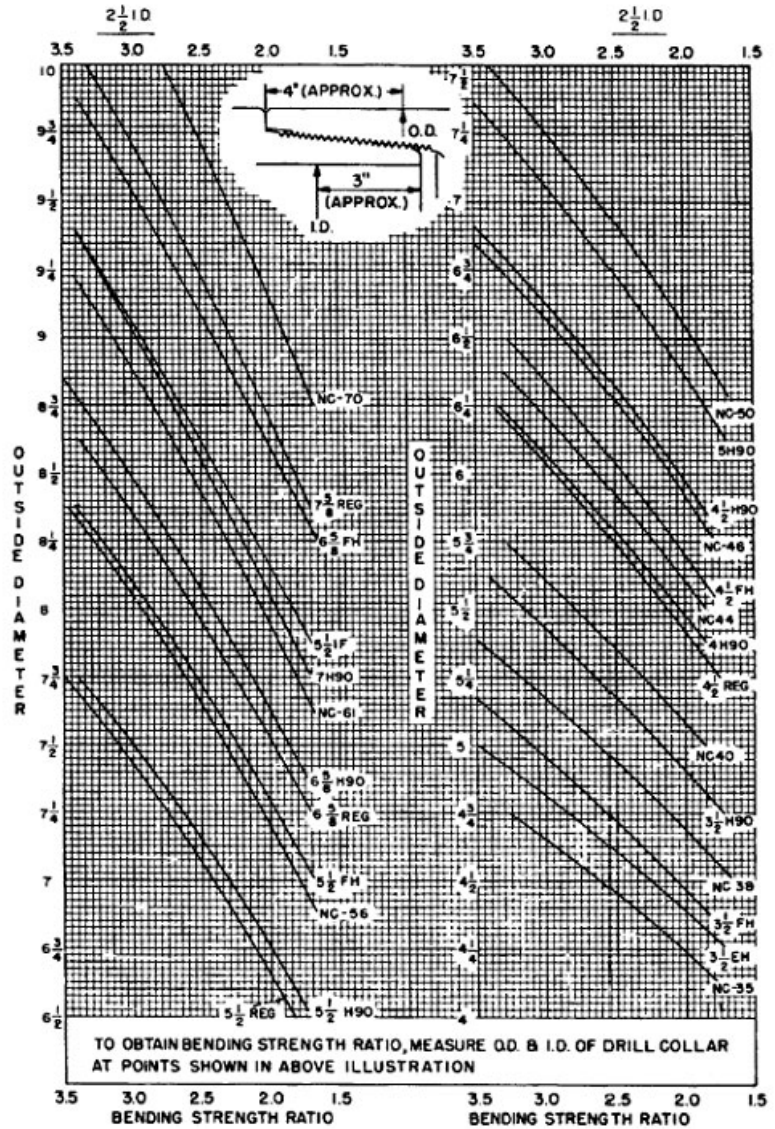
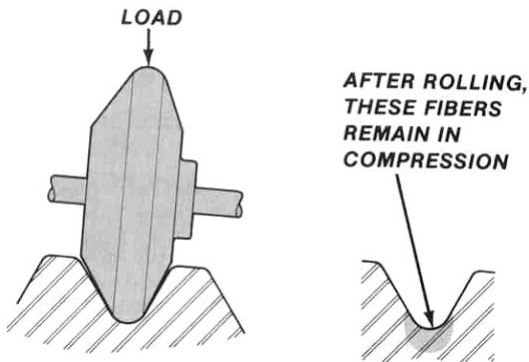


Figure 28—Drill Collar Bending Strength Ratios, 2 1/2-Inch ID

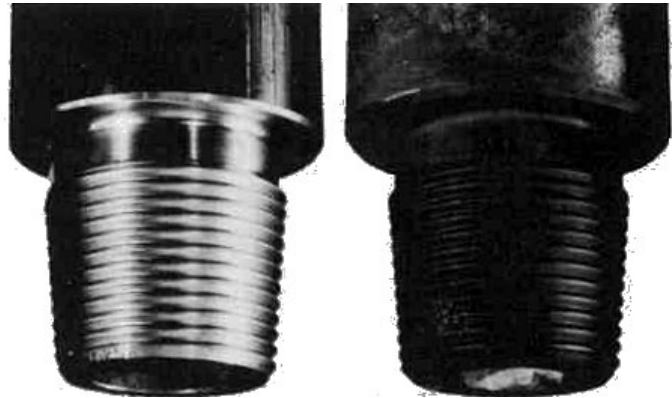
## - DRILL COLLAR THREADS FEATURES

### - Treatments

- Cold rolling increases fatigue resistance

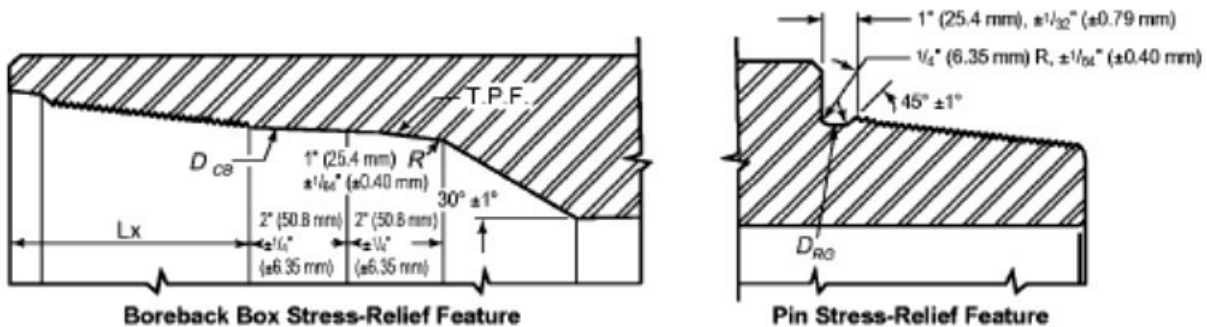


- Anti galling phosphating



### - Features

- Boreback box and pin stress features. Force loading on box and pin connections for reducing stress concentrations.



- Low torque features. Reduction of contact surface in order to reduce the make up torque on 8.5/8 regular connections

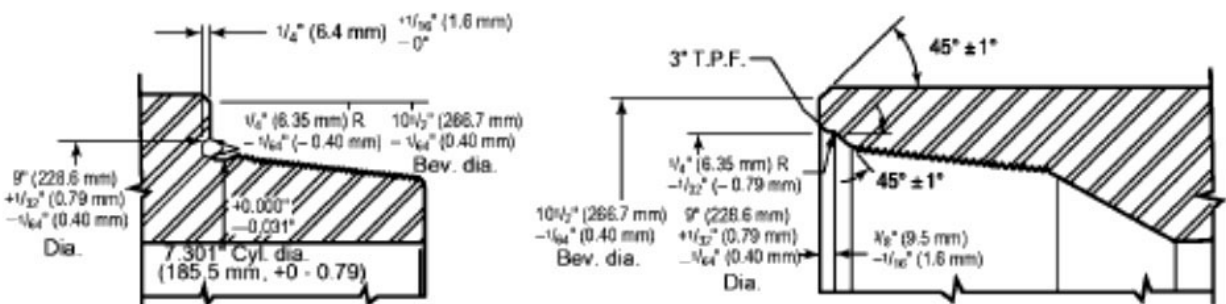


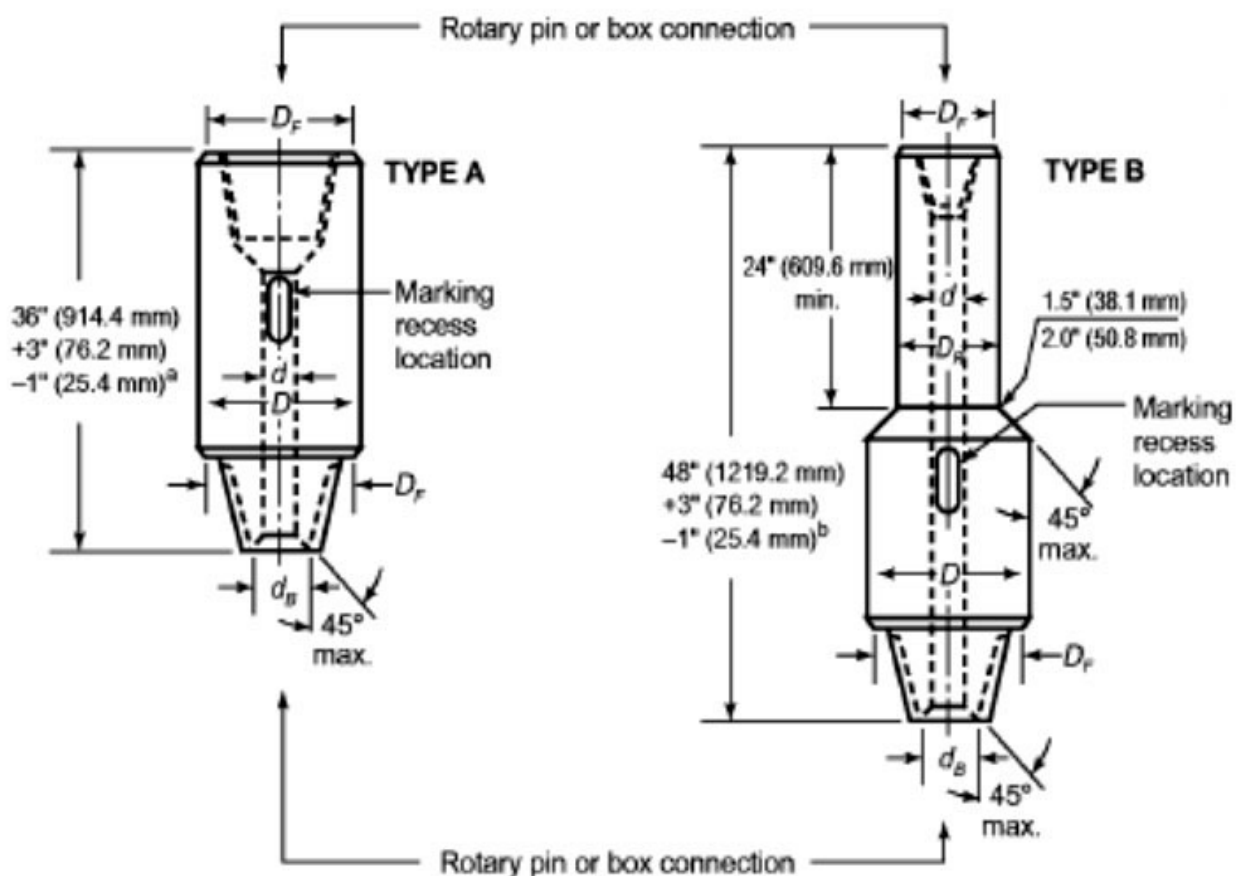
Figure 18—Low Torque Feature for 8<sup>5/8</sup> REG Connections Machined on ODs Larger Than 10<sup>1/2</sup> Inches (266.7 Millimeters) Excluding Bit Boxes

### 28.3 DRILL STEM SUBS

- Cross-over examples



- Schematic drawings



Note: See Table 9.

<sup>a</sup>If type A is a double box or double pin sub, the overall length is 36" (914.4 mm).

<sup>b</sup>If type B is a double box or double pin sub, the overall length is 48" (1219.2 mm).



- Float Valve Recess in Bit Subs

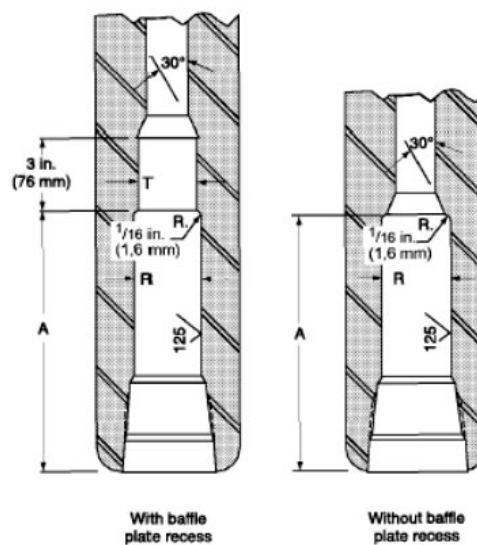


Table 12 – Float Valve Recess in Bit Subs

| Diameter of Valve Assembly | Diameter of Float Recess       | Length of Valve Assembly | API Reg. Bit Box |            | Ather Popular Connections |            |
|----------------------------|--------------------------------|--------------------------|------------------|------------|---------------------------|------------|
|                            |                                |                          | Size             | A +/- 1/16 | Size                      | A +/- 1/16 |
| D                          | R +/- 1/64 – 0<br>(D +/- 1/32) | L                        | -                | -          | NC38                      | 14 1/4     |
| 3 1/8                      | 3 5/32                         | 10                       | -                | -          | NC44                      | 13 1/16    |
| 3 5/32                     | 3 1/2                          | 8 5/16                   | 4 1/2            | 12 13/16   | NC46                      | 16 3/4     |
| 3 21/32                    | 3 11/16                        | 12                       | -                | -          | NC50                      | 14 1/2     |
| 3 7/8                      | 3 29/32                        | 9 3/4                    | 5 1/2            | 14 3/4     | 5 1/2 IF                  | 17         |
| 4 25/32                    | 4 13/16                        | 11 3/4                   | 6 5/8            | 17         | 5 1/2 FH                  | 17         |
| -                          | -                              | -                        | 7 5/8            | 17 1/4     | NC61                      | 17 1/2     |
| -                          | -                              | -                        | 8 5/8            | 17 3/8     | 6 5/8 IF                  | 19 7/8     |
| 5 11/16                    | 5 23/32                        | 14 5/8                   | 8 5/8            | 20 1/4     |                           |            |

## 28.4 LIFT SUBS

### - Lift Subs (Type D)

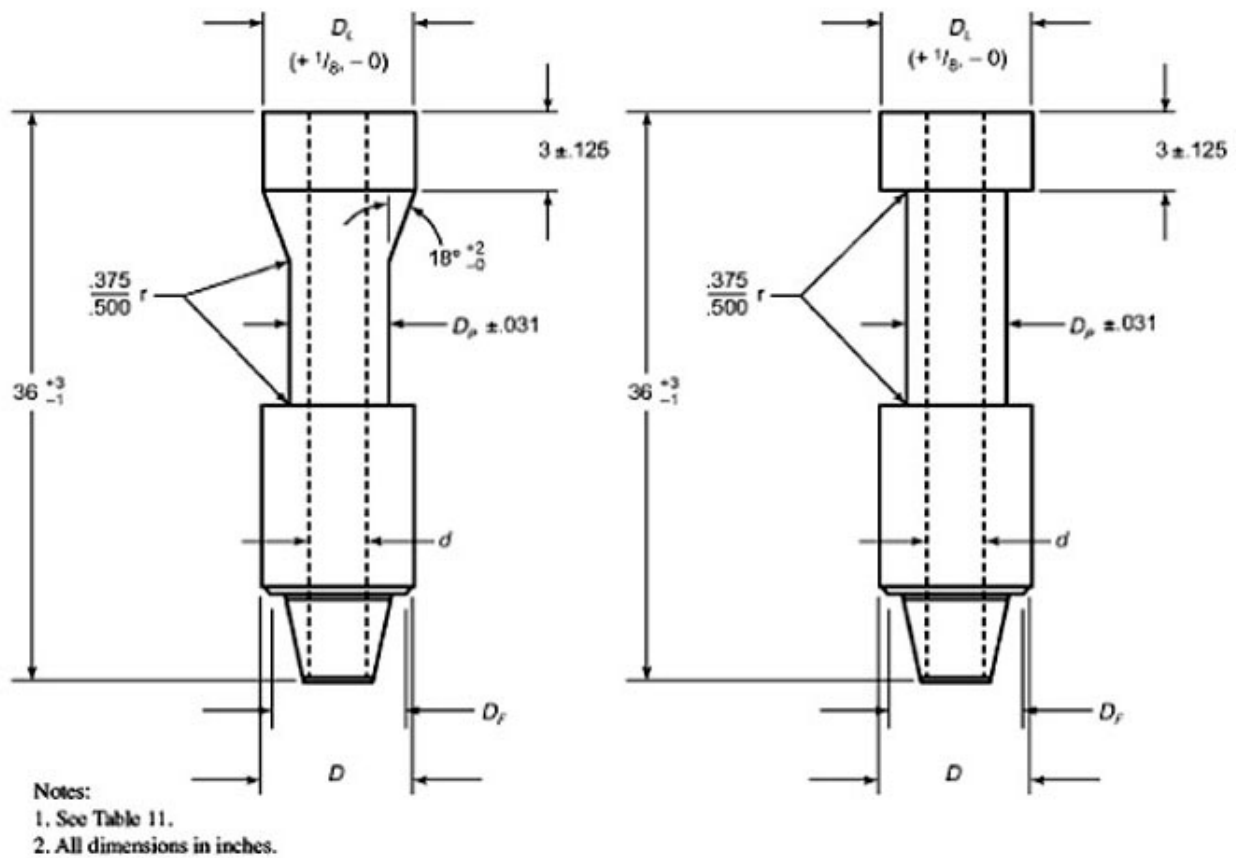


Figure 13—Lift Subs (Type D)

## 28.5 INSPECTIONS

Hewi wate, Drill collars, Short Drill Collars, Stem Sibs shall be inspected according to API RP 7G and API RP 5A5.

The relevant ISO standard is the 10407 Spec.

ENI requirements are defined by internal specification.

DS1 and NS2 are new standardizations issued by independent body.

### - DC Inspections from API RP7G

#### API RECOMMENED PRATICE 7G

#### 13.4 DRILL COLLAR INSOECTION PROCEDURE

The following inspection procedure for used drill collars is recommended:

- Visually inspect full length to determine obvious damage and overall condition.
- Measure OD and ID of both ends.

c. Thoroughly clean box pin threads. Follow immediately with wet fluorescent magnetic particle inspection for detection of cracks. A magnifying mirror may be used in crack detection of the box threads. Drill collars found to contain cracks should be considered unfit for further drilling service. Shop repair of cracked drill collars is typically possible if the unaffected area of the drill collar permits.

d. Use a profile gauge to check thread form and to check for stretched pins.

e. Check box counterbore diameter for swelling. In addition, use a straight edge on the crests of the threads in the box checking for rocking due to swelling of the box. Some machine shops may cut box counterbores larger than API standards, therefore, a check of the diameter of the counterbore may give a misleading result.

f. Check box and pin shoulders for damage. All field repairable damage shall be repaired by refacing and beveling. Excessive damage to shoulders should be repaired in reputable machine shops with API standard gauges.

## 29. PIPE HANDLING TOOLS

### INDEX

- 29.1 DEFINITIONS
- 29.2 ELEVATOR LINKS (BALES)
- 29.3 SLIPS
- 29.4 ELEVATORS
  - ELEVATORS for DP - DC Manual
  - ELEVATORS for DP - DC Remoted controlled
  - ELEVATORS for Casing
  - SINGLE JOINT ELEVATORS
- 29.5 TONGS
  - SPINNING WRENCHES
  - TONGS for DP - DC & CASING Manual
  - TONGS for DP - DC & CASING Automatic
  - SPINNING & TORQUE Combination Wrench
- 29.6 PIPE RACK
- 29.7 FINGERBOARD
- 29.8 PICK UP & LAY DOWN MACHINE
- 29.9 CSG STABBING BOARD

### 29.1 DEFINITIONS

#### Definition from API

- Load rating; maximum operating load, both static and dynamic, to be applied to the equipment.

Note: The load rating is numerically equivalent to the design load.

- Safe working load; the design load minus the dynamic load.
- Design safety factor; Factor to account for a certain safety margin between the maximum allowable stress and the specified minimum yield strength of a material.
- Dynamic load; Load applied to the equipment due to acceleration effects.
- Maximum allowable stress; Specific minimum yield strength divided by the design safety factor.

#### - Design safety factor

Design safety factor shall be established as follows (see Table 1)

The design safety factor is intended as a design criterion and shall not under any circumstances be construed as allowing loads on the equipment in excess of the load rating.

Table 1 — Design safety factor

| Load rating<br>$R$<br>kN (ton)                                                                                                                    | Design safety factor<br>$SF_D$                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| 1 334 kN (150 short tons) and less                                                                                                                | 3,00                                                                                     |
| 1 334 kN (150 short tons) to 4 448 kN (500 short tons) inclusive                                                                                  | $3,00 - [0,75 \times (R - 1\,334)/3\,114]^a$<br>$(3,00 - [0,75 \times (R - 150)/350])^b$ |
| Over 4 448 kN (500 short tons)                                                                                                                    | 2,25                                                                                     |
| <sup>a</sup> In this formula, the value of $R$ shall be in kilonewtons.<br><sup>b</sup> In this formula, the value of $R$ shall be in short tons. |                                                                                          |



## 29.2 ELEVATOR LINKS (BALES)

The elevator links provide the connection between the hook (or Top drive) and the elevator.

There are 3 different types of links:

- Perfection Link - Weldless Link - Tool Pusher Link



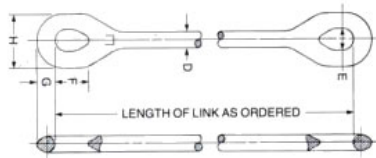
- Weldless Link

- Dimensional data

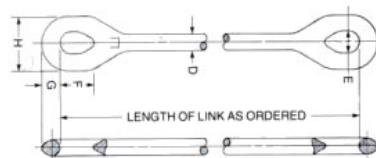
**DIMENSIONAL DATA—BJ WELDLESS LINKS**

| Dimensions | A      | B      | C      | D      | E      | F      | G      | H      | J   |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|-----|
| in.        | 2¼     | 5½     | 8      | 27⁄8   | 8      | 10     | 5      | 14     | ... |
| mm         | 57.15  | 139.70 | 203.20 | 73.03  | 203.20 | 254    | 127    | 355.60 | ... |
| in.        | 2¾     | 5½     | 8      | 3½     | 8      | 10     | 5      | 14     | ... |
| mm         | 69.85  | 139.70 | 203.20 | 88.90  | 203.20 | 254    | 127    | 355.60 | ... |
| in.        | 3½     | 6¾     | 10½    | 4½     | 9½     | 12     | 6      | 17     | ... |
| mm         | 88.90  | 171.45 | 257.18 | 114.30 | 241.30 | 304.80 | 152.40 | 431.80 | ... |
| in.        | 4¾     | 7½     | 12½    | 5½     | 9½     | 12     | 7½     | 19     | ... |
| mm         | 120.65 | 190.50 | 317.50 | 139.70 | 241.30 | 304.80 | 190.5  | 482.60 | ... |
| in.        | ...    | ...    | ...    | 6      | 8      | 13     | 7      | 19     | ... |
| mm         | ...    | ...    | ...    | 152.40 | 203.20 | 330.20 | 177.80 | 482.60 | ... |

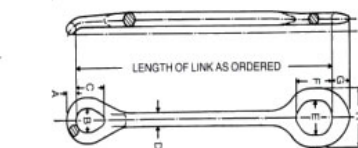
BJ Weldless links—  
2¼" to 4¾" sizes.



BJ Weldless links—  
5½" sizes.



BJ Weldless links—  
2¼" to 4¾" sizes.



- Specification

**SPECIFICATIONS - WELDLESS LINKS**

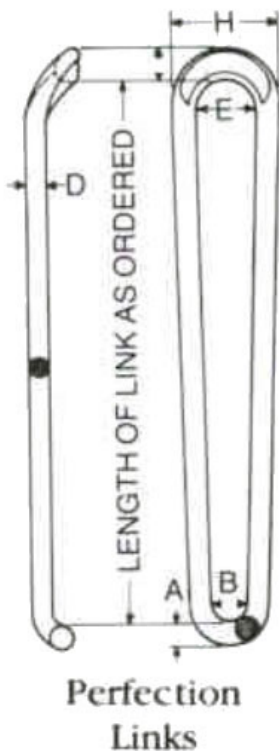
| Size-in.                           | Size-mm        | Rated Capacity/Set tons | Weight/Set |        |
|------------------------------------|----------------|-------------------------|------------|--------|
|                                    |                |                         | lb         | kg     |
| 2¼ x 60                            | 57.15 x 1524.0 | 250                     | 480        | 218.2  |
| 2¼ x 72                            | 57.15 x 1828.8 | 250                     | 530        | 240.9  |
| 2¼ x 84                            | 57.15 x 2133.6 | 250                     | 580        | 263.6  |
| 2¼ x 96                            | 57.15 x 2438.4 | 250                     | 630        | 286.4  |
| 2¼ x 108                           | 57.15 x 2743.2 | 250                     | 680        | 309.1  |
| 2¼ x 132                           | 57.15 x 3353.0 | 250                     | 780        | 354.6  |
| 2½ x 60                            | 69.85 x 1524.0 | 350                     | 620        | 281.8  |
| 2½ x 72                            | 69.85 x 1828.8 | 350                     | 685        | 311.4  |
| 2½ x 84                            | 69.85 x 2133.6 | 350                     | 740        | 335.7  |
| 2½ x 96                            | 69.85 x 2438.4 | 350                     | 805        | 365.9  |
| 2½ x 108                           | 69.85 x 2743.2 | 350                     | 870        | 394.6  |
| 2½ x 120                           | 69.85 x 3048.0 | 350                     | 935        | 425.0  |
| 2½ x 132                           | 69.85 x 3353.0 | 350                     | 1000       | 453.6  |
| 2½ x 150                           | 69.85 x 3810.0 | 350                     | 1095       | 497.7  |
| 2½ x 168                           | 69.85 x 4267.2 | 350                     | 1190       | 540.9  |
| 2½ x 180                           | 69.85 x 4572.0 | 350                     | 1255       | 570.5  |
| 2½ x 192                           | 69.85 x 4876.8 | 350                     | 1320       | 600.0  |
| 2½ x 216                           | 69.85 x 5486.4 | 350                     | 1450       | 659.1  |
| 2½ x 240                           | 69.85 x 6096.0 | 350                     | 1580       | 718.2  |
| 108" 350 ton special for TDS-4/5/6 |                |                         | 920        | 418.2  |
| 3½ x 108                           | 88.9 x 2743.2  | 500                     | 1450       | 659.1  |
| 3½ x 132                           | 88.9 x 3353.0  | 500                     | 1670       | 759.1  |
| 3½ x 144                           | 88.9 x 3688.0  | 500                     | 1780       | 809.1  |
| 3½ x 160                           | 88.9 x 4064.0  | 500                     | 1927       | 875.9  |
| 3½ x 168                           | 88.9 x 4267.2  | 500                     | 2000       | 909.1  |
| 3½ x 180                           | 88.9 x 4572.0  | 500                     | 2110       | 959.1  |
| 3½ x 190                           | 88.9 x 4826.0  | 500                     | 2202       | 1000.9 |
| 3½ x 264                           | 88.9 x 6705.6  | 500                     | 2882       | 1300.0 |
| 4¼ x 144                           | 120.7 x 3688.0 | 750                     | 2312       | 1050.9 |
| 4¼ x 160                           | 120.7 x 4064.0 | 750                     | 3178       | 1444.6 |
| 4¼ x 180                           | 120.7 x 4572.0 | 750                     | 3900       | 1769.0 |
| 4¼ x 216                           | 120.7 x 5486.4 | 750                     | 5200       | 2363.6 |



Weldless Link

- Perfection Link

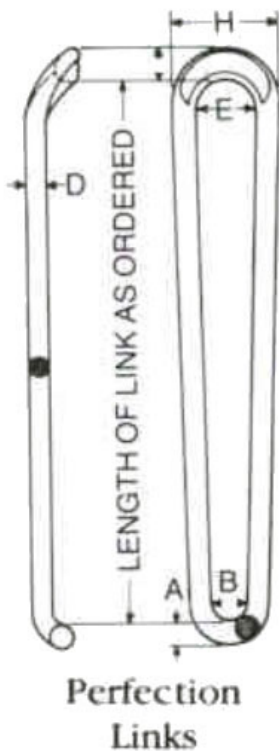
- Dimensional data



**DIMENSIONAL DATA—BJ PERFECTION LINKS**

|     |       |        |     |       |       |     |         |        |
|-----|-------|--------|-----|-------|-------|-----|---------|--------|
| in. | 7/8   | 1 5/8  | ... | 7/8   | 3     | ... | 1 11/64 | 4 3/4  |
| mm  | 22.23 | 41.28  | ... | 22.23 | 76.20 | ... | 29.77   | 120.65 |
| in. | 1 1/4 | 2 1/4  | ... | 1 1/4 | 3 1/2 | ... | 1 9/16  | 6      |
| mm  | 31.75 | 57.15  | ... | 31.75 | 88.90 | ... | 39.69   | 152.40 |
| in. | 1 1/2 | 4      | ... | 1 1/2 | 5     | ... | 1 27/32 | 8      |
| mm  | 38.10 | 101.60 | ... | 38.10 | 127   | ... | 46.83   | 203.20 |
| in. | 1 3/4 | 4      | ... | 1 3/4 | 5     | ... | 2 7/32  | 8 1/2  |
| mm  | 44.45 | 101.60 | ... | 44.45 | 127   | ... | 56.36   | 215.90 |

- Specification



**SPECIFICATIONS - PERFECTION LINKS**

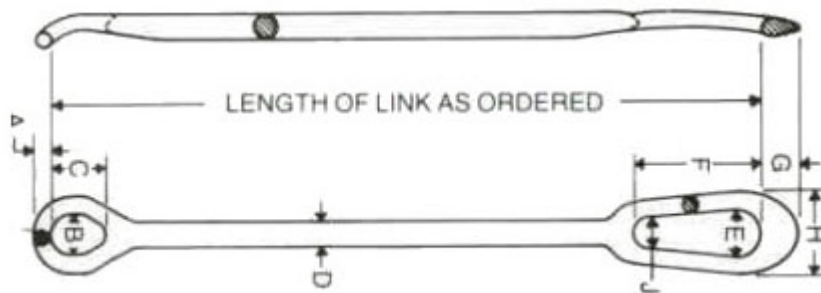
| Size-in. | Size-mm       | Rated Capacity/Set tons | Weight/Set |       |
|----------|---------------|-------------------------|------------|-------|
|          |               |                         | lb         | kg    |
| 2" x 30" | 50.8 x 762.0  | 100                     | 121        | 55.0  |
| 2" x 36" | 50.8 x 914.4  | 100                     | 140        | 63.6  |
| 2" x 42" | 50.8 x 1066.8 | 100                     | 162        | 73.6  |
| 2" x 60" | 50.8 x 1524.0 | 100                     | 222        | 100.9 |

- Tool Pusher Link

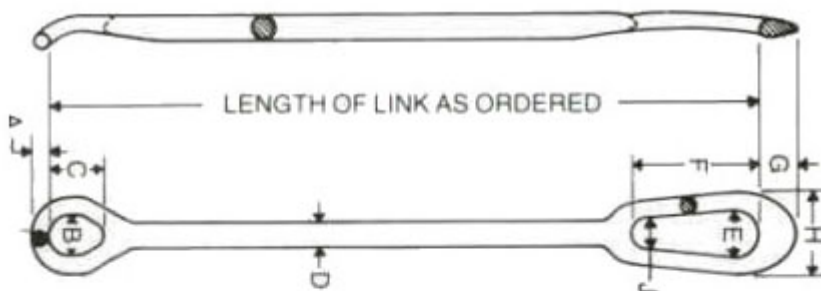
- Dimensional data

**DIMENSIONAL DATA—BJ TOOLPUSHER LINKS**

| Dimensions | A               | B      | C               | D               | E   | F                | G               | H               | J               |
|------------|-----------------|--------|-----------------|-----------------|-----|------------------|-----------------|-----------------|-----------------|
| in.        | 1 $\frac{3}{4}$ | 4      | 5 $\frac{1}{2}$ | 2 $\frac{7}{8}$ | 5   | 13 $\frac{3}{8}$ | 3 $\frac{1}{2}$ | 8 $\frac{1}{2}$ | 3 $\frac{1}{2}$ |
| mm         | 44.45           | 101.60 | 139.70          | 73.03           | 127 | 339.73           | 88.90           | 215.90          | 88.90           |



- Specification



**SPECIFICATIONS - TOOLPUSHER LINKS**

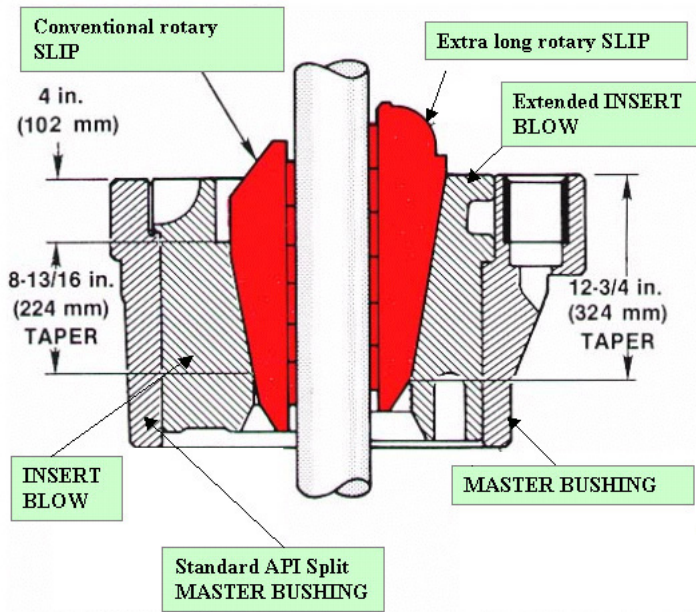
| Size-in.              | Size-mm        | Rated Capacity/Set tons | Weight/Set |       |
|-----------------------|----------------|-------------------------|------------|-------|
|                       |                |                         | lb         | kg    |
| 1 $\frac{3}{4}$ x 36  | 44.45 x 914.4  | 150                     | 125        | 56.7  |
| 1 $\frac{3}{4}$ x 48  | 44.45 x 1219.2 | 150                     | 160        | 72.6  |
| 1 $\frac{3}{4}$ x 60  | 44.45 x 1524.0 | 150                     | 190        | 86.2  |
| 1 $\frac{3}{4}$ x 72  | 44.45 x 1828.8 | 150                     | 230        | 104.3 |
| 1 $\frac{3}{4}$ x 84  | 44.45 x 2133.6 | 150                     | 270        | 122.5 |
| 1 $\frac{3}{4}$ x 96  | 44.45 x 2438.4 | 150                     | 310        | 140.6 |
| 1 $\frac{3}{4}$ x 120 | 44.45 x 3048.0 | 150                     | 390        | 177.3 |

## 29.3 SLIPS

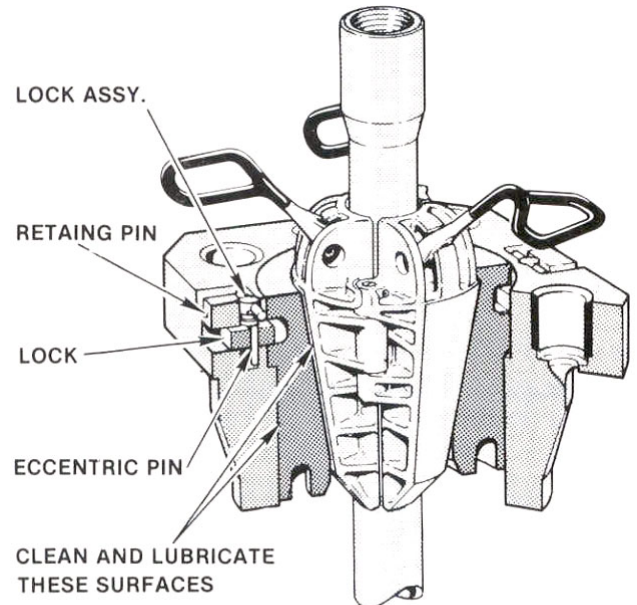
### MANUAL SLIPS

- API 7K standards

Slips are tapered 4 inch per ft on the diameter.



API 7K standards



Rotary Slips in Position

### Manual Slips for Drill Pipe

- Varco models

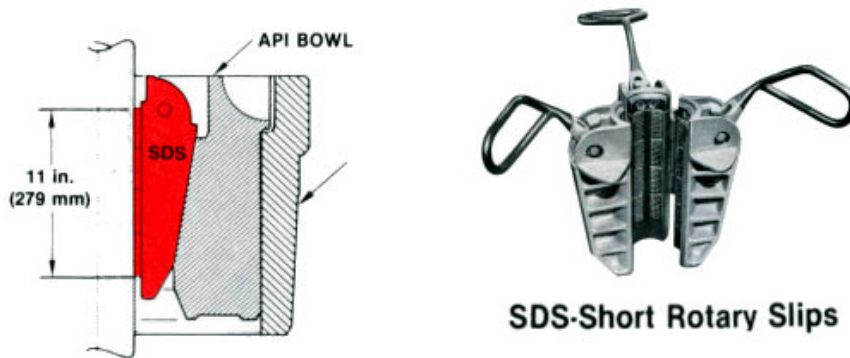
Most common slips are Varco.

Depending on length, Varco has models

- SDS - Short Rotary Slips
- SDML - Medium Rotary Slips
- SDXL - Extra Long Rotary Slips

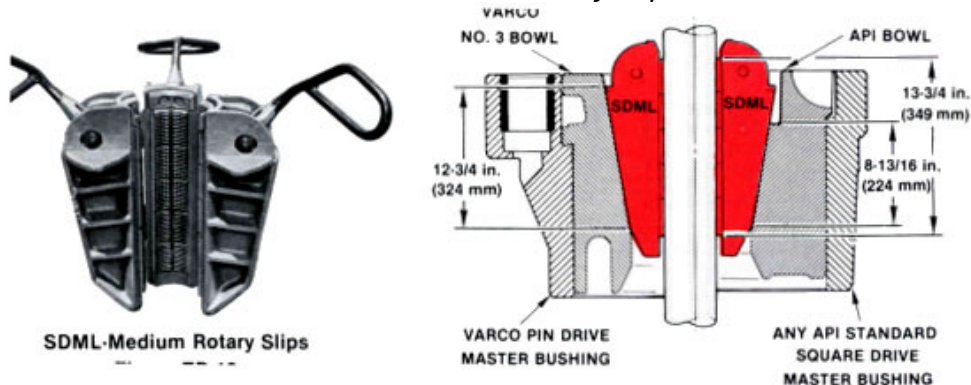


### SDS - Short Rotary Slips



| Slip Body Size (inches)                       | 3-1/2      |            |            | 4-1/2      |            |            |
|-----------------------------------------------|------------|------------|------------|------------|------------|------------|
| API Pipe Size (OD, inches)                    | 2-3/8      | 2-7/8      | 3-1/2      | 3-1/2      | 4          | 4-1/2      |
| Part No.: Slip complete w/inserts .....       | 19325      | 19326      | 19327      | 19329      | 19330      | 19331      |
| Weight: Slip complete w/inserts lb (kg) ..... | 117 (53,1) | 111 (50,3) | 107 (48,5) | 143 (64,9) | 136 (66,7) | 127 (57,6) |
| <b>INSERTS</b>                                |            |            |            |            |            |            |
| Set: Part No. ....                            | 2160-24    | 2161-24    | 2162-24    | 2163-36    | 2164-36    | 2165-36    |
| Weight lb (kg) .....                          | 21 (9,5)   | 16 (7,3)   | 10 (4,5)   | 32 (14,5)  | 25 (11,3)  | 16 (7,3)   |

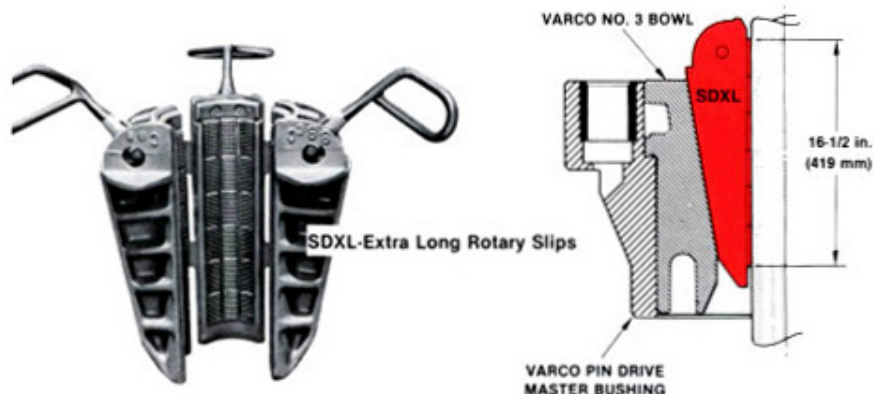
### SDML - Medium Rotary Slips



| Slip Body Size (inches)                       | 3-1/2      |            |            | 4-1/2      |            |            |
|-----------------------------------------------|------------|------------|------------|------------|------------|------------|
| API Pipe Size (OD, inches)                    | 2-3/8      | 2-7/8      | 3-1/2      | 3-1/2      | 4          | 4-1/2      |
| Part No.: Slip complete w/inserts .....       | 15524      | 15523      | 15522      | 15563      | 15564      | 15565      |
| Weight: Slip complete w/inserts lb (kg) ..... | 193 (87,5) | 188 (85,3) | 180 (81,6) | 207 (94)   | 199 (90,3) | 188 (85,3) |
| <b>INSERTS</b>                                |            |            |            |            |            |            |
| Set: Part No. ....                            | 2160-30    | 2161-30    | 2162-30    | 2163-45    | 2164-45    | 2165-45    |
| Weight lb (kg) .....                          | 26 (11,8)  | 21 (9,5)   | 13 (5,9)   | 39 (17,7)  | 31 (14,1)  | 20 (9)     |
| Slip Body Size (inches)                       | 5          |            |            | 5-1/2      |            |            |
| API Pipe Size (OD, inches)                    | 4          | 4-1/2      | 5          | 4-1/2      | 5          | 5-1/2      |
| Part No.: Slip complete w/inserts .....       | 15567      | 15568      | 15569      | 15571      | 15572      | 15573      |
| Weight: Slip complete w/inserts lb (kg) ..... | 204 (92,5) | 196 (88,9) | 185 (84)   | 200 (90,9) | 185 (84)   | 181 (82,1) |
| <b>INSERTS</b>                                |            |            |            |            |            |            |
| Set: Part No. ....                            | 2168-45    | 2166-45    | 2167-45    | 2168-45    | 2169-45    | 2170-45    |
| Weight lb (kg) .....                          | 39 (17,7)  | 31 (14,1)  | 20 (9)     | 39 (17,7)  | 31 (14,1)  | 20 (9)     |



SDXL - Extra Long Rotary Slips



| Slip Body Size (inches)<br>API Pipe Size (OD, inches) | 3-1/2       |           |            | 4-1/2       |             |            |
|-------------------------------------------------------|-------------|-----------|------------|-------------|-------------|------------|
|                                                       | 2-3/4       | 2-7/8     | 3-1/2      | 3-1/2       | 4           | 4-1/2      |
| Part No.: Slip complete w/inserts                     | —           | —         | —          | 15515       | 15514       | 15513      |
| Weight: Slip complete w/inserts lb (kg)               | —           | —         | —          | 229 (103,9) | 219 (99,3)  | 205 (93)   |
| <b>INSERTS</b>                                        |             |           |            |             |             |            |
| Set: Part No. ....                                    | 2160-36     | 2161-36   | 2162-36    | 2163-54     | 2164-54     | 2165-54    |
| Weight lb (kg) .....                                  | 32 (14,5)   | 25 (11,3) | 16 (7,3)   | 47 (21,3)   | 37 (16,8)   | 23 (10,4)  |
| Slip Body Size (inches)<br>API Pipe Size (OD, inches) | 5           |           |            | 5-1/2       |             |            |
|                                                       | 4           | 4-1/2     | 5          | 4-1/2       | 5           | 5-1/2      |
| Part No.: Slip complete w/inserts                     | 15518       | 15517     | 15516      | 15521       | 15520       | 15519      |
| Weight: Slip complete w/inserts lb (kg)               | 237 (107,5) | 227 (103) | 213 (96,6) | 234 (106,1) | 224 (101,5) | 210 (95,3) |
| <b>INSERTS</b>                                        |             |           |            |             |             |            |
| Set: Part No. ....                                    | 2168-54     | 2166-54   | 2167-54    | 2168-54     | 2169-54     | 2170-54    |
| Weight lb (kg) .....                                  | 47 (21,3)   | 37 (16,8) | 23 (10,4)  | 47 (21,3)   | 37 (16,8)   | 23 (10,4)  |

## Manual Slips for Drill Collars

### - DCS - Multi Segment Drill Collar Slips

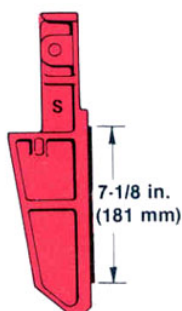
#### DCS - Multi Segment Drill Collar Slips



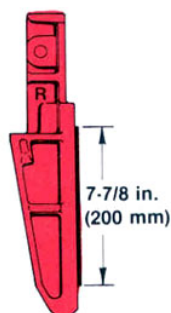
#### DCS - Data Dimensions

| Slips | Slip Size<br>Drill Collar Range<br>(inches) | Circular Buttons |        |      |                |
|-------|---------------------------------------------|------------------|--------|------|----------------|
|       |                                             | Part<br>No.      | Weight |      | Qty<br>Per Set |
|       |                                             |                  | lb     | kg   |                |
| DCS-S | 3 - 4                                       | 2628-49          | 12     | 5,4  | 49             |
|       | 4 - 4                                       | 2620-49          | 6      | 2,7  | 49             |
| DCS-R | 4-1/2 - 6                                   | 2628-63          | 16     | 7,3  | 63             |
|       | 5-1/2 - 7                                   | 2620-63          | 8      | 3,6  | 63             |
| DCS-L | 6-3/4 - 8-1/4                               | 2630-88          | 11     | 5    | 88             |
|       | 8 - 9-1/2                                   | 2630-96          | 12     | 5,4  | 96             |
|       | 8-1/2 - 10                                  | 2627-104         | 26     | 11,8 | 104            |
|       | 9-1/4 - 11-1/4                              | 2630-112         | 14     | 6,3  | 112            |
|       | 11 - 12-3/4                                 | 2625-136         | 36     | 16,3 | 136            |
|       | 12 - 14                                     | 2630-136         | 17     | 7,7  | 136            |

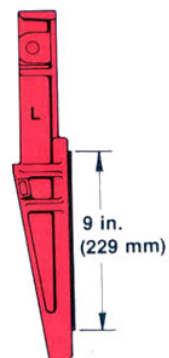
### - DCS - Drill Collar Slips Grip Length



**DCS-S  
RANGE  
3 - 4-7/8**



**DCS-R  
RANGE  
4-1/2 - 7**



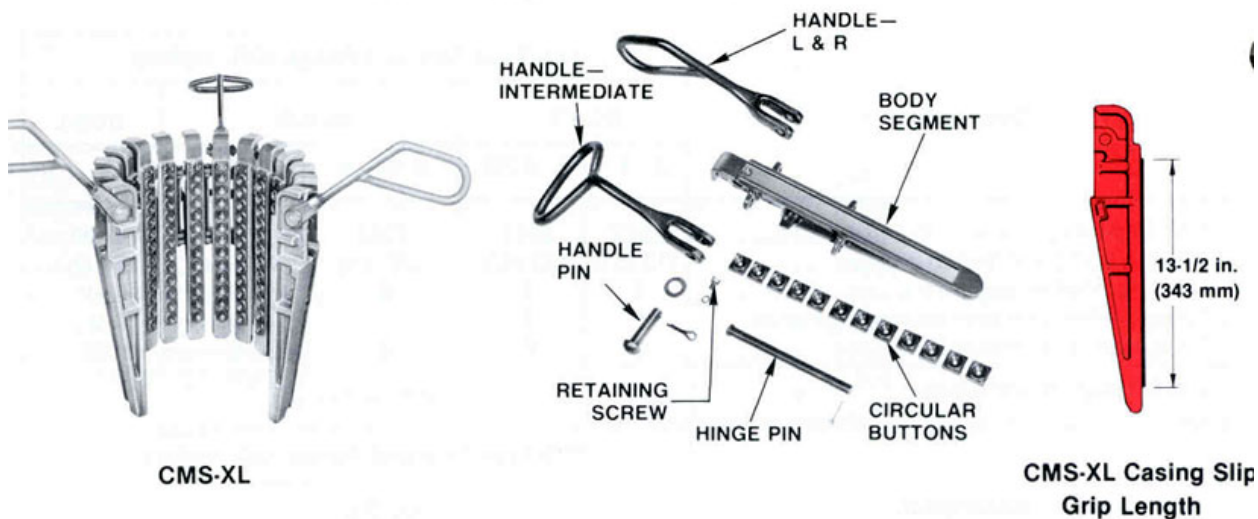
**DCS-L  
RANGE  
5-1/2 - 14**

#### DCS-Drill Collar Slip Grip Lengths

## Manual Slips For Casing

- CMS-XL

### CASING SLIPS



CMS-XL Casing Slips Grip Length

| Description                                    | Casing Size (OD, inches) |            |            |            |            |            |             |
|------------------------------------------------|--------------------------|------------|------------|------------|------------|------------|-------------|
|                                                | 6-5/8                    | 7          | 7-5/8      | 8-5/8      | 9-5/8*     | 10-3/4*    | 11-3/4*     |
| Part No. Slip complete w/Circular Buttons..... | 5315                     | 5301       | 5303       | 5305       | 5307       | 5309       | 5311        |
| Weight, complete w/Circular Buttons, lb(kg)... | 196 (88,9)               | 184 (83,5) | 166 (75,3) | 181 (82,1) | 192 (87,1) | 209 (94,8) | 260 (117,9) |
| Total number of Segments.....                  | 12                       | 12         | 12         | 13         | 14         | 15         | 17          |
| Total number of Intermediate Segments.....     | 10                       | 10         | 10         | 11         | 12         | 13         | 15          |
| Total number of Hinge Pins.....                | 11                       | 11         | 11         | 12         | 13         | 14         | 16          |

| Description                                    | Casing Size (OD, inches) |             |             |             |             |             |             |
|------------------------------------------------|--------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                                | 13-3/8*                  | 16*         | 18-5/8*     | 20*         | 24*         | 26*         | 30*         |
| Part No. Slip complete w/Circular Buttons..... | 5313                     | 5325        | 5333        | 5329        | 5331        | 5346        | 5342        |
| Weight, complete w/Circular Buttons, lb(kg)... | 247 (112)                | 308 (139,7) | 367 (166,5) | 383 (173,7) | 443 (200,9) | 486 (220,4) | 546 (247,7) |
| Total number of Segments.....                  | 18                       | 21          | 25          | 26          | 30          | 33          | 37          |
| Total number of Intermediate Segments.....     | 16                       | 19          | 23          | 24          | 28          | 31          | 35          |
| Total number of Hinge Pins.....                | 17                       | 20          | 24          | 25          | 29          | 32          | 36          |

## Manual Slips for Conductor Pipe

- CP-S Conductor Pipe Slip



CP-S Conductor Pipe Slip  
Figure TD-20

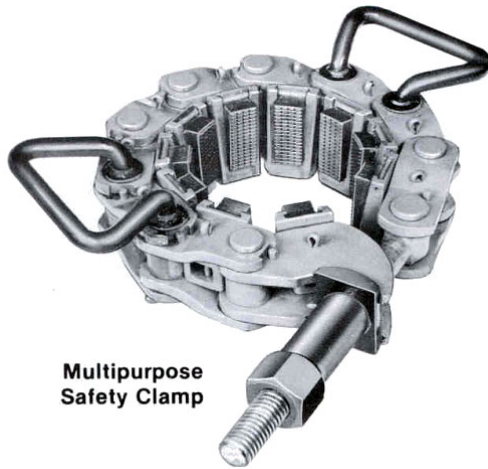
Table TD-41 CP-S Ordering Information

| Description                                            | Pipe Size (OD, inches) |           |           |
|--------------------------------------------------------|------------------------|-----------|-----------|
|                                                        | 24                     | 26        | 30        |
| Part No. — Slip complete<br>w/Circular Buttons.....    | 5338                   | 5344      | 5340      |
| Weight Complete with<br>Circular Buttons lbs (kg)..... | 276 (125)              | 296 (134) | 319 (145) |
| Total No. Segments.....                                | 13                     | 14        | 16        |
| Total No. Hinge Spacer.....                            | 12                     | 13        | 15        |

All CP-S Slips are furnished with 4 handles. All parts except Hinge Spacer Block, P/N 11944 are interchangeable with CMS-XL Slips.

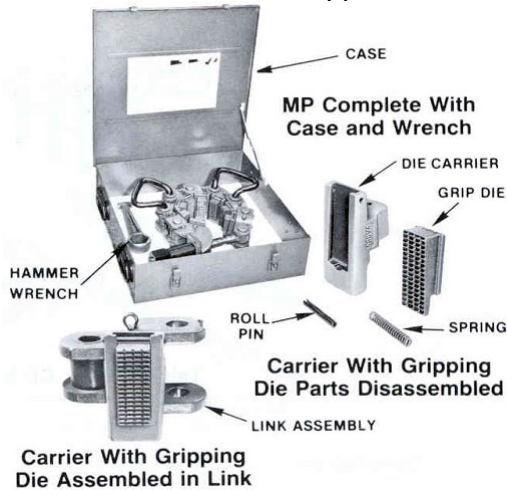
## Safety Clamp

Safety Clamp



Multipurpose  
Safety Clamp

Carrier with Grippin



Safety Clamp Data

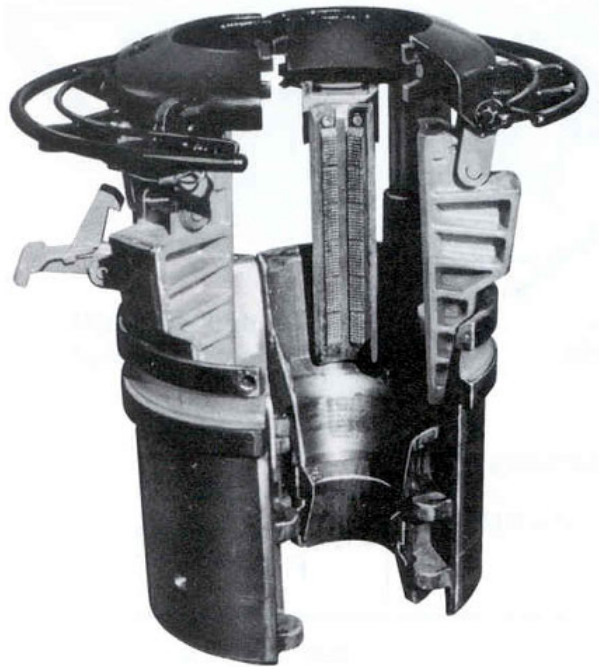
| Range (inches)                                                                                                                                               | Quantity                                     |                                              | Weight                                               |                                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|----------------------------------------------|------------------------------------------------------|----------------------------------------------------------------|
|                                                                                                                                                              | Links                                        | Gripping Dies                                | lb                                                   | kg                                                             |
| <b>MP-S</b><br>2-7/8 — 4-1/8<br>4 — 5                                                                                                                        | 7<br>8                                       | 8<br>9                                       | 83<br>91                                             | 37,6<br>41,3                                                   |
| <b>MP-R</b><br>4-1/2 — 5-5/8<br>5-1/2 — 7<br>6-3/4 — 8-1/2<br>8 — 9-1/4<br>9-1/4 — 10-1/2                                                                    | 7<br>8<br>9<br>10<br>11                      | 8<br>9<br>10<br>11<br>12                     | 81<br>89<br>97<br>105<br>113                         | 36,7<br>40,4<br>44<br>47,6<br>51,3                             |
| <b>MP-M</b><br>10-1/2 — 11-1/2<br>11-1/2 — 12-1/2<br>12-1/2 — 13-5/8<br>13-5/8 — 14-3/4<br>14-3/4 — 15-7/8                                                   | 12<br>13<br>14<br>15<br>16                   | 13<br>14<br>15<br>16<br>17                   | 121<br>129<br>137<br>145<br>153                      | 54,9<br>58,5<br>62,1<br>65,8<br>69,4                           |
| <b>MP-L</b><br>15-7/8 — 17<br>17 — 18-1/8<br>18-1/8 — 19-3/8                                                                                                 | 17<br>18<br>19                               | 18<br>19<br>20                               | 173<br>181<br>189                                    | 78,5<br>82,1<br>85,7                                           |
| <b>MP-XL</b><br>19-3/8 — 20-3/8<br>20-3/8 — 21-1/2<br>21-1/2 — 22-5/8<br>22-5/8 — 23-3/4<br>23-3/4 — 24-7/8<br>24-7/8 — 26<br>26 — 27-1/8<br>29-3/8 — 30-1/2 | 19<br>20<br>21<br>22<br>23<br>24<br>25<br>28 | 20<br>21<br>22<br>23<br>24<br>25<br>26<br>29 | 196<br>204<br>212<br>220<br>228<br>236<br>244<br>336 | 88,9<br>92,5<br>96,2<br>99,8<br>103,4<br>107<br>110,7<br>152,4 |



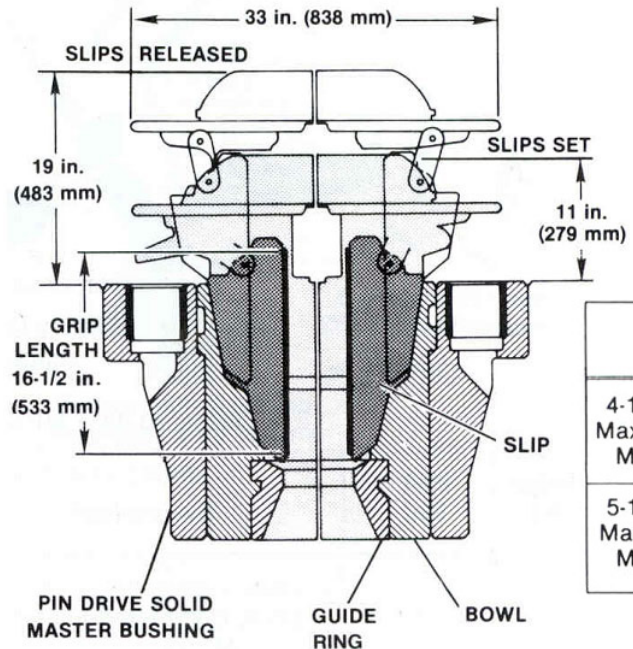
## AUTOMATIC POWER SLIPS

### - Automatic slips mechanically released

#### - PS-15 Spring Slip Assembly



#### - Size and Nomenclature

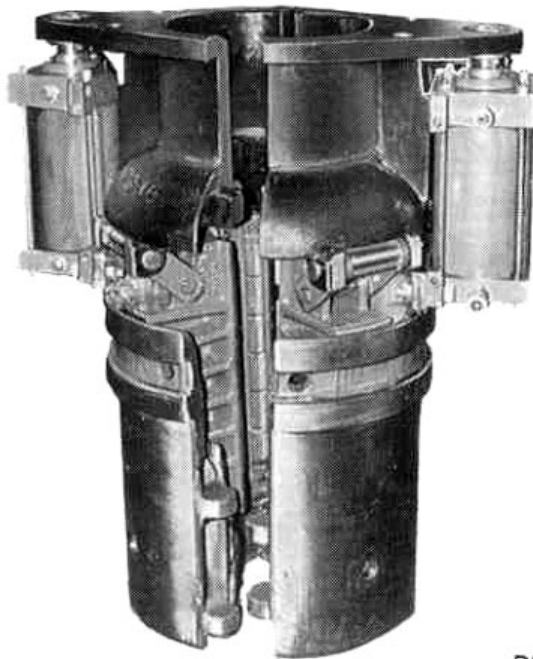


### - Remote controlled Automatic slips

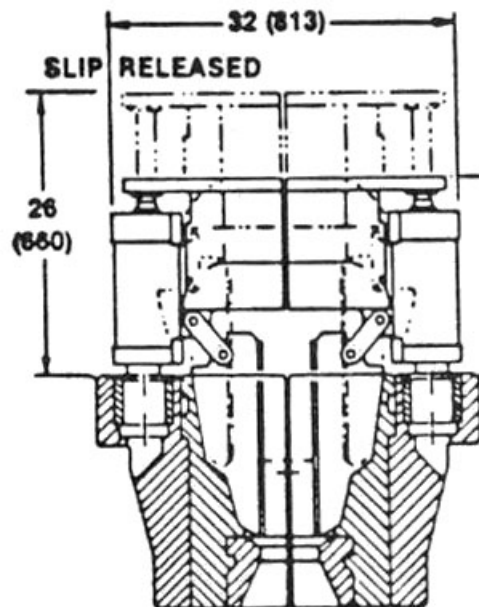
#### - PS-16 Power Slip

#### VARCO

#### - PS-16 Size

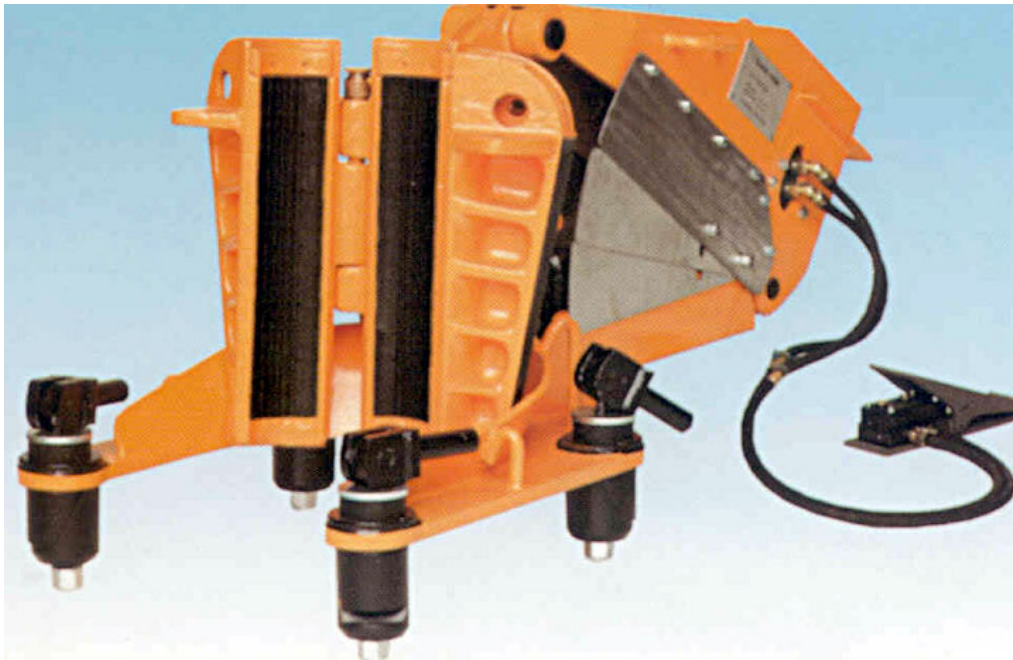


PS-16



**Blohm & Voss**

*PS-150 Air-operated Power Slip*



**29.4 ELEVATORS**

- ELEVATORS for DP - DC Manual
- ELEVATORS for DP - DC Remoted controlled
- ELEVATORS for Casing
- SINGLE JOINT ELEVATORS

**- ELEVATORS for DP - DC Manual**

- Manual Elevators

Lower Image



Upper Image





## VARCO BJ Center Latch for 18 Tool Joint

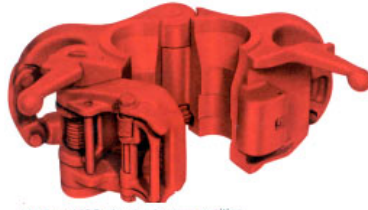
- Varco G series Elevator

Varco BJ Type GG Elevator



BJ Type GG elevator

Varco BJ Type MGG Elevator



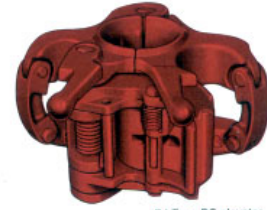
BJ Type MGG elevator in open position.

Varco BJ Type MG Elevator



BJ Type MG elevator

Varco BJ Type RG Elevator



BJ Type RG elevator

## RATED CAPACITIES—G SERIES ELEVATORS

| Size (O.D.)                                    |            | GG   |        | MGG  |       | RG   |        | MG   |       |
|------------------------------------------------|------------|------|--------|------|-------|------|--------|------|-------|
| in.                                            | mm         | tons | tonne  | tons | tonne | tons | tonne  | tons | tonne |
| 2 <sup>3</sup> / <sub>8</sub> .....            | 60.33      | ...  | ...    | ...  | ...   | 150  | 136.08 | 100  | 90.72 |
| 2 <sup>7</sup> / <sub>8</sub> .....            | 73.03      | ...  | ...    | ...  | ...   | 150  | 136.08 | 100  | 90.72 |
| 3 <sup>1</sup> / <sub>2</sub> (FH & IF) .....  | 88.9       | ...  | ...    | 250  | 226.8 | 150  | 136.08 | 100  | 90.72 |
| 4 .....                                        | 101.6      | 350  | 317.52 | 250  | 226.8 | 175  | 158.76 | 100  | 90.72 |
| 4 <sup>1</sup> / <sub>2</sub> (Reg. & FH) .... | 114.3      | 350  | 317.52 | 250  | 226.8 | 175  | 158.76 | 100  | 90.72 |
| 5, 4 <sup>1</sup> / <sub>2</sub> (IF) .....    | 127, 114.3 | 350  | 317.52 | 250  | 226.8 | 200  | 181.44 | 100  | 90.72 |
| 5 <sup>1</sup> / <sub>2</sub> .....            | 139.70     | 350  | 317.52 | 250  | 226.8 | 200  | 181.44 | ...  | ...   |

2

## - VARCO BJ Side Door for 18 Tool Joint

### SPECIFICATIONS

### BJ TYPE "SLB" AND "SLBB" SIDE DOOR ELEVATORS

For Drill Pipe with 18° Shouldered Tool Joints

| SIZE (O.D.)                                     | "SLB"                               | "SLBB"    |
|-------------------------------------------------|-------------------------------------|-----------|
| 2 <sup>3</sup> / <sub>8</sub> .....             | 2 <sup>3</sup> / <sub>8</sub> ..... | .....     |
| 2 <sup>7</sup> / <sub>8</sub> .....             | 2 <sup>7</sup> / <sub>8</sub> ..... | .....     |
| 3 <sup>1</sup> / <sub>2</sub> .....             | 3 <sup>1</sup> / <sub>2</sub> ..... | .....     |
| 4" .....                                        | 4" .....                            | 500       |
| 4 <sup>1</sup> / <sub>2</sub> (Reg. & FH) ..... | 4 <sup>1</sup> / <sub>2</sub> ..... | 350 & 500 |
| 5", 4 <sup>1</sup> / <sub>2</sub> (IF) .....    | .....                               | 350 & 500 |
| 5 <sup>1</sup> / <sub>2</sub> .....             | .....                               | 500       |

### ELEVATOR COMPLETE

| API Size                                                                         | Frame No. | Min. & Max. Size Weldless Links                                   | Weight Lbs.—Oz. | Rated Cap. Tons |
|----------------------------------------------------------------------------------|-----------|-------------------------------------------------------------------|-----------------|-----------------|
| 4 <sup>1</sup> / <sub>2</sub> ", 5" .....                                        | 30931—*   | 2 <sup>1</sup> / <sub>4</sub> " x 3 <sup>1</sup> / <sub>2</sub> " | 718—0           | 350             |
| 4" 4 <sup>1</sup> / <sub>2</sub> ", 5", 5 <sup>1</sup> / <sub>2</sub> (IF) ..... | 32227—*   | 3 <sup>1</sup> / <sub>2</sub> " x 4 <sup>3</sup> / <sub>4</sub> " | 1342—0          | 500             |
| 2 <sup>3</sup> / <sub>8</sub> ", 3 <sup>1</sup> / <sub>2</sub> " .....           | 36950—*   | 1 <sup>3</sup> / <sub>4</sub> " x 3 <sup>1</sup> / <sub>2</sub> " | 450             | 150             |
| 4" 4 <sup>1</sup> / <sub>2</sub> " .....                                         | 36997—*   | 2 <sup>1</sup> / <sub>4</sub> " x 3 <sup>1</sup> / <sub>2</sub> " | 680             | 250             |

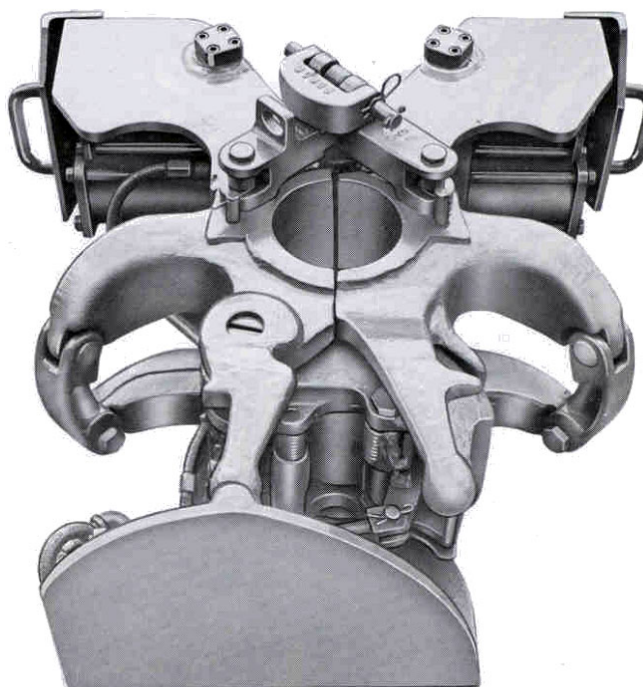
**- ELEVATORS for DP - DC Remoted controlled**

**- VARCO BJ Air Operated**

Air Operated BJ center latch elevators are recommended for use with BJ power pipe handling system.

These elevators will close and latch automatically on contact with drill pipe or collar which is to be raised or lowered.

The elevators are opened by remote control, by the driller.



Air-powered elevator latches on contact with pipe and opens by remote control.

**- BLOHM VOSS Air Operated**



| Type       | Capacity<br>short/tons | P/N    | 18 Degree Drill Pipe | Drill Collars<br>Range | Power<br>required |
|------------|------------------------|--------|----------------------|------------------------|-------------------|
| ACL-250    | 250                    | 612565 | 3.1/2" - 5 .1/2"     |                        | 6 bar min.        |
| ACL-350    | 350                    | 613565 | 3 .1/2" - 6. 5/8"    |                        |                   |
| ACL-500    | 500                    | 615100 | 4" - 6. 5/8"         |                        |                   |
| ACLS-150/2 | 150                    | 621456 |                      | 4" - 6.1/4"            | 6 bar min.        |
| ACLS-150/3 | 150                    | 621446 |                      | 6.1/4" - 8"            |                   |
| ACLS-150/4 | 150                    | 621400 |                      | 8" - 9.5/8"            |                   |

## - ELEVATORS for DP & DC (with variable size bushings)

### - BLOHM VOSS Air Operated

These elevators have replaceable bushings to fit different sizes of pipe.

They can be operated manually or by remote control.

*BLOHM VOSS Air Operated: Pipe Sizes range*



| VES-CL 150<br>Load Rating 150 Tons | VES-CL 250<br>Load Rating 250 Tons | VES-CL 350<br>Load Rating 350 Tons | VES-CL 500<br>Load Rating 500 Tons |
|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| Pipe Size Range                    | Pipe Size Range                    | Pipe Size Range                    | Pipe Size Range                    |
| Drill Pipe: 2 7/8"–5"              | Drill Pipe: 2 7/8"–5"              | Drill Pipe: 2 7/8"–6 5/8"          | Drill Pipe: 2 7/8"–6 5/8"          |
| Drill Collars: 3 1/2"–5 1/4"       | Drill Collars: 3 1/2"–5 1/4"       | Drill Collars: 3 1/2"–6 3/4"       | Drill Collars: 3 1/2"–6 3/4"       |
| Casing: 3 1/2"–5"                  | Casing: 3 1/2"–5"                  | Casing: 3 1/2"–7"                  | Casing: 3 1/2"–7"                  |
| Tubing: 2 3/8"–4 1/2"              | Tubing: 2 3/8"–4 1/2"              | Tubing: 2 3/8"–5 1/2"              | Tubing: N/A                        |

## - ELEVATORS for DC

### - DC lifting subs

Most contractors have decided, for safety reasons, not to use elevators for drill collars with upsets. Due to drilling wear, the elevator contact area on the collar is decreased and can become very dangerous.

Instead, contractors prefer to use DC lifting subs.

They add to trip time, but significantly increase safety.

### - DC lift Drill Collar Handling System

Tripping time are reduced because it's not necessary to change out the elevator.



DC lifting subs



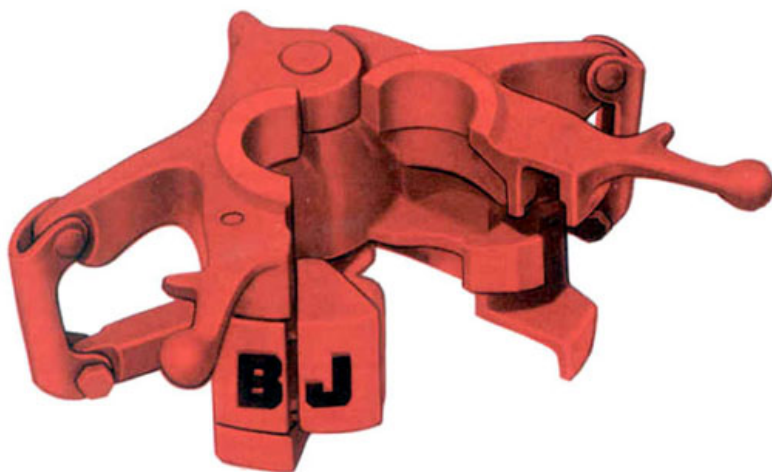
Lifting Sub  
for 18" taper  
elevator type

DC lift Drill Collar Handling System



D-C Lift system employs (top to bottom) special adapter for drill pipe elevator, links, and collar type elevator for handling drill collars. Regular elevator latches around adapter when pulling drill collars from hole.

- Varco BJ Type SLA-100



BJ Type, SLA-100 elevator in open position.  
Available in A.P.I. sizes from 5½"-8⅝" O.D.

Size, Type and Capacity

COLLAR TYPE CENTER LATCH ELEVATORS

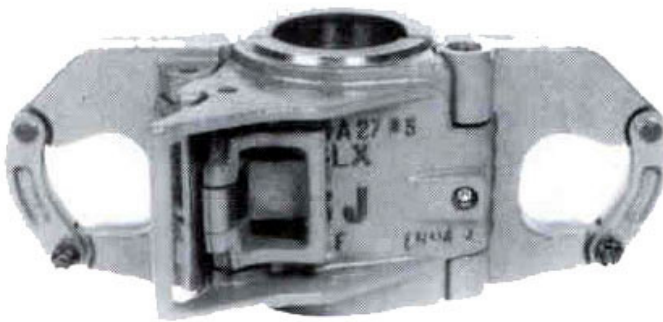
| SIZE<br>inches | TYPE  | CAP. |
|----------------|-------|------|
| 3½ - 4½        | TA    | 65T  |
| 2¾ - 2⅞        | TA    | 100T |
| 3½ - 5         | TA    | 100T |
| 4½ - 8⅝        | TA    | 150T |
| 4½ - 8⅝        | TA AO | 150T |
| 8½ - 11¼       | TA    | 150T |
| 8½ - 11¼       | TA AO | 150T |
| 2¾ - 3½        | RA    | 125T |
| 4 - 4½         | RA    | 175T |
| 4½ - 5½        | RA    | 175T |
| 6⅝ - 7         | RA    | 175T |
| 2¾ - 3½        | MAA   | 175T |
| 4 - 4½         | MAA   | 225T |
| 4½ - 7         | MAA   | 250T |
| 3½             | AA    | 250T |
| 4 - 4½         | AA    | 275T |
| 4½ - 7         | AA    | 300T |

## - ELEVATORS for Casing

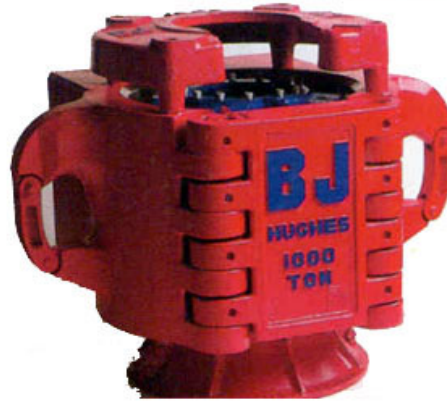
Special elevators are used for running casing.  
The most common manufactures are Varco and BJ.

Two main types:

- Side Door Type
- Slip Type



**Side Door Elevator**

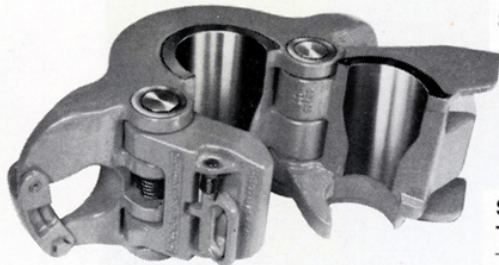


**Slip Type Elevator**

## - Side Door Elevators

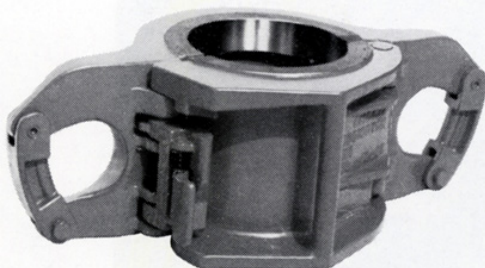
These are used for light weights or for the first joints of csg.

### SD-Type Elevator



**SD-Side Door Elevator, 18-Degree Type**

| Type   | P/N     | r.c.     | Size O.D.  |
|--------|---------|----------|------------|
| SD-350 | 633 500 | 350 tons | 4" - 51/2" |



**SDS-Type Elevator**

**SDS-Side Door Elevator, 90-Degree Type**

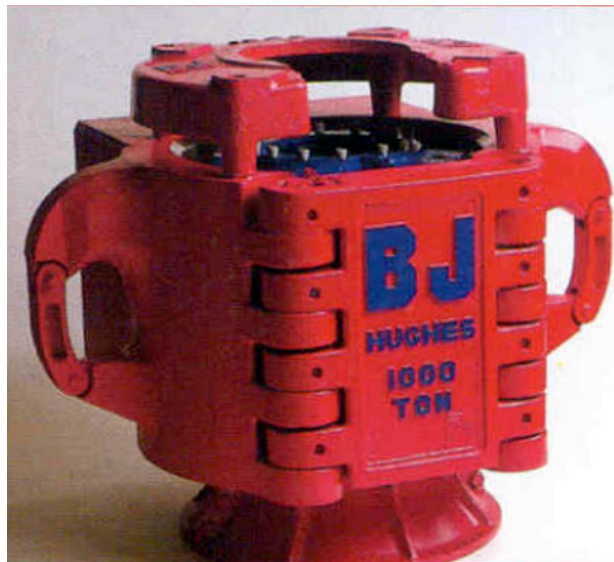
| Type      | P/N     | r.c.     | Size O.D.             |
|-----------|---------|----------|-----------------------|
| SDS- 65/1 | 640 600 | 65 tons  | 1,660" - 2.7/8"       |
| SDS-100/1 | 641 020 | 100 tons | 2.3/8" - 4.1/8"       |
| SDS-100/2 | 641 000 | 100 tons | 4" - 6.3/4"           |
| SDS-100/3 | 641 040 | 100 tons | 6.3/4" - 9.5/8"       |
| SDS-150/1 | 641 500 | 150 tons | 4" - 6.3/4"           |
| SDS-150/2 | 641 520 | 150 tons | 6.3/4" - 9.5/8"       |
| SDS-150/3 | 641 540 | 150 tons | 10" - 12.3/4"         |
| SDS-150/4 | 641 560 | 150 tons | 13" - 16"             |
| SDS-150/5 | 641 580 | 150 tons | 16.3/4" - 21.1/2"     |
| SDS-150/7 | 641 620 | 150 tons | 24" - 30"             |
| SDS-250/0 | 642 600 | 250 tons | 6.1/2" - 9.5/8"       |
| SDS-250/1 | 642 500 | 250 tons | 9.5/8" - 13.3/8"      |
| SDS-250/2 | 642 520 | 250 tons | 13.17/32" - 18.25/32" |
| SDS-250/3 | 642 540 | 250 tons | 18.5/8" - 21.1/2"     |
| SDS-250/5 | 642 580 | 250 tons | 24" - 30"             |
| SDS-350/1 | 643 500 | 350 tons | 6.5/8" - 9.5/8"       |
| SDS-350/2 | 643 520 | 350 tons | 10.3/4" - 16.3/4"     |
| SDS-350/4 | 643 560 | 350 tons | 18.5/8" - 21.1/2"     |
| SDS-350/5 | 643 580 | 350 tons | 24" - 30"             |

### **Slip Type**

- Slip type Elevators
- Ton Elevator / Spider Varco Type

#### **- Slip type Elevators**

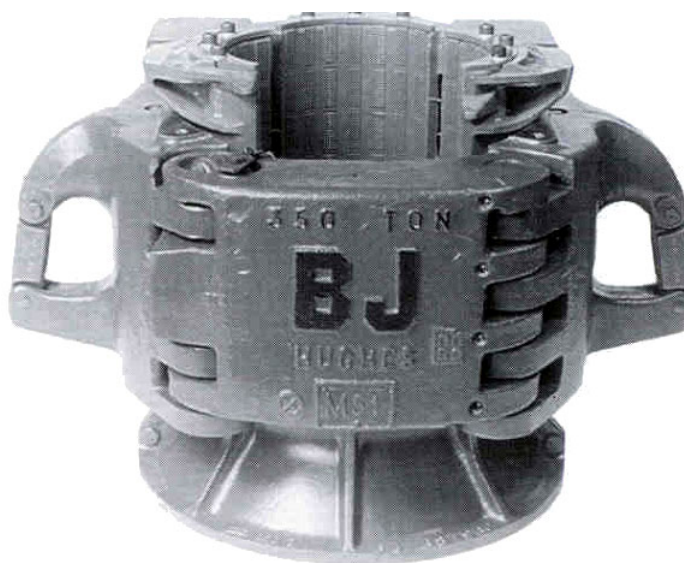
Operated manually or by remote control, these can be used as elevators or clamps.



#### **- Ton Elevator / Spider Varco Type**

Size range from 2 3/8" up to 24" for 200 ton to 1000 ton

- 350 Ton Elevator / Spider BJ Type
- Size 4 1/2" to 13 3/8"
- 500 Ton Elevator / Spider BJ Type
- Size 4 1/4" to 14"
- Size 16" to 24 1/2"
- 750 Ton Elevator / Spider BJ Type
- Size 6 5/8" to 14"
- 1000 Ton Elevator / Spider BJ Type
- Size 7 5/8" to 14"

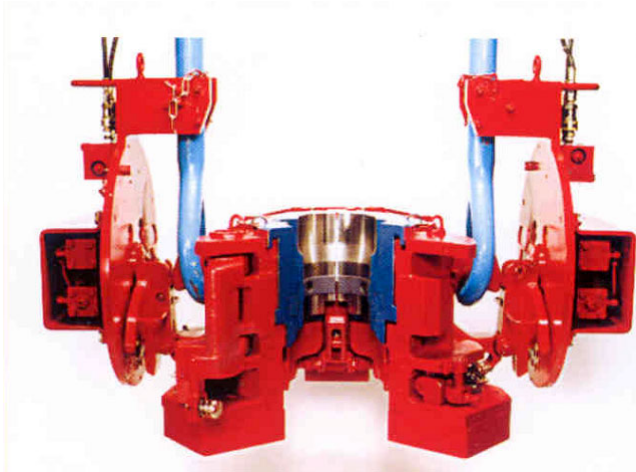


*350 Ton Elevator/Spider BJ Type*



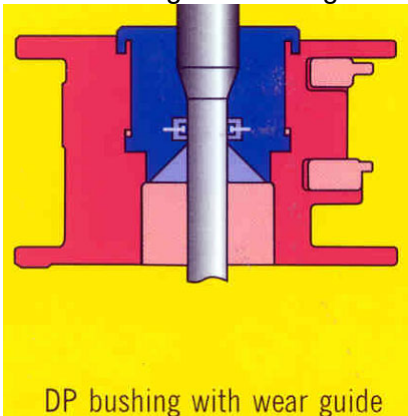
- ELEVATORS for DP-DC-CASING & TUBING

- VARCO BX



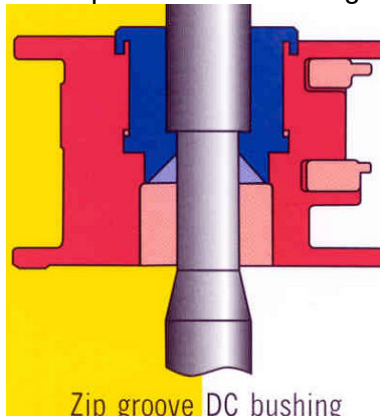
|                 | Frame 2*       | Frame 3        | Frame 4-50<br>Frame 4-75** |
|-----------------|----------------|----------------|----------------------------|
| Load rating     | 350 Tons       | 150 Tons       | 150 Tons                   |
|                 |                | Drill Collar   | Drill Collar               |
|                 |                | 250 Tons       | 350 Tons                   |
|                 |                | Csg >14"       | Casing                     |
|                 |                | 350 Tons       | 500 Tons                   |
|                 |                | Csg ≤ 14"      | Drill Pipe                 |
| Pipe size range |                |                |                            |
| Drill pipe      | N/A            | N/A            | 3 1/2"-6 5/8"              |
| Drill collars   | 9 1/2"-11 1/4" | 9 3/4"-11 1/4" | 4 3/4"-9 3/4"              |
| Tubing          | N/A            | N/A            | N/A                        |
| Casing          | 9 5/8"-14"     | 9 5/8"-20"     | 4 1/2"-9 5/8"              |

DP Bushing with wear guide



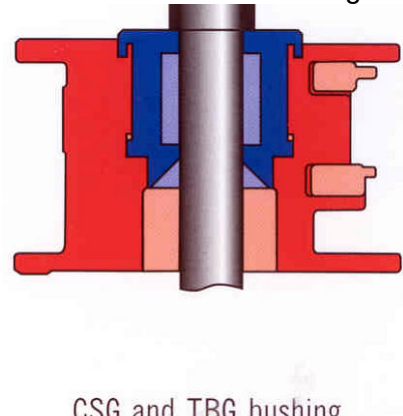
DP bushing with wear guide

Zip Groove DC Bushing



Zip groove DC bushing

CSG and TBG Bushing



CSG and TBG bushing



## - SINGLE JOINT ELEVATORS

*Blohm + Voss Type SJS*

### **Blohm+Voss TYPE SJS**

#### **SINGLE JOINT CENTER LATCH ELEVATOR COLLAR-TYPE**



SJS-4/1 tons  
SJS-4/2 tons  
SJS-5/3 tons  
SJS-5/4 tons

SJS-5/5 tons  
SJS-6/6 tons  
SJS-6/8 tons

- Data

| SIZE   |    | TYPE     | FRAME NR. | CAP. | WEIGHT |    |
|--------|----|----------|-----------|------|--------|----|
| inches | mm | VARCO BJ |           |      | lb-oz  | kg |

#### AUXILIARY ELEVATORS S-SERIES

|                 |         |        |       |  |     |     |
|-----------------|---------|--------|-------|--|-----|-----|
| 2 3/8 - 3 1/2   | 60-89   | SJ     | 33010 |  |     |     |
| 4 - 5 1/2       | 102-140 | SJ     | 33039 |  | 51  | 23  |
| 6 - 7 7/8       | 152-194 | SJ     | 33040 |  | 69  | 31  |
| 8 3/8 - 10 1/4  | 219-273 | SJ     | 33041 |  | 98  | 44  |
| 11 3/4 - 13 3/8 | 298-340 | SJ     | 33042 |  | 130 | 59  |
| 16 - 20         | 406-508 | SJ     | 33043 |  | 213 | 97  |
| 21 1/2 - 24 1/2 | 546-622 | SJ     | 33044 |  | 283 | 128 |
| 2 7/8 - 5 1/2   | 73-140  | SP 5°  | 36171 |  | 56  | 22  |
| 6 3/8 - 7 7/8   | 168-194 | SP 5°  | 36385 |  | 69  | 31  |
| 8 3/8 - 9 3/8   | 219-244 | SP 5°  | 36173 |  | 82  | 37  |
| 10 3/4          | 273     | SP 5°  | 36174 |  | 80  | 36  |
| 3 1/2 - 5       | 89-127  | SP 18° | 36172 |  | 56  | 22  |
| 6 3/8           | 168     | SP 18° | 70252 |  | 70  | 32  |
| 2 3/8 - 4 1/2   | 60-114  | SP 12° | 53615 |  |     |     |

## 29.5 TONGS

DP and DC make-up occurs in two stages:

- Spin the two tool joints together (spinning)
- Torque connection to tighten it (Make-up torque)

Viceversa for Break-down operations.

For DP and DC make up torque values are indicated in API RG 7G.

Two tongs are used and positioned on the 2 tool joints. The top one for the torque and the bottom one as back up tong.

## SPINNING WRENCHES

- Spinning chain

Spinning was historically done with the spinning chain; but this was dangerous and the safety of all on the drill floor depended on the skill and experience of the man throwing the chain.

- Spinning wrench

The automatic spinning wrench is now replacing the spinning chain in many drilling rigs.

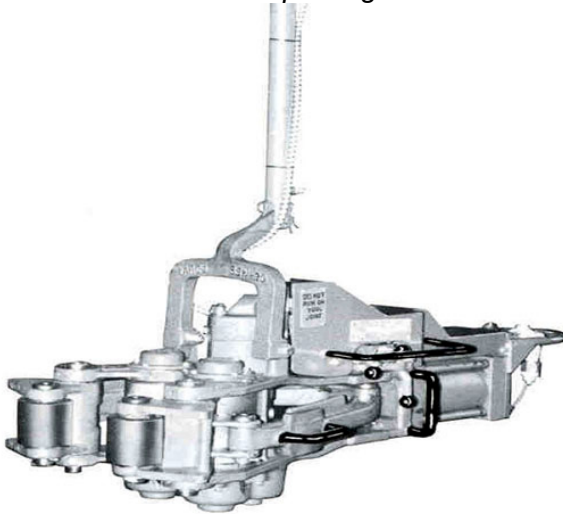
Spinning chain



Weatherford Drill Pipe Spinner



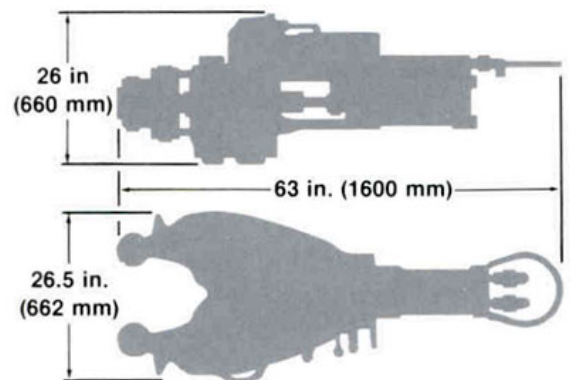
VARCO SSW30 Spinning wrench



VARCO SSW30 – Specifications

### Specifications

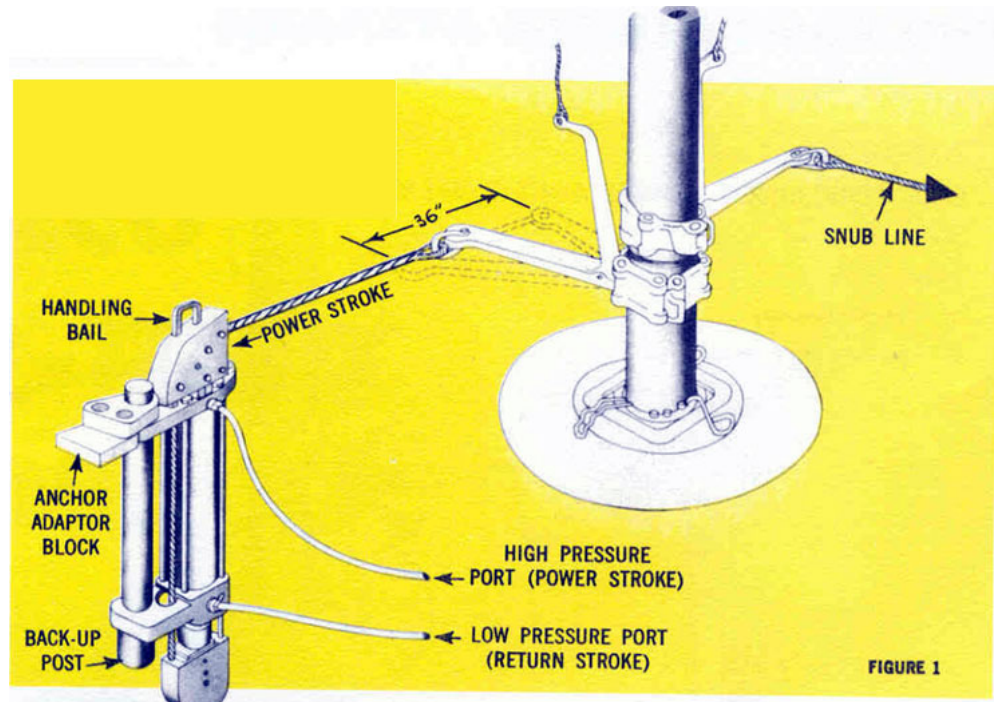
Size Range.....2-7/8 - 9-1/2 inch (73-241 mm) OD  
 Normal Operating Pressure.....2000 psi (138 atm)  
 Torque (5-inch dia pipe).....900 to 1000 ft-lbs  
 (1215-1350 N·m)  
 Speed (5-inch dia pipe).....100 rpm  
 Weight.....850 lbs (385 kg)  
 Hyd Power Reqmt.....29 to 45 GPM (110-170 l/min)



## TONGS for DP - DC & CASING Manual

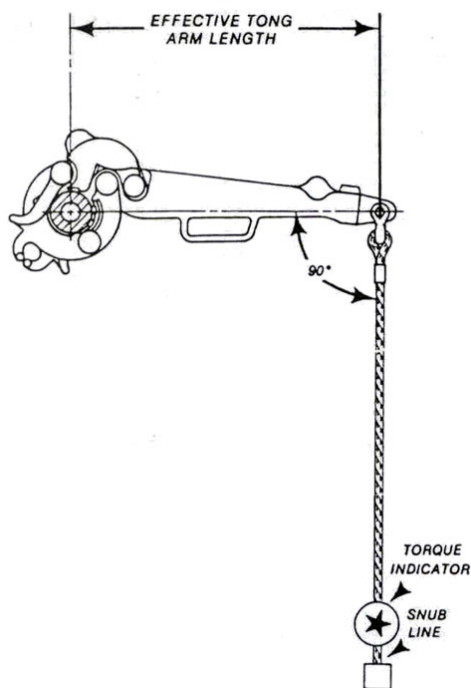
- Operational  
Two tongs are used and positioned on the 2 tool joints. The top one for the torque and the bottom one as back up tong.

Torque is applied by pulling the top tong with the cathead. For high torques a hydraulic piston is used for pulling (Ezy Torque).

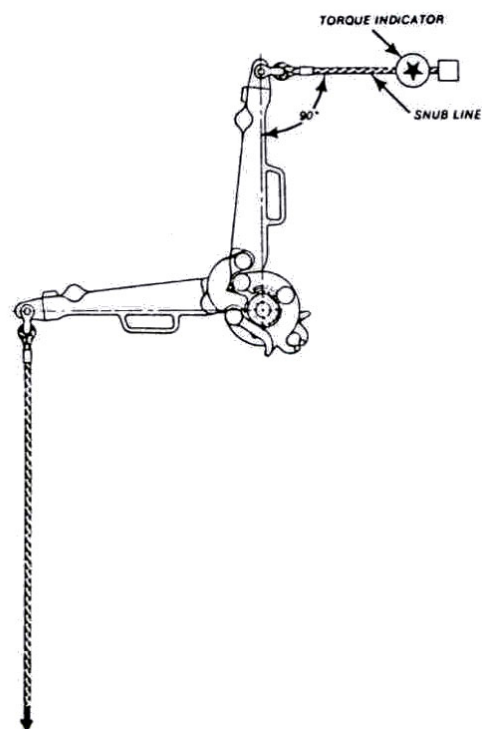


Ezy Torque Drilco

- Torque applied  
Torque applied is the result of the pull multiplied by the tong arm length.



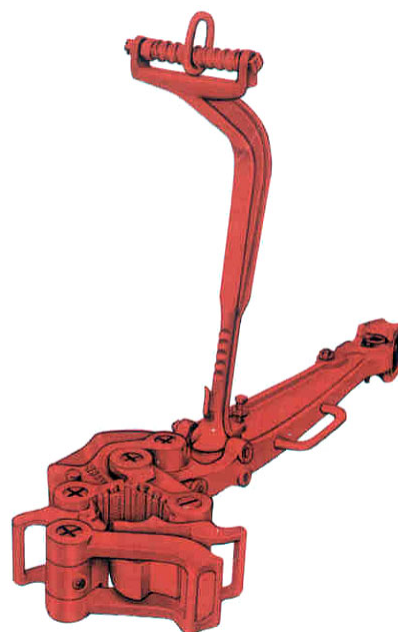
- Torque Indicator  
The pull should be applied as perpendicular as possible to the arm to avoid false values.



## VARCO BJ Tongs - Manual

These are the most common

- BJ Type SXD-200 Tong
- BJ Type SDD Tong
- BJ Type DB Tong
- BJ Type B Tong
- BJ Extended Type "B" Casing Tong Head
- BJ Type C Tong



VARCO BJ Tongs - Manual

### VARCO BJ Type SXD-200 Torque Ratings

#### MANUAL TONG TORQUE RATINGS

| Type &<br>Part No. | Part No.<br>Lug Jaws | Size Lug Jaw                                                   |               | Torque  |         |
|--------------------|----------------------|----------------------------------------------------------------|---------------|---------|---------|
|                    |                      | in.                                                            | mm            | ft-lb   | N·m     |
| SXD                | 33516-1              | 8 – 9 <sup>5</sup> / <sub>8</sub>                              | 203.20–244.48 | 200.000 | 271,200 |
| 33511              | 33517-5              | 9 – 11 <sup>1</sup> / <sub>8</sub>                             | 228.6–282.58  | 200.000 | 271,200 |
|                    | 33518-5              | 11– 12 <sup>1</sup> / <sub>2</sub>                             | 279.40–317.50 | 200.000 | 271,200 |
|                    | 33516-1              | 11 <sup>1</sup> / <sub>2</sub> –13 <sup>1</sup> / <sub>4</sub> | 292.10–336.55 | 200.000 | 271,200 |
|                    | 33517-5              | 13–14 <sup>3</sup> / <sub>4</sub>                              | 330.20–374.65 | 200.000 | 271,200 |
|                    | 33518-5              | 14 <sup>3</sup> / <sub>8</sub> –16                             | 365.12–406.40 | 200.000 | 271.200 |
|                    |                      |                                                                |               |         |         |

#### - Ezy Torque

The EZY-TORQUE is used for high make up torques (DC > 9.1/2 OD) when the cathead is not enough.



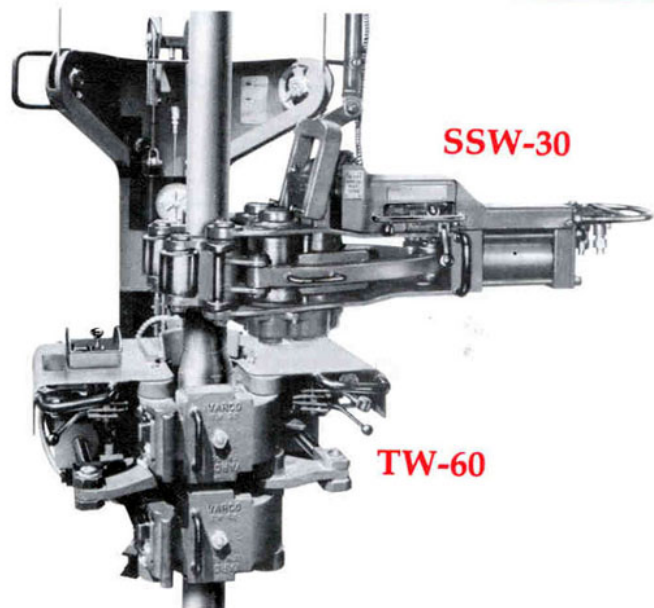
## TONGS for DP - DC & CASING Automatic

### - DP torque Wrench

Making up and breaking out made simple.

The hydraulically powered TW-60 makes up and breaks out drill pipe tool joints and drill collars from 4 to 8 inch OD.

Torque is adjustable and can be pre-set to the required value



*Example of DP Combined Spinning & Torque Wrench*

## SPINNING & TORQUE Combination Wrench

- Tongs for DP - DC Automatic
- Tongs for CSG Automatic

### - Tongs for DP - DC Automatic



VARCO - Example of IRON-ROUGHNECK

## IRON-ROUGHNECK

### SPECIFICATIONS

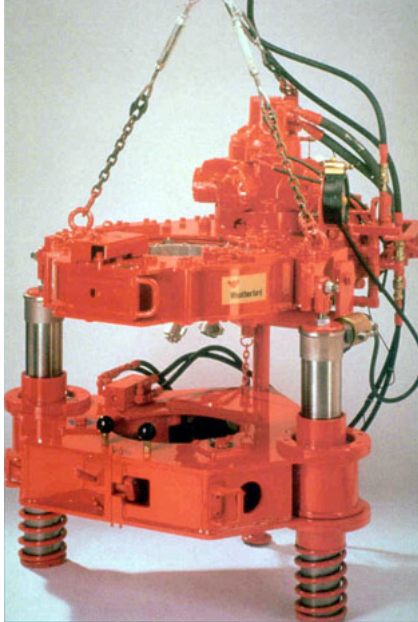
|                                            |                                                                     |
|--------------------------------------------|---------------------------------------------------------------------|
| <b>Weight (Typical)</b> .....              | 12,100 lb. (5 676 kg)                                               |
| <b>Four-Roller Spinning Wrench SSW-50*</b> |                                                                     |
| Tubular Size Range, O.D.** .....           | 3-1/2 in. (89 mm) drill pipe to<br>9-3/4 in. (248 mm) drill collars |
| Spin Torque .....                          | 2,000 ft.-lbs (2 712 N•M)<br>5 in. (127 mm) in. pipe                |
| <b>Gateless Torque Wrench TW-102</b>       |                                                                     |
| Tubular Size Range O.D. ....               | 3-1/2 in. (89 mm) drill pipe to<br>9-3/4 in. (248 mm) drill collars |
| Make-up Torque .....                       | 100,000 ft.lbs. (135 580 N•M)                                       |
| Break-out Torque.....                      | 120,000 ft.lbs. (162 696 N•M)                                       |
| Tilt Angle for Mousehole Make-up .....     | ± 3 to 7°                                                           |

AR 3200 Automated Iron Roughneck

## Tongs for CSG Automatic

- Spinning & DP torque Wrench combination

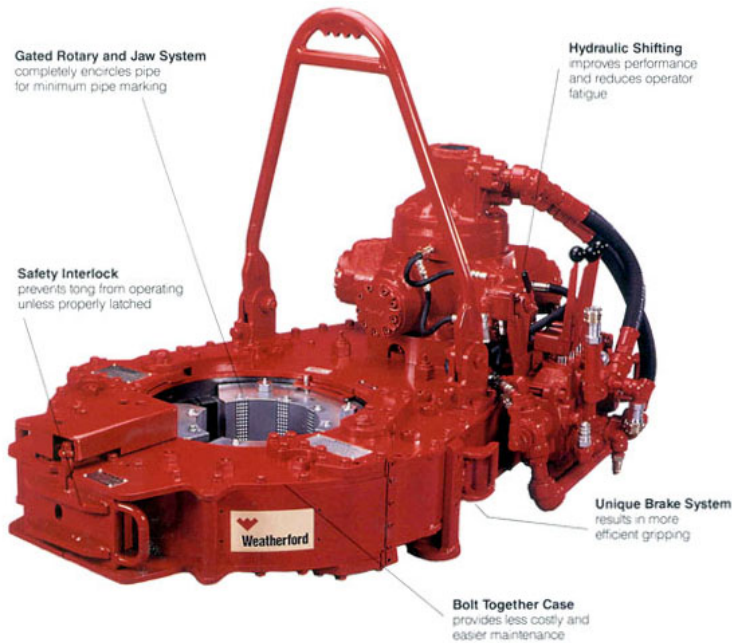
### Examples of POWER TONGS



**Hydraulic Power Tong Selection Chart**

| Model | Size Ranges  | Torque        |
|-------|--------------|---------------|
| 14-50 | 6 5/8" – 14" | 50,000 ft-lbs |
| 16-18 | 2 3/8" – 16" | 18,000 ft-lbs |
| 16-25 | 2 3/8" – 16" | 25,000 ft-lbs |
| 24-50 | 5 1/2" – 24" | 50,000 ft-lbs |

*Model 14.5-50 High Torque Casing Tong*



*TorkWinder 10-145 Weatherford*



## 29.6 PIPE RACK

The pipe rack is the place where tubulars are stored and positioned before lifting them up the rig floor.

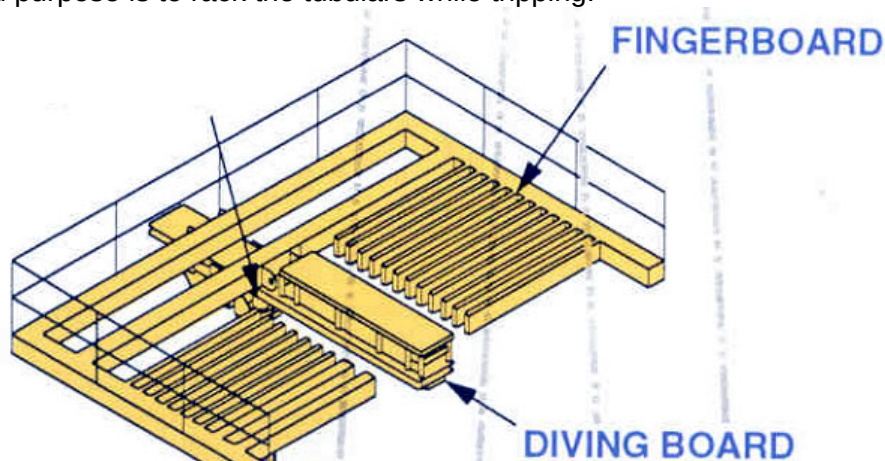
In the photo shows Casings already equipped with centralizers already to be run in the well.



*Pipe rack: Casings*

## 29.7 FINGERBOARD

The Fingerboard purpose is to rack the tubulars while tripping.

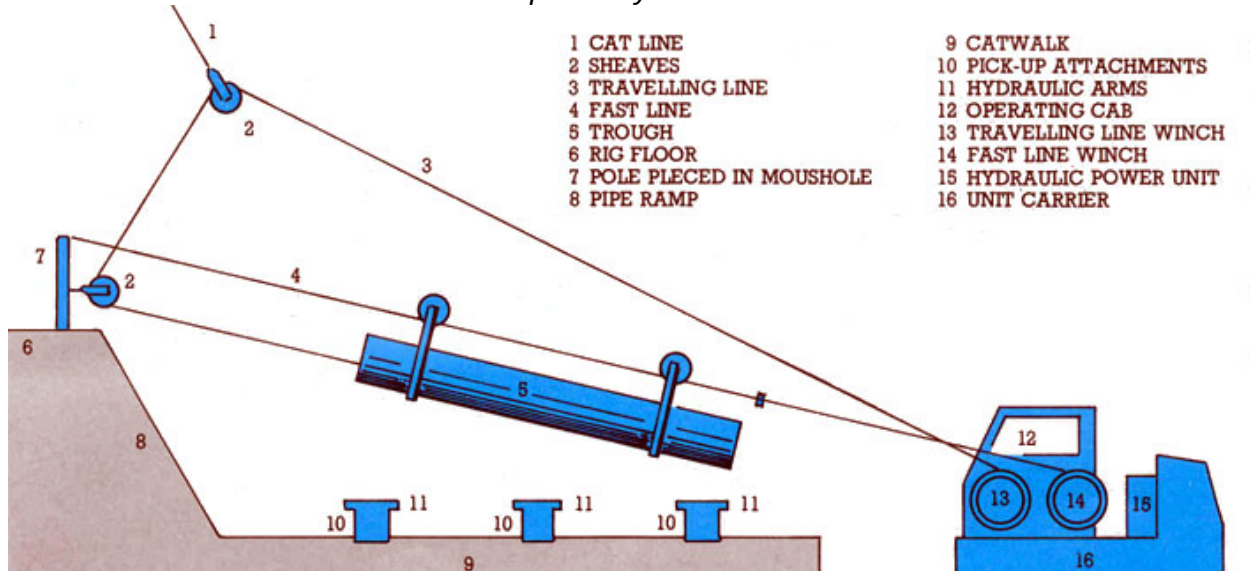




## 29.8 PICK UP & LAY DOWN MACHINE

The pick up and lay down machine was designed to move tubulars without damaging them and move heavy.

*Pick up and lay down machine*



## 29.9 CSG STABBING BOARD

Casing Stabbing Board is a personnel mobile platform used for csg operations. Its installed in the derrick.

It can be moved up and down to enable the operator to guide the Csg joint from top side. Its equipped with several antifall devices.





### 30. DIVERTER

#### INDEX

- 30.1 FUNCTION
- 30.2 TYPICAL CONFIGURATION
- 30.3 TYPES AND CHARACTERISTICS
- 30.4 INSPECTIONS

#### 30.1 FUNCTION

##### - Description

The Diverter is installed on the conductor pipe before drilling of first phase of the well and is designed to keep personnel and Rig safe.

It consist of an annular type blow out preventer and is designed to divert shallow gas away from the well area while drilling surface hole.

In doing so, the well remains open but diverting the pressure avoids fracturing a formation.

##### - Manufacture specifications

Diverter system are manufactured according to API 16A and RP 64.

The relevant ISO standard is the 13533 Spec.

ENI requirements are defined by "Well control policy" and an internal specification.

#### 30.2 TYPICAL CONFIGURATION

##### - Off-shore application (API RP 64)

Schematic arrangement for an off-shore application, as per API RP 64 recommendations.

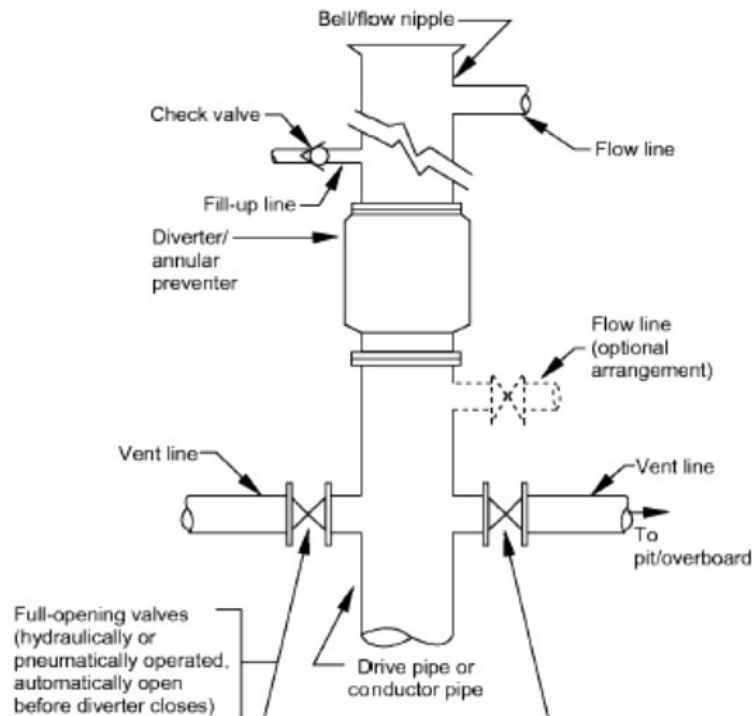
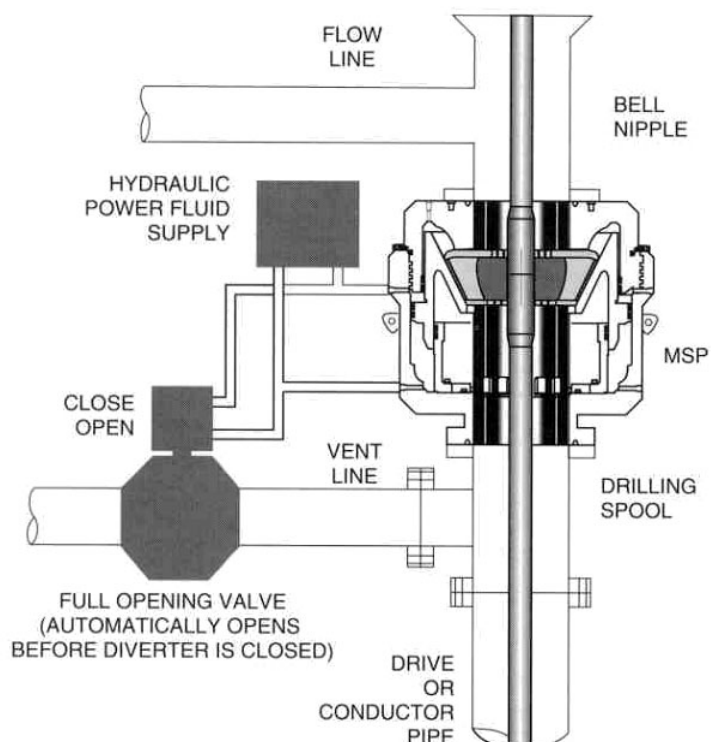


Figure 6.3—Example Diverter System—Control Sequenced Flow System

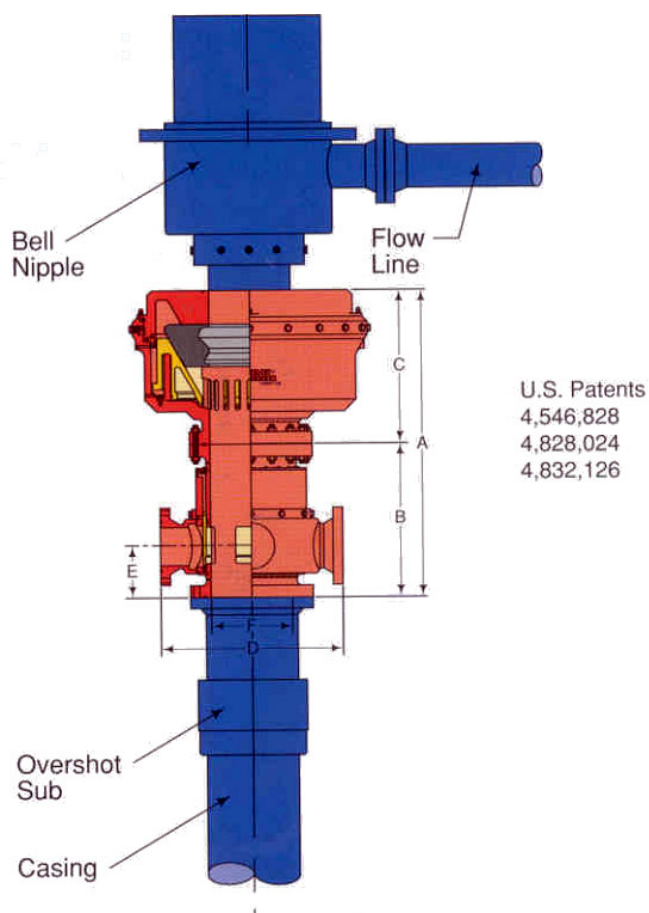
- Hydril's suggested configurations

Examples of Hydril's suggested configurations.



- Hydril example with SXV spool arrangement

This integral type spool with diverter has the advantage of remote controls, eliminating the use of lateral valves.



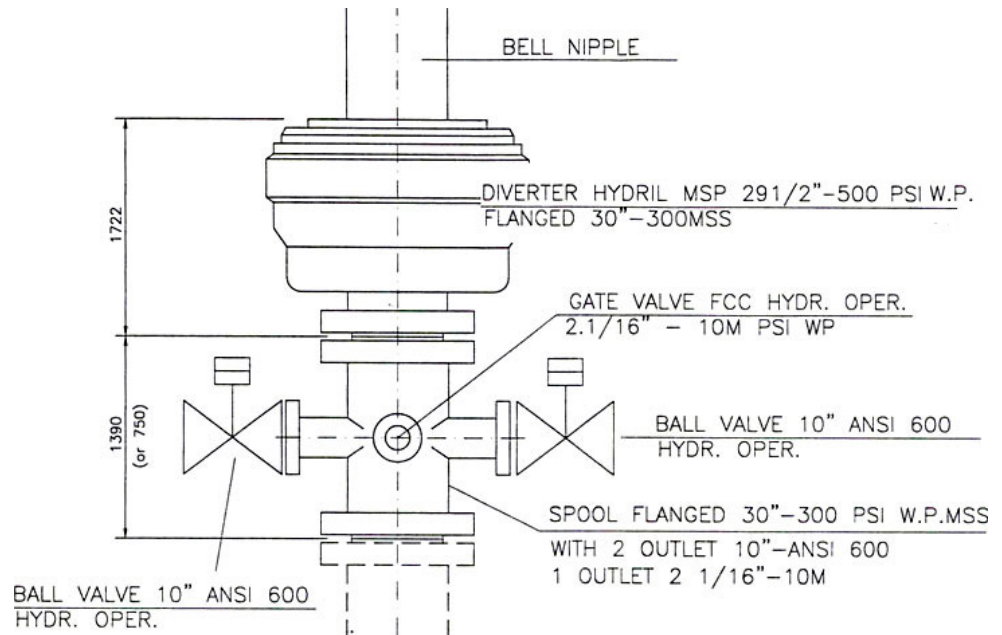
## - SXV MSP Engineering Data

**SXV/MSP Engineering Data**

| BORE SIZE (INCHES)           | 21.25 (IN.)                             |               | 29.50 (IN.)                   |               | 30.00 (IN.)                   |               |
|------------------------------|-----------------------------------------|---------------|-------------------------------|---------------|-------------------------------|---------------|
| WORKING PRESSURE (PSI)       | 2,000                                   |               | 500                           |               | 1,000                         |               |
| SYSTEM OF MEASURE            | U.S.                                    | METRIC        | U.S.                          | METRIC        | U.S.                          | METRIC        |
| CLOSING PRESSURE             | 1,500-3,000 PSI                         | 103-207 BARS  | 1,500-3,000 PSI               | 103-207 BARS  | 1,500-3,000 PSI               | 103-207 BARS  |
| PACKING UNIT OPERATING RANGE | 21.25 (IN.) TO CSO                      | 540 MM TO CSO | 29.50 (IN.) TO CSO            | 749 MM TO CSO | 30.00 (IN.) TO CSO            | 762 MM TO CSO |
| SXV CLOSING CHAMBER VOLUME*  | 4.0 GALLONS                             | 15.1 LITERS   | 5.5 GALLONS                   | 20.8 LITERS   | 5.5 GALLONS                   | 20.8 LITERS   |
| SXV OPENING CHAMBER VOLUME*  | 1.0 GALLON                              | 3.8 LITERS    | 1.0 GALLON                    | 3.8 LITERS    | 1.0 GALLON                    | 3.8 LITERS    |
| MSP CLOSING CHAMBER VOLUME*  | 31.05 GALLONS                           | 118 LITERS    | 60.00 GALLONS                 | 227 LITERS    | 87.6 GALLONS                  | 332 LITERS    |
| MSP OPENING CHAMBER VOLUME*  | 18.93 GALLONS                           | 72 LITERS     | —                             | —             | 27.8 GALLONS                  | 105 LITERS    |
| SXV WEIGHT                   | 4,000 LBS                               | 1814 KG       | 7,000 LBS                     | 3175 KG       | 7,000 LBS.                    | 3175 KG       |
| MSP WEIGHT                   | 16,320 LBS                              | 7403 KG       | 24,500 LBS                    | 11113 KG      | 32,500 LBS                    | 14742 KG      |
| VENT OUTLET SIZE (NOMINAL)   | 12-16 (IN.)                             | —             | 12-16 (IN.)                   | —             | 12-16 (IN.)                   | —             |
| SXV TOP CONNECTION           | 21.25 (IN.) - 2,000 6B API RX-73 FLANGE | —             | 30.00 (IN.) - 600 MSS FLANGE  | —             | 30.00 (IN.) - 600 MSS FLANGE  | —             |
| SXV BOTTOM CONNECTION        | 21.25 (IN.) - 2,000 6B API RX-73 FLANGE | —             | 30.00 (IN.) - 600 MSS FLANGE  | —             | 30.00 (IN.) - 600 MSS FLANGE  | —             |
| MSP TOP CONNECTION           | 21.25 (IN.) - 2,000 STUDDER             | —             | 30.00 (IN.) - 600 MSS STUDDER | —             | 30.00 (IN.) - 600 MSS STUDDER | —             |
| MSP BOTTOM CONNECTION        | 21.25 (IN.) - 2,000 6B API RX-73 FLANGE | —             | 30.00 (IN.) - 600 MSS FLANGE  | —             | 30.00 (IN.) - 600 MSS FLANGE  | —             |
| A SXV/MSP STACKUP HEIGHT*    | 112.00 (IN.)                            | 2845 MM       | 120.81 (IN.)                  | 3069 MM       | 111.12 (IN.)                  | 2823 MM       |
| B SXV HEIGHT*                | 59.50 (IN.)                             | 1511 MM       | 53.00 (IN.)                   | 1346 MM       | 53.00 (IN.)                   | 1346 MM       |
| C MSP HEIGHT                 | 52.50 (IN.)                             | 1334 MM       | 67.8125 (IN.)                 | 1722 MM       | 58.125 (IN.)                  | 1476 MM       |
| D OUTLET FLANGE/FLANGE       | 42.50 (IN.)                             | 1080 MM       | 56.00 (IN.)                   | 1422 MM       | 56.00 (IN.)                   | 1422 MM       |
| E OUTLET CL TO SXV BOTTOM*   | 18.60 (IN.)                             | 472 MM        | 19.3 (IN.)                    | 490 MM        | 19.3 (IN.)                    | 490 MM        |



-Typical configuration  
on Saipem's Rigs  
Typical configuration  
on Saipem's medium  
and high power Rigs



### - Diverter Installations

- Diverter with spool for land rig



- Diverter with spool installed on land rig



- Diverter valve





### 30.3 TYPES AND CHARACTERISTICS

#### - Hydril MSP

The 29 " Diverter is the most commonly used.

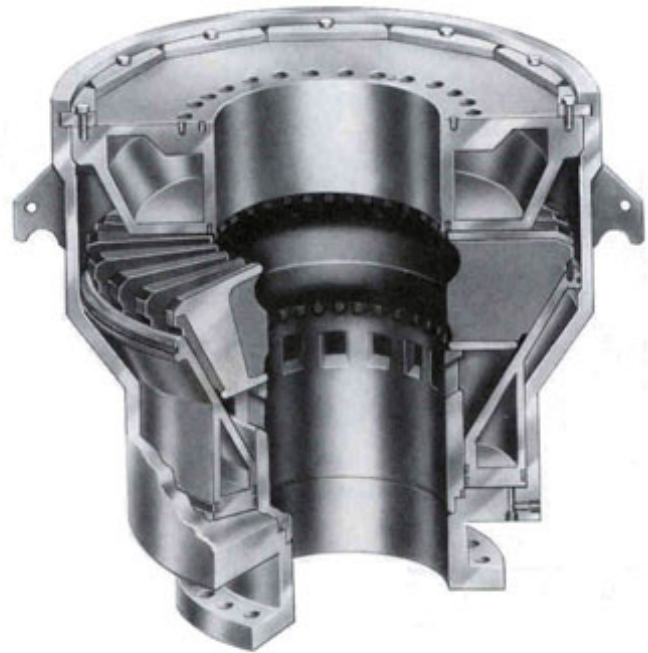
It allows the running of 27 " bit.

For fast moving type Rigs, uses the 20" annular BOP

The MSP 29-1/2"-500 requires only closing pressure.

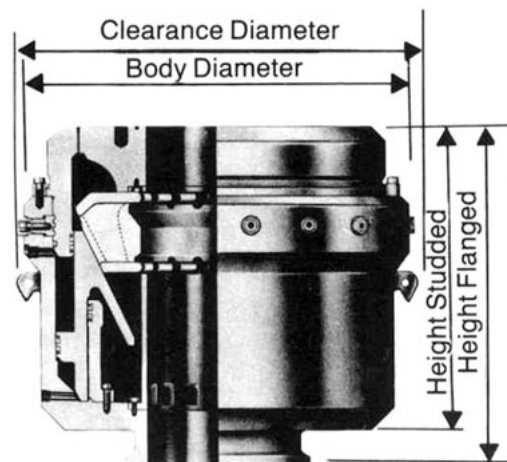
Seal off is effected by hydraulic pressure applied to the closing chamber which raises the piston, moving the packing unit radially inward into a sealing engagement.

Any normal closing unit having a separate regulator valve for the annular BOP and sufficient accumulator volume can be used to operate the MSP.



**Hydril MSP 29-1/2-500 psi**

#### - Diverter Data



- Table Data

|                                                                     |                |         |              |          |
|---------------------------------------------------------------------|----------------|---------|--------------|----------|
| BORE SIZE (inches)                                                  |                | 21-1/4  | HL<br>21-1/4 | 29-1/2   |
| WORKING PRESSURE (psi)                                              |                | 2000    | 2000         | 500      |
| HEAD TYPE                                                           |                | LATCHED | SCREWED      | LOCKRING |
| OLD NOMINAL SIZE                                                    |                | 20"     | 20"          | 29-1/2"  |
| SHELL TEST PRESSURE Factory Only                                    |                | 3000    | 3000         | 800      |
| OPERATING CHAMBER TEST PRESSURE Factory Only                        |                | 3000    | 3000         | 2275     |
| • OPERATING<br>CHAMBER<br>VOLUME (Gal.)<br>(For Full Piston Stroke) | CLOSING        | 31.05   | 31.75        | 60       |
|                                                                     | OPENING        | 18.93   | 19.25        | –        |
| FULL PISTON STROKE (inches)                                         |                | 11-1/4  | 11-1/2       | 13-9/16  |
| BODY DIAMETER (inches)                                              |                | 56-5/8  | 52-1/2       | 75       |
| CLEARANCE DIAMETER (inches)                                         |                | 58-3/4  | 61-1/4       | 82.5     |
| **HEIGHT (inches)                                                   | FLANGED BOTTOM | ▲       | 48           | –        |
|                                                                     | STUDDED BOTTOM | 46      | –            | –        |
|                                                                     | CIW HUB BOTTOM | ▲       | 48           | –        |
| **WEIGHT (lbs.)<br>approximate                                      | FLANGED BOTTOM | 16320   | –            | 24500    |
|                                                                     | STUDDED BOTTOM | 15290   | –            | –        |
|                                                                     | CIW HUB BOTTOM | ▲       | 12700        | –        |
| STANDARD RING GROOVE                                                | FLANGED        | RX-73   | –            | R-95     |
|                                                                     | STUDDED        | RX-73   | –            | –        |
|                                                                     | CIW HUB        | ▲       | RX-73        | –        |

- Table Initial Closing Pressure (psi)

Required for MSP 29-1/2"-500 BOP / DIVERTER

| Closing Pressure 500 psi Wellbore |          |          |
|-----------------------------------|----------|----------|
| 12" ipe                           | 5" Pipe  | CSO      |
| 959 psi                           | 1350 psi | 1500 psi |

### 30.4 INSPECTIONS

The Diverter System shall be inspected (modally and frequency) according to the manufacturer's recommendations and as per API RP 53.

ENI requirements are defined by an internal specification.

## **31. ANNULAR PREVENTER**

### **INDEX**

- 31.1 FUNCTION
- 31.2 FUNCTIONING PRINCIPLES
- 31.3 TYPES AND CHARACTERISTICS
  - CAMERON BOP
  - HYDRIL BOP
  - SHAFFER BOP
- 31.4 INSPECTIONS

### **31.1 FUNCTION**

The annular preventer is part of the BOP STACK installed on the well head once the anchor casing is run and cemented in the hole.

The BOP is the second and final safety device to handle the uncontrolled flow of formation fluids (hydrostatic mud pressure is the first) from well.

The annular BOP is engineered to close tightly on any cylindrical body with dimensions as large as the maximum opening ID of the BOP to dimension as small as the fully closed position.

The annular BOP can close on Drill Pipes, Drill Collars, Casing, Tubing, Tool joints the kelly and wire line.

It is not request, as with the Ram BOP, to check the position of Tool Joint before closing.

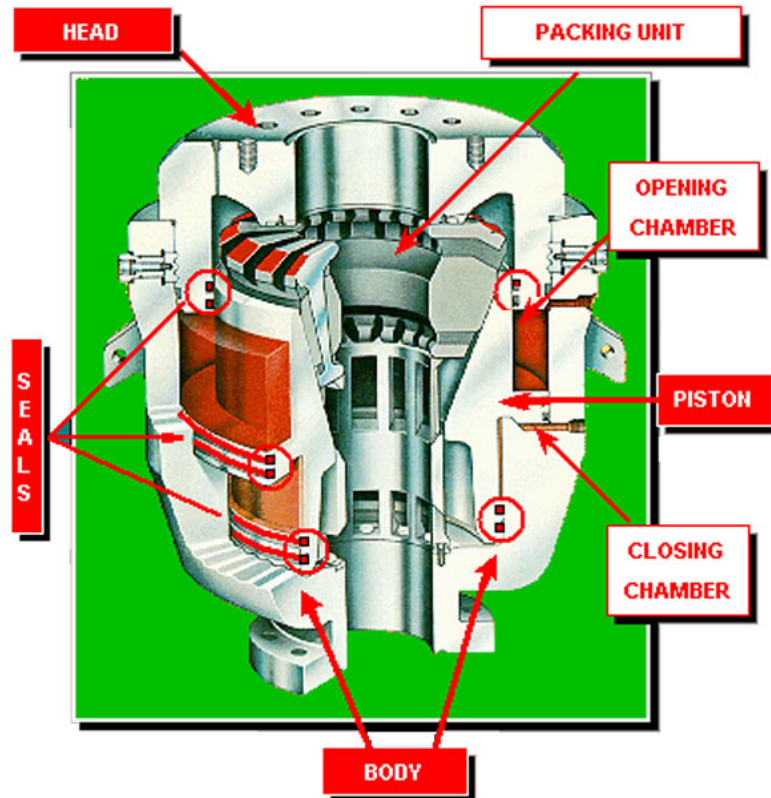


### - Components

Annular BOPs are equipped with a piston closing device which is hydraulically operated by applying pressure to closing and opening chambers.

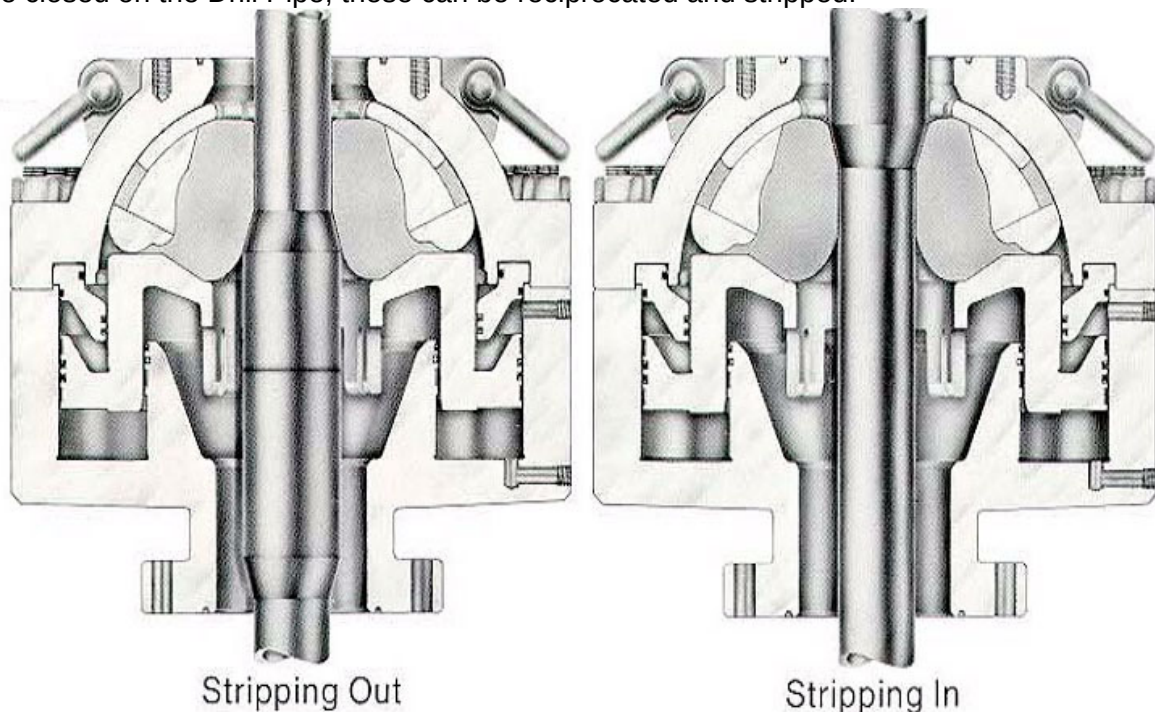
The main BOP components are:

- body
- head
- piston
- closing/opening chambers
- packing unit
- seals



### - Special operation: Stripping

Once closed on the Drill Pipe, these can be reciprocated and stripped.



### - Manufacture specifications

Annular Preventer are manufactured according to API 16A.

The relevant ISO standard is the 13533 Spec.

ENI requirements are defined by "Well control policy" and an internal specification.



## 31.2 FUNCTIONING PRINCIPLES

### - Packing Unit

Packing Unit is moved by a hydraulically pressurized piston to seal around any cylindrical body (DP or DC).

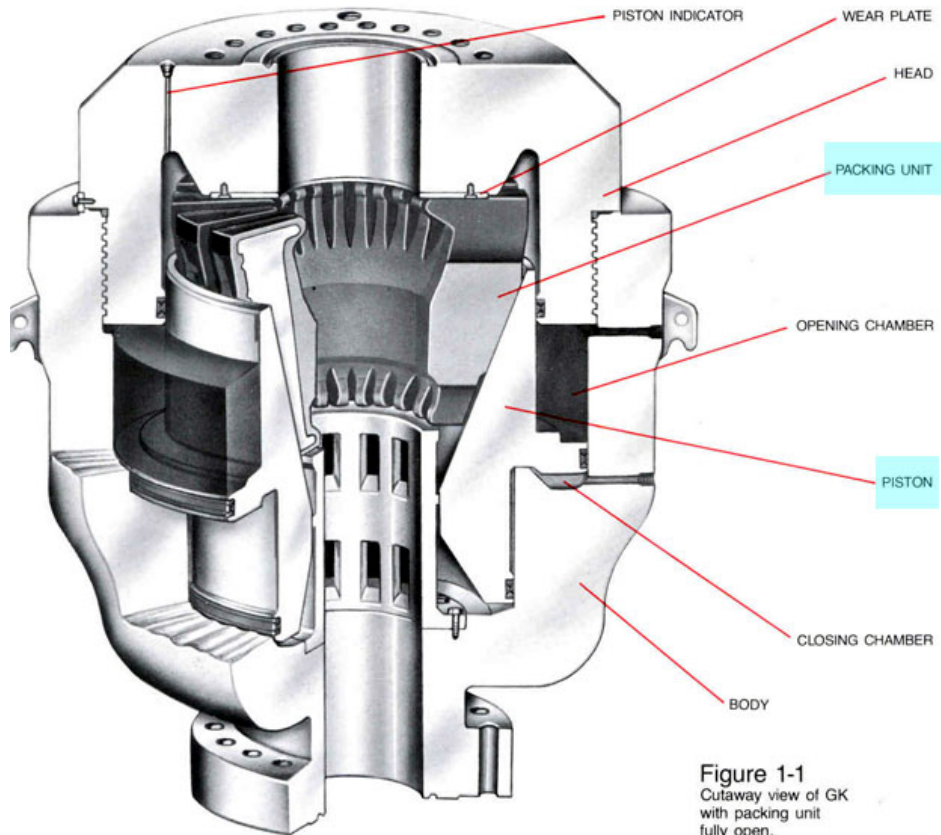
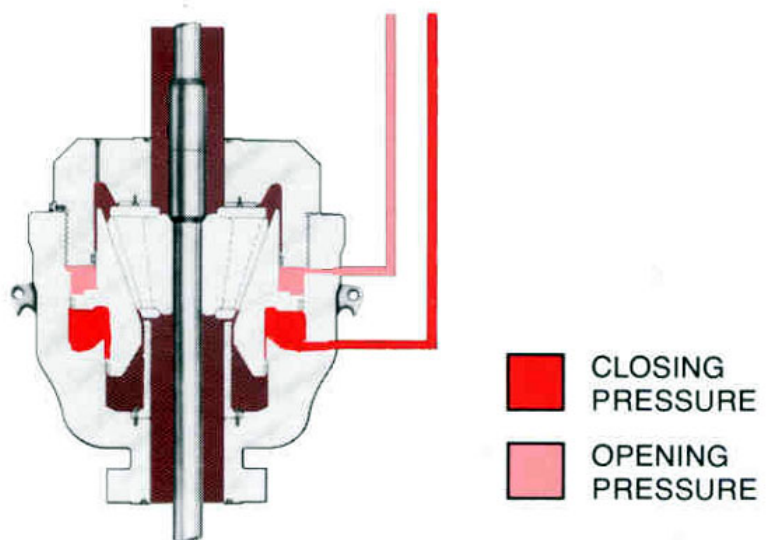


Figure 1-1  
Cutaway view of GK with packing unit fully open

### - Operational fluid pressure

The operational fluid pressure is relatively low and can be regulated by the well pressure and by the diameter of the body being closed in the BOP.

Usually the BAG BOP's are well-pressure assisted. This means that the well pressure helps to keep the BOP closed against the pipe body.



Closing and Opening Pressure

### 31.3 TYPES AND CHARACTERISTICS

Manufacturers of Annular Preventers include:

- CAMERON
- HYDRIL
- SHAFFER

#### - CAMERON BOP

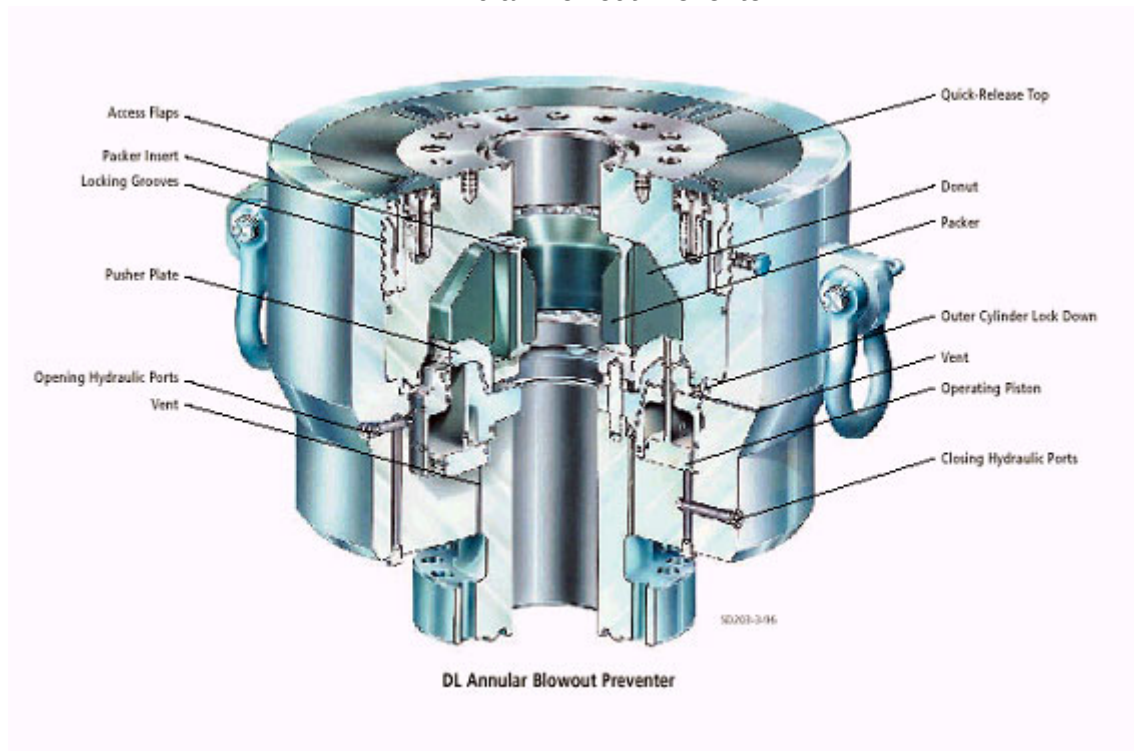
The most common types are "D" and "DL"

##### - Engineering Features

A quick-release top with a one-piece split lock ring permits quick packer change out with no loose parts involved.

The design also provides visual indication of whether the top is locked or unlocked

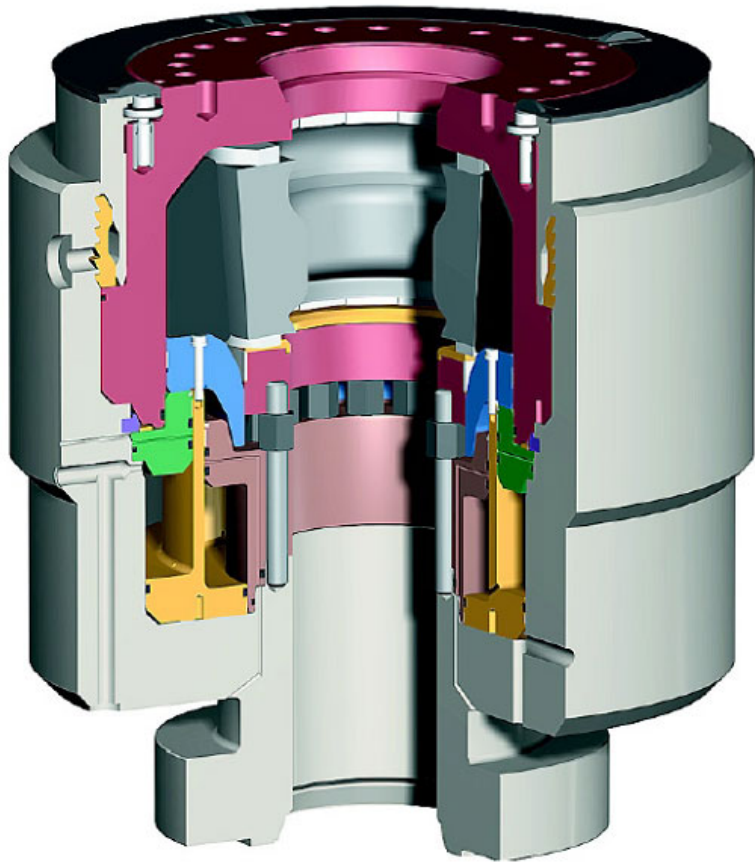
DL Annular Blowout Preventer



- Section view of CAMERON "DL" Type

- The Cameron DL BOP is shorter in height than comparable annular preventers and features light weight for use on platforms and rigs where weight is a consideration.

- Twin seals separated by a vented chamber positively isolate the BOP operating system from well bore pressure. High strength polymer bearing rings prevent metal-to-metal contact and reduce wear between all moving parts of the operating systems.



- Others Engineering Features

All Cameron DL BOPs are manufactured to comply with NACE MR-01-75 for H<sub>2</sub>S service.

Popular sizes of the DL BOP are available with high performance CAMULAR annular packing subassemblies.

The Cameron DL BOP is available in sizes from 7-1/16" to 21-1/4" and in working pressures from 2000 to 20,000 psi working pressure and in single or double body configurations.

- HYDRIL BOP

- Hydril Bag Bop Types

Hydril GK



Hydril GL



Hydril MSP



SIZES AND PRESSURE RATINGS OF ANNULAR BLOWOUT PREVENTERS

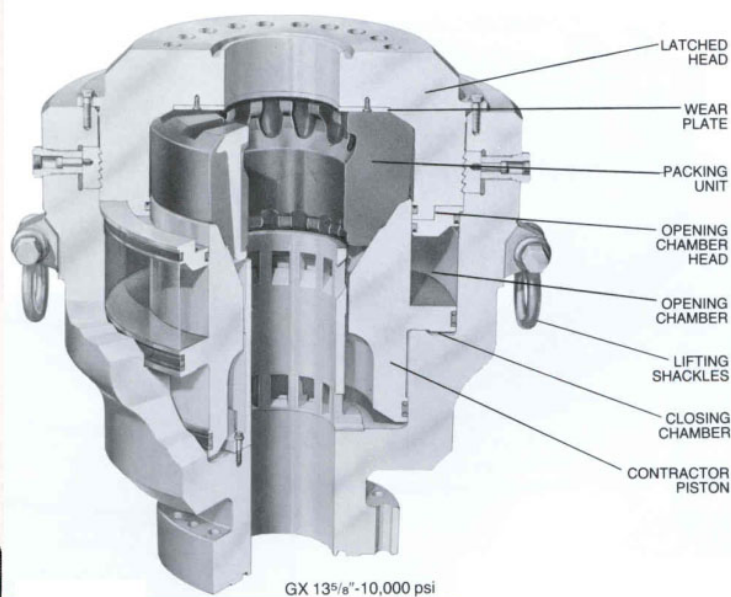
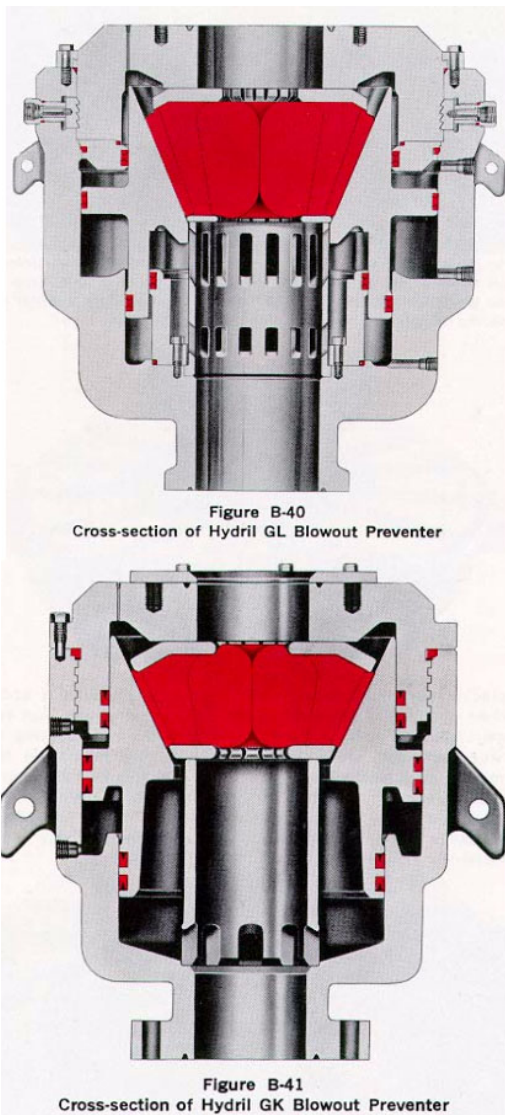
| Bore Size<br>(Inches) | Working Pressure Ratings (psi) |      |      |      |       |        |        |        |
|-----------------------|--------------------------------|------|------|------|-------|--------|--------|--------|
|                       | 500                            | 1000 | 2000 | 3000 | 5000  | 10,000 | 15,000 | 20,000 |
| 2-9/16                | —                              | —    | —    | GKS  | GKS   | GKS    | —      | —      |
| 4-1/16                | —                              | —    | —    | —    | —     | GS     | GS     | —      |
| 6-3/8                 | —                              | —    | —    | RS   | —     | —      | —      | —      |
| 7-1/6                 | —                              | —    | MSP  | GK   | GK    | GK     | GK     | GK     |
| 9                     | —                              | —    | MSP  | GK   | GK    | GK     | —      | —      |
| 11                    | —                              | —    | MSP  | GK   | GK    | GX     | GX     | —      |
| 13-5/8                | —                              | —    | —    | GK   | GL/GK | GX     | GX     | —      |
| 16-3/4                | —                              | —    | —    | —    | GL/GK | GX     | —      | —      |
| 18-3/4                | —                              | —    | —    | —    | GL    | GX     | —      | —      |
| 21-1/4                | —                              | —    | MSP  | —    | GL    | —      | —      | —      |
| 29-1/2                | MSP                            | —    | —    | —    | —     | —      | —      | —      |
| 30                    | —                              | MSP  | —    | —    | —     | —      | —      | —      |



- Section View

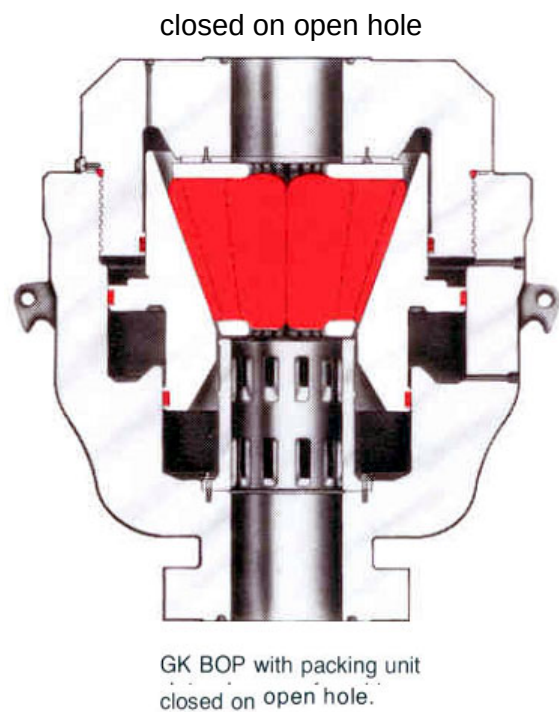
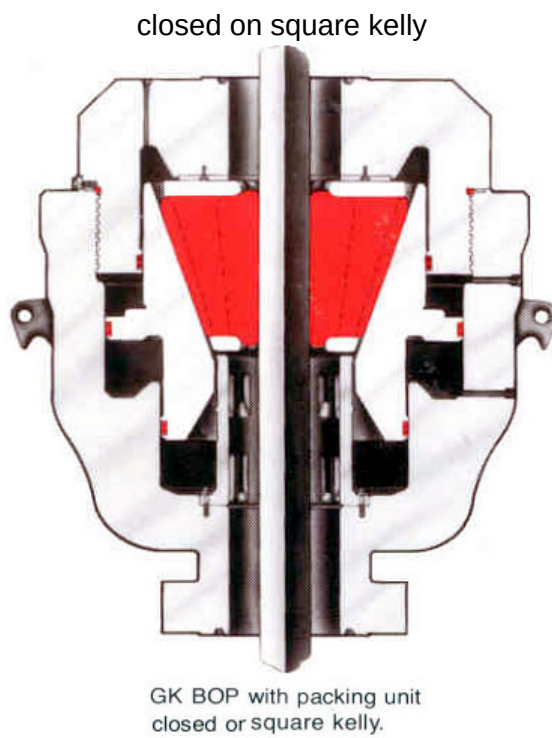
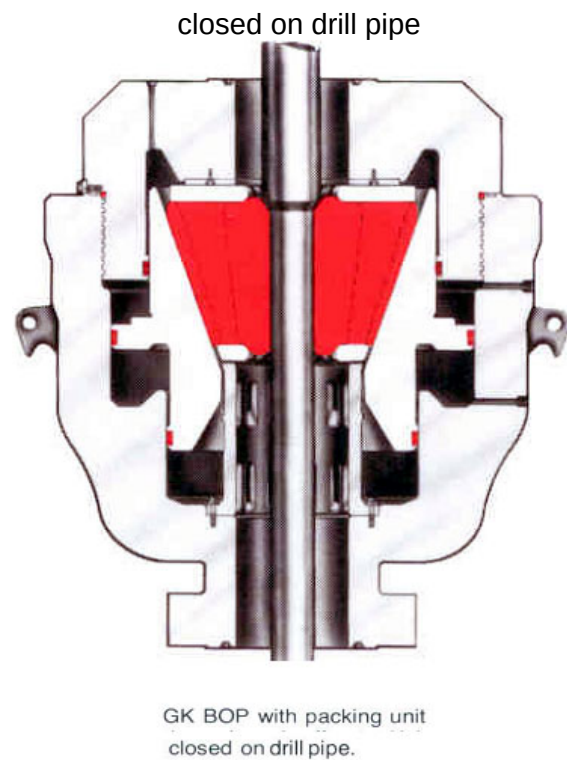
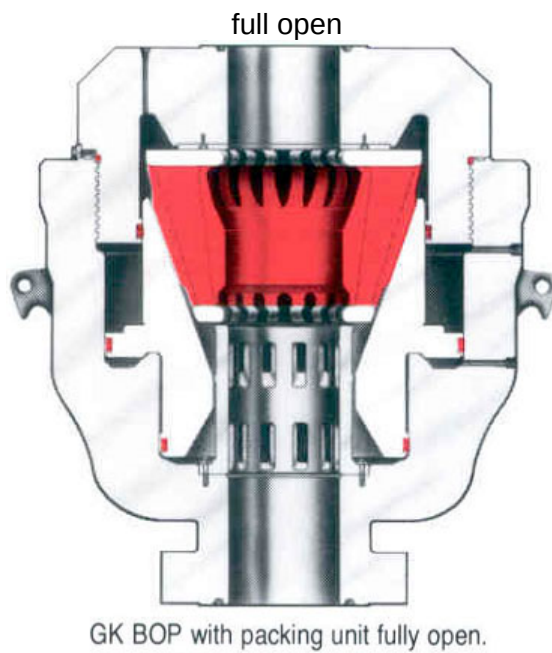
- Cross-section Hydril GK
- Cross-section Hydril GL

- Cross-section Hydril GX



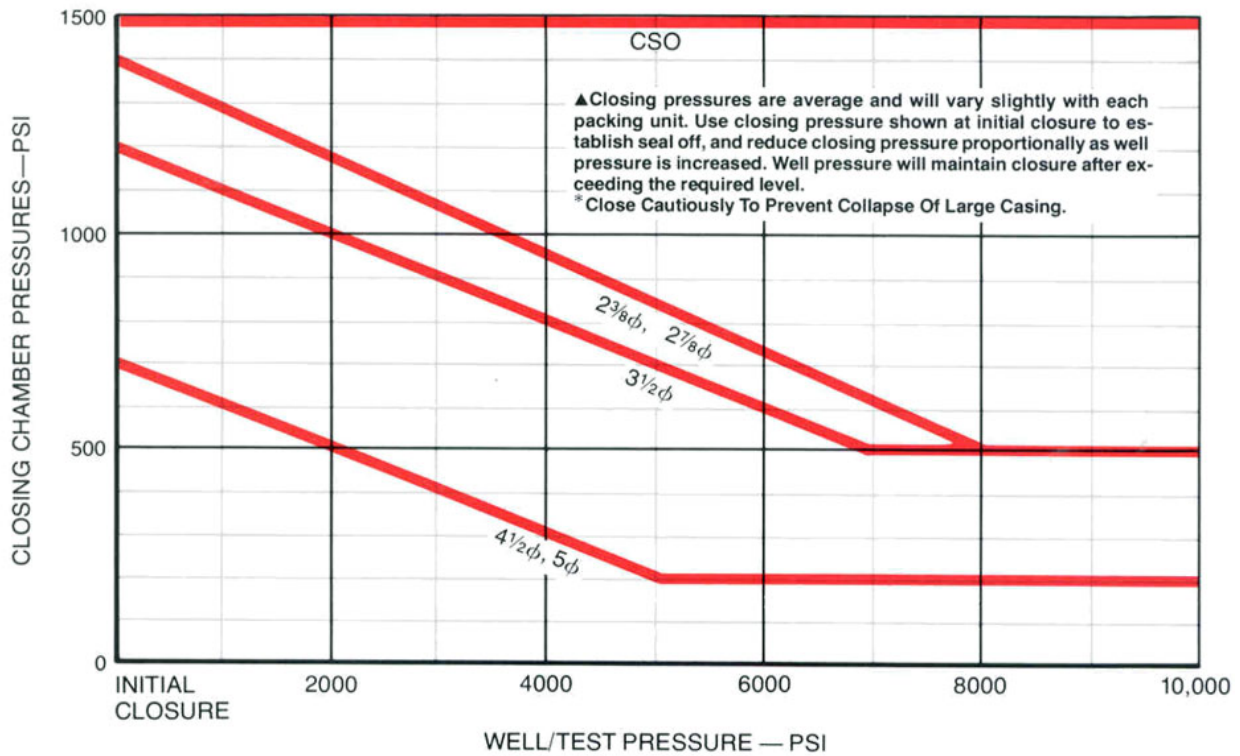
## - Closing Positions View

Hydril GK BOP with packing unit:



## - Closing pressure

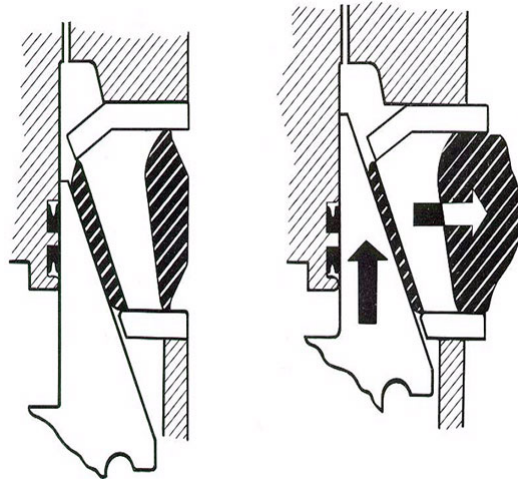
The graphic shows the closing pressure versus body diameter and Well pressure



## - Well-pressure assisted

BAG BOPs are well-pressure assisted.

This means that the well pressure helps to keep the BOP closed against the pipe body.



### - Packing Unit Options

The type of packing used depends on the mud type and climatic conditions

Natural Rubber



Nitrile Rubber



Neoprene Rubber



#### - Natural Rubber

Is compounded for drilling with water-base drilling fluids. Natural rubber can be used at operating temperatures between

-30 F to 255 F (-35 C to 107 C)

#### - Nitrile Rubber

(a synthetic compound) is for use with oil-base or oil-additive drilling fluids. It provides the best service with oil-base muds, when operated at temperatures between

20 F to 190 F (-7 C to 88 C)

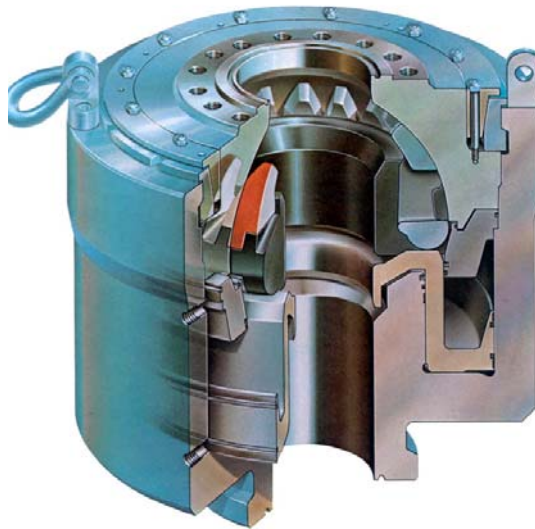
#### - Neoprene Rubber

Is for low-temperature operating service and oil-base drilling fluids. It can be used at operating temperatures between

-30 F to +170 F (-35 C to 77 C)

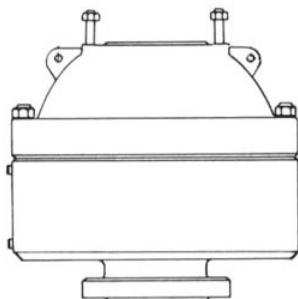


- SHAFFER BOP



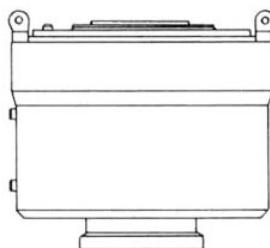
- Shaffer Bag Bop Types

- Bolted Cover Spherical BOP   - Wedge Cover Spherical BOP   - Dual wedge-cover model

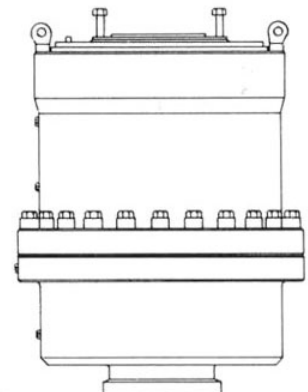


Bolted-cover Spherical BOP

Lightweight model also available



Wedge-cover Spherical BOP

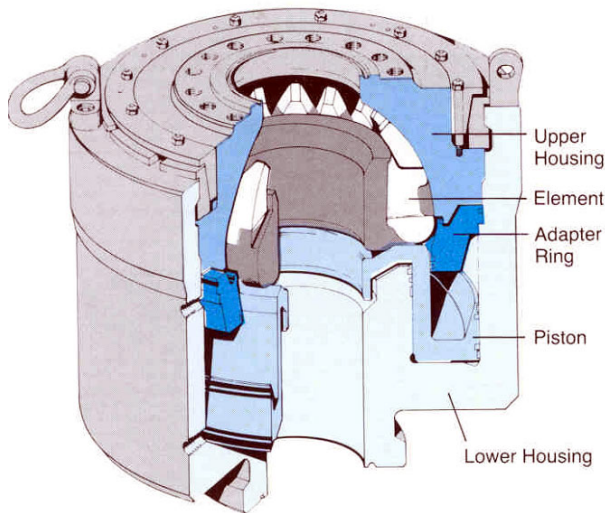


Dual wedge-cover model  
also available

| SPHERICAL BOP MODELS AND SIZES |        |        |   |    |        |        |        |        |        |    |
|--------------------------------|--------|--------|---|----|--------|--------|--------|--------|--------|----|
| Working Pressure (psi)         | 4 1/16 | 7 1/16 | 9 | 11 | 13 5/8 | 16 3/4 | 18 3/4 | 20 3/4 | 21 1/4 | 30 |
| 10,000                         |        |        |   |    |        |        |        |        |        |    |
| 5,000                          |        |        |   | L  | L      | D      | D      |        | D      |    |
| 3,000                          |        |        |   |    |        |        |        |        |        |    |
| 2,000                          |        |        |   |    |        |        |        |        | L      |    |
| 1,000                          |        |        |   |    |        |        |        |        |        |    |

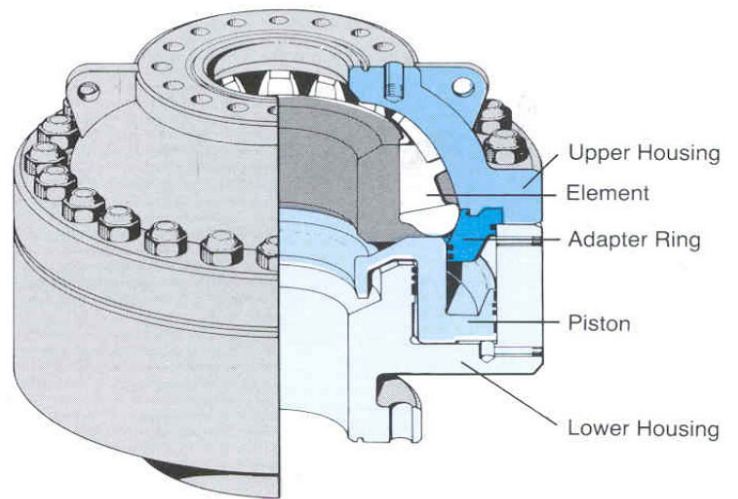
## - Shaffer Section View

Bolted Cover Spherical BOP



Wedge Cover Spherical BOP

Wedge Cover Spherical BOP



Bolted Cover Spherical BOP

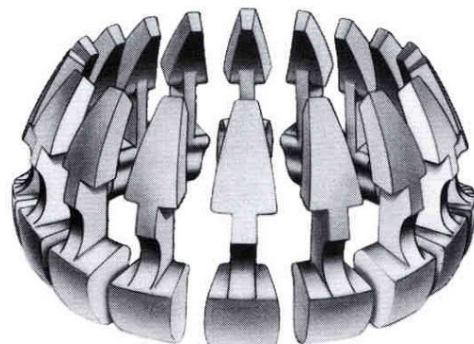
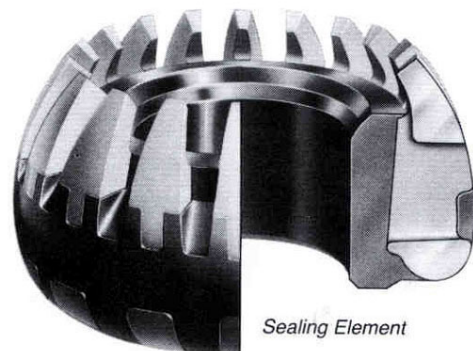
## - Shaffer Bag Bop Packing

- *Suitable for H<sub>2</sub>S and Arctic Service*  
Shaffer standard Sphericals meet all applicable American Petroleum Institute (API) and National Association of Corrosion Engineers (NACE) requirements for internal H<sub>2</sub>S service.

Field conversion for external H<sub>2</sub>S service involves changing only the studs, nuts and lifting shackles.

- *Steel Segments Reinforce sealing Element*  
Steel segments molded into the elements partially close over the rubber to prevent excessive extrusion when sealing under high pressures.

These segments always move out of the well bore when the element is worn far beyond normal replacement condition.



## 31.4 INSPECTIONS

The BOP Bag Preventers shall be inspected (modally and frequency) according to the manufacturer's recommendations and as per API RP 53.

ENI requirements are defined by an internal specification that stipulates the Bag BOP shall be recertified by a Manufacturer authorized workshop at least every five years.

## 32. RAM PREVENTER

### INDEX

- 32.1 FUNCTION
- 32.2 DATA
- 32.3 TYPES AND CHARACTERISTICS
  - CAMERON RAMS BOP
  - HYDRIL RAMS BOP
  - SHAFFER RAMS BOP
- 32.4 INSPECTIONS

### 32.1 FUNCTION

The BOP is the second barrier to stopping uncontrolled formations fluids from coming into the well.

The BOP is only used when the first barrier (hydrostatic mud pressure) has failed.

In addition to the bag preventer, a number of rams are used.

ENI "Well control policy" stipulates the minimum BOP stack requirements. (In terms of numbers for surface and underwater BOP)



The number and type of rams in the BOP stack depends on:

- Maximum pressure expected in the well.
- BHA dimensions (OD).

BOPs are designed to enable the crew to easily change the size and type of rams.

#### - Types of rams

The types of rams in use include:

- Pipe Rams
- Variable Rams
- Blind Rams
- Blind / Shear Rams



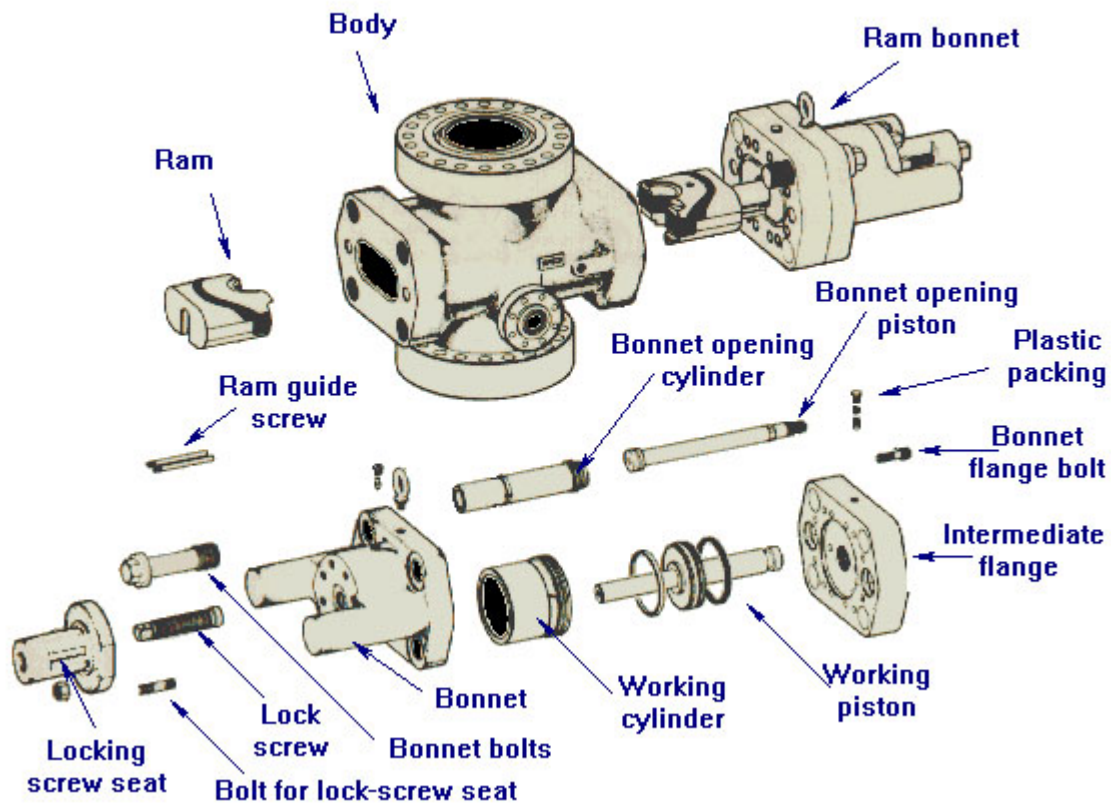


## - Manufacture specifications

RAM Preventer are manufactured according to API 16A.  
The relevant ISO standard is the 13533 Spec.

ENI requirements are defined by "Well control policy" and an internal specification.

### *Bop Rams - Parts*





## 32.2 DATA

### - Size and working pressures

Size and rated working pressures are (see table1)

**Table 1 – API 16A Equipment Size and Rated Working Pressure**

| API Size Designation                                                                                                                                | Rated Working Pressure (psi) | Drift Diameter (inch) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-----------------------|
| 7 1/16                                                                                                                                              | 2,000 thru 20,000            | 7.032                 |
| 9                                                                                                                                                   | 2,000 thru 15,000            | 8.970                 |
| 11                                                                                                                                                  | 2,000 thru 20,000            | 10.970                |
| 13 5/8                                                                                                                                              | 2,000 thru 15,000            | 13.595                |
| 16 3/4                                                                                                                                              | 2,000 thru 10,000            | 16.720                |
| 18 3/4                                                                                                                                              | 2,000 thru 15,000            | 18.720                |
| 20 3/4                                                                                                                                              | 3,000                        | 20.720                |
| 21 1/4                                                                                                                                              | 2,000 thru 10,000            | 21.220                |
| 26 3/4                                                                                                                                              | 2,000 thru 3,000             | 26.720                |
| 30                                                                                                                                                  | 2,000 thru 3,000             | 29.970                |
| Note: Specific size and pressure rating combinations are not necessarily available for each type of end or outlet connection, e.g., flange and hub. |                              |                       |

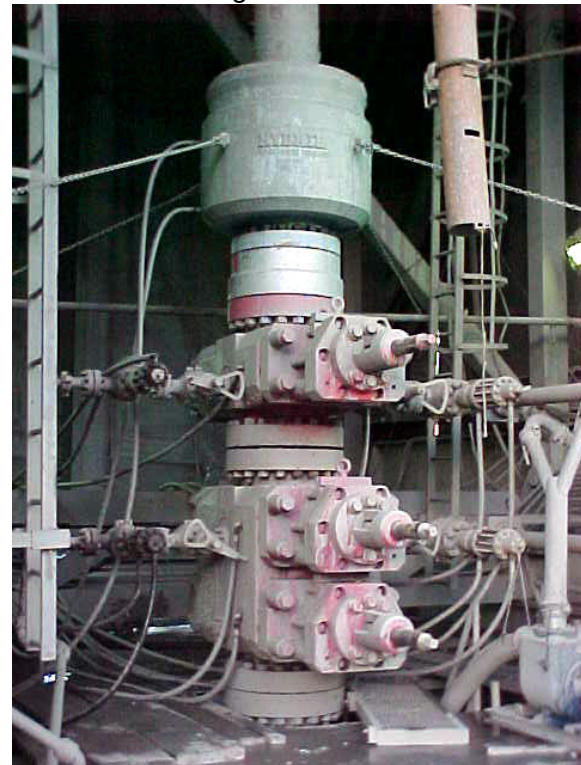
### - Connections type (flanged or clamped)

BOP top and bottom connections can be flanged or clamped.

Clamped BOP



Flanged BOP Stack



**Table 3: Pressure Ratings and Size Ranges Flange Connections**

| Pressure Rating<br>(psi) | Type 16B           | Type 16BX             |
|--------------------------|--------------------|-----------------------|
| 2,000                    | 2 1/16 thru 21 1/4 | 26 3/4 thru 30        |
| 3,000                    | 2 1/16 thru 20 3/4 | 26 3/4 thru 30        |
| 5,000                    | 2 1/16 thru 11     | 13 5/8 , thru 21 1/4  |
| 10,000                   |                    | 1 13/16 , thru 21 1/4 |
| 15,000                   |                    | 1 13/16 , thru 18 3/4 |
| 20,000                   |                    | 1 13/16 , thru 13 5/8 |

**Table 4: Pressure Rating and Size Ranges for API Type 16B and 16BX Hubs**

| Pressure Rating<br>(psi) | Type 16B                | Type 16BX             |
|--------------------------|-------------------------|-----------------------|
| 2,000                    | 7 1/16 , 16 3/4, 21 1/4 |                       |
| 3,000                    | 11, 13 5/8 , 16 3/4     |                       |
| 5,000                    |                         | 2 1/16 , thru 21 1/4  |
| 10,000                   |                         | 1 13/16 , thru 21 1/4 |
| 15,000                   |                         | 1 13/16 , thru 18 3/4 |
| 20,000                   |                         | 1 13/16 , thru 11     |

### 32.3 TYPES AND CHARACTERISTICS

The main companies that manufacture RAM type preventers include:

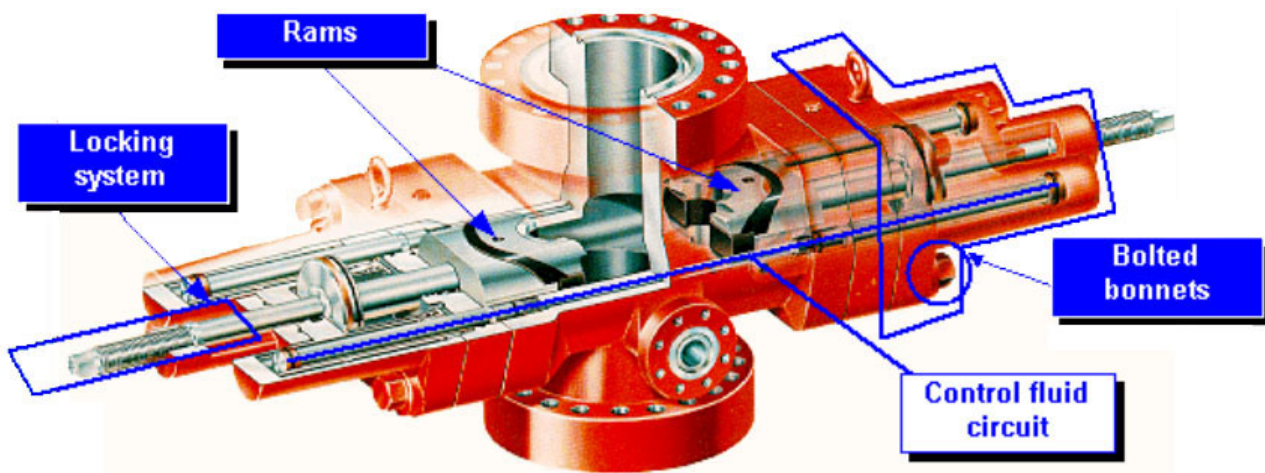
- CAMERON
- HYDRIL
- SHAFFER

#### - CAMERON RAMS BOP

The most commonly used ram BOP is the U type

- CAMERON Type U
- CAMERON Type TL

#### CAMERON Type U



#### - Main Features

The Cameron U BOP is the most widely used ram-type BOP in the world and offers the widest range of sizes of any Cameron ram-type BOP.

Application: Surface and subsea

Bore Sizes and Working Pressures:

7-1/16", 11", 13-5/8" 3000 - 15,000 psi  
 16-3/4" 3000 - 10,000 psi  
 18-3/4" 10,000 psi  
 20-3/4" 3000 psi  
 21-3/4" 2000, 5000, 10,000 psi  
 26-3/4" 3000 psi

Body Styles: Single, double

Pressure-Energized Rams: Yes

Bonnet Seal Carrier: Available

Hydromechanical Lock: Wedgelocks (with pressure balance chambers)

Hydraulically Opening Bonnets: Yes

#### - Ram

The rams in the U BOP are pressure-energized.

Well bore pressure:

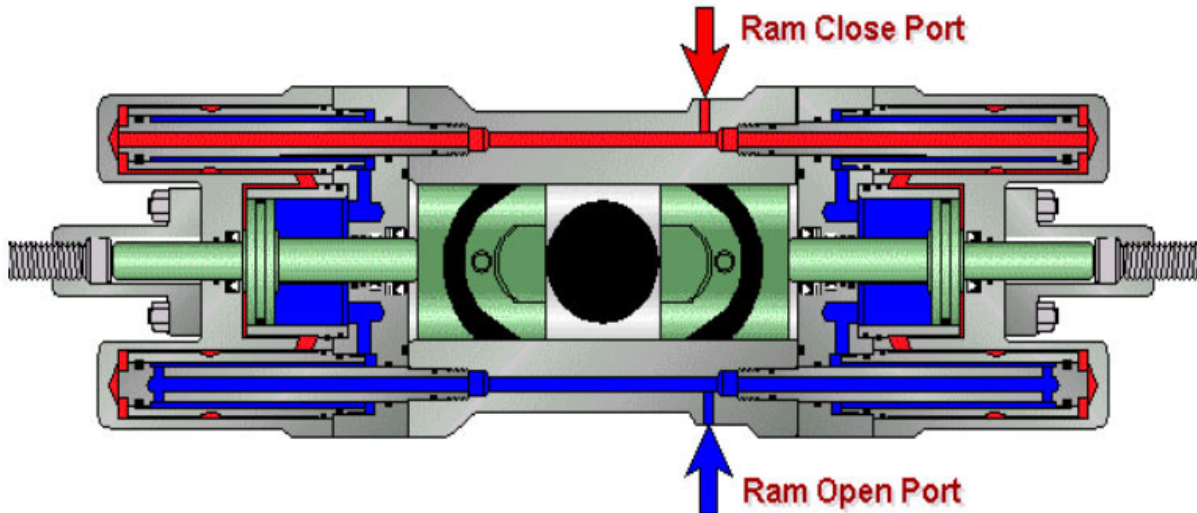
- increases the rams' sealing integrity
- maintains the seal in case of hydraulic pressure loss

Increased well bore pressure actually improves seal integrity.

#### - Working System

Working System for ram BOP opening and closing CAMERON type U

If leaks were observed, replace the seals and repeat the test.



Working System for ram BOP opening and closing

#### - Ram Locking System (ram lock)

A manual locking system is standard for the U BOP.

It consists of a locking screw housing and a locking screw.

The locking system is not in the operating system, and can be removed without disturbing any operating system seals.

The locking screws are "run in" when the rams are closed, locking the rams in the closed position. The screws must be backed out before the rams can open.

#### - Bonnets

There are three types of bonnets available for some U BOPs:

- pipe bonnets (pipe rams)
- standard shear bonnets (shear rams)
- large bore shear bonnets (shear rams)
- super shear Bonnet

#### - Large Bore Shear Bonnets

The large bore shear bonnet is available for many U BOPs as a replacement for the standard shear bonnet. It was developed to meet a need for greater shearing pressure brought about by:

- heavier walled and higher strength pipe
- greater variance in pipe ductility

Large bore shear bonnets eliminate the operating cylinder.

This increases the available closing area 35% or more, which increases closing force by 35% or more.

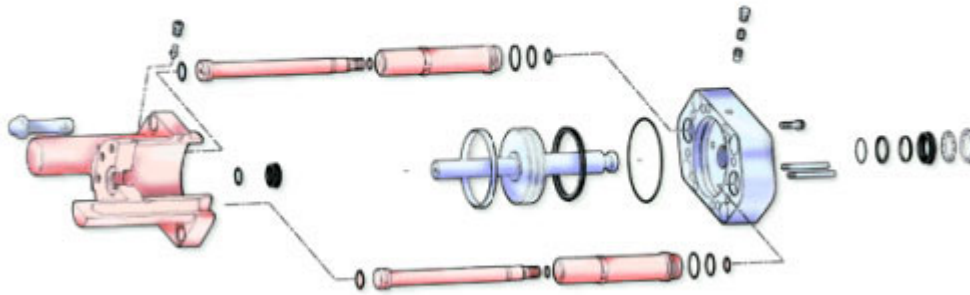
The large bore shear bonnets also have a different operating piston, and changes in the machining of the intermediate flange and bonnet.



Note: Some shear bonnets can be converted to large bore shear bonnets

## Large Bore Shear Bonnets

- ◆ heavier walled and higher strength pipe
- ◆ greater variance in pipe ductility



**Large Bore Shear Bonnet Assembly, Exploded View**

### - Super Shear Bonnets

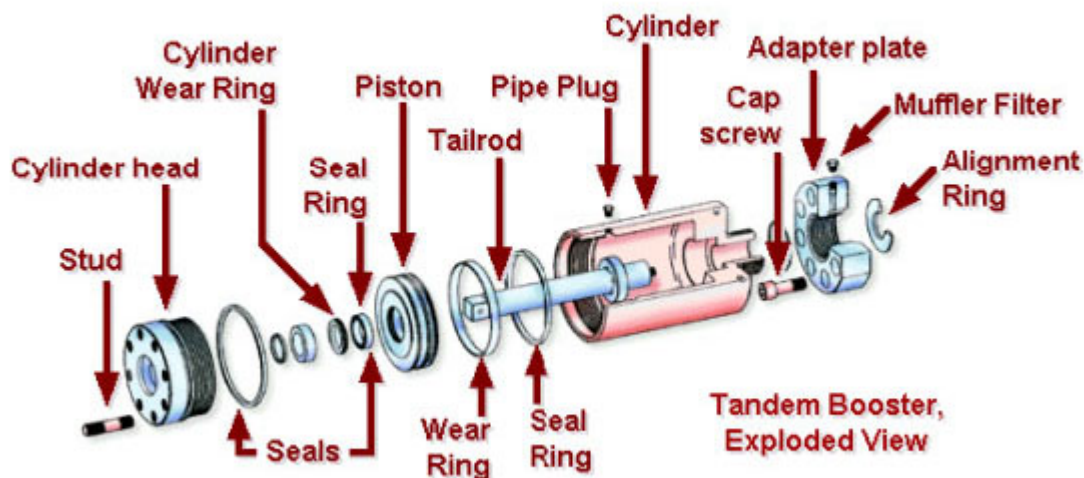
A BOP equipped with Super Shear Bonnets and non-sealing Super Shear Rams provides a solution to the problem that can result when shearing becomes necessary and a drill collar is in the bore.

### - Tandem Booster

Tandem boosters can be used with the U shear ram.

They increase the force available to shear pipe by 100% - 124%, without increasing the wear and tear on the packers.

## Tandem Boosters



**Tandem Booster, Exploded View**

## Ram Types

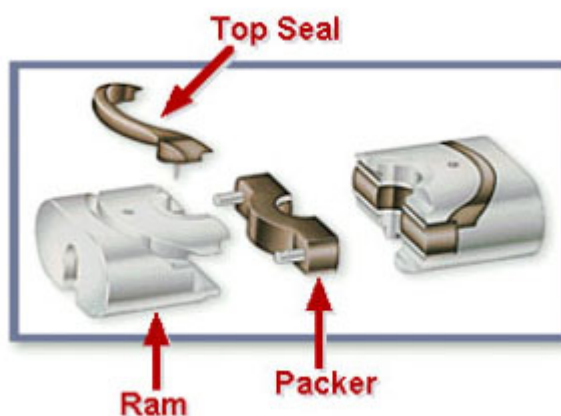
### - Ram selection

A wide selection of ram is available to meet all applications.



### - Pipe rams

Pipe rams close and seal on one specific size of pipe. They are also used for "hang-off". With hang-off, the ram is used to suspend pipe or casing by closing underneath a tool joint. Note: Older pipe rams may not be hang-off rams.



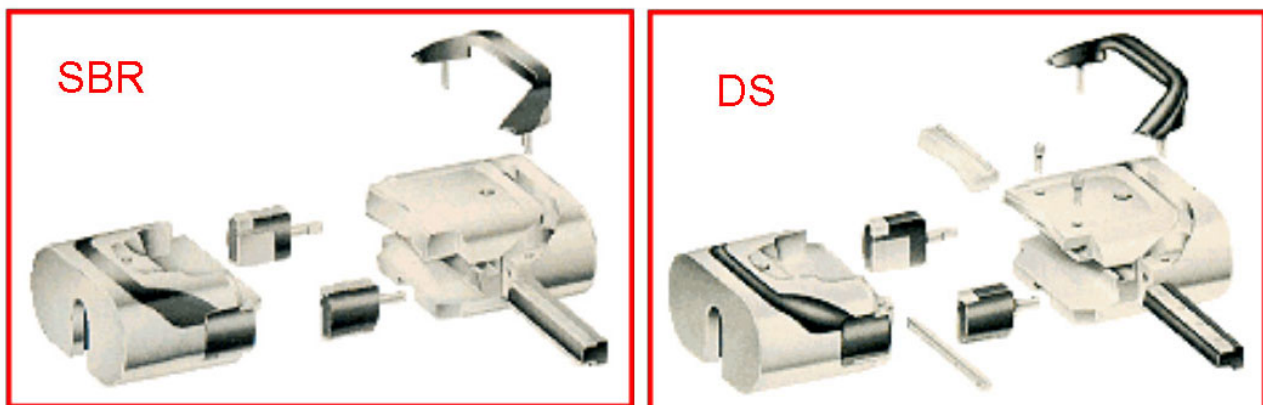
### - Blind rams



- Shear rams

CAMERON manufactures 3 types of shear rams:

1. **SBR** (Shearing Blind Ram); which is the most common type and is available for all pipe diameters.
2. **H2S**; equipped with an interchangeable blade with the right degree of hardness to carry out shearing and H2S service. It is available for 13 5/8" models and for 5.000 / 10.000 psi.
3. **DS**; it is the most recent model: it has a wider sealing zone, which ensures a better sealing after shearing. It is available for 11" and 13 5/8" models and for 5.000 / 10.000 psi.



- Shearing Capability

| SHEARING CAPABILITY |       |                       |     |     |     |                           |     |     |     |                   |     |                   |                  |
|---------------------|-------|-----------------------|-----|-----|-----|---------------------------|-----|-----|-----|-------------------|-----|-------------------|------------------|
| PIPES               | GRADE | 11"<br>3.000 - 10.000 |     |     |     | 13 5/8"<br>3.000 - 10.000 |     |     |     | 13 5/8"<br>15.000 |     | 18 3/4"<br>10.000 | 20 3/4"<br>3.000 |
|                     |       | SBR                   |     | DS  |     | SBR                       |     | DS  |     | SBR               |     | SBR               | SBR              |
|                     |       | SB                    | LB  | SB  | LB  | SB                        | LB  | SB  | LB  | B                 | LB  | B                 | SB LB            |
| 3 1/2" 13.3 #FT     | E     | Yes                   | Yes | Yes | Yes | Yes                       | Yes | Yes | Yes | Yes               | Yes | Yes               | Yes              |
|                     | G     | Yes                   | Yes | Yes | Yes | Yes                       | Yes | Yes | Yes | Yes               | Yes | Yes               | Yes              |
|                     | S     | Yes                   | Yes | Yes | Yes | Yes                       | Yes | Yes | Yes | Yes               | Yes | Yes               | Yes              |
| 3 1/2" 15.5 #FT     | E     |                       |     | Yes |     | Yes                       | Yes | Yes | Yes | Yes               | Yes | Yes               | Yes              |
|                     | G     |                       |     | Yes |     | Yes                       | Yes | Yes | Yes | Yes               | Yes | Yes               | Yes              |
|                     | S     |                       |     | Yes |     | Yes                       | Yes | Yes | Yes | Yes               | Yes | Yes               | Yes              |
| 5" 19.5 #FT         | E     |                       |     | Yes |     | Yes                       | Yes | Yes | Yes | Yes               | Yes | Yes               | Yes              |
|                     | G     |                       |     | Yes |     |                           |     | Yes |     | Yes               |     | Yes               |                  |
|                     | S     |                       |     | Yes |     |                           |     | Yes |     | Yes               |     | Yes               |                  |
| 5" 25.6 #FT         | X     |                       |     |     |     |                           |     |     |     | Yes               |     | Yes               |                  |
|                     | S     |                       |     |     |     |                           |     |     |     | Yes               |     | Yes               |                  |

- Variable bore rams (VBR)

The VBR seals on several sizes of pipe or hexagonal Kelly within its specified size range. A typical range is from 5 " to 3 ".

Other size ranges such as 7" to 4 " are available upon request.

VBRs are not intended for long-term stripping.





VBR II™ Packer



VBR Components

- Table VBR Hang-Off

| VBR Hangoff        |        |        |                                             |                             |          |         |           |          |          |          |
|--------------------|--------|--------|---------------------------------------------|-----------------------------|----------|---------|-----------|----------|----------|----------|
| BOP                | Range  |        | Drill Pipe Tool Joint Hangoff Capacity (lb) |                             |          |         |           |          |          |          |
|                    | Max    | Min    | 2 3/8"                                      | 2 7/8"                      | 3 1/2"   | 4 1/2"  | 5"        | 5 1/2"   | 6 5/8"   | 7 5/8"   |
| 7-1/16" 3/15M U    | 3 1/2" | 2 3/8" | 30,000                                      | 30,000                      | 150,000  | X       | X         | X        | X        | X        |
|                    | 4"     | 2 7/8" | X                                           | 30,000                      | 100,000  | X       | X         | X        | X        | X        |
| 11" 3/5M U         | 5"     | 2 7/8" | X                                           | 30,000                      | 110,000  | 150,000 | 300,000*  | X        | X        | X        |
| 11" 10M U          | 5"     | 3 1/2" | X                                           | X                           | 110,000T | 150,000 | 300,000*  | X        | X        | X        |
| 11" 15M U          | 5"     | 2 7/8" | X                                           | 40,000                      | 150,000  | 200,000 | 450,000*  | X        | X        | X        |
| 13-5/8" 3/10M U    | 5"     | 2 7/8" | X                                           | 30,000                      | 150,000  | 200,000 | 450,000*  | X        | X        | X        |
|                    | 5 1/2" | 3 1/2" | X                                           | X                           | 150,000  | 200,000 | 450,000   | 450,000* | X        | X        |
|                    | 7"     | 4 1/2" | X                                           | X                           | X        | 140,000 | 190,000   | 240,000  | 450,000* | X        |
| 13-5/8" 15M U      | 5"     | 3 1/2" | X                                           | X                           | 200,000  | 200,000 | 450,000*  | X        | X        | X        |
|                    | 5 1/2" | 3 1/2" | X                                           | X                           | 200,000  | 200,000 | 450,000   | 450,000* | X        | X        |
|                    | 7"     | 5"     | X                                           | X                           | X        | X       | 250,000   | 300,000  | 450,000* | X        |
| 13-5/8" 10M T/TL   | 5"     | 2 7/8" | X                                           | 30,000                      | 150,000  | 200,000 | 450,000*  | X        | X        | X        |
| 16-3/4" 5M U       | 7"     | 3 1/2" | X                                           | X                           | 185,000T | 210,000 | 285,000T  | 285,000  | 450,000* | X        |
| 16-3/4" 10M U      | 5"     | 2 7/8" | X                                           | 70,000                      | 294,000T | 350,000 | 450,000T* | X        | X        | X        |
|                    | 7"     | 5"     | X                                           | X                           | X        | X       | 285,000T  | 285,000  | 450,000* | X        |
| 18-3/4" 10M U      | 7 5/8" | 3 1/2" | X                                           | X                           | 200,000  | 240,000 | 350,000   | 350,000  | 375,000  | 450,000* |
| 18-3/4" 10M U II   | 5"     | 2 7/8" | X                                           | 120,000                     | 300,000  | 350,000 | 450,000*  | X        | X        | X        |
|                    | 7 5/8" | 3 1/2" | X                                           | X                           | 200,000  | 240,000 | 350,000   | 350,000  | 375,000  | 450,000* |
| 18-3/4" 15M U II   | 5"     | 3 1/2" | X                                           | X                           | 140,000  | 300,000 | 450,000*  | X        | X        | X        |
|                    | 7 5/8" | 3 1/2" | X                                           | X                           | 140,000  | 240,000 | 350,000   | 350,000  | 375,000  | 450,000* |
| 18-3/4" 5/10M T/TL | 7 5/8" | 3 1/2" | X                                           | X                           | 60,000   | 175,000 | 225,000   | 275,000  | 350,000  | 450,000* |
| 18-3/4" 15M T/TL   | 5"     | 3 1/2" | X                                           | X                           | 140,000  | 240,000 | 450,000   | 450,000* | X        | X        |
|                    | 5 1/2" | 3 1/2" | X                                           | X                           | 140,000  | 240,000 | 450,000   | 450,000* | X        | X        |
|                    | 6 5/8" | 3 1/2" | X                                           | X                           | 140,000  | 240,000 | 350,000T  | 350,000  | 600,000T | X        |
|                    | 7 5/8" | 3 1/2" | X                                           | X                           | 140,000  | 240,000 | 350,000   | 350,000  | 375,000  | 450,000* |
|                    |        |        | ITALIC                                      | Denotes calculated value    |          |         |           |          |          |          |
|                    |        |        | T                                           | Denotes actual Test results |          |         |           |          |          |          |



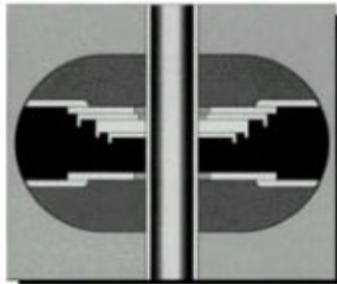
## - FLEXPACKER Ram Packer

The FLEXPACKER is designed to complement the VBR range by closing and sealing around several specific diameters of tubing and pipe.

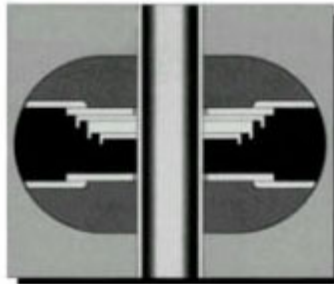


U BOP FLEXPACKER™

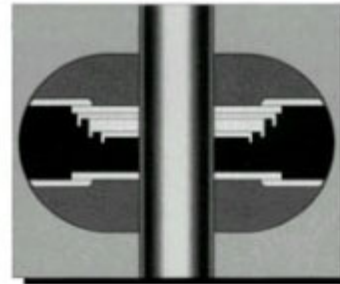
Close on different Pipe OD



3 1/2" Pipe



4 1/2" Pipe



2 7/8" Pipe

## CAMERON Type TL

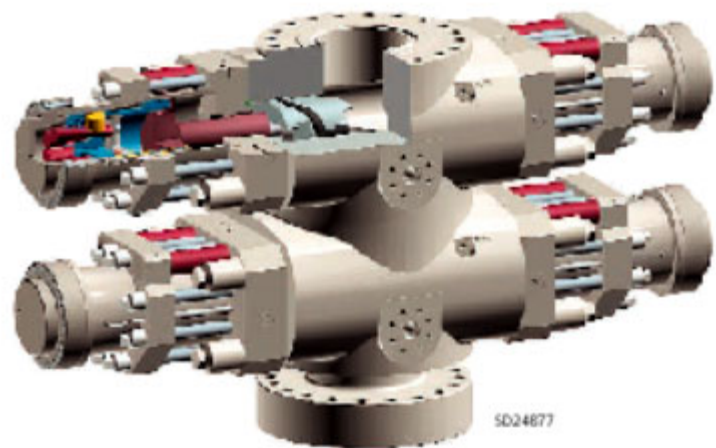
### - TL BOP Features

The TL BOP integrates all of the design features of Cameron's popular T and U BOPs into a lightweight unit. The TL offers side ram removal and other features which reduce maintenance and rig time.

Application: Surface and subsea  
Bore Sizes and Working Pressures:  
 18-3/4" 5000, 10,000, 15,000 psi  
 13-5/8" 10,000 psi

Body Styles: Single, double, triple  
Pressure-Energized Rams: Yes  
Bonnet Seal Carrier: Standard  
Hydro mechanical Lock:  
 Ram Loks (5000, 10,000, 15,000 psi WP)  
 ST lock (10,000, 15,000 psi WP)  
 Wedgelocks (5000 psi WP)

Hydraulically Opening Bonnets: Yes  
Bonnet Studs Instead of Bolt: Yes



TL Blowout Preventer  
(Shown With RamLocks)

TL Blowout Preventer

## Cameron Ram Selection Chart

Cameron Ram Selection Chart

| Description                  | TL BOP                  | UM BOP                  | U BOP                   | Elastomer      | Per NACE |
|------------------------------|-------------------------|-------------------------|-------------------------|----------------|----------|
| <b>Shearing</b>              |                         |                         |                         |                |          |
| Shearing Blind Rams          | Available in Some Sizes | Available               | Available               | CAMRAM Nitrile | Yes      |
| DVS Shear Rams               | Available in Some Sizes | Available in Some Sizes | Available in Some Sizes | CAMRAM Nitrile | Yes      |
| Super Shear Rams             | Available               | Available in Some Sizes | Available               | See Note       | No       |
| <b>Variable Bore Sealing</b> |                         |                         |                         |                |          |
| VBR-Its                      | Available in Some Sizes | Available in Some Sizes | Available in Some Sizes | CAMRAM Nitrile | Yes      |
| FlexPackers                  | Available in Some Sizes | Available in Some Sizes | Available in Some Sizes | CAMRAM Nitrile | Yes      |
| FlexPacker-NRs *             | Available in Some Sizes | Available in Some Sizes | Available in Some Sizes | CAMRAM Nitrile | Yes      |
| Dual Bore FlexPackers        | Available in Some Sizes | Available in Some Sizes | Available in Some Sizes | CAMRAM Nitrile | Yes      |
| <b>Pipe Rams</b>             |                         |                         |                         |                |          |
| Standard Service             | Yes                     | Yes                     | Yes                     | CAMRAM Nitrile | Yes      |
| High Temperature Service     | Yes                     | Yes                     | Yes                     | CAMLAST        | Yes      |
| <b>Snubbing/Stripping</b>    |                         |                         |                         |                |          |
| Grip and Seal Rams           | Not Available           | 7" Only                 | Not Available           | CAMRAM Nitrile | Yes      |
| Snubbing Insert Packers      | Not Available           | 7" Only                 | Not Available           | CAMRAM Nitrile | Yes      |

Note: Super Shear Rams do not seal

\* Cameron also offers special hang-off FlexPacker-NR assemblies

### - HYDRIL RAMS BOP

### - Hydрил Ram BOP types

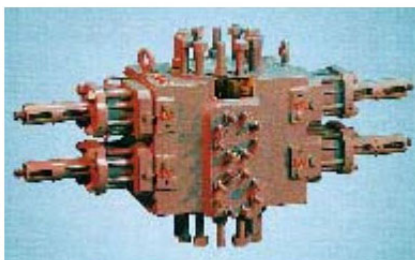
#### - Conventional Ram BOPs



#### - Compact Ram BOPs



#### - Workover Ram BOPs

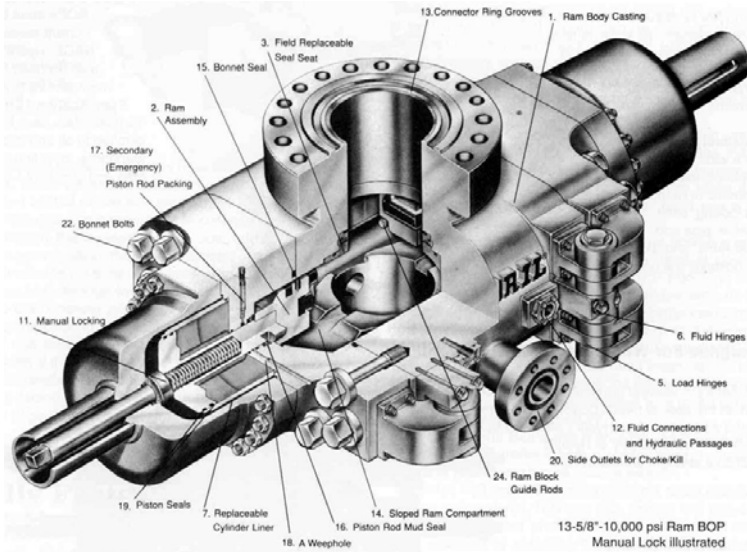


### - Hydрил Ram BOP Sizes

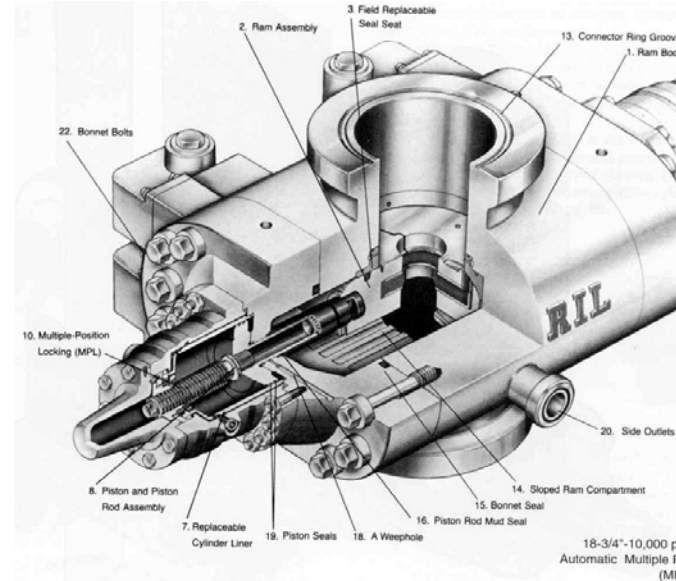
|         | 2000 | 3000 | 5000 | 10000 | 15000 | 20000 |
|---------|------|------|------|-------|-------|-------|
| 7-1/16" |      | X    | X    | X     | X     |       |
| 9"      |      | X    | X    |       |       |       |
| 11"     |      | X    | X    | X     |       | X     |
| 13-5/8" |      | X    | X    | X     | X     |       |
| 16-3/4" |      |      |      | X     |       |       |
| 18-3/4" |      |      | X    | X     | X     |       |
| 20-3/4" |      | X    |      |       |       |       |
| 21-1/4" | X    |      | X    |       |       |       |

## Manual Lock / Automatic Lock

### - Manual Lock



### - Automatic Lock



### - Features

**The Ram Assembly** provides reliable seal off the wellbore for security and safety. The Ram accommodates a large volume of feedable rubber in the front packer and upper seal for long service life.

**The Field Replaceable Seal Seat** provides a smooth sealing surface for the ram upper seal. The seal seat utilizes specially selected and performance effective materials for maximum service life. The field replaceable seal seat eliminates shop welding, stress relieving, and machining for repair, thus reducing downtime and direct repair costs.

**Hinged Bonnets** swing completely clear of overhead restrictions (such as another BOP) and provide easy access for rapid change to reduce downtime.

**Manual Locking** utilizes a heavy-duty acme thread to manually lock the ram in a sealed-off position or to manually close the ram if the hydraulic system is inoperative.

Ram Seal Off is retained by wellbore pressures. Closing forces are not required to retain an established ram seal off.



**- BOP Data**

|                                             |             |           |        |        |               |               |        |               |               |               |        |        |               |
|---------------------------------------------|-------------|-----------|--------|--------|---------------|---------------|--------|---------------|---------------|---------------|--------|--------|---------------|
| Bore Size (in.)                             |             |           | 13-5/8 | 13-5/8 | 13-5/8        | 13-5/8        | 16-3/4 | 18-3/4        | 18-3/4        | 18-3/4        | 20-3/4 | 21-1/4 | 21-1/4        |
| Working Pressure (psi)                      |             |           | 3000   | 5000   | 10,000        | 15,000        | 10,000 | 5000          | 10,000        | 15,000        | 3000   | 2000   | 5000          |
| Old Nominal Sizes (in.)                     |             |           | 12     | 13-5/8 | 13-5/8        | 13-5/8        | 16-3/4 | 18-3/4        | 18-3/4        | 18-3/4        | 20     | 20     | 21-1/4        |
| Cylinder Bore (in.)                         | Manual Lock | Pipe Ram  | 10     | 10     | 14-1/4        | NA            | NA     | 14-1/4        | NA            | NA            | 10     | 10     | 14-1/4        |
|                                             |             | Shear Ram | 14-1/4 | 14-1/4 | 14-1/4        | NA            | NA     | NA            | NA            | NA            | 14-1/4 | 14-14  | 14-1/4        |
|                                             | MPL         | Pipe Ram  | 10     | 10     | 14-1/4        | 14-1/4        | 14-1/4 | 14-1/4        | 14-1/4        | 15.5          | 14-1/4 | 14-1/4 | 14-1/4        |
|                                             |             | Shear Ram | 14-1/4 | 14-1/4 | 14-1/4        | 14-1/4        | 14-1/4 | 14-1/4        | 14-1/4        | 15.5          | 14-1/4 | 14-1/4 | 14-1/4        |
| Gallons To Close (1 Set)                    | Manual Lock | Pipe Ram  | 5.4    | 5.4    | 12.2          | NA            | NA     | 17.1          | NA            | NA            | 8.1    | 8.1    | 17.5          |
|                                             |             | Shear Ram | 11.5   | 11.5   | 12.2          | NA            | NA     | 17.1          | NA            | NA            | 17.2   | 17.2   | 17.5          |
|                                             | MPL         | Pipe Ram  | 5.9    | 5.9    | 12.8          | 12.6          | 14.5   | 17.9          | 17.1          | 19.4          | 18.0   | 18.0   | 19.3          |
|                                             |             | Shear Ram | 12.0   | 12.0   | 12.8          | 12.6          | 15.6   | 17.9          | 17.1          | 19.4          | 18.0   | 18.0   | 19.3          |
| Gallons To Open (1 Set)                     | Manual Lock | Pipe Ram  | 4.9    | 4.8    | 11.6          | NA            | NA     | 16.1          | NA            | NA            | 7.2    | 7.2    | 16.6          |
|                                             |             | Shear Ram | 11.2   | 11.2   | 11.6          | NA            | NA     | 16.1          | NA            | NA            | 16.3   | 16.3   | 16.6          |
|                                             | MPL         | Pipe Ram  | 4.9    | 5.2    | 11.6          | 11.0          | 14.1   | 16.1          | 15.6          | 16.7          | 16.3   | 16.3   | 16.6          |
|                                             |             | Shear Ram | 11.2   | 11.2   | 11.6          | 11.0          | 14.1   | 16.1          | 15.6          | 16.7          | 16.3   | 16.3   | 16.6          |
| Closing Ratio                               | Manual Lock | Pipe Ram  | 4.8    | 4.8    | 10.2          | NA            | NA     | 10.1          | NA            | NA            | 4.75   | 4.75   | 10.2          |
|                                             |             | Shear Ram | 10.1   | 10.1   | 10.2          | NA            | NA     | 10.1          | NA            | NA            | 10.14  | 10.14  | 10.2          |
|                                             | MPL         | Pipe Ram  | 5.2    | 5.2    | 10.6          | 7.74          | 10.6   | 10.6          | 10.6          | 7.27          | 10.6   | 10.6   | 10.6          |
|                                             |             | Shear Ram | 10.6   | 10.6   | 10.6          | 7.74          | 10.6   | 10.6          | 10.6          | 7.27          | 10.6   | 10.6   | 10.6          |
| Opening Ratio                               | Manual MPL  | Pipe      | 2.1    | 2.1    | 3.8           | 3.56          | 2.41   | 1.9           | 1.9           | 2.15          | .98    | .98    | 1.9           |
|                                             |             | Shear Ram | 4.7    | 4.7    | 3.8           | 3.56          | 2.4    | 2.2           | 1.9           | 2.15          | 2.2    | 2.2    | 1.9           |
| Max. Hydraulic Operating Pressure (psi)     |             |           | 3000   | 3000   | 3000          | 3000          | 3000   | 3000          | 3000          | 3000          | 3000   | 3000   | 3000          |
| Bonnet Bolts<br>†Torque Required (Ft. Lbs.) |             |           | 1400   | 2350   | 4900<br>*2000 | 8500<br>*2000 | 6750   | 2400<br>*2000 | 7500<br>*2000 | 8500<br>*2000 | 1300   | 900    | 2400<br>*2000 |

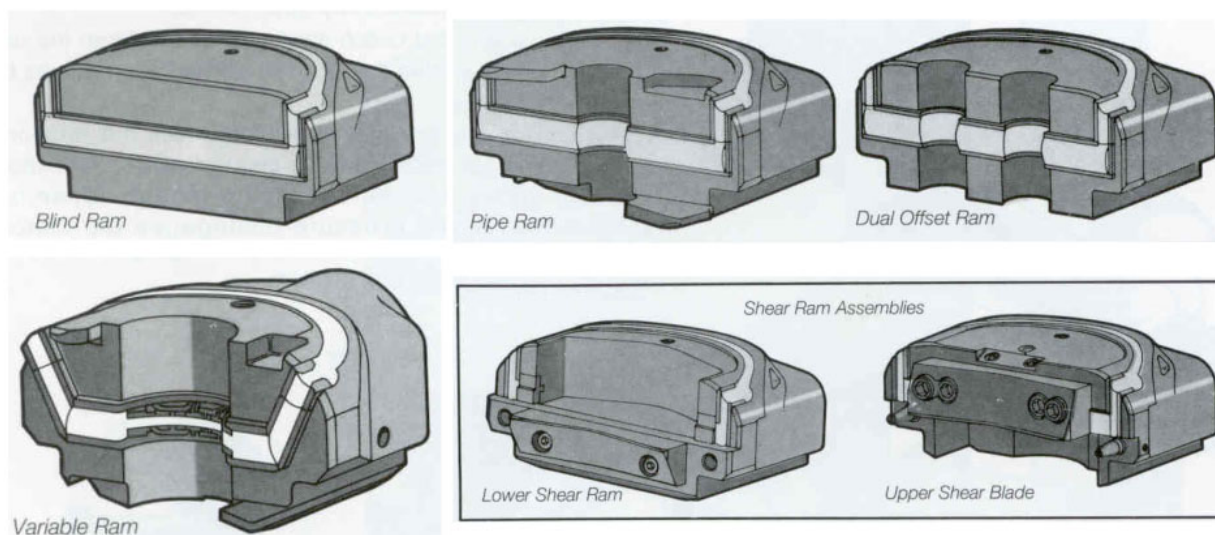
†Based on Hydril Thread Lubricant with coefficient of friction = 0.069

\* Low torque bonnet seal

**- Hydril BOP rams**

**Rams Type**

- Blind Ram
- Pipe Rams
- Variable rams
- Shear rams



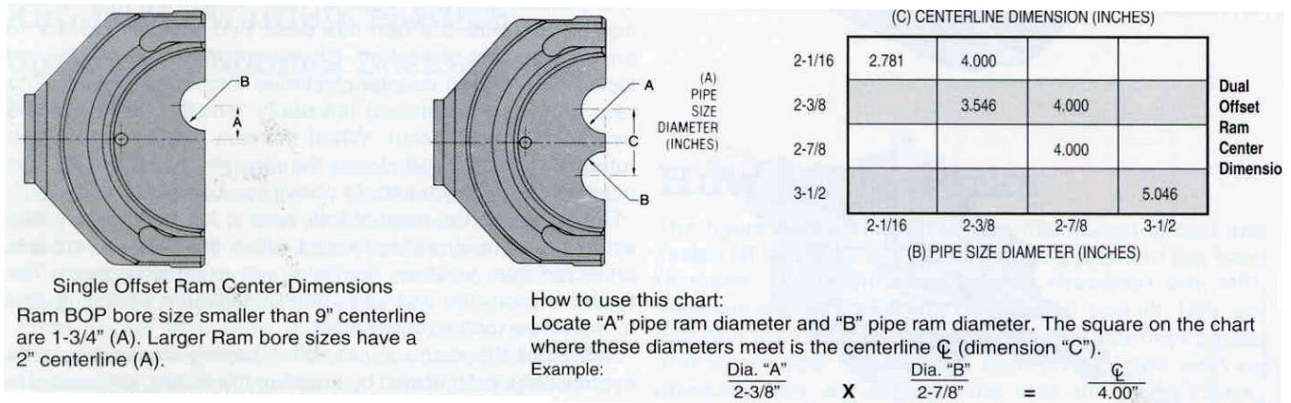


## - Ram Size

**TABLE 1 RAM SIZES FOR HYDRIL BLOWOUT PREVENTERS**

| Bore Size (in.) | Pipe Size   |       |       |       |     |        |       |       |        |    |        |    |        |   |       |   |       |       |
|-----------------|-------------|-------|-------|-------|-----|--------|-------|-------|--------|----|--------|----|--------|---|-------|---|-------|-------|
|                 | Blind Shear | Blind | 1.315 | 1.660 | 1.9 | 2-1/16 | 2-3/8 | 2-7/8 | 3-1/2* | 4* | 4-1/2* | 5* | 5-1/2* | 5 | 6-5/8 | 7 | 7-5/8 | 8-5/8 |
| 7-1/16          |             | ▼     | ▼     | ▼     | ▼   | ▼      | ▼     | ▼     | ▼      | ▼  | ▼      | ▼  | ▼      | ▼ | ▼     | ▼ | ▼     | ▼     |
| 9               |             | ▼     | ▼     | ▼     | ▼   | ▼      | ▼     | ▼     | ▼      | ▼  | ▼      | ▼  | ▼      | ▼ | ▼     | ▼ | ▼     | ▼     |
| 11              | ▼           | ▼     | ▼     | ▼     | ▼   | ▼      | ▼     | ▼     | ▼      | ▼  | ▼      | ▼  | ▼      | ▼ | ▼     | ▼ | ▼     | ▼     |
| 13-5/8          | ▼           | ▼     | ▼     | ▼     | ▼   | ▼      | ▼     | ▼     | ▼      | ▼  | ▼      | ▼  | ▼      | ▼ | ▼     | ▼ | ▼     | ▼     |
| 16-3/4          | ▼           | ▼     | ▼     | ▼     | ▼   | ▼      | ▼     | ▼     | ▼      | ▼  | ▼      | ▼  | ▼      | ▼ | ▼     | ▼ | ▼     | ▼     |
| 18-3/4          | ▼           | ▼     | ▼     | ▼     | ▼   | ▼      | ▼     | ▼     | ▼      | ▼  | ▼      | ▼  | ▼      | ▼ | ▼     | ▼ | ▼     | ▼     |
| 20-3/4          | ▼           | ▼     | ▼     | ▼     | ▼   | ▼      | ▼     | ▼     | ▼      | ▼  | ▼      | ▼  | ▼      | ▼ | ▼     | ▼ | ▼     | ▼     |
| 21-1/4          | ▼           | ▼     | ▼     | ▼     | ▼   | ▼      | ▼     | ▼     | ▼      | ▼  | ▼      | ▼  | ▼      | ▼ | ▼     | ▼ | ▼     | ▼     |

\*Hanging Rams are standard for 13-5/8-15,000, 16-3/4-10,000, 18-3/4-10,000, 18-3/4-15,000 and are optional for 13-5/8-5000, 16-3/4-5000, 21-1/4-2000, and 21-1/4-5000.



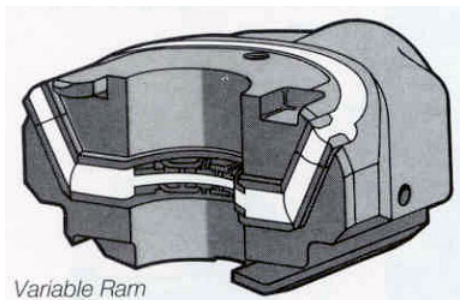
## - HYDRIL variable rams

### Universal Seal Off

The HVR gives a universal seal off feature especially useful on tapered drill strings and drill pipe that does not have a constant diameter over its length. Two ram BOPs with HVRs can be used on a tapered string to provide a backup for all drill pipe sizes. This application eliminates having one pipe ram for small diameter pipe and one for large diameter pipe.

If a BOP stack is assembled with a blind or blind/shear ram and two sets of Hydril Variable Rams 3-1/2" to 5-1/2", providing the backup seal off capability needed on a tapered string.

The HVR is therefore ideally suited for subsea use by expanding the seal off capability of one ram assembly within a BOP.



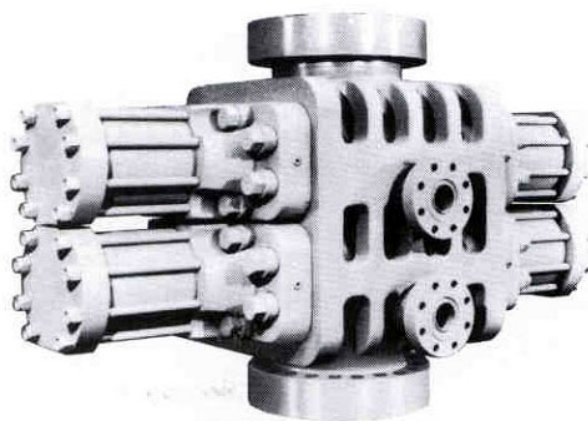
| Variable Ram Assemblies    |                                                          |
|----------------------------|----------------------------------------------------------|
| Ram BOP Size               | Seal Off Range                                           |
| 7-1/16"-3,000/5,000 Sentry | 2-3/8"-2-7/8"                                            |
| 13-5/8"-5,000              | 2-7/8"-5"<br>3-1/2"-5-1/2"<br>3-1/2"-6"<br>4-1/2"-7"     |
| 13-5/8"-10,000             | 2-7/8"-5"<br>3-1/2"-5-1/2"<br>3-1/2"-6"<br>5"-7"         |
| 13-5/8"-15,000             | 3-1/2"-5"<br>5"-7"                                       |
| 18-3/4"-5,000 Conventional | 2-7/8"-5"<br>4-1/2"-7"                                   |
| 18-3/4"-5,000 Compact      | 2-7/8"-5 1/2"<br>3-1/2"-5"<br>3-1/2"-5 1/2"<br>4-1/2"-7" |
| 18-3/4"-10,000             | 3-1/2"-5"<br>3-1/2"-5 1/2"<br>4-1/2"-7"                  |
| 18-3/4"-15,000             | 3-1/2"-5-1/2"<br>5"-7"<br>4-1/2"-7"                      |
| 20-3/4"-3,000              | 2-7/8"-5"<br>4-1/2"-7"                                   |
| 21-1/4"-2,000/5,000        | 2-7/8"-5"                                                |
| 21-1/4"-2,000/5,000        | 4-1/2"-7"                                                |

- SHAFFER RAMS BOP

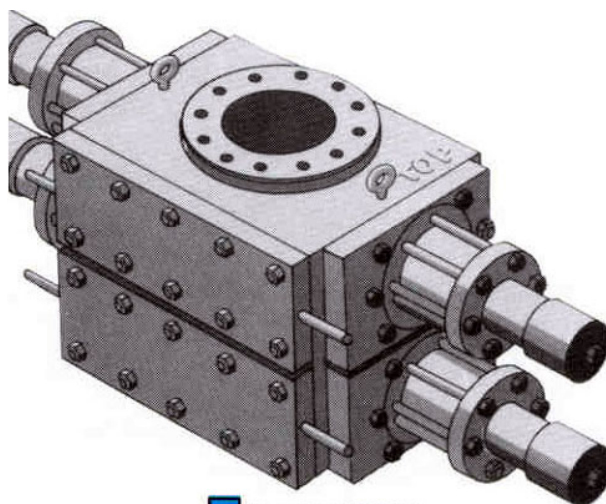
- Shaffer Rams BOP types

- Model SL BOP
- Model LWS BOP

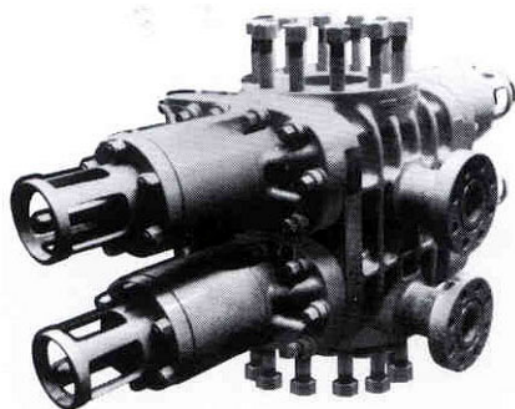
- Model Sentinel BOP
- Model LWP BOP



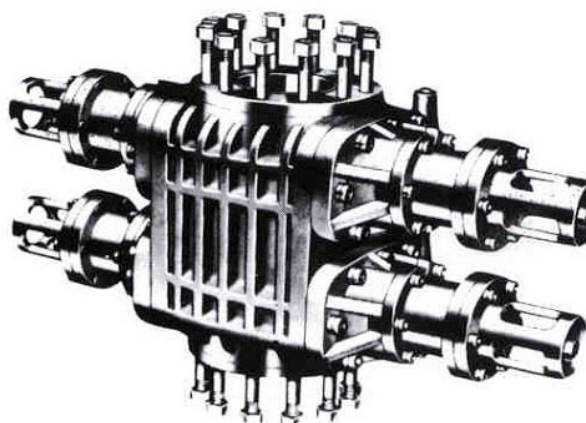
■ Model SL BOP



■ Sentinel BOP



■ Model LWS BOP

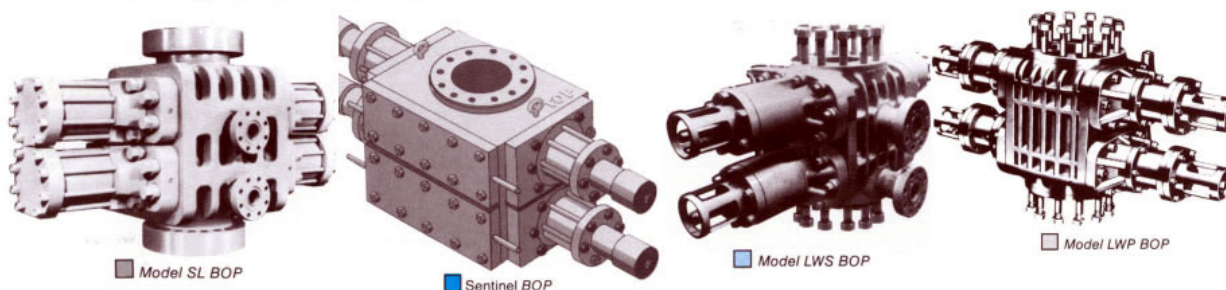


■ Model LWP BOP



## - Shaffer Rams BOP Sizes

| RAM BOP SIZES AND MODELS |                                |                                |   |    |                                |                                |                                |                                |                                |
|--------------------------|--------------------------------|--------------------------------|---|----|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| Working Pressure (psi)   | Bore (in.)                     |                                |   |    |                                |                                |                                |                                |                                |
|                          | 4 <sup>1</sup> / <sub>16</sub> | 7 <sup>1</sup> / <sub>16</sub> | 9 | 11 | 13 <sup>3</sup> / <sub>8</sub> | 16 <sup>3</sup> / <sub>4</sub> | 18 <sup>3</sup> / <sub>4</sub> | 20 <sup>3</sup> / <sub>4</sub> | 21 <sup>1</sup> / <sub>4</sub> |
| 15,000                   |                                |                                |   |    |                                |                                |                                |                                |                                |
| 10,000                   |                                |                                |   |    |                                |                                |                                |                                |                                |
| 5,000                    |                                |                                |   |    |                                |                                |                                |                                |                                |
| 3,000                    |                                |                                |   |    |                                |                                |                                |                                |                                |
| 2,000                    |                                |                                |   |    |                                |                                |                                |                                |                                |



## - Main Features

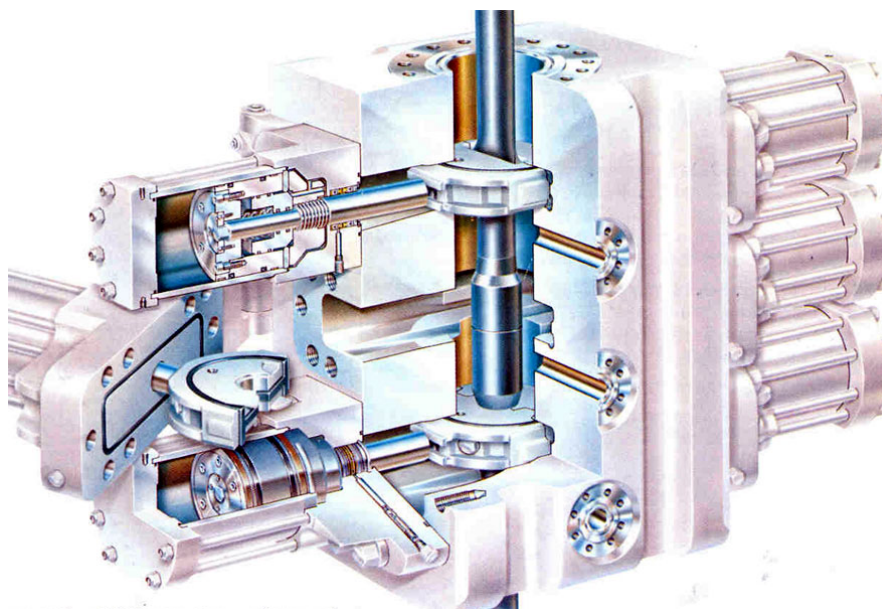
**Self-draining body** has a ram compartment with skids to support the rams and a sloped bottom which allows mud and sand to drain back into the well bore.

This keeps the ram cavity free of caked mud and debris so that the rams stay ready for action.

**Single, double and triple** models are available.

**Full environment H<sub>2</sub>S trim**, conforming to API and NACE requirements, is available.

**Arctic models are available** which meet API specifications for low-temperature service.



## - Operating system

### - Hydraulic passages

Hydraulic passages drilled through the body eliminate the need for external manifold pipes between the hinges.

Each set of rams requires only one opening and one closing line.

There are two opening and two closing hydraulic ports, clearly marked, on the back side of the BOP.

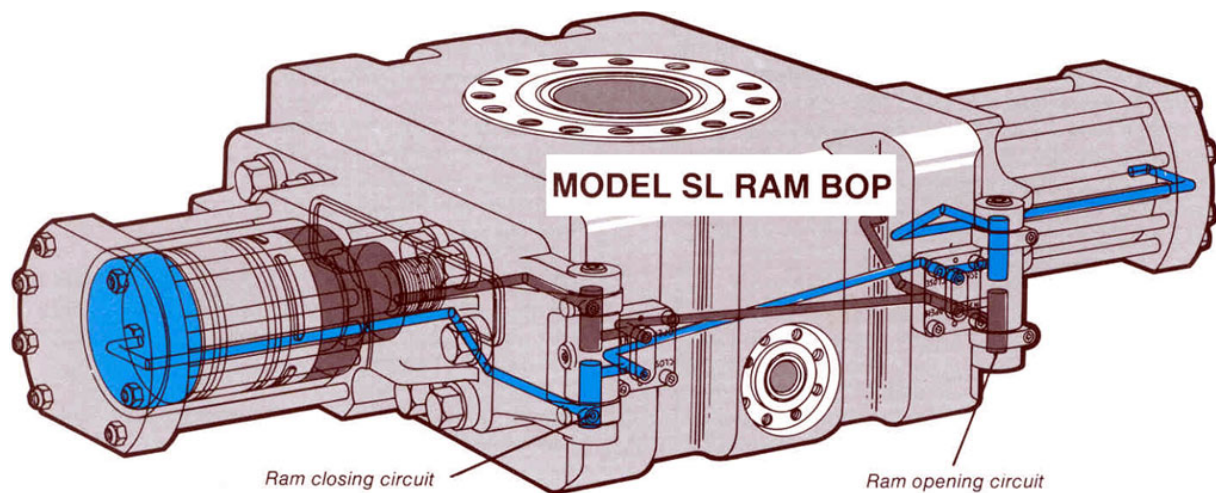
The extra hydraulic ports facilitate connecting the control system to the preventer.

### - Hydraulic pressure

A hydraulic closing unit with 1,500 psi output will close any Model SL ram BOP with rated working pressure in the well bore, except for the 7 1/16", 11" and 13 5/8" - 15,000 psi BOPs, which require 2,200 psi. However, these units will close against 10,000 psi well pressure with less than 1,500 psi hydraulic pressure.

A 3,000 psi hydraulic pressure may be used, but this will accelerate wear of the piston seals and the ram rubbers.

A 5,000 psi hydraulic pressure test is applied to all Model SL cylinders at the factory. However, it is recommended that this pressure not be used in the field application.



Operating system Ram BOP SHAFFER

## Locking system

Ram BOP SHAFFER locking system

- Automatic lock system
- Manual lock system

### - Automatic lock system

Model SL Poslock & Multilock Systems

SL preventers equipped with Poslock or Multilock pistons are locked automatically in the closed position each time they are closed. The preventers will remain locked in the closed position even if closing pressure is removed. Open hydraulic pressure is required to reopen the pistons.



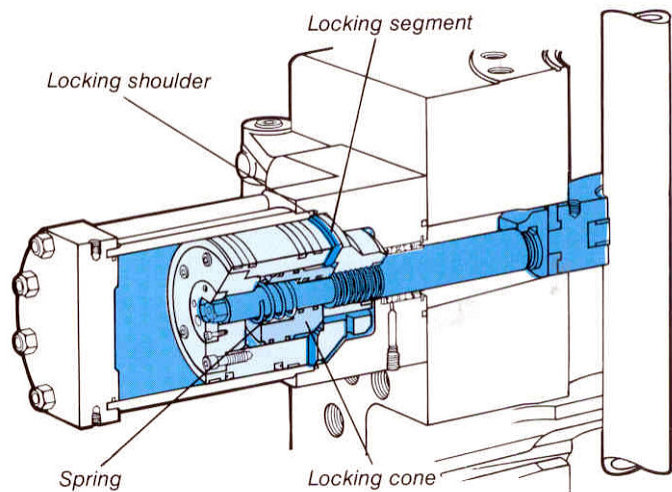
The Poslock and Multilock systems both utilize locking segments to achieve the positive mechanical lock. The Poslock System has one set of segments and provides for one position locking which is the maximum requirement for standard pipe rams. The Multilock System has two sets of segments thus allowing a range of locking positions which is required when multirams are utilized. Multilocks accommodate for most multiram ranges offered, however the ranges covered for a selected multiram should be verified with the SHAFFER representative.

The hydraulics required to operate the Poslock are provided through opening and closing operating ports. Operation of the Poslock requires no additional hydraulic functions, such as are required in some competitive ram locking systems.

#### - Close Position

When closing hydraulic pressure is applied, the complete piston assembly moves inward and pushes the rams into the well bore. As the piston reaches the fully closed position, the locking segments slide toward the piston O.D. over the locking shoulder while the locking cone is forced inward by the closing hydraulic pressure.

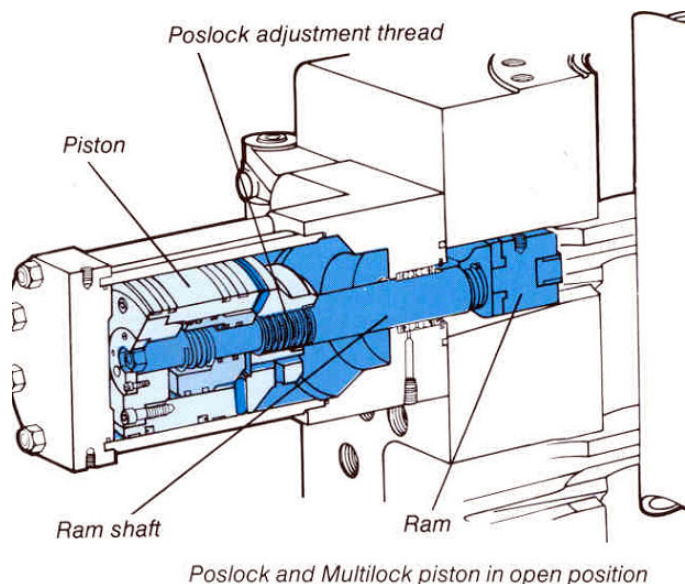
The locking cone holds the locking segments in position and is prevented by a spring from vibrating outward if the hydraulic closing pressure is removed. Actually, the locking cone is a second piston inside the main piston. It is forced inward by closing hydraulic pressure and outward by opening hydraulic pressure.



#### - Open position

When opening hydraulic pressure is applied, the locking cone moves outward and the locking segments slide toward the piston I.D. along the tapered locking shoulder.

The piston is then free to move outward and open the rams.



#### NOTE ( Pistons adjustment )

Poslock and Multilock pistons are adjusted in the factory and normally do not require adjustment in the field except when changing between pipe rams and shear rams.

The adjustment is easy to check and easy to change.

## Manual lock system

### - Model SL Manual-Lock System

Manual-lock pistons move inward and close the rams when closing hydraulic pressure is applied. If desired, the rams can be manually locked in the closed position by turning each locking shaft to the right until it shoulders against the cylinder head.

Should hydraulic pressure fail, the rams can be manually closed and locked.

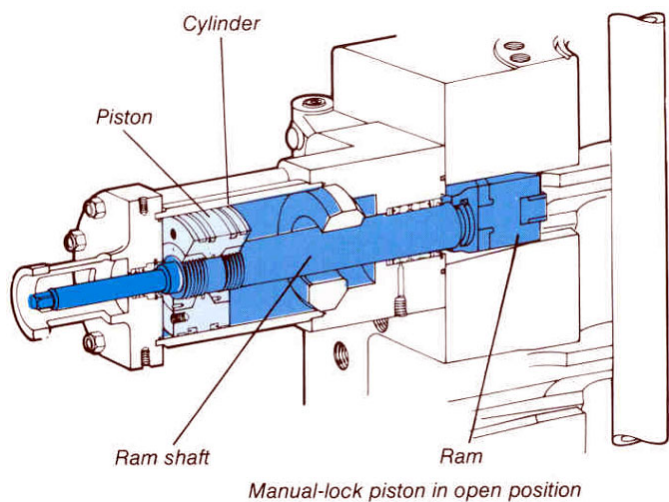
They cannot be manually reopened.

The manual locking shafts are visible from outside and provide a convenient ram position indicator.

Threads on the manual locking shaft are enclosed in the hydraulic fluid and are not exposed to corrosion from mud and salt water or to freezing.

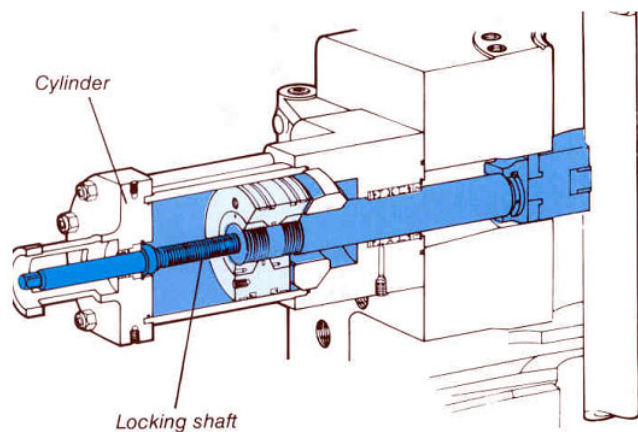
### - Open position

Rams are opened by first turning both locking shafts to their unlocked position, then applying opening hydraulic pressure to the pistons, which move outward and pull the rams out of the well bore.



### - Close Position

Manual lock-piston in closed and locked position



## - SHAFFER BOP Rams

### - Model SL-D rams

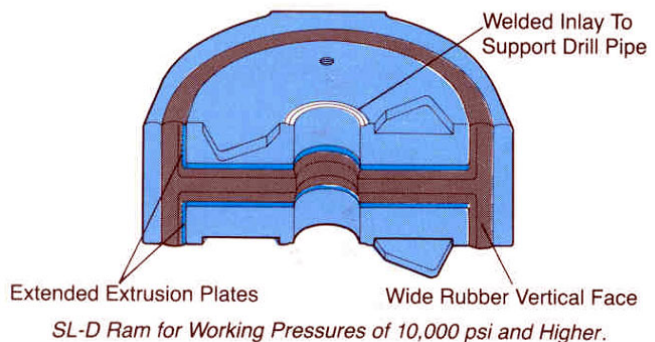
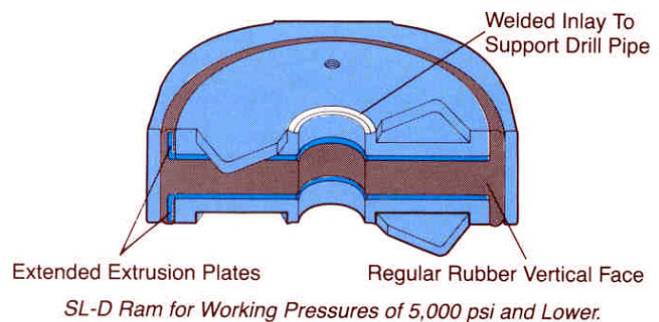
Model SL-D rams will support a 600,000-pound drill string load when a tool joint is lowered onto the closed rams.

These rams comply with API and NACE H2S specifications.

A patented, \*H2S-compatible, hard inlay is welded around the pipe bore to cut into the 18 taper on the bottom of the tool joint and from a supporting shoulder. The remainder of the ram block is alloy steel with hardness below Rc22.

### - SL Ram Mounting

SL Rams Mount Horizontally on Preventer Rated for Working Pressures of 10,000 and Lower except 7 1/16" 10,000 psi

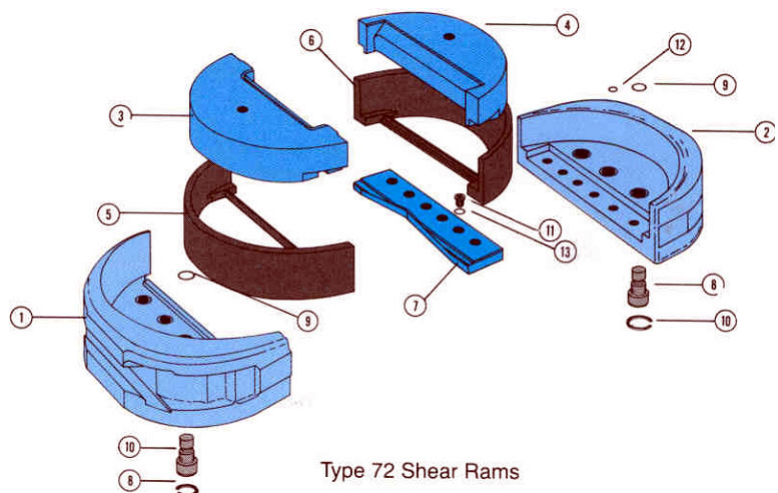


### - Type 72 Shear Rams

For 21 1/4" 2,000 psi Model LWS

For 20 3/4" 3,000 psi Model LWS

For 7 1/16" and 11" 5,000 psi Model LWS



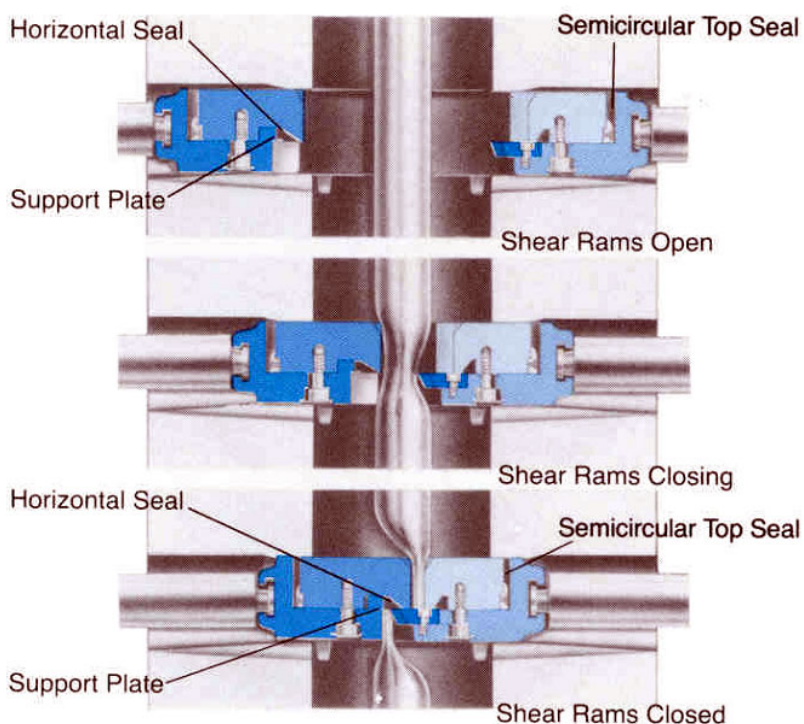


### - Shear Pipe Operation

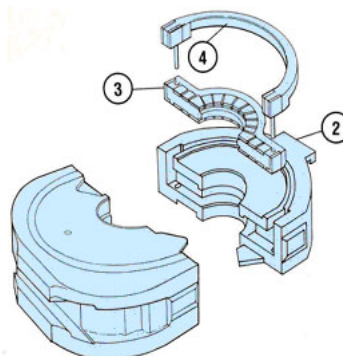
Type 72 shear rams shear pipe and seal the well bore in one operation.

They also function as blind or CSO (Complete Shut-Off) rams for normal operations.

The hydraulic closing pressure normally required to shear drill pipe is below 1,500 psi accumulator pressure in BOPs with 14" pistons. However, this varies, depending on the size, weight and grade of pipe.



### - Multy Rams



| Working Pressure (psi)    | 15,000 |        |        | 10,000 |        |        |        |        |       |
|---------------------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| Bore (inches)             | 18 3/4 | 7 1/16 | 7 1/16 | 18 3/4 | 18 3/4 | 16 3/4 | 13 5/8 | 13 5/8 | 11    |
| Lower Range               | 3 1/2  | 2 3/8  | 2 3/8  | 3 1/2  | 3 1/2  | 3 1/2  | 3 1/2  | 3 1/2  | 3 1/2 |
| Upper Range               | 5      | 3 1/2  | 3 1/2  | 5 1/2  | 5      | 5      | 5      | 5      | 5     |
| Pipe Suspension (000 LBS) |        |        |        |        |        |        |        |        |       |
| 3 1/2                     | 200    | N/A    | N/A    | 200    | 200    | 200    | 200    | NO     | NO    |
| 4                         | 200    | N/A    | N/A    | 200    | 200    | 200    | 200    | NO     | NO    |
| 4 1/2                     | 400    | N/A    | N/A    | 200    | 400    | 400    | 400    | 400    | 400   |
| 5                         | 600    | N/A    | N/A    | 600    | 600    | 600    | 600    | 600    | 600   |
| 5 1/2                     | N/A    | N/A    | N/A    | 600    | N/A    | N/A    | N/A    | N/A    | N/A   |

## 32.4 INSPECTIONS

The BOP Ram Preventers shall be inspected (modally and frequency) according to the manufacturer's recommendations and as per API RP 53.

ENI requirements are defined by an internal specification that stipulates the Ram BOP shall be recertified by a Manufacturer authorized workshop at least every five years.



### 33. BOP CONTROL SYSTEM

#### INDEX

- 33.1 FUNCTION
- 33.2 RESPONSE TIMES
- 33.3 MAIN COMPONENTS
  - ACCUMULATOR UNIT
  - DRILLER CONTROL PANEL
  - SECONDARY CONTROL PANEL (Remote)
- 33.4 ACCUMULATOR OPERATIONS
- 33.5 INSPECTIONS

#### 33.1 FUNCTION

##### - Description

Accumulators produce and store hydraulic energy to be used when BOP must be closed rapidly because of emergency conditions. It's equipped with the necessary controls to actuate BOP's and hydraulic valves during drilling and in case of a blowout.

BOP control system must provide :

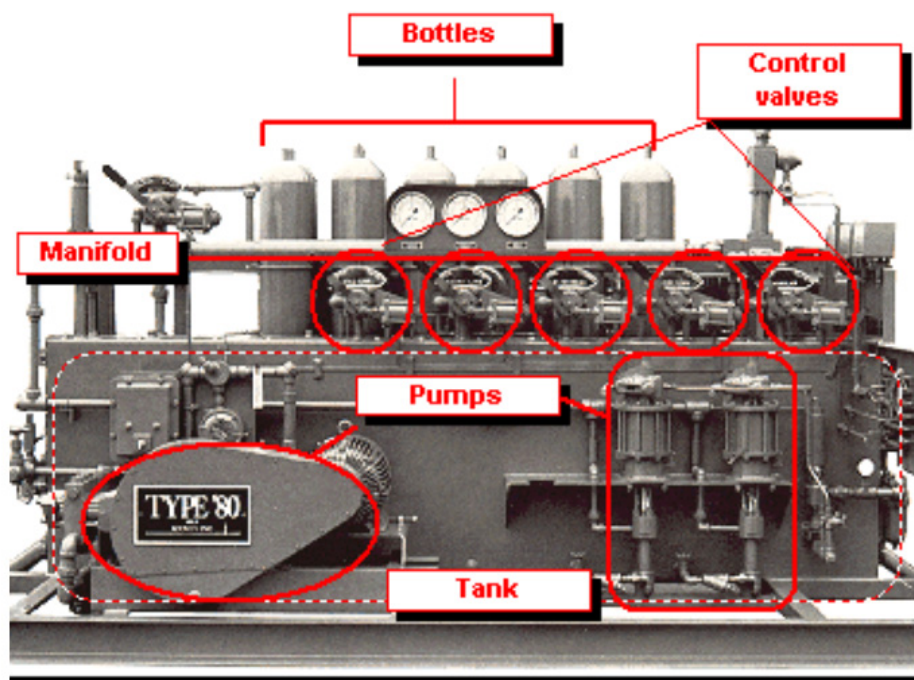
- A minimum pre-determined pressurized volume to operate all BOP functions in an emergency situation.
- Reasonable accumulator recharge time.

##### - Nomenclature

The Accumulators is composed by:

- a tank containing hydraulic fluid (oil) at atmospheric pressure;
- one or more high-pressure pumping units to pressure fluid;
- nitrogen precharged bottle to store pressurized fluid.

The high-pressure control fluid is conveyed to a manifold and sent to closing mechanisms through provided control valves.



- Manufacture specifications

Surface BOP Control System are manufactured according to API 16D and API RP 53.

ENI requirements are defined by "Well control policy" and an internal specification".

### 33.2 RESPONSE TIMES

#### - Response times

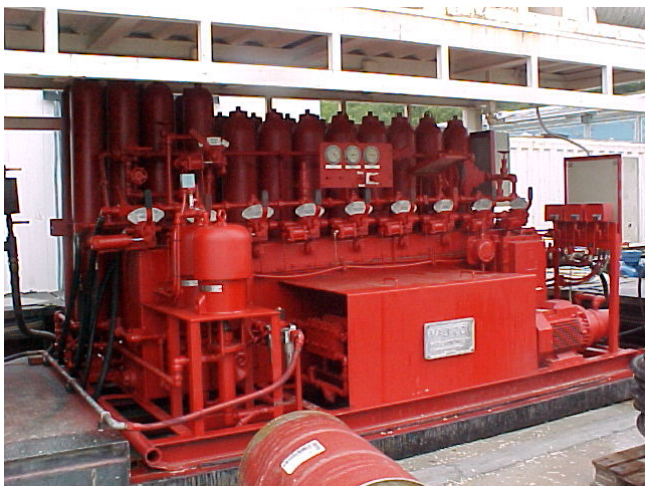
API RP 53 and ENI Well Control Policy stipulate:

- **Closing response for a Ram BOP max 30 seconds**
- **Closing response for a BAG BOP 18" max 30 seconds**
- **Closing response for a BAG BOP >18" max 45 seconds**

#### - Pumps system charging time

The subsea control system should have a minimum of two independent pump systems (i.e. one electric and one pneumatic or two electric powered by two separate electrical power sources).

The combination of all pumps should be capable of charging the entire accumulator system from the established minimum working pressure to the maximum rated system pressure in **fifteen minutes or less**.



Accumulator



Accumulator Pumps

#### - ACCUMULATORS CAPACITY

##### - Accumulator Dimension

The accumulator is dimensioned depending on the required fluid total volume to carry out a given number of closing-opening operations (Volumetric capacity) and on the bottle fluid actually usable (Usable fluid volume).

For the accumulator dimensioning the following values are to be considered:

- precharging pressure; it is the initial pressure with bottles filled with nitrogen only (1000 psi);
- working pressure; it is the final pressure with bottles filled with control fluid (3000 psi).
- minimum working pressure; it is the minimum pressure value which allows the accumulator to be used (which is 200 psi above the precharging pressure)

ENI requirements are more strict than API.

### Surface BOP accumulator capacity by ENI Well Control:

The **capacity of the accumulators** should be, at least, equal to the volume (V1), necessary to close and open all BOP functions installed on stack once, plus 25% of V1.

The liquid reserve remaining on accumulators should still be the minimum operating pressure of 1,200 psi (200 psi above the precharge pressure)

$$V_t = \frac{V_1}{P_a / P_{min} - P_a / P_{max}}$$

Where:

- V<sub>t</sub> = Accumulators total Volume
- V<sub>1</sub> = needed volume included 25% of safety factor
- P<sub>a</sub> = precharged nitrogen pressure
- P<sub>min</sub> = pressure left after closing and opening operations
- P<sub>max</sub> = max accumulator pressure allowed

Note: more stricted requirements are requested by ENI Well Control Policy for the Underwater BOP.

### - Accumulator capacity calculation

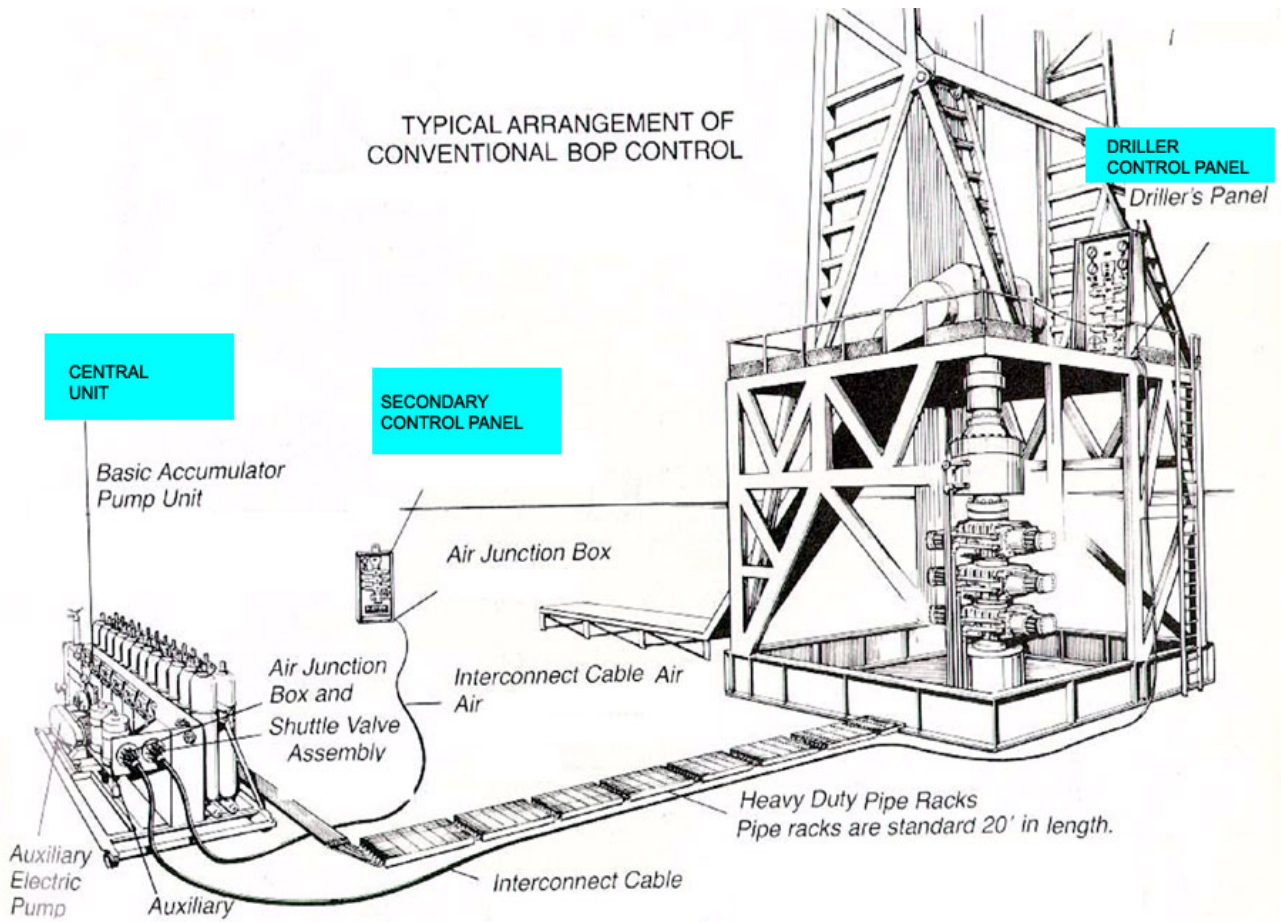
BOP 13 5/8 15.000 psi :Control system 3000 psi - precharge 1000 psi

| TYPE BOP                            | open-gal  | close-gal |
|-------------------------------------|-----------|-----------|
| Hydril GK 13 5/8 10.000             | 26,5      | 37,18     |
| Cameron 13 5/8 15000 U - pipe rams  | 10,4      | 10,6      |
| Cameron 13 5/8 15000 U - pipe rams  | 10,4      | 10,6      |
| Cameron 13 5/8 15000 U - pipe rams  | 10,4      | 10,6      |
| Cameron 13 5/8 15000 U - shear rams | 16        | 16,2      |
| Hydraulic Valve 2 1/16 10k          | 0,153     | 0,162     |
| Hydraulic Valve 4 1/16 10K          | 0,57      | 0,6       |
| <b>total gal</b>                    | <b>74</b> | <b>86</b> |

$$V_t = \frac{(74 + 86) \times 1.25}{1000 / 1200 - 1000 / 3000} = \frac{200}{0,83 - 0,33} = 400 \text{ gal}$$

### 33.3 MAIN COMPONENTS

- CENTRAL UNIT
- DRILLER CONTROL PANEL
- SECONDARY CONTROL PANEL (Remote)



Typical Arrangement of Conventional BOP Control



## - ACCUMULATOR UNIT

Accumulators produce and store hydraulic energy to be used when BOP must be closed rapidly because of emergency conditions.

It is equipped with the necessary controls to actuate BOP's and hydraulic valves during drilling and in case of a blowout.

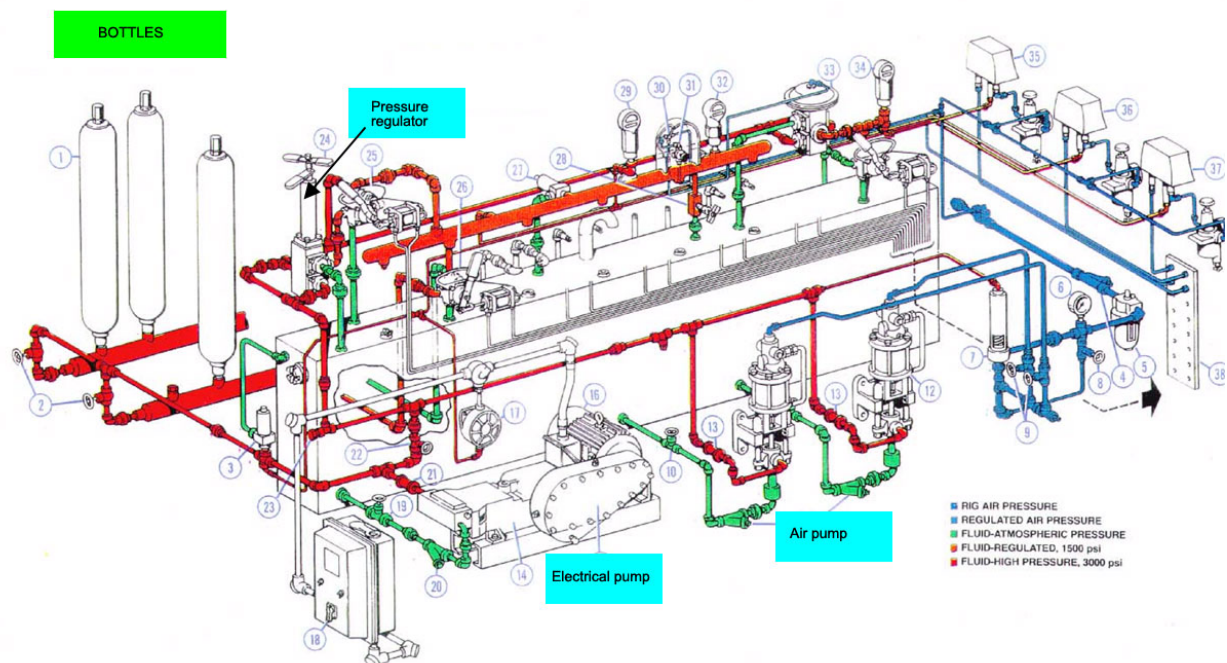
### - Components and Nomenclature

The accumulators is composed of:

- a tank containing hydraulic fluid (oil) at atmospheric pressure;
- one or more high-pressure pumping units to pressurise fluid;
- nitrogen precharged bottles to store pressurised fluid

The high-pressure control fluid is conveyed to a manifold and sent to closing mechanisms through provided control valves.

### - Accumulator Unit - Nomenclature



### - Bottles

Bottles must work at pressure values below their maximum working pressure value.

Precharging pressure must be read whenever an installation is started and checked and regulated in the following, if necessary.

To accomplish pressurisation use nitrogen.

### - Valves and pressure gauges

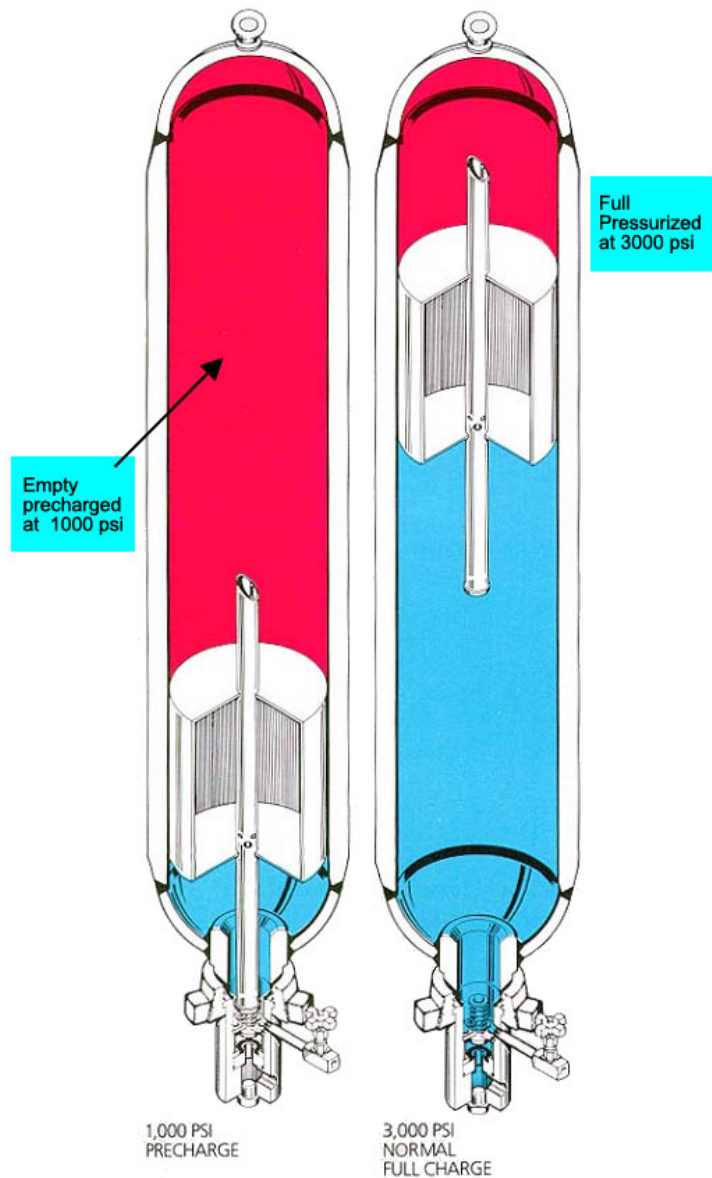
When the bottles are installed on more than one manifold, suitable valves must be installed to allow isolation of each manifold.

The working pressure of these valves must be the same as that of the accumulator and must be kept open, except when the accumulator is not working.

A pressure gauge for the precharging pressure check must always be available.

### - Precharge and Full charge

- Empty precharged at 1000 psi
- Full Pressurized at 3000 psi



Accumulator Precharge and Full charge

### - Charging pumps

Each accumulator must be equipped with a sufficient number of pumps to carry out the following:

1. pump capability; when the bottles are excluded, the pumps must allow, within a maximum two-minute time:
  - close the annular BOP
  - close one pipe-ram BOP with the same diameter as the pipes being used
  - open the hydraulic valve on the choke line
  - raise the manifold pressure to a value which equals the precharging pressure plus 200 psi (see pump capability test)
2. charging time; the use of all of the pumps must allow the accumulator to be charged from the pre-charging pressure value up to the maximum working pressure value within a maximum 15 minute time.

3. working pressure; the installed pumps must keep a working pressure equal to the accumulator working pressure (3000 psi)

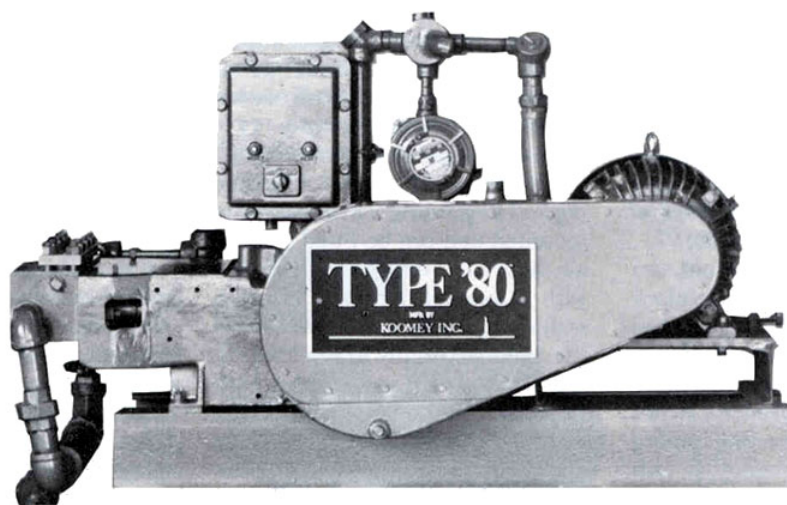
4. power requirement; the necessary power to allow the pumps to function must always be available to allow them to start automatically whenever the pressure value decreases below 90% of the working pressure (2700 psi for 3000 psi working pressure values).

- For safety reasons, two or three independent power sources must be available for each accumulator, each of them meeting the above requirements (point 1) to allow pump operation.

- A double power source combining electric power and compressed air is recommended.

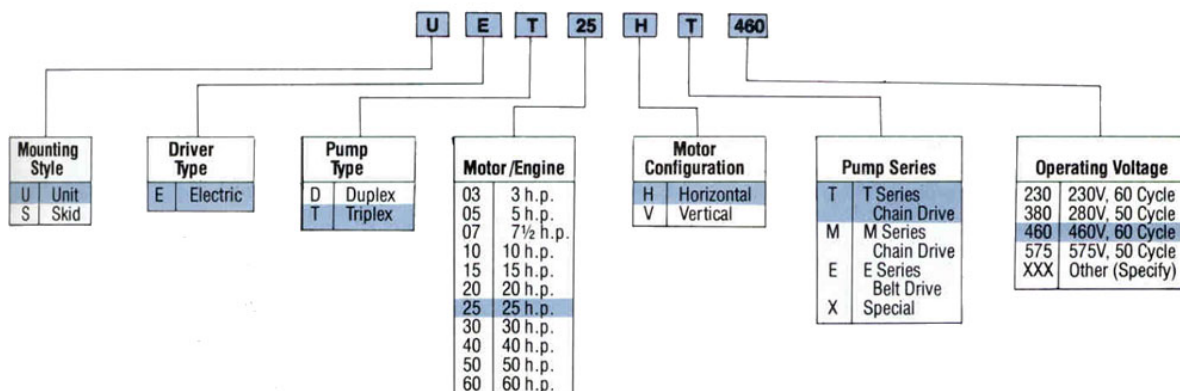
### - Electrical pump

Conventional - Electric, Motor Driven Pumps



MODEL NO. UET15HT460 ELECTRIC PUMP ASSEMBLY

#### CONVENTIONAL — ELECTRIC, MOTOR DRIVEN PUMPS MODEL NUMBER IDENTIFICATION SYSTEM



- Model Number Identification system

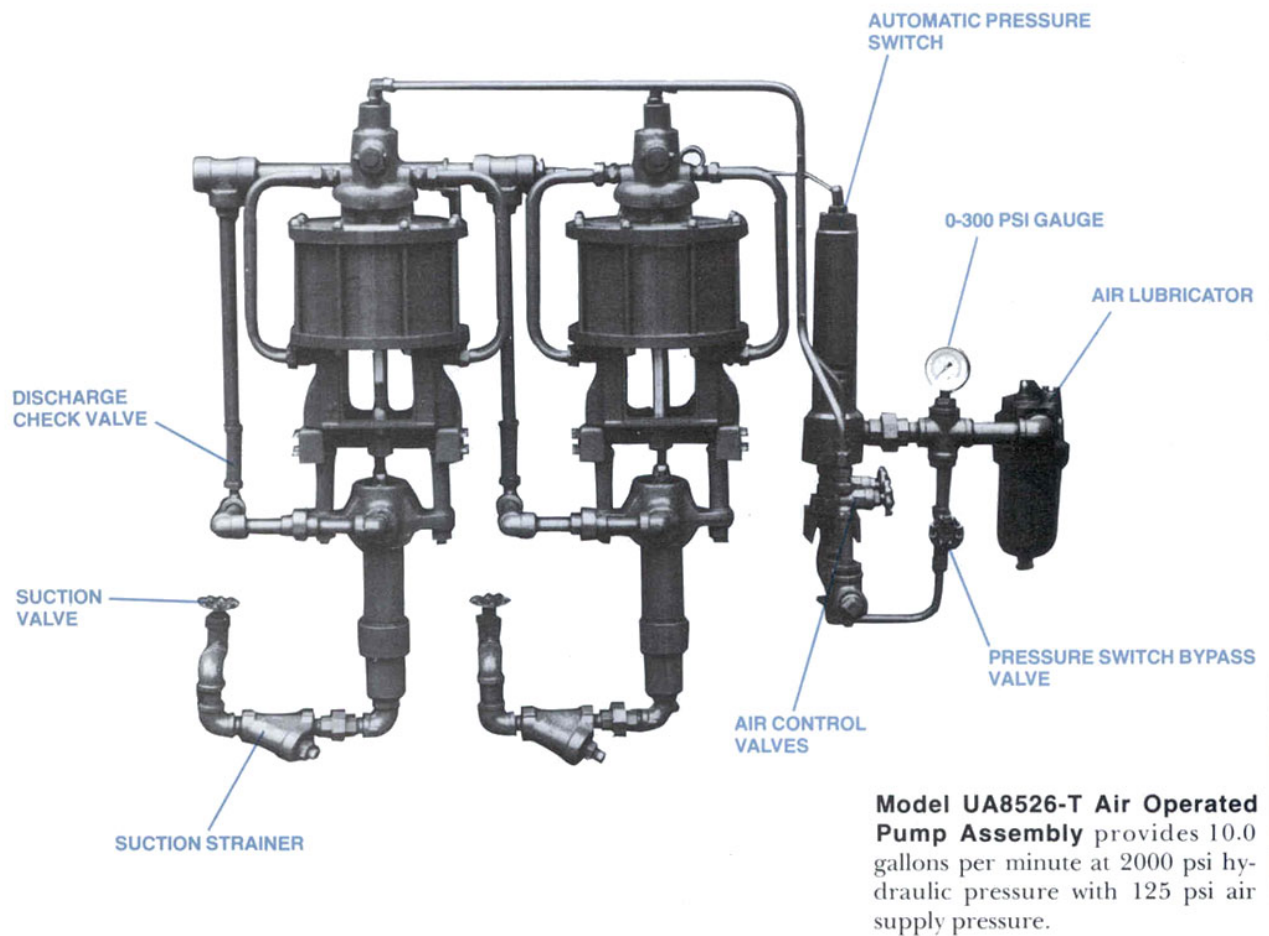
U Mounting Style (U= Unit S= Skid)  
E Driver Type (E = Electric)  
T Pump Type (D= Duplex T= Triplex)

#### U E T 25 H T 460

25 Motor / Engine  
H Motor Configuration (H=Horizontal V=Vertical)  
T Pump Series  
460 Operating Voltage

## - Air Operated pump Assembly

### Conventional - Air Operated pump Assembly



## - Model Number Identification system

### U A 85 26 T - T

|    |                                  |
|----|----------------------------------|
| U  | Mounting Style (U= Unit S= Skid) |
| A  | Driver Type (A = Air)            |
| 86 | Motor Size                       |
| 26 | Pump Quantity & Size             |
| T  | Pump Series                      |

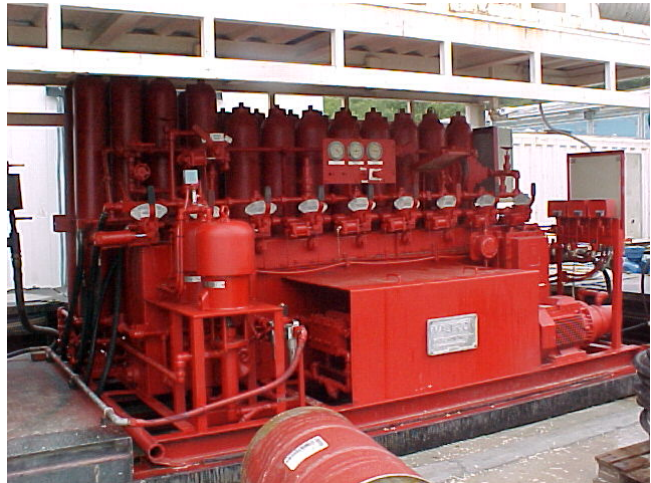


### - Control fluid tank

1. Hydraulic fluid; a suitable hydraulic fluid must be used in the accumulator (hydraulic oil or water with lubricant).

Diesel, motor oil, kerosene or any other similar fluid are not recommended because they can damage the rubber seals.

2. Reservoir capacity; each accumulator must have a tank whose capacity should be at least twice the volume of the usable fluid.



### - Valve connections and other parts

a. three high-accuracy pressure gauges, to read the accumulator, the manifold and the annular BOP pressure;

b. pressure-regulation valve to control the annular BOP pressure value;

c. by-pass valve which allows, when required, to send all the accumulator pressure on the manifold;

d. check valve to separate the two pumps, the bottles and the pressure regulating valve of the BOP from the manifold;

e. full-opening valves on the closing line and on the annular openings;

f. full-opening valve installed on the manifold and equipped with a junction to allow fast connection to another pump;

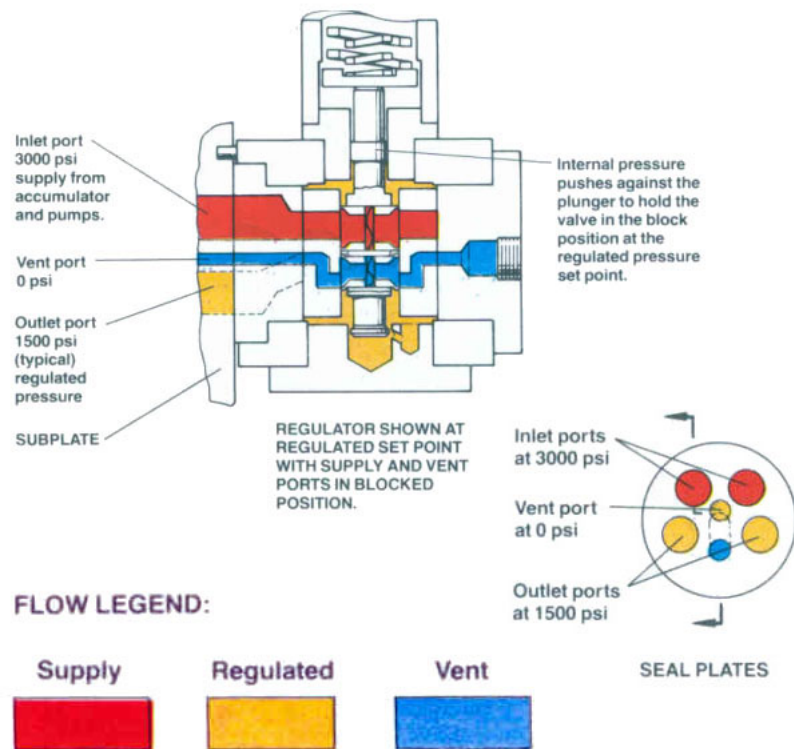
## - Pressure regulators

### - Manual Operated Regulator

This Manual operated TR Regulator includes an internal override and is used as a manifold regulator for operation of the ram preventers and gate valves

### - Remote Operated Regulator

This air operated TR Regulator provides remote regulation for operation of all types of annular preventers.



- Functioning

## - Control Manifold

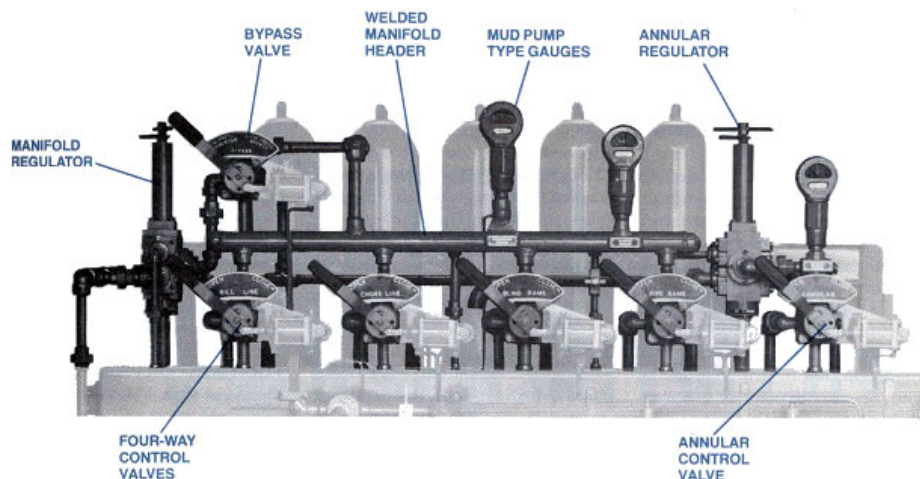
On the closing valves ("4-way valves") the following must be clearly indicated:

- controlled BOP or choke line
- valve position (opened, neutral, closed);

During drilling operations the valves must always be in the following positions:

- BOP valves in the open position (not in neutral position);
- choke line hydraulic valves in the closed position.

The valve controlling the blind rams closure must be equipped with a cover to prevent ram unintentional closure.



## Control Manifold

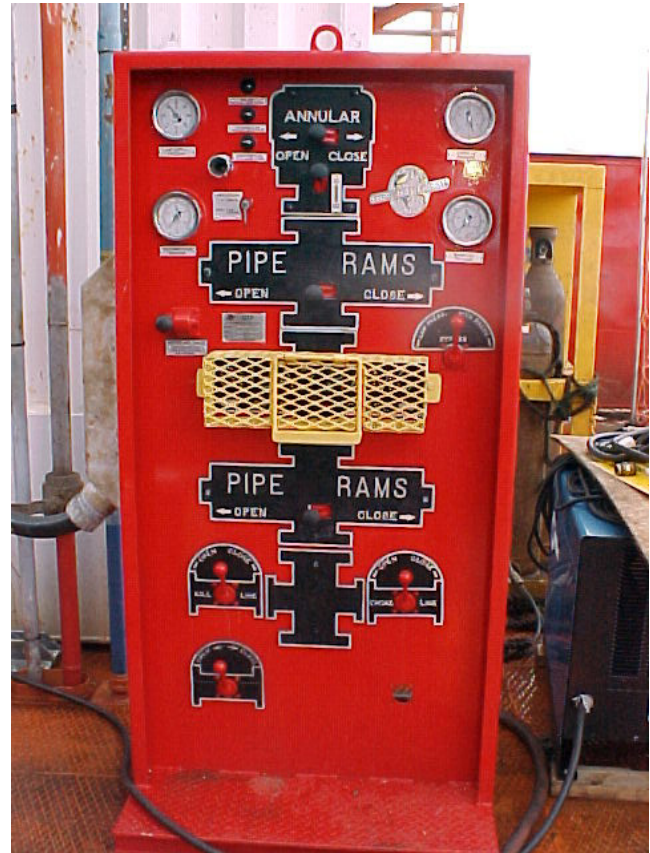
### - DRILLER CONTROL PANEL

The remote-must be installed so that every BOP and every hydraulic valve can be remotely operated.

One remote-control panel must be positioned so that it is easily accessible and another one must be put at a safe distance from the rig floor (for example in the superintendent's office).

The control valves remote control system can be:

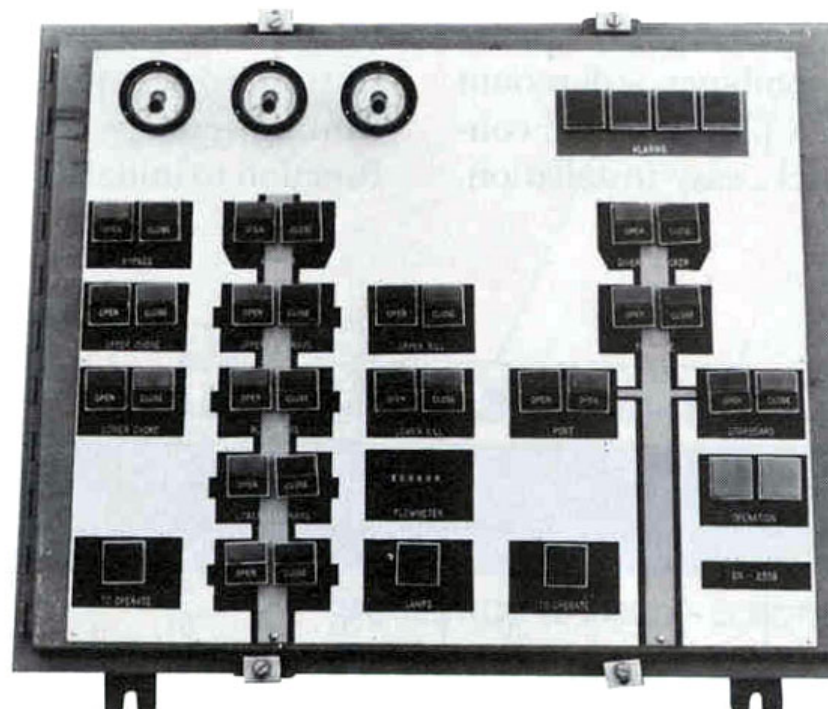
- pneumatic (air)
- hydraulic
- electrical-pneumatic
- electrical-hydraulic



*Drill Floor Control Panel*

### SECONDARY CONTROL PANEL (Remote)

Secondary Control Panel



### 33.4 ACCUMULATOR OPERATIONS

The pressure accumulator functioning is characterised by the following stages:

**a. precharge;** accumulator bottles are filled with nitrogen at the estimated precharging pressure (1000 psi);

**b. charge.** The control fluid is pumped from the tank by the pumps, pressurised and sent to the bottle charging line.

The charging process ends as soon as the accumulator pressure gets to the desired value. (charging pressure 3000 psi);

**c. discharge;** when the control valves are actuated, the pressurised control fluid stored in the bottles is sent to the working lines to set the connected mechanisms to either opening or closure.

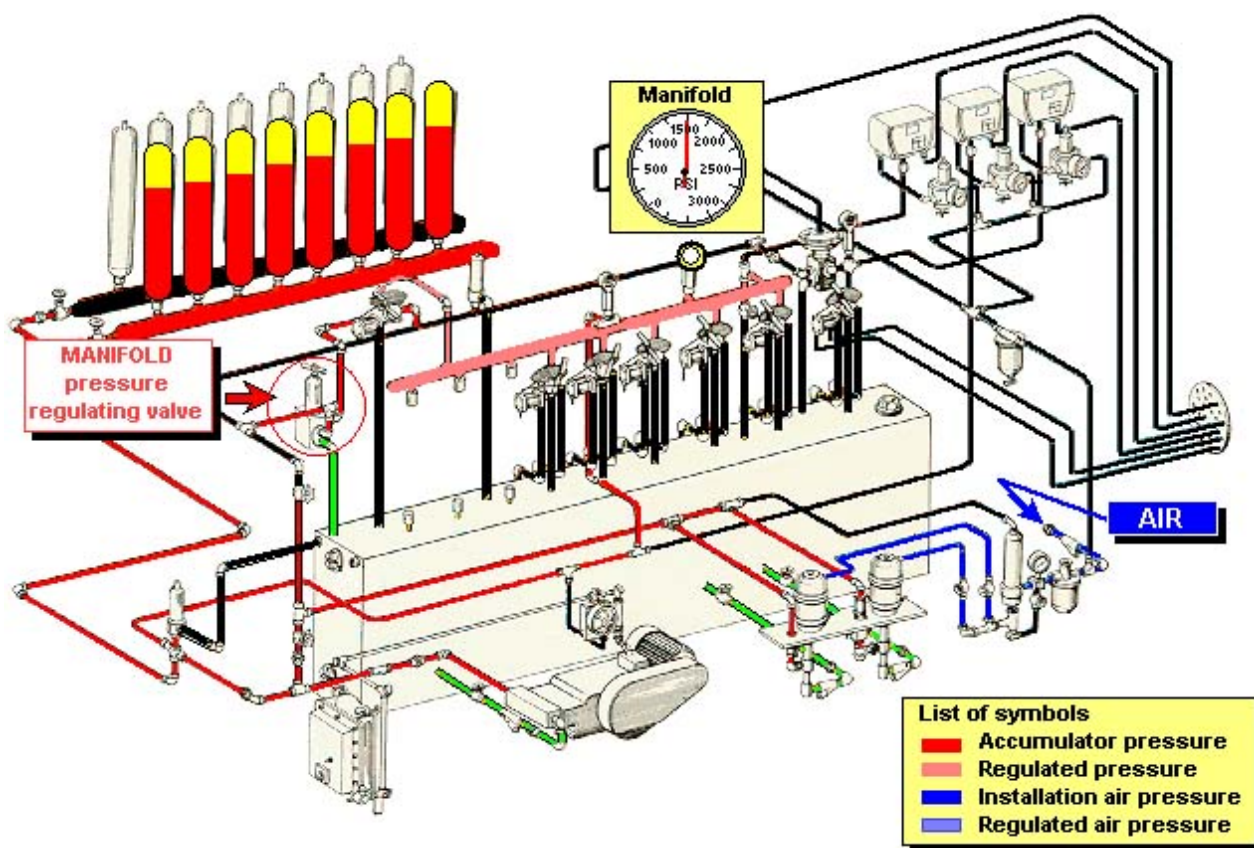
Discharging operations cause a decrease of the accumulator pressure and the pumps may be actuated if the pressure values decrease below the defined limit.

**d. pump control;** adequate pressure automatic switches (hydro-electrical and hydro-pneumatic) allow the pump functioning to be controlled and actuated when the accumulator pressure decreases below the minimum value or stopped when it reaches its minimum allowable value (charging pressure).

**e. regulation;** the control fluid pressure can be adjusted by adequate valves which allow pressure to be reduced and controlled by two regulators:

- the manifold pressure regulating valve controls the ram-BOP and the hydraulic valves opening/closing pressure.
- the annular BOP pressure regulating valve controls the annular BOP opening/closing pressure.





### 33.5 INSPECTIONS

Surface BOP Control system must be inspected according to the manufacturer's recommendations and API RP 53

## 34. INSIDE BOP

### INDEX

#### 34.1 FUNCTION

#### 34.2 TYPES OF INSIDE BOP

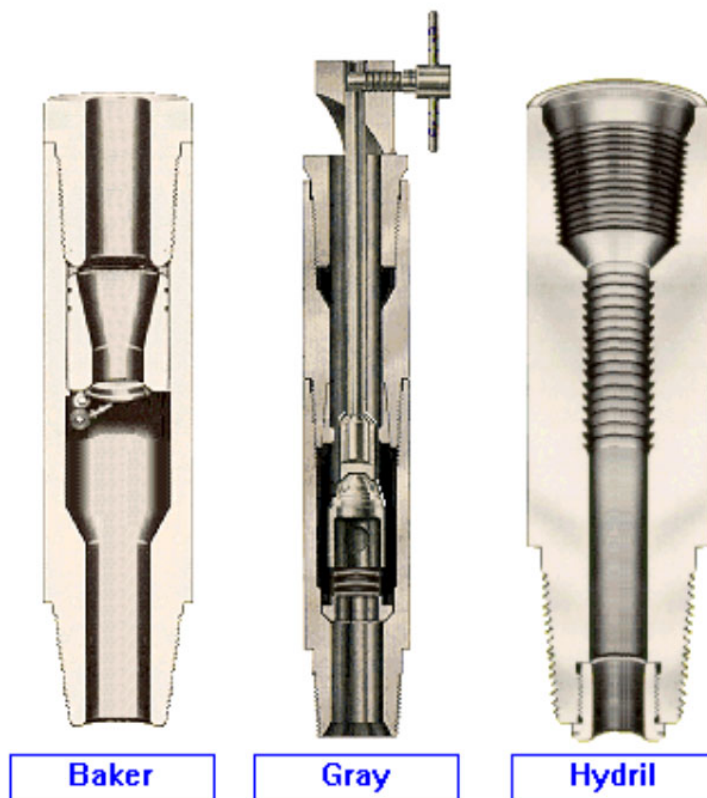
- DROP-IN VALVE
- FLOAT VALVE
- GRAY FLOAT VALVE
- SAFETY VALVES

#### 34.1 FUNCTION

There are several pieces of equipment in addition to the primary blowout prevention equipment that are sometimes necessary to control a kick.

The equipment which furnishes closure inside the drill string is called an "INSIDE BLOWOUT PREVENTER".

They are installed on the top or inside the BHA with the purpose to provide a means of closing the string for well control or even to permit to repair/replace some tools.



Inside BOP

- Manufacture specifications

Inside BOP are manufactured according to API 6A (and API 7 for the connections)

The relevant ISO standard is the 10423 Spec.

### 34.2 TYPES OF INSIDE BOP

- DROP-IN VALVE
- FLOAT VALVE
- GRAY FLOAT VALVE
- SAFETY VALVES

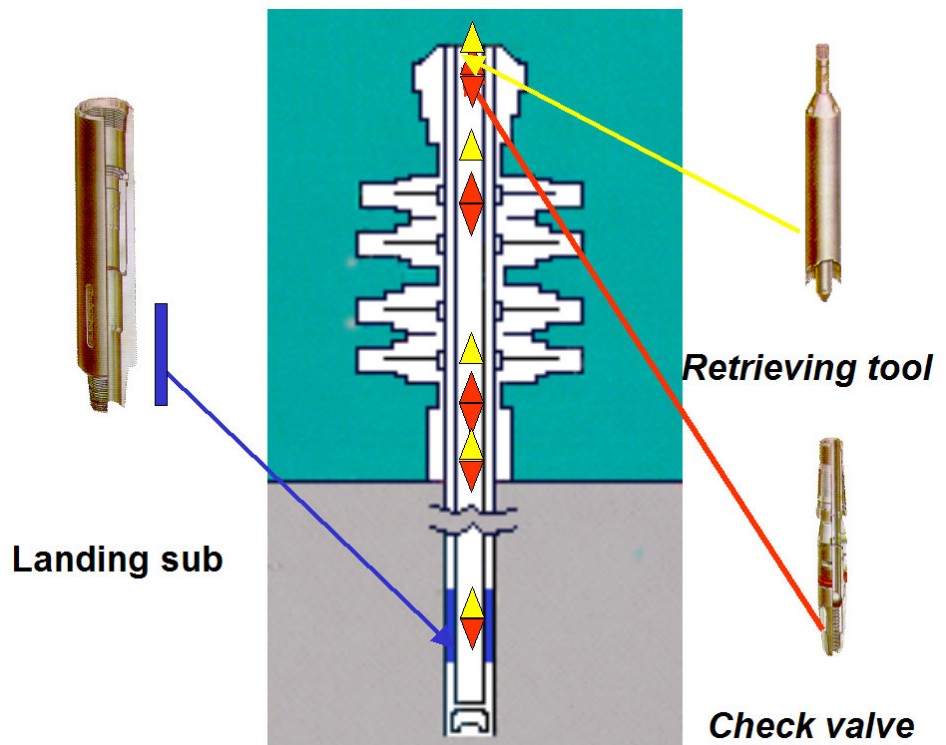
#### DROP-IN VALVE

- Components:

**Landing Sub** installed in the drilling string;

**Check valve:** pump down or drop-in type dropped inside the string and latches inside the landing sub used for stripping or before to cut with shear rams.

**Retrieving Tools** are used if the check valve is wireline retrievable.



Main manufacturer are:

- HYDRIL
- SMF

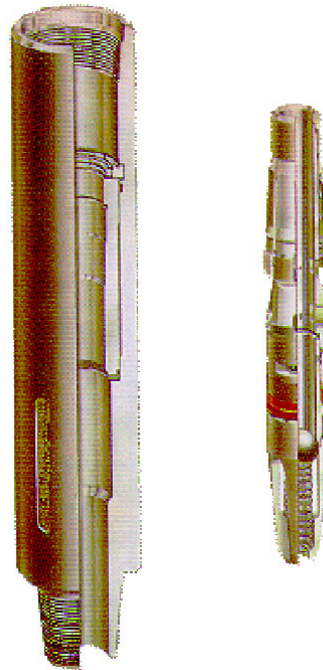
## - HYDRIL DROP-IN VALVE Checkguard

Developed in the 1930s (market pioneer)  
Installed in the lower end of the drill string above the bit to prevent backflow

- Configurations and API specification  
5 configurations

- #19 1 3/16" I.D. thru bore
- #27 1 11/16" I.D. thru bore
- #35 2 3/16" I.D. thru bore
- #43 2 11/16" I.D. thru bore
- #48 3" I.D. thru bore

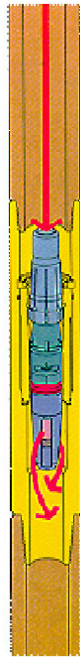
Conforms to API, specification 7



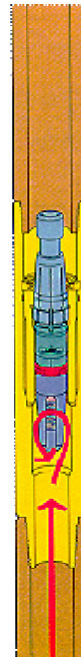
## - Working Principles



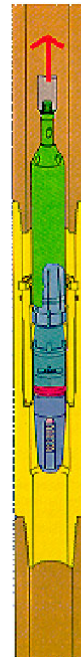
- Installing Checkguard valve



- Pumping down Checkguard valve



- Close Checkguard valve



- Retrieving Checkguard valve

### - Installing Checkguard valve

Checkguard valve is installed as needed. Remaining top side, it is not subject to constant wear as many downhole valves are. Abrasive wear on typical drill pipe float valves results in frequent replacement and can prevent closure.

Only the Checkguard landing sub is installed as the drill string is run.



When control is needed, the valve is pumped down the drill string where it latches automatically in the landing sub.

*- Pumping down Checkguard valve*

Downward flow areas are maximized for high flow capacity and long life.

The check valve sits in the landing sub in the replaceable landing sleeve, latching positively.

The sleeve has recessed areas into which the check valve packer seals.

*- Close Checkguard valve*

Checkguard valve seals pressure up to 15,000 psi.

Yet it is lightweight and easily handled.

The ball closes against upward pressure.

*- Retrieving Checkguard valve*

It is wire-line retrievable.

Wire line retrievable, eliminating the need to trip the drilling string.

Retrieval can also be accomplished after tripping out the drill string.

In this illustration, the retrieving tool unlatches the check valve and lifts it to the surface.

## FLOAT VALVE

Float valve may be considered an INSIDE BOP.

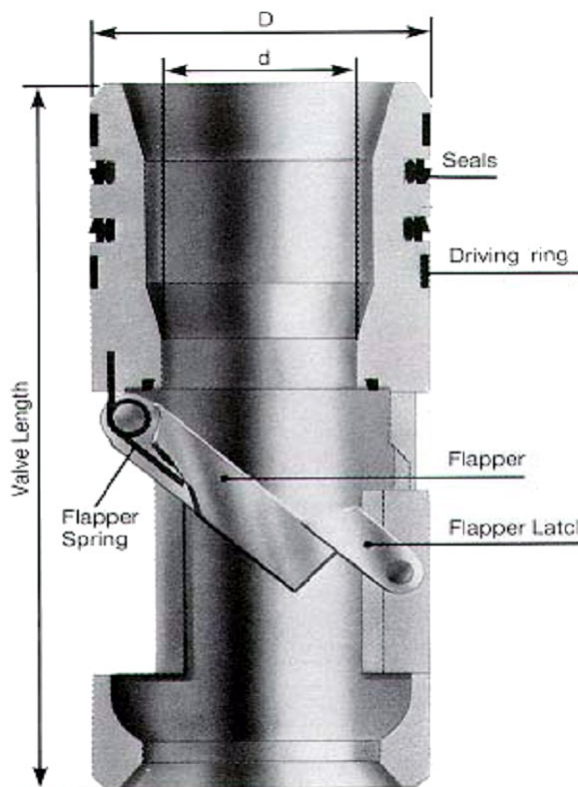
Basically a flapper or poppet type check valve that is installed in the bit sub to prevent backflow during connections.

It allows circulation only in one direction.

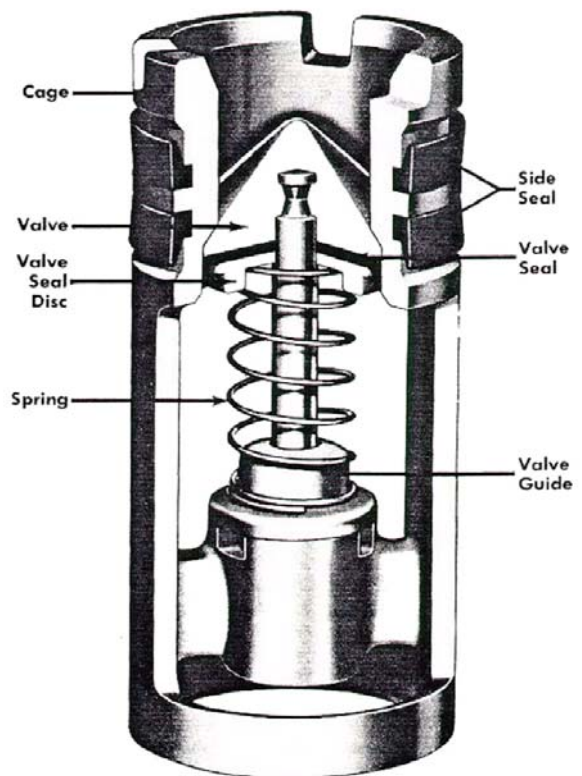
- FVR Float Valve

- Float Valve

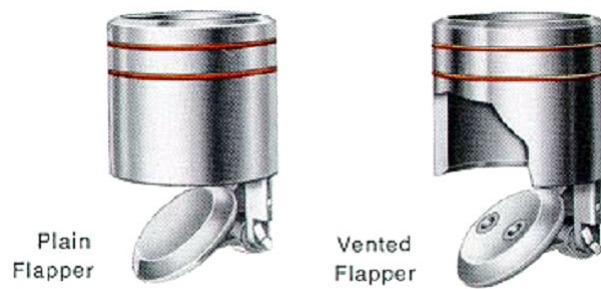
- Plain Flapper and Vented Flapper



FVR Float Valve



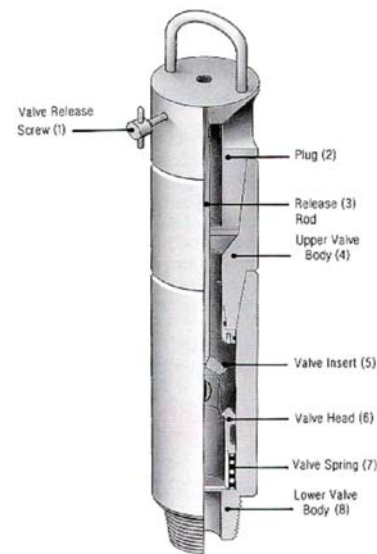
Float Valve



## GRAY FLOAT VALVE

Always on the rig floor ready to be installed, the hold-open type has the back pressure valve pinned in an open position so that the valve can be installed when mud is flowing.

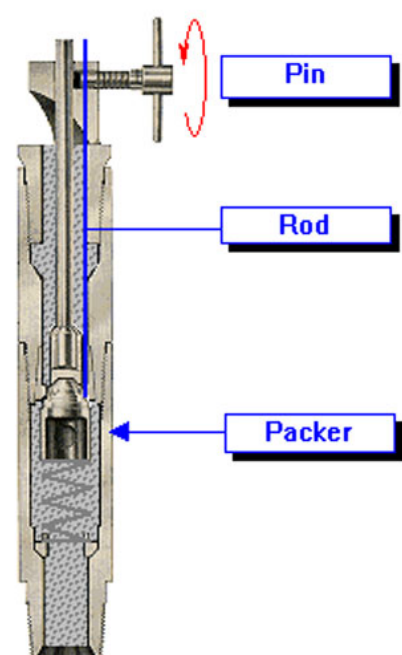
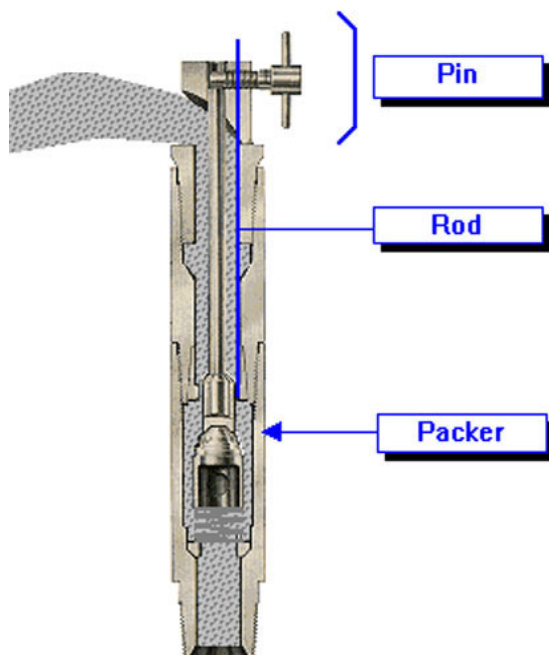
The pin is removed after installation to allow closure.



BVR Valve Assembly

Open position

Close position



## SAFETY VALVES

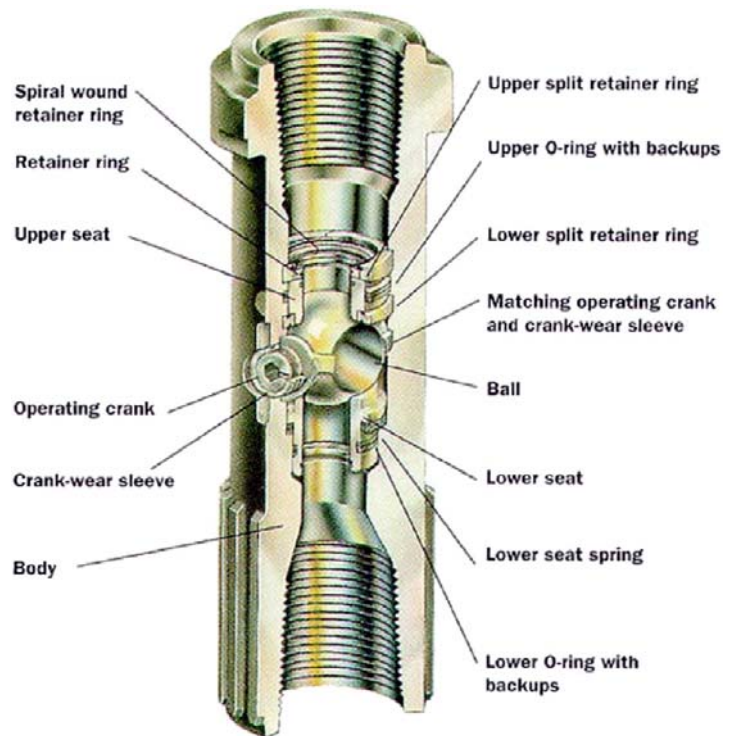
- Kelly Cock
- Rigs with TOP DRIVE
- Actuator Types

### - Kelly Cock

The kelly cock is a safety valve placed above the kelly (UPPER KELLY COCK) and below the kelly (LOWER KELLY COCK).

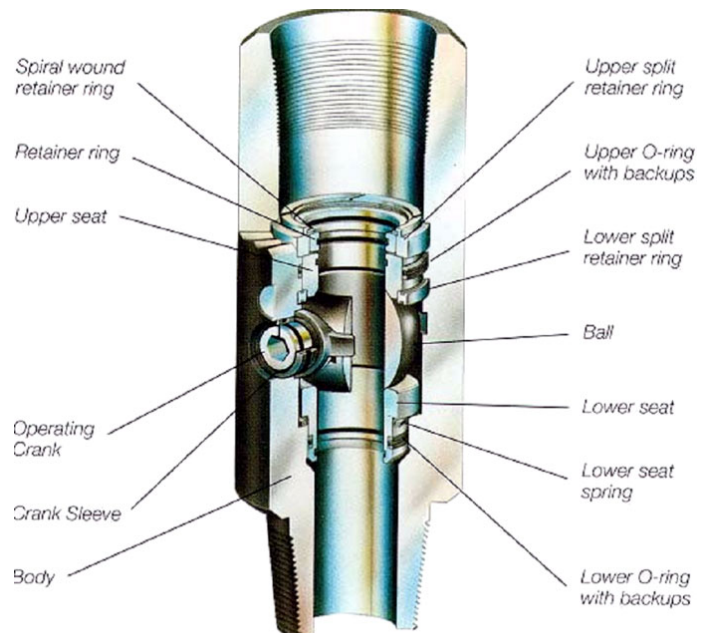
Its basic purpose is to provide a means of closing the string should the swivel, hose, or stand-pipe leak or rupture under conditions of a threatened blowout.

This arrangement permits these items to be repaired or replaced. A special wrench to operate the kelly cock is required and must be taken in a readily accessible place known to every crew member.



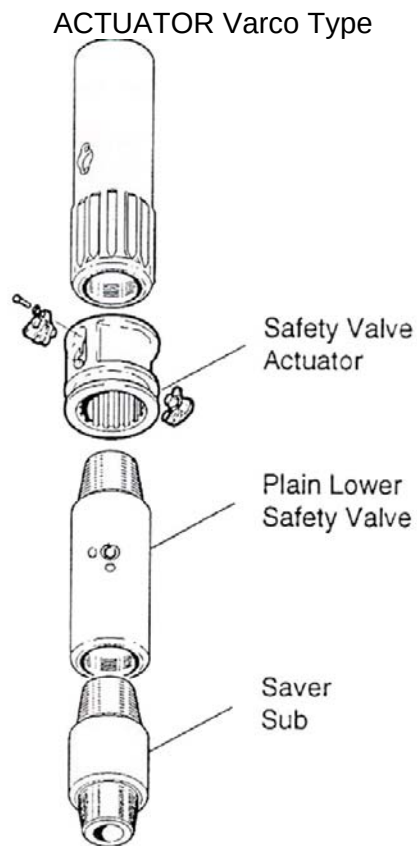
### - Rigs with TOP DRIVE

Rigs with TOP DRIVE have two valves: A manual one on bottom part (lower kelly cock) and one on the top remotely operated (upper kelly cock).

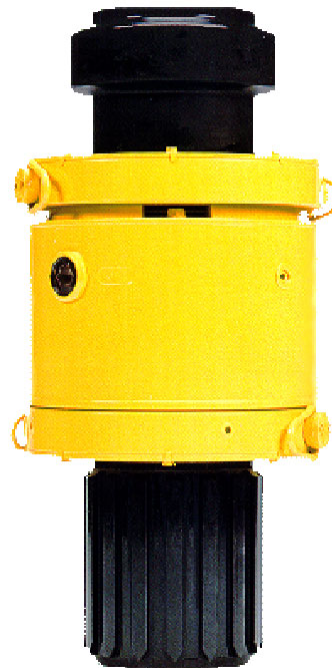


*Cutaway view of standard Hydral Kellyguard in open position.*

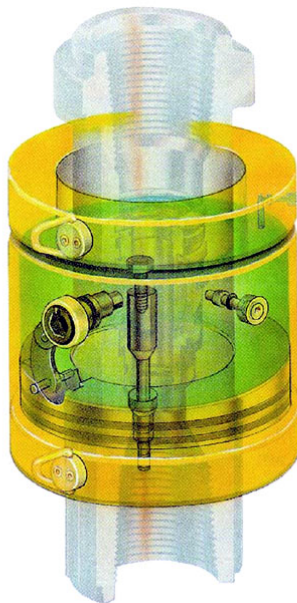
## - Actuator Types



ACTUATOR Hydril Type

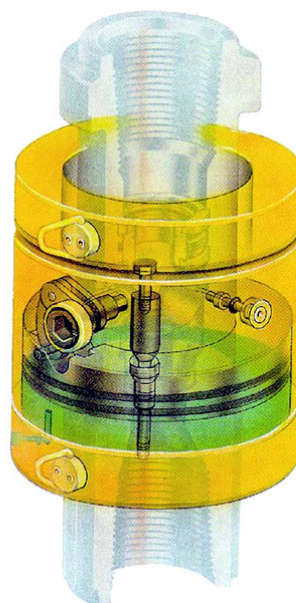


ACTUATOR Hydril Type



**Open.** Annular piston opens and closes Kellyguard valve through a simple linkage. The linkage is designed to maintain the open position even during the most jarring, harsh drilling conditions.

Open position



**Closed.** The piston is operated by low air pressure through air-swivel rings at the top and bottom.

Closed position



## 35. KILL & CHOKE LINES and VALVES

### INDEX

- 35.1 FUNCTION
- 35.2 TYPICAL ASSEMBLY
- 35.3 INSPECTIONS
- 35.4 MANUAL VALVES & REMOTE CONTROLLED VALVES

### 35.1 FUNCTION

The high-pressure mud circuit is the surface circuit connected to the well head; it is used to circulate with the well shut and when high pressure ratings are recorded. Its main components are high-pressure lines and valves through which the mud flows in and out of the well during blowout control.

The high-pressure circuit has an extremely important function and therefore all parts must be regularly checked and maintained to ensure full efficiency and functionality.

The high-pressure circuit includes:

- kill lines
- choke lines
- choke manifold
- flare lines
- high-pressure valves
- adjustable chokes

#### - KILL & CHOKE LINES

##### - Choke Line function

The choke line and manifold provide a means of applying back pressure on the formation while circulating out a formation fluid influx from the wellbore following an influx or kick.

The choke line (which connects the BOP stack to the choke manifold) and lines down-stream of the choke should:

- Be as straight as possible
- Be firmly anchored to prevent excessive whip or vibration.
- Have a bore of sufficient size to prevent excessive.

There can be either one or two and they are inserted in the BOP stack through drilling Spools or connected to the BOP lateral flange. On the section connected to the BOP stack two valves are installed:

- manual valve
- remotely operated hydraulic valve



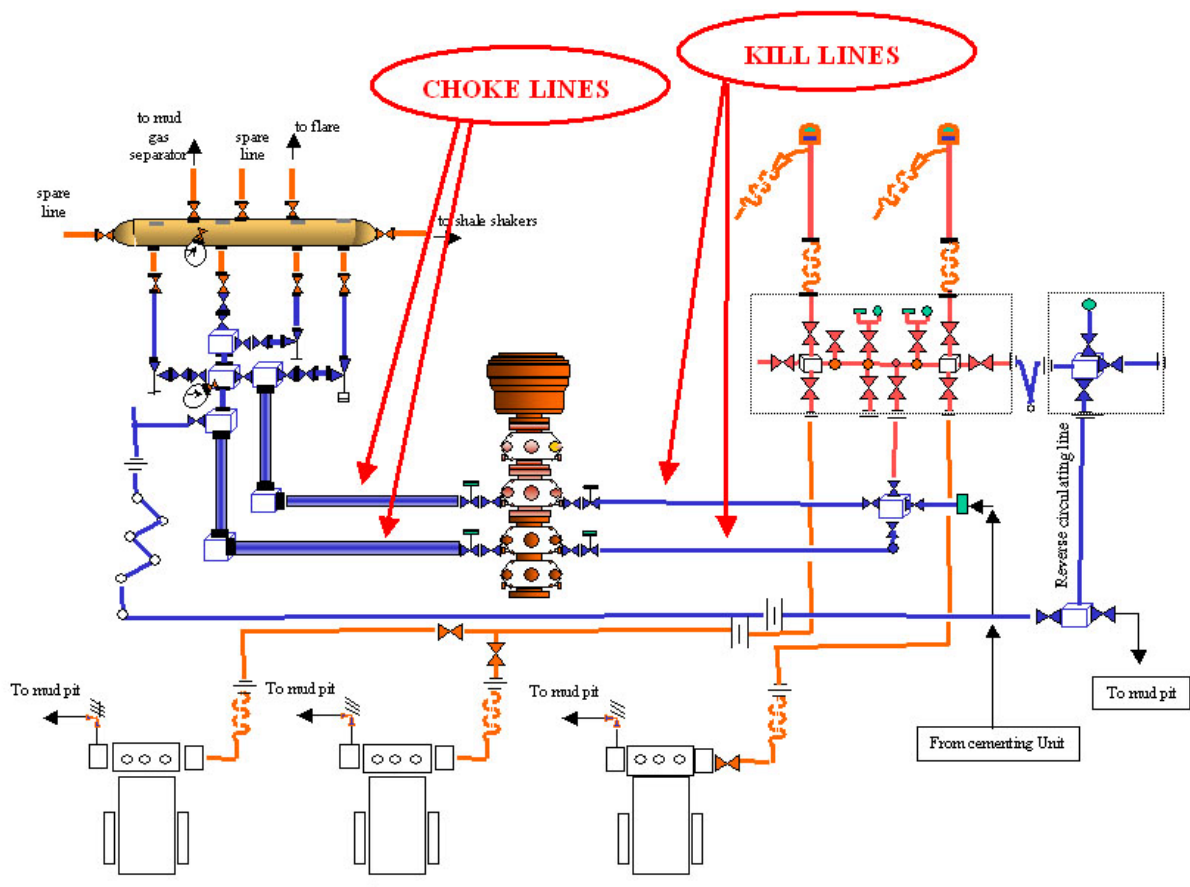
### - Kill Line function

Kill lines are an integral part of the surface equipment required for drilling well control. The kill line system provides a means of pumping into the wellbore when the normal method of circulating down through the kelly or drill pipe cannot be employed.

The kill line connects the drilling fluid pumps to a side outlet on the BOP stack. The location of the kill line connection to the stack depends on the particular configuration of BOPS and spools employed; the connection should be below the ram type BOP most likely to be closed.

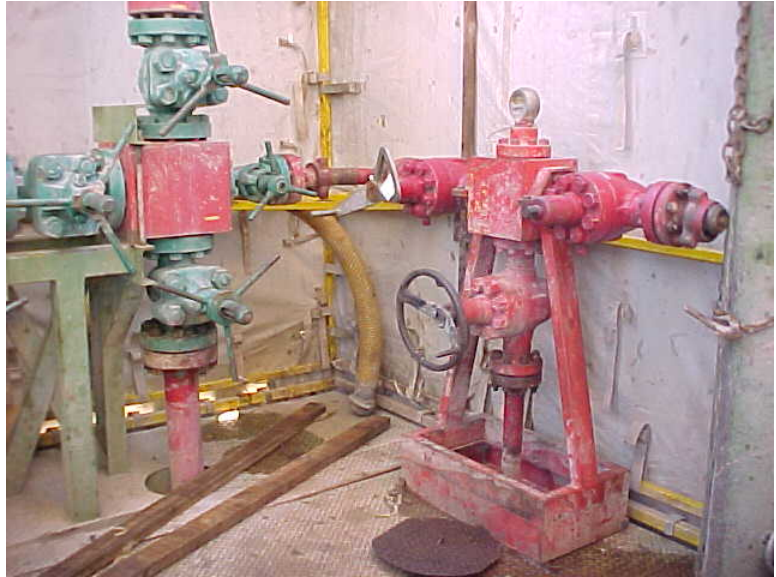
There can be either one or two and they are inserted in the BOP stack through drilling Spools or connected to the BOP lateral flange. On the section connected to the BOP stack two valves are installed:

- manual valve
- remotely operated hydraulic valve



### - Reverse Line

Reverse Line connects the rig floor mud manifold to the choke manifold. It allows the reverse circulating with BOP closed.



### - Manufacture Specifications

Choke and kill lines are built following the API specification 16 C. They can be:

- Rigid steel
- Flexible hose (Coflexip)
- Articulated steel (chiksan)

Arranging rams is important, but choke and kill flowline (wing valves) placement is equally important to fully utilize the BOP.

Again, compromises are made between the most conservative position of having no flowlines below the bottom ram and a middle road position of arranging the flowline for maximum BOP usage.

ENI requirements are defined by "Well control policy" and an internal specification.

#### ENI policy requires:

- Rigid steel lines for land rigs with BOP of 10.000 or 15.000 psi w.p.
- Chiksan lines and quick connections are not allowed.
- Drilling spool is optional; kill and choke lines can be directly connected to the lateral outlet of the BOP.

## **- KILL & CHOKE VALVES**

Kill lines connect mud pumps to the BOP-stack side outlets and are used to pump into the well when circulation through the pipes is not possible.

There can be one or two and they can be either installed on the BOP stack through the drilling spools or connected to the BOP lateral flange.

On the section connected to the BOP stack two valves are installed:

- manual valve
- remotely operated hydraulic valve.

### **- Kill & Choke Valves function**

High-pressure valves are usually gate valves and are installed on the high-pressure mud circuit to control blowouts (kill lines, choke lines and choke manifold).

Because of their particular structure, these valves must be kept either completely opened or completely closed, to avoid erosion due to the mud flow.

They can be either manual or remotely operated by a hydraulic actuator.

### **- Kill manifold**

Kill manifold connects the kill lines coming from BOP Stack to the (kill) line from Rig floor Mud Manifold.

It allows the connection of the Cement Unit for killing operations.



### **- Manufacture Specifications**

The Gate valves are manufactured according to API 6A and API 17D.



## - Cameron Gate Valves

## Comparison of Cameron Gate Valves

| Application                 | Valve Model |    |     |       |   |      |     |
|-----------------------------|-------------|----|-----|-------|---|------|-----|
|                             | DT-S        | FL | FLS | FLS-R | M | M215 | MCS |
| <b>Environment</b>          |             |    |     |       |   |      |     |
| Surface                     | ✓           | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| Subsea (to 8000 ft, 2438 m) |             | ✓  | ✓   |       |   |      | ✓   |
| <b>Characteristics</b>      |             |    |     |       |   |      |     |
| Slab Gate                   | ✓           | ✓  | ✓   | ✓     |   |      | ✓   |
| Expanding Gate              |             |    |     | ✓     | ✓ |      |     |
| Forged Body                 |             | ✓  | ✓   | ✓     |   |      | ✓   |
| Cast Body                   | ✓           |    |     |       | ✓ | ✓    |     |
| Manual                      | ✓           | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| Actuated                    |             | ✓  | ✓   |       |   |      | ✓   |
| Clad                        |             | ✓  | ✓   |       |   |      |     |
| Fire Resistant              |             | ✓  | ✓   | ✓     | ✓ |      |     |
| Wireline Cutting            |             | ✓  | ✓   | ✓     |   |      |     |

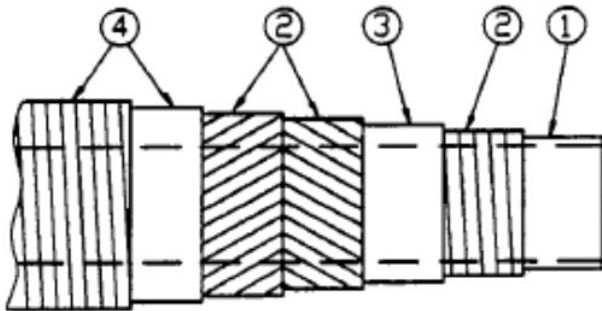
## Comparison of Cameron Gate Valves by Application

| Application/Service               | Valve Model |    |     |       |   |      |     |
|-----------------------------------|-------------|----|-----|-------|---|------|-----|
|                                   | DT-S        | FL | FLS | FLS-R | M | M215 | MCS |
| <b>Service</b>                    |             |    |     |       |   |      |     |
| Standard                          | ✓           | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| High Temperature (+350°F, +176°C) |             | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| Low Temperature (-75°F, -59°C)    |             | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| H <sub>2</sub> S                  |             | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| CO <sub>2</sub>                   |             | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| Inhibitors                        |             | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| Produced Water                    |             | ✓  | ✓   | ✓     | ✓ | ✓    |     |
| High Chlorides                    |             |    | ✓   | ✓     |   |      |     |
| Free Sulphur                      |             |    | ✓   | ✓     |   |      |     |
| Fracturing Proppants              |             |    | ✓   | ✓     |   |      |     |
| Mercury (Trace)                   |             |    | ✓   | ✓     |   |      |     |
| Acidizing                         |             |    | ✓   | ✓     |   |      |     |
| Sand                              |             |    | ✓   | ✓     |   |      |     |
| <b>Drilling Application</b>       |             |    |     |       |   |      |     |
| Mud Manifold Valve                |             | ✓  | ✓   | ✓     |   |      |     |
| Choke and Kill Valve (Surface)    |             | ✓  | ✓   | ✓     |   |      |     |
| Choke and Kill Valve (Subsea)     |             |    |     |       |   |      | ✓   |
| Fracturing Valve                  |             |    | ✓   | ✓     |   |      |     |
| <b>Service</b>                    |             |    |     |       |   |      |     |
| High Temperature (+350°F, +176°C) |             | ✓  | ✓   | ✓     |   |      | ✓   |
| Low Temperature (-75°F, -59°C)    |             | ✓  | ✓   | ✓     |   |      | ✓   |
| Salt Water                        |             | ✓  | ✓   | ✓     |   |      | ✓   |
| Drilling Mud                      |             | ✓  | ✓   | ✓     |   |      | ✓   |
| H <sub>2</sub> S                  |             | ✓  | ✓   | ✓     |   |      | ✓   |

- TYPICAL LINES CONSTRUCTION

- Typical flexible line construction

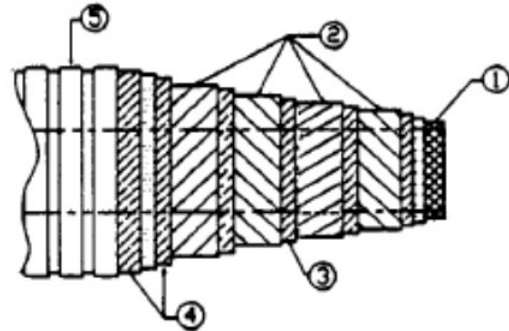
- Non Bonded Flexible Line



NON-BONDED FLEXIBLE LINE

1. FLUID CONTAINING INNER TUBE
2. REINFORCEMENT WINDINGS
3. INTERMEDIATE SHEATH
4. OUTER JACKET

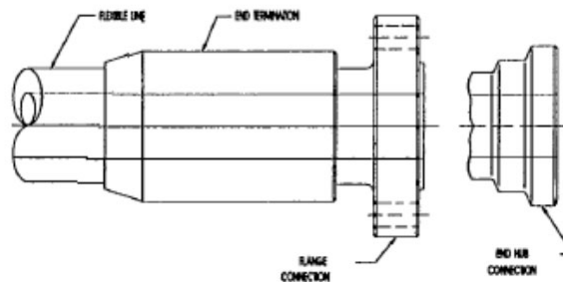
- Bonded Flexible Line



BONDED FLEXIBLE LINE

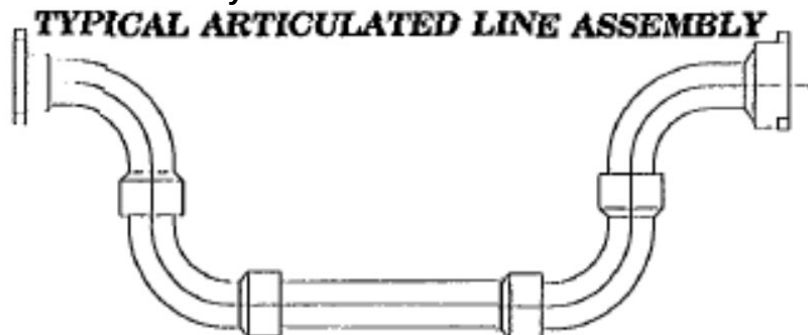
1. FLUID CONTAINING INNER TUBE
2. REINFORCEMENT WINDINGS
3. HIGH TENSILE FABRIC
4. CUSHION AND COVER
5. OUTER JACKET

9.14.5 TYPICAL FLEXIBLE LINE END TERMINATION



Typical Flexible Line End Termination

- Typical articulated line assembly



- DATA (as per API 16C)

- Rigid steel

TABEL 3.4.1

EQUIPMENT BORE SIZES AND RATED WORKING PRESURES

| Size<br>(minimum through<br>bore)<br>in. (mm)                                                                                                                | Rated Working<br>Pressure<br>Psi (MPa) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|
| 2 1/16 (52)<br>2 9/16 (65)<br>3 1/8 (78)<br>4 1/16 (103)                                                                                                     | 2000 (13,8)                            |
| 2 1/16 (52)<br>2 9/16 (65)<br>3 1/8 (103)<br>4 1/16 (103)                                                                                                    | 3000 (20,7)                            |
| 2 1/16 (52)<br>2 9/16 (65)<br>3 1/8 (103)<br>4 1/16 (103)                                                                                                    | 5000 (34,5)                            |
| 1 13/16 (46)<br>2 1/16 (52)<br>2 9/16 (65)<br>3 1/8 (103)<br>4 1/16 (103)                                                                                    | 10,000 (69,0)                          |
| 1 13/16 (46)<br>2 1/16 (52)<br>2 9/16 (65)<br>3 1/8 (103)<br>4 1/16 (103)                                                                                    | 15,000 (103,5)                         |
| 1 13/16 (46)<br>2 1/16 (52)<br>2 9/16 (65)<br>3 1/8 (103)<br>4 1/16 (103)                                                                                    | 20,000 (138,0)                         |
| Note: Specific size and pressure rating combinations are not necessarily available for each type of end or outlet connection (e.g. flange, hub and threaded) |                                        |

- Articulated steel

TABEL 3.4.2 UNION, SWIVEL JOINT AND ARTICULATED LINE SIZES & RATED WORKING PRESURES

| ID<br>In. (mm)                                              | Rated Working<br>Pressure<br>Psi (Mpa) |
|-------------------------------------------------------------|----------------------------------------|
| 2 (50,8)<br>3 (76,2)<br>4 (101,6)                           | 3000 (20,7)                            |
| 1 (25,4)<br>1 ½ (38,1)<br>2 (50,8)<br>3 (76,2)<br>4 (101,6) | 5000 (34,5)                            |
| 1 (25,4)<br>2 (50,8)<br>3 (76,2)<br>4 (101,6)               | 10,000 (69,0)                          |
| 2 (50,8)<br>2 ½ (63,5)<br>3 (76,2)                          | 15,000 (103,5)                         |
| 2 (50,8)<br>2 ½ (63,5)<br>3 (76,2)                          | 20,000 (138,0)                         |

-Flexible hose

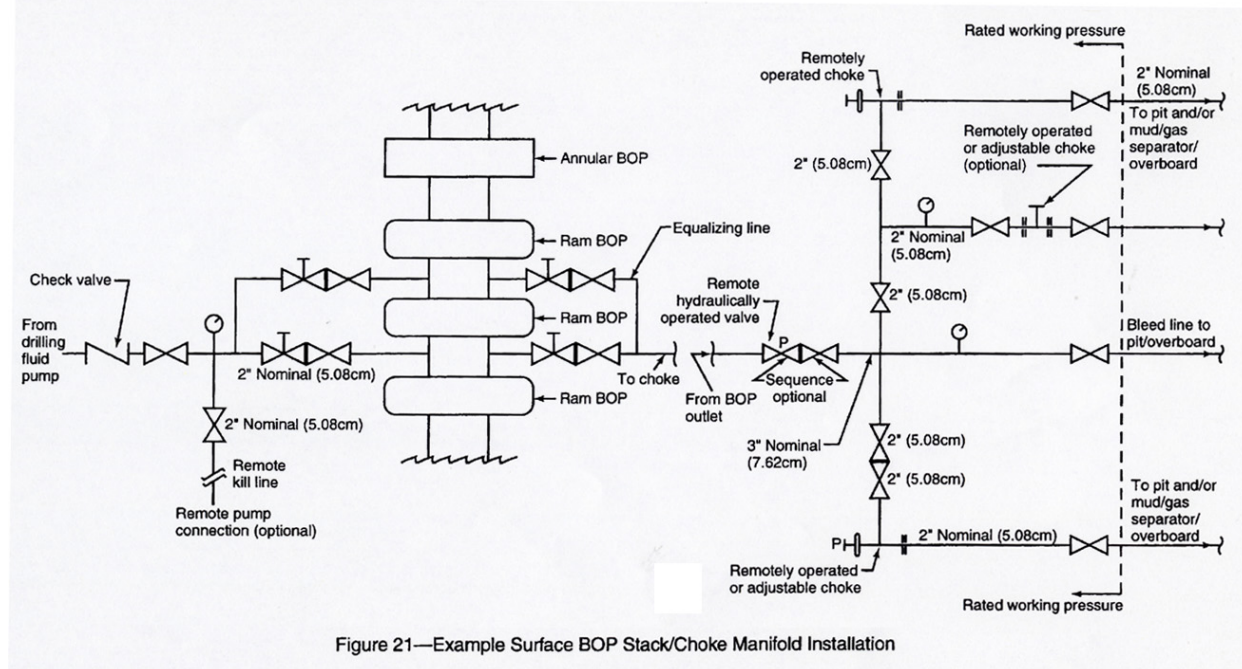
TABLE 3.4.3: FLEXIBLE LINE SIZES & RATED WORKING PRESSURES

| ID<br>In. (mm)                                  | Rated Working<br>Pressure<br>Psi (MPa) |
|-------------------------------------------------|----------------------------------------|
| 2 (50,8)<br>3 (76,2)<br>3 ½ (88,8)<br>4 (101,6) | 5000 (34,5)                            |
| 2 (50,8)<br>2 ½ (63,5)<br>3 (76,2)<br>4 (101,6) | 10,000 (69,0)                          |
| 2 (50,8)<br>2 ½ (63,5)<br>3 (76,2)              | 15,000 (103,5)                         |
| 2 (50,8)<br>2 ½ (63,5)<br>3 (76,2)              | 20,000 (138,0)                         |

## 35.2 TYPICAL ASSEMBLY

### - Example of typical BOP Assembly (as per API RP 53)

Example Surface BOP Stack/Choke Manifold Installation



### - ENI typical assembly

#### ENI Well Control Policy

##### 6.1 BOP STACK SYSTEMS

###### 6.1.1 Land Rigs, Jack-Ups And Fixed Platform

a) The pressure rating requirement for BOP equipment is based on the 'maximum anticipated surface pressure' as stated in the Drilling Procedures Manual'. Projects that require a different working pressure in the whole system shall be agreed upon by the Company and Drilling Contractor.

The minimum BOP stack requirements are as follows:

###### **A 5,000psi WP stack should have at least:**

- Two ram type preventers (one shear ram and one pipe ram).
- One 2,000psi annular type preventer.

###### **A 10,000psi stack should have at least:**

- Three ram type preventers (one shear ram and two pipe ram).
- One 5,000psi annular type preventer.

###### **A 15,000psi stack should have at least:**

- Four ram type preventers (one shear ram and three pipe ram)
- One 10,000psi annular type preventer.

b) While drilling, all pipe ram preventers shall always be equipped with the correct sized rams to match drill pipe being used. If a tapered drill string is being used e.g. 3½" and 5", one set of rams will be dressed to match the smaller drill pipe size.

During casing jobs or production testing, the choice of pipe rams shall be defined by the Company, depending on external diameter(s) of the casing/drilling/testing string(s) in the operation and BOP stack composition.

c) At least one ram preventer, below the shear rams, shall be equipped with fixed pipe rams to fit the upper drill pipe in use. The minimum distance between shear rams and hang-off pipe rams shall be 80cm (30").

d) The use of variable bore rams (VBRs) is acceptable but they should not be used for



hanging off pipe which is near to the lower end of their operating range.

e) Rig site repair of BOP equipment is limited to replacing of worn or damaged parts.

**Under no circumstances is welding or cutting to be performed on any BOP equipment.** Replacement parts should only be those supplied or recommended by the equipment manufacturer.

f) Each choke and kill line BOP outlet shall be equipped with two full bore valves, the outer valve of which will be hydraulically operated (preferably fail-safe closed).

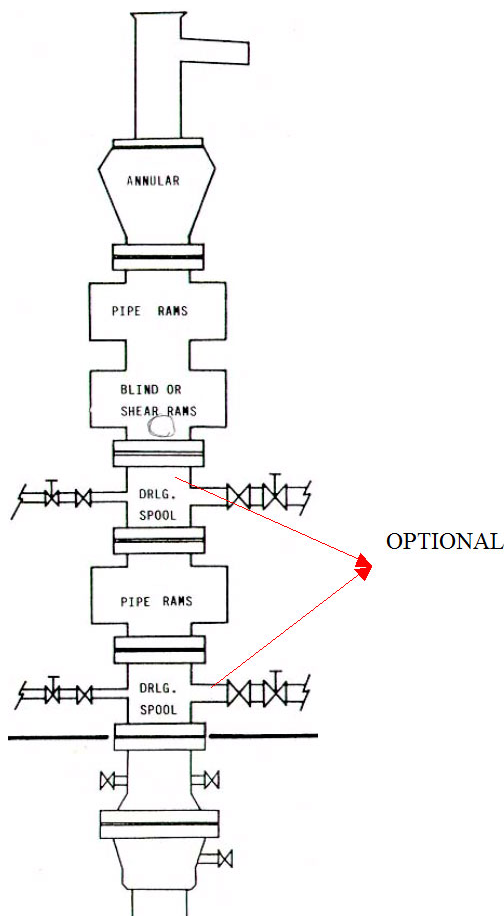
g) The minimum diameter of the choke line will be 3" ID, while the kill line should have not less than a 2" ID. Articulated choke lines (Chiksan) are not acceptable unless derogation is agreed for a particular application.

h) A number of various arrangements in the position of the choke and kill line outlets are used in BOP stack configurations throughout the oil industry. The rig operating manual should highlight these variations, their limitations and all the potential uses of a particular layout.

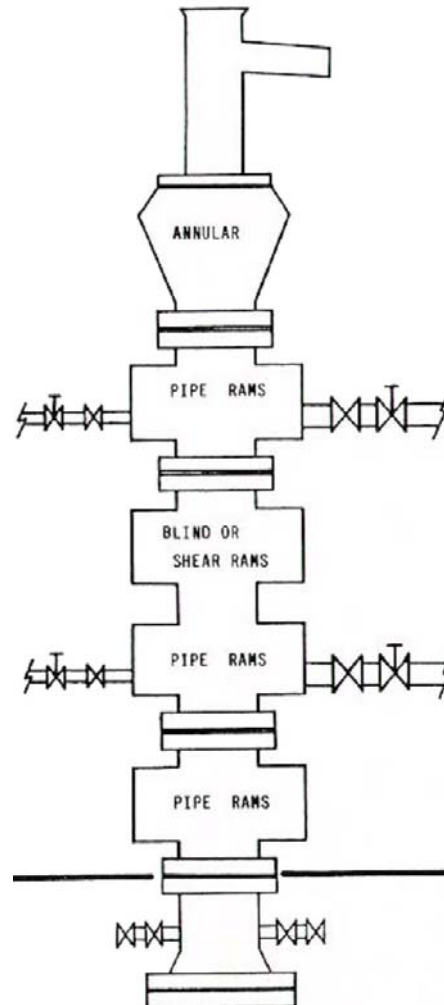
i) The inclusion of shear rams requires the choke and kill lines positions to be such that the direct circulation of the kick, through the drill pipe stub after shear rams activation, can be performed with the drill string hang-off on the closed pipe rams and holding pressure.

j) On a four ram BOP stack, Eni-AGIP recommends that the positioning of choke and kill line outlets below the lowest pipe rams be avoided as these are the like the last resort 'Master Valve' of the BOP stack.

- Standard ENI configuration of 3 rams



- Standard ENI configuration of 4 rams



### 35.3 INSPECTIONS

The Kill & Choke lines and valves shall be inspected (modally and frequency) according to the manufacturers recommendations and as per API RP 53.

ENI requirements are defined by an internal specification that stipulates the Kill & Choke lines and valves shall be recertified by a Manufacturer authorized workshop at least every five years.

Note: For the rigid lines is requested the Thickness measurements  
For H2S service equipment the Hardness is required

### 35.4 MANUAL VALVES & REMOTE CONTROLLED VALVES

- Gate Valve Cameron Type "FL"
- Cameron Manual Valve FLS
- Cameron Manual Valve FLS-R
- Hydraulic Actuator for Cameron Valve

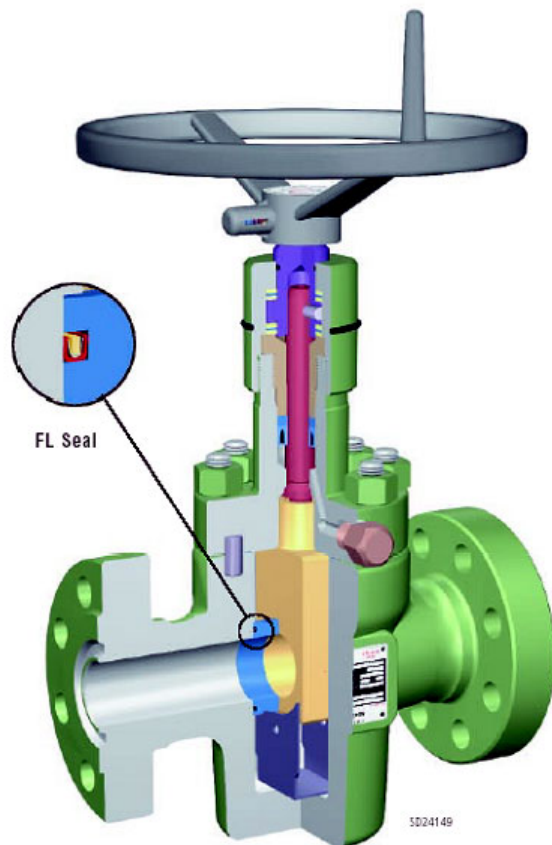
#### - Gate Valve Cameron Type "FL"

Cameron FL Gate Valves have earned a reputation in all types of applications. They are full-bore, through-conduit valves with forged bodies and slab gates. FL valves feature a single spring-loaded, pressure-energized, non-elastomeric lip seal. This seal assists in low pressure sealing and protects against contaminants.

#### - Features

Bi-directional design. Positive metal-to-metal sealing (gate-to-seat and seat-to-body). Simple, reliable gate and seat design. Metal-to-metal bonnet seal. Backseating stem allows stem seal replacement under pressure.

Grease injection fitting on downstream side of the stem backseat for safety. Grease fitting in bonnet eliminates body penetration. Easy closing and sealing.



Gate valve CAMERON type 'FL'

#### - Characteristics

Sizes: 2-1/16" through 4-1/16"  
Working Pressure: 2000 through 5000 psi  
Operating Temperatures: -75F to +350F (-59C to +176C)  
End Connections: Threaded, flanged, block valve configuration  
Materials: Variety of trims available  
Industry Standard: API 6A, 17D.

## - Cameron Manual Valve FLS

FLS Gate Valves have earned a reputation in all types of applications.

They are full-bore, through-conduit valves with forged bodies and slab gates.

FLS valves feature dual spring-loaded, pressure-energized, non-elastomeric lip seals. These seals assist in low pressure sealing and protect against contaminants.

### - Features

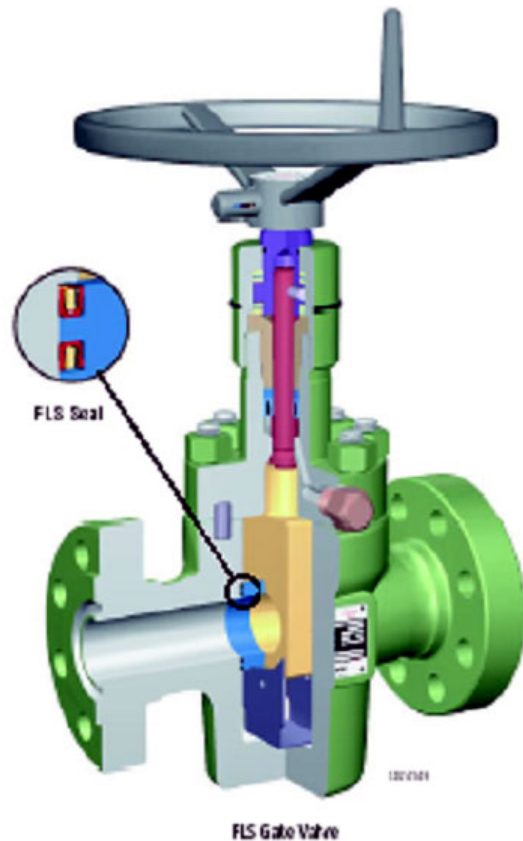
Bi-directional design. Positive metal-to-metal sealing (gate-to-seat and seat-to-body).  
Metal-to-metal bonnet seal.

Backseating stem allows stem seal replacement under pressure.

Grease injection fitting on downstream side of the stem backseat for safety.

Grease fitting in bonnet eliminates body penetration.

Easy closing and sealing.



FLS Gate Valve

### - Characteristics

Sizes: 1-13/16" through 9"

Working Pressure: 2000 through 20,000 psi

Operating Temperatures: -75F to +350F (-59C to +176C)

End Connections: Threaded, flanged, block valve configuration

Materials: Variety of trims available

Industry Standard: API 6A, 17D

### - Cameron Manual Valve FLS-R

FLS-R Gate Valves were designed for use as manual valve in high pressure, large bore applications.

These valves incorporate a lower balancing stem and a unique ball screw mechanism for ease of operation in the field.

The FLS-R is value-engineered for reliability, low torque, ease of operation and service.

The FLS-R has many of the same features as the FLS, including the gate and seat design and the pressure-energized lip seal technology.

#### - Features

Bi-directional design.

Positive metal-to-metal sealing (gate-to-seat and seat-to-body).

Lower stem balances pressure thrust on upper stem to reduce torque, prevent body cavity pressure build-up during operation, and provide position indication.

Spring-loaded, pressure energized, non-elastomeric stem seal.

Pressure-energized metal-to-metal bonnet seal.

Either stem can be backseated to allow stem seal replacement with valve under pressure.

Grease injection fittings located on the downstream side of the stem and the balancing stem backseat for safety.

#### - Characteristics

Sizes: 4-1/16" through 9"

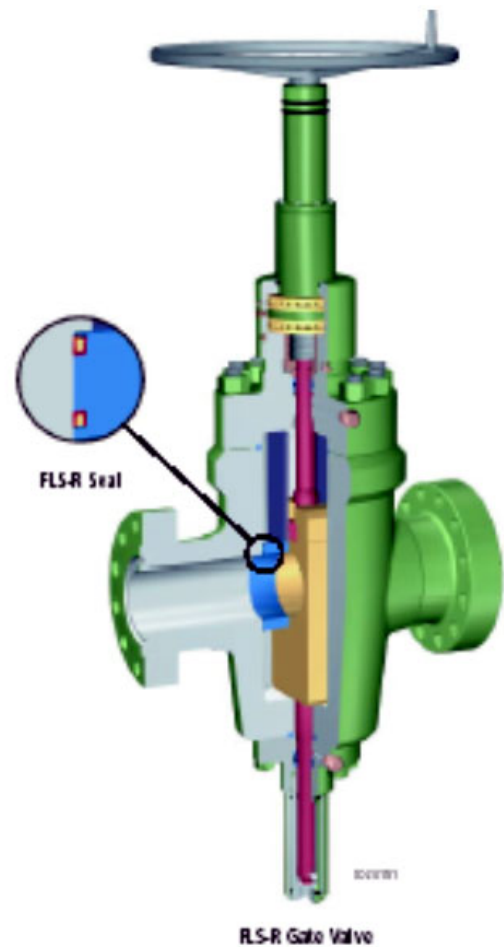
Working Pressure: 5000 through 15,000 psi

Operating Temperatures: -75F to +350F (-59C to +176C)

End Connections: Threaded, flanged

Materials: Variety of trims available

Industry Standard: API 6A, 17D



*FLS-R Gate Valve*



## **- Hydraulic Actuator for Cameron Valve**

### **- Tailrod Hydraulic Actuators**

Cameron Tailrod Hydraulic Actuators are used on FL and FLS Gate Valves in landbased drilling applications.

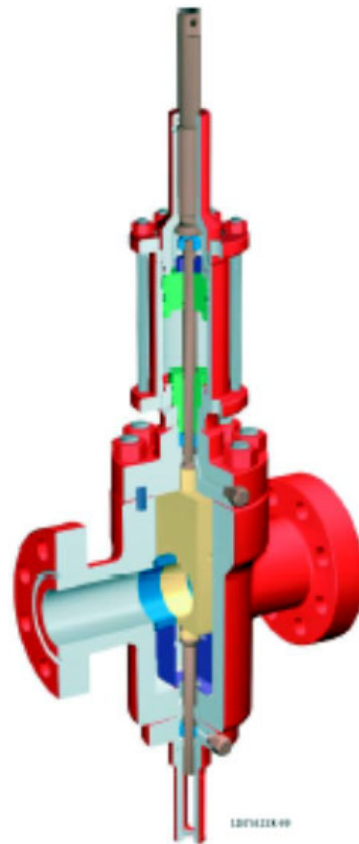
#### **- Features**

Cylinder wall can withstand a non-shock pressure of 3000 psi.

Cylinder ports are located a sufficient distance from the cylinder head to allow piston to cover the exhaust port before the end of the stroke, providing sufficient damping to protect the valve from shock loading.

Tailrod passes through a stuffing box in the valve body, compensates for the volume displaced by the operating stem, and provides visual indication of valve opening and closing.

Tailrod and operating stem have backseating shoulders which allow replacement of the stem packing while valve is under pressure.



CAMERON Tailrod Hydraulic Gate Valve

*CAMERON Tailrod Hydraulic Gate Valve*

### **- Characteristics**

|                         |                               |
|-------------------------|-------------------------------|
| Sizes:                  | 1-13/16" through 6-3/18"      |
| Working Pressure:       | 2000 through 5000 psi         |
| Operating Temperatures: | -75F to +350F (-59C to +176C) |
| Operating Pressure:     | 1500 to 3000 psi              |
| Materials:              | Variety of trims available    |
| Industry Standard:      | API 6A                        |
| Options:                | Manual closing, locking screw |

## **36. CHOKE MANIFOLD & MUD GAS SEPARATOR**

### **INDEX**

#### **36.1 CHOKE MANIFOLD**

- CHOKE MANIFOLD FUNCTION
- TYPICAL CHOKE MANIFOLD ASSEMBLY
- CHOKE MANIFOLD COMPONENTS
- CHOKE MANIFOLD INSPECTIONS

#### **36.2 MUD GAS SEPARATOR**

- MUD GAS SEPARATOR FUNCTION
- TYPES OF MUD GAS SEPARATORS
- MUD GAS SEPARATOR INSPECTIONS

### **36.1 CHOKE MANIFOLD**

#### **- CHOKE MANIFOLD FUNCTION**

The BOP can close in the well but additional equipment is needed to allow controlled release of the well fluids, to circulate under pressure, to bleed pressure and to allow injection against high well pressure.

Variable chokes control the release of well fluids under pressure, but, because of abrasive wear and possible plugging, at least two are required.

Those chokes must be manifolded in order to quickly change from one to the other.

#### **- Features**

The choke manifold is composed of a group of valves and lines connected to the well head through the choke lines.

It is used, during blowout control, to maintain the correct back pressure adjusting the flow exiting the well through an adjustable choke.

The choke manifold can be equipped with a buffer chamber to convey high-pressure exit flows to a single line and to the connected discharge line (flare line, shale shaker, waste pits and mud gas separator).

The buffer chamber has a lower working pressure value than all other choke manifold areas. Such difference should be kept into account during pressure tests.

Flare lines are used to convey any gas coming from the choke as far from the well as possible.

In case of small quantities, the gas is simply discharged, whereas in case of large volumes it is burnt.

Such lines have to be as straight as possible, avoiding bendings and turns to reach the farthest possible area (towards the wind direction); they also have to be anchored to the ground to prevent them from moving because of vibrations due to violent gas flows.

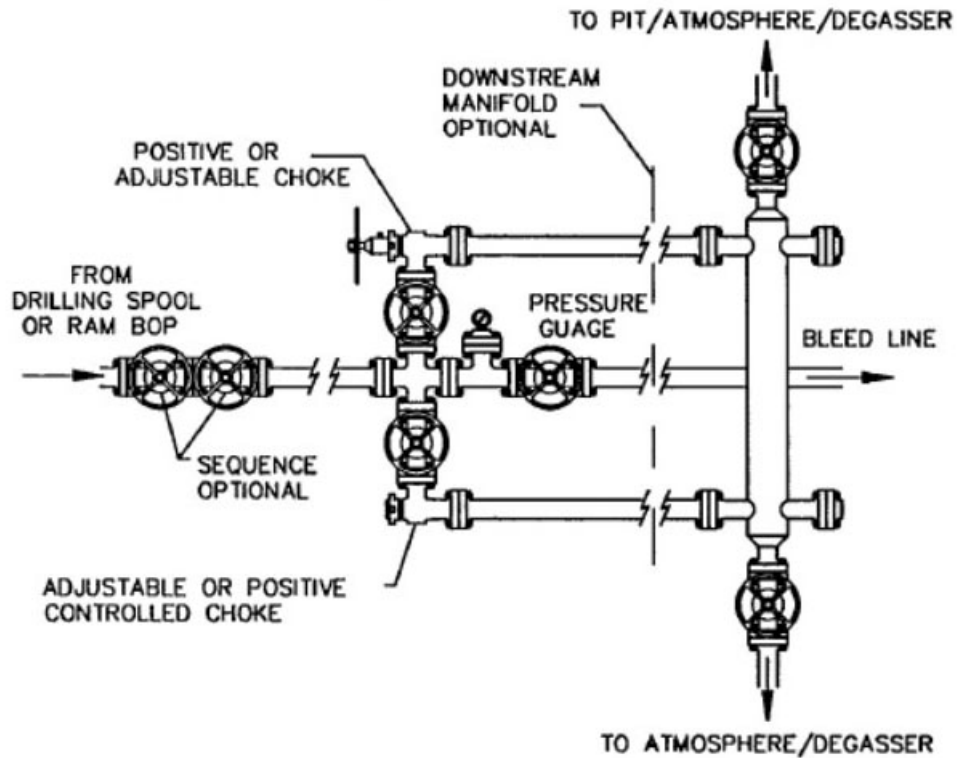
After being installed, they have to be field tested at a reasonably low pressure value, high enough to grant certainty of sealing.

#### **- Manufacture Specifications**

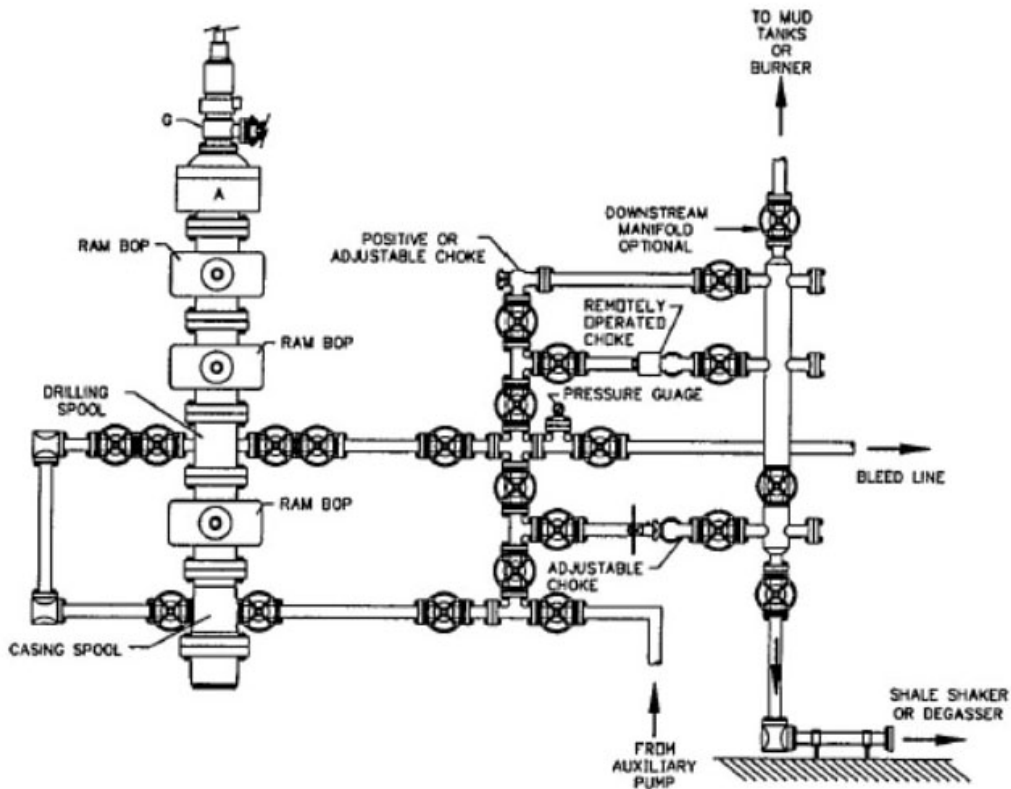
See Chapter "Manufacture Specification" in subject "KILL & CHOKE LINE and VALVES"

- TYPICAL CHOKE MANIFOLD ASSEMBLY
- Typical Choke Manifold Assembly API 16-C

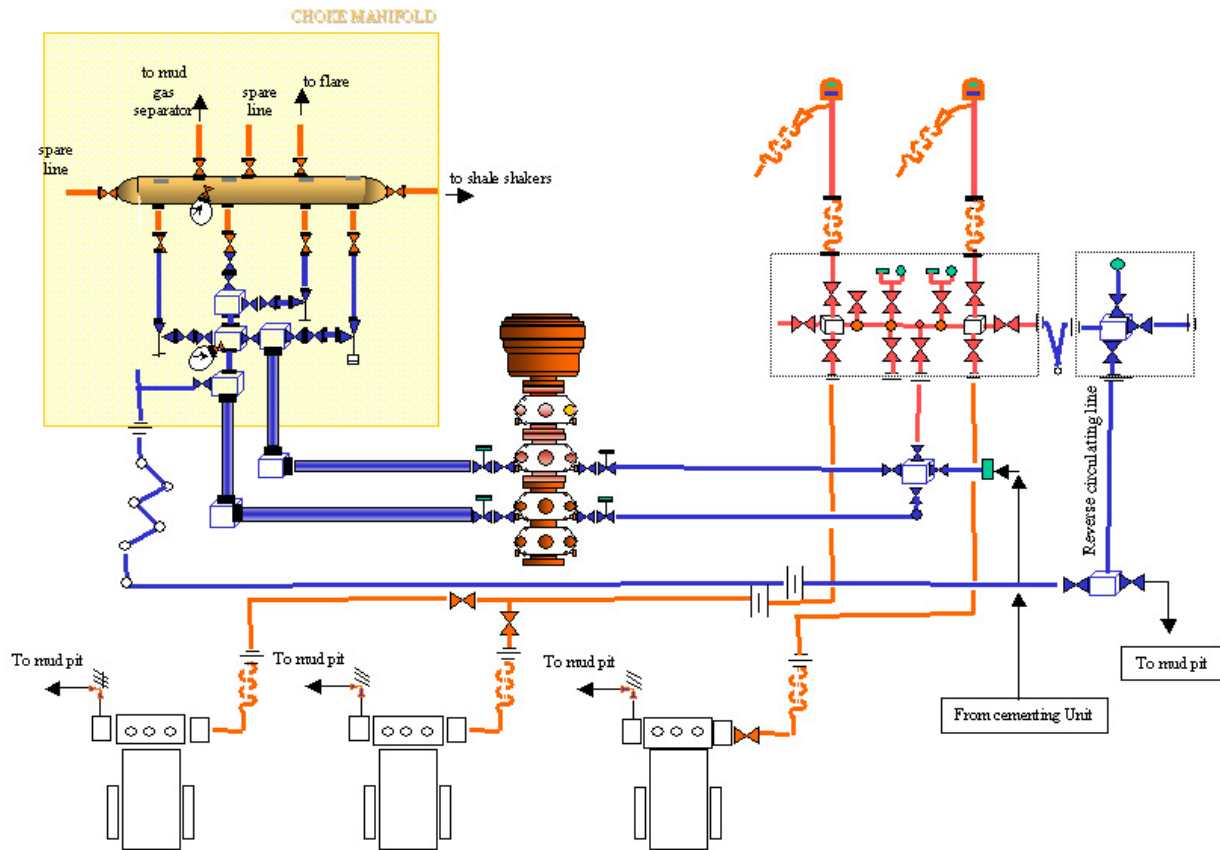
### 10.7.2 TYPICAL 5000 PSI (34,5 MPa) MANIFOLD



### 10.7.3 TYPICAL 10,000 (69,0 MPa) — 20,000 PSI (138,0 MPa) MANIFOLD

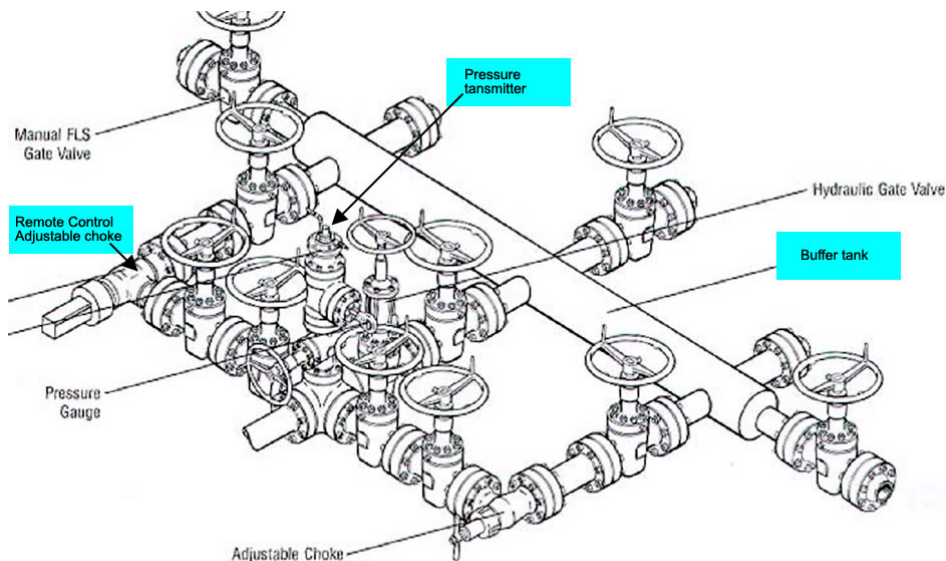


## - ENI Typical Choke Manifold Assembly



## - CHOCKE MANIFOLD COMPONENTS

- Manual / Remote Control Valves
- Manual / Remote Control Adjustable Chokes
- Pressure Transmitter
- Buffer tank



Typical Choke Manifold Designed for Land Drilling Applications



### - Manual / Remote Control Adjustable Chokes

Chokes are valves with an adjustable hole to control the fluid flow coming from the well. They can be either manually operated (shutter cock) or remotely hydraulically operated (automatic control).

Their main function is to provide back pressure to balance the well pressure to allow blowouts to be controlled.

Manual chokes are usually kept as reserve chokes, while during blowout control operations automatic chokes are preferably used since they can certainly provide greater safety and functionality (they can be remotely controlled).

## DRILLING CHOKES

- CAMERON Manual Drilling Choke
- CAMERON Hydraulic Drilling Chokes
- SHAFFER Hydraulic Drilling Chokes
- DRILLING CHOKE CONTROL PANEL

### CAMERON Manual Drilling Choke

Cameron drilling chokes are available in manually actuated and hydraulically actuated models.

Cylindrical gate and seat provide high flow capacity and quiet operation.

Gate and seat can be replaced or reversed without removing choke from the manifold.

Manual chokes offer thrust bearings for low torque operation.

#### - Characteristics

Size: 3-1/16" through 4-1/16"  
Working Pressure: 5000 through 20,000 psi  
Standard Orifice: 1-3/4"  
Service Rating: Suitable for H<sub>2</sub>S and 250F (121 C) service  
Trims: High temperature trim available.

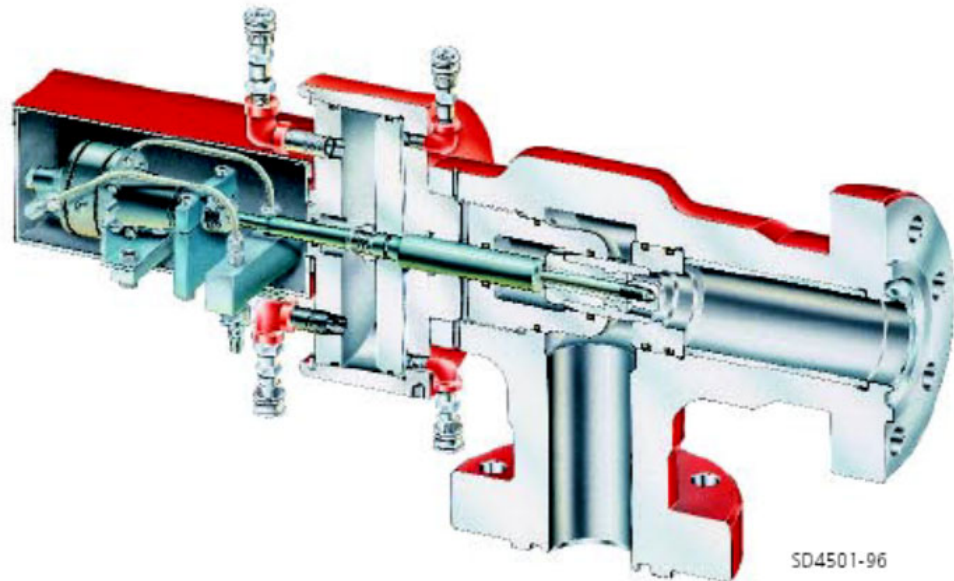


*Manually Actuated Drilling Choke*

## CAMERON Hydraulic Drilling Chokes

Cylindrical gate and seat provide high flow capacity and quiet operation.

Gate and seat can be replaced or reversed without removing choke from the manifold. Manual chokes offer thrust bearings for low torque operation.



*CAMERON Hydraulic Drilling Chokes*

### - Characteristics

Size: 3-1/16" through 4-1/16"

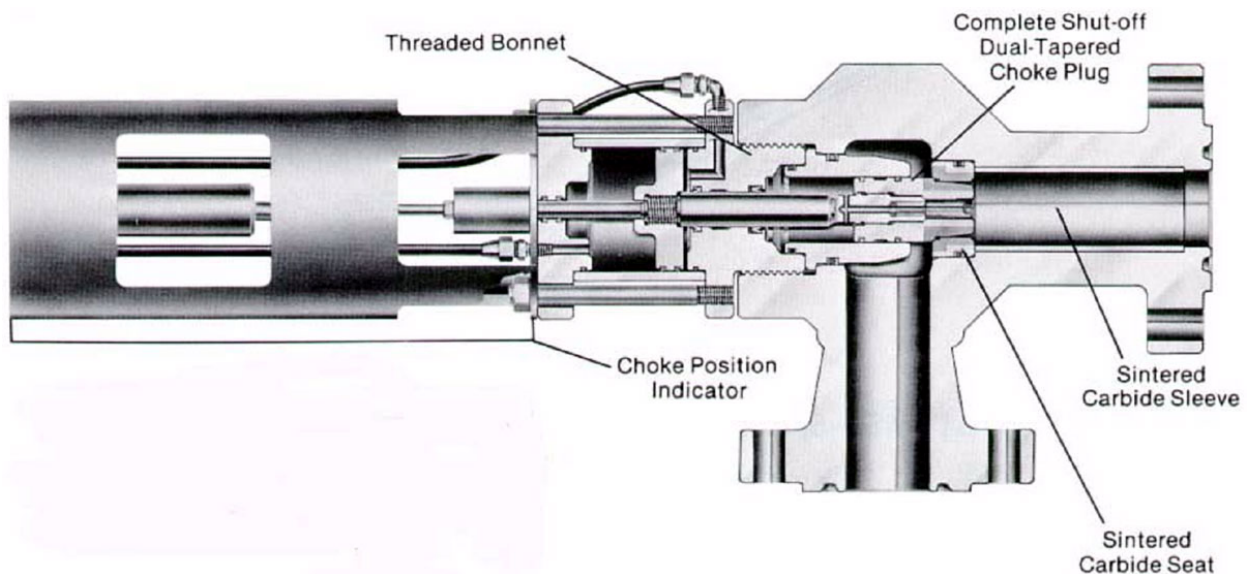
Working Pressure: 5000 through 20,000 psi

Standard Orifice: 1-3/4"

Service Rating: Suitable for H<sub>2</sub>S and 250F (121 C) service

Trims: High temperature trim available.

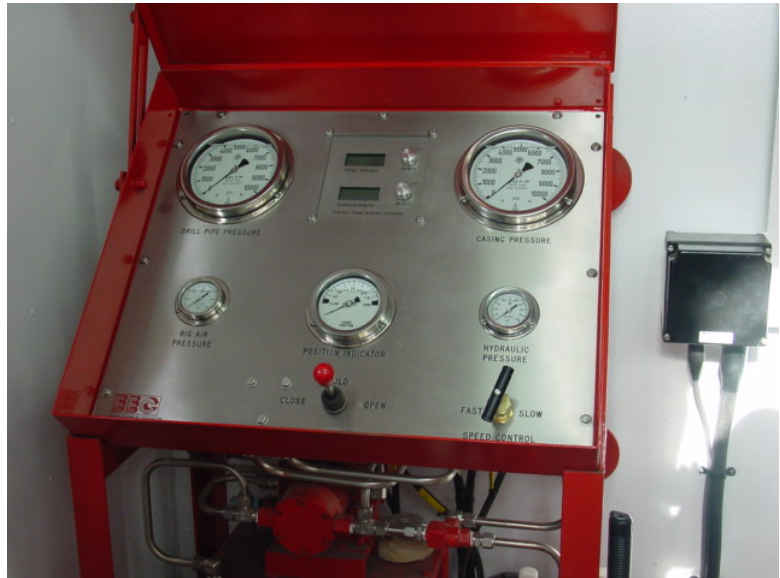
## SHAFFER Hydraulic Drilling Chokes



## - DRILLING CHOKE CONTROL PANEL

The function of the remote hydraulic choke control system is to provide reliable control of the drilling choke from one or more remote locations with the sensitivity and resolution required to perform all well control procedures which the choke valve is designed to provide, including:

1. well flow shut-in procedures.
2. throttling of mud, gas, liquid hydrocarbons and formation debris at any rate of flow up to the physical capacity of the internal flow conduit.



The control system shall provide:

1. An actuator capable of setting the orifice in the choke at any size from fully open to fully closed at any pressure up to the rated working pressure of the choke.
2. Power hydraulic fluid to the choke actuator in sufficient pressure and volume to completely close the choke from the fully open position in 30 seconds.
3. Operating controls enabling the operator to set orifice openings of any size up to fully open that will result in any annulus pressure desired (±10 psi) from 0 psi to the choke rated working pressure. The control device should be suitably marked for direction of control.
4. A choke position indicator that shows at the control console the relative position of the choke trim or relative orifice size as a percentage of fully open.
5. A gauge on the control panel for rig air to display the air or gas pressure available to power the console P-P.
6. A gauge on the control panel to display system hydraulic pressure, from the hydraulic pump or accumulator system.
7. Drill pipe and casing pressure gauges scaled 0 psi to fully rated working pressure of the choke. These gauges are clearly marked "Drill Pipe Pressure" or "Casing Pressure" and must be independent systems from other gauge systems.

### **- Cameron Basic II choke console**

#### **- Digital choke Console**

The Cameron Basic II choke console is designed for dual choke operation.

It features gauge displays for choke position and rig, air, hydraulic standpipe and choke manifold pressures.

A choke speed adjustment valve controls the opening and closing speed of the hydraulic choke.

Cameron also offers a digital read-out choke panel housed in a stainless steel cabinet.



**Digital Choke Console**

### **- CHOKE MANIFOLD INSPECTIONS**

See Chapter "INSPECTIONS" in subject "KILL & CHOKE LINE and VALVES"



## 36.2 MUD GAS SEPARATOR

### - MUD GAS SEPARATOR FUNCTION

The mud gas separator is used to separate gas from drilling fluid that is gas cut. The separated gas can then be vented a safe distance from the rig.

#### - Manufacture Specifications

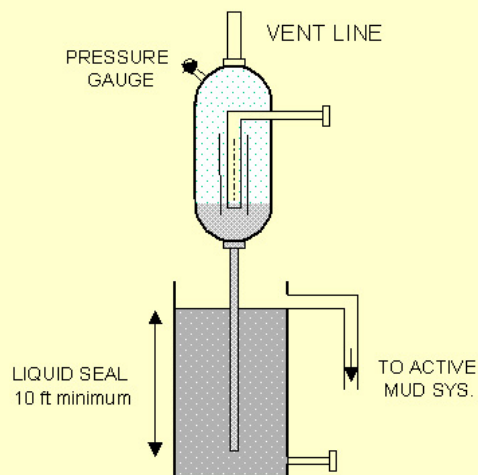
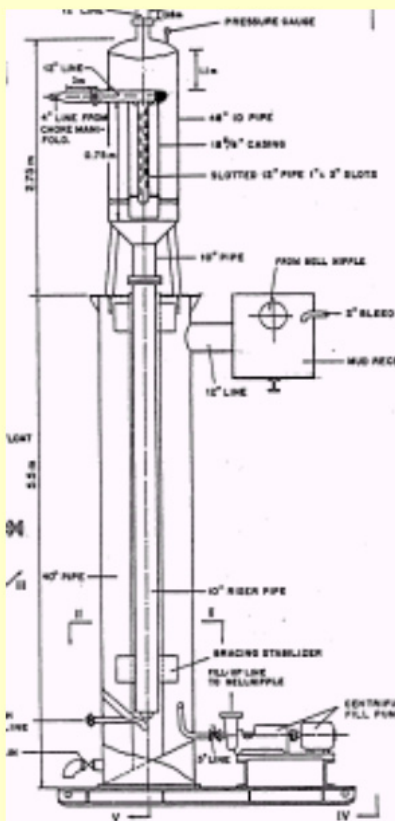
Mud Gas Separator is manufactured according to API RP 53. ENI requirements are defined by an internal specification.

The dimensions of a separator are critical in that they define the volume of gas and fluid a separator can effectively handle.

An example of some mud gas separator sizing guidelines can be found in:  
SPE Paper No. 20430: Mud Gas Separator Sizing and Evaluation, G.R. MacDougall, December 1991



*Mud gas separator*



#### Separator Design

$$\text{Minimum ID (inch)} = 15.56 \times \sqrt{\text{KILL RATE (bbl/min)}}$$

#### Note

Mud liquid seal hydrostatic pressure must exceed vent-line friction pressure to prevent a Separator Blow-through condition

**Mud Gas Separator per Land Rig**

## **- TYPES OF MUD GAS SEPARATORS**

Generally, two basic types of mud gas separators are in use.

The most common type is the atmospheric mud gas separator, sometimes referred to as a gas buster or poor-boy separator.

Another type of mud gas separator is designed such that it can be operated at moderate back pressure, usually less than 100 psi (0.69 MPa), although some designs are operated at gas vent line pressure which is atmospheric plus line friction drop.

All separators with a liquid level control may be referred to as pressurized mud gas separators.

### **- Operational**

Both the atmospheric and pressurized mud gas separators have advantages and disadvantages. Some guidelines are common to both types.

A bypass line to the flare stack must be provided in case of malfunction or in the event the capacity of the mud gas separator is exceeded.

Precautions must also be taken to prevent erosion at the point the drilling fluid and gas flow impinges on the wall of the vessel.

Provisions must be made for easy clean out of the vessels and lines in the event of plugging.

Unless specifically designed for such applications, use of the rig mud gas separator is not recommended for well production testing operations.

### SWACO's H2S Mud/Gas Separator

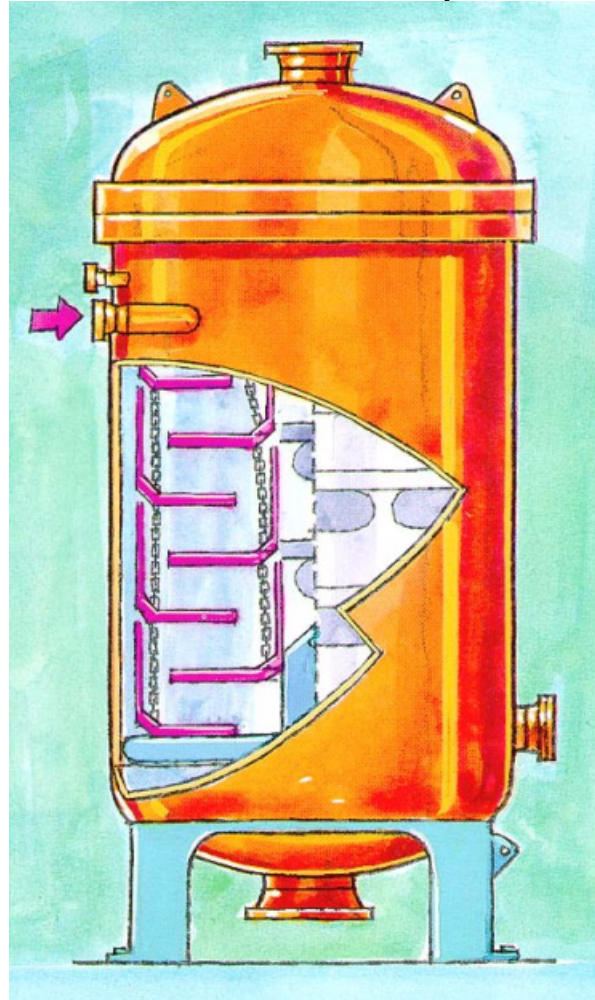
Is a field proven and extremely reliable necessary piece of safety equipment for today's drilling operations. It is ideal for use where drilling is likely to encounter large volume of gas, sour gas or when an operator is drilling with an underbalance mud column.

The H2S Mud/Gas Separator is primarily used to separate and safely vent large pockets of free gas than may include toxic gases such as hydrogen sulfide from the drilling mud system.

**SWACO's H2S Mud/Gas Separator**



**SMEDVIG Mud Gas Separator**



### - MUD GAS SEPARATOR INSPECTIONS

Mud gas Separator shall be inspected according to the manufacturers recommendations and as per API RP 53.

ENI requires at least periodical internal inspection and pressure test.



## 37. INSTRUMENTATION

### INDEX

- 37.1 FUNCTION
- 37.2 PARAMETERS
- 37.3 SENSORS AND INDICATORS
- 37.4 INTERFACE (Panels, Consoles)
- 37.5 INTEGRATED SYSTEMS

### 37.1 FUNCTION

The function of the instrumentation on a drilling rig is to provide a continuous readout of selected parameters during normal operations.

The instruments in Driller's console has the important role of protecting the personnel and the rig.

- Output Data source

Comes directly from sensors installed on measuring points.

OR

Is calculated on output data provided by sensors

### 37.2 PARAMETERS

#### - Data from Sensors

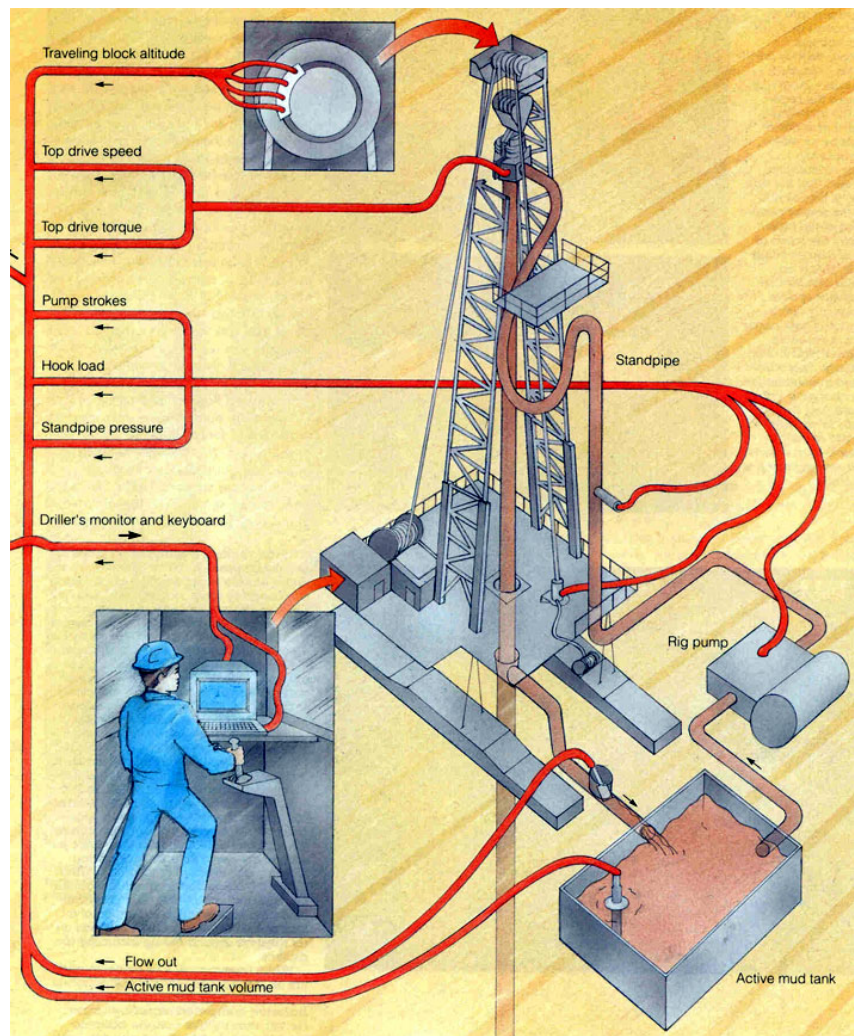
Data taken directly from sensors installed on measurement points are:

- Rotary speed revolution
- Rotary torque moment
- BHA weight
- Pump output pressure
- Pump stroke rate
- Pit levels
- Trip tank levels
- Flow rate (from well)
- Hook position (height)

#### - Data Calculated

Data calculated from sensors input includes:

- Bit depth
- Weight on bit
- BHA Running/pulling speed
- Penetration rate
- Pump output flow rate





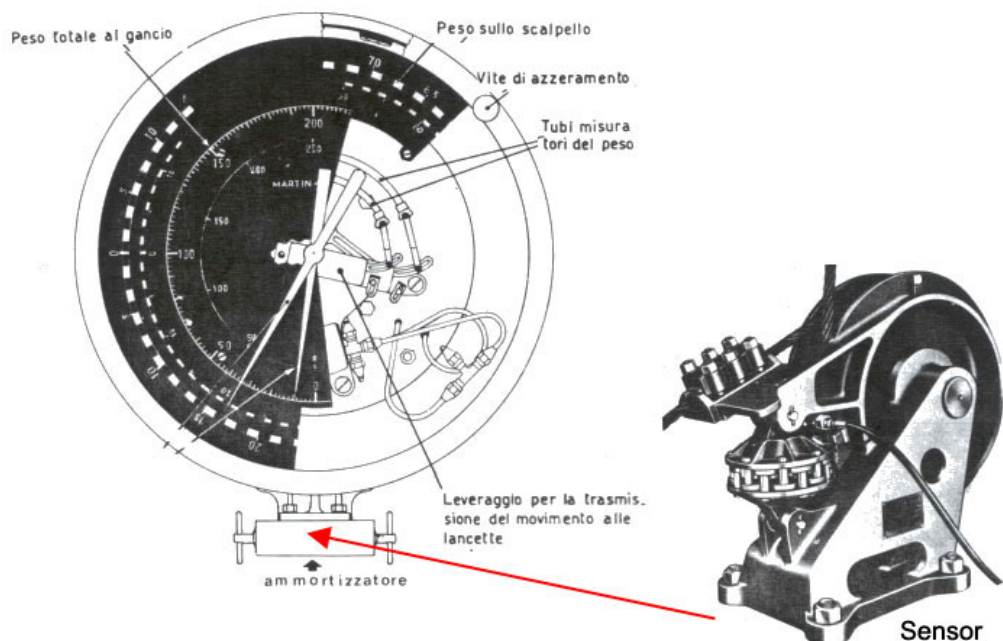
### 37.3 SENSORS AND INDICATORS

Sensors are used where it is necessary to take remote measurements. Sensor can be:

- **Hydraulic** The Hydraulic sensor are normally used on Hook load sensor. They are installable in dangerous area.
- **Pneumatic** In the past, Pneumatic sensors were used because they were installable in dangerous areas, but they are sensitive to the Rig working location environment and to the used compress air purity.
- **Electronic** Those of Electronic type are even more used because they are more accuracy, easily interfaceable and compatible with acquisition system and data elaboration.

#### Hook Load Indicator

The Hook Load indicator uses a Hydraulic sensor installed on the dead line anchor, which transforms the Load to a pressure signal read by a load force gauge.



- Models by "Totco Martin Decker"  
Weight indicator



Type EB  
Weight Indicator

Driller's Panel



Compact Driller's Panel with  
EB Weight Indicator

Series

#### Type 200, AWE-Series

For deadline loads to 200,000 lbs.  
With 10,12,14, and 16 lines strung.  
E551 compression load cell.  
16" indicator

#### Type 150, AWE-Series

For deadline loads to 150,000 lbs.  
With 10,12,14, and 16 lines strung.  
E551 compression load cell.  
16" dial indicator

#### Type 125, AWE-Series

For deadline loads to 125,000 lbs.  
With 10,12,14, and 16 lines strung.  
E551 compression load cell.  
16" dial indicator

## Pressure Gauges

### - Pressure Gauge (Manometer)



Standard capacities include:

- 0-1,000 psi
- 0-3,000 psi
- 0-5,000 psi
- 0-6,000 psi
- 0-10,000 psi
- 0-15,000 psi

### - Pressure Gauge (Sensor + Manometer)

Single Point Indicator



Standard Capacities

Rugged E17-152 Diaphragm  
Protector mounts with 2" NPT sub  
Hose lengths to 50 feet are standard; longer  
lengths available in some pressure ranges

**Standard Capabilities include:**

- 3,000, 5,000, 6,000, 10,000 and 15,000 psi
- 210, 350, 420, 700 and 1,000 kg/cm<sup>2</sup>
- 21, 35, 42, 70, 100 MPa

### - Electronic Digital Gauge

This new electronic Digital Gauge is available in different levels of functionality, from a simple single input display to a full function dual input alarmed display system with graphical trend display, calculated values, and WITS. Designed to meet UL and CENELEC standards for intrinsic safety, the unit operates off its own battery pack or external power source.

Virtually any drilling parameter display by a hydraulic or electronic analog indicator can now be displayed more accurately and reliably using the Digital Gauge.



Digital Gauge Basic Model

*Digital Gauge Basic Model*



Digital Gauge with optional graphics module

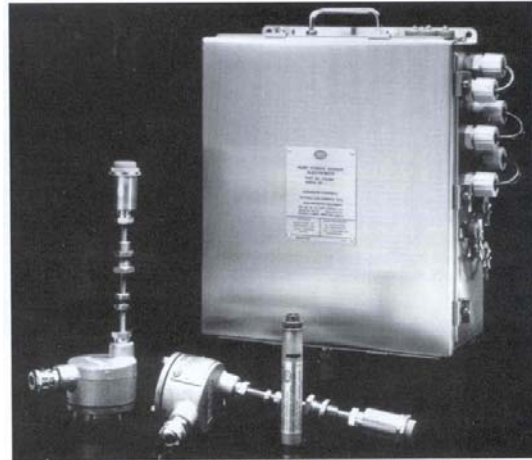
*Digital Gauge with Optional Graphics Module*

## Mud Pump Stroke Indicator



- SPM

- M/D TOTCO RATEMASTER



A complete M/D TOTCO RATEMASTER includes an electronics module, required cable, mounting hardware, and required sensors

- M/D TOTCO RATEMASTER

The M/D TOTCO RATEMASTER represents a significant advancement over traditional methods of measuring rotary table RPM and pump SPM.

Since there are no generators required to create a signal, there are no moving parts.

All SPM sensing is done by permanently mounted oil-tight proximity switches.

The RPM sensor is a magnetically activated probe mounted next to the rotary table or adjacent to an object that rotates in proportion to the table.

The microprocessor control box outputs both pulse and analog signals that can be utilized by devices such as:

- Electric Meters
- Drilling Recorders
- Electronic Circular Recorders
- Dual Digital Pump Stroke Counters
- Battery Operated Pump Stroke Counters

## Rotary/TOP Drive Speed Indicator

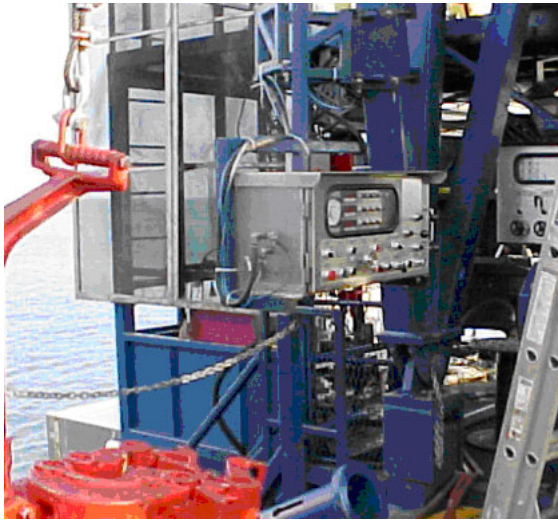


Digital Gauge Basic Model

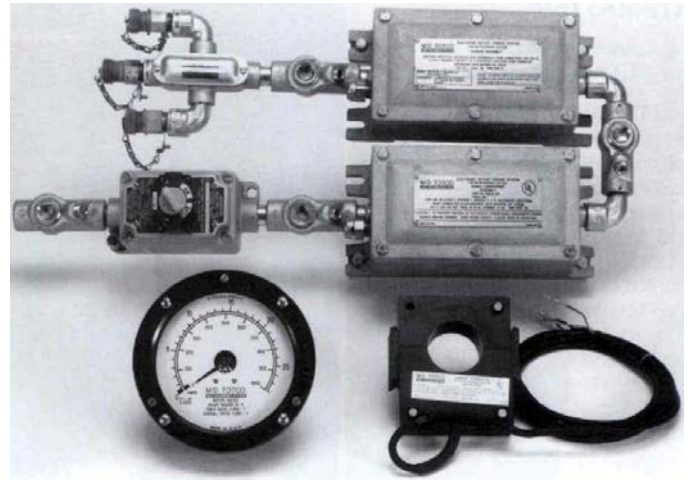


## Rotary Table / Top Drive Torque Indicator

Essential equipment for all electric motor driven rotary table



TOP Drive Control Panel



M/D TOTCO

### - M/D TOTCO

The M/D TOTCO solution to measuring rotary torque on electric rigs is accurate, simple, and reliable, having proven itself over the years in hundreds of installations world-wide.

The M/D TOTCO ERT system displays torque on a rugged panel or box-mounted meter calibrated in either foot pounds or metric equivalents.

- Simple, no moving parts to wear out
- Split core transducer measuring electrical current to the motor clamps around power cable, no shunts or direct electrical connections required.

## Tong Pull Indicator

### - TONG TORQUE H6E-Series

Models and capacities to work with all manual tongs

Permanent installation models for box or console include 25' hose assembly, portable installation models with 5' hose mount indicator and cylinder directly on tong handle.

Capacities to 25,000 pounds line pull with metric equivalents available.



TONG TORQUE H6E-Series



### **Mud Pit Level Indicator**

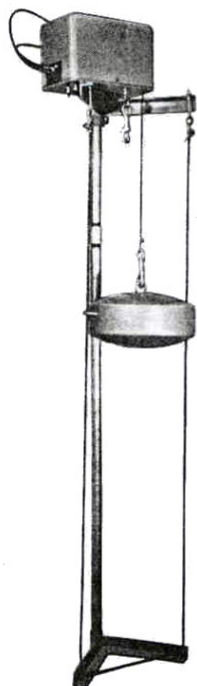
One of the most common indicators has a float that sends a signal indicating its position on the surface of the fluid from a base starting point.

The two types of indicators used most often are:

- Pneumatic
- Electric

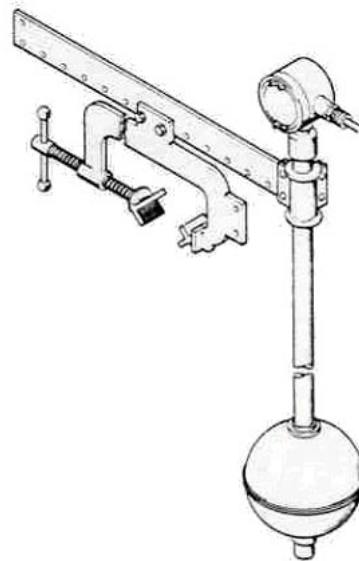
Newer Sensors are using Ultrasonic Source which reflected the surface level of the fluid in the mud pit.

- Pneumatic



PNEUMATIC VERTICAL PIT  
LEVEL SENSOR  
PN 270400

- Electric

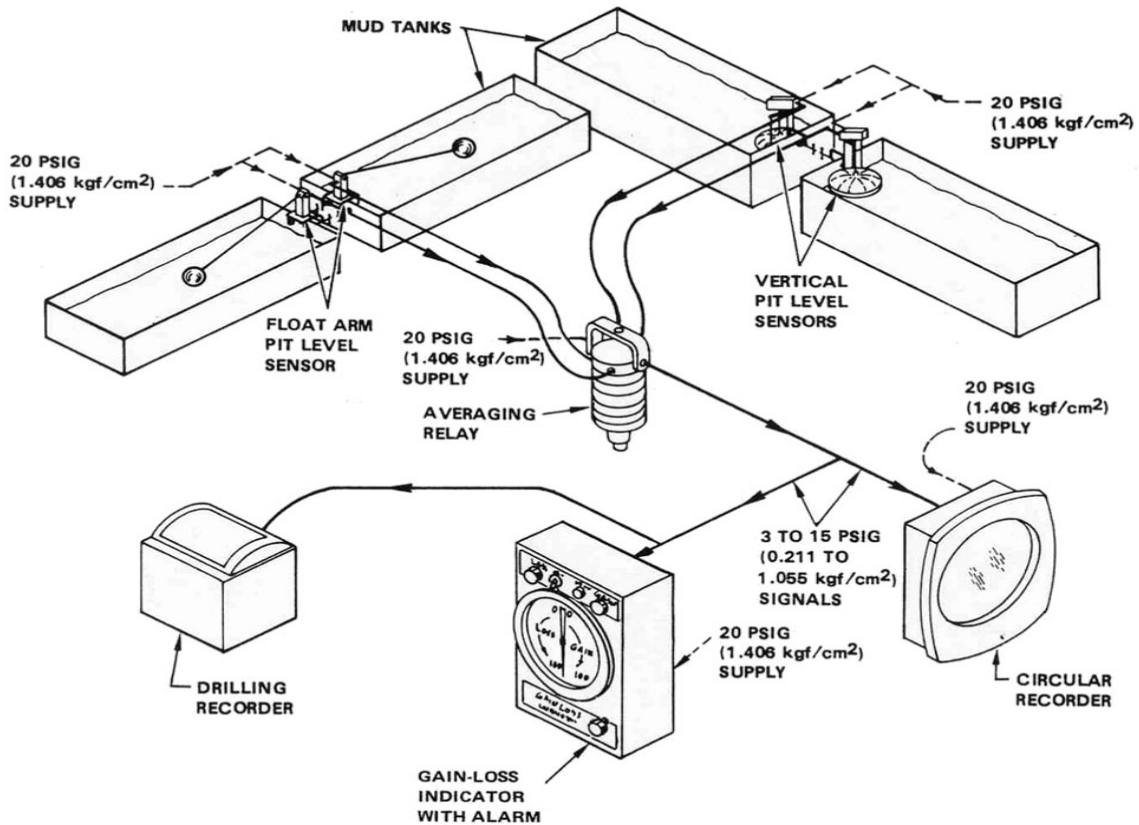


ELECTRIC VERTICAL PIT  
LEVEL SENSOR  
PN 272819

### **- Mud Pit Level system & Recording**

The level in each tank of the active system is continuously compared to a preset value. Any change in level trips an audible alarm and is also shown on the display (analog or digital) on the Driller's console.

### Tank of the Active System



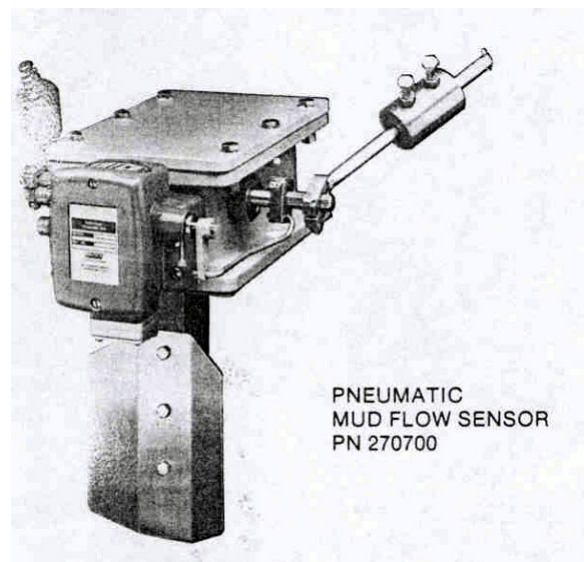
### Flow Indicator

#### - Mud flow

Mud flow is measured by movement of a paddle positioned in the Flow-line.

Valves are very rough and are reported as a percentage of the mud flow through the stand pipe.

Different sensors are used.



## Drilling Recorder

### - Paper Recorder

This paper recorder is the most commonly used today, although more rigs are becoming equipped with a digital recorder through a dedicated server.

Recorders are available in 2,4,6, and 8 pen configurations.

All recorders include drill string weight, penetration weight, and other parameters of your choice.



### - Parameters

#### Fluid Pressure

Provides an accurate record of fluid system pressure. Changes in pressure indicate potential washouts, kicks, plugged bits, or numerous other downhole problems.

#### Pit Level

Indicates the level of drilling fluid in the pits. A gain or loss in pit level is a warning of kicks or lost circulation.

#### Fluid Flow

Provides a relative record of fluid flow in the return line. Significant flow changes could indicate lost circulation, an influx of formation fluid, or a kick.

#### Weight

This measurement is sensitive enough to detect downhole problems such as tight hole or cave-ins as they occur.

#### Penetration

This parameter is indicated on the English chart by a short mark for each foot drilled and a longer mark for each five feet. On metric charts, indications are at 1/4 and full meters.

#### Rotary RPM

Indicates the revolutions per minute of the rotary table, an important function for optimum penetration.

#### Torque

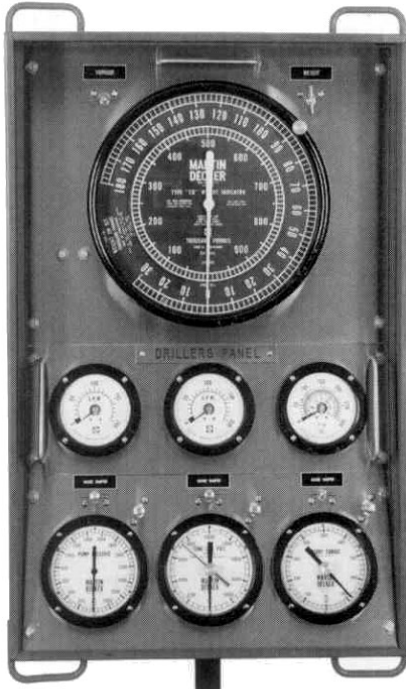
Shows electric or hydraulic rotary torque changes during drilling which inform the driller of formation transitions, worn bit, and tight or out-of-gauge hole.

#### Pump Rate RPM

Permits accurate calculations of fluid volume pumped into the circulating system. Comparison of pump rate.

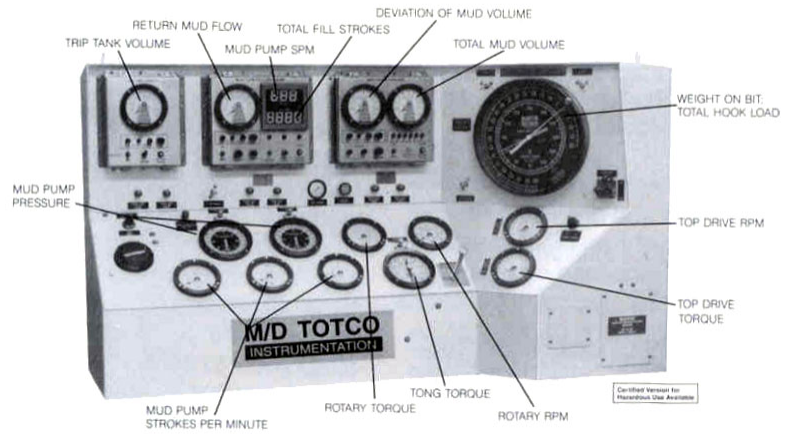
### 37.4 INTERFACE (Panels, Consoles)

*Example of Driller's panel with base instrumentation.*



Compact Driller's Panel with EB Weight Indicator

*- Example of integrated panel complete with all the instrumentation.*





### 37.5 INTEGRATED SYSTEMS

Example of integrated instrument system

#### - SPECTRUM 1000

##### HOOK LOAD

- Digital and circular bar graph display.
- Electronically settable scales for hook load automatically adjusts for changes to lines strung.
- Alarm limit display with high setting and keyboard entry code number.

##### BIT WEIGHT

- Digital and circular bar graph display.
- Electronically settable scales for bit weight.

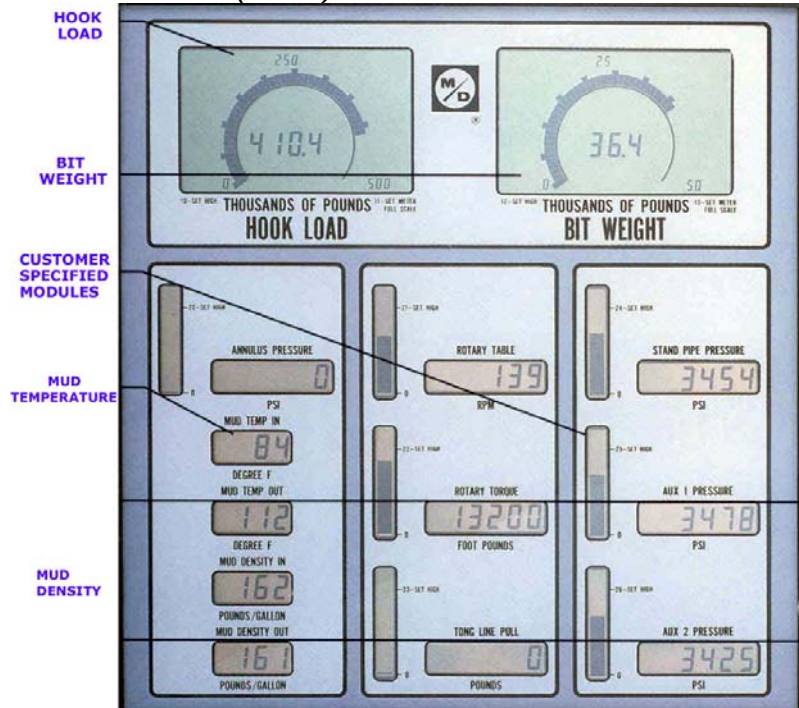
##### CUSTOMER SPECIFIED MODULES

- Torque, RPM, and pressure display.
- Numerical readout and bar graph displays configured to high alarm limit per customer requirements.

##### MUD TEMPERATURE AND DENSITY

- Monitors mud temperature and density in and out.

SPECTRUM 1000 (side 1)



SPECTRUM 1000 (side 2)

### MUD FLOW FILL UNIT

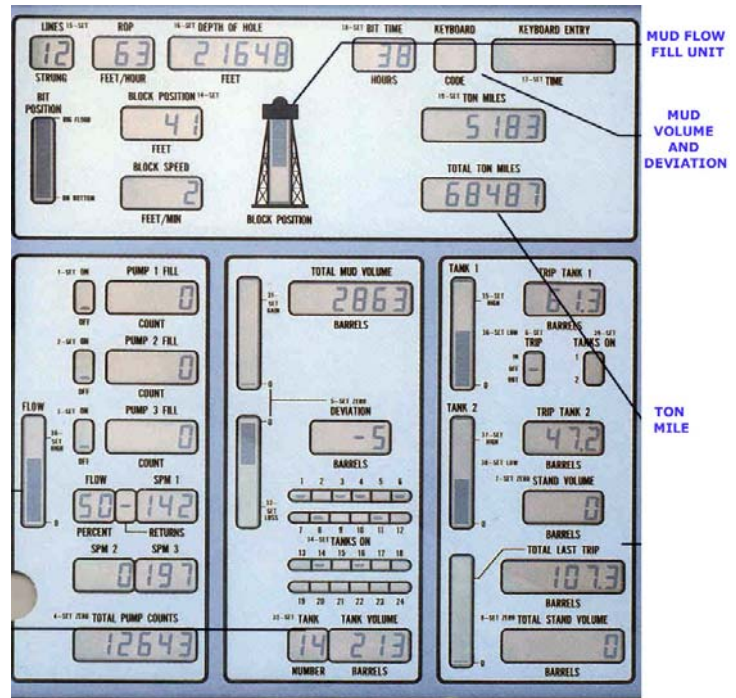
- Monitors an unlimited number of mud pumps.
- Displays strokes per minute and tot strokes for each pump.
- Bar graph display for flow based on high set limit.

### MUD VOLUME AND DEVIATION

- Monitors and unlimited number of mud tanks.
- Monitors any single tank.
- Bar graph display for gain and loss

### TON MILE

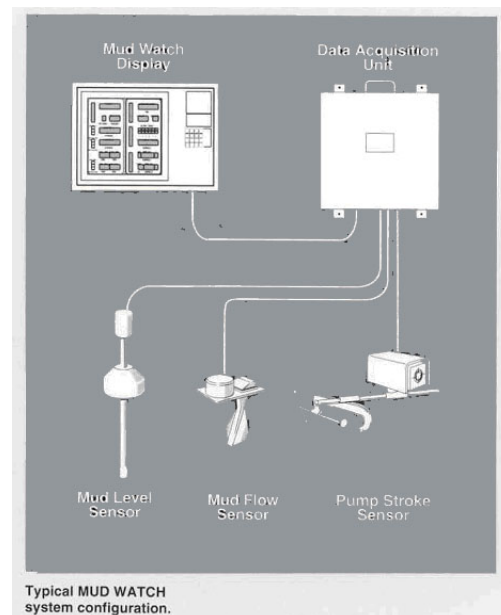
- Display total ton miles
- Display settable "work watcher" ton miles.



### - MUD WATCHER

Sandartd system features include:

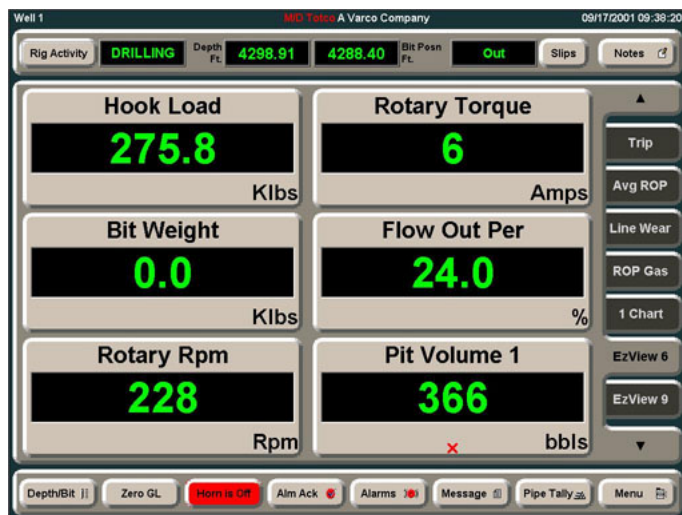
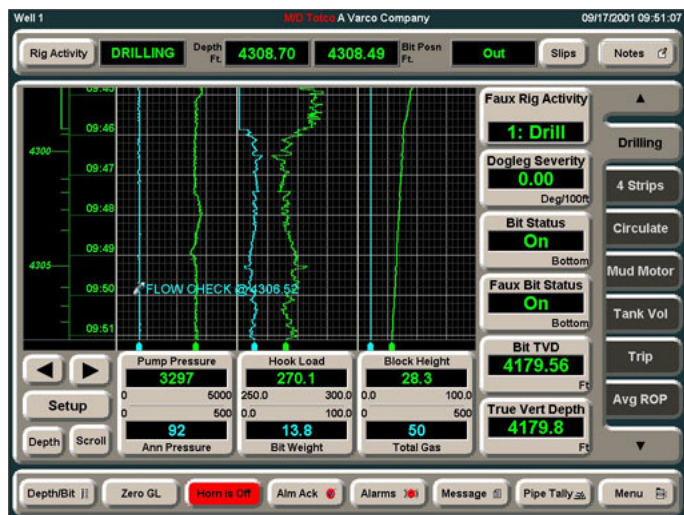
- I.S. display panel, with barriers
- Audible and visible alarms
- Volume and deviation, up to 12 tanks
- Trip tank
- Return mud flow
- SPM and cumulative strokes, up to 3 pumps
- 1 user definable input
- Time of day display



### - RIG SENSE

- View 1

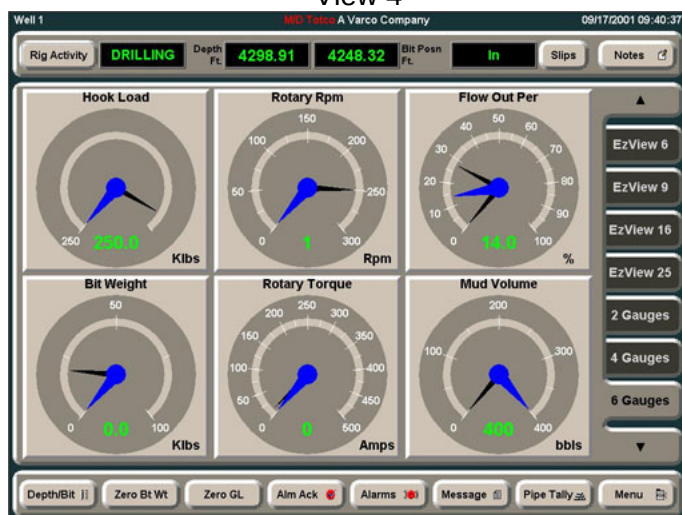
- View 2



- View 3

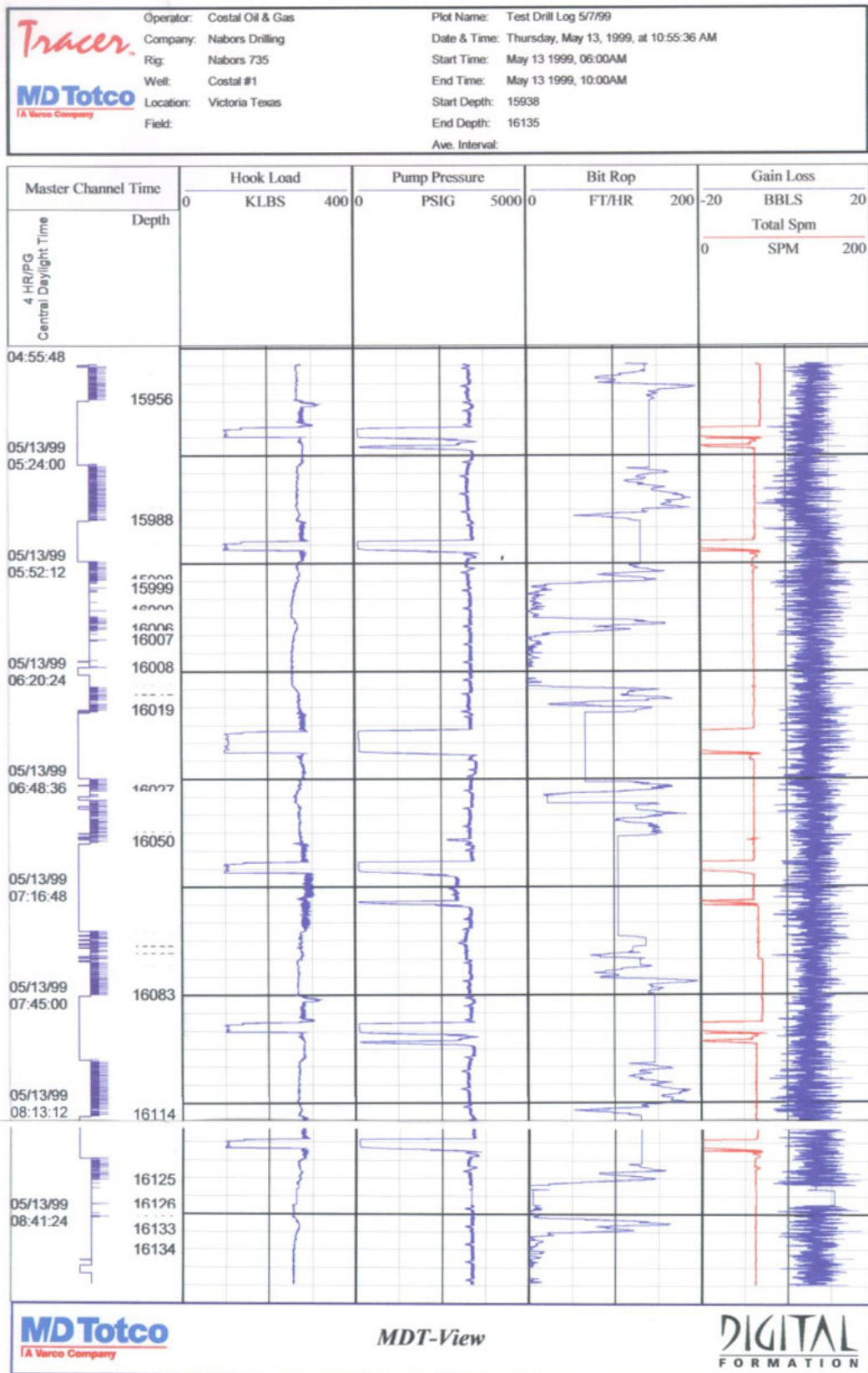


- View 4





- Output





**- Driller's Console installed on new generation off-shore Rigs**

Single driller with touchscreens for:

- Control of SCR/AC Drive
- Drawworks & power swivel control
- Pipe handling control
- Drilling instrumentation, etc.



### 38. SOUND PROOFING

#### INDEX

- 38.1 GENERAL
- 38.2 SONOURUS SOUCES ON A LAND RIG
- 38.3 SOUND PROOFING

#### 38.1 GENERAL

##### - Noise limits

In Italy, noise limits on Rigs working near to home environment are defined by Ministerial Decree DPCM 1 March 1991.

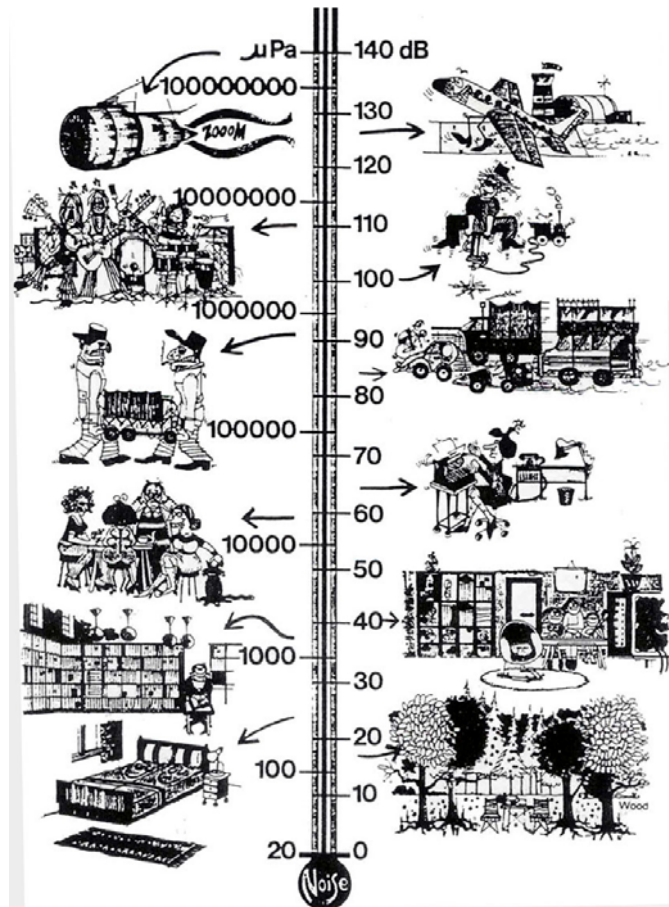
Since Drilling Rigs are mobile Rigs and the location of Rig site and its configuration changes from time to time, the government has established a noise level (Leq (A)) requirement.

Leq (A) = Equivalent continuous Level of pondered sonorous pressure "A"

##### - Decibel (Db) definition

Decibel is used to define acoustic energy level in acoustic; it is equivalent to 10 times the decimal logarithmic of the rate between the examined value in pa and the reference value (20 pa).

The chart on the right shows the relationship between acoustic pressure and Db.



Acoustic pressure and Db

#### 38.2 SONOURUS SOUCES ON A LAND RIG

##### - Operative phases

The operative phases that generate the most noise on a rig are:

- Drilling
- Tripping pipe

##### - Noisiest areas

The noisiest areas of the rig are:

- GENERATORS
- PITS and PUMPS shack Areas
- RIG FLOOR

### 38.3 SOUND PROOFING

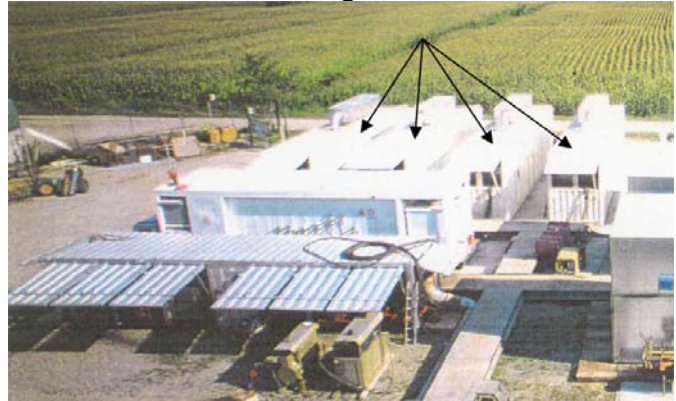
- ENGINES AREA
- MUD AREA
- RIG FLOOR AREA

#### - ENGINES AREA

Objective: attenuation of about 30 Db (A)  
Intervention points carried out:

1. Complete covering through sound proof container
2. Engine group linked up to frame through antivibrant
3. Installation of residential type silencer

*Engines Area*



#### - MUD AREA

Objective: Attenuation of 8 Db (A).

Intervention points carried out:

1. Vertical screening on shale shaker's four sides
2. Vertical screening on mud pits' external sides
3. Complete covering on mud pumps' engines.

*Vertical screening and Complete covering*



**Vertical screening on mud pits' external sides**

Objective: Attenuation of 8 Db (A)

Intervention points carried out:

- Vertical screening on mud pits' external sides
- Complete covering on mud pumps' engines



**Complete covering on mud pumps' engines**

*Mud Area: mud pits and mud pumps' engines*



## - RIG FLOOR AREA

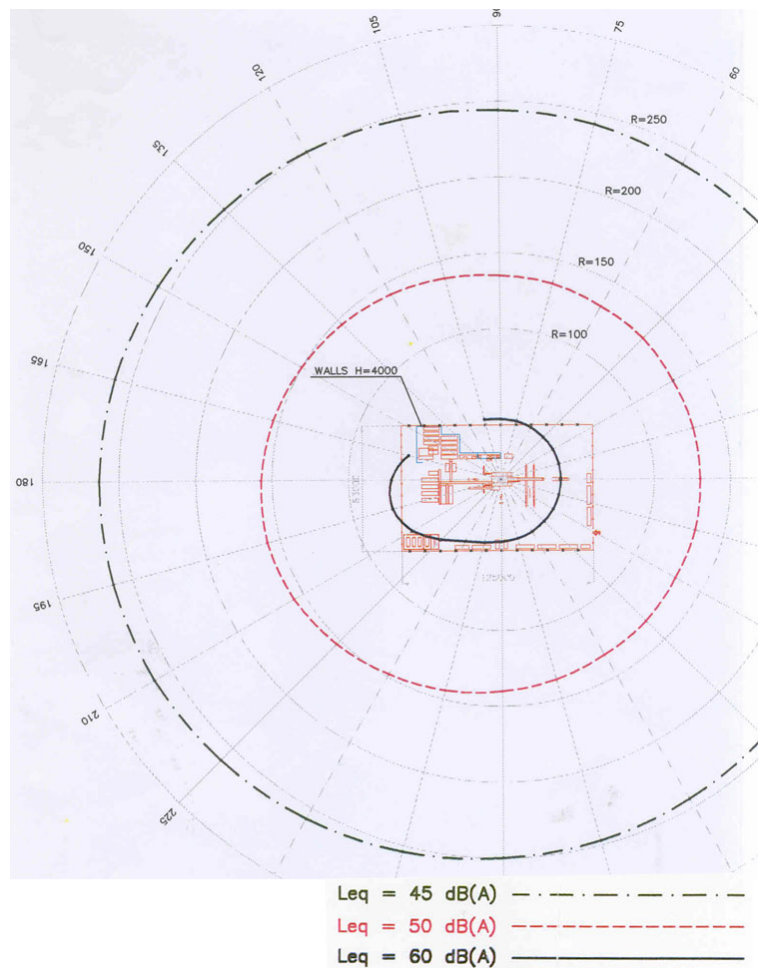
Objective: Attenuation of 30 Db (A)  
Intervention point carried out:

1. Vertical screening on the four sides of Rig floor.
2. Lower Vertical screening on Rig floor's four sides.

**Rig floor area**



Example of ISOLEVEL CURVES  
on area map around Rig site.





### 39. WINTERIZATION SYSTEM

#### INDEX

- 39.1 GENERAL
- 39.2 COMPONENTS
- 39.3 SOME OF THE MAIN DATA

#### 39.1 GENERAL

- Extreme cold weather

In order to operate continuously in extreme cold weather, Drilling Rig need to be properly equipped.

- Wind Chill Effect

When relevant, the WIND CHILL can have a big effect on the temperature.

|                      |     | TEMPERATURE in ° C            |     |     |     |           |     |     |                     |     |
|----------------------|-----|-------------------------------|-----|-----|-----|-----------|-----|-----|---------------------|-----|
| ESTIMATED WIND SPEED |     | 10                            | 4   | -1  | -7  | -12       | -18 | -23 | -29                 | -34 |
|                      |     | EQUIVALENT TEMPERATURE in ° C |     |     |     |           |     |     |                     |     |
| Km/h                 | m/s | ° C                           | ° C | ° C | ° C | ° C       | ° C | ° C | ° C                 | ° C |
| 0                    | 0   | 10                            | 4   | -1  | -7  | -12       | -18 | -23 | -29                 | -34 |
| 8                    | 2   | 9                             | 3   | -3  | -9  | -14       | -21 | -26 | -32                 | -38 |
| 16                   | 4   | 4                             | -2  | -9  | -16 | -23       | -29 | -36 | -43                 | -50 |
| 24                   | 7   | 2                             | -6  | -13 | -21 | -28       | -38 | -43 | -50                 | -58 |
| 32                   | 9   | 0                             | -8  | -16 | -23 | -32       | -39 | -47 | -55                 | -63 |
| 40                   | 11  | -1                            | -9  | -18 | -26 | -34       | -42 | -51 | -59                 | -67 |
| 48                   | 13  | -2                            | -11 | -19 | -28 | -36       | -44 | -53 | -62                 | -70 |
| 56                   | 16  | -3                            | -12 | -20 | -29 | -37       | -45 | -55 | -63                 | -73 |
| 64                   | 18  | -3                            | -12 | -21 | -29 | -38       | -47 | -56 | -65                 | -73 |
|                      |     | Slightly dangerous            |     |     |     | Dangerous |     |     | Extremely dangerous |     |
|                      |     |                               |     |     |     |           |     |     |                     |     |

#### 39.2 COMPONENTS

Equipped used to isolate the rig include:

- Tarpaulin Covering
- Steam Boilers and Steam Radiators
- Warm Air Boilers
- Electric Resistance Heating (in mud pits)

##### - Tarpaulin Covering

Many areas are covered in order to contain the heat produced by boilers and other equipment. This helps protect personnel from the cold weather and wind.

It is preferable to use tarpaulins (made of fireproof materials) since they can be removed during the warmer weather.

Areas usually covered are:

- RIG FLOOR,
- MONKEY BOARD AND SUBSTRUCTURE
- SUBSTRUCTURE
- MUD PITS AND MUD PUMPS

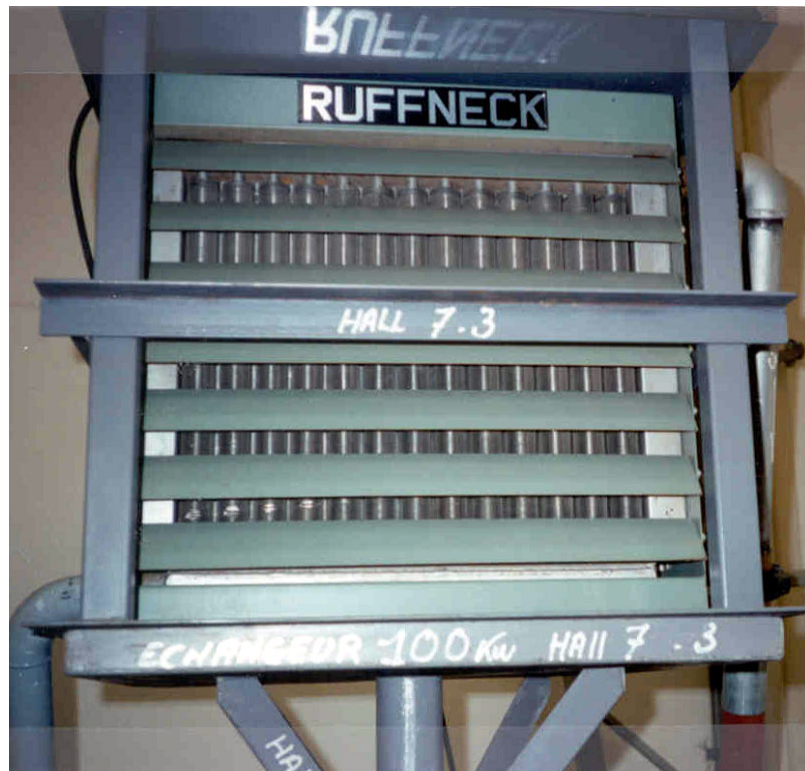


*Example of Tarpaulin Covering*

#### **- Steam Boilers and Steam Radiators**

Steam, generated by diesel oil heater, is produced at variable pressure and distributed through lines to various heating points where radiators (ruffneck heaters) are installed.

It is a good practice having a stand by boiler ready to work as back up.



*Ruffneck heaters*

### **- Warm Air Boilers**

Hot air generated by a diesel oil / gasoline boiler is distributed by lines and electric fans at the heating point.

Warm air boilers are used where steam lines can't be used. They are easy to install and do not require much maintenance.

### **- Electrics Aeroterm**

Hot air generated by an electric resistance is distributed through an electric fan.

They are used in remote areas of the rig such as the monkey board.

### **- Electric Resistance Heating (in mud pits)**

They are introduced into the mud pits and water pits and activated in order to avoid fluid cooling.

Moreover, proper electric cables are used with resistance functions that are wrapped around the lines exposed to the weather.

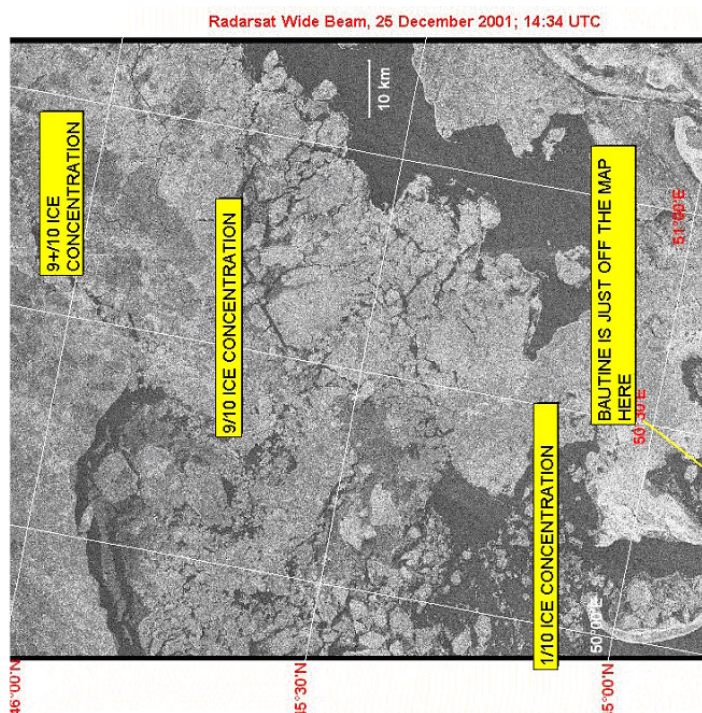


*Electric resistance heating*



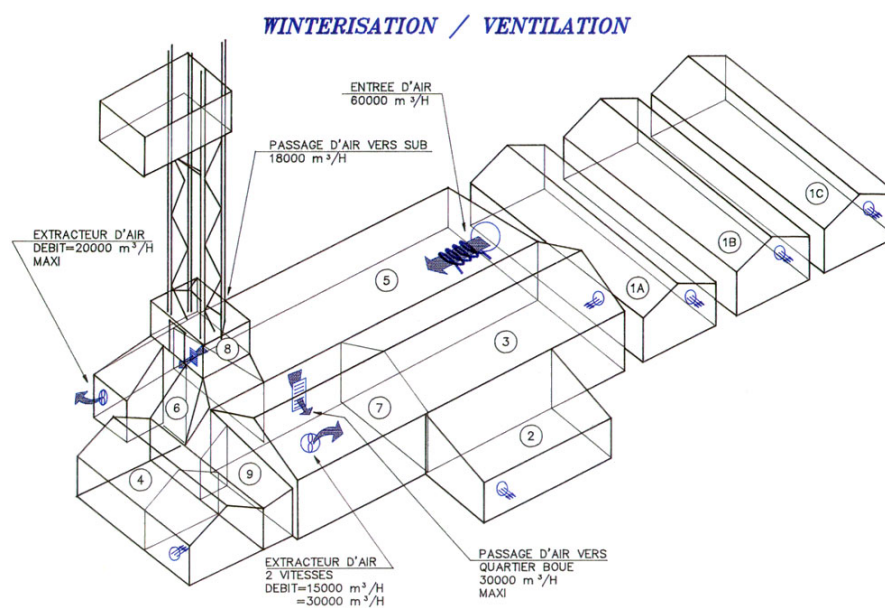
### 39.3 SOME OF THE MAIN DATA

- ICE VIEW FROM SATELLITE



Examples of winterization system's characteristics

- Winterisation / Ventilation



- Winterisation / Chauffage

#### WINTERISATION / CHAUFFAGE

| PUISSANCE                        | CHAUFFAGE<br>AIR CHAUD<br>EN KW | AEROTHERME<br>VAPEUR<br>EN KW | APPOINT<br>ELECTRIQUE<br>EN KW | SURFACE<br>CHAUFFEE<br>EN m <sup>2</sup> | VOLUME<br>CHAUFFEE<br>EN m <sup>3</sup> |
|----------------------------------|---------------------------------|-------------------------------|--------------------------------|------------------------------------------|-----------------------------------------|
| RIG<br>REP. 6-8                  |                                 | 450                           | 21                             | 620                                      | 4050                                    |
| PUISSANCE BOUE<br>REP. 2-3-4-5-7 | 592                             | 1212                          | 126                            | 3995                                     | 26641                                   |
| HANGAR<br>REP. 1A-1B-1C          | 1044                            |                               |                                | 2400                                     | 16320                                   |
| TOTAL                            | 1636                            | 1662                          | 147                            | 7015                                     | 47011                                   |



## 40. H<sub>2</sub>S MONITORING & PROTECTION

### INDEX

40.1 GENERAL

40.2 MONITORING SYSTEMS

40.3 BREATHING APPARATUS PROTECTION SYSTEM

### 40.1 GENERAL

#### - Hydrogen Sulphide (H<sub>2</sub>S)

Hydrogen Sulphide (H<sub>2</sub>S) is a toxic gas that can be present in crude oil and natural gas.

Sulphur Dioxide (SO<sub>2</sub>) is the effect of the combustion of H<sub>2</sub>S and is toxic as well.

H<sub>2</sub>S has the following tolerance limits:

Exposure at 10 ppm for 5 days per week (for a lifetime).

Consequence for higher concentrations are listed below:

*Table: Consequence for higher concentration*

| Concentration in p.p.m.<br>(part per milion in volume) | From 0 to 2 min                                | From 2 to 15 min                                   | From 15 to 30 min                                          | From 30 min to 1 h                                         |
|--------------------------------------------------------|------------------------------------------------|----------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
| 50 - 100                                               |                                                |                                                    |                                                            | Conjunctivitis, respiratory irritations                    |
| 100 - 150                                              |                                                | Coughing, conjunctivitis, loss of sense of smell   | Respiratory illness, pain on eyes, sleepiness              | Throat irritation                                          |
| 150 - 200                                              |                                                | Loss of sense of smell                             | Throat and aye irritation                                  | Increasing of throat and eyes irritation                   |
| 200 - 350                                              |                                                | Eye irritation and loss of sense of smell          | Increasing of eye irritation                               | Painfully lachrymator and tiredness                        |
| 350 - 450                                              |                                                | Eye irritation and loss of sense of smell          | Breathing difficulty, coughing, eye irritation             | Increasing of eyes and nose irritation, head ache          |
| 450 - 600                                              | Coughing, heart failure, loss of consciousness | Respiratory illness, eye irritation, heart failure | Serious eye irritation, palpitations, probability of death | Serious pain on eyes and head, nausea, trembling and death |
| 600 - 1500                                             | Heart failure, loss of consciousness, death    |                                                    |                                                            |                                                            |

#### - H<sub>2</sub>S Chemical And Physic Characteristics

Characteristic smell: rotten eggs  
 Boiling point: - 60 C  
 Flammable point: GAS  
 Ignition point: 260 C  
 Density (referred to air): 1,19 at 20 C

Threshold level (TLV-TWA): 10 ppm  
Explosive limit: 4,3% - 45%

**- Safety Precautions**

Continuous monitoring with fixed H<sub>2</sub>S Detection devices and/or frequently ambient air monitoring with H<sub>2</sub>S phials;  
Never rely on smell, since H<sub>2</sub>S anesthetizes the olfactory nerve (human sense of smell).

**- Personal Protection Means**

Breathing apparatus to operate in H<sub>2</sub>S environment;

## 40.2 MONITORING SYSTEMS

- FIXED MONITORING SYSTEM
- PORTABLE MONITORING SYSTEMS

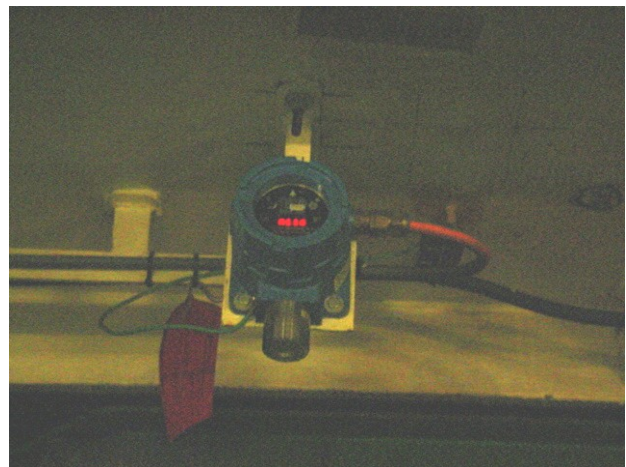
**- FIXED MONITORING SYSTEM**

- Fixed Detection Devices Monitoring System
- Monitoring & alarm Panel
- H<sub>2</sub>S Sensor & SO<sub>2</sub> Sensor
- Acoustic and visual alarm

**- Fixed Detection Devices Monitoring System**

Fixed automatic detection monitoring devices equipped with sensors are installed in areas where H<sub>2</sub>S is most likely to be detected.

- Wellhead area
- Rig floor
- Shale shaker area
- Mud suction pit
- Choke manifold area
- SO<sub>2</sub> burner area



**- Monitoring & alarm Panel**



CM901 GAS MONITORING & ALARM SYSTEM

## - H2S Sensor & SO2 Sensor

H2S Sensor

**SENSORE/TRASMETTITORE PER LA MISURA DI H<sub>2</sub>S CON TECNICA DI TRASMISSIONE A DUE CONDUTTORI 4-20 mA**

- Rapida rivelazione della concentrazione di H<sub>2</sub>S sui posti di lavoro e negli impianti industriali.
- Sensore a cella elettrochimica a lunga vita, utilizzabile anche in estreme condizioni d'impiego.
- Trasduttore elettronico di misura, 4-20 mA, a due conduttori per montaggio in campo; accetta alimentazioni non stabilizzate da 8 a 30 V cc.
- Taratura effettuabile direttamente sul sensore grazie al display digitale ed ai potenziometri posizionati sotto il display.
- Versione a sicurezza intrinseca EEx ia IIC T6 CENELEC.
- Certificato BVS N. 88.B.2020.



SO2 Sensor

**SENSORE/TRASMETTITORE PER LA MISURA DI SO<sub>2</sub> CON TECNICA DI TRASMISSIONE A DUE CONDUTTORI 4-20 mA**

- Rapida rivelazione della concentrazione di SO<sub>2</sub> sui posti di lavoro e negli impianti industriali.
- Sensore a cella elettrochimica a lunga vita, utilizzabile anche in estreme condizioni d'impiego, sviluppato e prodotto dalla Dräger.
- Trasduttore elettronico di misura, 4-20 mA, a due conduttori per montaggio in campo; accetta alimentazioni non stabilizzate da 8 a 30 V cc.
- Taratura effettuabile direttamente sul sensore grazie al display digitale ed ai potenziometri posizionati sotto il display.
- Versione a sicurezza intrinseca EEx ia IIC T6 CENELEC.
- Certificato BVS N. 88.B.2020.

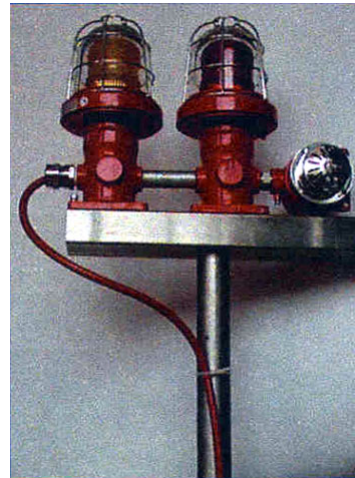


## - Acoustic and visual alarm

Acoustic and visual alarm system is pre-set at two levels.

The first level of pre alarm operates the yellow light and an intermittent sound.

The second level of alarm operates the red light and a continuous sound.





## - PORTABLE MONITORING SYSTEMS

### - Personal air control (PAC)

PAC (Personal Air Control) equip personnel working in potentially dangerous area with risk of toxic gas' presence.

### - Multi-Gas Detector

Detection devices to monitor for toxic gas type and its quantity in PPM.

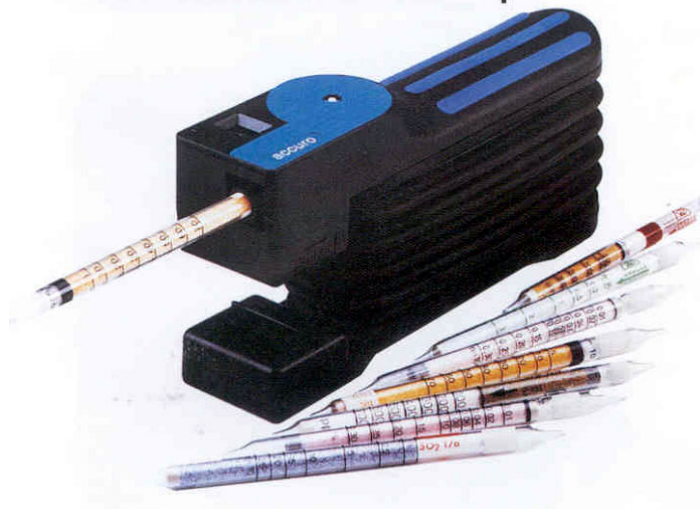
Personal air control



Multi-Gas Detector



Accuro Bellows Pump





### 40.3 BREATHING APPARATUS PROTECTION SYSTEM

- Fixed system (air cascade)
- FIXED SYSTEM'S COMPONENTS

- Fixed system (air cascade)

When drilling a well with H<sub>2</sub>S, it is a good ENI E&P practice to install a fixed system (air cascade) to distribute pressurised air that allows personnel to breathe non-contaminated air in the event of an emergency.

This system consists of:

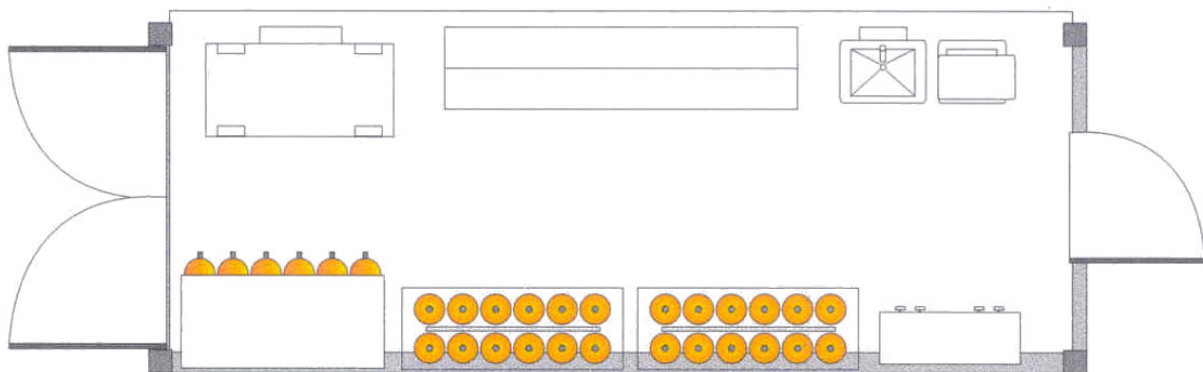
- A tank with pressurised air able to guarantee 10 hours of breathing for 10 people.
- 2 compressors located in opposite positions to recharge the system and guarantee pure air input.
- A distribution system in a strategic area.



Breathing Apparatus Protection System

#### - FIXED SYSTEM'S COMPONENTS

- Batteries of cylinders  
Two Bottles racks:  
containing 12 cylinders x 50 lt ea. = 24.000 lt of total capacity



Bottles racks

#### - CYLINDERS RECHARGING SYSTEM

- Air compressors:  
Electrical air compressor Bauer mod. KAP 15-15 E installed over a rack storing a spare SCBA cylinders under recharge;  
Diesel engine air compressor Bauer mod. Kap 15-15 DA installed on wells.

*BAUER KAP series High Pressure Breathing-air Compressors*

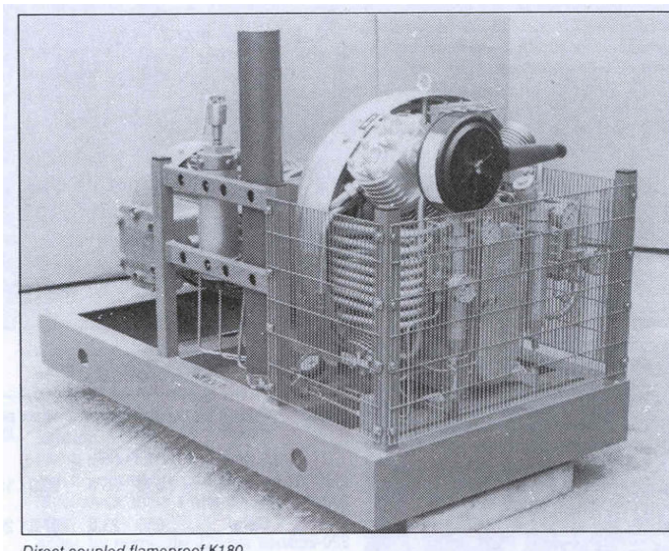
**Bauer KAP series.**

| Model:        | Prime mover:        | Charging rate     |      | Motor power |      |
|---------------|---------------------|-------------------|------|-------------|------|
|               |                     | free air delivery |      | hp:         | kW:  |
|               |                     | l/min:            | cfm: |             |      |
| KAP14-7.5 E   | Electric            | 260               | 9.2  | 7.5         | 5.5  |
| KAP14-7.5 B   | Honda GX340, petrol | 260               | 9.2  | 11.0        | 8.0  |
| KAP14-7.5 D/L | Lister LV1, diesel  | 260               | 9.2  | 10.0        | 7.5  |
| KAP14-10 E    | Electric            | 320               | 11.5 | 10.0        | 7.5  |
| KAP14-10 D/L  | Lister LV2, diesel  | 320               | 11.5 | 18.0        | 13.1 |
| KAP15-15 E    | Electric            | 440               | 15.5 | 15.0        | 11.0 |
| KAP15-15 D/L  | Lister LV2, diesel  | 440               | 15.5 | 18.0        | 13.1 |
| KAP180-20 E   | Electric            | 600               | 21.2 | 20.0        | 15.0 |
| KAP180-20 D/L | Lister TS3, diesel  | 600               | 21.2 | 21.0        | 16.0 |

- Cylinders Recharging

- Charging rate of 15.5 cfm/440 lpm.
- Includes a purification system to deliver breathing air to meet EN 132.
- Charging pressure up to 3000 psi
- Includes an automatic shut down facility on the detection of CO H<sub>2</sub>S and SO<sub>4</sub>

Electrical air compressor



Direct coupled flamenproof K180.

High Pressure, Diesel Powered Compressor



**- DISTRIBUTION SYSTEM**

**- Manifold and Breathing apparatus location**

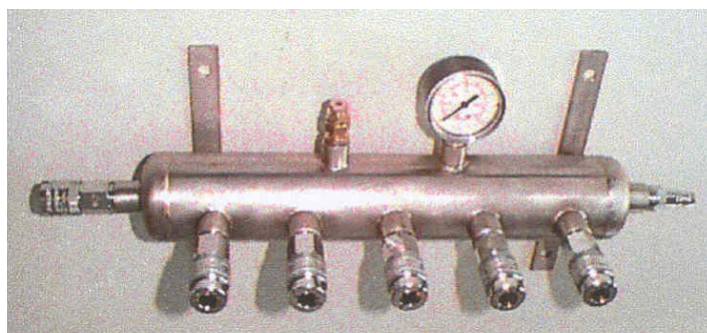
| Delivery Station Location | Manifold | Breathing Apparatus |
|---------------------------|----------|---------------------|
| Rig Floor                 | 3        | 10                  |
| Derrick man Platform      | 1        | 3                   |
| Well head area            | 2        | 8                   |
| Choke manifold area       | 1        | 3                   |
| Mud Mixing area           | 1        | 3                   |
| Mud Pump area             | 1        | 3                   |
| Mud Tanks area            | 1        | 3                   |
| Shale Shaker Area         | 1        | 3                   |
| Well Test Area            | 3        | 8                   |

**- Manifold**

Made of 2" stainless steel pipe rated 40 bar BP, 15 bar WP, with # 1 x 3/8" inlet and #6 x 3/8" outlets provided with safety quick-connectors and check valves.

Each outlet is capable to delivery 350 Nlt/min of breathing air.

Each manifold is provided with pressure gauge and safety valve.





## BREATHING APPARATUS

### - Breathing apparatus

Breathing apparatus with umbilical linked up to distribution manifold and back up cylinder of 10 minutes length.



### - 30 Minute Breathing Apparatus

CENTURION-LT with 1200 litre, 207 bar alloy steel cylinder 68 bar whistle.  
Rated duration 30 minutes.

#### Features

- Lightweight 'Panaseal' full facemask
- Automatic first breath activated positive pressure demand valve
- High performance pneumatic system
- Lightweight tubular frame
- Comfortable flame retardant polyester harness
- Safety locking cylinder valve
- Low cost simple servicing and maintenance
- Approved to BS 7004 EN 137



### 10 minute breathing apparatus

They are provided to all the personnel working on the Rig site.  
They are used to reach the safety points in case of emergency.

The world's most popular escape set with current users as diverse as NASA in the USA, navies on every continent, and industrial customers worldwide.

- All round vision, anti - misting PVC hood
- 10 minutes of self - contained breathing air for escape (400 litres at 40 litres per minute)





## - ARTIFICIAL BREATHING APPARATUS

Artificial Breathing Apparatus



Use of Artificial Breathing Apparatus



## 41. SAFETY EQUIPMENT

### INDEX

- 41.1 PERSONAL PROTECTIVE EQUIPMENT
- 41.2 EMERGENCY WASHING STATION
- 41.3 ESCAPE - EVACUATION - RESCUE
- 41.4 OMNIDIRECTIONAL FOGHORN
- 41.5 PERSONNEL LIFTING DEVICE
- 41.6 FIRE FIGHTING SYSTEM
- 41.7 SAFETY DEVICES

### 41.1 PERSONAL PROTECTIVE EQUIPMENT

#### - General Personal Protective Equipment

*List General Personal Protective Equipment*

|                              |        |                                          |
|------------------------------|--------|------------------------------------------|
| Fie Man outfits              | No.    | 4                                        |
| Safety Helmets               | Yes/No | Equipped (plus for 10 visitors included) |
| Safety Gloves                | Yes/No | Equipped                                 |
| Safety Boots                 | Yes/No | Equipped                                 |
| Ears Protection              | Yes/No | Equipped                                 |
| Eyes Protection              | Yes/No | Equipped                                 |
| For welding                  | Yes/No | Equipped                                 |
| For handling chemicals       | Yes/No | Equipped                                 |
| For Oil Base Mud and Brine   | Yes/No | Equipped                                 |
| Safety Belts                 | Yes/No | Equipped                                 |
| Explosion proof hand-torches | No     | Equipped                                 |
| Wind socks                   | No     | Equipped                                 |

#### - Personnel Protective means

*Personnel Protective Means*



## 41.2 EMERGENCY WASHING STATION

- Shower Station



- Eye Washing Station



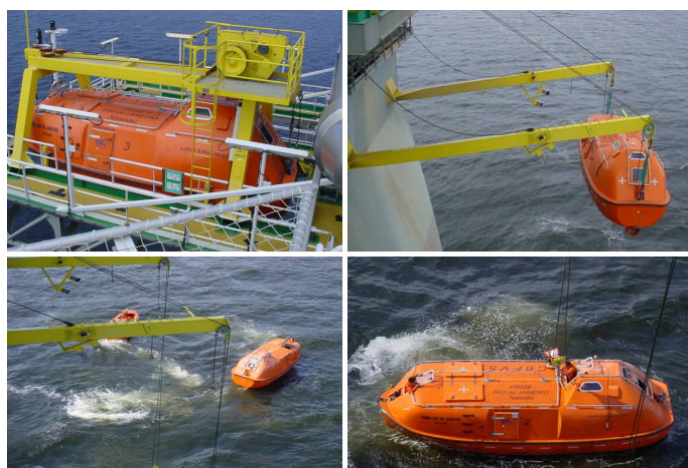
## 41.3 ESCAPE - EVACUATION - RESCUE

- Life Jackets

|              |      |              |
|--------------|------|--------------|
| Life Jackets | No.  | 200          |
| Quantity     | make | MLT          |
|              | type | USCG Style 1 |



- Life Boats



### Module Emergency Equipment & Safety

All safety equipment comply with any regulation:

Life boats

Quantity

No.  
make  
type

Will comply with IMO MOD code and Italian Law 886.

2

Water Craft

Equipped (Rigid, totally enclosed.  
Fire-proof and self-propelled)

People capacity of each

Comply with any Regulation

Certified by

No

60 persons per boat

:

IMO MODU Code

:

ABS

### - Life Rafts

#### Module Life Rafts

Life Rafts

Quantity

No.  
make  
type

6

RFD

Inflatable Type

People capacity of each

Comply with any Regulation

Certified by

No

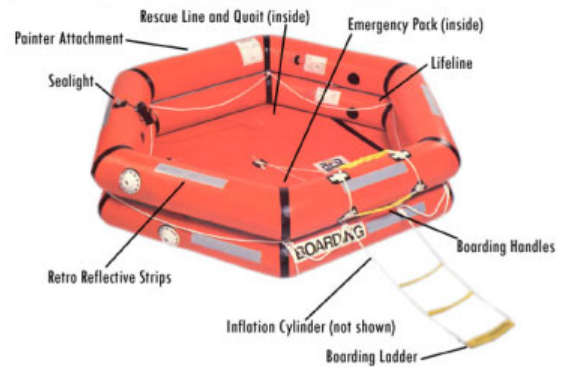
25 per craft

:

IMO MODU Code

:

ABS



### - Fast Rescue Craft

Fast Rescue Craft were designed to quickly rescue a man overboard.

#### - Module Rescue Boat

Rescue Boat

Quantity

No.  
make  
type

1

AMBAR

420 RHIB – 25 hp





- Arktos

In severe weather conditions, for survival, special Amphibious Life Boats have been created for Kazakhstan operations.

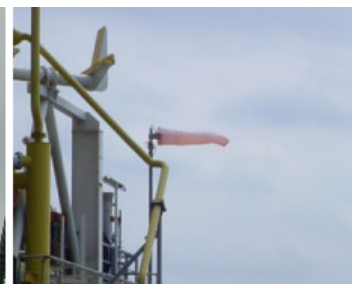


- Amphibious Life Boats



- Helicopters

Helicopters are the main means of transport for all Offshore installations or onshore in the bush (Nigeria - Ecuador, etc).



## ESCAPE SLIPWAY

### - Escape Slipway

### - Escape line for derrickman

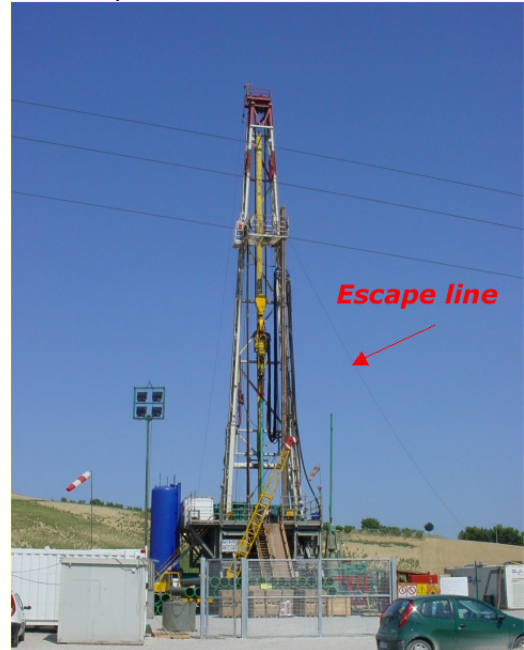
On land rigs, for the derrickman safety from the monkey board there is an aerial ropeway to permit a fast escape without using stairs.

This escape line is provided with a cinetic device for slackening of speed and stopping.

### - Escape Slipway



### - Escape line for derrickman



## 41.4 OMNIDIRECTIONAL FOGHORN

Like in the Navy, offshore installations must have

- Omnidirectional Foghorn to be used in poor visibility conditions.



### - Omnidirectional Foghorn



### - Device



### 41.5 PERSONNEL LIFTING DEVICE

#### - Man Riding

Man riding is the equipment used to lift personnel. After few accident happened in the oil field, it has been decided to build a specific tool for man lifting. It can pull a max weight of 150 kg otherwise it stops itself.

Man Riding



Baskets



### 41.6 FIRE FIGHTING SYSTEM

#### - Equipment

##### - Hydrants



##### - Extinguisher



#### - Helideck

Helideck has a dedicated fire fighting foam system with dedicated trained people ready anytime helicopter lands. The system works with sea water and foam together.

- Fire Fighting System on Elideck

**A.20.12 Fire Fighting System on Elideck**

- |                                                               |        |
|---------------------------------------------------------------|--------|
| 1 Fire monitors                                               | No.    |
| 2 Fire Hydrants                                               | No.    |
| 3 Portable Extinguisher                                       | No.    |
| 4 Fire Fighting system comply with rules                      | :      |
| 5 Emergency Rescue tool box complete with all requested tools | Yes/No |

|                                       |
|---------------------------------------|
|                                       |
| 2                                     |
| Foam system                           |
| 2 x 250 lb CO2                        |
| IMO MODU Code and Italian Law DM-121. |
| Yes                                   |

- Fire Monitoring & Fighting System

**A.20. Fire MONITORING & FIGHTING SYSTEM**

- 1 Comply with

Yes Will comply with IMO MODU CODE and 886 Italian Law

**A.20.1 Smoke/Heat/Fire Monitoring System**

- |                               |      |
|-------------------------------|------|
| 1                             | make |
| 2                             | type |
| 3 Sensor installed            | type |
| 4 Area monitored              | :    |
| 5 Area monitored              | :    |
| 6 Area monitored              | :    |
| 7 Area monitored              | :    |
| 8 Area monitored              | :    |
| 9 Area monitored              | :    |
| 10 Monitoring Panel Locations | :    |

|                         |
|-------------------------|
| Cerberus                |
| Guinard Model CZ10      |
| Heat/Smoke              |
| All Accomodities Spaces |
| Engine Room             |
| Mud Pump Room           |
| Mud Pit Room            |
| SCR Room                |
| Sack Storage            |
| Rig Floor/Radio Room    |

**A.20.2 Fire water Pumps**

- |                                       |        |
|---------------------------------------|--------|
| 1                                     | No.    |
| 2                                     | make   |
| 3                                     | type   |
| 4 Flow rate of each                   | gal/m  |
| 5 Pressure head                       | ft     |
| 6 Are they located in separated zones | Yes/no |

|         |
|---------|
| 2       |
| Mission |
| Magnum  |
| 600     |
| 270     |
| Yes     |

**A.20.3 Fire Fighting System on rig Floor**

- |                          |        |
|--------------------------|--------|
| 1 Fire Water Hydrants    | Yes/no |
| 2 Water Deluge           | Yes/no |
| 3 Portable Extinguishers | Yes/no |

|                    |
|--------------------|
| Yes                |
| Foam Deluge system |
| Yes                |

**A.20.4 Fire Fighting System in Cellar Deck area**

- |                          |        |
|--------------------------|--------|
| 1 Fire Water Hydrants    | Yes/no |
| 2 Water Deluge           | Yes/no |
| 3 Portable Extinguishers | Yes/no |

|     |
|-----|
| Yes |
| No  |
| Yes |



## 41.7 SAFETY DEVICES

### - Derrick signalling

All rigs must have Day and Night Signalling consisting in red or orange lights on top of the derrick



Derrick safety device



Safety Belt



## 42. COMUNICATION SYSTEMS

### INDEX

- 42.1 COMMUNICATIONS
- 42.2 OFFSHORE RIGS INTERCOMMUNICATION SYSTEM
- 42.3 LAND RIG REQUIREMENTS

### 42.1 COMMUNICATIONS

The three most common systems of communication on offshore drilling rigs are:

- Radio (with fax),
- Microwave
- Satellite

#### - Radio Communication

FM radio has replaced single side band as the favored radio communication. The rig, workboats and the shore base are linked by radio.

#### - Microwave Communications

Microwave communications are "line-of-sight", meaning that the signal must not be blocked by earth's curvature or any other obstruction.

Signals are transmitted between dish-shaped antenna which in line pointed at each other.

Microwaves can only be used if the rig is close to shore or to another fixture (such as a platform) which can re-transmit the signal.

#### - Satellite

Satellite is the most expensive means of communication. However, in remote locations, it is the only suitable system. Governmental permits are required.

### 42.2 OFFSHORE RIGS INTERCOMMUNICATION SYSTEM

#### S.7. RIG INTERCOMMUNICATION SYSTEM

##### S.7.1 Telephone system

- 1
- 2
- 3 Able to Communicate between the following

Main zones

Make  
Type

|                                                                                          |  |
|------------------------------------------------------------------------------------------|--|
|                                                                                          |  |
| <b>Mitel</b>                                                                             |  |
| <b>SX – 50</b>                                                                           |  |
| <b>30 positions at varius points on rigs.</b>                                            |  |
| <b>Note:</b> Hand-free system for Communication between Driller and Derric-man installed |  |
| Cement unit                                                                              |  |
| Co. Man Office                                                                           |  |
| Dog House                                                                                |  |
| Energ. Gen. Room                                                                         |  |
| Engine Room                                                                              |  |
| Mud Pit Room                                                                             |  |
| Rig Floor                                                                                |  |
| Shale Shaker                                                                             |  |
| Mud Logging Unit                                                                         |  |
| WellHead                                                                                 |  |

- Offshore Radios

**S. UNIT COMMUNICATION SYSTEM**

**S.1. SSB RADIO MARINE**

|                |      |
|----------------|------|
| 1              | No.  |
| 2              | Make |
| 3              | Type |
| 4 Output Power | Watt |

|                       |
|-----------------------|
|                       |
| <b>1</b>              |
| <b>Skanti Denmark</b> |
| <b>TRP 7201</b>       |
| <b>200</b>            |

**S.2. VHF-RADIO TELEPHONE**

|                |      |
|----------------|------|
| 1              | No.  |
| 2              | Make |
| 3              | Type |
| 4 Output Power | Watt |

|                              |
|------------------------------|
|                              |
| <b>2</b>                     |
| <b>Nera</b>                  |
| <b>GMDSS Skanti VHF 3000</b> |
| <b>25</b>                    |

**S.3. RADIO BEACON TRASMITTER**

|   |      |
|---|------|
| 1 | Make |
| 2 | Type |

|                  |
|------------------|
|                  |
| <b>Spilsbury</b> |
| <b>100 watt</b>  |

**S.4. SATELLITE COMMUNICATION SYSTEM**

|   |      |
|---|------|
| 1 | Make |
| 2 | Type |

|                 |
|-----------------|
|                 |
| <b>Nera</b>     |
| <b>Saturn B</b> |

**42.3 LAND RIG REQUIREMENTS**

**7.23.2 RIG INTERCOMMUNICATION SYSTEM**

**.1 Fixed installation**

|    |                                    |   |
|----|------------------------------------|---|
| 1  | Make and type                      | : |
| 2  | Company Office Commun. Pint        | : |
| 3  | Contractor Office Commun. Pint     | : |
| 4  | Rig Floor Communication Point      | : |
| 5  | SCR barrack Communication Point    | : |
| 6  | Mud Mixing Area Comm. Point        | : |
| 7  | Shale Shaker area Comm. Point      | : |
| 8  | Mud Pump Area Comm. Point          | : |
| 9  | Mud Logging Unit                   | : |
| 10 | Other Points                       | : |
| 11 | Interphone rig-floor Derrick pltf. | : |
| 12 | Interphone rig-floor Substructure  | : |
| 13 | Public address system              | : |

|                                           |
|-------------------------------------------|
|                                           |
| Requested                                 |
| Requested                                 |
| Requested                                 |
| Requested                                 |
| Requested                                 |
| Requested                                 |
| Requested                                 |
| Requested                                 |
| ( + )                                     |
| Requested                                 |
| ( + )                                     |
| Requested audible everywhere on work site |

**.2 Portable radios**

|   |                             |    |
|---|-----------------------------|----|
| 1 | Quantity                    | No |
| 2 | Make and type               | :  |
| 3 | Suitable for hazardous area | :  |

|                            |
|----------------------------|
|                            |
| <b>5</b>                   |
| Requested "hand free" type |
| Requested                  |

**.3 Tele communication for Contractor's use**

|   |               |
|---|---------------|
| 1 | Fax           |
| 2 | Cellularphone |

|           |
|-----------|
| Requested |
| Requested |
| ( + )     |

### 43. JACK UP RIG

#### INDEX:

#### 43.1 DESCRIPTION

#### 43.2 JACK UP TYPE

#### 43.1 DESCRIPTION

##### HULL:

Usually triangular; rarely square.

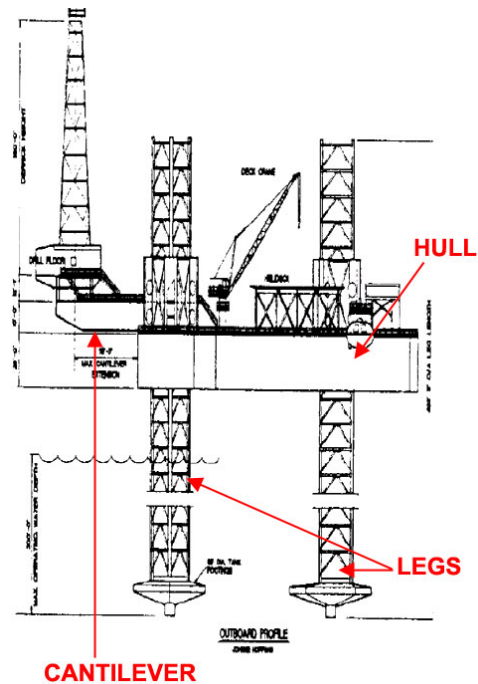
##### LEGS:

Lattice shaped, they can either be the shell type or truss type.

Triangular or square cross section styles are most common.

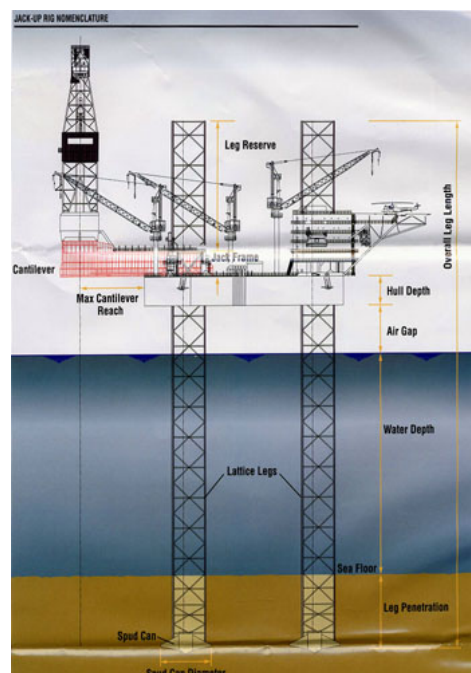
##### CANTILEVER:

Allows the derrick to be skidded to work on other wells on multi-well platforms



#### Nomenclature

- Overall Leg Length
- Hull Depth
- Air Gap
- Water Depth
- Leg Penetration
- Lattice Leg
- Spud Can
- Spud Can Diameter
- Jack Frame
- Leg Reserve
- Cantilever
- Max Cantilever Reach



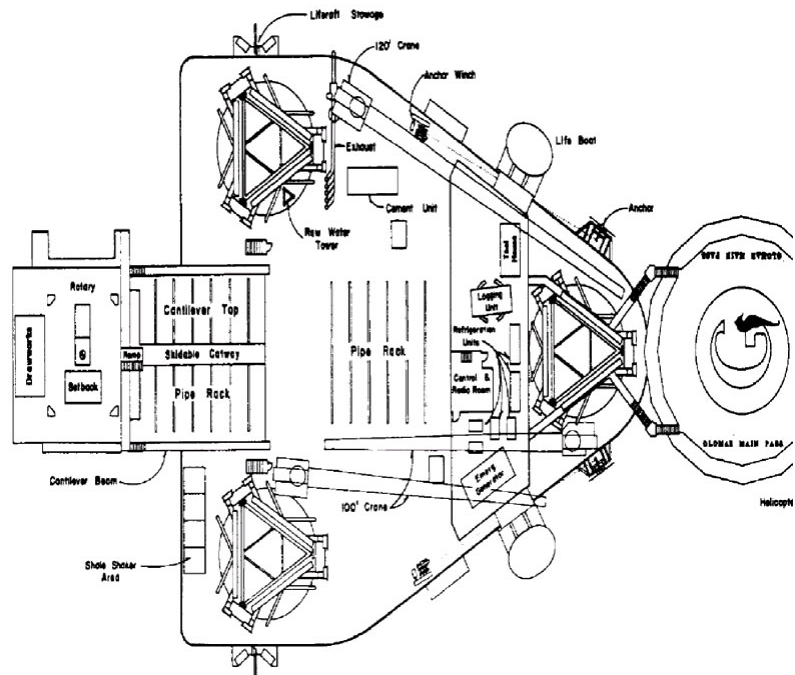


## - Hull description

The hull is the main structure of the rig and enables it to be towed out to the location with the legs up.

The hull usually has 3 levels:

- **Lower:** tanks for liquid storage (diesel, potable water, drilling water) and separate tanks for ballasting.
- **Intermediate:** generators, motors, compressors, mud pumps, mud pits, bulk silos, etc.
- **Main:** living quarters, cranes, pipe racks, cantilever with derrick, helideck, etc.



Hull

## - Legs description

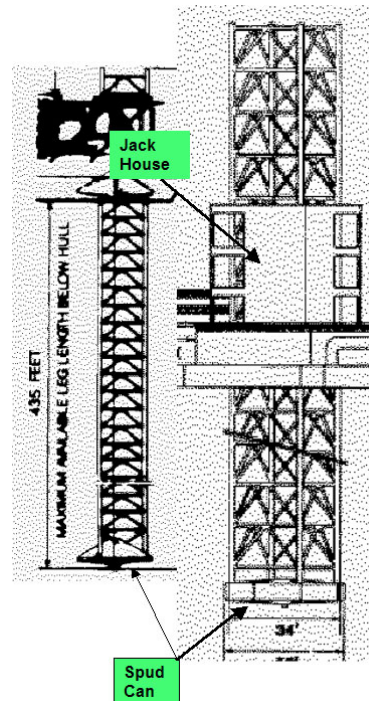
- Leg length, Jack house and Spud can

**Leg length** determines the maximum depth for the jack-up.

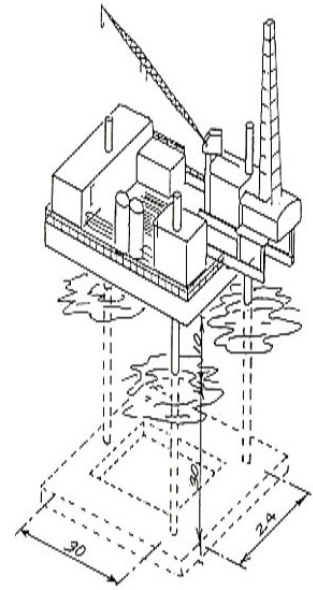
Racks are welded on each corner of the leg to all the pinion to move up and down the leg ( **jack house** ).

Legs are independent of each others.

A **spud can** is installed below each leg to facilitate better penetration of the sea bed. A jetting system is installed in each leg to wash out in jack down and leg recovering.

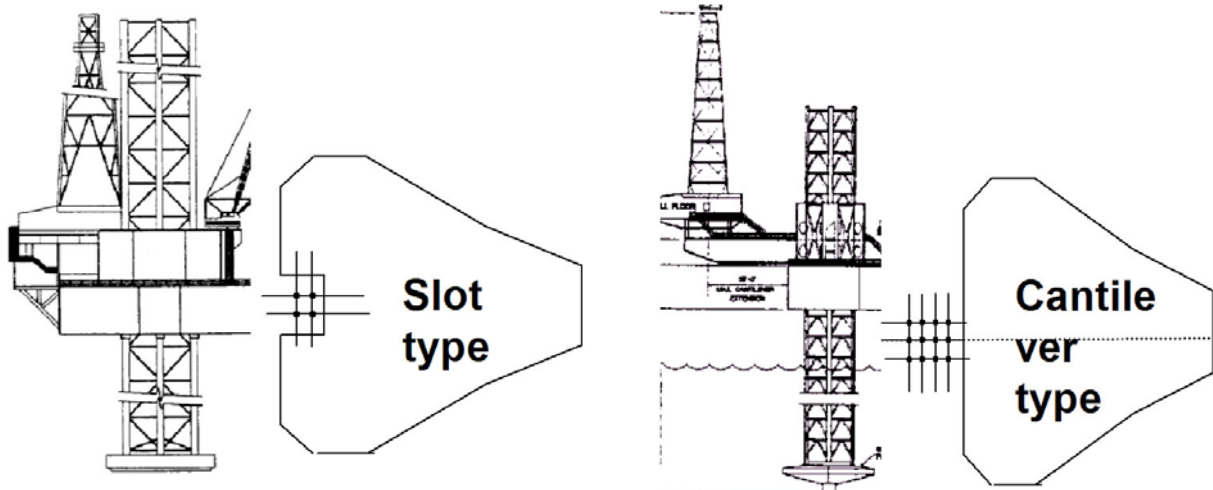


Specifically made for hard sea bed  
(not used for years).



### Jack Up Mat Supported

**CANTILVER TYPE** jack up can position the derrick in different wells moving on orthogonal beams. All new jack-up are made in this way.



### 43.2 JACK UP TYPE

All jack-ups, (Slot type or Cantilever, with spud can or mat support) are classified according to their nominal depth capacity:

**150-250 ft Nominal water depth**

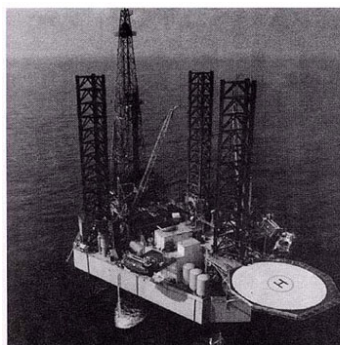
**300-350 ft Nominal water depth**

**400-450 ft Nominal water depth**

#### - 150-250 ft Nominal water depth

Most common models in this category are:

1. BMC 150 BMC 200 BMC 250 of Baker Marine
2. JU MC 150 JC MC 200 JC MC 250 of Bethlehem
3. L 780 of Fried & Glodman
4. Drill Hope C-150 and C-250 of Hitachi
5. Class 51 C, class 82 of Le Tourneau
6. 200 C – 45 of Mitsui
7. Mercury Class of Offshore Co



**Baker Marine  
BMC-150-H  
BMC-150-IC**

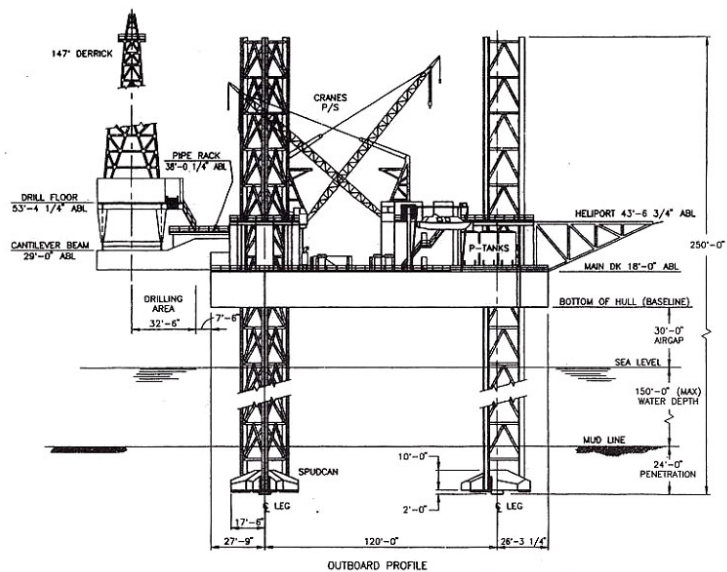
Independent leg jackup, three triangular legs.

No. built: 6  
No. existing: 5

Baker Marine built six jackups with triangular legs to this basic design.

#### Existing Units

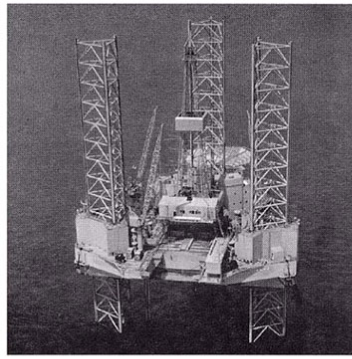
| Rig Name         | Water Depth | Rig Owner/Rig Manager     | Design Variation                 | Year in Service |
|------------------|-------------|---------------------------|----------------------------------|-----------------|
| Astra            | 148         | Lukoil                    | Baker Marine Services BMC-150-H  | 1983            |
| GP-19            | 150         | PDVSA/Pride International | Baker Marine Services BMC-150-H  | 1981            |
| Arabdrill VIII   | 160         | Arabian Drilling          | Baker Marine Services BMC-150-IC | 1982            |
| Noble Dick Favor | 150         | Noble Drilling            | Baker Marine Services BMC-150-IC | 1982            |
| Noble Don Walker | 150         | Noble Drilling            | Baker Marine Services BMC-150-IC | 1982            |



## - 300-350 ft Nominal water depth

Most common are:

1. Robray 300 "ETA"
2. L 780 MOD II , Monarch class  
"Friede & Glodman"
3. T 2000 T 2005 T 2601 - CFEM
4. 3 leg jack up "Gusto Engineering"
5. Giant Class "Hitachi"
6. Class 116, Super 300 « Le  
Tourneau »
7. 111 S & C « Levingston »
8. CJ62 –S 120 Marine Structure  
Consultants
9. 300 C « Mitsui »
10. Orion Class « Offshore Co. »



Bohai Drilling's jackup BOHAI IV on location off China.

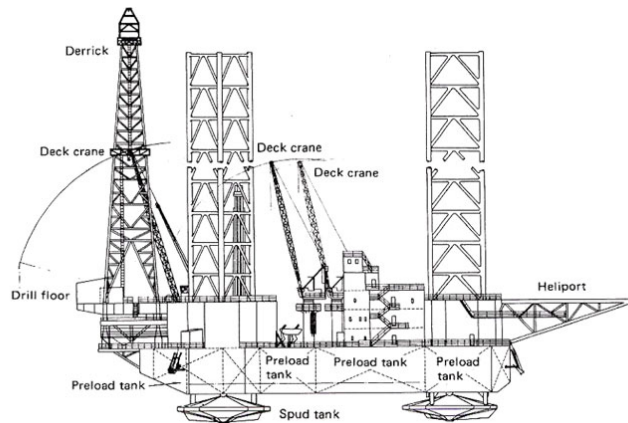
ETA  
Robray 300-C  
Robray 300-S

Independent leg jackup, three  
triangular legs. C denotes  
cantilever units, S denotes slot  
units, \* denotes cantilever added.

No. built: 6  
No. existing: 5

### Existing Units

| Rig Name           | Water<br>Depth | Rig Owner/Rig Manager             | Design Variation         | Year in<br>Service |
|--------------------|----------------|-----------------------------------|--------------------------|--------------------|
| Sagar Gaurav ..... | 300 .....      | ONGC .....                        | ETA Robray 300-C .....   | 1982               |
| Sagar Shakti ..... | 350 .....      | ONGC .....                        | ETA Robray 300-C .....   | 1982               |
| Bohai IV .....     | 300 .....      | China Oilfield Services Ltd ..... | ETA Robray R300-S* ..... | 1977               |
| Kan Tan II .....   | 300 .....      | Ministry of Geology/CNSPC .....   | ETA Robray 300-S .....   | 1977               |
| Yu Song .....      | 300 .....      | KS Tech/China Oilfield Svcs ..... | ETA Robray 300-S* .....  | 1976               |

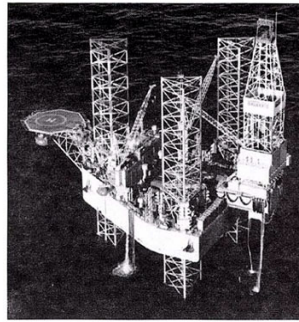




- 400-450 ft Nominal water depth

Most common models in this category are:

- Universe Class "Friede & Glodman"
- Super Gorilla "Le Tourneau"
- CJ70-150 MC "Marine Structure Consultants"
- 400 C "Mitsui"



Friede & Goldman  
L-780 MOD VI

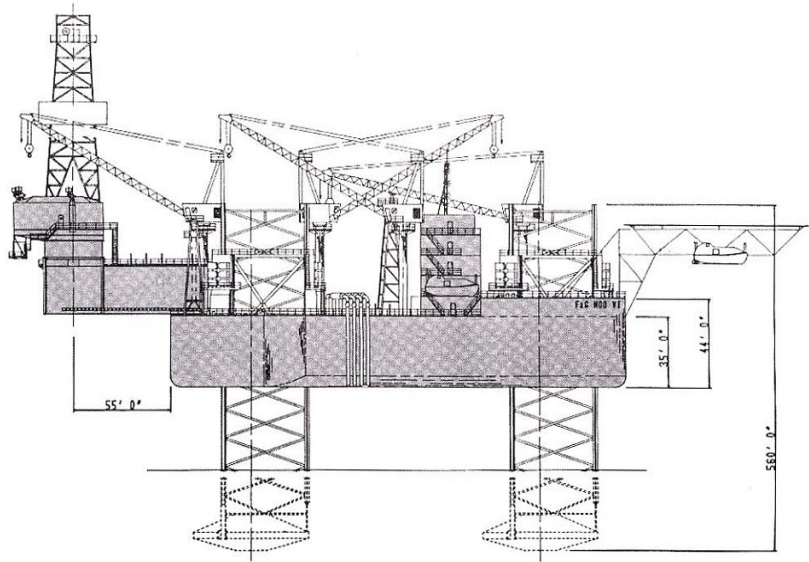
Independent leg, harsh  
environment jackup, three  
triangular legs, cantilever.

No. built: 2  
No. existing: 2

GlobalSantaFe's GALAXY I, was one of the world's largest  
jackup drilling units when delivered.

Existing Units

| Rig Name            | Water<br>Depth | Rig Owner/Rig Manager | Design Variation       | Year in<br>Service |
|---------------------|----------------|-----------------------|------------------------|--------------------|
| GSF Galaxy I .....  | 400 .....      | GlobalSantaFe .....   | F&G L-780 MOD VI ..... | 1991               |
| GSF Galaxy II ..... | 394 .....      | GlobalSantaFe .....   | F&G L-780 MOD VI ..... | 1998               |



## 44. JACK UP POSITIONING

### INDEX:

- 44.1 POSITIONING
- 44.2 MAX WATER DEPTH
- 44.3 PRELOAD
- 44.4 PUNCH THROUGH

### 44.1 POSITIONING

#### - Geophysical survey for jack-ups

The purpose of a well site geophysical survey is to investigate the sea bed or subsea to identify its litho-morphological features, determine the trend of sedimentary sequences and ascertain the presence of potential foundation hazards.

Potential hazards could include: faults, shallow gas, hardband outcropping, irregular sea bed topography and man-made hazards.

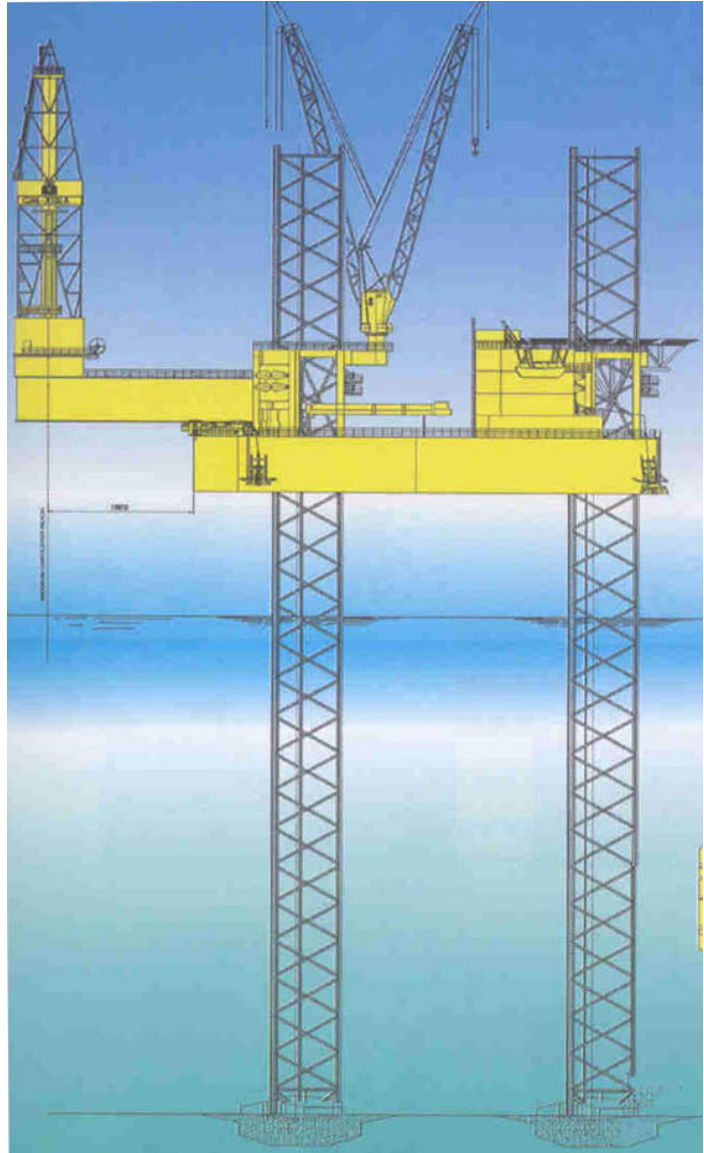
#### - Survey informations

The survey must give the following informations:

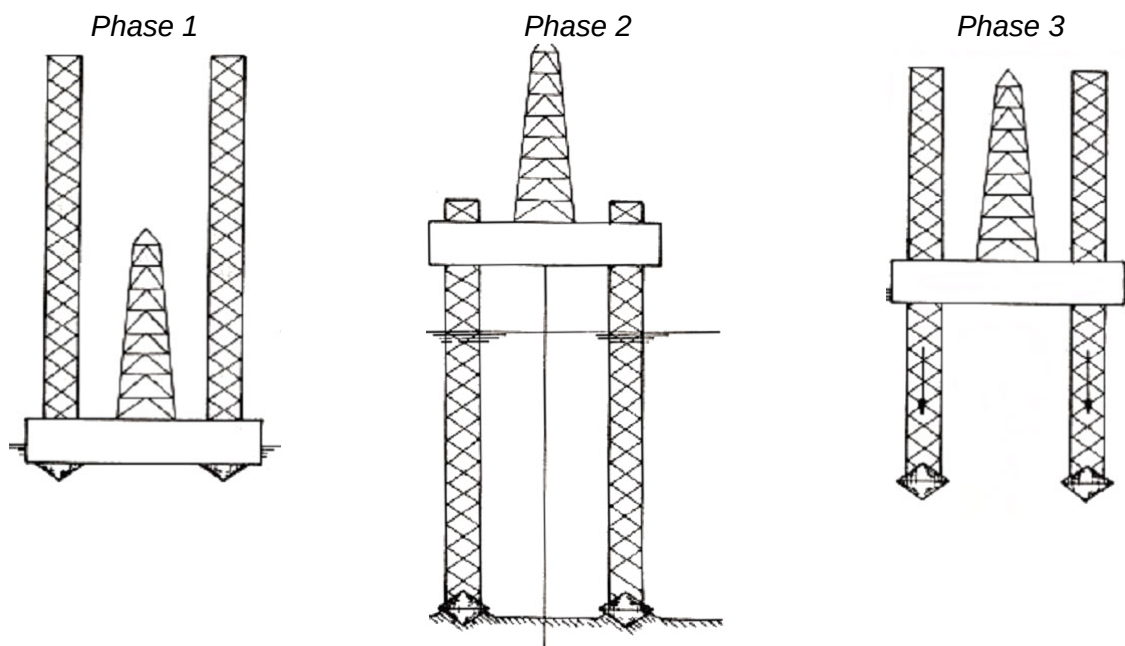
Water depth (bathymetric map)  
Morphology and consistency of the sea bed  
Stratigraphy and lithology of shallow gas  
Presence of obstacles or pre-existing structures.

#### - Final Air Gap

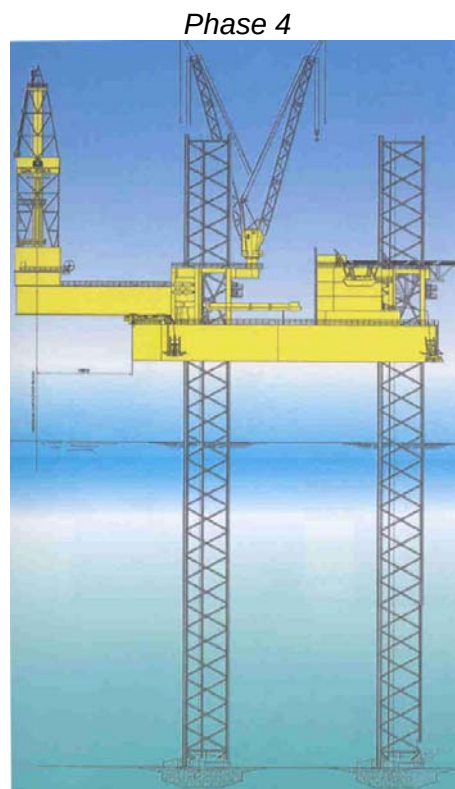
The final air gap is defined as the distance between the bottom of the hull of the jack up and the lowest astronomical tide. This distance is calculated to take account of prevailing weather conditions in an area, such that the rig hull is far enough out of the water to not be subjected to wave loads in the event of a heavy storm.



## POSITIONING PHASES



- PHASE 1 Floating rig is towed by one or more supply vessels.
- PHASE 2 Legs are lowered to bottom when rig is in correct position. Engage mudline simultaneously with legs.
- PHASE 3 Preload begins. Fill all preload tanks simultaneously to ensure equal load on legs.
- PHASE 4 Dump preload and Jack unit to the decided airgap. Prepare for drilling.

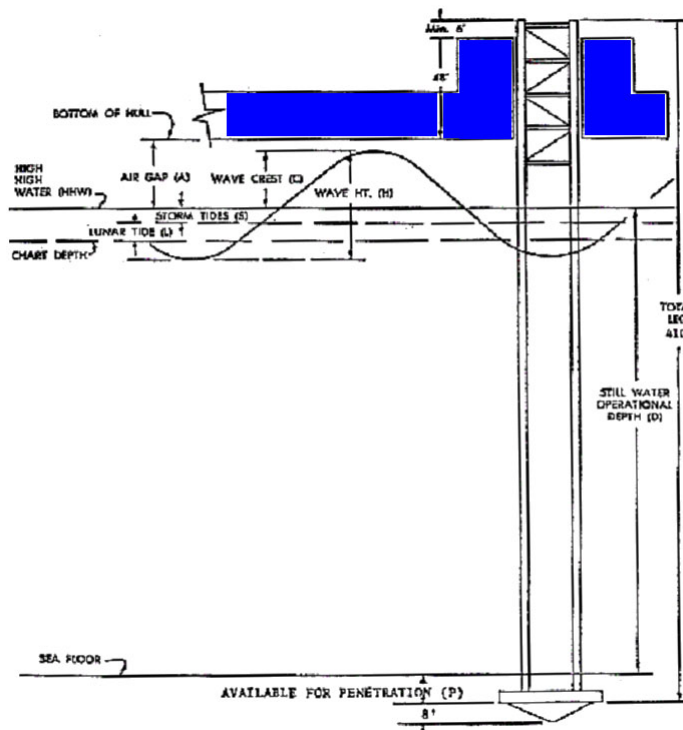


## 44.2 MAX WATER DEPTH

### JACK UP MAXIMUM OPERATING WATER DEPTH

#### - Classification

Jackups are classified by their working water depth.



#### - Limitations of working water depth

A jackup can have different limitations of working water depth, depending on weather conditions and leg penetration.

|   | Gulf Mexico Hurricane | Gulf Mexico Norn-Hur. | S.E. ASIA | BASIC CRIT. |
|---|-----------------------|-----------------------|-----------|-------------|
| D | 250                   | 300                   | 300       | 300         |
| H | 54                    | 50                    | 30        | 50          |
| C | 55                    | 33                    | 20        | 33          |
| A | 40                    | 38                    | 25        | 28          |
| V | 109                   | 109                   | 70        | 109         |
| S | 2.5                   | 2.0                   | 4         | 5           |
| L | 2.5                   | 2.5                   | 5         | 5           |
| P | 56                    | 18                    | 31        | 18          |

$D + P = 331$

V = Wind  
Vel. in  
Knots



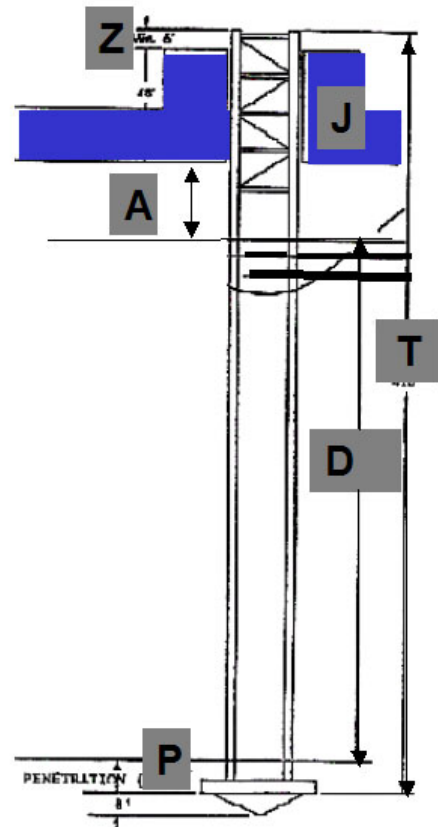
- Calculate maximum Water Depth

To calculate the maximum Water Depth :

$$D = T - (Z + J + A + P)$$

where

D= water depth + maximum tide  
 T= Leg length  
 Z= safety margin for top of the leg  
 J= jack house + hull  
 A= Air gap  
 P= Leg penetration



### 44.3 PRELOAD

Vertical loads on Jack-up legs are:

Hull and legs weight

1. Variable load during drilling
2. Maximum pull at the hook

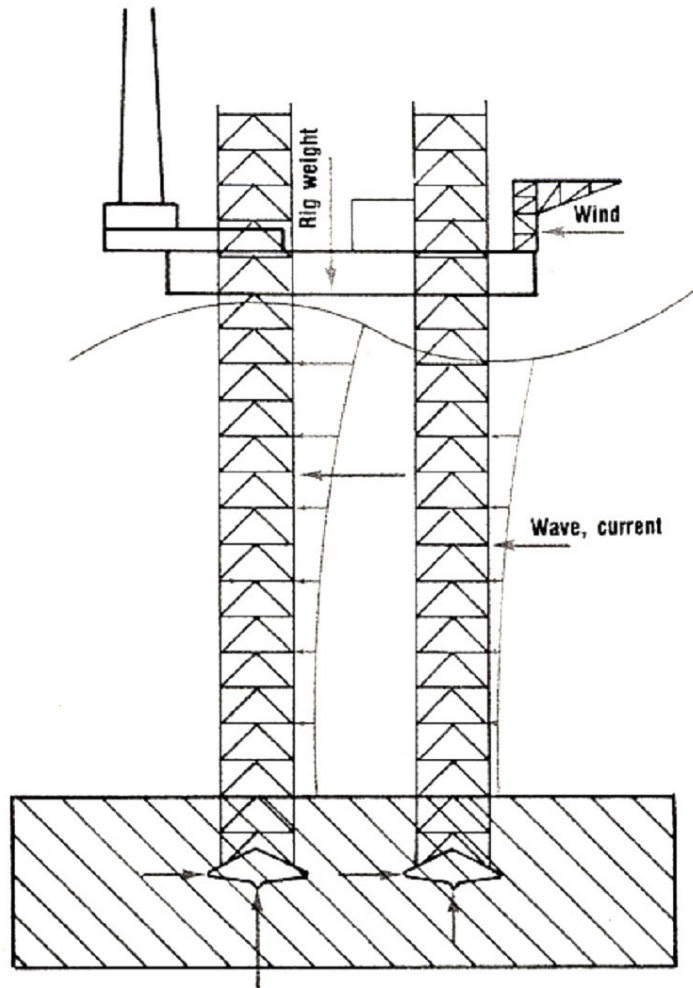
Horizontal loads are:

1. Wind
2. Waves
3. Sea Current

To achieve satisfactory rig stability on the sea bed, maximum anticipated vertical leg loads are simulated on each spudcan prior to jacking up to full operational air gap.

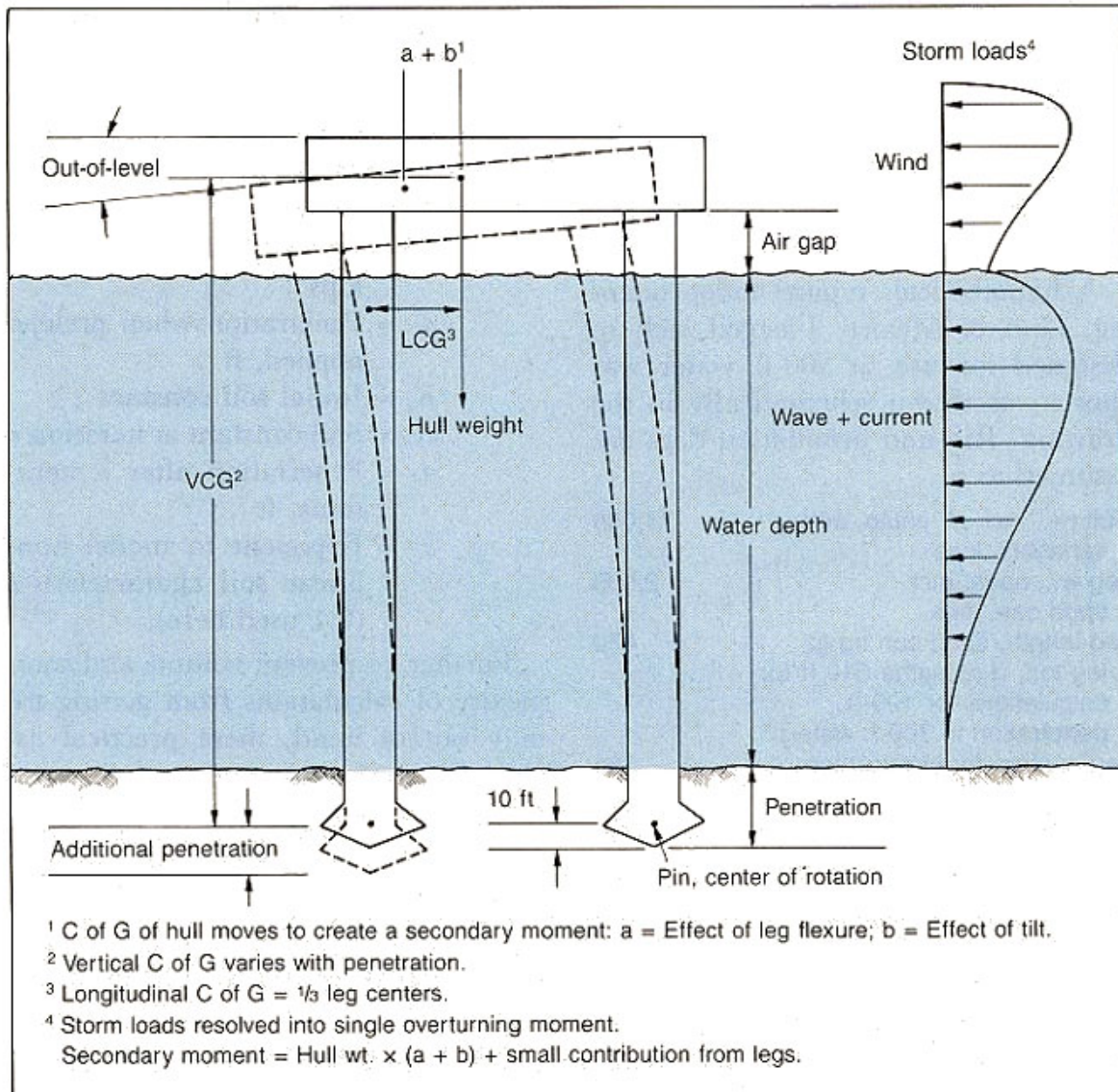
This preloading operation is necessary to ensure that all spud cans will achieve sufficient penetration.

Sufficient penetration provides a foundation stable enough to withstand the combination of maximum anticipated variable and drilling/operational loads, without further settlement or “punch through” occurring.



## PREDICTION OF LEG PENETRATION

The leg penetration study may be performed prior to the arrival of the jack-up unit at the site by using a small drilling vessel to obtain soil samples. Alternatively the study may be performed from the rig after legs have been lowered, but prior to the application of maximum load. The penetration of a footing (spudcan) into the soil occurs when the applied bearing pressure exceeds the bearing capacity of the soil. Penetration continues until the bearing capacity corresponding to ultimate soil strength equals the applied footing pressure.



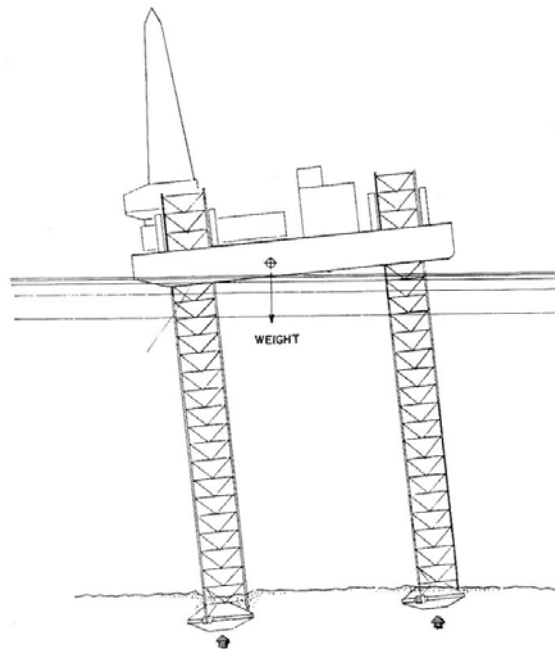
CONCEPT OF POTENTIAL deepwater jack-up instability in storm due to additional leg penetration in softer soils.

#### 44.4 PUNCH THROUGH

Punch through is the term used to describe a sudden breach of the seabed by one or more spudcans.

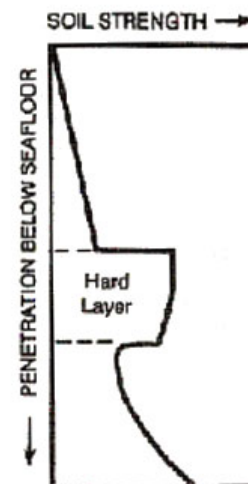
Punch through would almost certainly occur only during preloading and is a rare occurrence as the site survey would normally have identified the potential for punch through.

Punch through can cause extensive damage to a jack-up and emphasizes the reason to perform a full preloading with minimum air gap (usually 5-10 ft / 1.5 – 3 m).



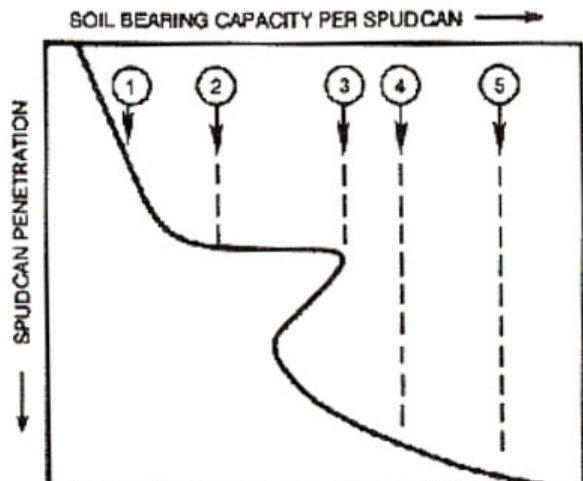
#### Different formations

Punch through occurs where the sea bed has a variety of different formations.



#### Spudcan Penetration

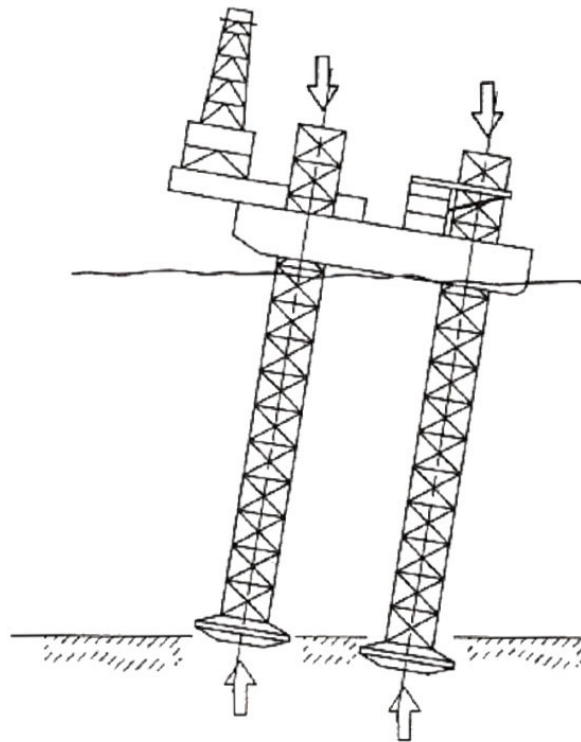
- 1 Normal leg penetration
- 2 Hard formation with zero penetration and pre-load increasing.
- 3 Max load on the formation
- 4 Punch through with rig inclination
- 5 Hard formation holding max preload.





## PUNCH THROUGH CONSEQUENCE

*Load misalignment following punch-through*



## 45. SUBMERSIBLE RIGS

### INDEX:

- 45.1 SWAMP BARGE
- 45.2 POSTED BARGE

### 45.1 SWAMP BARGE

Swamp barges were built specifically to drill in shallow water, swamps or delta rivers, where a jack up or semisub cannot operate.

They are designed to operate in 10 – 15 ft of water.

Swamp barges are towed in position with Supply Vessels. Once on they take on sea water to sit on the sea bed.

**Sunkar (Parker Drilling Co.)** is a swamp barge modified to work in Caspian Sea.

Swamp barges are usually employed in Nigeria (Niger River Delta), in Venezuela, and in the Caspian Sea.



*Sunkar (Parker Drilling Co.)*

### 45.2 POSTED BARGE

#### Types of Posted Barges

Most common are:

- **DMI 85 - Donhaiser Marine**
- **Pace 85 - Pace Marine Engineering**
- **Column submersible Transworld**

Posted barges are designed for depths up to 100 ft, a much deeper range than a swamp barge.

| RBF 78            |                               |                                                                                       |
|-------------------|-------------------------------|---------------------------------------------------------------------------------------|
| <b>Rig Type</b>   | Submersible Rigs              |  |
| <b>Design</b>     | DMI 85-MS Cant.               |                                                                                       |
| <b>Builder</b>    | Chicago Bridge & Iron Company |                                                                                       |
| <b>Year Built</b> | 1983                          |                                                                                       |

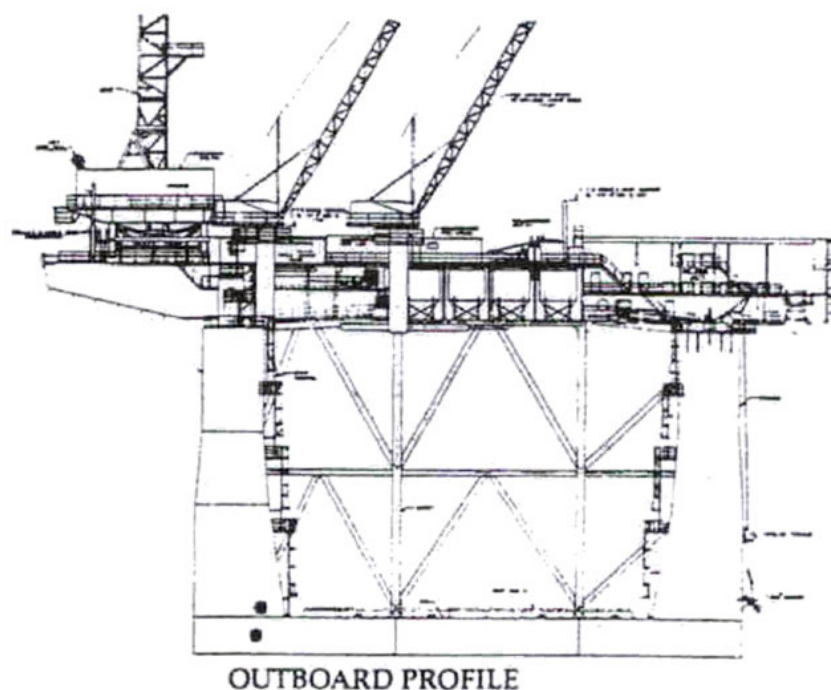
*DMI 85 - Donhaiser Marine*

## Pace Marine Engineering Systems Pace 85

Column stabilized (four columns),  
cantilever, submersible drilling rig.

No. built: 4  
No. existing: 4

| <u>Rig Name</u>           | <u>Water<br/>Depth</u> | <u>Rig Owner/Rig Manager (if other than owner)</u> | <u>Design Variation</u> | <u>Year in<br/>Service</u> |
|---------------------------|------------------------|----------------------------------------------------|-------------------------|----------------------------|
| Falcon 203 .....          | 85 .....               | R&B Falcon .....                                   | Pace 85 .....           | 1983                       |
| Noble Joe Alford .....    | 85 .....               | Noble Drilling .....                               | Pace 85 .....           | 1982                       |
| Noble Lester Pettus ..... | 85 .....               | Noble Drilling .....                               | Pace 85 .....           | 1982                       |
| Richmond .....            | 70 .....               | Atwood Oceanics .....                              | Pace 85 .....           | 1982                       |



## 46. TENDER DRILLING RIGS

### INDEX:

- 46.1 TENDER SHIP TYPE
- 46.2 TENDER JACK UP TYPE
- 46.3 TENDER SEMI TYPE

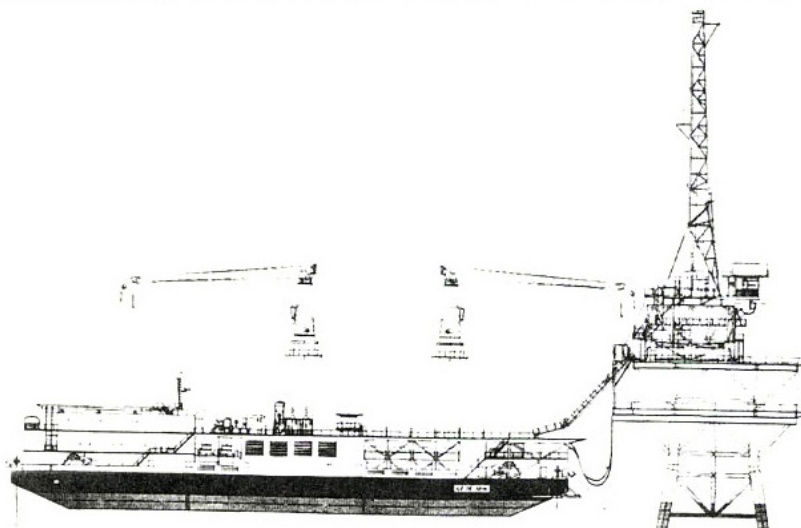
### 46.1 TENDER SHIP TYPE

Foramer  
Compact Tender

Self-erecting tender.

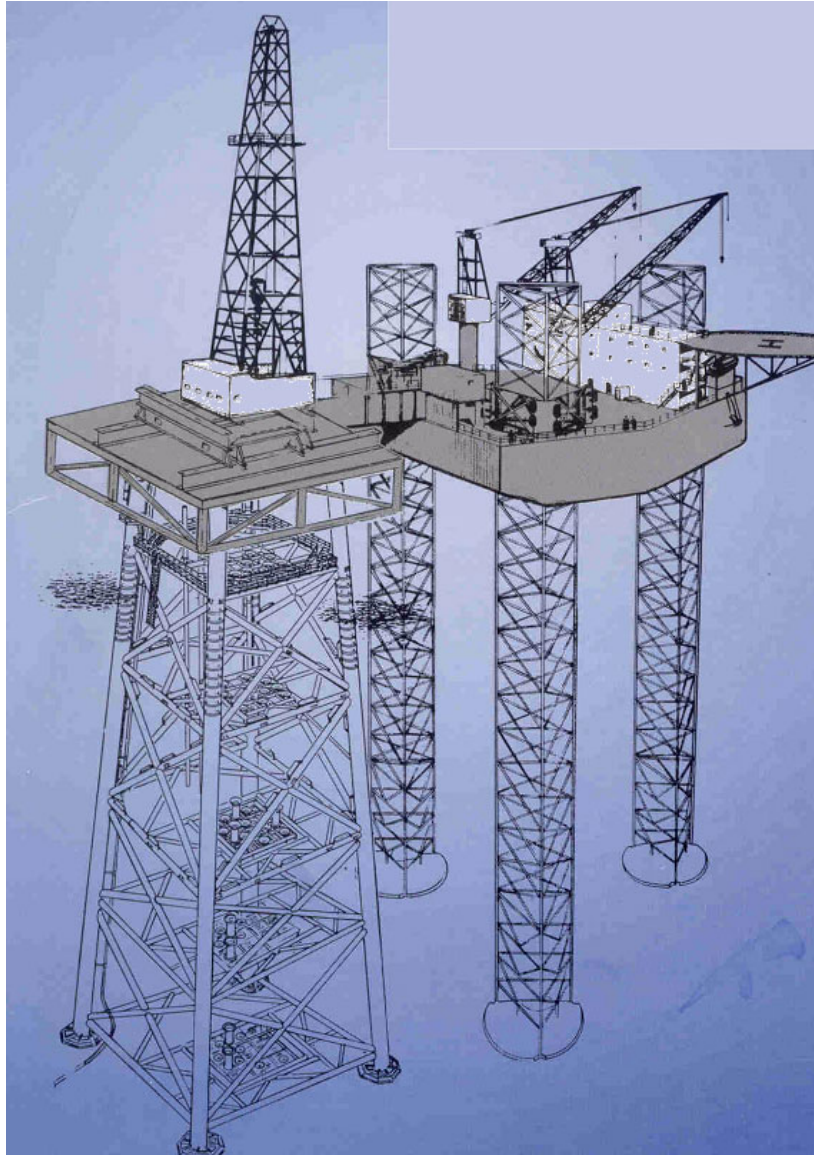
No. existing: 4

| <u>Rig Name</u>   | <u>Water<br/>Depth</u> | <u>Rig Owner/Rig Manager (if other than owner)</u> | <u>Design Variation</u> | <u>Year in<br/>Service</u> |
|-------------------|------------------------|----------------------------------------------------|-------------------------|----------------------------|
| Piranha .....     | 600 .....              | Pride Foramer .....                                | Jumbo type .....        | 1978                       |
| Alligator .....   | 330 .....              | Pride Foramer .....                                | Compact Tender .....    | 1982                       |
| Barracuda .....   | 330 .....              | Pride Foramer .....                                | Compact Tender .....    | 1982                       |
| Ile de Sein ..... | 450 .....              | Pride Foramer .....                                | Compact Tender .....    | 1981                       |





## 46.2 TENDER JACK UP TYPE



### 46.3 TENDER SEMI TYPE

**Breit Engineering  
Zephyr**

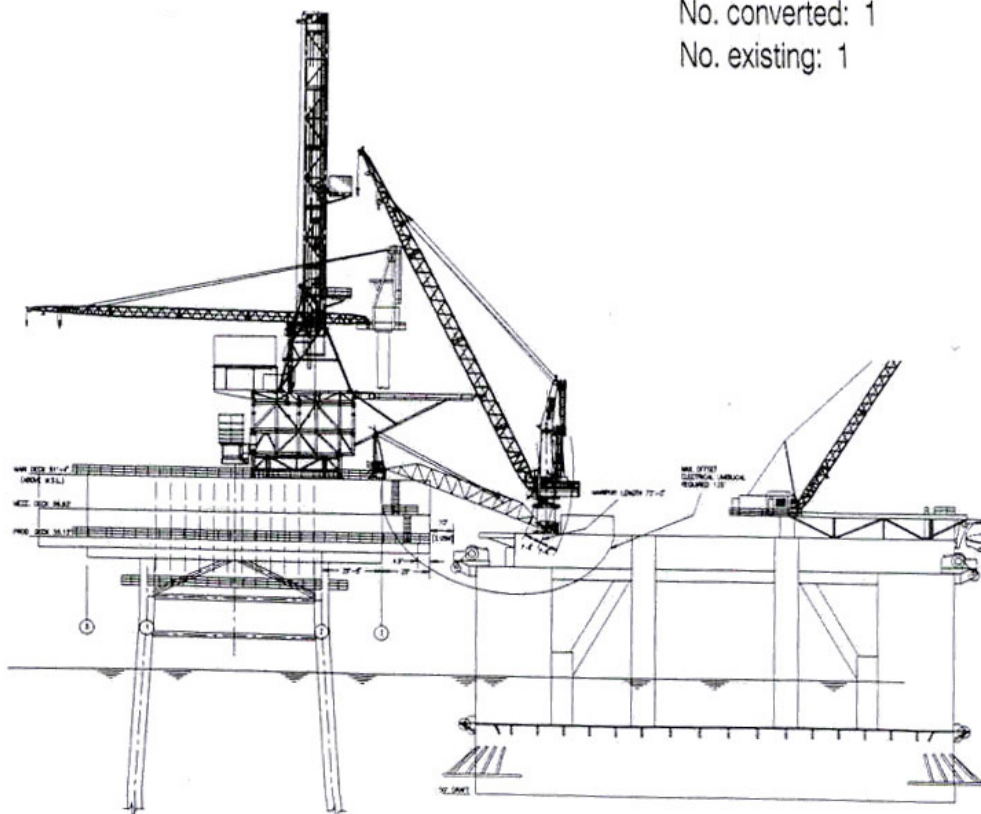
Self-erecting  
semisubmersible tender  
conversion.

| <u>Rig Name</u> | <u>Water<br/>Depth</u> | <u>Rig Owner/Rig Manager (if other than owner)</u> | <u>Design Variation</u> | <u>Year in<br/>Service</u> |
|-----------------|------------------------|----------------------------------------------------|-------------------------|----------------------------|
| Seahawk .....   | 600 .....              | Atwood Oceanics .....                              | Zephyr .....            | 1992*                      |

\*denotes conversion year

No. converted: 1

No. existing: 1



## 47. SELF CONTAINED DRILLING RIGS

### 47.1 SELF CONTAINED DRILLING RIGS

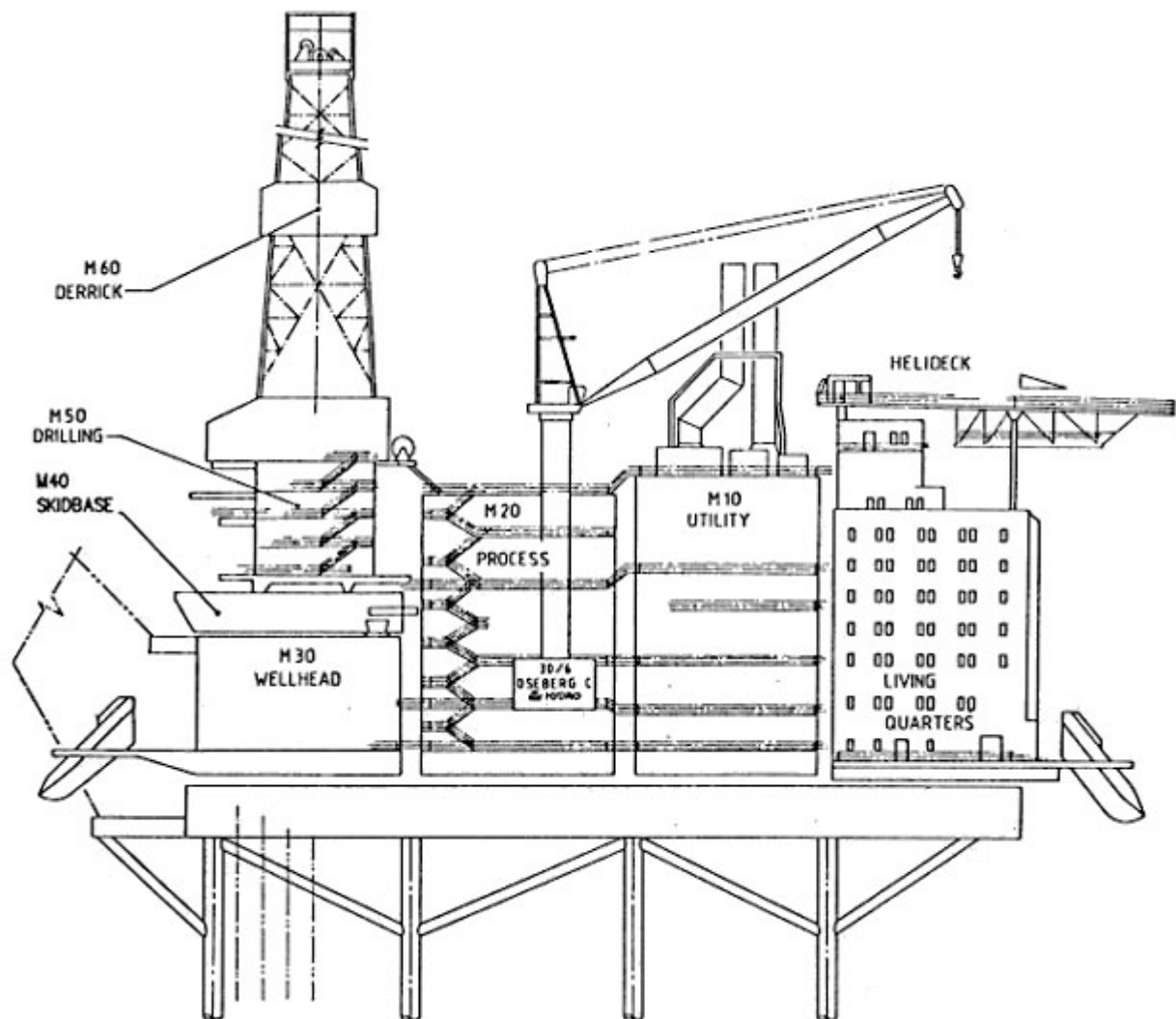
Self-contained rigs installed on fixex platforms (jackets) and are usually equipped with all production facilities for early production. Sometimes the rigs are moved off after drilling phase is finished and sometimes they stay on site future workover.

This is an 8 piles jacket rig in the Adriatic Sea.

All modules are removed after drilling and completion. Future work over activities are done by dedicated workover rigs.

8-piles jacket rigs are installed on jackets dimensioned to drill as many wells as possible, depending on the jacket structure.

The positioning of the derrick on a different well is obtained by moving the derrick structure on orthogonal beams with hydraulically operating jacks.



*Self contained drilling rigs*

## 47.2 JACKET RIG IN THE ADRIATIC SEA

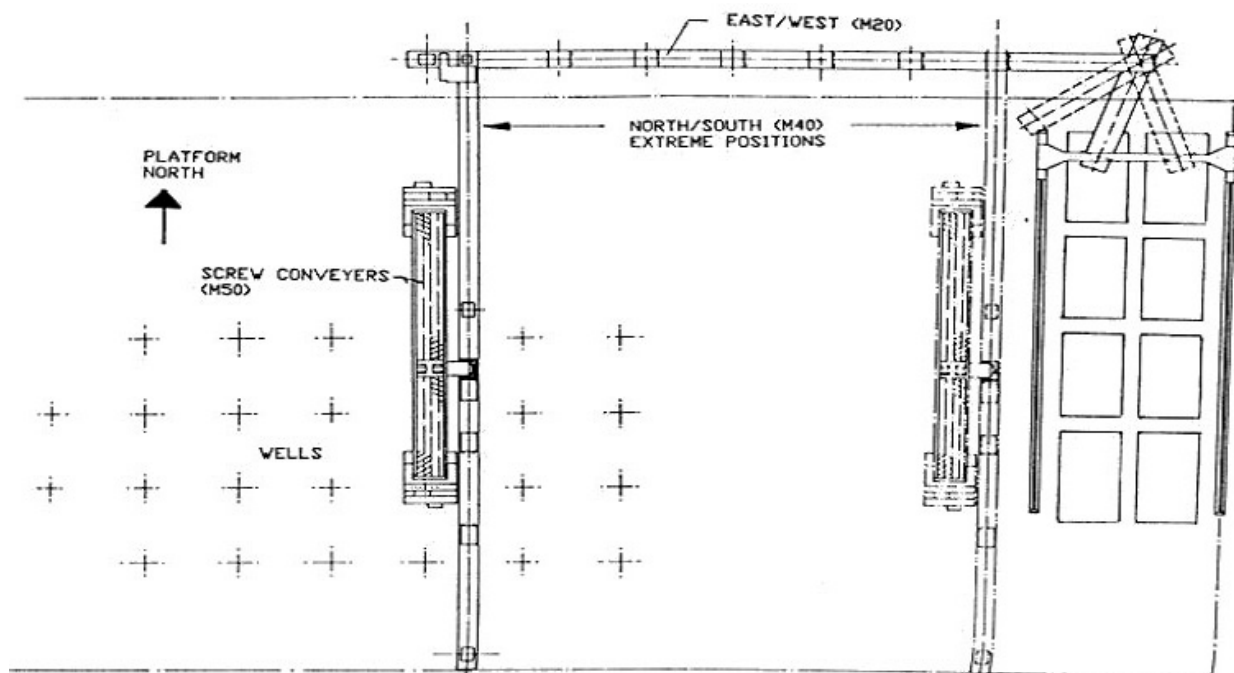
This is an 8-pile jacket rig in the Adriatic Sea. All modules are removed after drilling and completion. Future work over activities are done by dedicated workover rigs.



### - 8-piles jacket rigs installing

8-piles jacket rigs are installed on jackets dimensioned to drill as many wells as possible, depending on the jacket structure.

The positioning of the derrick on a different well is obtained by moving the derrick structure on orthogonal beams with hydraulically operating jacks.





## 48. SUPPLY VESSELS

### INDEX

#### 48.1 TYPES of SUPPLY VESSELS

ANCHOR HANDLING TOWING SUPPLY (AHTS)  
PRODUCTION SUPPLY (PSV)  
CREWBOAT / FAST SUPPLY (FSV)  
OIL SPILL RECOVERY (OSRV)  
UTILITY  
MINI-SUPPLY

#### 48.1 TYPES of SUPPLY VESSELS

##### - ANCHOR HANDLING TOWING SUPPLY (AHTS)

AHTS vessels are equipped with winches capable of towing drilling rigs and lifting and positioning their anchors and other marine equipment.

They range in size and capacity and are usually characterized in terms of horsepower and towing capacity.

AHTS vessels typically require 8,000 horsepower or more to position and service semi-submersible rigs drilling in deep water areas.



##### - PRODUCTION SUPPLY (PSV)

PSVs serve drilling and production facilities and support offshore construction and maintenance work.

They are differentiated from other vessels by cargo flexibility and capacity. In addition to deck cargo, such as pipe or drummed materials on pallets, supply vessels transport liquid mud, potable and drill water, diesel fuel and dry bulk cement.



Other characteristics, such as maneuverability, fuel efficiency or firefighting capability may also be important.

Towing supply vessels perform the same functions as supply vessels but are equipped with more powerful engines and a deck mounted winch, giving them the added capability to perform general towing duties, buoy setting and limited anchor handling work. Towing supply vessels are used primarily in international operations to tow, position and support jack-up drilling units.

**- CREWBOAT / FAST SUPPLY (FSV)**

Crewboats transport personnel and cargo to and from production platforms and rigs.

Older crewboats are generally designed for speed to transport personnel.

Newer crewboats (also referred to as fast supply vessels "FSV"), are generally larger, have greater cargo carrying capacities and are used primarily to transport cargo on a time sensitive basis.



**- OIL SPILL RECOVERY (OSRV)**

OSRVs specialize in providing cost-effective solutions to meet the environmental regulations of the U.S. and international energy and maritime industries.

They are also used for temporary storage of recovered oil and removal of oil & hazardous waste.



**- UTILITY**

Utility vessels provide service to offshore production facilities and also support offshore maintenance and construction work.

Their capabilities include the transportation of fuel, water, deck cargo and personnel.

They can have enhanced features such as firefighting and pollution response capabilities.



**- MINI-SUPPLY**

Mini-supply vessels vary from 145 ft. to 170 ft. in length and have enhanced cargo capacity and maneuverability as compared to standard utility vessels.

Besides fuel, water and deck cargo, some mini-supply vessels can transport methanol and have enhanced station keeping with dynamic positioning systems.



## 49. DRILLING RIGS IN CASPIAN SEA

### INDEX

- MOBILE LANDED DRILLING UNIT-SUNKAR
- CONVENTIONAL LAND RIG WINTERIZED
- KASHAGAN APPRAISAL
- MOBILE JACK-UP
- AKTOTE EXPLORATION
- AKTOTE ISLAND
- ESCAPE - EVACUATION - RESCUE
- SUPPLY VESSELS and WELL HEAD ICE PROTECTION

### - MOBILE LANDED DRILLING UNIT-SUNKAR



### - CONVENTIONAL LAND RIG WINTERIZED

Land rig winterized



Land rig winterized during winter season





**- KASHAGAN APPRAISAL - MOBILE JACK-UP**

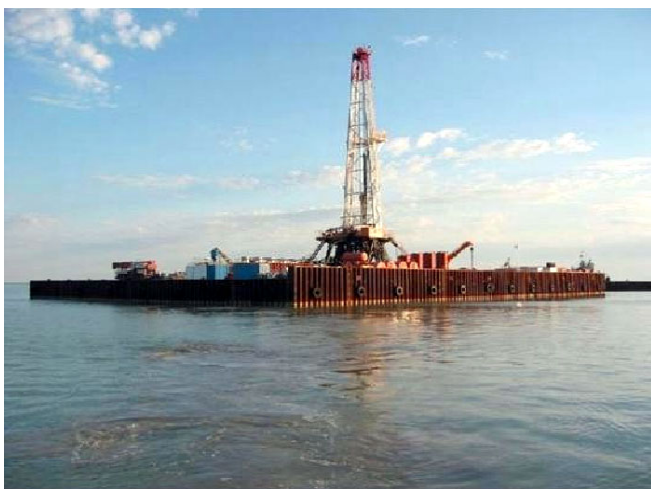
Kashagan Appraisal T- 47 on A island



Trident XX - Kalamkhas August 2002



**- AKTOTE EXPORATION**





**- AKTOTE ISLAND**

*RIG 321 on AKTOTE ISLAND*



**- ESCAPE - EVACUATION - RESCUE**



**- SUPPLY VESSELS and WELL HEAD ICE PROTECTION**

Supply Vessels



Well Head ice Protection



